Australian Government

BUILDING OUR FUTURE

NSW GOVERNMENT

M12 Motorway Environmental Impact Statement

Appendix L Flooding assessment report - Part 1

Roads and Maritime Services | October 2019

BLANK PAGE

Contents

Tables

Figures

Annexures

Glossary of terms and abbreviations

<table>
<tr><th>Term</th><th>Meaning</th></tr>
<tr><td>AEP</td><td>Annual exceedance probability (AEP) represents the probability of a flood event occurring or being exceeded in any one year. For example, a 5% AEP flood would have a 5% chance of occurring in any one year. An approximate conversion between ARI and AEP is provided below.
<table><tr><th>AEPs</th><th>ARI Years</th></tr><tr><td>63.2%</td><td>1</td></tr><tr><td>39.3%</td><td>2</td></tr><tr><td>18.1%</td><td>5</td></tr><tr><td>9.5%</td><td>10</td></tr><tr><td>5%</td><td>20</td></tr><tr><td>2%</td><td>50</td></tr><tr><td>1%</td><td>100</td></tr><tr><td>0.05%</td><td>2000</td></tr></table></td></tr>
<tr><td>ARI</td><td>Average recurrence interval (ARI) is an indicator used to describe the frequency of floods. It represents the long-term average number of years between the occurrence of a flood event of a given magnitude being equalled or exceeded. For example, floods with a discharge as great as or greater than the 100 year ARI flood event will occur on average 20 years in a long period.</td></tr>
<tr><td>Afflux</td><td>Afflux refers to the predicted changes, usually in flood levels, between two scenarios, pre-development conditions (without project) and post-development conditions (with project).
Positive afflux indicates flood level increase under post-development conditions and negative afflux indicates flood level decrease under post-development conditions comparing to pre-development conditions.</td></tr>
<tr><td>Construction footprint</td><td>The construction footprint is the area required to build the project. This includes the area required for temporary work such as sedimentation basins, drainage lines, access roads, construction ancillary facilities.</td></tr>
<tr><td>EIS</td><td>Environmental impact statement</td></tr>
<tr><td>EP&A Act</td><td>Environmental Planning and Assessment Act 1979</td></tr>
<tr><td>EPBC Act</td><td>Environment Protection and Biodiversity Conservation Act 1999</td></tr>
<tr><td>FMP</td><td>Flood management plan</td></tr>
<tr><td>LGA</td><td>Local government area</td></tr>
<tr><td>OEH</td><td>Office of Environment and Heritage</td></tr>
<tr><td>Operational footprint</td><td>Generally includes the M12 Motorway and additional areas required for operation and maintenance of the project</td></tr>
<tr><td>PMP</td><td>Probable maximum precipitation</td></tr>
<tr><td>Roads and Maritime</td><td>NSW Roads and Maritime Services</td></tr>
<tr><td>SEARs</td><td>Secretary’s environmental assessment requirements</td></tr>
<tr><td>SES</td><td>NSW State Emergency Service</td></tr>
<tr><td>TfNSW</td><td>Transport for NSW</td></tr>
</table>

Executive summary

Background

Roads and Maritime Services (Roads and Maritime) is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the M12 Motorway project to provide direct access between the Western Sydney Airport at Badgerys Creek and Sydney's motorway network (the project).

The project has been determined to be a controlled action under Section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) (EPBC 2018/8286) for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires assessment and approval from the Commonwealth Government.

The M12 Motorway would run between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham for a distance of about 16 kilometres and would be opened to traffic prior to opening of the Western Sydney Airport.

The project traverses four major creeks (Cosgroves, Badgerys, South and Kemps Creeks) and numerous minor cross drainage lines with intermittent flow. These creeks drain into South Creek which then flows north to join the Hawksbury River at Windsor.

The project includes five bridges influenced by flooding, and about 70 culvert crossings for the conveyance of overland flow across the proposed motorway. This includes additional minor culverts required for the shared user path which has an independent alignment to the main carriageways.

Purpose of this report

This report has been prepared to support the environmental impact statement (EIS) for the M12 Motorway project. The EIS has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the project (SSI 9364) and to enable the NSW Minister for Planning and Public Spaces and the Commonwealth Minister for the Environment to make a determination on whether the project can proceed. The report presents an assessment of the activities associated with the construction and operation of the project that have the potential to impact flooding.

Approach to assessment

A flooding assessment of the bridges was carried out with specialist flood modelling software 'TUFLOW'. Hydrological inputs included the Updated South Creek Flood Study (WorleyParsons, 2015) inflows supplemented with direct rainfall into the TUFLOW model.

Major inputs into the proposed scenario flood model include the proposed road embankments, bridge abutments, piers, and decks. Culverts have been designed separately to the flood modelling process, using the flood modelling results to guide expected flow and water level inputs.

The project lies within the South Creek valley, which will be subject to significant hydrological changes in future due to the construction of Western Sydney Airport and other large-scale land use changes upstream of the M12 Motorway. The likely increase in peak flooding flows have been considered in this assessment.

Overview of potential impacts

The potential flooding impacts (such as increased flood depths and reduced flood storage) during construction are associated with ancillary facilities and stockpiles, temporary creek crossings and earthworks (fill). Potential flood impacts are anticipated to be minimal as temporary ancillary facilities and stockpiles have been located outside the 100 year ARI active flooding zone where practicable, as presented in **Annexure A**.

In some locations, the 100 year ARI active flooding zone extends into the areas mapped as ancillary facilities (AF2 and AF5). However, there is sufficient land area within each of the impacted ancillary facilities to manage their operation with immunity to the 100 year ARI active flooding zone. Temporary creek crossings present an obstruction to the creek flow however associated impacts would be generally minor during large flood events, as the area becomes overwhelmed by much deeper and wider flows. Impacts associated with earthworks (for construction of the road embankment) would be similar to the operational impacts described below (ie would be minor). This is because the height and width of earthworks (fill) within the floodplains is not expected to be any larger than the embankments that would be present during operation.

The assessment of potential operational flooding issues associated with the project was carried out to determine potential impacts on flood behaviour based on the design outlined in the M12 Motorway EIS. The assessment used predictive flood and hydraulic models to determine changes to flood levels, velocities, flows, duration and hazard across the four floodplains within the operational footprint of the project.

The assessment found that the project, through implementation of the design outlined in the M12 Motorway EIS, can achieve the required design criteria of a 100 year ARI minimum flood immunity for the new infrastructure. The waterway bridges are influenced by road geometry considerations, which would ensure limited encroachment into the floodplains and minimal change to existing 100 year ARI flood levels.

Changes to flooding behaviour at waterway bridges are not predicted to create adverse flooding impacts. There would be noticeable local changes within the areas of creek adjustments however these are short, localised and contained within the project operational footprint. Effects on flows would be small and proximal to the bridges, with contraction and expansion mostly contained within proposed operational footprint. Areas of predicted afflux (change in flood levels) would be localised, be in the order of 0 millimetres to 143 millimetres, and not lead to adverse flooding impacts outside of project operational footprint.

Where increased velocity would potentially result in erosion, scour protection would be provided to eliminate risks of erosion to infrastructure and the environment. This would occur at the bridge abutments and around the piers.

There is one location where a change in flood hazard has the potential to be sensitive. This is at the proposed Luddenham Road underpass of the motorway (where there would be public access and therefore multiple people could be affected by interaction with floodwater). At this location, the design of the bridge as outlined in the M12 Motorway EIS has avoided changes to the existing flooding conditions as much as practicable and impacts are considered minor.

All floodplain areas would experience little change beyond localised effects at bridge abutments, piers, and at the creek adjustments. The surrounding land use would be unaffected by the project with respect to flooding. It is predicted that there would be no project related social or economic costs due to flooding.

In other areas where the project traverses minor drainage lines, culvert crossings are designed for the conveyance of overland flow under the proposed motorway. Culverts would be placed on existing flow paths and are designed to not restrict the free flow of water. Design of culverts has taken into consideration potential blockage and appropriate blockage factors have been included in sizing of culverts where applicable. Where the project would result in changes to flooding impacts beyond the project operational footprint upstream or downstream of the minor culverts, these changes would be minor (see Appendix M of the EIS).

The project would improve emergency management options for local and surrounding areas, including for evacuation as the motorway achieves the minimum 100 year ARI flood immunity.

The project is compatible with the predicted effects of climate change. The project would achieve minimum 100 year ARI flood immunity and flooding impacts would be within acceptable limits under climate change conditions.

Summary of environmental management measures

The flood modelling carried out involved assessing the impacts of the design (outlined in the M12 Motorway EIS) to minimise potential adverse flood impacts. During the detailed design phase, the design of the road geometry and bridge structures may change and further flood modelling will be required to demonstrate how the risk of flooding to the project, as well as the impact it would have on flood behaviour under present day conditions, will be mitigated.

To ensure the project avoids or minimises potential adverse flooding impacts, the detailed design flood investigations will involve:

- Updates to the catchment-wide hydrologic model based on all available information including known planned development within the catchment and any large-scale detention basins
- Consideration of any potential refinements to the design of the project, including potential changes to bridge lengths and heights
- Investigation of additional measures (if required) to minimise predicted flood impacts
- Design of scour protection where required along the project including at waterway bridges (piers and abutments), catch drains (open channels) and culvert outlets.

Where further flood modelling shows the project could result in an adverse flooding impact, Roads and Maritime will consult with landowners to implement appropriate mitigation measures.

Prior to construction, the project construction environmental management plan be developed and will include a flood management plan that details the processes for flood preparedness, materials management, weather monitoring, site management and flood incident management. The flood management plan would reference and be developed in accordance with the latest industry guidelines.

During construction, activities that may affect existing drainage systems, such as existing longitudinal drainage networks and cross drainage culverts, would be carried out so that existing hydraulic capacity of these systems is maintained where possible.

Conclusions

In summary, it is expected that no significant adverse flooding impacts would affect the community outside of the operational footprint in terms of:

- Afflux and impacts to properties, assets and infrastructure
- Peak flood velocities, downstream velocities and scour potential
- Flood hazard
- Hydraulic functions of flow conveyance
- Effects to beneficial floodplain inundation
- Land use impact
- Emergency management, evacuation and access
- Social and economic costs
- Climate change.

These results have been determined based on the existing catchment condition, land use, and the configuration of roads and bridges. The flood impact objectives presented in **Table 3-2** would be used to guide further detailed design, incorporating additional relevant information on catchment changes. This positive outcome would need to be assessed and confirmed at detailed design through subsequent flood modelling.

1. Introduction

1.1 Background

Roads and Maritime Services (Roads and Maritime) is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the M12 Motorway project to provide direct access between the Western Sydney Airport at Badgerys Creek and Sydney's motorway network (the project). In addition, the project has been determined to be a controlled action under Section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) (EPBC 2018/8286) for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires assessment and approval from the Commonwealth Government.

The M12 Motorway would run between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham for a distance of about 16 kilometres and would be opened to traffic prior to opening of the Western Sydney Airport. The project would commence about 30 kilometres west of the Sydney central business district, at its connection with the M7 Motorway. The project traverses the local government areas of Fairfield, Liverpool and Penrith. The suburbs of Cecil Park and Cecil Hills are found to the east of the M12 Motorway, with Luddenham to the west.

The project is predominately located in greenfield areas. The topography in and around the project comprises rolling hills and small valleys between generally north–south ridge lines. The existing land uses are semi-rural residential, recreational, agricultural, commercial and industrial. The main residential areas are Kemps Creek, Mount Vernon and Cecil Hills.

The project is required to support the opening of the Western Sydney Airport by connecting Sydney's motorway network to the airport. The project would also serve and facilitate the growth and development of the Western Sydney which is expected to undergo significant development and land use change over the coming decades. The motorway would provide increased road capacity and reduce congestion and travel times in the future and would also improve the movement of freight in and through western Sydney.

The project location is shown in **Figure 1-1** in relation to its regional context.

Further description of the project's proposed infrastructure in a flooding context is included in **Chapter 6**.

1.2 Project overview

The project would include the following key features:

- A new dual-carriageway motorway between the M7 Motorway and The Northern Road with two lanes in each direction with a central median allowing future expansion to six lanes
- Motorway access via three interchanges/intersections:
  - A motorway-to-motorway interchange at the M7 Motorway and associated works (extending about four kilometres within the existing M7 Motorway corridor)
  - A grade separated interchange referred to as the Western Sydney Airport interchange, including a dual-carriageway four lane airport access road (two lanes in each direction for about 1.5 kilometres) connecting with the Western Sydney Airport Main Access Road
  - A signalised intersection at The Northern Road with provision for grade separation in the future
- Bridge structures across Ropes Creek, Kemps Creek, South Creek, Badgerys Creek and Cosgroves Creek

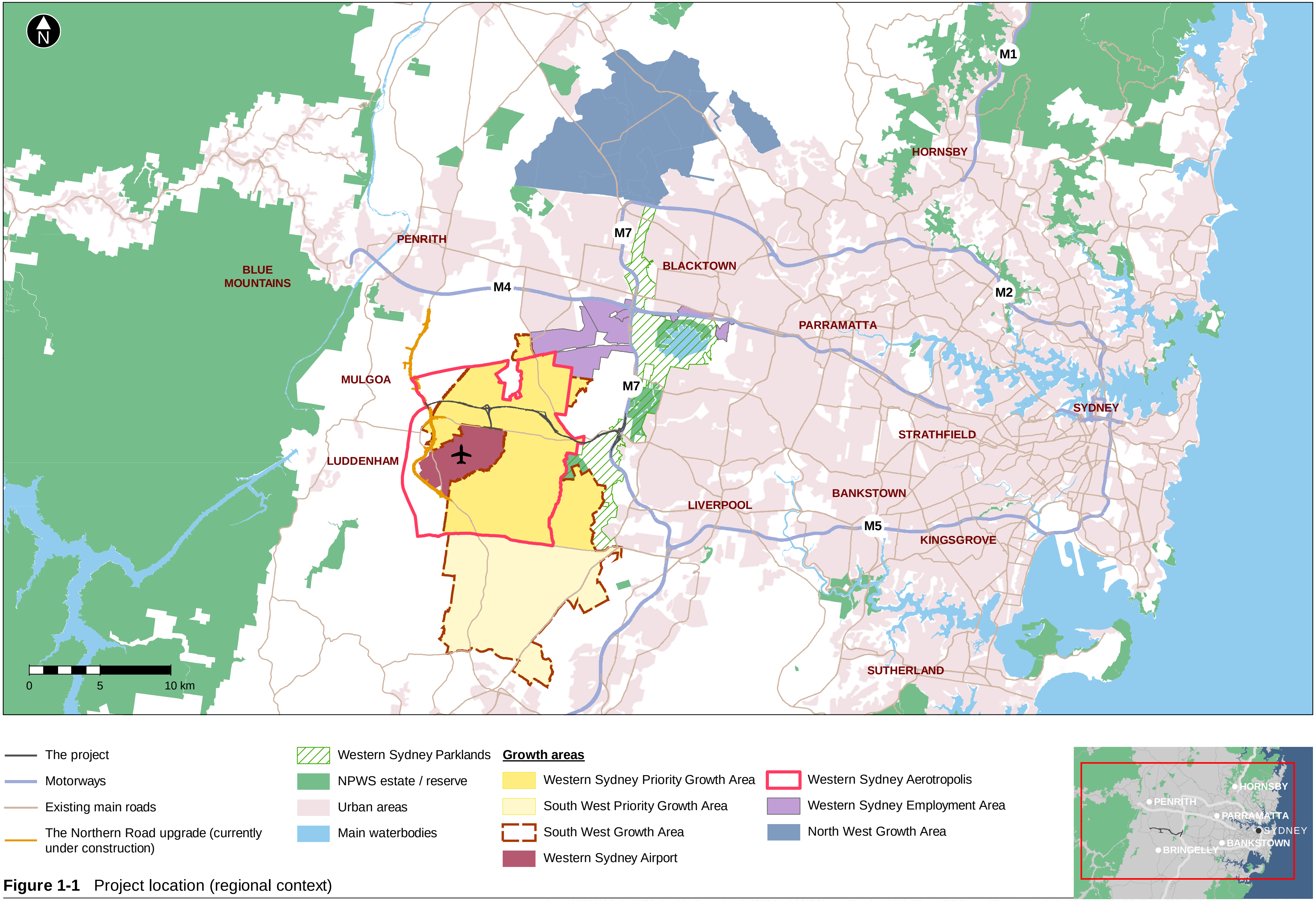


Figure 1-1 Project location (regional context)

Date: 18/07/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\Chapters\Chapter1_Introduction\FinalEIS\JAJV_EIS_Chap1_F001_ProjectOverview_Regional_r5v1.mxd
Created by : AA | QA by : NS

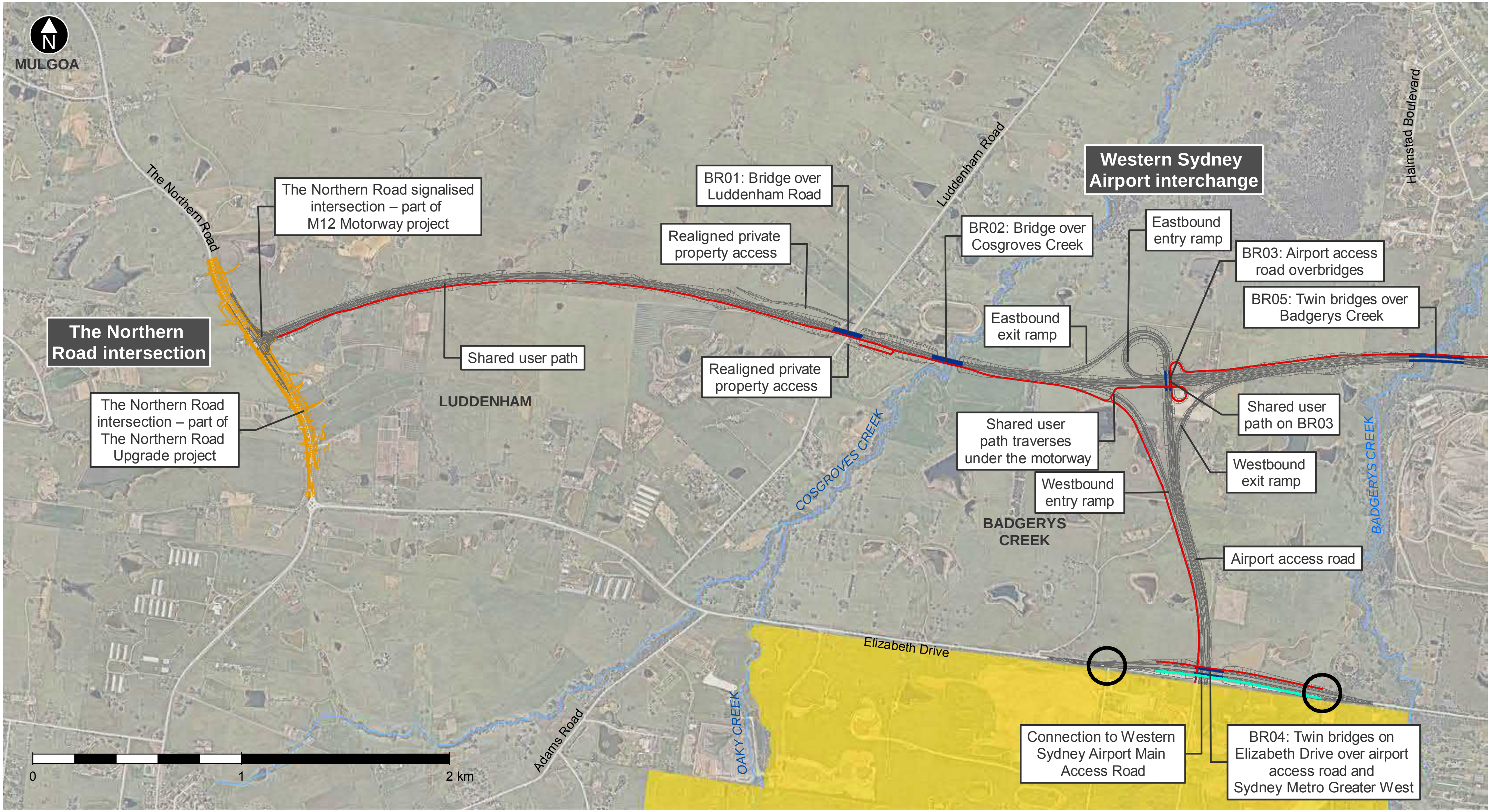
- Bridge structure across the M12 Motorway into Western Sydney Parklands to maintain access to the existing water tower and mobile telephone/other service towers on the ridgeline in the vicinity of Cecil Hills, to the west of the M7 Motorway
- Bridge structures at interchanges and at Clifton Avenue, Elizabeth Drive, Luddenham Road and other local roads to maintain local access and connectivity
- Inclusion of active transport (pedestrian and cyclist) facilities through provision of pedestrian bridges and an off-road shared user path including connections to existing and future shared user path networks
- Modifications to the local road network, as required, to facilitate connections across and around the M12 Motorway including:
  - Realignment of Elizabeth Drive at the Western Sydney Airport, with Elizabeth Drive bridging over the airport access road and future passenger rail line to the airport
  - A realignment of Clifton Avenue over the M12 Motorway, with associated adjustments to nearby property access
  - Relocation of Salisbury Avenue cul-de-sac, on the southern side of the M12 Motorway
  - Realignment of Wallgrove Road north of its intersection with Elizabeth Drive to accommodate the M7 Motorway northbound entry ramp
- Adjustment, protection or relocation of existing utilities
- Ancillary facilities to support motorway operations, smart motorways operation in the future and the existing M7 Motorway operation, including gantries, electronic signage and ramp metering
- Other roadside furniture including safety barriers, signage and street lighting
- Adjustments of waterways, where required, including Kemps Creek, South Creek and Badgerys Creek
- Permanent water quality management measures including swales and basins
- Establishment and use of temporary ancillary facilities, temporary construction sedimentation basins, access tracks and haul roads during construction
- Permanent and temporary property adjustments and property access refinements as required.

