7. Assessment of key issues

7.8 Flooding

This section provides a summary of the potential flooding impacts that may be generated by construction and operation of the project and presents a proposed approach to the management of these impacts. **Table 7-125** outlines the SEARs that relate to flooding and identifies where they were addressed in this EIS. The full assessment of flooding impacts is provided in **Appendix L**.

Table 7-125 SEARs (flooding)

Secretary's requirement	Where addressed in this EIS
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;	**Section 7.8.4** addresses the project's likely impacts on flooding during construction and operation
b. consistency (or inconsistency) with applicable Council floodplain risk management plans and rural floodplain management plans;	**Section 7.8.1** addresses all relevant local guidelines and floodplain management plans,
c. compatibility with the flood hazard of the land;	**Section 7.8.4** addresses compatibility with flood hazards
d. compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	**Section 7.8.4** addresses compatibility with hydraulic functions
e. adverse effects to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the project;	**Section 7.8.4** addresses beneficial inundation of the floodplain environment
f. downstream velocity and scour potential;	**Section 7.8.4** addresses downstream velocity and scour potential
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	Consultation with the NSW SES and Council is discussed in **Section 7.8.2** Impacts on emergency management arrangements are discussed in **Section 7.8.4**
h. any impacts the development may have on the social and economic costs to the community as consequence of flooding.	Social and economic costs are discussed in **Section 7.8.4**

7.8.1Policy and planning setting

Guidelines

The main guidelines, specifications and policy documents that are relevant to the project include:

- Floodplain Development Manual (OEH, 2005)
- Floodplain Risk Management Guidelines
- Australian Rainfall and Runoff (Institution of Engineers, Australia, 1987)
- Austroads Guide to Bridge Technology Part 4 (Austroads, 2018)
- Roads and Maritime Specification D&C G36 – Environmental Protection (Management System) (G36) (Roads and Maritime, 2017d)
- 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, 2007c)
- Penrith City Council LGA, South Creek Floodplain Risk Management Study and Plan (pending availability)
- Liverpool City Council LGA, Austral Floodplain Risk Management Study & Plan (Liverpool City Council, 2003)
- Fairfield City Council LGA, Rural Area Flood Study (BMT WBM, 2013) pending completion and approval.

Floodplain management plans

The project is mostly located within the Penrith LGA. At the time of writing of the flooding assessment, there were no council floodplain risk management plans or rural floodplain management plans for the Penrith area.

As of May 2019, a consultant was appointed to prepare the South Creek Floodplain Risk Management Study and Plan (Penrith City Council, 2016). Should this become available prior to future project planning stages, it would be considered along with other relevant floodplain management plans.

Part of the project lies within the Liverpool LGA and is covered by the Austral Floodplain Risk Management Study & Plan 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 such as minor culverts, however these are not at a scale that need to be considered in the context of a floodplain risk management plan, as the flood modelling results presented in this section were used to guide the sizing of culverts.

The design of any structure that performs a water conveyance function (whether or not this is the primary purpose), including bridges and culverts, will be subject to further analysis and refinement during the project's detailed design stage.

The easternmost part of the project is located within the Fairfield LGA, within an upper area of the Ropes Creek catchment. This area was the subject of the Rural Area Flood Study (BMT WBM, 2013). The associated floodplain management plan is yet to be completed and approved. The motorway elements within the Fairfield LGA are not located in a main-watercourse flooding zone and the minor cross drainage features of the project in this location are not at a scale that need to be considered in the context of a floodplain risk management plan.

As a result, the project is considered to be consistent with and does not impact the existing local floodplain risk management plans. This would be reviewed further during detailed design, with particular reference to the South Creek Floodplain Risk Management Study and Plan currently being prepared by Penrith City Council.

7.8.2 Assessment methodology

Overview

The project would traverse four significant waterways, requiring bridges over (Cosgroves, Badgerys, South and Kemps Creeks). A minor waterway next to Luddenham Road would also be bridged as well as numerous minor drainage lines. Potential flood impacts were assessed by advanced computer modelling of flood conditions at these significant waterways 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 probable maximum flood (PMF) storm events were modelled as part of this flood assessment for both the existing and proposed conditions. A climate change scenario has also been assessed, which looks at the effects of increased intensity of the 100 year ARI rainfall events, and rises in sea level over time (see *Future climate change* section below). Inputs to the model included proposed road embankments, bridge abutments, piers and decks. Culverts were designed separately to the flood modelling process but referenced the flood modelling results to guide flow and water level inputs.

The project also traverses Ropes Creek near the tie-in to the existing M7 Motorway. While the hydrology of Ropes Creek was assessed, flooding impacts were not modelled at Ropes Creek as the design of the bridge at this location was developed to match the existing bridge (including bridge type, spans, piers and vertical alignment).

As part of the design process, the existing M7 Motorway bridges were investigated to understand their form and function, including their hydraulic and hydrologic performance. The existing bridges while spanning Ropes Creek, are not primarily waterway bridges. Their span width and vertical clearance are governed by road design requirements (clearance above Villiers Road and the adjacent property access road). Hence the bridge decks are above the 2000 year ARI flood level, and the total opening and flood conveyance beneath the bridges provides capacity in excess of the 100 year ARI flood immunity requirement.

Further, the flooding conditions and hydraulics in the area surrounding the M7 Motorway bridges are controlled by the Wallgrove Road embankment and the existing culvert crossing under Wallgrove Road. The proposed bridge widening would maintain the same span widths and therefore total opening for flood conveyance would be the same. Based on this investigation, flooding impacts at this location are not expected. Accordingly, 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.

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 the following:

- Cosgroves Creek
- Badgerys Creek
- South Creek
- Kemps Creek
- 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 were designed separately to the flood modelling process.

Desktop assessment

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 has calculated the rates of flow in the waterways. These flows change over time, generally building up to a peak 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 was completed for both existing conditions (no motorway) and proposed conditions with the project embankments and bridges included. The flood modelling results of these two conditions were compared, with the changes in flooding behaviour seen constituting the predicted flooding impact that the motorway may produce.

Hydrological modelling

The hydrological modelling for the project was 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 used in the assessment, 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 section and **Appendix L**. The results of the hydrological modelling related to more localised hydrological changes within the major creeks and other drainage lines are discussed in **Section 7.9** and **Appendix M**.

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.

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 hydrodynamic nature of TUFLOW modelling accounted for likely flood storage effects as well as runoff routing within the modelled area. For the purposes of modelling, all terrain sinks and farm dams were assumed 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 operational footprint unimpeded by introducing only the earthworks fill areas near the major waterways.

Spill-through bridge abutments, bridge piers, bridge decks were included in the model, as well as the localised adjustments of Badgerys, South and Kemps Creeks were included in the model.

Criteria

Flooding and drainage design criteria

Flooding and drainage design criteria for the project include minimum requirements for flood capacity, creek adjustments, transverse drainage design, blockage and climate change. The requirements are outlined in detail in **Appendix L** and were adopted based on Roads and Maritime and/or industry standard practice, Austroads guidelines, Practical Consideration of Climate Change (DECC, 2007c) and project specific requirements where relevant.

Flood immunity objectives

The flood immunity objective for the project is to provide 100 year 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 (DIPNR, 2005).

Flood impact objectives

The flood impact objective is to minimise adverse flooding impact on 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 operational footprint, by not creating a flooding environment that restricts requisite design options or increases flood risk.

The flood impact objectives for the project are presented in **Table 7-126**.

Table 7-126 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 millimetre increase for the 20 and 100 year ARI flood events. Justification: This objective is consistent with other Roads and Maritime projects.	Less than 100 millimetre increase for the 20 and 100 year ARI events. Justification: An additional 100 millimetre of flood water is unlikely to cause damage or substantially increase the duration of time that recreation areas are unable to be used.	Generally less than 250 millimetre increase with localised increases of up to 400 millimetre 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 (OEH, 2005)		

Future climate change

An assessment of the project's potential future flood impacts under a climate change scenario was based on: 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, 2007c)
- Rises in sea level of 0.4 metres by 2050 and 0.9 metres by 2100 in accordance with the NSW Government's Sea Level Rise Policy Statement (DoP, 2009). 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 a theoretical 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 was 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.

Consultation

Consultation carried out in relation to potential flood impacts and emergency management arrangements for flooding is detailed in Section 4 of **Appendix L**. In summary, consultation was carried out with the following:

- Penrith City Council
- Liverpool City Council
- Fairfield City Council
- NSW SES.

Consultation with Penrith, Liverpool and Fairfield councils during preparation of the flooding assessment focused on floodplain management strategies and initiatives either in place or in preparation, including:

- The South Creek Floodplain Risk Management Study and Plan (Penrith City Council)
- Austral Floodplain Risk Management Study and Plan (Liverpool City Council)
- Rural Area Flood Study (Fairfield City Council).

Council feedback during consultation was that the project should not increase flooding in the local catchment, worse than the existing conditions.

During consultation, the NSW SES were briefed and provided with the project design and flood modelling. No issues were raised during the briefing and no feedback was received on the project design. The project is not proposed to be a designated evacuation route and is above the 1 in 100 flood zone.

Consultation would continue during the project’s future design stages and would include direct consultations with affected landowners during detailed design and construction.

