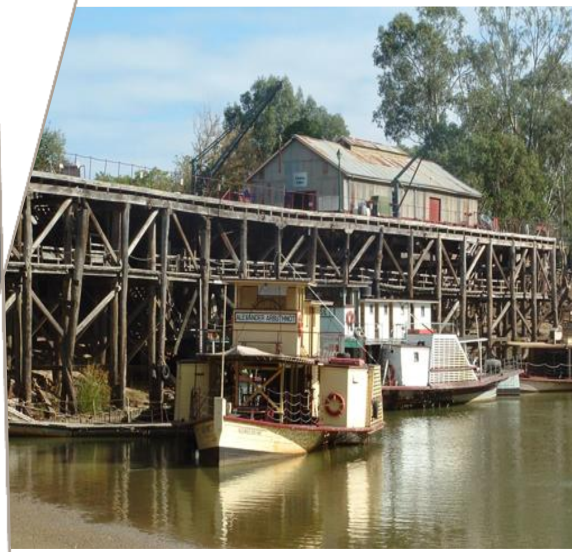
Echuca-Moama Bridge EES



Specialist Hydrology Report

Prepared for
VicRoads and NSW Roads and Maritime Services

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Glossary of Terms

Term	Definition
1 in 100 year flood	A flood which results from a storm which has a statistical probability of occurring once in every 100 years.
Access	The location by which vehicles and / or pedestrians enter and / or leave property adjacent to a road.
Afflux	A rise in upstream water level caused by introducing a constriction such as a bridge, into a stream, channel or floodplain.
Alignment Option	The location and geometric form of a carriageway in both the horizontal and vertical directions. For this Project the Alignment Option being assessed is the Mid-West Option.
Average Recurrence Interval (ARI)	The statistical probability of a flood occurring in a given number of years i.e. a 1 in 100 year ARI event.
Arterial Road	The nominated traffic routes (such as Murray Valley Highway or Cohuna-Echuca Road / Warren Street), for longer distance travel and larger vehicles.
At grade intersection	An intersection where all roads cross at the same level usually controlled by traffic signals or Stop or Give Way signs.
Attenuation	The reduction in the magnitude of sound pressure level during transmission over a distance or around a barrier.
Axel load limit	Restrictions on how much load can be carried on an axel, single or dual tyres, and on the vehicle or vehicle combinations.
Australian Height Datum (AHD)	The Australian standard height datum for calculating levels.
B-double	An articulated vehicle hauling two semi-trailers with the rear semi-trailer superimposed onto the front semi-trailer of the articulated vehicle. This is achieved by the use of a fifth wheel permanently located towards the rear of the front semi-trailer.
Batter	In road construction, an artificial uniform slope created on the sides of fills or cuts. The proposed batters for the Project have a slope of 2:1 (vertical to horizontal).
Benefit Cost Ratio (BCR)	The ratio of the discounted benefits over the life of a project to the discounted capital costs, or the project's discounted total agency costs.
Bored pile	A steel or reinforced concrete post that is inserted vertically into the ground by drilling, or formed in the ground in a pre-bored hole, to support a load.
Bridge	A bridge is a structure built to cross an obstacle in the road network. The Project comprises bridges across the Campaspe River, the Murray River and some bridging components over the Campaspe/Murray River floodplains.
Carriageway	That portion of a road or bridge devoted particularly to the use of vehicles, inclusive of shoulders and auxiliary lanes, such as the two-lane, two-way carriageway in the Initial Alignment.
Chainage	The distance of a point along a control line, measured from a datum point.

Term	Definition
Clear Zones	An area within the recovery area which is ideally kept clear of hazards (or within which unmovable hazards are shielded). The width of the clear zone reflects the probability of an accident occurring at that location and the cost-effectiveness of removing hazards. The clear zone width is dependent on traffic speeds, road geometry and traffic volume.
Concept Design	Initial high-level functional layout of a concept, such as a road or road system, to provide a level of understanding to later establish detailed design parameters.
Construction Environmental Management Framework (CEMP)	A site or project specific plan developed to ensure that appropriate environmental management practices are followed during the construction and/or operation of a Project.
Construction Area	The area defined for the Project that would be directly impacted by construction activities. It typically includes areas where vegetation would be removed and could include site compounds and laydown areas, which are outside the proposed Right-of-Way.
Corridor	An area of travel between two points. It may include more than one major route and more than one form of transport. Two corridors were investigated prior to the development of the EES. These corridors were identified as the Mid-West 2 Corridor (which included the Mid-West 2A and Mid-West 2B options) and the Mid-West Corridor, (which included the Mid-West Option).
Culvert	One or more subsurface adjacent pipes or enclosed channels for conveying surface water or a stream below formation level.
Cut	The depth from the natural surface of the ground to the construction level.
dB(A)	The human ear is not equally sensitive to all parts of the sound frequency range and the scale most commonly used is the A-weighted decibel or dB(A). This unit most accurately reflects human perception of the frequency range normally associated with road traffic noise.
Deceleration lane	An auxiliary traffic lane provided to allow vehicles to decrease speed on the approach to an intersection.
Design speed	A speed fixed for the design and correlation of those geometric features of a carriageway that influence vehicle operation. The alignment option has been designed to 90 kilometres per hour, for a posted speed limit of 80 kilometres per hour.
Earthworks	All operations involved in loosening, removing, depositing, shaping and compacting soil or rock.
Environmental Management Framework (EMF)	Outlines the environmental measures recommended to be adopted as part of the EES.
Environment	For the purpose of the EES, environment incorporates physical, biological, heritage, cultural, economic and social aspects.
Environment Effects Statement (EES)	A statement prepared at the request of the Victorian Minister for Planning, pursuant to the Victorian *Environmental Effects Act 1978*, on the potential environment impact of a proposed development.