The project overview presented in this document represents the design outlined in the M12 Motorway EIS. If the project is approved, a further detailed design process would follow, which may include variations to the design. Flexibility has been provided in the design to allow for refinement of the project during detailed design, in response to any submissions received following the exhibition of the environmental impact statement (EIS), or if opportunities arise to further minimise potential environmental impacts.

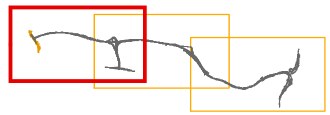
The key features of the project are shown on **Figure 1-2**.

1.3 Purpose and scope of this report

This report has been prepared to support the EIS for the project. The EIS has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the project (SSI 9364), as well as the Australian Government assessment requirements under the EPBC Act. The EIS for the project provides sufficient information to enable the NSW Minister for Planning and Public Spaces and the Commonwealth Minister for the Environment to make a determination on whether the project can proceed. The report presents an assessment of the construction and operational activities for the project that have the potential to impact flooding. The SEARs relating to hydrology are addressed in Appendix M of the EIS.



The project
Part of The Northern Road upgrade project
Shared user path
Future shared user path (by others)
Existing roads
Waterways
Bridges
Western Sydney Airport
Note. The roads within this zone are being removed as part of airport construction.
Potential future intersections (by others)
Note: Locations to be confirmed



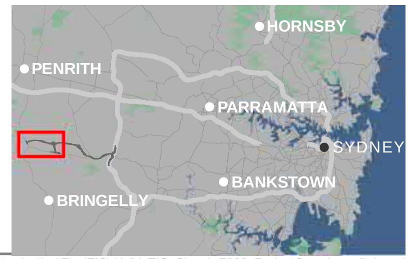
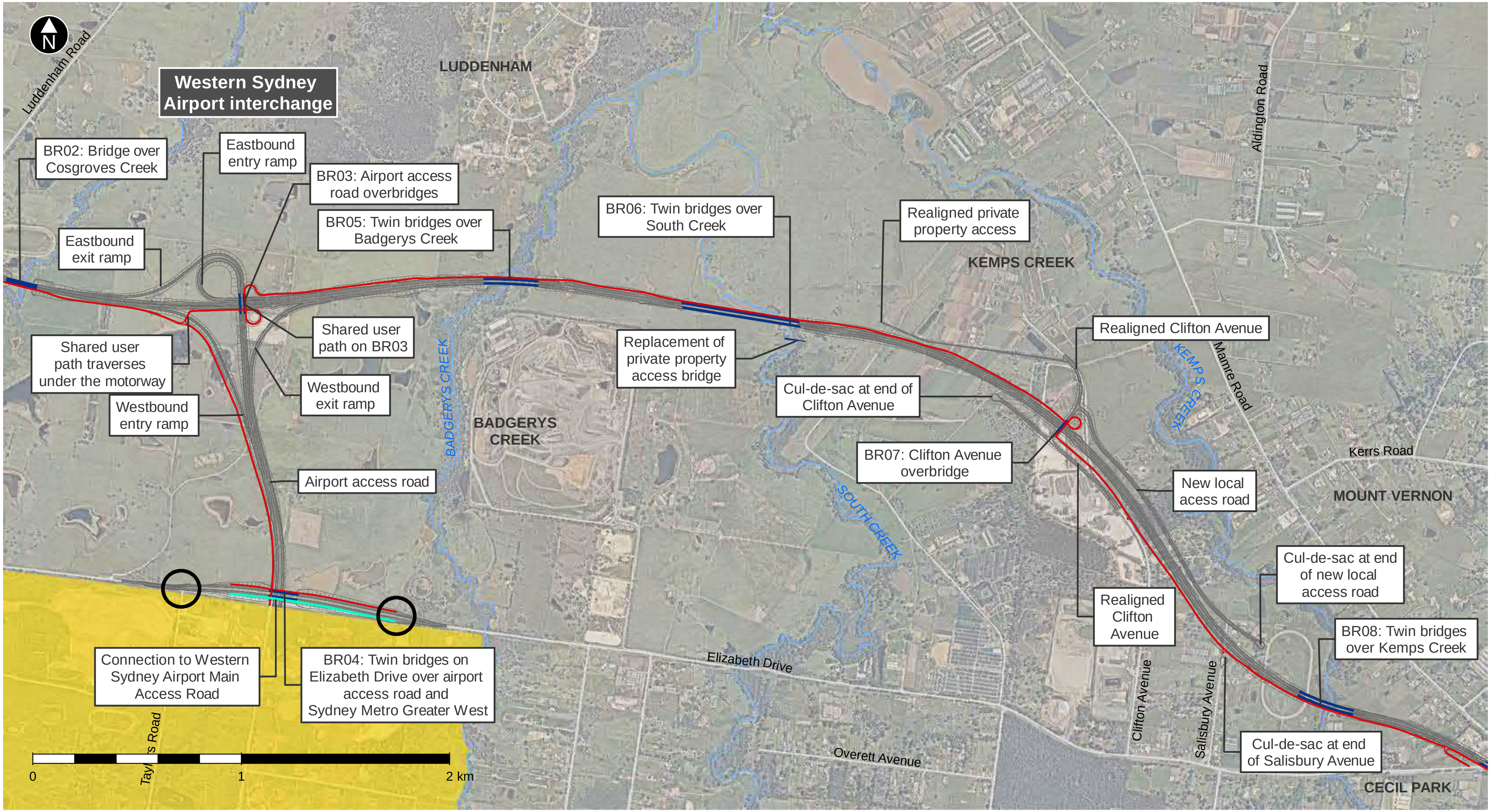
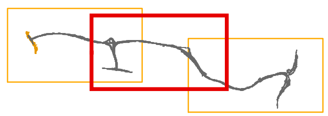


Figure 1-2 Key features of the project



- The project
- Part of The Northern Road upgrade project
- Shared user path
- Future shared user path (by others)
- Existing roads
- Waterways
- Bridges
- Western Sydney Airport
  Note. The roads within this zone are being removed as part of airport construction.
- Potential future intersections (by others)
  Note: Locations to be confirmed



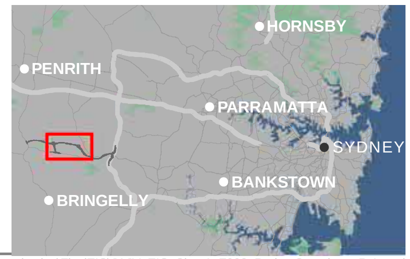


Figure 1-2 Key features of the project

Date: 28/06/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\Chapters\Chapter1_Introduction\FinalEIS\JAJV_EIS_Chap1_F003_ProjectOverview_r5v1.mxd
Created by : EM | QA by : RB

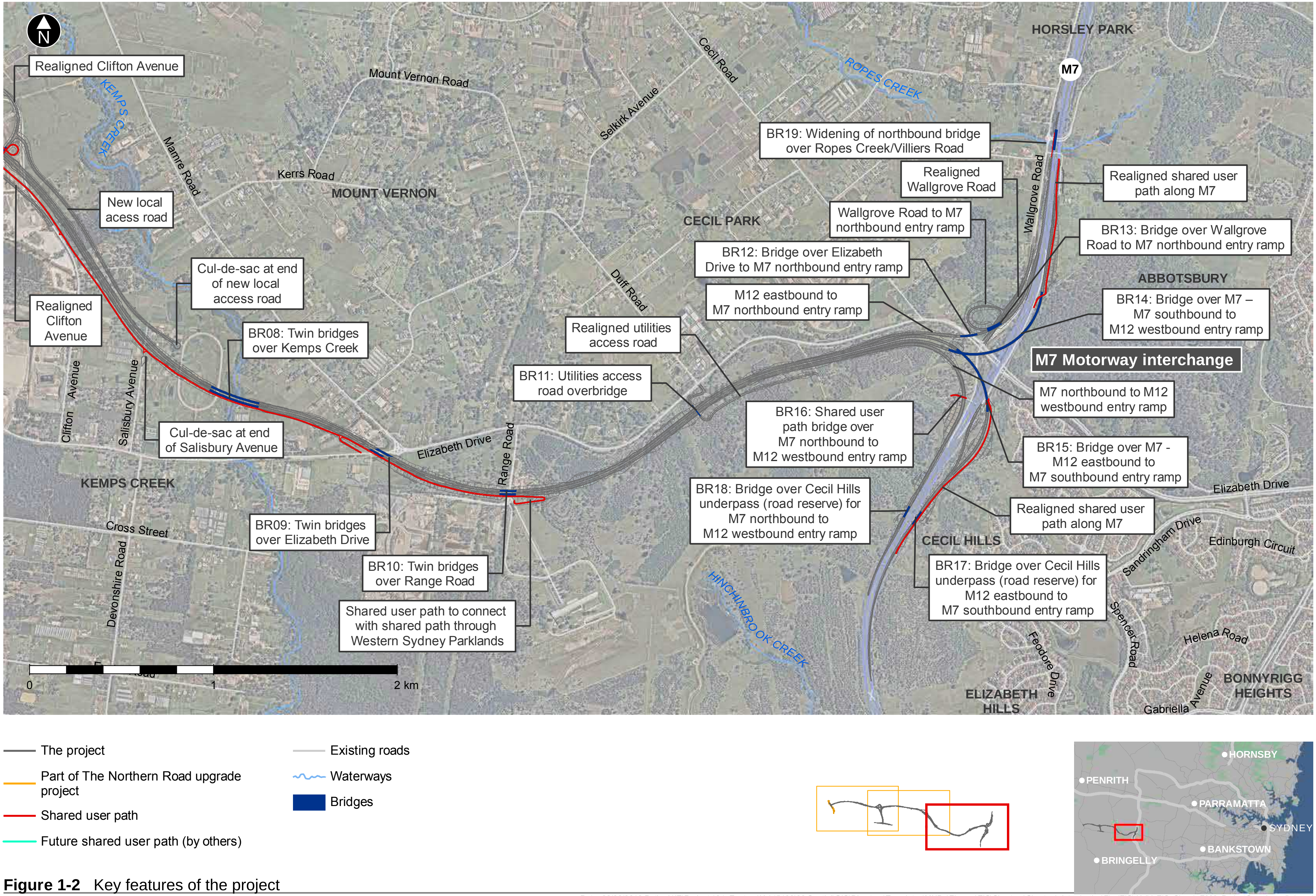


Figure 1-2 Key features of the project

1.4 SEARs

On 18 June 2018, the Secretary of the NSW Department of Planning and Environment issued to Roads and Maritimes the draft Secretary's environmental assessment requirements (SEARs) for the M12 Motorway EIS. The SEARS were finalised and reissued on 12 July 2018. The project was then determined to be a controlled action under the EPBC Act, and updated SEARs were issued on 30 October 2018 that include the Commonwealth assessment requirements under the EPBC Act. **Table 1-1** lists those requirements relating specifically to the assessment of the Project's potential impacts on flooding, with a reference to the chapter or section of this report where each requirement is addressed.

Table 1-1 SEARs (flooding)

Secretary's requirement	Where addressed
13. Flooding	
1. The Proponent must assess and (model where required) the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including: (a) any detrimental increases in the potential flood affectation of other properties, assets and infrastructure;	Modelled impacts of the project on flood behaviour as it would affect property, assets and infrastructure during construction are described and assessed in **Section 7.1** The project's likely flood impacts on property, assets and infrastructure during operation are described and assessed in **Section 7.2.1**
(b) consistency (or inconsistency) with applicable Council floodplain risk management plans and Rural Floodplain Management Plans;	The project's consistency with applicable floodplain management plans is addressed in **Section 2.1**
(c) compatibility with the flood hazard of the land;	The project's compatibility with the existing flood hazard of the surrounding land is addressed in **Section 7.1** and **Section 7.2.3**
(d) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	The project's compatibility with hydraulic function of existing flow conveyance is addressed in **Section 7.1** and **Section 7.2.4**
(e) adverse effects to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the project;	Beneficial inundation of the floodplain is discussed in **Section 7.1** and **Section 7.2.5**
(f) downstream velocity and scour potential;	The project's potential impacts on downstream velocity and scour potential are addressed in **Section 7.1** and **Section 7.2.2**
(g) impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council; and	The project's potential impacts on emergency management procedures for flooding are addressed in **Section 7.1** and **Section 7.2.6**
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding.	The potential social and economic costs of flooding impacts likely to result from the project are addressed in **Section 7.1** and **Section 7.2.7**

2. Policy and planning setting

2.1 Floodplain management plans

The SEARS require that the flooding assessment for the project identify consistency (or inconsistency) with applicable council floodplain risk management plans and rural floodplain management plans. This section discusses those plans in relation to each of the three relevant council areas (Penrith, Liverpool and Fairfield).

2.1.1 Penrith

The project is predominantly located within the Penrith City Council Local Government Area (LGA). There are currently no council floodplain risk management plans or rural floodplain management plans for the Penrith LGA. A public information sheet from Penrith City Council dated March 2016 (***https://www.penrithcity.nsw.gov.au/images/documents/services/other-services/flood-studies/South_Creek_Flood_Study_Factsheet.pdf***) states that a consultant had been appointed to prepare the South Creek Floodplain Risk Management Study and Plan and this should be considered should it become available in future project planning stages.

2.1.2 Liverpool

A portion of the project at the eastern end is within the Liverpool City Council LGA. The LGA boundary between Penrith and Liverpool is located along Elizabeth Drive. A small section of the project lies within an area covered by the Austral Floodplain Risk Management Study & Plan (Perrens Consultants, September 2003).

The motorway main carriageways within this area are not located in a main-watercourse flooding zone. There are several local overland flow-paths where the drainage design for the project includes minor cross-drainage structures however these are not at a scale that need to be considered in the context of a floodplain risk management plan.

2.1.3 Fairfield

The most eastern part of the project, which connects to the north with the M7 Motorway, is located within the Fairfield Council LGA. This part of the project lies within an upper area of the Ropes Creek catchment, which was the subject of the Rural Area Flood Study (BMT WBM, 2013). The associated floodplain management plan is yet to be completed and approved.

Similar to the section of the project located within the Liverpool City Council LGA, the motorway elements within the Fairfield Council area are not located in a main-watercourse flooding zone. There are several local overland flow-paths where the drainage design for the project includes minor cross-drainage design structures however these are not at a scale that need to be considered in the context of a floodplain risk management plan.

The project therefore is consistent with and does not impact local floodplain risk management plans.

2.2 Relevant guidelines

The main guidelines, specifications and policy documents relevant include:

- Floodplain Development Manual (OEH, 2005)
- Floodplain Risk Management Guidelines
- Australian Rainfall and Runoff (Institution of Engineers, Australia, 1987)
- AusRoads Guide to Bridge Technology Part 4 (Austroads, 2018)
- Roads and Maritime Specification D&C G36 – Environmental Protection (Management System) (G36) (Roads and Maritime Services (Roads and Maritime), 2017)
- New South Wales State Emergency Management Plan (EMPLAN) (Office of Emergency Management, 2012) New South Wales State Flood Plan (a sub-plan of EMPLAN) (State Emergency Management Committee, 2015)
- New South Wales State Emergency Management Plan – Evacuation Management Guidelines (SEMC Evacuation Working Group, 2014)
- New South Wales Flood Prone Land Policy (OEH 2005)
- Practical Consideration of Climate Change (DECC, 2007)
- Penrith City Council LGA, South Creek Floodplain Risk Management Study and Plan (pending availability)
- Liverpool City Council LGA, Austral Floodplain Risk Management Study & Plan (Perrens Consultants, 2003)
- Fairfield City Council LGA, Rural Area Flood Study (BMT WBM, 2013) pending completion and approval.

3. Assessment methodology

3.1 Overview

The project traverses four significant floodplains (Cosgroves, Badgerys, South and Kemps Creeks), a minor waterway next to Luddenham Road, as well as numerous minor drainage lines. During the development of the project's design, hydraulic structures such as bridges and culverts were developed and incorporated into the project to ensure that it, and adjacent areas, were protected from flooding.

The assessment of potential flood impacts involved advanced computer modelling of the flood conditions at the four main creeks (Cosgroves, Badgerys, South and Kemps Creeks) and the proposed bridge over Luddenham Road. The flooding assessment was carried out with specialist flood modelling software, with hydrological inputs from the adopted hydrological model for the valley (the XP-RAFTS model from the Updated South Creek Flood Study (WorleyParsons, 2015)). Local rainfall was applied directly to the surfaces of the flood model. The 5, 20, 50, 100, and 2000 year ARI as well as the PMF storm events have been modelled as part of this flood assessment for both the existing and proposed conditions. A climate change scenario has also been considered.

The project also traverses the Ropes Creek floodplain near the tie-in to the existing M7 Motorway. The proposed design involves bridge widening works on the existing M7 northbound bridge. As the proposed bridge widening adopts the same design (including bridge type, spans and piers) as the existing bridge structure, the project vertical alignment would also be similar to the existing M7 Motorway in this location, no changes to current flood conditions are expected and the Ropes Creek bridge has not been considered further within the flood modelling for the project.

Culverts have been designed separately to the flood modelling process, but the flood modelling results were used to guide flow and water level inputs. Culverts would be placed on existing flow paths and have been designed so as to not restrict the free flow of water. Design of culverts has taken into consideration potential blockage and appropriate blockage factors have been included in sizing of culverts where applicable.

Major inputs into the design of the project's hydraulic structures included the proposed road embankments, bridge abutments, piers, and decks.

Existing and proposed scenario results were compared to assess the likely changes expected due to the project. The project elevations resulting from the geometric design meant that a high level of flood immunity could be achieved with minimum impacts on the existing flood conditions.

3.2 Study area

The study area for the flooding assessment focused on the five key areas where the project would influence, or be influenced by, flooding including: Cosgroves, Badgerys, South and Kemps Creeks and the minor waterway next to Luddenham Road that will be bridged by the project.

The assessment did not include flood modelling of minor waterways and drainage lines that would be crossed by the project. While the project includes culverts designed for free-flowing cross drainage, these have been designed separately to the flood modelling process.