Further details of consultation with stakeholders is documented in **Chapter 6**.

7.8.3 Existing environment

Catchment

The project is located primarily within the South Creek sub-catchment of the Hawkesbury-Nepean catchment, within the Lower Nepean River Management Zone. Within the South Creek catchment, the project intersects Cosgroves Creek, Badgerys Creek, Kemps Creek, South Creek and Ropes Creek. These creeks generally flow to the north, into South Creek which then flow north to join the Hawkesbury River at Windsor.

The South Creek catchment was extensively modified and disturbed due to increasing urbanisation and associated land clearing for agriculture and rural land uses. 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 derived from Wianamatta Group Shales (see **Section 8.1.3**) 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 mostly agricultural farm land.

A small portion of the project drains to Hinchinbrook Creek (part of the Georges River catchment) however this area is not relevant to the flooding assessment as the M12 Motorway would not cross Hinchinbrook Creek and would not influence flooding in that catchment.

Topography

The topography of the study area may be characterised into three general terrain types: Rolling Hills Terrain; Flat to Gently Undulating Terrain; and Creek Channels/Alluvial Floodplain Terrain, with slopes ranging from 0 to 20 degrees.

Further information on the topography is provided in **Section 8.1**. 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.

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 (see **Section 8.2.3**) (BOM, 2018b).

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, 2018b).

Flooding

Flood modelling was carried out to assess the existing flood conditions during stormwater events.

Table 7-127 identifies the existing flood impacts (ie without the project) during a 100-year flood event at the key flooding locations. Peak water levels and depths for each of these locations during the 100-year ARI flood are shown in **Figure 7-115** to **Figure 7-119**.

Table 7-127 Existing flood conditions key locations along the M12 Motorway during the 100-year ARI flood event

Catchment	Flood conditions during the 100 year ARI flood event
Luddenham Road valley	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 about 90 metres wide.
Cosgroves Creek	Cosgroves Creek has a peak 100 year ARI runoff of 80 cubic metres per second along a flow-path about 120 metres wide.

Catchment	Flood conditions during the 100 year ARI flood event
Badgerys Creek	Badgerys Creek has a peak 100 year ARI runoff of 130 cubic metres per second along a flow-path about 170 metres wide. The project crosses this floodplain at a substantial angle. The effective floodplain is about 300 metres wide as it crosses the operational footprint.
South Creek	South Creek has a peak 100 year ARI runoff of 490 cubic metres per second along a flow-path about 500 metres wide. The low-flow channel of the creek crosses under the operational footprint at an angle and runs virtually parallel for several hundred metres. During a 100 year ARI flood the creek fills the wider floodplain and flows almost perpendicular to the project.
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 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 variable, ranging from about 170 metres to about 310 metres across, or wider if the secondary flow-path inside the oval is considered.

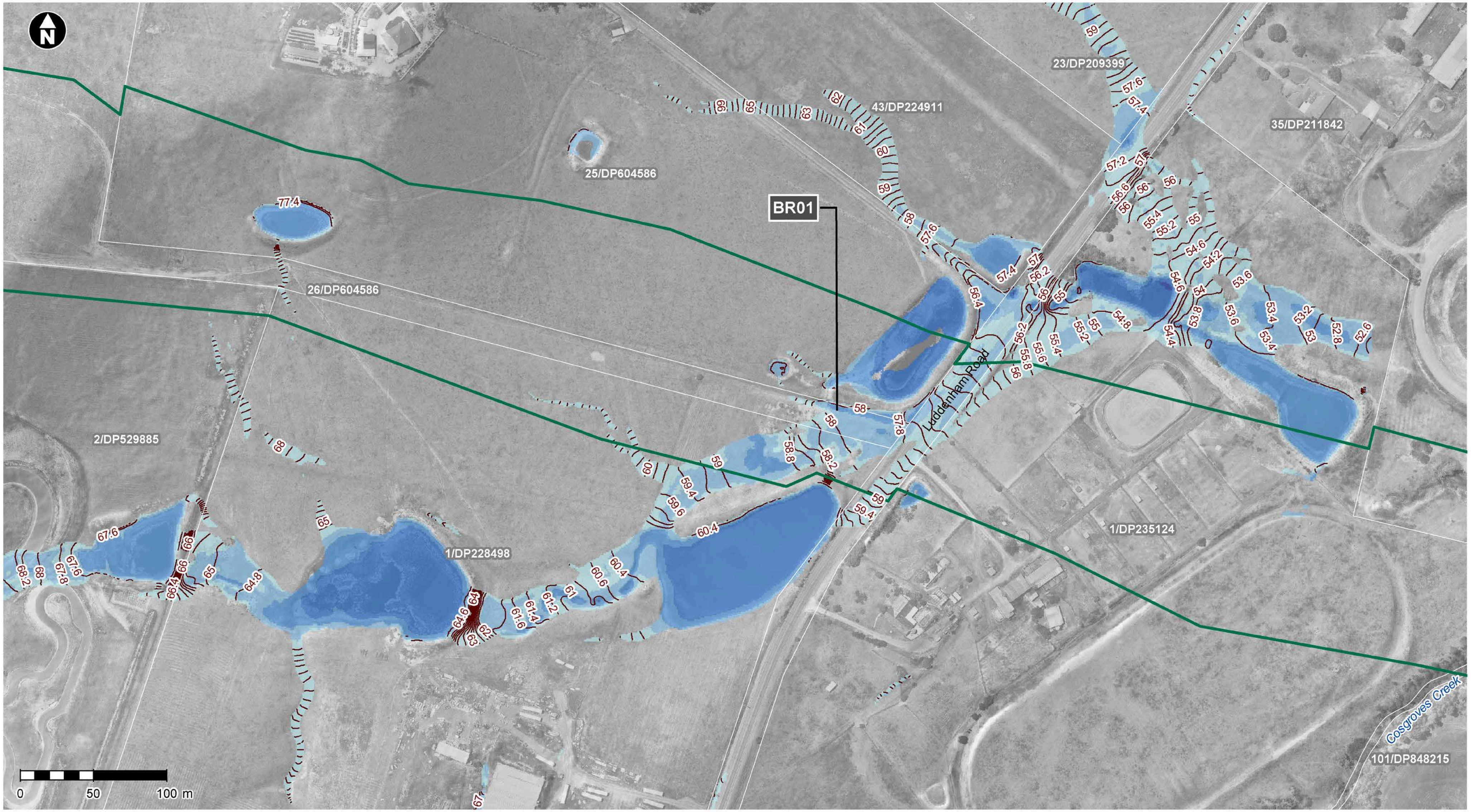
7.8.4 Assessment of potential impacts

Construction impacts

Construction activities have the potential to affect flood conditions as follows:

- 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 M12 Motorway design assumes there will be no preloading of the motorway embankment. This means that the worst case construction scenario is when the final form of the embankment is complete.
- 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 on the overall flooding conditions in the floodplains is expected. See Annexure A flood maps of **Appendix L** which include ancillary facility locations AF1 to AF9 in relation to 100 year ARI flood levels.
- 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 two banks of the creeks. Temporary crossings are low lying causeways, consisting of a low-level trafficable weir with culverts conveying low flows. The temporary crossings remain dry during normal creek flow conditions when the water is low, but 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.

The flooding assessment presented in **Appendix L** determined that the potential flooding impacts of the construction of the project would be commensurate with the operational assessment presented below.



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

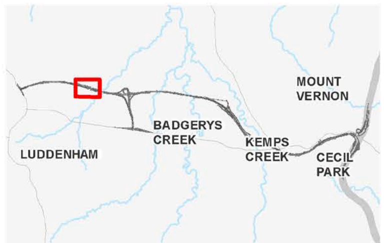


Figure 7-115 Existing conditions during 100 year ARI flood event – Luddenham Road