Term	Definition
EES Scoping Requirements	The Scoping Requirements under the Victorian Environment Effects Act 1978 entitled 'The Second Crossing of the Murray River at Echuca-Moama', dated June 2014.
Fill	One or more of the following: 1. The depth from the subgrade level to the natural surface. 2. That portion of road where the formation is above the natural surface. 3. The material placed in an embankment.
Floodplain	An area of low-lying ground next to a river, formed mainly of river sediments and subject to flooding. For this study the floodplain includes the Murray River floodplain and Campaspe River floodplain.
Floodway	Land that is identified as carrying active flood flows associated with waterways and open drainage systems.
Freehold land	Privately owned land.
Gradeline	The level and gradient of a road carriageway along the centreline.
High Mass Limits (HML)	Allows for higher axle loading for various axle groups in compliance with National accreditation and restricted to specific routes
High Productivity Freight Vehicle (HPFV)	Larger combination vehicles such as B triples and super B doubles that are restricted to specific arterial routes
Highway	A principal road in the road network with direct property access, such as the Murray Valley Highway.
Initial Alignment	For the purpose of this EES, the initial alignment comprises the construction of a two lane, two-way carriageway road including a single bridge across each waterway.
Intersection	The place at which two or more roads meet or cross.
Land use	The type of development permitted in an area whether it be industrial, commercial, residential and recreational or a combination of some or all of these different uses.
Local access path	Minor path generally located in a local or residential area that links road and/or other path cycling routes, such as those paths within Victoria Park.
Major Road	A road to which is assigned a permanent priority for traffic movement over that of other roads.
Mid-West Option (Preferred Alignment)	The Mid-West Option extends from the Murray Valley Highway along Warren Street before diverting to the northwest where it crosses Campaspe Esplanade and the Campaspe River, then turns north-east to cross the Murray River north of the Victoria Park Boat Ramp. This option then extends north in New South Wales to cross Boundary Road in Moama and connect with the Cobb Highway at Meninya Street.

Term	Definition
Mid-West 2A Option	The Mid-West 2A Option extends north/northwest on a new alignment from the intersection of the Murray Valley Highway and Warren Street, crosses the Campaspe River north of the Echuca Cemetery, before turning northeast towards Reflection Bend on the Murray River. This option then passes immediately south of Reflection Bend and crosses the Murray River north of the Victoria Park Boat Ramp, then extends north in New South Wales to cross Boundary Road in Moama and connect with the Cobb Highway at Meninya Street.
Mid-West 2B Option	The Mid-West 2B Option extends north/northwest on a new alignment from the intersection of the Murray River Highway and Warren Street, crosses the Campaspe River northeast of the Echuca Cemetery, before turning north towards the Echuca Sports and Recreation Reserve. This option crosses the Murray River north of the Victoria Park Boat Ramp, then extends north in New South Wales to cross Boundary Road in Moama and connect with the Cobb Highway at Meninya Street.
Mitigation Measures	Measures which are implemented to reduce an adverse impact caused by road construction and operation.
No Project Option	This assumes no additional bridge crossing of the Murray River and assumes existing road conditions and networks remain unchanged.
Preferred Alignment	The Preferred Alignment is the Mid-West Option.
Property	A property is land owned by a single landowner. It may include multiple contiguous titles owned by the same registered proprietor.
Recovery Area	The area beside the traffic lane required for a run-off-road vehicle to stop safely or be brought under control before rejoining the traffic lane.
REF	Review of Environmental Factors pursuant to the Environmental Planning and Assessment Act 1979 (NSW) to assess impacts of the Project in NSW.
Right-of-Way	The Right-of-Way (ROW) is a strip of land the extent of which is reserved under a planning ordinance for the public purpose of a road and, in this case, encompasses sufficient land to construct the Project. The Right-of-Way for the Project comprises the sealed road surfaces (including shoulders / verges) and a 5-7 metre clear zone either side of the road formation of the Ultimate Duplication.
Right-turn lane	Right-turn lanes are used to provide space for the deceleration and storage of turning vehicles.
Risk Assessment	The processes of reaching a decision or recommendation on whether risks are tolerable and current risk control measures are adequate, and if not, whether alternative risk control measures are justified or would be implemented.
Roads and Maritime Services (Roads and Maritime)	Roads and Maritime Services are the co-proponent for the Echuca-Moama Bridge EES. Roads and Maritime Services are the NSW state government department responsible for the environmental assessment on the NSW component of the Project.
Roundabout	A channelised intersection at which all traffic moves clockwise around a central traffic island. The roundabouts proposed as part of the Project are