3.3 Criteria

3.3.1 Flooding and drainage design criteria

Design criteria relating to flooding and drainage developed for this project are summarised in **Table 3-1**. These criteria are applied to the design of the project, rather than the assessment of flood impacts from the project, however are relevant as they help explain the context for the design as it relates to flooding, and therefore also help explain the potential flood impacts discussed in **Section 7** of this report.

Table 3-1 Flooding and drainage design criteria

Item	Criteria	Comments
Flood capacity		
Channels and open drains where channels will not surcharge onto carriageway	5 year average recurrence interval (ARI)	Roads and Maritime standard practice
Where channels will surcharge onto carriageways	As per flood immunity of carriageway	Industry standard practice
Culverts where surcharge is allowable	50 year ARI	Roads and Maritime standard practice
Structures where surcharge is undesirable	100 year ARI	Roads and Maritime standard practice
Major storm event checks for no structural damage	2000 year ARI	Roads and Maritime standard practice
Temporary drainage (construction staging)	The greater of the 2 year ARI storm event and twice the construction duration	Roads and Maritime standard practice
Waterways diversions		
Waterway diversions (creek adjustments)	To be avoided where possible and minimised in length. If required: minimise the longitudinal slope as much as practicable Similar cross section to existing channel.	Industry standard practice
Transverse drainage design		
Minimum pipe size	450 mm diameter (refer blockage criteria below)	Roads and Maritime standard practice
Pipe type	Reinforced Concrete Pipe (RCP), Spigot and socket (rubber ring seal)	Roads and Maritime standard practice
Minimum cover	300 mm (from bottom of Selected Material Zone)	Roads and Maritime standard practice
Pipe culvert bedding support type	HS3 (Haunch and side zone support)	Roads and Maritime standard practice
Integration with minor drainage	Where water quality treatment of road surface runoff is not required, road surface and cross drainage systems can be combined.	Roads and Maritime standard practice

Item	Criteria	Comments
Bridge submergence	Generally unacceptable. A minimum freeboard of 0.6-1 m should generally apply. Exceptions can be made subject to consideration of buoyancy, structural stability, debris accumulation and scour protection. (The 0.6m-1.0m is applied for major rivers where flow velocity is very high or the crossing is located in sag where there is no flood relief structure on the floodplain. Setting the freeboard too high would delay early overtopping which is not desirable in the urban environment.	Austroads (Guide to Bridge Technology) Part 4, **Section 7.1.1** (Flood Height)
Navigation clearance	No navigational clearance requirements	Project specific criteria
Blockage		
Transverse culverts less than or equal to 600 mm diameter (or box culvert height)	50 % blockage	Roads and Maritime standard practice
Consideration of local Council blockage requirements and the site-specific likelihood of blockage	Varies	Roads and Maritime standard practice and project specific criteria
Climate change		
Rainfall intensity	10 % increase	Practical Consideration of Climate Change (DECC, 2007)

3.3.2 Flood immunity objectives

The flood immunity objective for the project is to provide 100 year average recurrence interval (ARI) flood immunity to the main carriageways, and to maintain or improve the trafficability of surrounding local roads. Trafficability in this context generally relates to flood depth and velocity combinations for vehicles as outlined in the NSW Floodplain Development Manual (Department of Infrastructure Planning and Natural Resources, 2005).

3.3.3 Flood impact objectives

The flood impact objective is to minimise adverse flooding impact to land, buildings, infrastructure, and public safety as much as practicable, under existing hydrologic conditions. In addition, the project aims to provide design flexibility for future local road upgrades for roads intersecting the project alignment, by not creating a flooding environment that restricts design options or increases flood risk.

Some local roads would be spanned completely by the project, such as Luddenham Road and Elizabeth Drive, while other local roads that intersect the alignment would be divided by the raised motorway embankment and transitioned into cul-de-sacs. With this arrangement of connectivity to surrounding roads, the motorway levels have been designed to optimise the earthwork cut and fill balance and to conform to the environmental constraints, of which flooding was a part.

The main carriageways along the project will have minimum 100 year ARI flood immunity. The motorway elevations at each of the four main waterways have been set higher than major flooding conditions with considerations of bridge structure thickness and minimising potential flooding impacts.

Geometric requirements of the road design, such as minimum allowable longitudinal grade, governed the final road elevations in most locations, along with cost optimisation of the earthworks. Flood levels were generally not the governing constraint for the setting of the main carriageway levels.

Flood level increases have been limited to about 100 millimetres under 100 year ARI conditions using the base hydrology of the Updated South Creek Flood Study (WorleyParsons, 2015). This means that the potential impact of the project is minimal. The flood impact objectives proposed to be adopted for the project are outlined in **Table 3-2**. These relate to hydrological conditions produced by a fully developed catchment, including the effects of large-scale detention basins.

Table 3-2 Flood impact objectives – for fully developed catchment land use conditions

Parameter	Objective		
	Houses, urban and commercial areas	Recreational areas	Agricultural areas
Flood level (height)	Less than 50 mm increase for the 20 and 100 year ARI flood events. Justification: This objective is consistent with other Roads and Maritime projects.	Less than 100 mm increase for the 20 and 100 year ARI events. Justification: An additional 100 mm of flood water is unlikely to cause damage or substantially increase the duration of time that recreational areas are unable to be used.	Generally, less than 250 mm increase with localised increases of up to 400 mm flooding acceptable over small areas (nominally less than five hectares) in the 20 and 100 year ARI flood event. Justification: These lands can accommodate higher flood levels for short periods of time (a few hours) without any substantial increases in land damage or decreased use of the land.
Flood velocity	Velocity-depth to remain in the zone of low hazard for children (ie less than 0.4 m^2/s) where current flow velocity-depth is currently low hazard.	Velocity to remain below one metre per second unless currently greater. Where existing velocity is above one metre per second, a maximum 20 % increase. Appropriate scour and stability protection should be provided where these criteria cannot be achieved.	Velocity to remain below one metre per second unless currently greater. Where existing velocity is above one metre per second, a maximum 20 % increase. Appropriate scour and stability protection should be provided where these criteria cannot be achieved.
Flood duration	A maximum increase in inundation time of one hour in a 100 year ARI rainfall event must be achieved where the flood affected land is sensitive to flood duration for the commercial sustainability of the property. For practicality of measurement, the inundation duration must be measured when and where the flood depths in floodplains exceed the threshold of high provisional flood hazard, as defined in the NSW Floodplain Development Manual (NSW Government, 2005).		

3.4 Assessment approach

3.4.1 General

The flood modelling process comprises hydrological and hydraulic modelling.

Hydrological modelling converts rainfall data into overland flow data, for input into the hydraulic model. The hydrological modelling calculates the rates of flow in the waterways. These flows change over time, generally building up to a peak flow value then abating. Flow versus time data is a 'hydrograph' and is an important input into the hydraulic model.

The hydraulic modelling process has used inputs of hydrographs, terrain, and surface roughness to calculate the flood behaviour through the creeks and floodplains. This includes flow direction, flood levels, depths, and velocities.

Hydraulic modelling has been completed for both existing conditions (no motorway) and proposed conditions with the proposed motorway embankments and bridges included. The flood modelling results of these two conditions have been compared, with the changes in flooding behaviour seen constituting the predicted flooding impact that the motorway may produce.

The following sections provide an overview of the flood modelling to describe the process.

3.4.2 Hydrological modelling

The hydrological modelling for the project has been based on the following:

- Major waterways: South Creek XP-RAFTS model (as used on the Updated South Creek Flood Study (WorleyParsons, 2015)
- Minor waterways: TUFLOW rainfall-on-grid modelling supplemented with Probabilistic Rational Method.

XP-RAFTS is a hydrological modelling software package. TUFLOW is a hydraulic modelling software package particularly suited to complex floodplain modelling where overland flow is two-dimensional in nature.

For consistency with the historical flood study data, the hydrologic modelling was guided by Australian Rainfall and Runoff 1987 (ARR 1987) rainfall data and methods (Institute of Engineers Australia, 1987). It is anticipated that this was a slightly conservative approach compared to the data and methods of the new edition of Australian Rainfall and Runoff 2016 (ARR 2016) (Institute of Engineers Australia, 2016). The expected difference between the methods was a 10 per cent increase in flows by using ARR 1987.

The TUFLOW rainfall-on-grid modelling incorporated the modelling of 18 storm durations to derive the critical duration event for each culvert crossing. The routing incorporated the expected flow diversions towards culvert headwalls by the proposed project embankments.

The results of the hydrological modelling relevant to broad scale flood impacts are discussed within this report. The results of the hydrological modelling related to more localised hydrological changes within the major creeks and other drainage lines are discussed in Appendix M of the EIS.

3.4.3 Hydraulic modelling

The hydraulic modelling used a combination of TUFLOW modelling for the major waterways and Hy-8 culvert modelling for the minor waterways. Flows, headwater and tailwater values for the Hy-8 modelling were taken from TUFLOW results.

Hy-8 is a culvert modelling software package particularly suited to the iterative design process of culvert size optimisation. Culverts were designed and sized so as to not restrict the free flow of water. The design of culverts considered appropriate longitudinal gradients and reasonably small upstream excavation to minimise the change in headwater levels and avoid any flood impacts beyond the project footprint. Appropriate blockage factors have been included in sizing of culverts where applicable.

For the waterway bridges, two TUFLOW models were created; an overall model containing all the main creeks, and an additional model for the Luddenham Road bridge. The latter model was required as the catchment was significantly smaller than the catchments for the main creeks, so it responded to a much shorter duration storm (two hours compared to 36 hours for the main creeks). A higher resolution was used for this model due to the more intricate nature of the flow paths and the sensitivity of Luddenham Road to flooding. The higher resolution was invoked using a two metre cell size compared to the five metre cell size used in the large-scale model.

The hydrodynamic nature of TUFLOW modelling accounted for likely flood storage effects as well as runoff routing within the modelled area. All terrain sinks were filled with ponded water before Design Storm modelling. This introduced some conservatism to the results but was a reasonable approach given the complexity of the terrain, particularly the presence of many farm dams, which were considered within the model to be full.

TUFLOW modelling for the major waterways assumed that culverts had no flood retardation effects. This was done by letting local overland flow cross the project alignment unimpeded by introducing only the earthworks fill areas near the major waterways.

Spill-through bridge abutments were incorporated into the TUFLOW model so that contraction and expansion effects were modelled. Bridge piers were included as well as bridge decks. Localised adjustments at Badgerys Creek, South Creek and Kemps Creek were represented in the TUFLOW model.

Refinements to the modelling would continue to occur as the design is further developed and the inputs are refined.

3.5 Future climate change

An assessment of the project's potential future flood impacts under a climate change scenario was based on:

- Increases in 100 year ARI design rainfall intensities ranging between 10 and 30 per cent in accordance with the NSW Government's Floodplain Risk Management Guideline: Practical Considerations of Climate Change (DECC, 2007)
- Rises in sea level of 0.4 m by 2050 and 0.9 metres by 2100 in accordance with the NSW Government's Sea Level Rise Policy Statement (NSW Government, 2010). Given, the project is situated greater than 30 metres above sea level, sea level rise has had no bearing on the outcomes of the flooding assessment.

The guideline for climate change assessment typically focuses on the 100 year ARI event. However, the 2000 year ARI event had already been assessed because it had been used as an input for the structural design of the bridges. The 2000 year ARI flows are higher than the 100 year ARI plus climate change flows, therefore the climate change assessment was carried out using the 2000 year ARI flows, and as such this is a conservative assessment.

There are currently no guidelines which quantify the likely increase in probable maximum precipitation (PMP) associated with future climate change. By its definition, the PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism regarding rainfall production. On this basis, no adjustment has been made to the PMP rainfall intensities for future climate change.

The site is located sufficiently high and away from any coastal influence. As a result, the project is not sensitive to the sea level rise predictions.

3.6 Key assumptions

It is anticipated that major development expected to occur in the areas upstream of the project would increase catchment runoff in flooding events. It is likely that the runoff management of individual developments, including the Western Sydney Airport, would include detention basins that restrict peak outflows to the existing peak flow rates, or thereabouts. This would not necessarily keep peak flows the same as existing in areas downstream, including the M12 Motorway, for the reason outlined below.

An increase in impervious area would result in an increase in runoff volume, because less rainfall is retained on a paved surface compared to a vegetated surface. Typically, site runoff is directed to a stormwater detention basin that restricts the outflow rate to match the predicted peak outflow rate pre-development. Due to the additional volume of runoff, the outflows of a basin, although restricted in flow rate, remain at the peak flow rate for longer time periods compared to existing conditions. Downstream waterways that previously experienced staggered peak flows from sub-catchment inflows are more likely to experience coinciding peak runoff rates, leading to an overall increase in flow rate.

This may particularly be the case for Badgerys Creek, South Creek and Kemps Creek. Each creek has numerous sub-catchments where peak flows may currently arrive at the project alignment staggered over time. Cosgroves Creek is less susceptible because it has a smaller catchment. The flow path next to Luddenham Road would be unaffected due to its small size.

These potential cumulative impacts need to be considered through a regional-scale assessment, which is beyond the scope of the design process of any individual proposal.

The current design of the project exceeds the minimum 1 in 100 year ARI flood immunity requirement (due to the design having been governed by road geometry and other design requirements) and therefore provides some excess capacity to accommodate larger flows as a result of future development within the catchment. However, the design can be further optimised during detailed design and the minimum design requirement (1 in 100 year ARI flood immunity) would apply. Additionally, any future developments, and/or any such regional-scale assessment carried out, would need to take into account the presence of the M12 Motorway within the landscape and/or results of the flood modelling from this project.

Government stakeholders for developments in the South Creek valley have acknowledged the need for a catchment-wide approach to the hydrological modelling inclusive of the stormwater management plans of upstream major developments.

In addition to the above, this report is subject to the following qualifications:

- The base terrain data was LiDAR one metre Digital Elevation Models from Land and Property Information (circa early 2011). LiDAR does not penetrate water, so areas of standing water have elevations at around the water surface level at the date of data capture. Ground survey and bathymetric survey of creeks and dams were not available for the project
- The Updated South Creek Flood Study (WorleyParsons, 2015) hydrology model (XP-RAFTS format) has been used as the basis for hydrological inflows. This model has been comprehensively calibrated and refined as outlined in the flood study documentation for that study. The study was prepared using Australian Rainfall and Runoff 1987 data and methods. Since the commencement of the design for the project, a new edition of Australian Rainfall and Runoff (ARR) (Institute of Engineers Australia, 2016) has been issued in advanced draft format, subject to industry review. It is anticipated that results using the data and methods of ARR 2016 would show slightly less peak flow values than with the 1987 data and methods, when catchment development inputs are held constant

- The initial water levels in undrained areas of the TUFLOW models (particularly the farm dams) were input as full. This was suggested by Roads and Maritime at 20 per cent comments phase and adopted from that point forward. For the design of culverts (as outlined in the M12 Motorway EIS) this is a conservative but practical approach, as the relatively small flow rates at culverts can be significantly affected by this assumption. Future design refinement of culverts could potentially revisit this assumption on a case by case basis if the cost savings are deemed significant compared to the increased risks. For the waterway bridges, the initial water levels were not seen as a sensitive input due to the greater runoff volumes and longer duration critical storms where the dams would be full before peak flow arrival
- The flood models have been based on the design freeze on 20 June 2018, during the 50 per cent deliverable design phase
- The main focus of the flooding analysis to date was the 100 year ARI. Discussion in this report generally refers to these results unless stated otherwise. The five, 20, and 50 year ARI storms have been run, as well as an approximate 2000 year ARI (estimated at twice the flow of the 100 year ARI) and the Probable Maximum Flood (PMF). Future modelling would be guided towards updating the design elements, incorporating the independent peer review comments, and refining the 2000 year ARI hydrology.

4. Consultation

A summary of consultation carried out in relation to potential flood impacts during the preparation of M12 Motorway EIS is provided in **Table 4-1**. Consultation with all relevant parties, including Councils and the NSW State Emergency Service (SES), would continue during future design stages.

Table 4-1 Consultation summary

Stakeholder	Date	Consultation	Evidence
Penrith City Council	18/10/2018	Discussion on flooding. General Council feedback related to the project not increasing flooding beyond existing levels.	Meeting minutes
	21/12/2018	Roads and Maritime sent design and flooding/drainage report and asked for comments by 11/01/19. No feedback received or issues raised in regards to emergency management arrangements.	Email
Liverpool City Council	05/12/2018	Discussion on flooding. General Council feedback related to the project not increasing flooding beyond existing levels.	Meeting minutes
	21/12/2018	Roads and Maritime sent design and flooding/drainage report and asked for comments by 11/01/19. Comments received 07/01/19 – no concerns raised in regard to flooding or emergency management arrangements.	Email
Fairfield City Council	26/11/2019	Discussion on flooding. General Council feedback related to the project not increasing flooding beyond existing levels.	Meeting minutes
	27/11/2019	Roads and Maritime sent design layout and cross sections of M12 that interface with Fairfield LGA, and flooding/drainage report. No feedback received or issues raised in regard to emergency management arrangements.	Email
NSW State Emergency Service (SES)	12/12/2018	Roads and Maritime provided design and flood modelling information for feedback. No feedback received or issues raised.	Email
	27/03/2019	Roads and Maritime briefed the South West Metropolitan Region Emergency Management Committee on the project. Members of SES sit on the committee. No issues were raised in regard to flooding or emergency management arrangements.	Email

5. Existing environment

This section includes a description of the existing environment related to flooding and has been informed by the desktop investigations carried out for the project.

5.1 Catchment description

The project is located within the South Creek sub-catchment of the Hawkesbury-Nepean catchment. The Hawkesbury-Nepean catchment covers more than 22,000 square kilometres and provides drinking water, recreational opportunities, agricultural and fisheries produce and tourism resources for the Sydney Metropolitan area. The Hawkesbury-Nepean Catchment is of national significance, being the longest coastal catchment in NSW flowing 470 kilometres from the headwaters of the Nepean River in Goulburn before joining the Hawkesbury River in Sydney's west and draining to Broken Bay. There are many major rivers flowing into this catchment including the Hawkesbury, Nepean, Mulwaree, Wingecarribee, Wollondilly, Mulwaree, Tarlo, Nattai, Coxs, Kowmung, Grose, Capertee, Colo and Macdonald. There are also several creeks including Berowra, Mangrove, Cattai, South and Mooney Mooney creeks. The catchment contains a variety of landscapes including rainforest, open woodlands, heathlands, wetlands and highland freshwater streams.

The project lies within the Lower Nepean River Management Zone of the Hawkesbury-Nepean Catchment. Whilst almost half the Hawkesbury-Nepean Catchment is protected in national parks and water catchment reserves, the immediate catchment of the project has been extensively modified and disturbed due to increasing urbanisation and associated land clearing. The Hawkesbury River is the ultimate downstream receiving environment and is located about 29 kilometres from the project at the closest point. The catchment is shale based and characterised by meandering streams. The project is located within the Cumberland Plain, a subregion of the Sydney Basin which consists of relatively flat and low-lying topography. However, small ridgelines are present around Horsley Park, Orchard Hills and Cecil Hills. The landscape within the study area is gently undulating and contains predominantly agricultural farmland.

The project intersects Cosgroves Creek, Badgerys Creek, Kemps Creek and South Creek, and drains to Ropes Creek. These creeks drain into South Creek which then flow north to join the Hawksbury River at Windsor. The project footprint traverses floodplains with urban land uses under existing conditions. Key urban land uses in the floodplains include rural residential uses near Cosgroves Creek, Badgerys Creek and South Creek floodplain. There is some grazing land near the Kemps Creek crossing and some commercial/ industrial uses at Elizabeth Drive and Mamre Road.

5.2 Topography

The topography of the construction footprint may be characterised into three general terrain types:

- Rolling hills terrain, which occurs in the western and eastern portions of the project
- Flat to gently undulating terrain, which occurs in the central portion of the project
- Creek Channels/Alluvial floodplain terrain, which dissects the flat to gently undulating terrain within the central portion of the project.