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI\JAJV_FLD_All_100pc_F001_100yrARI1ExFloodLDepth_DDP_A4L_r1v1.mxd
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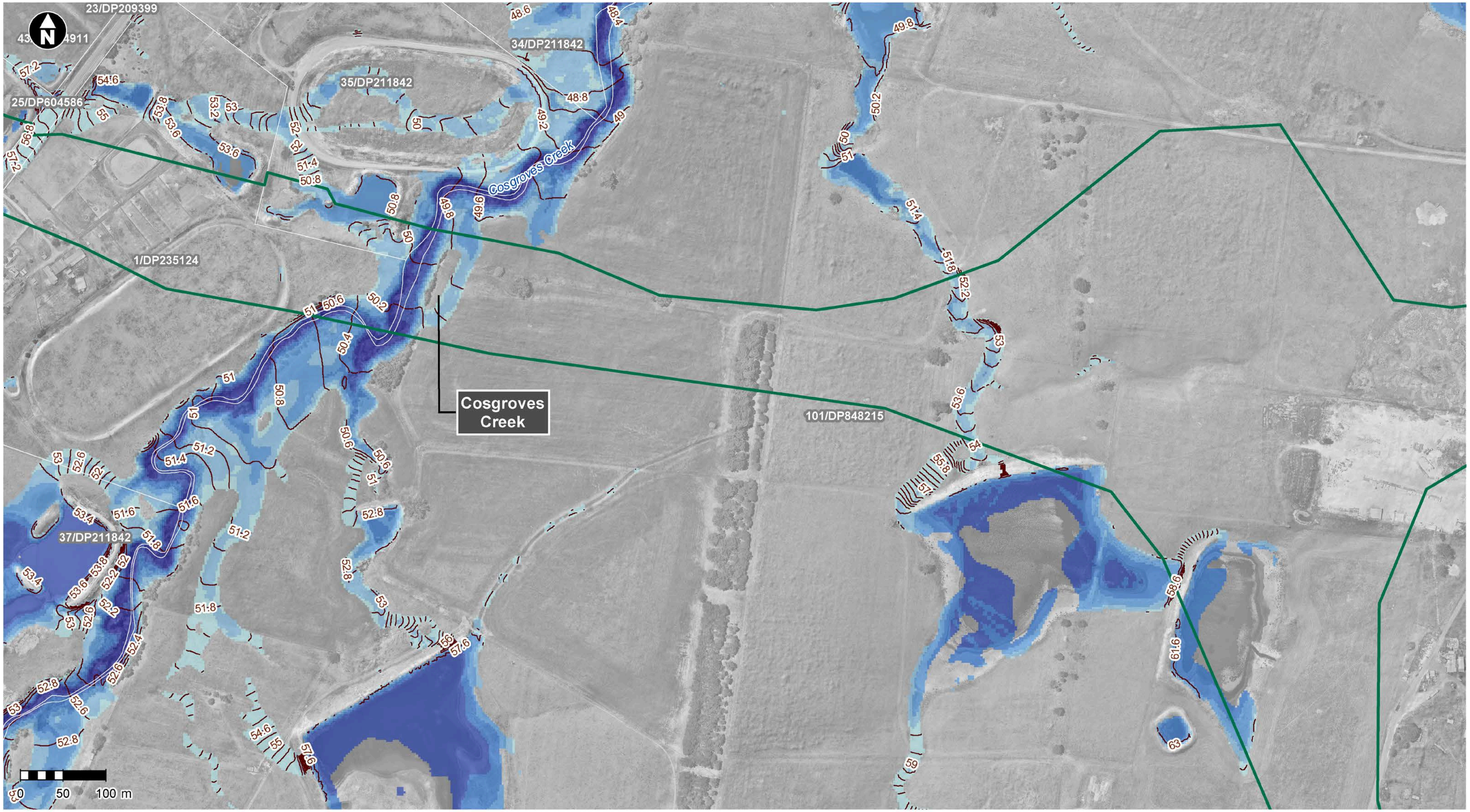

Legend

- 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

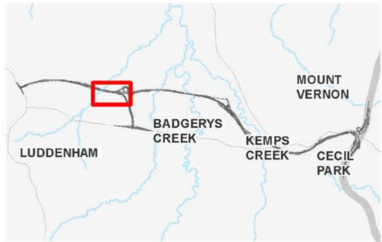

Figure 7-116 Existing conditions during 100 year ARI flood event – Cosgroves Creek

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesign\ARI\JAJV_FLD_All_100pc_F001_100yrARI1ExFloodLDepth_DDP_A4L_r1v1.mxd
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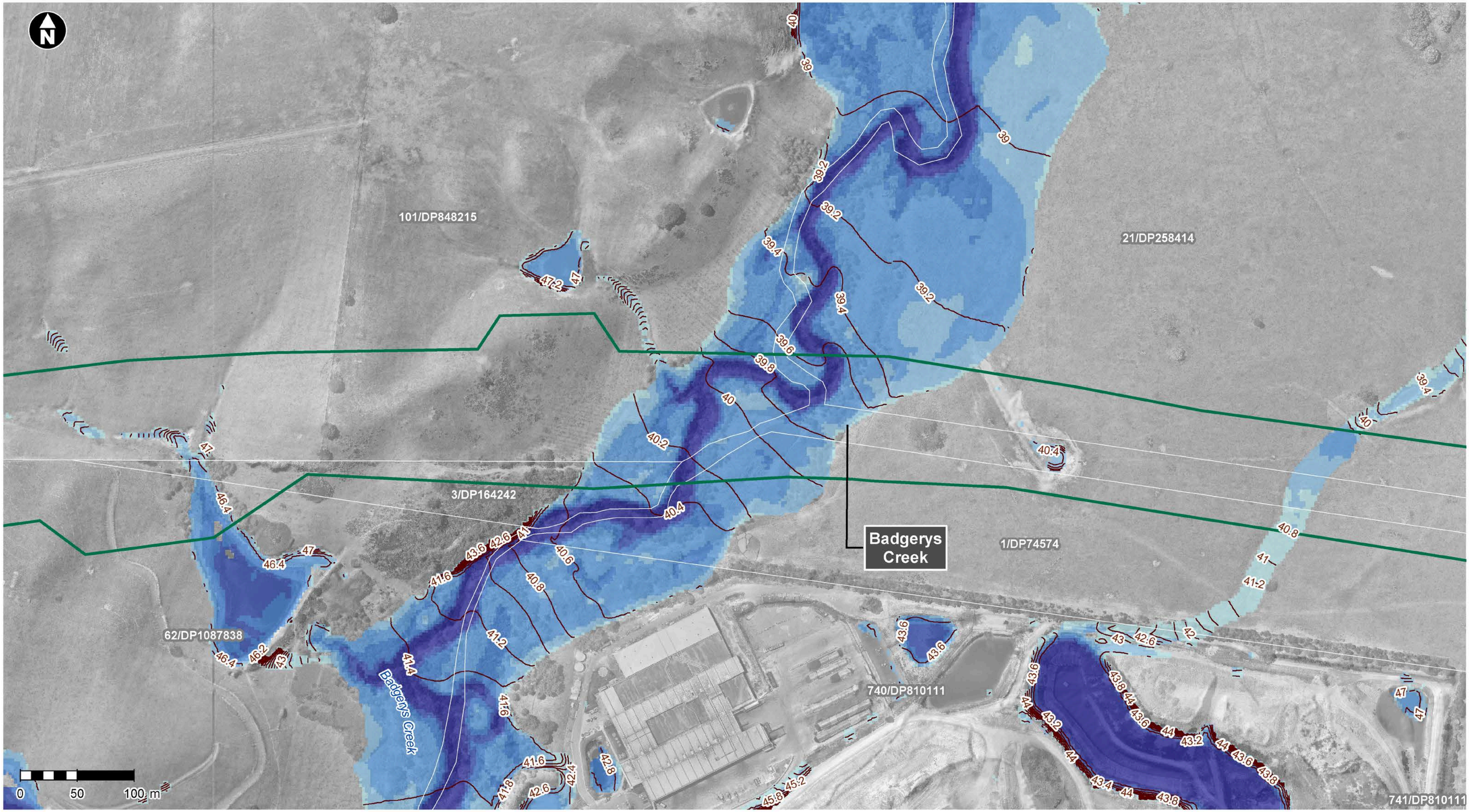


Legend

0.2m Flood Height Contour (m AHD)

Cadastre

The project operational footprint

Flood Depth (m)

< 0.2

0.2 - 0.5

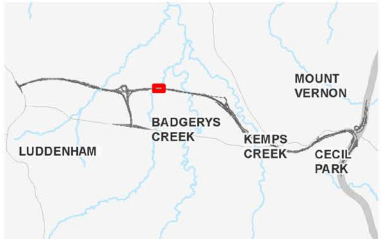
0.5 - 1.0

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 7-117 Existing conditions during 100 year ARI flood event – Badgerys 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