Term	Definition
	located at the Murray Valley Highway and on Warren Street, which are both three-leg roundabouts.
Sedimentation Basins	Engineered basins designed to contain road drainage and spills on the new carriageway, preventing contaminates from entering the floodplain.
SEPP	State Environment Protection Policy
Service Road	A road designed or developed to be used, wholly or mainly, by traffic servicing adjacent land along Warren Street as part of the Mid-West Option only.
Shared Path	A paved area particularly designed (with appropriate dimensions, alignment and signing) for the movement of cyclists and pedestrians.
Staged Construction	A construction sequence in which the initial alignment comprising a single traffic lane in each direction is constructed and then, should traffic demand warrant an increase in road capacity, the road and bridge structures are duplicated, providing two traffic lanes in each direction.
Study Area	The area identified by individual specialists to determine potential impacts for the Project relating to a specific discipline.
Super “T”	A load-bearing structure (usually reinforced concrete) with a T-shaped cross-section.
The Project	The Echuca-Moama Bridge EES (Project) involves the construction and operation of a second road bridge crossing of the Murray and Campaspe Rivers at Echuca-Moama.
Title	A title is an official record of who owns a parcel of land. Adjoining titles in the same ownership are considered and assessed as a ‘property’ in the impact assessment.
Turning lanes	An auxiliary lane reserved for turning traffic, providing deceleration length and storage for turning vehicles.
Two Way Carriageway	A carriageway with two traffic lanes allotted for use by traffic in opposing directions.
Ultimate Duplication	For the EES, the Ultimate Duplication comprises the construction of a duplicated roadway and bridges. The Ultimate Duplication would be constructed when future traffic demand warrants an increase in road capacity. The EES considers the potential impacts of the Ultimate Duplication.
VicRoads	VicRoads (Roads Corporation) is the co-proponent for the EES. VicRoads is responsible for project management of the planning and would manage the construction of the Project.
Work Hours	Work schedule during construction of the Project in which employees are required to work a certain number of hours but can schedule those hours as they wish. Typical work hours for the Project would be from 7.30 am (or sunrise – whichever is the earlier) to 5.30pm or sunset (whichever is the later).

Executive Summary

VicRoads, in partnership with New South Wales Roads and Maritime Services (Roads and Maritime), is undertaking planning activities for a second Murray River crossing at Echuca-Moama. The second crossing, known as the 'Echuca-Moama Bridge Project' (the Project) would alleviate congestion on the existing bridge, provide an alternate access for traffic between the two towns and cater for road freight, including vehicles with Higher Mass Limits (HML) and High Productivity Freight Vehicles (HPFV).

On 14 June 2013, the Minister for Planning determined that an Environment Effects Statement (EES) would be required to assess the potential environmental effects of the Project within Victoria. As the Project extends into NSW, a Review of Environmental Factors (REF) would be required to assess impacts within New South Wales. This impact assessment has been prepared to inform the EES and REF.

Three alignment options, known as the Mid-West, the Mid-West 2A and Mid-West 2B were considered as part of the scoping leading to the EES. Of these three alignments, the Mid-West Option was determined to be the better performing option when considering a balance between environmental, social and economic considerations and was selected for detailed risk and impact assessment. The Mid-West Option utilises existing road reserves for part of its length, has the least impact on biodiversity and habitat values, cultural heritage values and satisfies the Project objectives. This report considers the impacts of the Mid-West Option and supports its selection as the Preferred Alignment.

This Hydrology Impact Assessment Report has been prepared in response to the EES Scoping Requirements for the Project. The assessment included review of previous investigations, consideration of the existing conditions, an options assessment, environmental risk assessment and impact assessment.

The impacts from the Project include:

- Flood impacts – ensuring the existing flood conditions are not altered or impacted by the Project.
- Construction impacts – ensure the risks associated with construction are managed appropriately.
- Operation impacts – ensure the risks with the operation of the proposed second bridge are managed appropriately.
- Groundwater impacts – ensuring the existing groundwater conditions not altered or impacted by the Project.
- Scour impacts – Ensure that the Project manages the risk for scour during floods.

This assessment has demonstrated that the planned controls for this Project have resulted in a Project that:

- would not have a significant effect on the function, values and beneficial uses of surface water for the lower Campaspe River and Murray River; and
- would not contaminate the soil and groundwater from construction and operation activities.

The Project also provides a range of benefits to the township of Echuca-Moama by:

- providing a second route across the Campaspe River and Murray River,
- providing a second flood evacuation route up to the 100 year ARI event for the main township of Echuca; and
- increased flood protection of Warren Street as this now has additional culverts and mitigation structures proposed which reduce the frequency of the road overtopping. The road is also to be designed to withstand overtopping to improved standards which would reduce the likelihood of damage in a flood event. Sections of the road are also raised to above the 100 year ARI event which further reduces the likelihood of flood damage.

The residual risks following the implementation of the planning controls are no greater than the existing conditions and in some instances reduced. The impact of flooding is maintained at existing levels in line with the required legislation, however the inclusion of the additional flood free evacuation route had decreased the risk to community in that area.

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1 Introduction

1.1 Project Overview

We are instructed that VicRoads, in partnership with New South Wales Roads and Maritime Services (Roads and Maritime), is undertaking planning activities for a second Murray River crossing at Echuca-Moama. The Project, known as the Echuca-Moama Bridge Project would alleviate congestion on the existing bridge and provide an alternate access for residents and improved security of access for the local community, as well as catering for freight and agricultural machinery.

As part of the assessment and approvals processes, the Project was referred to the Victorian Minister for Planning for a decision whether an assessment under the *Environmental Effects Act* 1978 is needed to determine the Project's potential for significant effects on the environment. On 14th June 2013 the Minister determined an Environment Effects Statement (EES) would be required.

This Hydrology and Groundwater Impact Assessment has been prepared to inform the EES and REF. The EES is required to consider the potential effects of the Project on the environment, inform the public and other stakeholders and to enable a Ministerial Assessment of the Project to inform decision makers. The purpose of the REF is to document the likely impacts of the proposal on the environment and to detail recommended protective measures to be implemented during construction and operation.