Within the rolling hills terrain, the topography typically comprises rounded hills with slopes of five to 20 degrees, ie around 10-35 per cent grade, and local relief of typically up to 10-30 metres. Within this general terrain type, the ground surface levels along the project range from about relative level (RL) 70 metres Australian Height Datum (AHD) to RL115 metres AHD.

The topography of the flat to gently undulating terrain in the central portion of the construction footprint typically comprises gentle rises and undulations with broad rounded crests with slopes of zero to five degrees, ie up to around eight per cent grade, and local relief of up to about 15 metres. Ground surface levels along the central portion of the project range from about RL35-RL70 metres AHD. The flat to gently undulating terrain type is dissected by the Creek Channel/Alluvial floodplain terrain type by four meandering creeks, Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek, with each creek flowing to the north.

The topography of the alluvial floodplains next to the creeks comprises low slopes of around zero to two degrees, which extend from the creek channels out to a maximum distance of about 500 metres.

5.3 Rainfall and climate

The average yearly rainfall in the vicinity of the project, based on data collected at the Badgerys Creek AWS and averaged from 2014 to 2018, is 680.9 millimetres. The wettest month is February, with an average rainfall of 98.5 millimetres, while the driest month is July with an average of 23.6 millimetres (BOM, 2018).

Average maximum temperatures at the Badgerys Creek AWS, averaged from 2014 to 2018 are lowest in June at 21.2 degrees Celsius and highest in January at 41.2 degrees Celsius. Average minimum temperatures were lowest in July at 13.7 degrees Celsius, and highest in December at 21.1 degrees Celsius (BOM, 2018).

5.4 Flooding

This section describes the existing flood conditions (ie without the project) at Luddenham Road and the major waterways for the 100 year ARI flood event. **Figure 5-1** to **Figure 5-5** show these existing flood conditions. Existing flood conditions for all other storm events are provided in **Annexure A**.

5.4.1 Luddenham Road

The Luddenham Road valley is small compared to the catchments of the other waterways. Peak flows tend to occur with short duration, high intensity storms rather than the long duration, saturating storms that produce peak flows in the main waterways.

The main flow-path along the valley floor contains numerous farm dams that intercept and capture runoff. If these dams become full during a storm, the dams overflow, and excess runoff bypasses them to their side. Luddenham Road is not raised far above the valley floor so would be susceptible to regular flooding.

The peak runoff during the 100 year ARI event is 10 cubic metres per second along a flow-path approximately 90 metres wide. Peak water levels and depths for the 100 year ARI flood are shown in **Figure 5-1**.

5.4.2 Cosgroves Creek

Cosgrove Creek has a peak 100 year ARI runoff of 80 cubic metres per second along a flow-path approximately 120 metres wide. Peak water levels and depths for the 100 year ARI flood are shown in **Figure 5-2**. The land use immediately adjacent to Cosgroves Creek near the project corridor is mainly agriculture and grazing. The extents of flooding are generally confined in the creek for events up to 100 year ARI. Minor flooding is anticipated in the existing horse training track in Lot 35/ DP211842 north of the project footprint.

5.4.3 Badgerys Creek

Badgerys Creek has a peak 100 year ARI runoff of 130 cubic metres per second along a flow-path approximately 170 metres wide. The M12 crosses this floodplain at a significant skew. The effective floodplain width along the full width of the M12 alignment is about 300 metres. Peak water levels and depths for the 100 year ARI flood are shown in **Figure 5-3**. The land use in the vicinity of Badgerys Creek near the project footprint is mainly rural farmland and are not subjected to flooding outside of the floodplain width.

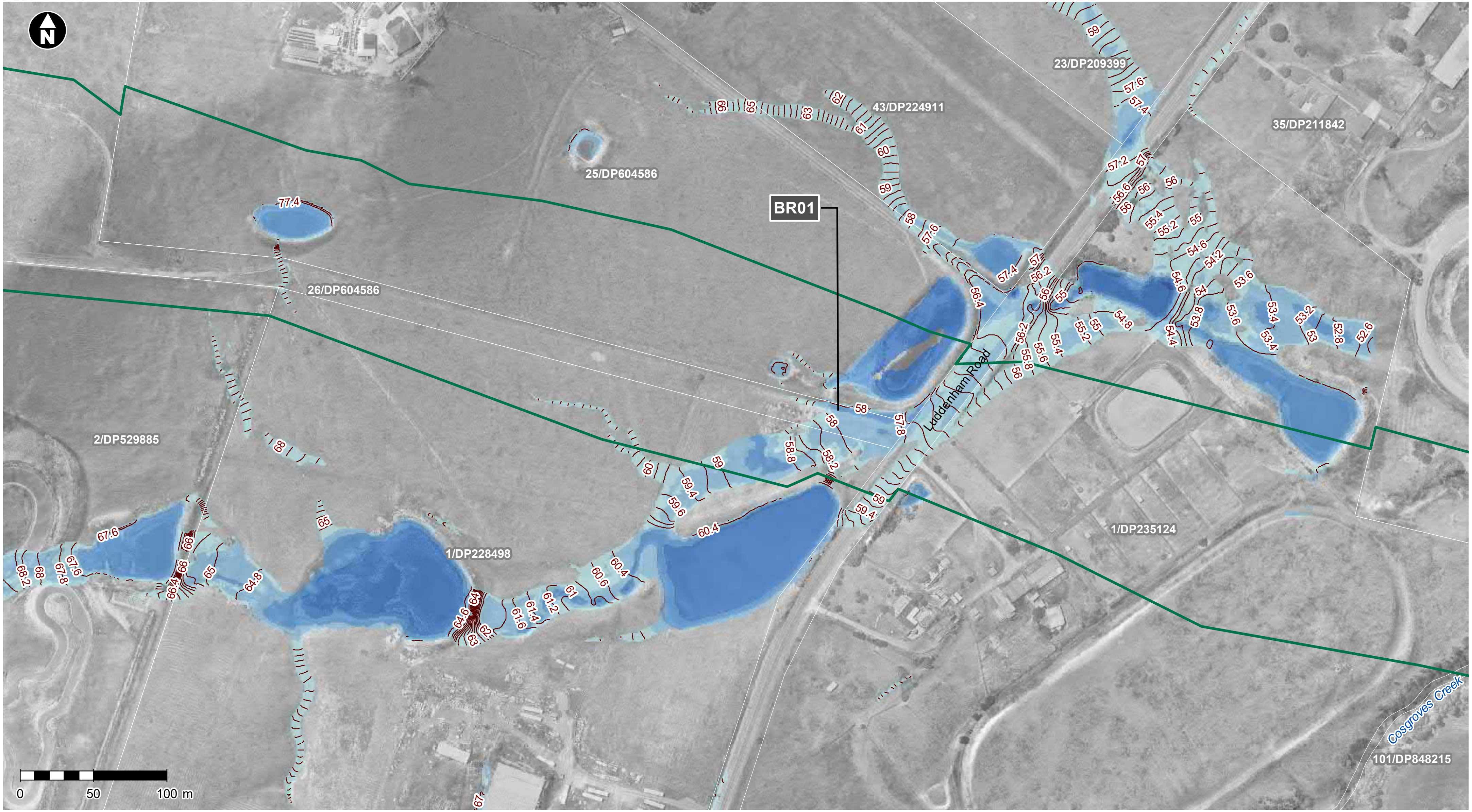
5.4.4 South Creek

South Creek has a peak 100 year ARI runoff of 490 cubic metres per second along a flow-path approximately 500 metres wide. The low-flow channel of the creek crosses under the M12 alignment at a skew and is virtually parallel to it for several hundred metres. During a 100 year ARI flood the creek fills the wider floodplain and flows almost perpendicular to the M12. Peak water levels and depths for the 100 year ARI flood are shown in **Figure 5-4**. The land use in the vicinity of South Creek near the project footprint is mainly rural farmland and are not subjected to flooding outside of the floodplain width.

5.4.5 Kemps Creek

Kemps Creek has a peak 100 year ARI runoff of 260 cubic metres per second along a flow-path heavily influenced by a large, oval embankment from an existing horse training facilities on its western side. The embankment confines the width of the flow but is built at a height that results in some overtopping in large floods. The 100 year ARI flow-path width is therefore difficult to define, ranging from about 170 metres to about 310 metres across, or wider if the secondary flow-path inside the oval is considered. Peak water levels and depths for the 100 year ARI flood are shown in **Figure 5-5**.

The existing horse training track is not subject to major flooding for events up to 50 year ARI. The oval embankment is anticipated to be overtopped in larger floods. The extent of Kemps Creek flooding near the project footprint extends into the back of several rural residential properties along Mamre Road.



Legend

0.2m Flood Height Contour (m AHD)

Cadastre

The project operational footprint

Flood Depth (m)

< 0.2

0.2 - 0.5

0.5 - 1.0

1.0 - 1.5

1.5 - 2.0

> 2.0

Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design

1:3,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

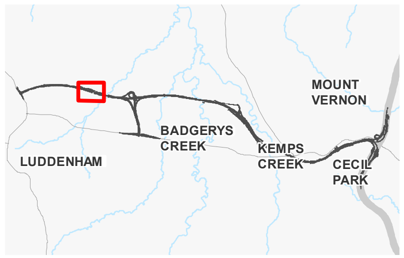
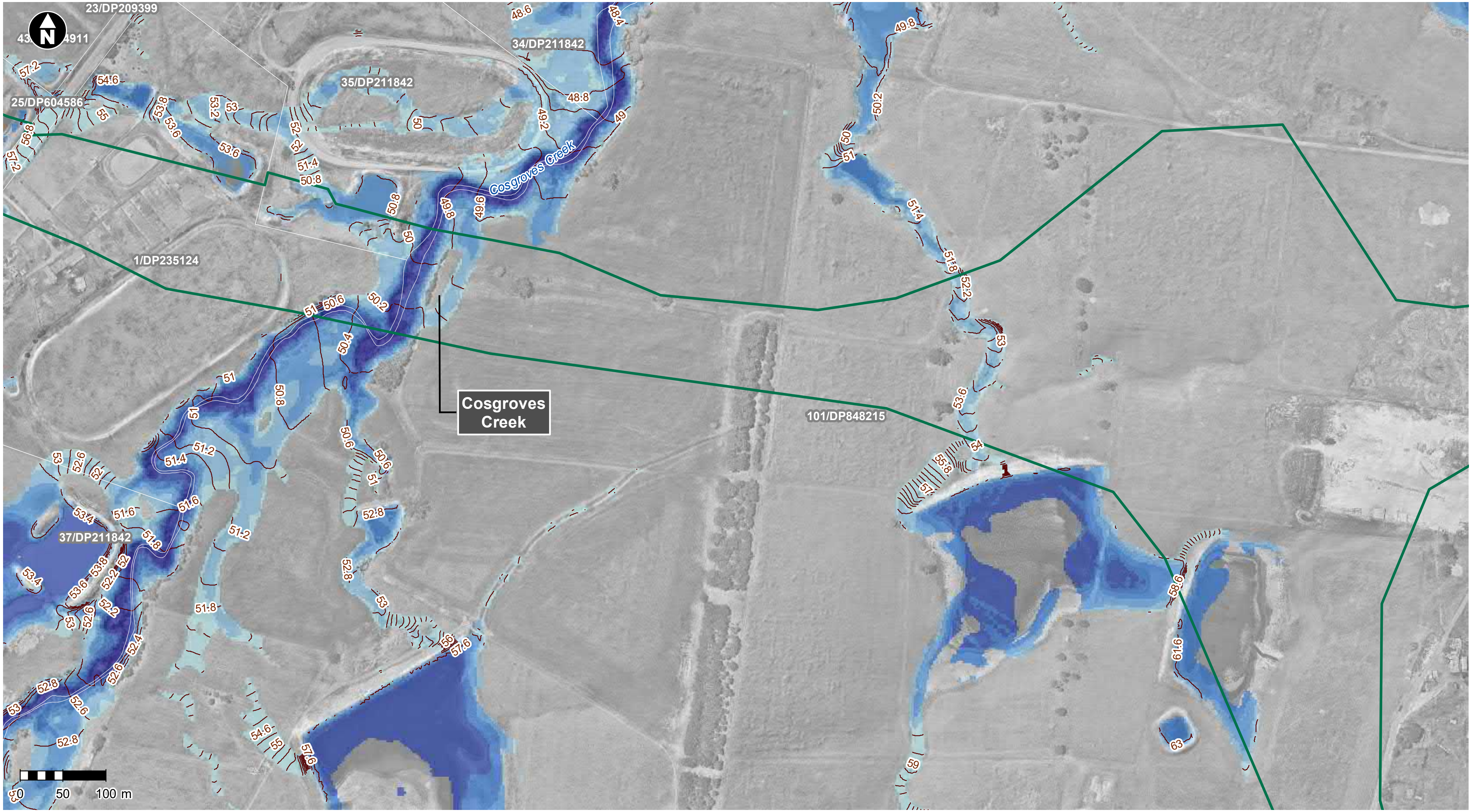


Figure 5-1 Existing conditions 100 year ARI flooding - Luddenham Road

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI\JAJV_FLD_All_100pc_F001_100yrARI1ExFloodLDepth_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB



Legend

0.2m Flood Height Contour (m AHD)

Cadastre

The project operational footprint

Flood Depth (m)

- < 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:6,000 at A4

Coordinate System: GDA 1994 MGA Zone 56

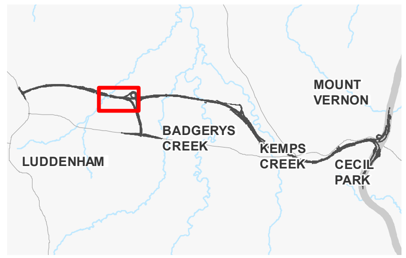
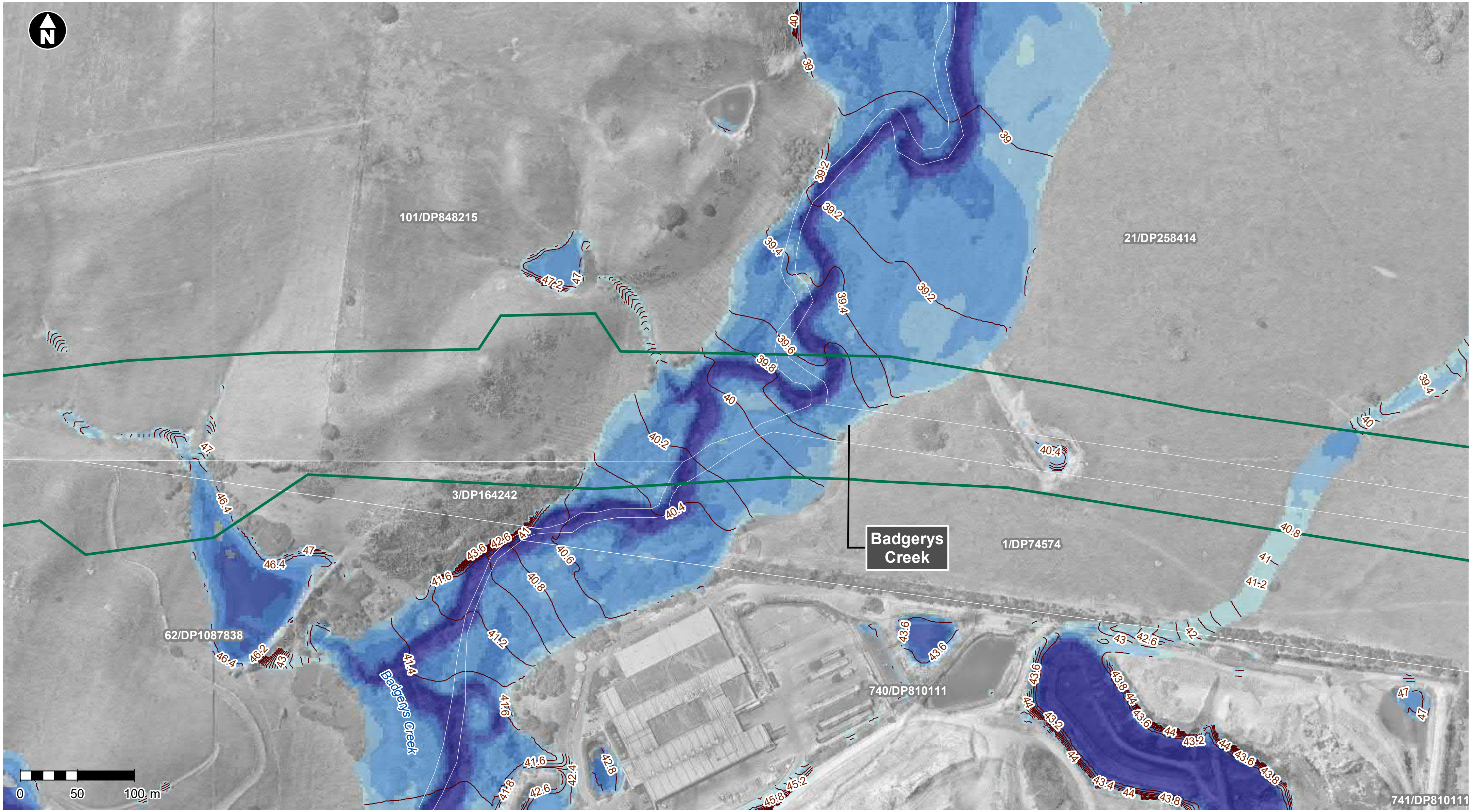


Figure 5-2 Existing conditions 100 year ARI flooding - Cosgroves Creek

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI\JAJV_FLD_All_100pc_F001_100yrARIExFloodLDepth_DDP_A4L_r1v1.mxd

Created by : EM | QA by : RB



Legend

- 0.2m Flood Height Contour (m AHD)
- Cadastre
- The project operational footprint

Flood Depth (m)

- < 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

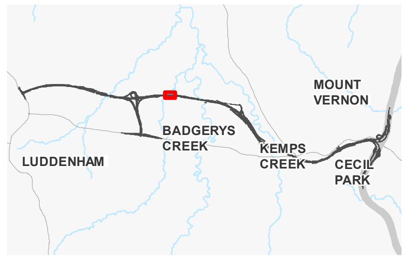
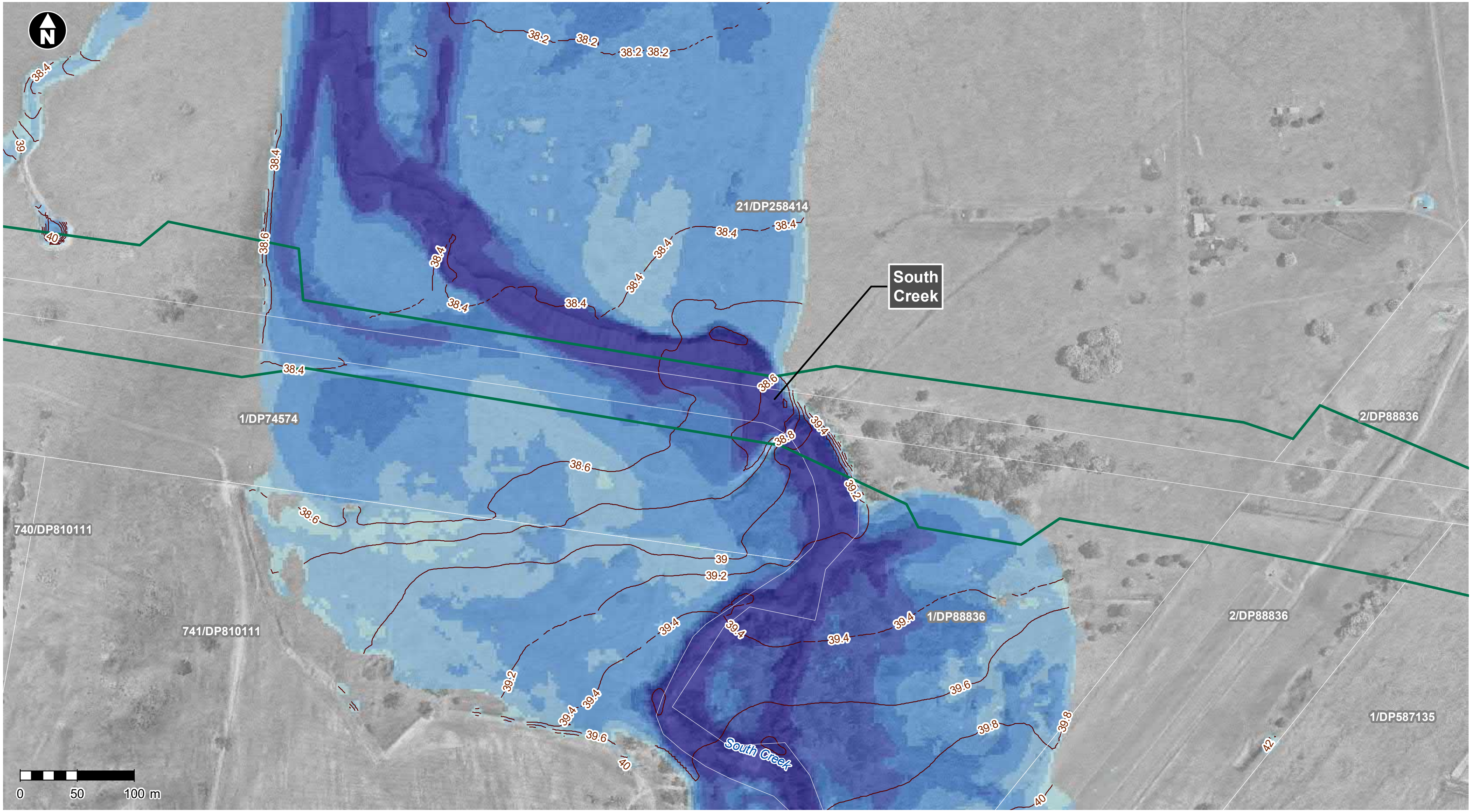