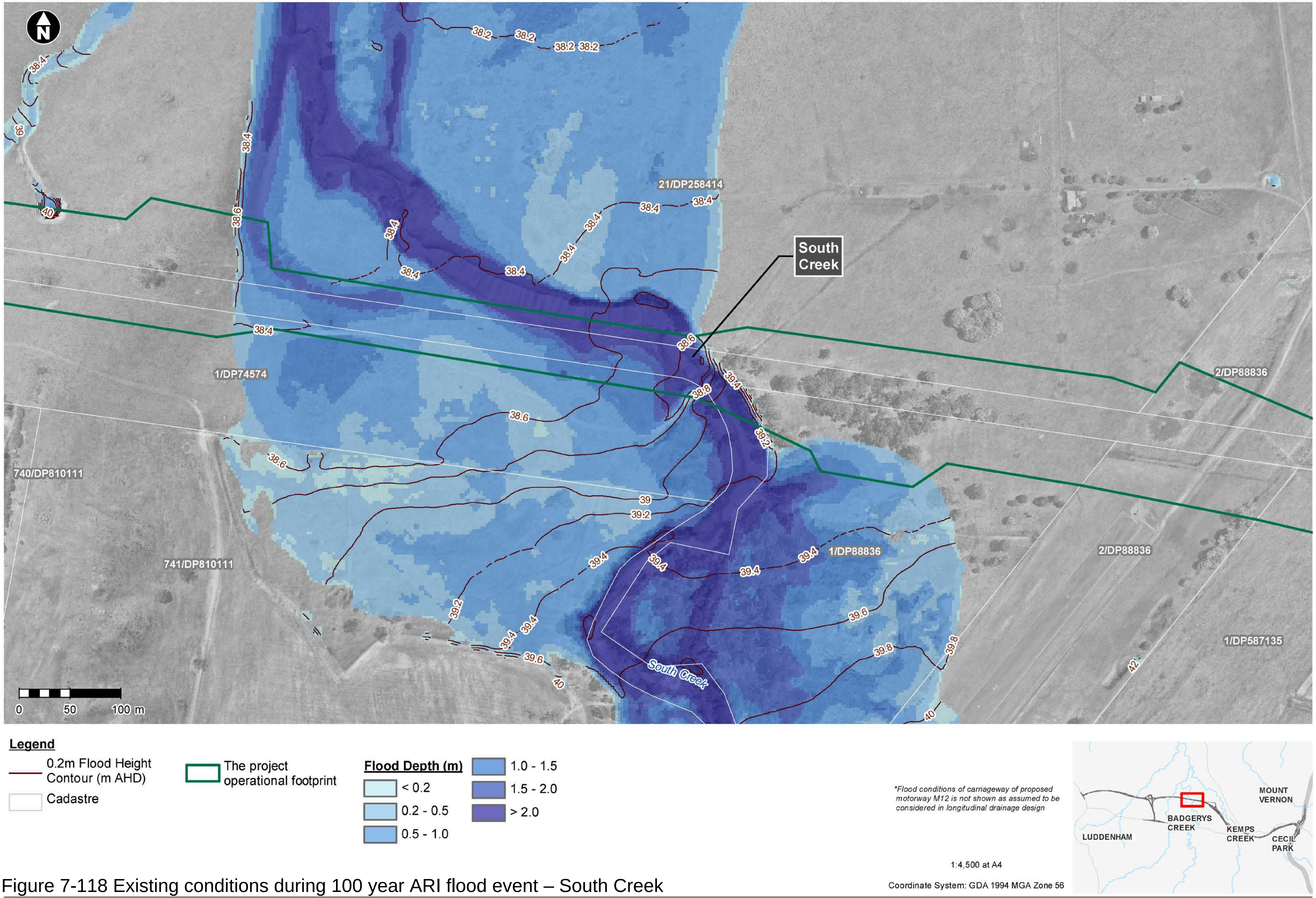
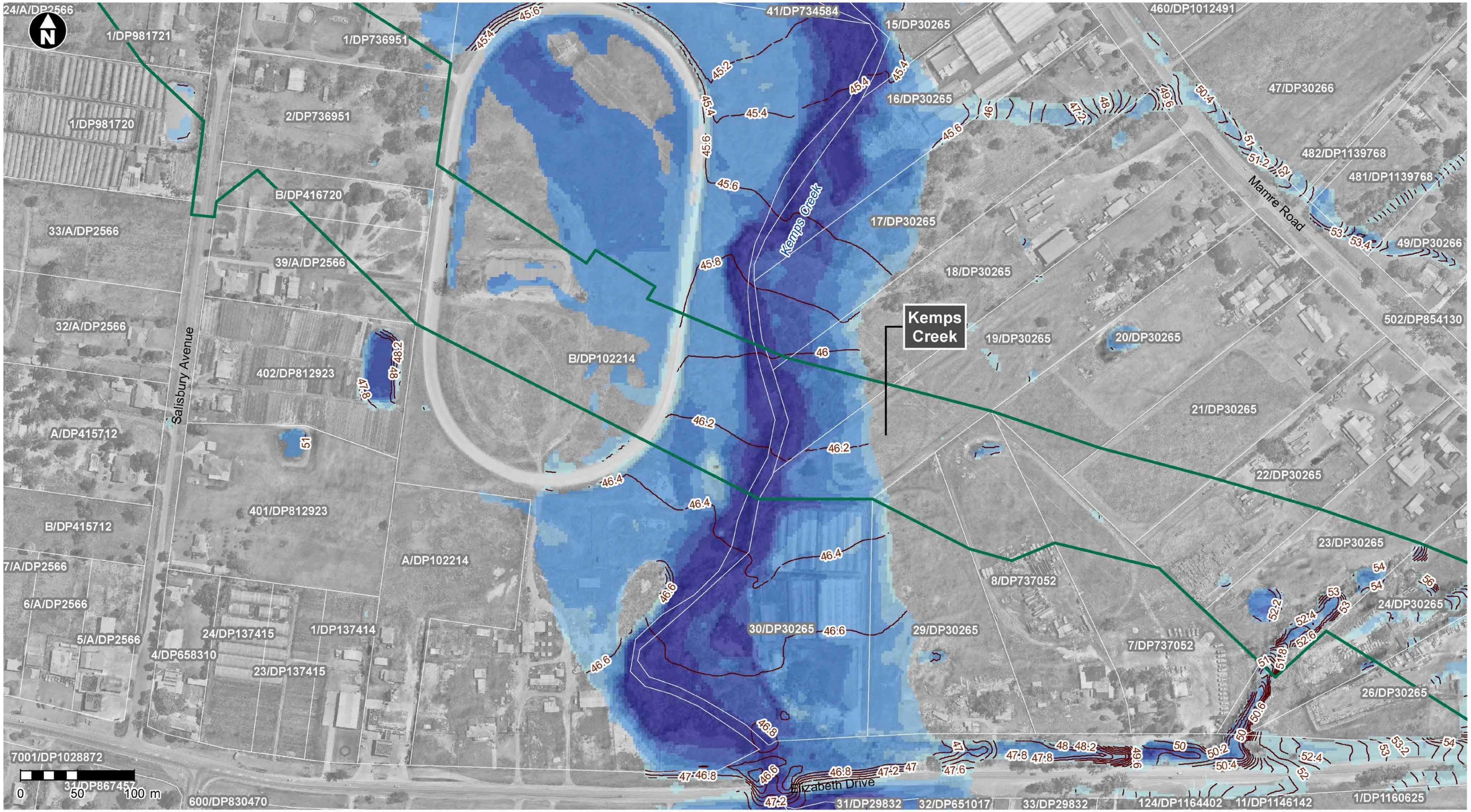


Figure 7-118 Existing conditions during 100 year ARI flood event – South Creek

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

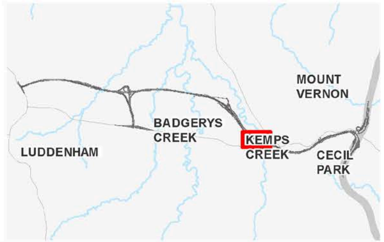


Figure 7-119 Existing conditions during 100 year ARI flood event – Kemps Creek

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesignARI\JAJV_FLD_All_100pc_F001_100yrARI1ExFloodLDepth_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB

Operational impacts

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 section and shown in **Figure 7-120** to **Figure 7-124.**

Changes to flood impacts under the full range of ARI conditions modelled are provided in Annexure A of **Appendix L**. These maps show the afflux conditions in relation to the proposed road design, operational footprint, bridge outlines and property boundaries. Predicted afflux associated with the project at these locations is described in **Table 7-128**.

Flood modelling results show that there would be no impact on buildings currently present in the area surrounding the project. Changes to the inundation durations are predicted to be minimal under flood events up to and including the 100 year ARI and are likely to increase inundation time by less than the maximum allowable increase (ie one hour in a 100 year ARI event). The proposed bridge openings would be wide enough to avoid holding water upstream of the motorway.

Outside of the operational footprint, the flood modelling results show that for the 100 year ARI event, the project would result in very minor changes to existing flood levels, as illustrated on the flood maps in **Figure 7-120** to **Figure 7-124**, and described in **Table 7-128**. Further, comparison of these results with the existing 100 year ARI flood conditions shown in **Figure 7-115** to **Figure 7-119** show that the flooding extents outside of the project's operational footprint would not change as a result of the project.

The modelling showed some minor, localised increases in afflux, while at some locations the project would result in very small reductions in afflux. However, all of the modelled increases are within the existing flooding footprint. The flood maps referred to above show the maximum increases in afflux to be mostly concentrated around bridge abutments, within the existing flood footprint, with the maximum increase for the 100 year ARI event being around 100 millimetres (over existing).

For all of the storm events modelled (see Annexure A of **Appendix L**), the results showed that use of the land surrounding the main creeks would be unaffected by the project with respect to flooding.

Potential changes to the surrounding catchment hydrology resulting from future urban development or land use changes may lead to an increase in flooding. While future developments and land use changes cannot be quantified, an increase in flow due to other developments may result in the predicted impact of the M12 Motorway being larger than expected. Bridges have therefore been designed with capacity to convey higher flows, in the knowledge that hydrology of the surrounding catchments is likely to change as surrounding land uses change and urban development intensifies.

Bridge designs would be refined in detailed design, and further modelling carried out to confirm flooding impacts and the minimum flood immunity objective of 1 in 100 year ARI would continue to apply.

Land use impact

Outside of the project's 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. As shown in the maps in **Figure 7-120** to **Figure 7-124**, the project is not predicted to result in any additional flood impact outside of the existing flooding footprint. Therefore the use of the land surrounding the main creeks would be unaffected by the project with respect to flooding.