The EES for the Project has considered three alignment options. As part of the options assessment for the EES, the Mid-West Option was identified as the better performing option and this impact assessment has been prepared based on the Mid-West Option (the Preferred Alignment).

1.2 Purpose of this document

The purpose of this Hydrological and Groundwater Impact Assessment report is to document the hydrological impacts and to outline the methodology, risks and proposed mitigation for the Project within Victoria and NSW.

2 Project Description

2.1 Project Background

Echuca and Moama are currently linked by a single road bridge across the Murray River with a single carriageway in either direction. The existing bridge was built in 1878 and originally operated as a combined road/rail bridge until 1989, whereby a separate rail bridge was constructed. The nearest alternative road crossings of the Murray River are at Barham, 86 km to the west, Barmah 36 km to the east, or Tocumwal 120 km to the east.

The existing road bridge and its approaches have inherent safety and operational limitations including its inability to carry over-width loads and higher mass-limited vehicles used by an increasing proportion of the freight transport industry. Rehabilitation works to upgrade the operational capacity of the bridge would require lengthy road closures and would be further complicated by heritage considerations.

The existing bridge does not provide a suitable level of service for the increased volume of light vehicle traffic experienced during peak summer tourist events. Extensive delays are commonly experienced at these times which are easily exacerbated by any minor traffic incidents. This results in sizeable delays and in particular restricts the movement of emergency services vehicles from one town to the other.

Early investigations to provide for a second Murray River Crossing at Echuca-Moama commenced in 1965. Since then, VicRoads has undertaken extensive planning investigations including route options development and environment impact assessments. Over the past 15 years, five corridors have been considered for an additional Murray River crossing. These investigations have included:

- an Environment Effects Statement (EES) / Environmental Impact Statement (EIS) study in 2000/2001 which determined a Western Corridor as the option approved by the Planning Panel;
- preparation of an Environmental Report in 2010 for a Mid-West corridor (this process was superseded in late 2010 following a change in Government); and
- the current EES process which formally commenced in 2013.

As a result of the investigations completed and stakeholder consultation conducted, VicRoads has amassed significant knowledge of existing environmental, social and economic conditions and community values in the Echuca-Moama region.

2.2 The Project

The Echuca-Moama Bridge Project (the Project) involves the construction and operation of a second road bridge crossing of the Murray and Campaspe Rivers at Echuca-Moama. The Project extends between Echuca (within Victoria) and Moama (in New South Wales) and is therefore subject to the provisions of the Victorian and New South Wales approvals processes. As part of the EES (within Victoria), the Preferred Alignment is assessed against a ‘No Project’ option, whereby it is assumed that the existing road conditions and networks remain unchanged and in NSW a Review of Environmental Factors (REF) is being prepared to consider the construction impacts of the Project.

The Project comprises a Right-of-Way sufficient to build a four lane road and duplicated bridges across both Rivers. The Project includes an elevated roadway and extensive bridging across the Campaspe and Murray River floodplains, as well as changes to existing approach roads.

Construction of the Project would be staged to meet traffic demands and includes the Initial Alignment and an Ultimate Duplication. The Initial Alignment comprises two lanes (a single carriageway in either direction) and the Ultimate Duplication, which comprises the two lanes in both directions and duplicated bridges next to the bridges built during the Initial Alignment.

The project would involve bridge crossings of the Murray River and Campaspe River. Further bridging and culverts would be provided over low lying flood prone land, providing adequate clearance for movement of flood waters. The piers of the Campaspe and Murray River bridges would be constructed outside of the river channel (summer flow / low water mark extent).

The proposed bridge over the Campaspe River is designed to fully span the river, without support structures in the river channel. At the Campaspe River, bridge piers would be located clear of the river banks to the north and south of the river.

The proposed bridge over the Murray River is designed to span the summer water level river channel, and support structures would not be required within the river channel, but are placed on the river bank above typical baseflow river level. A cantilever structure is proposed over the Murray River, with piers in the river banks supporting a 90-95m clear span over the river channel. The piers would be located above the normal summer flow (summer river water level).

Some construction works may be required on or near the banks of the Murray River. The construction process for Murray River Bridge piers would involve the installation of coffer dams in dry conditions if possible.

The Project design includes provision for spill basins to be constructed adjacent to the alignment to capture run-off from the new roadway. The spill basins have been incorporated into the design consistent with discussions with the EPA and allow for the capture and/or treatment of run-off from the road surface and enable removal or release into the flood plain as required. The spill basins would be located as close to the road carriageway as possible to minimise the construction footprint of the Project. On the elevated carriageway from Warren Street in Echuca to Cobb Highway in Moama, the spill basins would be constructed within the batter slope.

The height of the spill basins would be determined during detailed design. The EPA has instructed VicRoads to adopt a risk based approach to spill basin design. This would involve an assessment of construction and maintenance costs, access requirements and public safety, spill risk and effectiveness and reliability of required management measures.

This Hydrology Impact Assessment explores the impact of the Ultimate Duplication on the existing flooding conditions for both the Murray and Campaspe Rivers. The assessment aims at developing the Ultimate Duplication to the point where the impact on flooding meets the requirements of the controlling legislation and authorities.