Figure 5-3 Existing conditions 100 year ARI flooding - Badgerys Creek



Legend

- 0.2m Flood Height Contour (m AHD)
- Cadastre
- The project operational footprint

Flood Depth (m)

- < 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

*Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

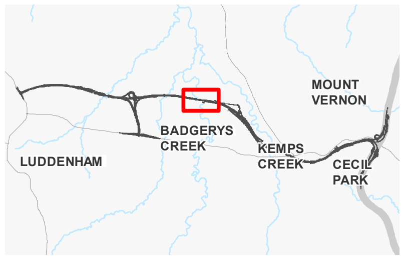
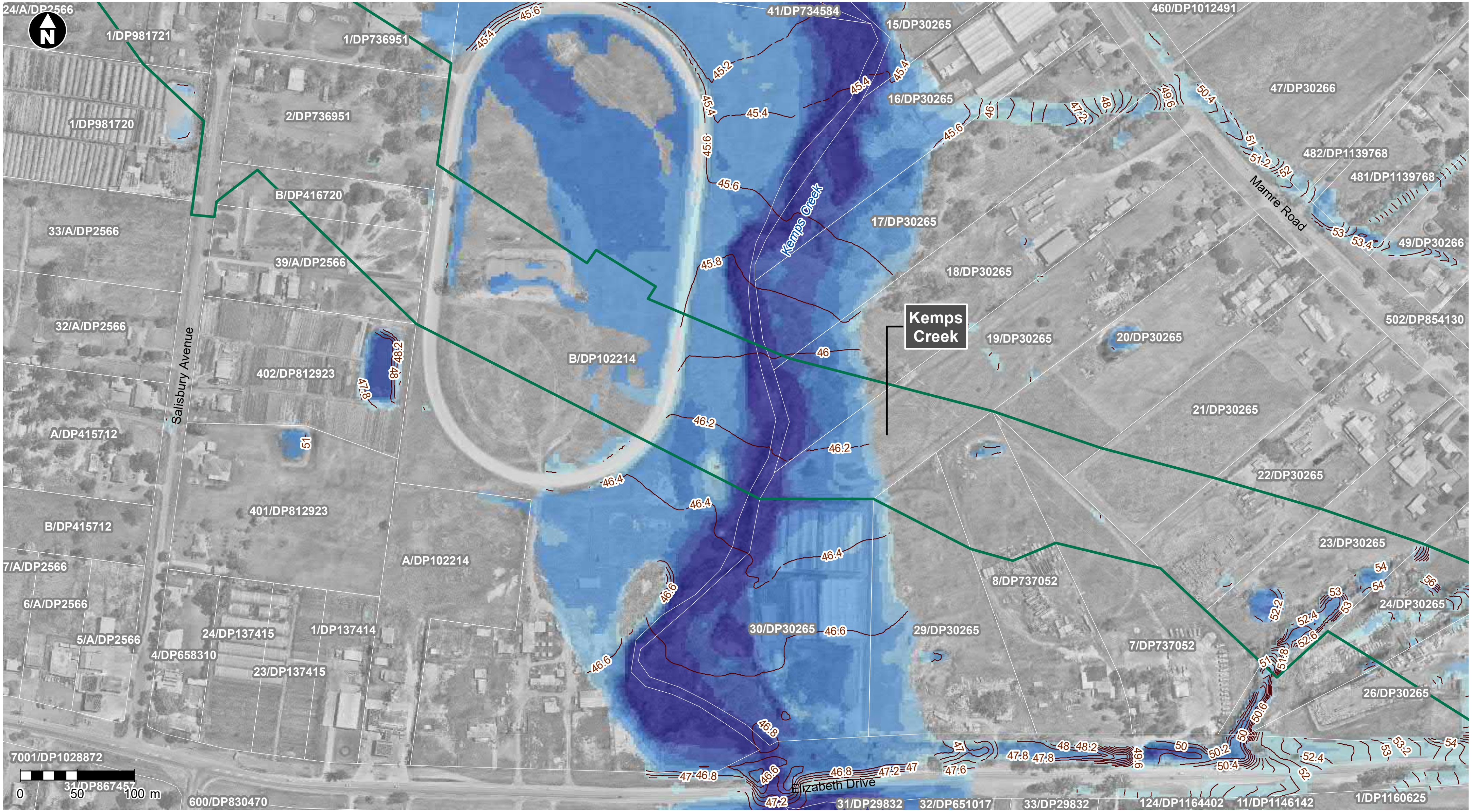


Figure 5-4 Existing conditions 100 year ARI flooding - South Creek

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI\JAJV_FLD_All_100pc_F001_100yrAR1ExFloodLDepth_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB



Legend

0.2m Flood Height Contour (m AHD)

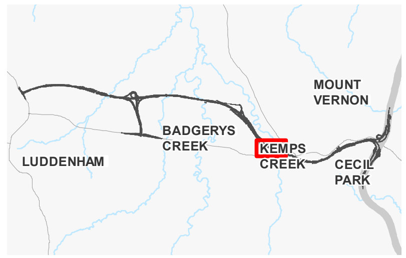
Cadastre

The project operational footprint

Flood Depth (m)

- < 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

*Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design



1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

Figure 5-5 Existing conditions 100 year ARI flooding - Kemps Creek

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI\JAJV_FLD_All_100pc_F001_100yrAR1ExFloodLDepth_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB

6. Proposed flooding infrastructure

6.1 Overview

In a flooding context, the project crosses around 16 kilometres of terrain that is susceptible to a range of flooding conditions. The alignment crosses four major creeks (Cosgroves, Badgerys, South and Kemps Creeks), a minor waterway adjacent to Luddenham Road, and numerous minor drainage lines with intermittent stream flow. The project also traverses Ropes Creek near the tie-in to the existing M7 Motorway.

The project has a combination of cut and fill earthworks along its length. The major flooding areas are in locations of earthworks fill (embankments). The earthworks fill embankments are as high as 12 metres high in some locations. Bridges would be required in these locations so that floodwater crosses the alignment with minimal obstruction.

6.2 Bridges and creek adjustments

The project would require new bridge crossings at Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek. Another bridge has been included in the design at Luddenham Road where a tributary of Cosgroves Creek crosses the project alignment. Bridge widening works on the existing M7 Motorway northbound bridge will be required at Ropes Creek.

All new bridges have spill-through abutments of slope 1.5 (height) to 1 (vertical), and bridge beam lengths about 30 metres long. Pier intervals match the beam lengths at generally around 30 metre spacing.

The two bridges at the western end (Luddenham Road and Cosgroves Creek) are single structures with no gap between the motorway carriageways. The piers for these bridges have seven columns. The other waterway bridges are twin structures and have separated carriageways. The number of columns for these bridges is either three or four depending on which bridge includes the shared user path; the wider bridges have four columns per pier.

All column diameters were designed to be 900 millimetres, and column spacings within the piers were four metres. The proposed depth of the bridge superstructure is 2.9 metres or 3.2 metres depending on the bridge and allowing for blockage of the bridge parapets.

Bridge piers have generally been aligned to the direction of flow to reduce the exposure to debris blockage and to minimise drag forces.

Bridge lengths were designed to optimise the road geometry and to minimise impacts on the surrounding land.

The existing bridge over Ropes Creek on M7 Motorway would be widened. The bridge widening was designed to match existing bridge with similar bridge type, bridge spans and piers arrangement and therefore, as discussed in **Section 3.1**, no changes to current flood conditions are expected and this bridge and it has not been considered further within the flood modelling for the project.

Localised adjustments of Badgerys Creek, South Creek and Kemps Creek would occur at the bridge locations to coordinate with bridge pier locations, minimise bridge lengths, reduce risk of erosion around bridge piers, provide suitable flood conveyance, reduce the number of times the creeks would be disturbed during construction and minimise shading of the creeks. The proposed creek adjustments would have a similar capacity to the existing creek channels and where possible would be designed and constructed in a way that mimics natural flow conditions. The need for, extent and design of the creek adjustments would be reconsidered during detailed design, taking into account potential environmental benefits from minimising the adjustments to the creeks' natural alignment and form.

6.3 Culverts and channels

There are about 70 locations where culverts are required to transfer overland flow across the project alignment. Culverts will be placed on existing flow paths and have been designed so as to not restrict the free flow of water. In some locations the project embankments direct minor overland flow paths towards a culvert. Formalised channels have been designed along the base of the proposed embankments for the more significant lengths of diversion to minimise the potential for erosion.

6.4 Main carriageway vertical alignment

The proposed main carriageway levels were required to be above 100 year ARI flood levels. Generally, road design constraints other than flooding defined the main carriageway vertical alignment including the limitations on the steepest vertical grade and the overall cut/fill balance to minimise earthworks cost.

6.5 Shared user path

The shared user path has been designed to be independent of the main carriageway alignment, both horizontally and vertically. An important consideration for the shared user path location is public safety in flooding conditions. The shared user path has therefore been designed to be level with the main carriageway at the four major creeks crossing the project. The shared user path has reduced flood immunity in other locations, as discussed further in **Section 7.2.3**.

6.6 Construction activities

6.6.1 Construction of the project

The key construction activities would include:

- Site establishment and mobilisation
- Early works and property adjustments
- Demarking environmental protection exclusion areas
- Clearing, grubbing and topsoil stripping, including clearing of all areas within the construction footprint (except within any nominated environmental protection exclusion areas) and temporary ancillary facilities
- Demolition of existing buildings
- Earthworks and haulage of material
- Stockpiling and storage of material
- Traffic management and access
- Construction of the motorway, intersections, interchanges and road widening
- Construction of bridges
- Construction of drainage structures
- Installation of noise mitigation measures
- Relocation or existing or installation of additional utilities and services
- Changes to property access
- Installation of signposting, lighting and roadside furniture

- Landscaping, waste disposal and rehabilitation of disturbed areas with no future use
- Finishing work
- Site rehabilitation and demobilisation.

Temporary creek adjustments during construction have not been allowed for in the flood modelling. If any temporary adjustments are proposed during detailed design, the impact would be assessed.

6.6.2 Ancillary facilities

The construction activities will require the establishment of temporary ancillary facilities. These ancillary facilities would provide support to the construction of the project and may include material and earthworks stockpiling areas, construction support areas for bridges, a main project office and compound area, secondary offices located as needed along the project, workshops for servicing plant and equipment, double-handling and laydown areas and concrete and/or asphalt batching plants.

The final type, location and number of ancillary facilities would be determined by the construction contractor and identified in a site establishment management plan (SEMP) prepared as part of the construction environmental management plan (CEMP). Potential ancillary facility locations are shown in **Annexure A** and include:

- AF 1 – East of The Northern Road
- AF 2 – North of Elizabeth Drive opposite the Elizabeth Drive / Badgerys Creek Road intersection
- AF 3 – North of Elizabeth Drive between proposed Airport Access Road and Rail line
- AF 4 – West of Clifton Avenue, north of proposed mainline
- AF 5 – West of Mamre Road North of Elizabeth Drive
- AF 6 – South of Elizabeth Drive opposite Duff Road Demolition of existing buildings
- AF 7 – West of M7 Motorway, North east corner of Western Sydney Parklands
- AF 8 – East of M7 Motorway, south of Elizabeth Drive
- AF 9 – East of M7 Motorway, north of Elizabeth Drive.

7. Assessment of potential impacts

7.1 Construction impacts

The design of the project has considered the requirement to minimise impact on existing traffic, enable safe construction access and egress, and minimise the duration of construction. The design also considered the potential flood impacts associated with the construction activities listed in **Section 6.6.**

The following construction activities have the potential to affect the existing flood conditions:

- Earthworks: the fill associated with the construction of the motorway embankment would cause flow constriction and loss of storage similar to the effects described as part of the permanent works. The size of the embankments supporting the design outlined in the M12 Motorway EIS assumes there will be no preloading of the motorway embankment. This means that the worst construction scenario for flooding during construction is when the final form of the embankment is complete. Depending on the construction methodology adopted, preloading may be required and should be taken into account during future design stages
- Stockpile and ancillary facilities: the inclusion of any temporary fill within the floodplain, such as platforms and stockpiles, could affect flow paths and reduce floodplain storage. All but two of the nine proposed ancillary facilities would be located outside of the major floodplains, to avoid or minimise impacts from project earthworks on flow behaviour in the floodplains. Ancillary facilities AF2 and AF5 would be partially impacted by the 100 year ARI flood extents: at AF2 there is an existing farm dam, and at both locations there are localised flow paths impacted during the 100 year ARI event. As the two localised flow paths are away from the main creek floodplains however, negligible impact to the overall flooding conditions in the floodplains is expected. See **Annexure A** flood maps which include ancillary facility locations AF1 to AF9 in relation to 100 year ARI levels, and further discussion below
- Temporary creek crossings: during the construction of the waterway bridges, temporary crossings of the watercourses may be required to allow construction vehicles to drive between the banks of creeks. Temporary crossings may include low lying causeways, consisting of a low-level trafficable weir with culverts conveying low flows. The temporary crossings would remain dry during normal creek flow conditions when the water is low but could become covered by water in times of floods. This type of crossing, whilst being occasionally impassable, is suitable for construction activities.

Temporary creek crossings present an obstruction to the creek flow. However, this obstruction is generally minor during large flood events, as it becomes overwhelmed by much deeper and wider flows. For instance, a temporary crossing of South Creek at Bridge BR06 is expected to obstruct approximately five per cent of the one per cent AEP total flow area at the location. This would result in a localised increase in peak water levels of about 50 millimetres, which is within the permissible range of hydraulic impacts listed in **Table 3-2**. Similar limited impacts are expected at all floodplain crossings.

A review of construction activities indicates that the impacts on flood behaviour will be similar to the operational phase as described in **Section 7.2.** This is because the height and width of earthworks (fill) within the floodplains is not expected to be any larger than the embankments that would be present during operation. As a result, the performance of the project against the following SEARs during the construction phase will be the same as that during the operational phase:

- Afflux and impact to properties, assets and infrastructure
- Changes to peak stormwater flows, downstream velocity and scour potential
- Flood hazards
- Hydraulic functions of flow conveyance
- Adverse effects to beneficial floodplain inundation

- Land use impact
- Emergency management, evacuation and access
- Social and economic costs
- Impact of future climate change on flood behaviour.

While the findings of this initial assessment provide an indication of the potential impacts of construction activities on flood behaviour, further investigation would need to be carried out during detailed design, as layouts and construction staging strategies are further developed by the contractor. Consideration would also need to be given to setting an appropriate hydrologic standard for mitigating the impacts of construction activities on flood behaviour, taking into account their temporary nature and therefore the likelihood of a flood of a given AEP occurring during the construction period.

Prior to construction, a flood management plan should be prepared that sets out measures which are aimed at mitigating the impacts of construction activities on flood behaviour as far as practicable.

All the ancillary facilities are located outside of the one per cent AEP floodplains except at two locations. The mapping provided in **Annexure A** show proposed locations AF2 and AF5 where the ancillary facilities appear to be within the 100 year ARI flood extents. At AF2 this is due to the presence of a localised flow path and an existing farm dam. At AF5 it is due to a localised flow path. As the two localised flow paths are away from the main creek floodplains negligible impact to the overall flooding conditions in the floodplains is expected. Temporary drainage management measures in line with those documented in **Section 9** would be put in place to minimise any potential impact during construction.

7.2 Operational impacts

7.2.1 Increases in flood affectation - other properties, assets and infrastructure

Changes in flood levels (afflux) for the pre-development conditions (without project) and post-development conditions (with project) under the 100 year ARI flood event are described in the following sections and shown in **Figure 7-2** to **Figure 7-5**. These maps show the afflux conditions in relation to the proposed road design, operational footprint, bridge outlines and property boundaries. Afflux maps for all other flood events are shown in **Annexure A**. Additional maps showing flood height contours, flood depths and flood velocity under existing conditions and post-construction of the project are also available in **Annexure A**.

In the following tables, flood levels are reported along the upstream boundary of the operational footprint, at the point nearest the centre of the bridges. Changes in flood levels are reported along the upstream and downstream operational footprint boundaries across each waterway. The terms ‘upstream’ and ‘downstream’ are general and indicative for the overall floodplain. Flow directions are complex at some bridges, particularly at South Creek (bridge BR06) where some flow runs almost parallel to the bridge at its eastern end.

As discussed in the following sections, the maximum increase in 100 year ARI flood levels would be 143 millimetres at South Creek. The affluxes associated with flood events more frequent than the 100 year ARI flood are predicted to be smaller. These affluxes are considered to be minimal. They are within the adopted flood impact criteria set out in **Section 3.3.3** and below the maximum acceptable threshold applied on similar significant state infrastructure projects in both rural and urban environments. All areas of afflux are within already flooded land; there is minimal expansion of the floodplain extent.

Luddenham Road

At the Luddenham Road bridge, the flood elevation increase is predicted to be up to 31 millimetres at the upstream operational footprint. Setting the eastern bridge abutment clear of the current road allows flexibility for design options for a future Luddenham Road upgrade without a need to adjust the project infrastructure and without risk of additional flooding impacts.

Refer to **Table 7-1** and **Figure 7-1** for the 100 year afflux at Luddenham Road bridge resulting from the proposed conditions. The results indicate that the impacts to the adjacent properties are negligible and the existing flooding conditions on Luddenham Road are not changed.

Table 7-1 100 year ARI Luddenham Road peak water levels

Bridge	Pre-development peak water level (m AHD)	Post-development maximum afflux at operational boundary – Upstream **(mm)**	Post-development maximum afflux at operational boundary – Downstream **(mm)**
Luddenham Road - BR01	58.899	31	27

Cosgroves Creek

At Cosgroves Creek, the flood level increase is predicted to be up to 5 millimetres at the upstream operational footprint. Flood modelling results indicate higher levels of afflux locally along the motorway embankment; however, these would be contained within the operational footprint.

Refer to **Table 7-2** and **Figure 7-2** for the 100 year afflux at Cosgroves Creek resulting from the proposed conditions. The flood level increase is minor and impacts to the adjacent properties, mainly agriculture and grazing, are negligible. There will be no impact to the extent of flooding and the nature of flooding at the horse training track in Lot 35/DP211842 is anticipated to be the same as the existing flooding conditions.