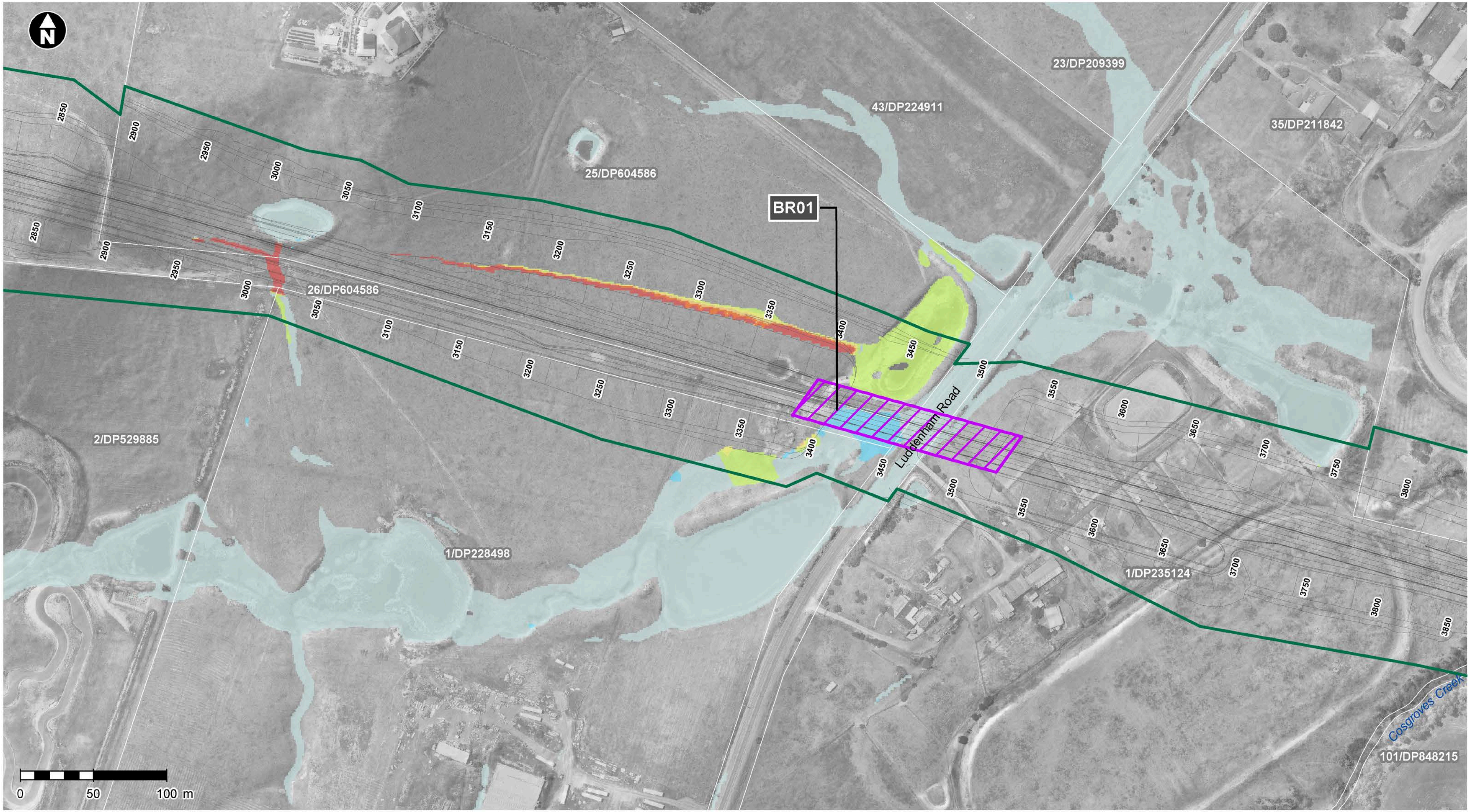
Impacts on buildings and inundation durations

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

Table 7-128 Predicted afflux at key locations for 100 year ARI rain event

Bridge/ Waterway	Maximum afflux change (millimetres) at operational boundary	Impact
Luddenham Road BR01	Upstream: 31 Downstream: 27	Adjacent to the western abutment, some existing localised ponding would increase in depth as shown in **Figure 7-120**. This is associated with a local minor drainage line and two existing farm dams. Outside of this location, the project would have little or no impact on existing afflux levels. 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.
Cosgroves Creek BR02	Upstream: 5 Downstream: 0	The project would have a very minor impact on flood levels at Cosgroves Creek, as shown in **Figure 7-121**. There would be a small, localised flow concentration next to the eastern abutment during the 100 year ARI event, however this would be contained wholly within the operational footprint.
Badgerys Creek BR05	Upstream: 17 Downstream: 35	The project would involve a minor, localised adjustment to the low-flow channel of Badgerys Creek to reduce the risk of erosion around bridge piers. The flood impact assessment included consideration of the creek adjustment. As shown in **Figure 7-122**, during the 100 year ARI event, the project would result in a localised impact directly adjacent to the adjusted creek channel, which would be mostly contained within the operational footprint.
South Creek BR06	Upstream: 93 Downstream: 143	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 removal of an existing (private property) bridge at the location of the proposed bridge. The overall impact is a localised increase in afflux during the 100 year ARI event, directly adjacent to the adjusted creek channel beneath the bridge, as shown in **Figure 7-123**. As shown in the figure, the modelling also indicates that peak afflux would be reduced over a small area of the creek's floodplain upstream and downstream of the bridge. This would occur as a result of the creek adjustment removing some existing local flow constrictions. The design of the creek adjustment would be further developed at detailed design.
Kemps Creek BR08	Upstream: 1 Downstream: 12	The project would involve a minor and localised adjustment to Kemps Creek to reduce the risk of erosion around bridge piers. The flood impact assessment included consideration of the creek adjustment, which would have a localised impact directly adjacent to the adjusted creek channel during the 100 year ARI event. The impact would be contained within the operational footprint as shown in **Figure 7-124**.

Changes to the inundation durations are predicted to be minimal under flood events up to and including the 100 year ARI and are likely to increase inundation time by less than the maximum allowable increase (one hour in a 100 year ARI event). The proposed bridge openings would be wide enough to avoid holding water upstream of the M12 Motorway, which would be the reason for increased duration of inundation upstream. As a result, the flood impact objective listed in **Table 7-126** for inundation duration is achieved for the project.



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

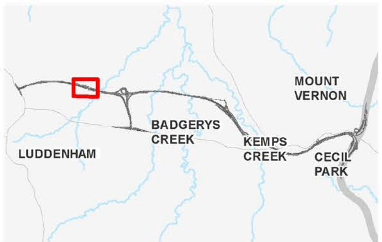
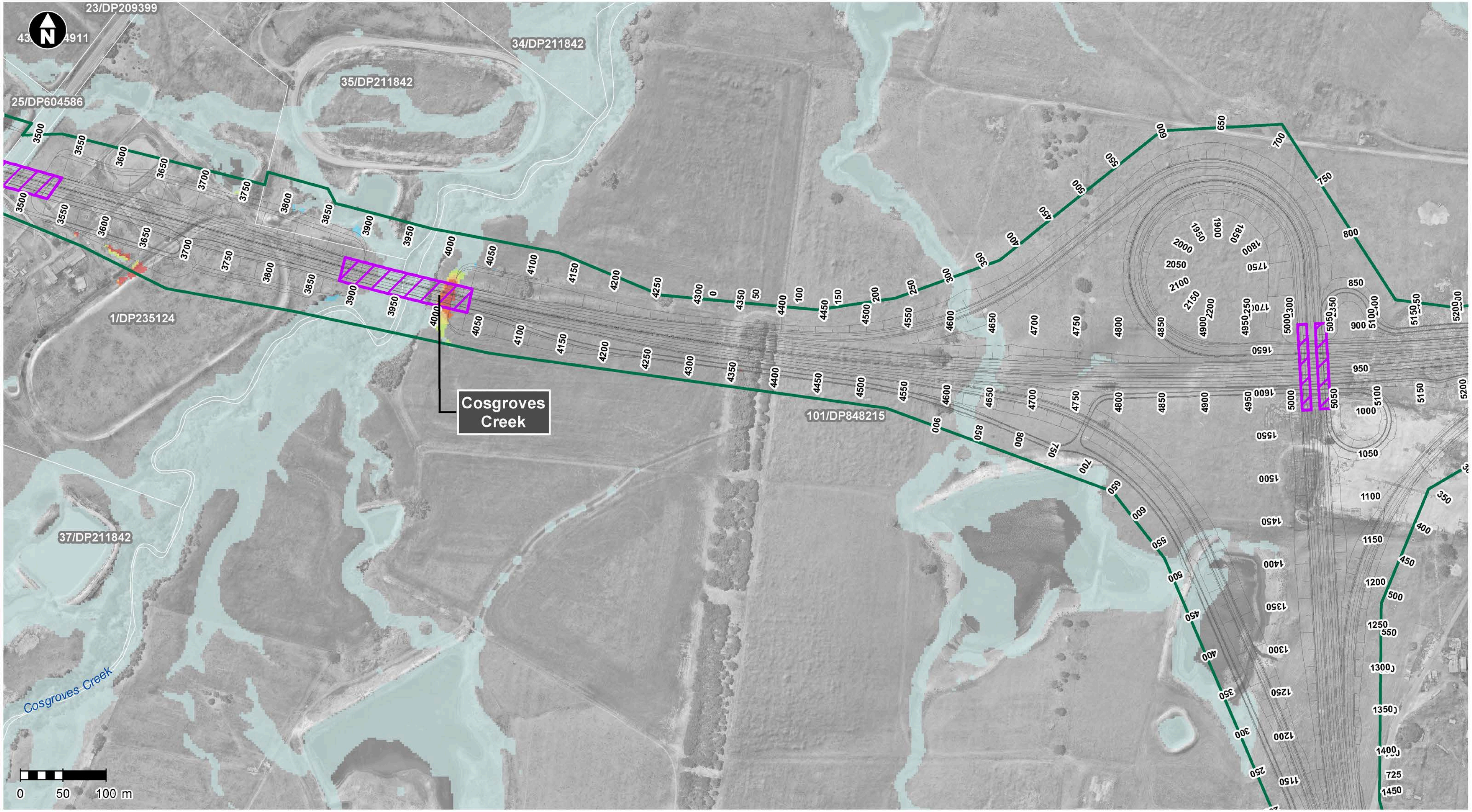