2.2.1 Project Objectives

The Project objectives are to:

- improve accessibility and connectivity for the community of Echuca-Moama and the wider region;
- provide security of access between Echuca and Moama;
- enable cross border access for high productivity vehicles and oversized vehicles;
- improve emergency accessibility during flood events;
- provide road infrastructure that supports:
  - the local and regional economy of Echuca-Moama; and
  - the state and national economies through improved connectivity of goods and services

2.2.2 Preferred Alignment

VicRoads undertook an assessment of alignment options based upon the information from previous assessments and existing conditions in the area. The result was the selection of a Preferred Alignment option for consideration by specialists. The Preferred Alignment, known as the "Mid-West" option was determined to be the better performing option when considering a balance between environmental, social and economic considerations. The Preferred Alignment is approximately 4.3km in length and utilises existing road infrastructure along part of Warren Street (Echuca-Cohuna Road), and when compared to the other options has the least amount of vegetation removal and least amount of raised road formation and bridging, impacting on the overall cost of the Project. Refer to the Echuca-Moama Project EES Main Report for more details on the assessment of alignment options to support the selection of the Preferred Alignment.

The Preferred Alignment extends from the Murray Valley Highway along Warren Street before diverting to the northwest where it extends to the west of Victoria Park Oval. The alignment then turns north-east to cross the Murray River before extending north to connect with the Cobb Highway (Refer Figure 1).

More specifically, the Preferred Alignment comprises:

- a new roundabout at the intersection of the Murray Valley Highway;
- upgrade works along Warren Street, including widening of the road pavement, shoulder sealing, upgrading flood relief structures, line marking and intersection upgrades at Homan Street and Redman Street;
- construction of a new service road on the western side of Warren Street between Homan Street and Redman Street;
- line marking for a dedicated right-turn lane for traffic turning into Homan Street;
- construction of a new 'three-leg' roundabout approximately 120 m south of Campaspe Esplanade;
- construction of a new road extending north-west from Warren Street and construction of a new bridge across the Campaspe River and Crofton Street;
- construction of a new road extending north over part of the former Echuca College site and construction of a new road over a slab on the edge of an existing sand hill;
- a new road extending north-east over the western and northern tennis court in Victoria Park and to the north of the Echuca Caravan Park;
- construction of a new bridge over the Murray River near the existing boat ramp;
- construction of an elevated road east of the Murray River to connect with a realigned Meninya Street (the existing Cobb Highway) and a new signalised intersection; and
- signalising of the intersections at Cobb Highway and Perricoota Road and Cobb Highway and Francis Street.

The main construction activities associated with the Project would comprise:

- civil and structural works associated with the construction of new elevated roadway and bridges across the Murray and the Campaspe River;
- construction of earthworks and flood relief structures for the new Link Road across the Murray River and Campaspe River floodplains; and
- improvements to existing roads and intersections on approaches in Victoria and New South Wales, including the construction of a large diameter roundabout at the Murray Valley Highway / Warren Street intersection and traffic signals with Meninya Street and Perricoota Road in Moama.

Figure 1 Project Alignment

2.3 Study Area

The Study Area for this Hydrology Impact Assessment is broader than the Project Area described above. The model of the Murray and Campaspe Rivers is required to extend over a large area to ensure that the model is representing the flood flows within the system accurately and to capture all impacts on the peak flood depths caused by the impacts of the Project at Echuca and Moama. Due to the low slope of the river channel bed the Murray River and Campaspe River floodplains are sensitive to changes in land form and impacts can be observed kilometres upstream or downstream from the bridge site.

The model encompasses both Victoria and NSW as the Murray River floodplain resides in both states. Large areas of the Murray River floodplain and the Campaspe River floodplain are included in the Study Area due to the proximity of the confluence of the two systems. The full model Study Area is shown in Figure 2.