Table 7-2 100 year ARI Cosgroves Creek peak water levels

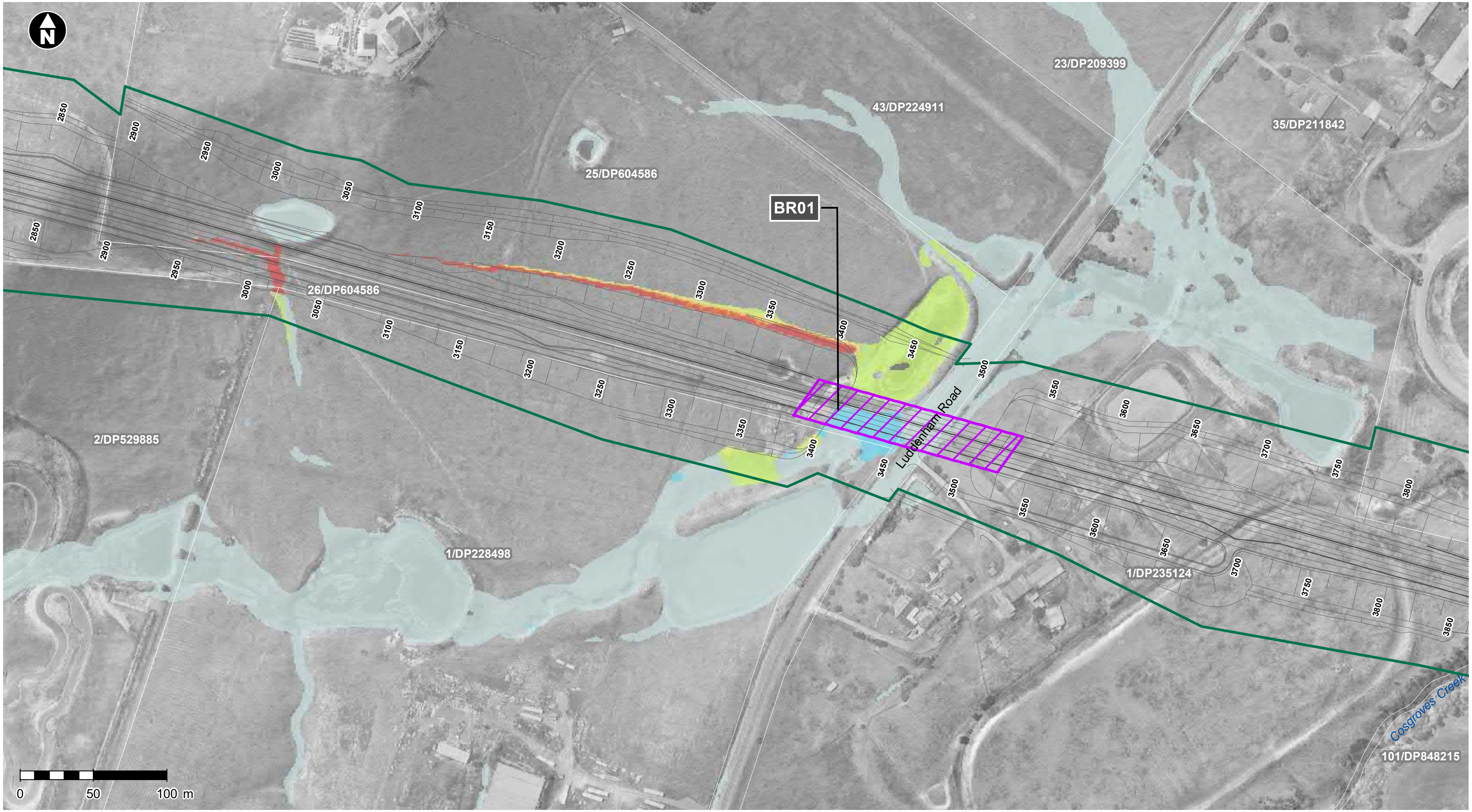
Bridge	Pre-development peak water level (m AHD)	Post-development maximum afflux at operational boundary – Upstream **(mm)**	Post-development maximum afflux at operational boundary – Downstream **(mm)**
Cosgroves Creek – BR02	50.296	5	0

Badgerys Creek

The project would involve an adjustment to Badgerys Creek to reduce the risk of erosion around bridge piers which would otherwise be located within the existing creek low-flow channel. The flood impact assessment included consideration of the creek adjustment, which has a localised impact directly adjacent to the adjusted creek channel and the impact is contained within the operational footprint.

The flood elevation increase at Badgerys Creek is predicted to be up to 35 millimetres at the downstream operational footprint. Flood modelling results indicate higher levels of afflux locally along the motorway embankment; however, these would be contained within the operational footprint.

Refer to **Table 7-3** and **Figure 7-3** for the 100 year afflux at Badgerys Creek resulting from the proposed conditions. The flood level increase is minor and impacts to the adjacent properties, mainly rural farmland, are negligible. There will be no noticeable change to the extent of flooding.



Legend

The project
Bridge outline
Cadastre
The project operational footprint

Peak flood afflux (mm)

< -20
-20 to 20
20 to 40
40 to 60
60 to 80
80 to 100
100 >

*Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design

1:3,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

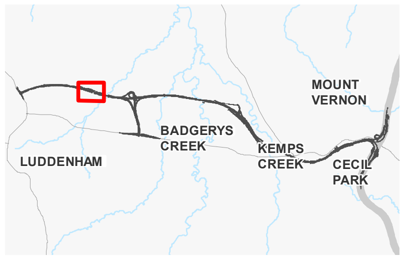
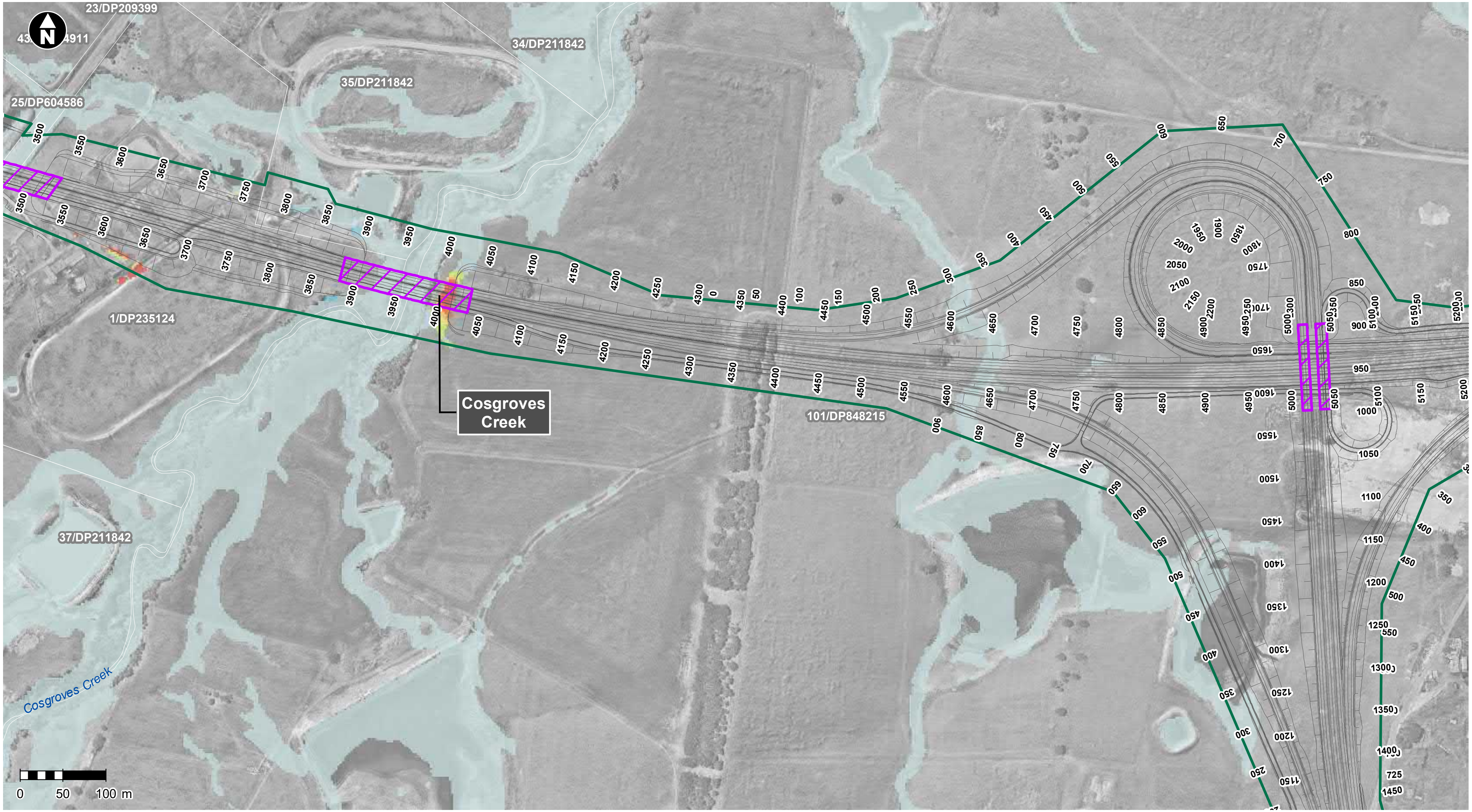


Figure 7-1 Luddenham Road 100 year afflux

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_Afflux\JAJV_FLD_All_100pc_F008_100yrARIAfflux_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB



Legend

- The project
- Bridge outline
- Cadastre
- The project operational footprint

Peak flood afflux (mm)

- < -20
- -20 to 20
- 20 to 40
- 40 to 60
- 60 to 80
- 80 to 100
- 100 >

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:6,000 at A4

Coordinate System: GDA 1994 MGA Zone 56

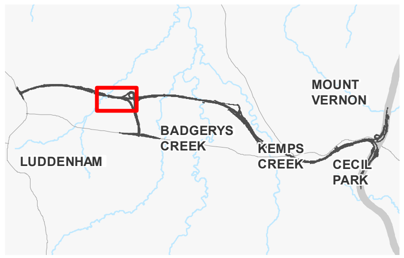
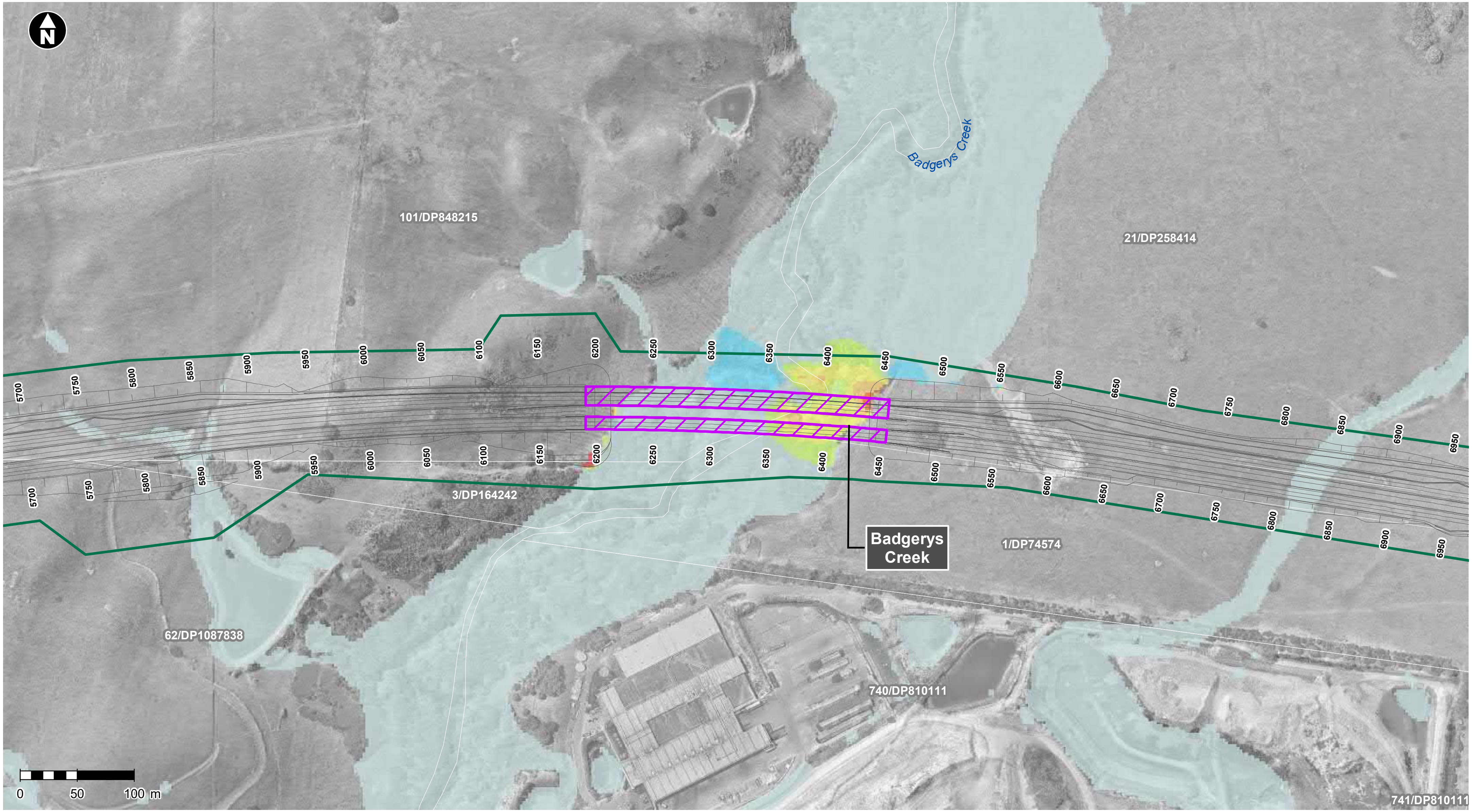


Figure 7-2 Cosgroves Creek 100 year afflux

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_Afflux\JAJV_FLD_All_100pc_F008_100yrARIAfflux_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB



Legend

- The project
- Bridge outline
- Cadastre
- The project operational footprint

Peak flood afflux (mm)

- < -20
- -20 to 20
- 20 to 40
- 40 to 60
- 60 to 80
- 80 to 100
- 100 >

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

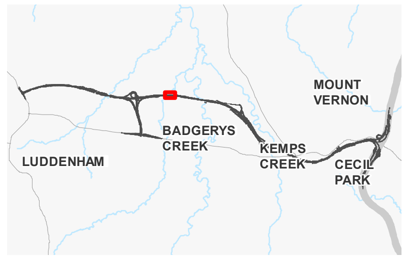


Figure 7-3 Badgerys Creek 100 year afflux

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_Afflux\JAJV_FLD_All_100pc_F008_100yrARIAfflux_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB

Table 7-3 100 year ARI Badgerys Creek peak water levels

Bridge	Pre-development peak water level (m AHD)	Post-development maximum afflux at operational boundary – Upstream **(mm)**	Post-development maximum afflux at operational boundary – Downstream **(mm)**
Badgerys Creek – BR05	40.166	17	35

South Creek

At South Creek the project would result in a localised redistribution of flow due to a minor creek adjustment around a bridge pier and the shifting of a small footbridge beneath the proposed bridge. The overall effect would be a localised flood level increase directly adjacent to the realigned creek channel. The design of the creek adjustment would be further developed at detailed design.

The flood level increases would be within already flooded land, and there would be no expansion of the floodplain extent. The greatest change in flood level would be at the 'downstream' boundary. The flow direction at this location is predominantly parallel to the bridge, so the 'upstream' and 'downstream' terms should be viewed in terms of the overall floodplain flow direction rather than at a localised scale.

The flood level increase at South Creek is predicted to be up to 143 millimetres at the downstream operational footprint. Flood modelling results indicate higher levels of afflux locally along the motorway embankment; however, these would be contained within the operational footprint.

Refer to **Table 7-4** and **Figure 7-4** for the 100 year afflux at South Creek resulting from the proposed conditions. The flood level increase would be minor and impacts to the adjacent properties, mainly rural farmland, would be negligible. There would be no noticeable change to the extent of flooding.

Table 7-4 100 year ARI South Creek peak water levels

Bridge	Pre-development peak water level (m AHD)	Post-development maximum afflux at operational boundary – Upstream **(mm)**	Post-development maximum afflux at operational boundary – Downstream **(mm)**
South Creek – BR06	38.479	93	143

Kemps Creek

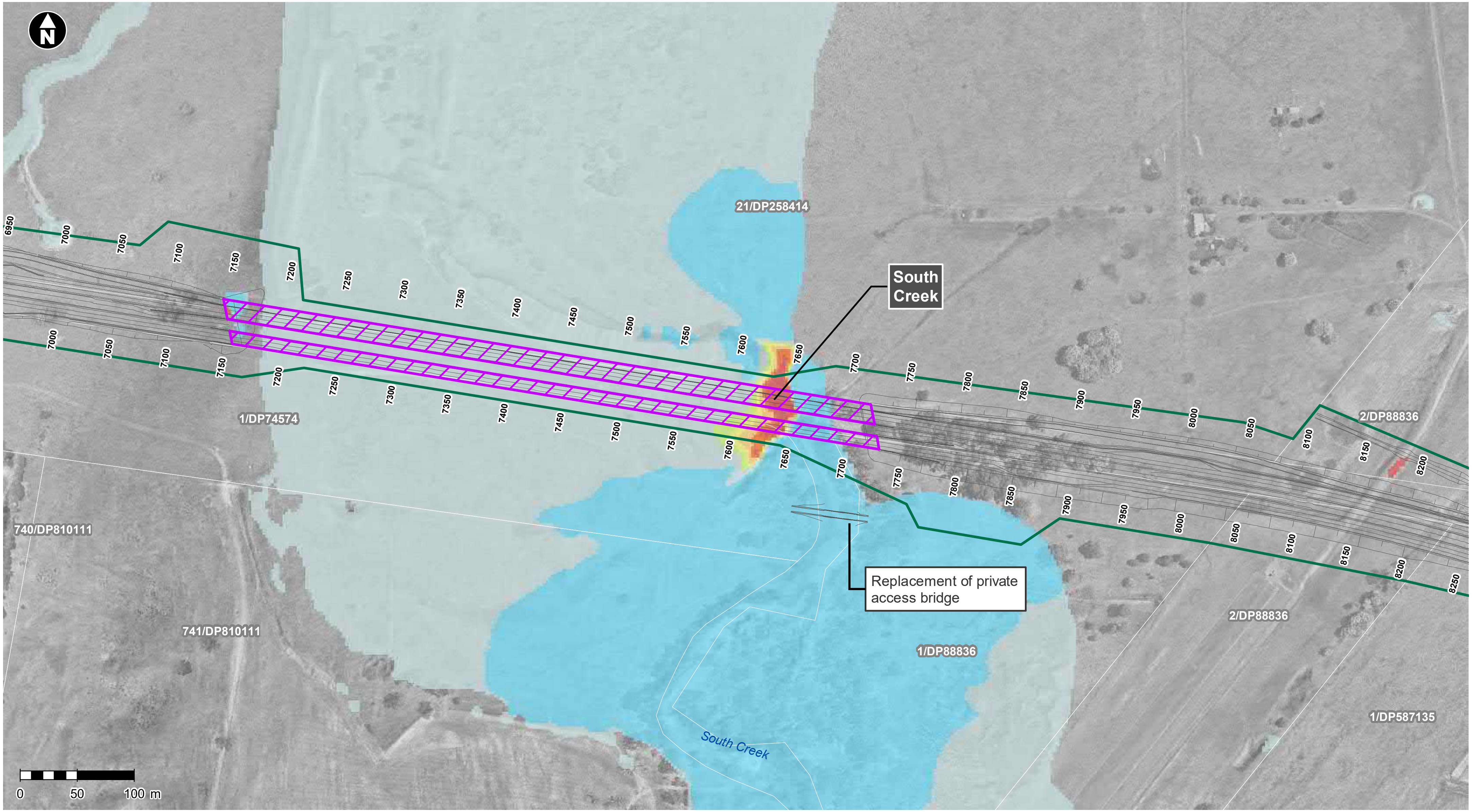
The flood level increase at Kemps Creek is predicted to be up to 12 millimetres at the downstream operational footprint. Higher levels of afflux might occur locally along the motorway embankment; however, these would be contained within the operational footprint.