Figure 7-120 Luddenham Road 100 year afflux

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



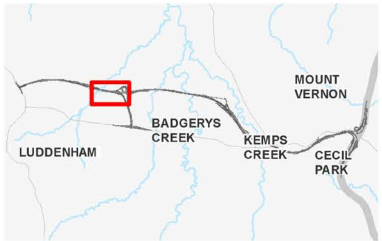
Legend

- 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 7-121 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

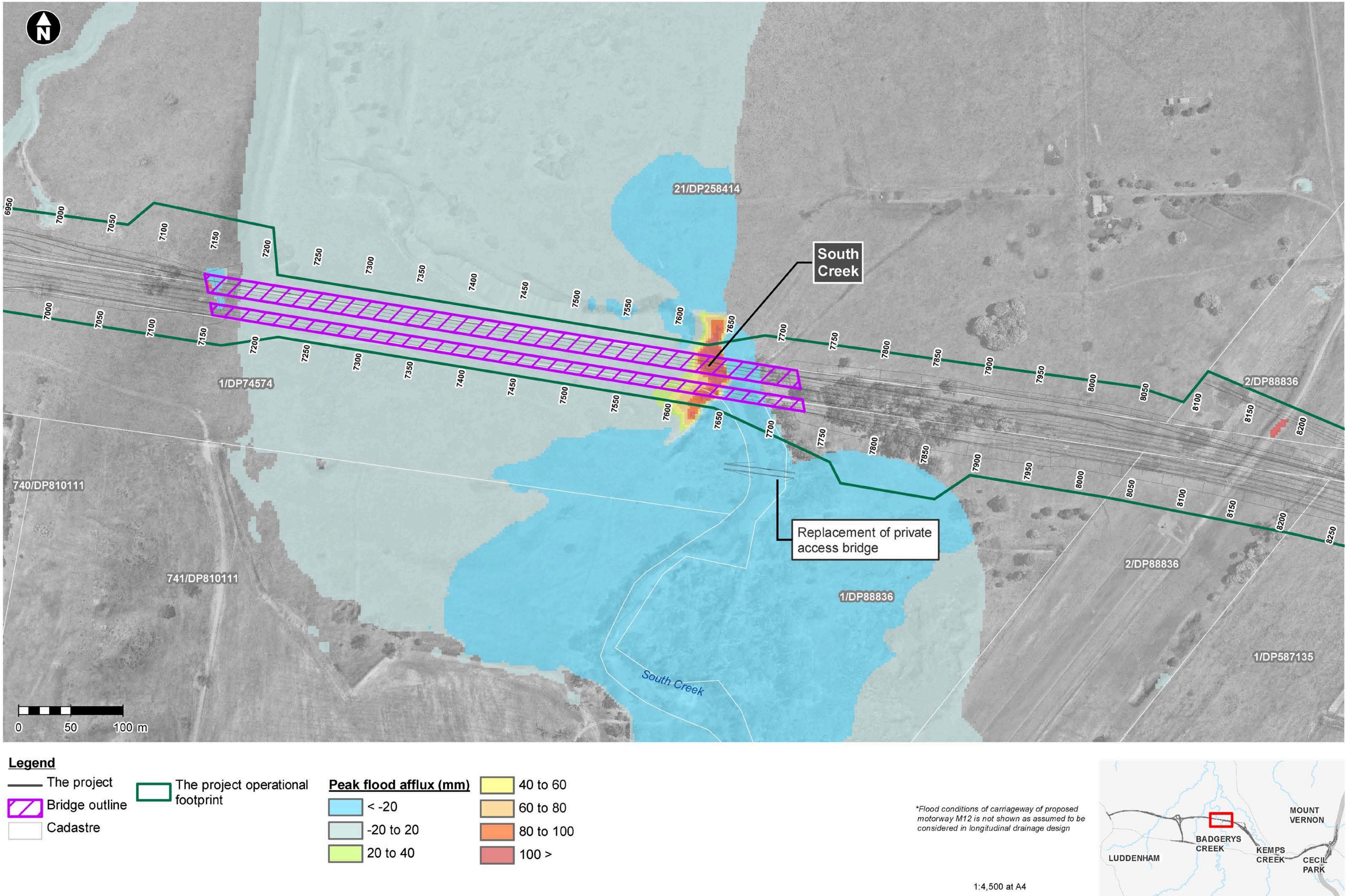
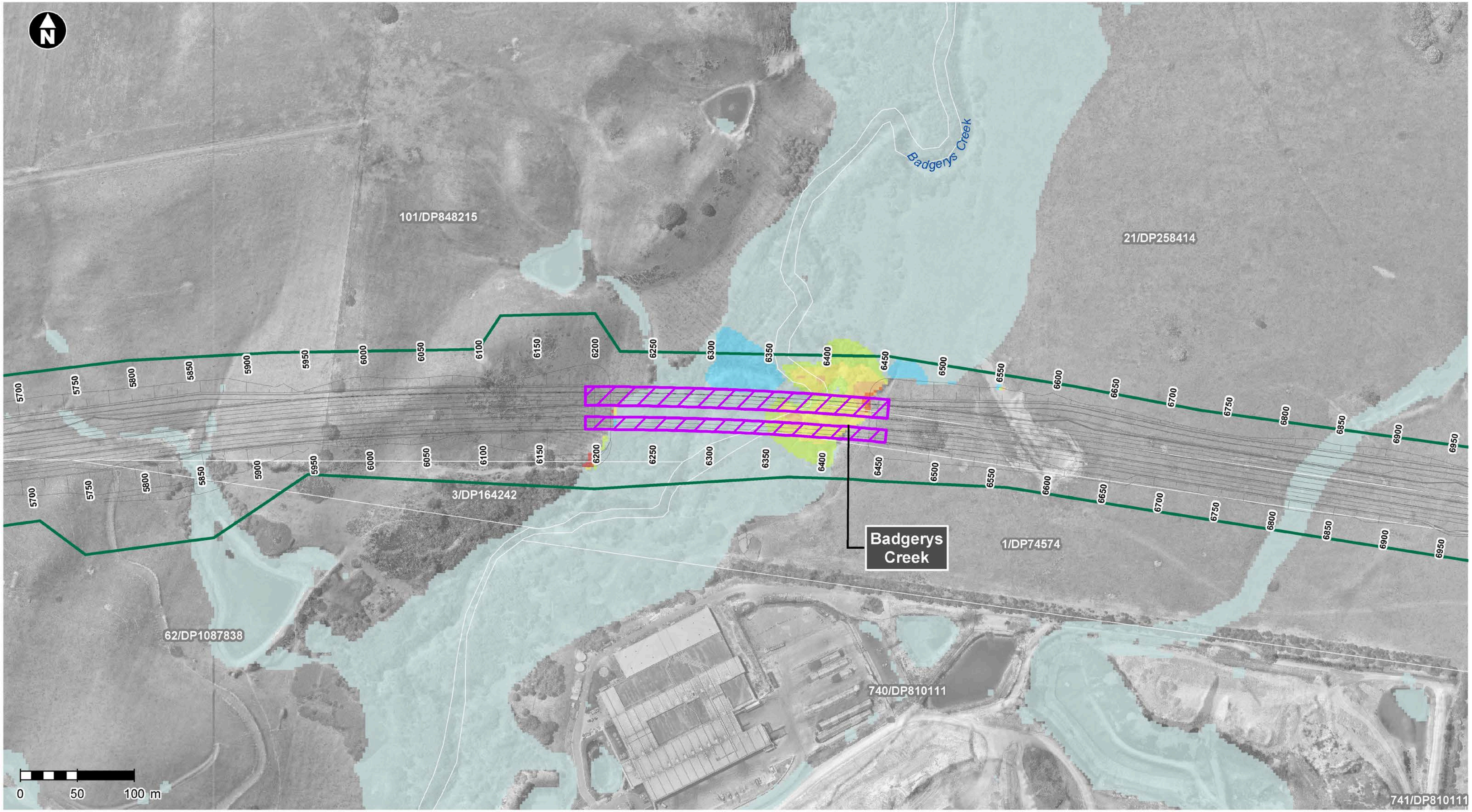