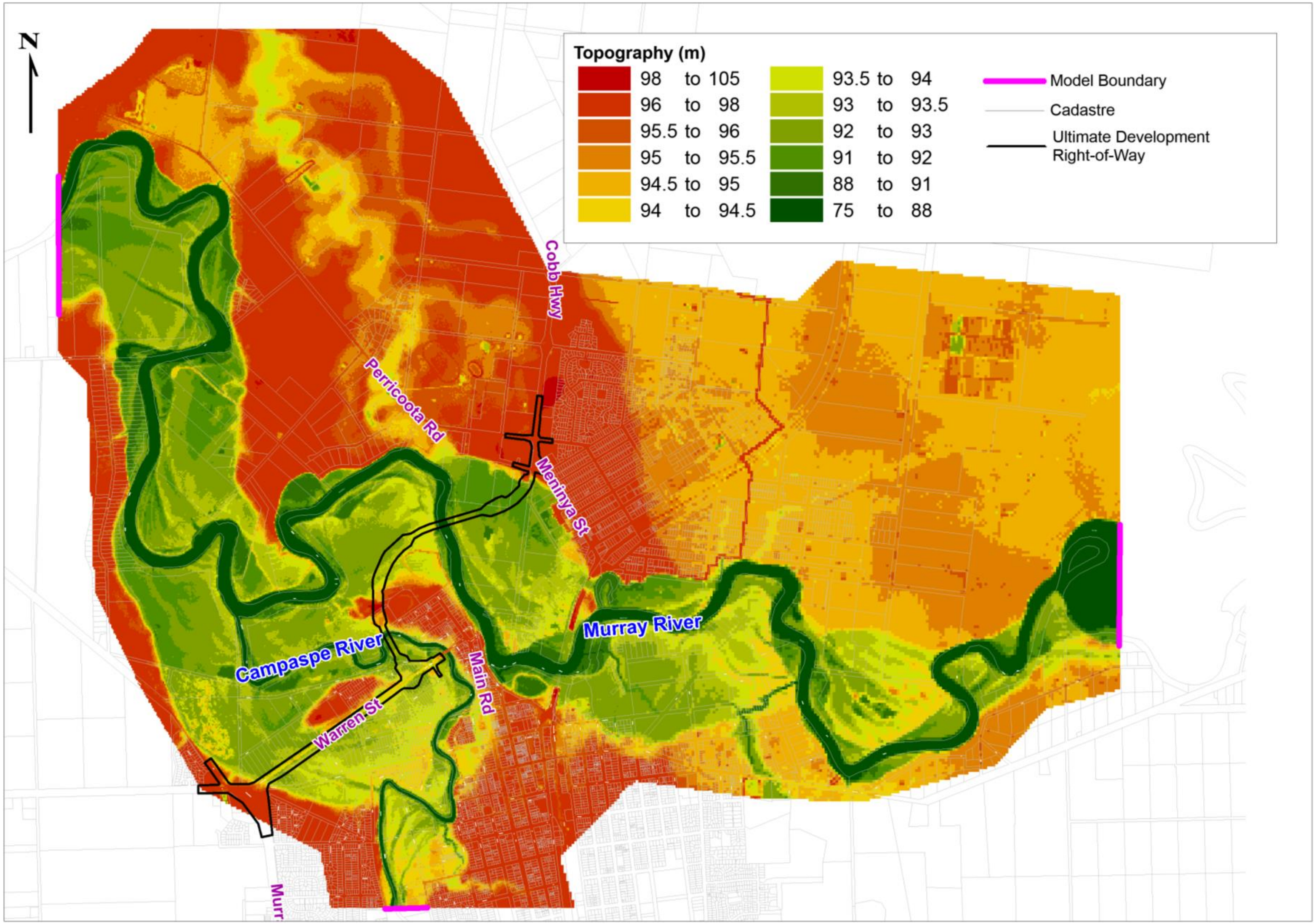

Figure 2 Study Area Map

3 Existing Conditions

3.1 Overview

The existing conditions for the Study Area were developed by assessing the Murray River and Campaspe River systems for a range of flood conditions. The Study Area is comprised of two river systems, the Murray River floodplain and the Campaspe River floodplain. The Murray River is the larger of the two systems and the Campaspe River confluence with the Murray River is downstream of the Echuca-Moama township.

The Murray River is Australia's longest river at over 2,500 km in length. At Echuca the upstream catchment is highly regulated due to large dams, the most significant includes Lake Hume. The regulated nature of the system and the large catchment area result in long warning times for flooding and a slow rise in peak flood levels. Flood levels can remain elevated for long durations extending into weeks for widespread flood events upstream of Echuca. The Murray River floodplain at Echuca is over 1 km wide and the primary gauge at the Echuca Wharfe has flood warning levels including:

- Minor at 93.50 m AHD
- Moderate at 93.90 m AHD
- Major at 94.40 m AHD

The most recent large flood was in January 2011 and this flood reached a peak level of 92.85 m AHD at the gauge which was below the minor flood risk at the gauge. Flood conditions within Echuca are dependent on inflows from local tributaries, the most significant include the Goulburn River and the Campaspe River.

The Campaspe River catchment extends from the Great Dividing Range in the south to the Murray River in the north, a total distance of approximately 150 km. The catchment has an average width of 25 km and a total area of approximately 4,000 km^2. The Campaspe River flows a length of 240 km from the headwaters of the catchment near Woodend, joining with the Coliban River at Lake Eppalock before entering the Murray River downstream of Echuca (North Central Catchment Management Authority, 2015).

The Murray River and Campaspe River flow year round, with both Rivers being a multi-use resource that have beneficial uses including:

- irrigation;
- domestic, industrial and stock water supply;
- recreation and leisure; and
- habitat.

The Preferred Alignment would be required to cross both the Murray River and Campaspe Rivers only once and the Preferred Alignment is shown in Figure 2. The Murray River crossing is located downstream of the main Echuca township and the Campaspe River crossing would be downstream of the existing Campaspe River bridge on Warren Street.

The method for assessing the Preferred Alignment associated with the hydrology and groundwater involves first defining the existing flooding conditions based on current hydrology and landform. These conditions form the basis for assessing the Preferred Alignment to determine if there is likely to be any impact to the peak flood levels or behaviour. Bridge spans and mitigation structures for conveying the floodwater are then used to return the flood behaviour back to as near as possible to existing conditions.

This section outlines the development of the hydrology and hydraulic model used to define the existing conditions for the assessment of the required mitigation structures in the Preferred Alignment and Ultimate Duplication.

3.2 Previous Studies

It is important for this study to note the history of the Echuca-Moama bridge investigation as this is where a large amount of the calibration and validation of the hydrology and hydraulic models has been undertaken. Importantly the hydrology throughout the entire process has remained constant to provide a consistent platform for assessing the historically proposed alignments through to the current Preferred Alignment. The hydrology has also remained constant because the system is underpinned by a robust assessment that is still valid for the current assessment due to the size and stability of the Murray River and Campaspe River systems.

The hydrology through the various stages of investigation have been based on the following study:

- Moama-Echuca Flood Study, prepared by SKM for the Department of Land and Water Conservation, NSW, and the Department of Conservation and Natural Resources, Vic, May 1997 (SKM Moama-Echuca Flood Study (1997)).