Refer to **Table 7-5** and **Figure 7-5** for the 100 year afflux at Kemps Creek resulting from the proposed conditions. The flood level increase and the impacts to the adjacent properties, mainly rural farmland and rural residential, would be negligible. The flooding impact to the horse training track and the frequency of the oval embankment being overtopped would be similar to the existing flooding conditions. There would be no noticeable change in flood extent at the rural residential properties along Mamre Road.

There would be no noticeable change to the extent of flooding.

Table 7-5 100 year ARI Kemps Creek peak water levels

Bridge	Pre-development peak water level (m AHD)	Post-development maximum afflux at operational boundary – Upstream **(mm)**	Post-development maximum afflux at operational boundary – Downstream **(mm)**
Kemps Creek – BR08	46.299	1	12



Legend

- The project
- Bridge outline
- Cadastre
- The project operational footprint

Peak flood afflux (mm)

- < -20
- -20 to 20
- 20 to 40
- 40 to 60
- 60 to 80
- 80 to 100
- 100 >

**Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design*

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

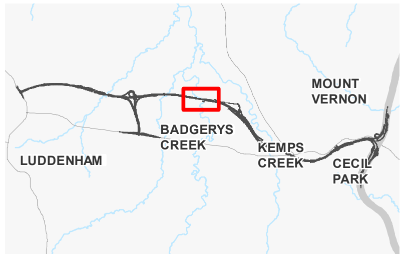
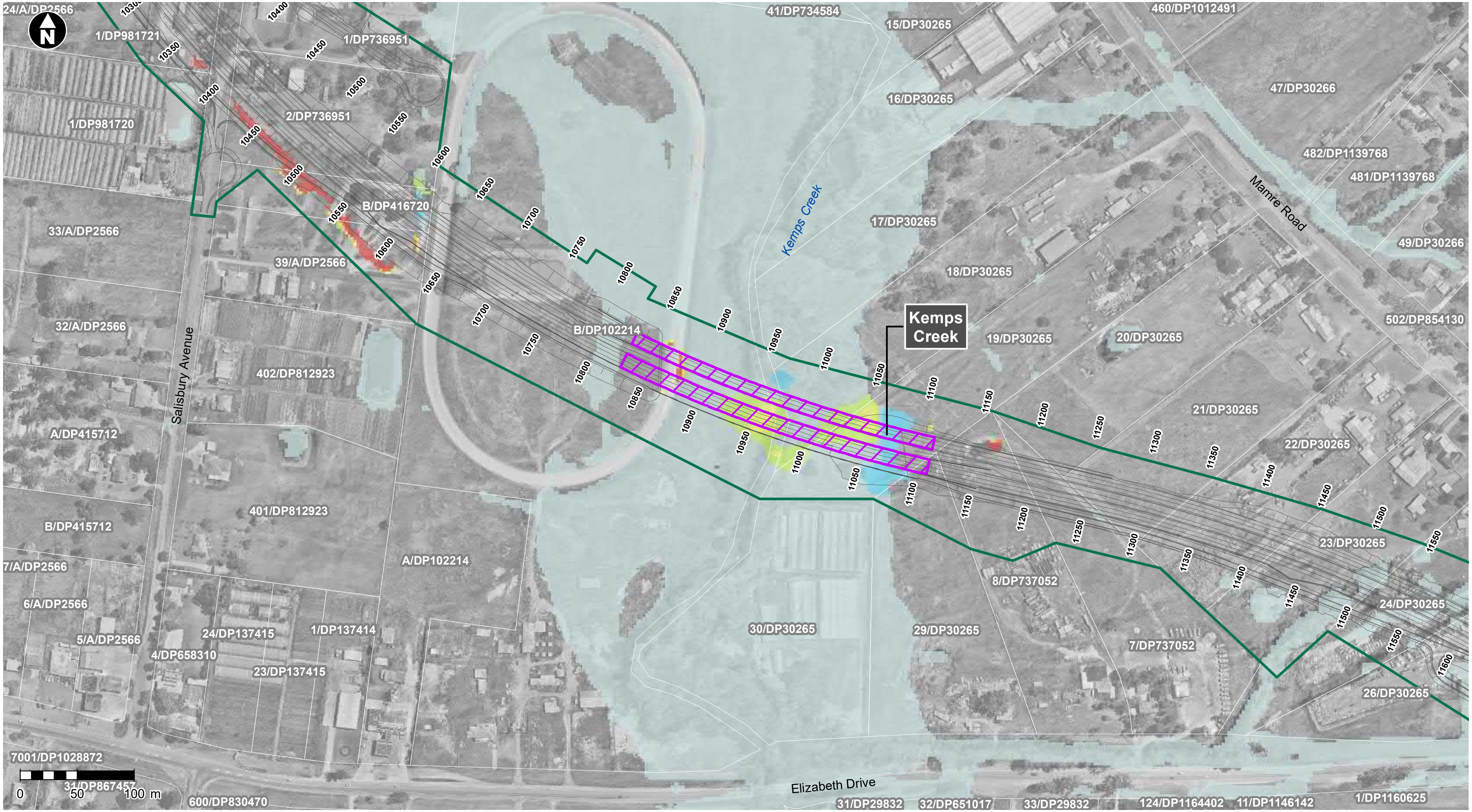


Figure 7-4 South Creek 100 year afflux

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_Afflux\JAJV_FLD_All_100pc_F008_100yrARIAfflux_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB



Legend

- The project
- Bridge outline
- Cadastre
- The project operational footprint

Peak flood afflux (mm)

- < -20
- -20 to 20
- 20 to 40
- 40 to 60
- 60 to 80
- 80 to 100
- 100 >

*Flood conditions of carriageway of proposed motorway M12 is not shown as assumed to be considered in longitudinal drainage design

1:4,500 at A4

Coordinate System: GDA 1994 MGA Zone 56

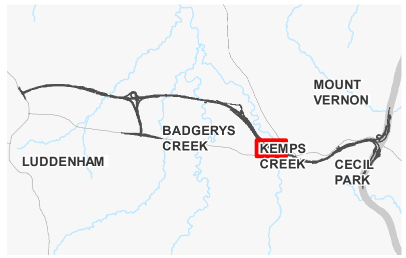


Figure 7-5 Kemps Creek 100 year afflux

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI_Afflux\JAJV_FLD_All_100pc_F008_100yrARIAfflux_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB

Land use impact

Outside of the operational footprint, the proposed flooding conditions are predicted to be largely the same as existing, even under large flooding conditions including the 100 year ARI. The use of the land surrounding the main creeks would be unaffected by the project with respect to flooding.

Impacts to buildings and inundation durations

The flood modelling results show that there would be no impact to buildings currently present in the areas surrounding the project. This has been based on a visual scan of available aerial photography from public sources.

Changes to the inundation durations are predicted to be minimal under flood events up to and including the 1 in 100 year ARI and are likely to increase inundation time by less than the maximum allowable increase outlined in **Section 3.3.3** (ie one hour in the 100 year ARI). The proposed bridge openings would be wide enough to avoid holding water upstream of the motorway, which would be the reason for increased duration of inundation upstream. As a result, the flood impact objective listed in **Table 3-2** for inundation duration would be achieved for the project.

Changes in surrounding catchments

Section 3.6 provides a discussion about potential future changes to the surrounding catchment hydrology which may lead to an increase in flooding. If an increase in flow does occur due to these other developments, the predicted impact of the M12 Motorway may be larger than expected. While the current design of the bridges would accommodate some changes in the surrounding catchment, the bridge designs would be refined in detailed design and further modelling undertaken to confirm flooding impacts. This flood modelling would take into account any updated regional flood modelling and information available at the time.

Farm dams

The potential for adverse flood impacts to result in potential dam failure (eg due to increased inundation by floodwaters) was considered as part of this assessment however are considered unlikely given the potential flood impacts associated with the project are minor and contained generally within the project's operational footprint.

Changes in the hydrology of minor drainage lines downstream of the project have been investigated as part of the assessment of surface water and hydrology impacts. That assessment looked at potential impacts on farm dams and showed that the project would alter the catchments of minor drainage lines such that some minor watercourses would experience increased flows, while others would experience reduced flows. As a consequence, some farm dams may take less time to fill, and remain full for longer, while others may take longer to fill. Appropriate management measures such as adjustments to dam spillways may be required and would be implemented in consultation with affected landowners

The potential impact on farm dams as a result of altered flood impacts has been assessed in more detail in Appendix M of the EIS, and would be further considered as part of further flood investigations to be undertaken as part of detailed design.

7.2.2 Changes to peak stormwater flows, downstream velocity and scour potential

Changes to the flooding behaviour at the waterway bridges are predicted to be minimal. The largest local changes would be at the creek adjustments which are short. Effects on the flows would be small and proximal to the bridges, with contraction and expansion mostly contained within proposed operational footprint (refer to the flood maps in **Annexure A**). Where velocity would be increased above the natural threshold of erosion, scour protection would be provided to eliminate any risks of erosion to the infrastructure and the environment. This would occur at the bridge abutments and around the piers.

Culverts are a more sensitive influencer on flow and velocity changes, though the area of influence remains localised at the inlet and outlet of the culverts. The design methodology adopted has minimised changes to peak flows and velocity as much as practical, and wherever localised changes would still occur, scour protection would be provided to prevent erosion.

In a hydraulic context, most culverts are in relatively steep terrain. Existing flow in these waterways is along creek beds that have evolved to the rainfall and land-use changes of their catchments. The creek beds are much rougher and meandering compared to a culvert which is smooth and straight. As a result, velocity increases would be unavoidable.

Culverts have been designed with as low gradient as practical and sized so that headwater levels are no higher than existing. Even so, outlet velocities are higher than existing. Scour protection would be provided at all culvert outlets, and in some cases an energy dissipation device would be required. Potential for scour would be considered further in detailed design including the need for protection measures at bridge piers and abutments and catch drains (open channels) where flow velocities could result in scour.

Further discussion of potential hydrological impacts is included in Appendix M of the EIS.

7.2.3 Flood hazards

Flood hazards are generally measured as a combination of flow depth and velocity and are categorised by ranges of each. Significant thresholds of flood hazard include depth and velocity combinations where vehicles begin to float, and where people walking through floodwater become unstable and may fall. The consequences of these occurrences have their own range of outcomes which formulate part of the definition of flood risk.

Flood hazards are mainly associated with human interaction with floodwater. Locations impacted by the project that may be sensitive to a change in flood hazard are limited. Luddenham Road is the only flood-prone location where public access is freely allowed and some measure of flood hazard currently exists. Luddenham Road would underpass the proposed M12 Motorway at a location that would be at risk of flooding. To mitigate this risk, the width of the bridge over Luddenham Road (BR01) has been designed to avoid changes to existing flood conditions. This additional width also provides the opportunity for future widening of Luddenham Road, while at the same time reducing the flood hazard for Luddenham Road users in future.

A key flood hazard consideration for the project was the inclusion of a shared user path which could potentially deliver more people to hazardous flood areas which are currently largely inaccessible to the public (including areas at Luddenham Road, Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek). Flood risk could be raised considerably as a result of the introduction of more people to these areas. To minimise flood hazards for pedestrians and cyclists, the shared user path has been designed to be at the same level as the main M12 Motorway level at all waterway bridges. In other areas, the shared user path is located outside the high flood hazard area. Cross drainage culverts and vertical alignment have been designed to provide adequate flood immunity to the shared user path in these less hazardous flood areas.

The introduction of a major transport route into the transport network would have a beneficial influence on flood evacuation in a broader context. Efficient flow of a traffic network can reduce the likelihood of delays for users reliant on the network for flood evacuation elsewhere.

7.2.4 Hydraulic functions of flow conveyance

Flow conveyance in open creeks is usually thought of in terms of the distribution between in-bank (creek channel) and over-bank (floodplain) flows. The only areas where the project would change this distribution are at the proposed creek adjustments, although the difference in flow patterns at these locations relate more to a swapping of creek bed and over-bank geometry rather than to a change in conveyance between creek and floodplain.

The minimal changes to flood levels at each of the main creeks show that conveyance would not be adversely impacted by the project.

At culvert locations, conveyance would not be altered, as the design approach was to match existing headwater levels as opposed to allowing headwaters to rise, introducing flood storage effects.

7.2.5 Adverse effects to beneficial floodplain inundation

All floodplain areas would experience little change beyond localised effects at bridge abutments, piers, and at the creek adjustments (see **Annexure A** for flood maps). The relatively long bridge spans between piers (about 30 m), would allow the floodplain to change naturally in future, noting that the piers would be protected from scour. Sediment transfer along the floodplain is expected to be unaffected apart from the localised influence of the piers.

The delivery of stormwater to floodplain areas through the project culverts would remain unchanged beyond the operational footprint.

7.2.6 Emergency management, evacuation and access

The project would provide a major transport network link to the region, designed with greater than 100 year ARI flood immunity. Having this transport link would improve emergency management options, both for flooding near the project and for surrounding areas where the traffic improvements will help dissipate evacuating vehicles. The project is not, however, proposed to be a designated flood evacuation route.

The project would cut some minor access tracks, but these would not have any flood evacuation role.

Consultation carried out with the SES and Councils regarding potential flood impacts of the project and emergency management arrangements for flooding is summarised in **Chapter 4**.

7.2.7 Social and economic costs

As discussed in **Section 7.2.1**, outside of the projects' operational footprint, the proposed flooding conditions are predicted to be largely the same as existing, even under large flooding conditions like the 100 year ARI. The use of the land surrounding the main creeks would be unaffected by the project with respect to flooding, as shown on the flood maps in **Annexure A**. As such, it is predicted that there would be no flood related social or economic costs due to the project.

It is more likely that changes to the catchment hydrological response due to planned major developments in the South Creek valley would affect the flood-related social and economic costs for areas surrounding the project. While the current design of the bridges would accommodate some changes in the surrounding catchment, and therefore may help dissipate social and economic costs associated with future developments, the bridge design would be refined in detailed design and further modelling undertaken to confirm flooding impacts associated with the project itself.

As discussed in **Section 3.6**, government stakeholders for developments in the South Creek valley have acknowledged the need for a catchment-wide approach to the hydrological modelling inclusive of the stormwater management plans of upstream major developments. Such an assessment is outside the scope of this project however the flood modelling results herein have been made available for this purpose.

7.2.8 Climate change

As described in **Section 3.5**, a conservative climate change assessment was carried out by analysing the 0.05 per cent AEP flow rates (which are far in excess of the one per cent AEP flow rates with the standard climate change factors of between 10 and 30 per cent applied). Despite this conservative approach, the vertical alignment of the motorway is still well above the 0.05 per cent AEP flood levels and the future climate change will have minimal impact on flooding due to the project. As discussed above, bridge design would be refined in detailed design and further modelling undertaken to confirm flooding impacts associated with the project, including potential increased sensitivity to climate change from any design refinements.

Similarly, the sizing of the cross drainage culverts for minor drainage lines has included adequate freeboard. The freeboard adopted would accommodate for the increase flow rates from climate change and the flood immunity of the motorway is unlikely to be impacted. Further assessments would be undertaken to confirm climate change impact in detailed design subject to cross drainage culverts design refinement.

8. Cumulative impacts

Cumulative flooding impacts may arise from the interaction of construction and operational activities of the project and other approved or proposed projects in the area. When considered in isolation, specific project impacts are considered minor. These minor impacts may be more substantial, however, when the impact of multiple projects on the same receivers is considered. As such, the flooding impacts discussed in **Section 7** are assessed in consideration of the recently completed, ongoing and proposed projects described in **Section 8.1.** These projects are relevant to the consideration of cumulative flooding impacts both temporally and spatially as they would be in the same surface water catchment and construction and/or operation may have overlapping timeframes, as discussed further below.

The identified projects are in varying stages of delivery and planning. This section provides an assessment of cumulative flooding impacts based on the most current and publicly available information. In many instances this is a high-level qualitative assessment.

Since potential flooding impacts of the project are minor and localised, both during construction and operation, the project is expected to have a minor contribution to cumulative flooding impacts associated with the project and other identified projects in the area.

As noted in **Section 3.6,** it is anticipated that major development upstream of the project would increase catchment runoff in flooding events. While individual developments would include detention basins that restrict peak outflows to the existing peak flow rates, this would not necessarily keep peak flows the same as existing in areas downstream, including at the M12 Motorway.

Increased runoff is typically managed through stormwater detention basins that restrict outflow rates, however the peaks ae extended for longer time periods compared to existing conditions. Hence downstream waterways that previously experienced staggered peak flows from sub-catchments upstream have the potential to experience coinciding peak runoff rates, leading to an overall increase in flow rate.

These potential cumulative impacts need to be considered through a regional-scale assessment, which is beyond the scope of the design process of any individual proposal. The current design of the project exceeds the minimum 1 in 100 year ARI flood immunity requirement (due to the design having been governed by road geometry and other design requirements) and therefore provides some excess capacity to accommodate larger flows as a result of future development within the catchment. However, the design can be further optimised during detailed design and the minimum design requirement (1 in 100 year ARI flood immunity) would apply. Additionally, any future developments, and/or any such regional-scale assessment carried out, would need to take into account the presence of the M12 Motorway within the landscape and/or results of the flood modelling from this project.

8.1 Summary of relevant projects

8.1.1 Western Sydney Airport

The Australian Government is currently constructing the Western Sydney Airport on the 1,780-hectare Commonwealth-owned land at Badgerys Creek. The airport will service both domestic and international markets and development will be staged in response to ongoing growth in aviation demand.

Stage 1 includes the establishment of the following to provide operational capacity for about 10 million passengers per year and freight traffic:

- A single 3,700 metre runway in the north-western portion of the site
- A terminal
- Other support facilities
- Foundation for further expansion.

It is anticipated that the demand in relation to this airport will reach about 82 million passengers a year by 2063. To cater for this, a second parallel runway will be constructed at a later stage.

The EIS for the Western Sydney Airport was placed on display in October 2015 and finalised on 15 September 2016 with a Revised Draft Airport Plan. The assessment found that the airport would result in some adverse impacts on the environment and community, particularly in relation to the following:

- Air quality
- Biodiversity
- Health
- Noise
- Water quality.

Mitigation measures were proposed to reduce these potential impacts during construction.

Construction activities for Stage 1 involve three major work phases as follows:

- Site preparation works, including:
  - Securing the construction impact zone
  - Establishing site services and construction facilities
  - Clearing vegetation
  - Undertaking major earthworks
- Aviation infrastructure works, including construction of the:
  - Runway, taxiways and apron areas
  - Internal road network
  - Terminal complex
  - Air traffic control tower
  - Freight, cargo and maintenance facilities
  - Fuel farm.
- Site commissioning activities at the completion of the aviation infrastructure works:
  - Involves testing and commissioning of all facilities in readiness for the operation.

The Western Sydney Airport is relevant to the consideration of cumulative flooding impacts both temporally and spatially as: it is located within the same surface water catchment, directly upstream of the project (see **Figure 1-1**); and construction and operation of these two projects would have overlapping timeframes as discussed in **Table 8-1.**

8.1.2 Sydney Metro Greater West

Transport for NSW (TfNSW) recently identified recommended corridors for a rail option to provide a major transport link between the North West Growth Area, Western Sydney Airport, and the South West and Greater MacArthur Growth Area. This rail option would connect the existing Main South Line (T8) near

Macarthur Station to the existing Main Western Line (T1) near St Marys Station, via the Western Sydney Airport.

This railway servicing the new Western Sydney Airport would be developed and delivered by Sydney Metro. It is referred to as the Sydney Metro Greater West. Planning for this project is currently underway and as such, environmental assessment results are not yet available.