Figure 7-122 Badgerys Creek 100 year afflux

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



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

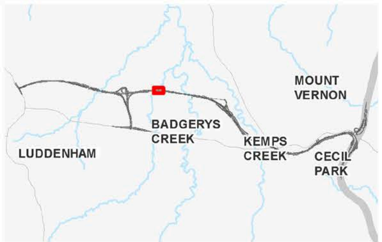


Figure 7-123 South Creek 100 year afflux

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

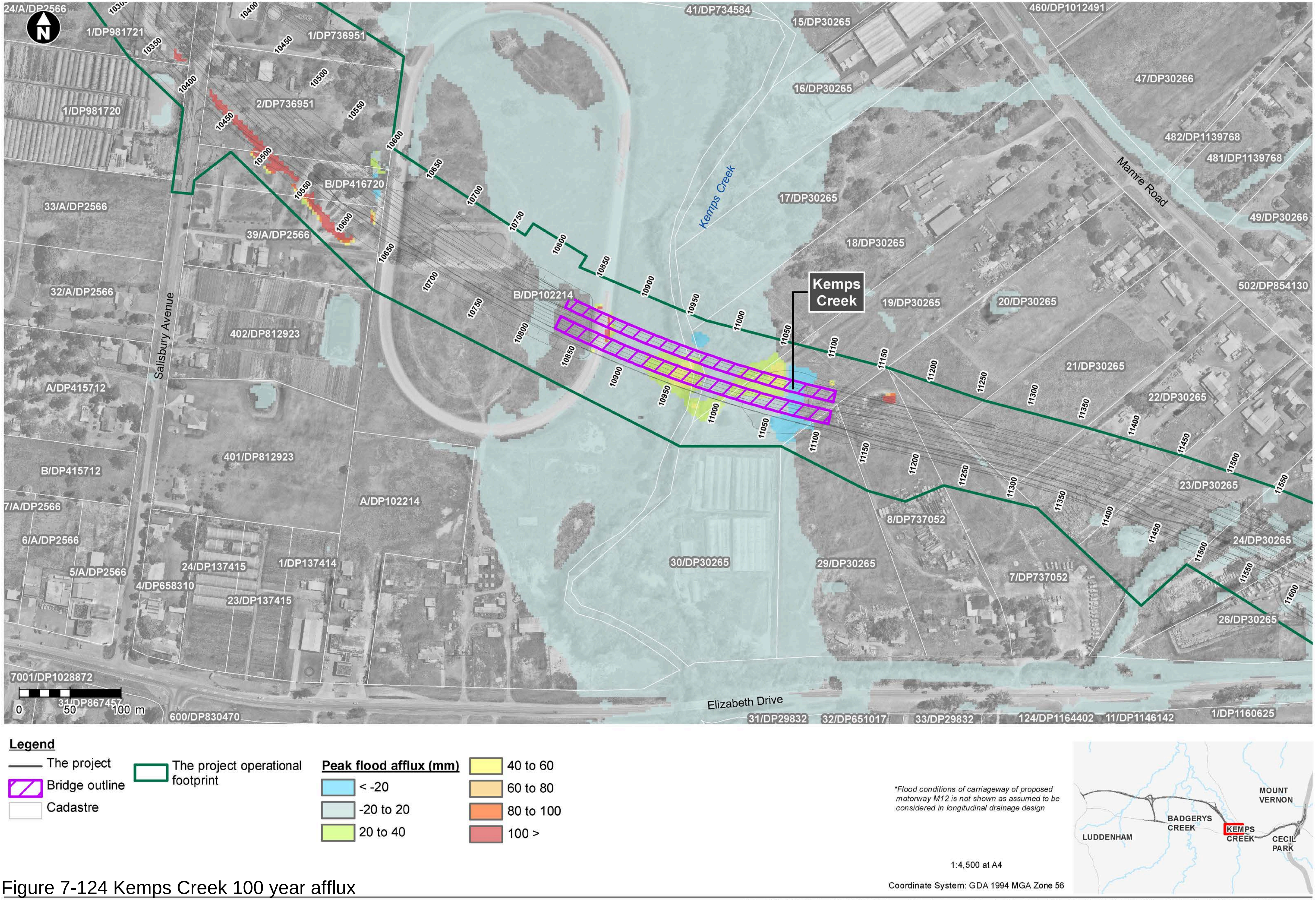


Figure 7-124 Kemps Creek 100 year afflux

Date: 28/06/2019 Path: M:\GIS\MXDs\Figures\Technical_reports\Flood_100pcDesignARI_Afflux\JAJV_FLD_All_100pc_F008_100yrARIAfflux_DDP_A4L_r1v1.mxd
Created by : EM | QA by : RB

Changes in surrounding catchments

Appendix L provides a discussion about potential future changes to the surrounding catchment hydrology which may lead to an increase in flooding.

Major developments including the Western Sydney Airport and Western Sydney Aerotropolis are expected to occur in the areas upstream of the M12 Motorway in the future, and these developments would increase catchment runoff in flooding events. An increase in impervious area would result in an increase in runoff volume, because less rainfall is retained or absorbed by a paved surface than by a vegetated surface. Typically, site runoff from urban development is directed to a stormwater detention basin that restricts the outflow rate to match that which would have occurred before development. However, additional runoff volumes mean that outflows from a basin, although restricted in flow rate, are likely to remain at the peak flow rate for longer time periods compared to existing or pre-developed 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.

As discussed above, if an increase in flow does occur due to these other developments, the predicted impact of the M12 Motorway may be larger than expected. Bridges have therefore been designed with capacity to convey higher flows, in the knowledge that hydrology of the surrounding catchments is likely to change as surrounding land uses change and urban development intensifies. Bridge designs would be refined in detailed design and further modelling carried out to confirm flooding impacts. This flood modelling would take into account any updated regional flood modelling and information available at the time.

The combined impacts of the project and other planned (surrounding) developments are discussed further in **Section 7.8.5**. **Appendix L** provides further discussion about potential future changes to the surrounding catchment hydrology which may lead to an increase in flooding.

Farm dams

The potential for adverse flood impacts on result in potential dam failure (eg due to increased inundation by floodwaters) was considered as part of this assessment. However, dam failure is 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 were investigated as part of the assessment of surface water and hydrology impacts (see **Section 7.9**). 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 would be further considered as part of flood impact management investigations, during detailed design.

Changes to peak stormwater flows, downstream velocity and scour potential

Changes to flood behaviour as a result of the proposed bridges are predicted to be minimal. The largest local changes, which are represented by the peak flood afflux diagrams shown in **Figure 7-120** to **Figure 7-124**, would be due to potential creek adjustments. Creek adjustments are likely to be required at Badgerys Creek, South Creek and Kemps Creek bridges.

The creek adjustments, if required, would affect only short sections of the low-flow channel to ensure that bridge piers are not located within the waterway. They would also avoid encroachment of the structure into the environmental flows, help to 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. Creek diversions are discussed in greater detail in **Section 7.9**.

The proposed creek adjustments would have a similar capacity to the existing creek channels and would be designed as far as practicable in a way that mimics natural flow conditions. Effects on the flows would be small and proximal to the bridges with flow contraction and expansion mostly contained within the proposed operational footprint.

The project's potential impacts on flow velocity are discussed and assessed in **Section 7.9**. That assessment shows that during the 100 year ARI event, flow velocities at the proposed bridge locations in Cosgroves, Badgerys, South and Kemps creeks would mostly increase by less than 20 per cent, and peak velocities would be less than 1.0 metres per second. At Badgerys, South and Kemps creeks however, there would be localised increases in velocity of more than 20 per cent, with small areas where peak flows would exceed 1.0 metres per second. At Badgerys Creek and Kemps Creek, these increases would be contained within the project's operational footprint. At South Creek, this increase would impact small areas within the creek channel upstream and downstream of the proposed bridge.

Where velocity would be increased above the natural threshold of erosion (which would be different for each flow path depending on its geomorphology), scour protection would be provided to minimise any risks of erosion to the infrastructure (such as abutments and piers) and the environment.

Generally, flow and velocity changes are more sensitive to the design and placement of culverts, though the area of influence remains localised at the inlet and outlet of the culverts. Culverts were designed for the project to minimise changes to peak flows and velocity as much as practical by adopting as low a gradient as possible, and so that headwater levels are not higher than existing.

Scour protection would be provided at all culvert outlets, and in some cases an energy dissipation device would be required. Scour protection and/or energy dissipation (such as rock rip rap, rock mattress, geotextile layers) would be engineered during detailed design for the specific requirements of each culvert, and where required the engineered treatments would extend downstream from the culvert outlet to the project's operational boundary.

Potential for scour would be considered further at detailed design, including the need for protection measures at culvert outlets, bridge piers and abutments, and catch drains (open channels) where flow velocities could result in scour.

Flood hazards

Flood hazards are mainly associated with human interaction with floodwater. Flood hazards occur where humans can interact with floodwater with significant thresholds leading to vehicles beginning to float or pedestrians becoming unstable and falling.

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) was 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. Based on this design, the bridge approach embankments would not extend significantly into the active flow area and the impact on flood hazard would be minimal.