The SKM Moama-Echuca Flood Study (1997) was used to derive the hydrology for the assessments which, due to the interaction of the Murray River and Campaspe Rivers, is very complex. Details of the hydrology are discussed in Section 0.

Since 2009, Cardno have undertaken three major studies to identify and assess various alignments. Each of these studies has been through rigorous review and through the required approvals process. The studies preceding this EES included:

- Detailed Hydrology Study for the Echuca-Moama Bridge Planning Study – LJ5598 / RM2194 Final v1.1 (Cardno, 2009).
- Addendum: Detailed Hydrology Study for the Echuca-Moama Bridge Planning Study – LJ5598 / RM2277 Final v1.0 (Cardno, 2010).
- Detailed Hydrology Study for the Echuca-Moama Bridge Planning Study – Mid-West 2 Alignment – LJ5748 / RM2336 Final v1.0 (Cardno, 2013).

Through these studies Cardno have undertaken site inspections with VicRoads and now have a strong understanding of the required bridge spans and mitigation structures required to ensure levels reached during flood conditions are not significantly altered due to the Preferred Alignment.

3.3 Hydrology

The hydrology of the Murray River and Campaspe River is complex due to the interactions of the Murray River floodplain with the Campaspe River floodplain. This interaction results in a range of flood conditions which can result in varying flood impacts for Echuca-Moama. For NSW the flood impacts from the hydrology are a direct result of flooding from the Murray River system. For Victoria the flooding is a result of both flooding occurring in the Murray River and in the Campaspe River.

The basis of the hydrology was taken from a detailed investigation of the hydrology in the SKM Moama-Echuca Flood Study (1997). The analysis in that report was based on a Flood Frequency Analysis (FFA) with over 100 years of data (1865-1996), and tested using hydraulic modelling methods. The hydrology for the Murray River and Campaspe River systems is stable and as such this study is appropriate to provide the basis for the hydrology for the assessment. The key hydrological findings of the Moama-Echuca Flood Study (SKM, 1997) are summarised as follows:

- the determination of flood flow in the area is complex due to the interaction between the Campaspe River and Murray Rivers.
- the design levels were translated to an estimated rating-curve giving the expected flow at each gauge height as shown in Table 1.
- a wide range of Murray River flows can create similar levels at the Echuca gauge (located at the Echuca Wharf), depending on the flows of the Campaspe River.
- peak flood flows in the Campaspe River generally arrive at Echuca prior to peak flood flows in the Murray River (an average lag time of 6 days was assumed).
- the 100 year Average Recurrence Interval (ARI) level of 95.45 m AHD gives an estimated flow at the Echuca gauge of 1,431 m^3/s. However, other results in the SKM Moama-Echuca Flood Study (1997) report indicate the flow in the Murray River for an equivalent gauge height ranges from 1,128 to 1,310 m^3/s.

Table 1 Design Flows and Levels as per the Moama-Echuca Flood Study

Design ARI (Years)	Estimated Murray Flow (m^3/s)	Design Peak Levels at Echuca Wharf (m AHD)
10	1,055	94.45
20	1,195	94.85
50	1,343	95.20
100	1,431	95.45
200	1,505	95.60

In order to address the hydrological issues when assessing the impact of the proposed works for the project, consideration of a range of flood events was required. To ensure that peak flow and floodplain storage are appropriately taken into account various flood scenarios that can produce the peak flood-level at the Echuca gauge have been considered. This envelope of flood events modelled includes three scenarios:

- Scenario 1: A high flow event in the Murray River with no flooding in the Campaspe River.
- Scenario 2: A high level was assumed in the Murray River with a lower peak flow rate. This scenario represents longer duration flood events and double peaked flood events.
- Scenario 3: An event where the Murray River has elevated flood levels and a large Campaspe River event occurs.

These three scenarios capture the combination of flood events in the Murray River and Campaspe River system that will cause the highest flood levels associated with the design recurrence interval of the events. These events are the worst case scenarios to ensure that the Preferred Alignment is designed to facilitate all combinations of events up to the design recurrence intervals.

For hydrological analysis it is important to note that no two flood events are ever the same due to the complexity of catchment antecedent conditions, spatial and temporal variability of rainfall and the complex operation of the river systems (i.e. dams, reservoirs, extractions and so forth). In this case the timing of the

Campaspe River peak flows and the Murray River peak flows is another important driver of the peak flood level reached for the Study Area. The three events simulated for the design recurrence intervals capture the most extreme combination of flood events and as such they constitute the worst case scenario for a given recurrence interval. It is important to capture these extreme peaks in the design of the mitigation to ensure the Preferred Alignment meets the entire range of events that could be experienced for the Study Area for the design recurrence intervals (20, 50 and 100 year ARI events).

The flow rates and downstream levels for the 20, 50, 100 year ARI's for each scenario are shown in Table 2. These scenarios provide the flows and levels within the system that result in the flood levels required to be assessed for this EES.

Table 2 Design event model run parameters

	100 year Scenario			50 year Scenario			20 year Scenario		
Scenario	1	2	3	1	2	3	1	2	3
Murray Flow (m^3/s)	1431	1000	50	1343	900	50	1195	780	50
Campaspe Flow (m^3/s)	40	40	1175	40	40	950	40	40	675
Downstream conditions (m AHD)	94.2	95.0	95.0	93.65	94.75	94.75	92.6	94.35	94.35
Modelled peak flood level (mAHD)	95.46	95.44	N/A	95.22	95.20	N/A	94.87	94.84	N/A

The modelled peak flood levels shown in Table 2 are within +/- 0.02 m of the design peak flood levels for Scenarios 1 and 2. This comparison between the modelled peak flood levels and the predicted design levels forms the basis of the calibration and validation of the model parameters as the design events form the extreme envelope of potential flood events for the study area.