The Sydney Metro Greater West is relevant to the consideration of cumulative flooding impacts both temporally and spatially as: it would be located within the same surface water catchment; and construction and operation of these two projects would have overlapping timeframes as discussed in **Table 8-1**.

8.1.3 The Northern Road Upgrade

An upgrade of the Northern Road was approved in May 2018 as part of the Western Sydney Infrastructure Plan. The upgrade will improve the capacity of the existing road and create about eight kilometres of new road between Mersey Road, Bringelly and just south of the existing Elizabeth Drive, Luddenham to realign the section of The Northern Road that currently runs through the Western Sydney Airport site. Once the upgrade is complete, The Northern Road will connect the project and the M4 Western Motorway and improve connectivity with the Western Sydney Airport (Roads and Maritime, 2017). The upgrade is being carried out in six stages:

- Stage 1 – between The Old Northern Road, Narellan and Peter Brock Drive, Oran Park
  - Completed
- Stage 2 – between Peter Brock Drive, Oran Park and Mersey Road, Bringelly
  - Under construction
- Stage 3 – between Glenmore Parkway, Glenmore Park and Jamison Road, South Penrith
  - Under construction
- Stage 4 – between Mersey Road, Bringelly and Eaton Road, Luddenham
  - Under construction
- Stage 5 – between Littlefields Road, Luddenham and Glenmore Parkway, Glenmore Park
  - Construction scheduled for early 2019 to the end of 2022
- Stage 6 – between Eaton Road, Luddenham and Littlefields Road, Luddenham
  - Construction scheduled for mid-2019 to the end of 2021.

The Northern Road upgrade is relevant to the consideration of cumulative flooding impacts both temporally and spatially as it would be: located partially within the same surface water catchment, directly upstream of the project (see **Figure 1-1**), and construction and operation of these projects would have overlapping timeframes as discussed in **Table 8-1**.

8.1.4 Other road network upgrades

There are a number of other planned and potential road upgrade projects in the western Sydney area that may contribute to cumulative flooding impacts. These potential projects include:

- Elizabeth Drive upgrade – Roads and Maritime has started site investigations, including preliminary engineering, preliminary/strategic designs, environmental field investigations, and strategic modelling. These investigations are expected to be completed by mid-2019
- Mamre Road upgrade – the NSW Government has started early planning for a future upgrade of a 10 kilometre section of Mamre Road, between the M4 Motorway and Kerrs Road to support economic and residential growth in the area

- Outer Sydney Orbital – a future north-south motorway and freight rail line in Sydney's West to support the growth of western Sydney and the distribution of freight across Sydney and regional NSW (TfNSW, 2018b). While the Outer Sydney Orbital is in early stages of planning, it would provide connections to the Western Sydney Airport.

These projects are currently at varying stages of planning and no design or environmental assessment information is currently publicly available. These projects are relevant to the consideration of cumulative flooding impacts both temporally and spatially as they would be: located in the same surface water catchment; and construction and/or operation of these projects may have overlapping timeframes as discussed in **Table 8-1**.

8.1.5 Growth areas

Western Sydney is the focus of a number of plans and policies to promote changes in land use and to increase employment opportunities, in particular within the following defined areas:

- Western Sydney Aerotropolis – The area surrounding the Western Sydney Airport that was previously known as the Western Sydney Airport Growth Area (see **Figure 1-1**). The Aerotropolis would establish a new high-skill jobs hub across aerospace and defence, manufacturing, healthcare, freight and logistics, agribusiness, education and research industries, and is expected to contribute to establishing 200,000 new jobs for Western Sydney (DPE, 2018)
- South West Growth Area – The broader area south-east of the Western Sydney Aerotropolis (see **Figure 1-1**). This will guide new infrastructure investment, identify new homes and jobs close to transport, and coordinate services in the area. The NSW Government is currently at the early stages of investigations
- Western Sydney Employment Area – The area north-east of the Western Sydney Growth Area (see **Figure 1-1**). Established by the NSW Government to be a new employment space, providing opportunities for local people to work closer to home.

The land within the areas above would be developed by individual developers at varying timeframes. Each would be subject to their own environmental assessments, based on the scale and potential impact of each project. There are currently no defined plans available for the individual developments within these growth areas.

The project would traverse the Western Sydney Aerotropolis and indirectly service the Western Sydney Employment Area and South West Growth Area. The project would serve and facilitate the growth by providing increased road capacity and reducing congestion and travel times in the area.

These developments are relevant to the consideration of cumulative flooding impacts both temporally and spatially as they would be: located at least partially within the same surface water catchment; and construction and/or operation of these projects may have overlapping timeframes as discussed in **Table 8-1**.

Table 8-1 Assessment of potential cumulative impacts for relevant projects

Project	Relevance of the identified project to consideration of cumulative flood impacts of the M12 Motorway	Commentary	Flood impact	
			Construction	Operation
Western Sydney Airport (approved)	Spatial relevance and potential for construction and operation to overlap with construction and operation of the M12 Motorway.	Construction of WSA is under way and the airport is set to open in 2026. Construction of the M12 Motorway is expected to commence in quarter 1, 2022 and conclude in 2025. Construction of the WSA and the M12 Motorway will have the potential to cause cumulative impacts, as they are located in close proximity and would undergo construction at the same time. Development of the WSA would involve extensive earthworks which would change drainage direction and overland flow paths, thereby modifying the nature of flooding on the airport site (Department of Infrastructure and Regional Development (DIRD), 2016). The volume of runoff from the site would also increase as the impervious areas on the site expand. The WSA EIS proposes establishment of flood detention basins designed for the full impervious areas at commencement of the airport construction and this would enable the management of stormwater releases during construction and reduce offsite impacts of surface water flows (DIRD, 2016). Based on the minor construction flooding impacts predicted for the M12 Motorway, and the management approach for the WSA discussed above, there would be minor cumulative flooding impacts associated with the construction of the M12 Motorway and the WSA. The WSA and the M12 Motorway would be operational at the same time. The WSA will increase runoff volumes due to the transformation of the existing greenfield site into a predominantly impervious site. It will also increase the duration of the flood discharges out of the site. The WSA will provide detention basins on site to manage the peak flows out of the site so that they are capped at the existing rates for several design floods. As a result, the WSA does not intend to increase the peak flow conditions that would affect the M12 Motorway. Based on the minor operational flooding impacts predicted for the M12 Motorway, and the management approach for the WSA presented in **Section 8.1.1**, there would be minor cumulative flooding impacts associated with the operation of the M12 Motorway and the WSA.	Minor	Minor

Project	Relevance of the identified project to consideration of cumulative flood impacts of the M12 Motorway	Commentary	Flood impact	
			Construction	Operation
Sydney Metro Greater West	Spatial relevance and potential for construction and operation to overlap with construction and operation of the M12 Motorway.	Construction timeframes for the Sydney Metro Greater West are likely to overlap with the construction of the M12 Motorway. During times where construction activities are concurrent, increased flooding impacts are possible. This would be dependent on the specific construction locations and the different construction activities. The magnitude of cumulative construction impacts would be dependent on the specific construction locations, activities and impacts which are yet to be determined for the Sydney Metro Greater West. However, planning provisions require that future development cannot result in a significant change in peak flood flows, and as the M12 Motorway is expected to have minor and localised flood impacts, it would only have a minor contribution to cumulative construction flooding impacts. The Sydney Metro Greater West and the M12 Motorway would both be operational in the longer term (ie opening of the Metro may occur after the opening of the M12 Motorway). Planning for the Sydney Metro Greater West is currently underway and as such, environmental assessment results are not yet available. However, as the M12 Motorway is expected to have minor and localised flood impacts, it would only have a minor contribution to cumulative flooding impacts. Additionally, planning provisions require that future development cannot result in a significant change in peak flood flows, and therefore it is predicted that the operation of the Sydney Metro Greater West would not affect the storage and conveyance of the waterways flowing to the M12 Motorway, and as a result the potential cumulative operation impacts would be minor.	Minor	Minor
The Northern Road Upgrade (approved) • Stage 5 (Littlefields Road to Glenmore Park) • Stage 6 (Eaton Road to	Spatial relevance and potential for construction and operation to overlap with construction and operation of the M12 Motorway.	Construction activities associated with Stages 5 and 6 of The Northern Road may overlap with construction of the M12 Motorway. Both these stages are in the vicinity of the M12 Motorway. It is predicted that the construction of The Northern Road upgrade would not affect the storage and conveyance of the waterways flowing to the M12 Motorway. As a result, the hydrological assumptions and flows adopted for the M12 Motorway should not be affected. There would be negligible cumulative construction flooding impacts associated with the construction of the M12 Motorway and The Northern Road Upgrade Stages 5 and 6. The scale of the impacts would be dependent on the timing and location of concurrent construction activities for both projects.	Negligible	Negligible

Project	Relevance of the identified project to consideration of cumulative flood impacts of the M12 Motorway	Commentary	Flood impact	
			Construction	Operation
Littlefields Road)		It is predicted that the operation of The Northern Road upgrade will not affect the storage and conveyance of the waterways flowing to the M12 Motorway. As a result, the hydrological assumptions and flows adopted for the M12 Motorway should not be affected and here would be negligible cumulative operation flooding impacts associated with the operation of the M12 Motorway and The Northern Road Upgrade Stages 5 and 6.		
Other existing road network upgrades and potential road projects, including: • Elizabeth Drive Upgrade • Mamre Road Upgrade • Outer Sydney Orbital	Spatial relevance and potential for construction and operation to overlap with construction and operation of the M12 Motorway.	The timing for construction of these road upgrades has not yet been announced. However, there is potential for overlaps in construction timing between the M12 Motorway and some of these road upgrade works. During any timeframes where construction activities are concurrent, increased flooding impacts are possible. The magnitude of cumulative construction impacts would be dependent on the specific construction locations, activities and impacts which are yet to be determined for these projects. However, planning provisions require that future development cannot result in a significant change in peak flood flows, and as the M12 Motorway is expected to have minor and localised flood impacts during construction, it would only have a minor contribution to cumulative construction flooding impacts. The cumulative operational flooding impacts associated with these road upgrades projects would need to be taken into consideration as part of the environmental assessment and approval process for those upgrades. While precise timing for the road upgrades is unknown, they would eventually be operational at the same time as the M12 Motorway. However, as the M12 Motorway is expected to have minor and localised flood impacts, it would only have a minor contribution to cumulative flooding impacts. Additionally, planning provisions require that future development cannot result in a significant change in peak flood flows, and therefore it is predicted that the operation of the proposed road upgrades would not affect the storage and conveyance of the waterways flowing to the M12 Motorway and as a result the potential operation cumulative impacts would be minor.	Minor	Minor

Project	Relevance of the identified project to consideration of cumulative flood impacts of the M12 Motorway	Commentary	Flood impact	
			Construction	Operation
Major land releases, including: • Western Sydney Aerotropolis • South West Growth Area • Western Sydney Employment Area.	Spatial relevance and potential for construction and operation to overlap with construction and operation of the M12 Motorway.	The timing for the construction of developments within the relevant growth areas has not yet been announced. However, there is potential for overlaps in construction timing between some development of major land releases and the M12 Motorway. During times where construction activities are concurrent, increased flooding impacts are possible. The magnitude of cumulative construction impacts would be dependent on the specific construction locations, activities and impacts which are yet to be determined for these land releases. However, planning provisions require that future development cannot result in a significant change in peak flood flows, and as the M12 Motorway is expected to have minor and localised flood impacts during construction, it would only have a minor contribution to cumulative construction flooding impacts. The operation of the growth areas would increase runoff volumes due to the transformation of the existing greenfield sites into predominantly impervious sites. It will also increase the duration of the flood discharges out of the sites. The growth areas will likely provide detention basins on site to manage the peak flows out of their sites so that they are capped at the existing rates for several design floods. However, there are still potential flooding impacts associated with development occurring within Western Sydney and these impacts will need to be taken into accounts as part of the environmental assessment and approval process for those projects. As mentioned in **Section 3.6**, government stakeholders for developments in the South Creek valley have acknowledged the need for a catchment-wide approach to the hydrological modelling inclusive of the stormwater management plans of upstream major developments. Such an assessment is outside the scope of this assessment; however, the flood modelling results herein have been made available for this purpose.	Minor	Future consideration

9. Environmental management measures

Further flood investigations and modelling will be undertaken during detailed design to ensure the flood immunity objectives and design criteria for the project are met and to take into account any new information on land use and flooding within the broader catchment that may be available at that time.

The modelling will be carried out by a suitably qualified and experienced person and will consider potential flood impacts during both construction and operation of the project.

The detailed design flood investigations will involve:

- Updates to the catchment-wide hydrologic model based on all available information including known planned development within the catchment and any large-scale detention basins
- Consideration of any potential refinements to the design of the project, including potential changes to bridge lengths and heights
- Investigation of additional measures (if required) to minimise predicted flood impacts
- Design of scour protection where required along the project including at waterway bridges (piers and abutments), catch drains (open channels) and culvert outlets.

Where further flood modelling shows the project could result in an adverse flooding impact, Roads and Maritime will consult with landowners to implement appropriate mitigation measures.

Prior to construction, the project Construction Environmental Management Plan shall be developed and will include a flood management plan that details the processes for flood preparedness, materials management, weather monitoring, site management and flood incident management. The flood management plan would reference and be developed in accordance with relevant industry guidelines.

Management measures would be implemented during the construction and operational phases of the project to minimise the potential for flooding and drainage impacts. These environmental management measures are identified in **Table 9-1**. These measures should be read in conjunction with those outlined in Appendix M of the EIS and Chapter 9 of the EIS.

Table 9-1 Environment management measures (flooding)

Impact	Reference	Environmental management measure	Responsibility	Timing
Potential changes to flood impacts resulting from detailed design	F01	Further flood investigations and hydrological and hydraulic modelling will be undertaken during detailed design to ensure the flood immunity objectives and design criteria for the project are met. The modelling will be used to define the nature of both main stream flooding and major overland flow along the full length of the project corridor under pre- and post- project conditions and to define the full extent of any impact that the project will have on patterns of both main stream flooding and major overland flow. The hydraulic model(s) will be based on two-dimensional hydraulic modelling software. The modelling will take into account any updated regional flood modelling and information available at the time.	Contractor	Detailed design
Flooding impacts	F02	Should the updated flood modelling show the project will result in an adverse flooding impact, Road and Maritime will consult with landowners regarding appropriate mitigation measures to be implemented by the contractor in relation to each individual property.	Roads and Maritime /Contractor	Detailed design

Impact	Reference	Environmental management measure	Responsibility	Timing
Flooding impacts during construction	F03	A flood management plan will be prepared as part of the CEMP for the project and will detail the processes for flood preparedness, materials management, weather monitoring, site management and flood incident management. The flood management plan will be developed in accordance with: • Managing Urban Stormwater, Soils and Construction, Volume 1 4th Edition, March 2004 (Landcom 2004) and Managing Urban Stormwater, Volume 2D – Main Road Construction (DECC 2008) • Roads and Maritime Erosion and Sedimentation Management Procedure (Roads and Traffic Authority 2009) • Roads and Maritime Technical Guideline: Temporary Stormwater Drainage for Road Construction (Roads and Maritime 2011a) • Roads and Maritime Stockpile Management Guideline (Roads and Maritime 2011b).	Contractor	Prior to construction
Flooding and creek adjustment impacts	F04	Creek adjustments would be re-considered and/or further refined to minimise the impact to the creeks during detailed design.	Roads and Maritime /Contractor	Detailed design
Flooding impacts of bridges and culverts	F05	Detailed construction staging plans will be developed during detailed design so that bridges and culverts are constructed in a way that minimises flood risk.	Contractor	Detailed design
	F06	Measures to address potential impacts of culvert blockage on afflux will be further investigated during detailed design and may include the installation of debris deflectors, trash racks or similar on drainage inlets where reasonable and feasible.	Roads and Maritime /Contractor	Detailed design
Impacts on existing drainage systems	F07	Activities that may affect existing drainage systems during construction will be carried out so that existing hydraulic capacity of these systems is maintained where practicable.	Contractor	During construction
Flooding impacts during operation	F08	The proposed bridges, culverts and changes to watercourses will be further refined during the detailed design to minimise potential flooding impacts.	Roads and Maritime /Contractor	Detailed design

10. Conclusion

The project traverses four significant floodplains (Cosgroves, Badgerys, South and Kemps Creeks), a minor waterway next to Luddenham Road, as well as numerous minor drainage lines with culverts.

The project would construct bridges across the four main floodplains, with culverts used to convey the external catchment flows across the motorway in a controlled way that minimises the flooding risks to the infrastructure and the surrounding community.

An assessment of the potential flood impacts associated with the project was carried out to determine if the project would increase flooding levels and result in adverse flood impacts.

The following points summarise the outcome of the assessment:

- The project can achieve the 100 year ARI minimum flood immunity requirement for new infrastructure
- The waterway bridges are influenced by road geometry considerations, which would ensure limited encroachment into the floodplains and minimal change to 100 year ARI flooding levels
- Areas of predicted afflux would be localised, and not lead to adverse flooding impacts outside of the project operational footprint
- Flood hazard in the vicinity of the project would not change. The provision of a wide bridge at Luddenham Road would allow for future upgrades that would improve flood hazard at that location
- Potential increased flood risks for pedestrian and cyclists has been avoided through the design and construction of the shared user path at main carriageway level across the major creeks
- Current land-use will not be impacted due to flood-related impacts of the project and no social or economic costs associated with flooding impacts of the project
- Flood evacuation routes in the vicinity of the project would generally improve due to the introduction of a flood-free link in the transport network
- Construction flood impacts would be similar to the operational impacts, ie would be minor and localised. This is because the height and width of earthworks (fill) within the floodplains is not expected to be any larger than during the embankments that would be present during operation. Additionally, ancillary facilities are proposed to be located outside of the floodplains and temporary creek crossings would be constructed so that their impact on flood conditions would be minimised
- The current design would accommodate some increases in peak flows from development in the surrounding catchments. However, further investigation and flood modelling is required during detailed design to ensure the flood immunity objectives and design criteria for the project are met and to take into account any new information on land use and flooding within the broader catchment that may be available at that time
- The proposed hydraulic structures and changes to watercourses would be further investigated and refined during the detailed design to confirm that the potential flooding impacts are minimised.

11. References

Austroads (2009). Guide to Bridge Technology Part 4: Design Procurement and Concept Design, Austroads Inc. June 2009

DECC (2007). Practical Consideration of Climate Change, NSW Department of Environment and Climate Change. October 2007

Department of Environmental and Climate Change. NSW Government's Floodplain Risk Management Guideline: Practical Considerations of Climate Change. Prepared by DECC, 2007

Department of Planning. NSW Government's Sea Level Rise Policy Statement (NSW Government, 2009)

DIPNR (2005). Floodplain Development Manual – The management of flood liable land, NSW Department of Infrastructure, Planning and Natural Resources. April 2005

DIRD (2016). Western Sydney Airport Environmental Impact Statement, Department of Infrastructure and Regional Development, Commonwealth of Australia. September 2016

Fairfield City Council (2013). Rural Area Flood Study. Prepared by BMT WBM, November 2013

Institute of Engineers Australia (1987). Australian Rainfall and Runoff – A Guide to Flood Estimation, Reprinted Edition 1998. Institute of Engineers Australia 1998. (Note: the data and methods in this edition are based on the 1987 edition)

Institute of Engineers Australia (2016). Australian Rainfall and Runoff – A Guide to Flood Estimation. Institute of Engineers Australia 2016. (Note: the data and methods in this edition are based on the 2016 edition)

Landcom (2004). Managing Urban Stormwater – Soils and Construction, Landcom. Fourth Edition, March 2004

Liverpool City Council (2003). Austral Floodplain Risk Management Study and Plan. Review and Finalisation. Prepared by Perrens Consultants. September 2003

Office of Environment and Heritage, NSW Floodplain Development Manual (Department of Infrastructure Planning and Natural Resources, 2005)

WorleyParsons (2015). Updated South Creek Flood Study, Issue No. 4 – Final Report, 30 January 2015