As discussed elsewhere in this section, future land use changes and increased intensity of urban development are likely to influence the hydrology of stream catchments that are intersected by the M12 Motorway project. As discussed, it is not possible to predict the exact nature of these developments or quantify the hydrological impacts that might result. The project's design has made allowance for future changes to catchment hydrology through bridges having ample capacity to convey flows well in excess of those that were modelled for the 100 year ARI storm event. To verify the impact of the project and ensure that impacts are managed, further detailed hydrological and hydraulic modelling would be carried out during detailed design to ensure the flood immunity objectives and design criteria for the project are met, and to define the full extent of the project's impact on patterns of main stream flooding and overland flow.

To minimise flood hazards for pedestrians and cyclists, the shared user path was designed to be at the same level as the main M12 Motorway level, at all waterway crossings. In other areas the shared user path would be positioned mostly at or above the level of the motorway surface, which was designed with flood immunity for the 100 year ARI storm event. On some embankments, the shared user path would be lower than the M12 Motorway surface but would still be above the modelled 100 year ARI flood level.

The project would also provide improvements to emergency management, evacuation and access (see below).

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. However, the differences 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, as discussed elsewhere in this section, show that conveyance of stormwater flows would not be adversely impacted by the project. At culvert locations, flow 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.

At present, some (semi-natural) flood storage is provided in close proximity to the project at one location, which is a natural flow path upstream from the location of the Luddenham Road bridge (BR01), where a number of farm dams were constructed in the flow path. As illustrated in **Figure 7-120** and described in **Table 7-128**, the project would result in a minor increase in afflux in the existing farm dam immediately adjacent to the northern side of BR01, but would not impact any other storage areas. As discussed previously, the increase in afflux would be contained mostly within the project's operational footprint and would not have any impact on the overall existing flooding footprint in the 100 year ARI storm event.

Adverse effects to beneficial floodplain inundation

Beneficial floodplain inundation describes the natural process whereby a floodplain is subject to periodic inundation, with benefits to biodiversity, sediment transport, soil condition and groundwater reservoirs, and which preserves the overall biophysical health of a river, its catchment and floodplain. Adverse effects could arise from interventions such as the construction of embankments, placement of obstacles in flow paths (such as bridge piers), or the removal of natural flow constrictions that contribute to natural inundation event.

The flood maps at Annexure A of **Appendix L** show that in their existing state, even under 'Probable Maximum Flood' conditions, the floodplains of Cosgroves, Badgerys, South and Kemps creeks are not subject to total inundation. Therefore storm events that would inundate the floodplains are statistically rare and the extent of natural beneficial inundation is limited.

This assessment shows that floodplain areas would experience little change as a consequence of the project, beyond localised effects at bridge abutments, piers, and at the creek adjustments. The relatively long bridge spans (potentially up to or more than 30 metres), would not significantly alter the natural processes in the floodplains 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.

Stormwater flows across the M12 Motorway formation to floodplain areas, either through culverts or beneath bridges, would remain unchanged outside the project's operational footprint as a result of the project's construction and operation.

Emergency management, evacuation and access

The project would provide a major transport network link to the region, designed with immunity from the 100 year ARI flood event. Having this link would improve future emergency management options during any future flood event near the project, and for surrounding areas where the traffic improvements would help by providing an additional, new primary access route with direct connections to Sydney's wider arterial and motorway network.

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

Social and economic costs

Given that the project is unlikely to result in increased flood risk to surrounding areas, even under large flooding conditions like the 100 year ARI event, there are unlikely to be any project related social or economic costs due to the project. The use of the land surrounding the main creeks would be unaffected by the project with respect to flooding, as shown in the flood maps in Annexure A of **Appendix L**.

As discussed in this assessment, the designs for the proposed M12 Motorway bridges incorporate stormwater conveyance capacity in excess of the modelled flow volumes up to the 100 year ARI storm event. The bridge designs therefore would accommodate some future changes in the surrounding catchments, which could potentially occur as a consequence of future urban development upstream of the M12 Motorway. Although future developments are unknown and cannot be quantified or empirically assessed, the project therefore may help to dissipate social and economic costs associated with future developments, by affording some level of protection against future increased flood levels. The bridge designs would be refined in detailed design and further modelling would be carried out as discussed above. Flood modelling in detailed design would contribute to the wider understanding of the hydrology and flood behaviour of the impacted watercourses with the project in place, and may also provide a social and economic benefit through informing future planning for flood protection in any future urban developments in the surrounding area.

Climate change

As discussed, the project is well above the 2000 year ARI flood levels and future climate change is unlikely to exacerbate the project's impact on flooding. As discussed above, bridge design would be refined in detailed design and further modelling carried out to confirm flooding impacts associated with the project, including potential increased sensitivity to climate change from any design refinements.

Similarly, the sizing of cross drainage culverts for minor drainage lines has included adequate freeboard. The freeboard adopted would accommodate increased flow rates potentially resulting from climate change, and the flood immunity of the M12 Motorway is unlikely to be impacted. Further assessments would be carried out to confirm climate change impact in detailed design subject to design refinement of cross drainage culverts.

7.8.5 Cumulative impacts

Cumulative flooding impacts may arise from the interaction of construction and operation 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.

Numerous projects in varying stages of delivery and planning are currently underway near the M12 Motorway corridor. 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 cumulative flooding impacts associated with these projects are considered in **Table 7-129** and outlined in further detail in **Appendix L**. Additional details of each of the projects considered is provided in **Table 7-3**.

Table 7-129 Cumulative flooding impacts

Project and status	Cumulative impacts
Western Sydney Airport Approved. Under construction	Construction and operation of the Western Sydney Airport will overlap with construction and operation of the project. The Western Sydney Airport will increase runoff volumes due to the transformation of the existing green site into a mostly impervious site. Construction of the airport would involve extensive earthworks which would change drainage direction and overland flow paths, thereby modifying the nature of flooding on the airport site. It will also increase the duration of the flood discharges out of the site. The airport EIS proposes the establishment of flood detention basins designed for the full impervious areas at start of the airport construction and this would enable the management of stormwater releases during construction and reduce offsite impacts of surface water flows. During operation the detention bays would 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 Western Sydney Airport does not intend to increase the peak flow conditions that will affect the project.
Sydney Metro Greater West Not yet approved	The Sydney Metro Greater West and the M12 Motorway would have overlapping construction and operational timeframes. During any timeframes where activities are concurrent, increased flooding impacts are possible. However, as planning provisions require that future development cannot result in a significant change in peak flood flows, it is expected that the operation of the railway would not affect the storage and conveyance of the waterways flowing to the M12 Motorway and as a result the potential cumulative impacts would be minor.
The Northern Road upgrade Approved. Construction has begun	Construction activities associated with Stages 5 and 6 of The Northern Road upgrade may overlap with the project construction and the roads would be operational at the same time. It is predicted that the construction and operation of The Northern Road upgrade will not affect the storage and conveyance of the waterways flowing to the project. Hence there would be no cumulative flooding impacts associated with the operation of the project 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 Not yet approved	There are a number of planned road upgrade projects in the western Sydney area including Elizabeth Drive upgrade, Mamre Road upgrade and Outer Sydney Orbital. These projects are currently at varying stages of planning and no design or environmental assessment information is currently publicly available. During any timeframes where construction activities are concurrent, increased flooding impacts are possible. Planning provisions require that future development cannot result in a significant change in peak flood flows, and as the project are expected to have minor and localised flood impacts during construction, they would only have a minor contribution to cumulative flooding impacts. Similarly, the operation of the proposed road upgrades would not affect the storage and conveyance of the waterways flowing to the project and as a result the potential cumulative impacts would be minor.

Project and status	Cumulative impacts
Major land releases, including: • Western Sydney Aerotropolis • South West Growth Area • Western Sydney Employment Area. Future strategic government project	Western Sydney is the focus of a number of plans and policies to promote changes in land use including Western Sydney Aerotropolis, South West Growth Area, Western Sydney Employment Area. During any timeframes where construction activities are concurrent, increased flooding impacts are possible. Planning provisions require that future development cannot result in a significant change in peak flood flows, and as the project is expected to have minor and localised flood impacts during construction, it would only have a minor contribution to cumulative flooding impacts. The operation of the growth areas will increase runoff volumes due to the transformation of the existing greenfield sites into mostly impervious sites. It will also increase the duration of the flood discharges out of the sites. Appropriate management measures are likely to be implemented to manage peak flows however there are still potential flooding impacts associated with development occurring within Western Sydney and these impacts will need to be taken into account as part of the environmental assessment and approval process for those projects.

As discussed in further detail in **Appendix L**, 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 are 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.

7.8.6 Environmental management measures

The environmental management measures that would be implemented to minimise flooding impacts associated with the project, along with the responsibility and timing for those measures, are presented in **Table 7-130**.

Table 7-130 Environmental 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 carried out 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 on property	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
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 2008b) • 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 2011c) • Roads and Maritime Stockpile Management Guideline (Roads and Maritime 2011d).	Contractor	Prior to construction
Flooding and creek adjustment impacts	F04	Creek adjustments would be re-considered and/or further refined to minimise the impact on 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.	Contractor	Detailed design

Impact	Reference	Environmental management measure	Responsibility	Timing
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