These scenarios provide an envelope that adequately caters for the high flows found in a large single storm-event (Scenario 1) and the effect of flood storage and high tailwater levels that occur during a longer term flood event (Scenario 2). This approach is consistent with the findings of the SKM report which showed that the joint occurrence of various flow combinations in the Murray and Campaspe (the Campaspe flows effectively contributing to a higher tailwater level) could cause the 1% AEP flood level at Echuca. The high flow in the Campaspe (Scenario 3) ensures that the critical events for the Campaspe Floodplain are modelled.

To put the design flows in context, the most recent large flood events at Echuca of January 2011 reached a peak flood level of 92.85 m AHD which is well below the flood levels being assessed in this study. The majority of damage caused during this event was due to the peak flood levels from the Campaspe River rather than the Murray River. The minor, moderate and major flood warning levels are set at 93.50 m AHD, 93.90 m AHD and 94.40 m AHD at the Murray River at Echuca gauge respectively. The flood events being assessed for the EES exceed the major peak flood levels at Echuca.

3.3.1 Hydraulic Model Setup

The hydraulic model was built using the SOBEK modelling package. SOBEK is a hydraulic modelling package that is capable of solving unsteady 1D / 2D hydraulic modelling systems. The software is a well established and rigorously tested modelling package that provides a stable and robust hydraulic modelling system. The system has been represented using known information regarding the river cross sections, bridges, culverts and surface elevations. This information has been used to develop the unsteady 1D / 2D hydraulic model for the system which is then used to simulate the hydrology as described.

The existing ground surface elevations were generated from:

- Land survey provided by VicRoads in December 2008; and
- 1m elevation grid provided by the North Central CMA in January 2009. This data originates from the Murray Darling Basin Authority, and was captured in 2001.

The hydraulic model was first developed in 2009 when it was calibrated and validated to historical flood events to verify that it was reproducing existing conditions as expected. The model has since been refined and extended during 2012 to include a larger Study Area. The model was again calibrated and validated and subject to peer review as part of this process. The peer review process was undertaken by VicRoads and the North Central Catchment Management Authority who provided external review of the model calibration. The current model and surface elevations are shown in Figure 2.

The current hydraulic model uses a 10m x 10m grid cell for the immediate Study Area and a 20m x 20m grid cell for the extended upstream area to represent the 2D ground surface. The roughness of the ground surface (a measure of the resistance the ground surface has on water flowing over it) is controlled using a parameter called Mannings' roughness. The roughness was calibrated using known flood levels associated with a range of historic events. All structures and elements within the model have been cross checked using manual hydraulic assessment.

The model was simulated using a constant upstream flow boundary and fixed water level downstream as stated in Table 2. The use of constant flow rates and downstream boundaries is appropriate for this system due to the extended time of inundation during a flood event.

3.3.2 Existing Conditions (ie. No Project Option) Model Results

The existing conditions or "No Project Option" model results were developed using the hydrology outlined in Section 0 and the peak flood levels have been developed based on the maximum flood depths from the three scenarios run for the 20, 50 and 100 year ARI events. The peak depth plots are presented in:

- 20 year ARI conditions (Figure 3);
- 50 year ARI conditions (Figure 4); and,
- 100 year ARI conditions (Figure 5).

Water surface elevations (WSE) in mAHD are also shown at key locations to assist with road design purposes. It can be seen from the results figures that the flood extents for all of the events do not vary significantly. The main difference is the increase in flows in the break-out from the Murray River across Perricoota Road as the ARI increases.

Much of the Murray floodplain has depths above 1.5 and 2.5 m in the 20 and 100 year ARI events respectively. The Murray River and the Campaspe River floodplains are separated by a ridge that passes through the corner of High St. and Warren St. This ridge is not overtopped in the 100 year ARI event (Figure 5). The existing conditions results show that the caravan park is not flooded in the 20 year ARI event due to a levee surrounding this location, but is flooded to depths greater than 1.5 m in the 50 and 100 year ARI events as this levee is overtopped.

Much of the Campaspe River floodplain has depths above 0.5 and 2 m in the 20 and 100 year ARI events respectively. The Campaspe River floodplain is split into two branches by a raised area around Homan Street and the Echuca Cemetery. Warren Street is a key hydraulic control in the Campaspe River floodplain and as such is an important part of the assessment of the Preferred Alignment and Ultimate Duplication. Figure 3 shows that Warren Street currently overtops in the 20 year ARI event.

It should be noted that the results shown here are the upper estimate of the peak flood levels associated with each of the design events. For example if a 20 year ARI flood event occurred on the Campaspe River when the Murray River was not in flood then levels would be likely to be lower than those shown. It is necessary as part of this Hydrological and Groundwater Impact Assessment to consider the worst case scenario for each design event for design purposes.

The velocity of floodwaters in the Murray and Campaspe floodplains is approximately 0.3 and 0.4 m/s respectively. Within the main river channels velocities can reach above 1.0 m/s however they are typically below 1.5 m/s.

Downstream of the confluence of the Campaspe and Murray Rivers the floodplain is well-defined and narrow (for the Murray River system at approximately 1 km across). In this area depths are generally above 1.5 m and 3 m in the 20 and 100 year ARI events respectively.

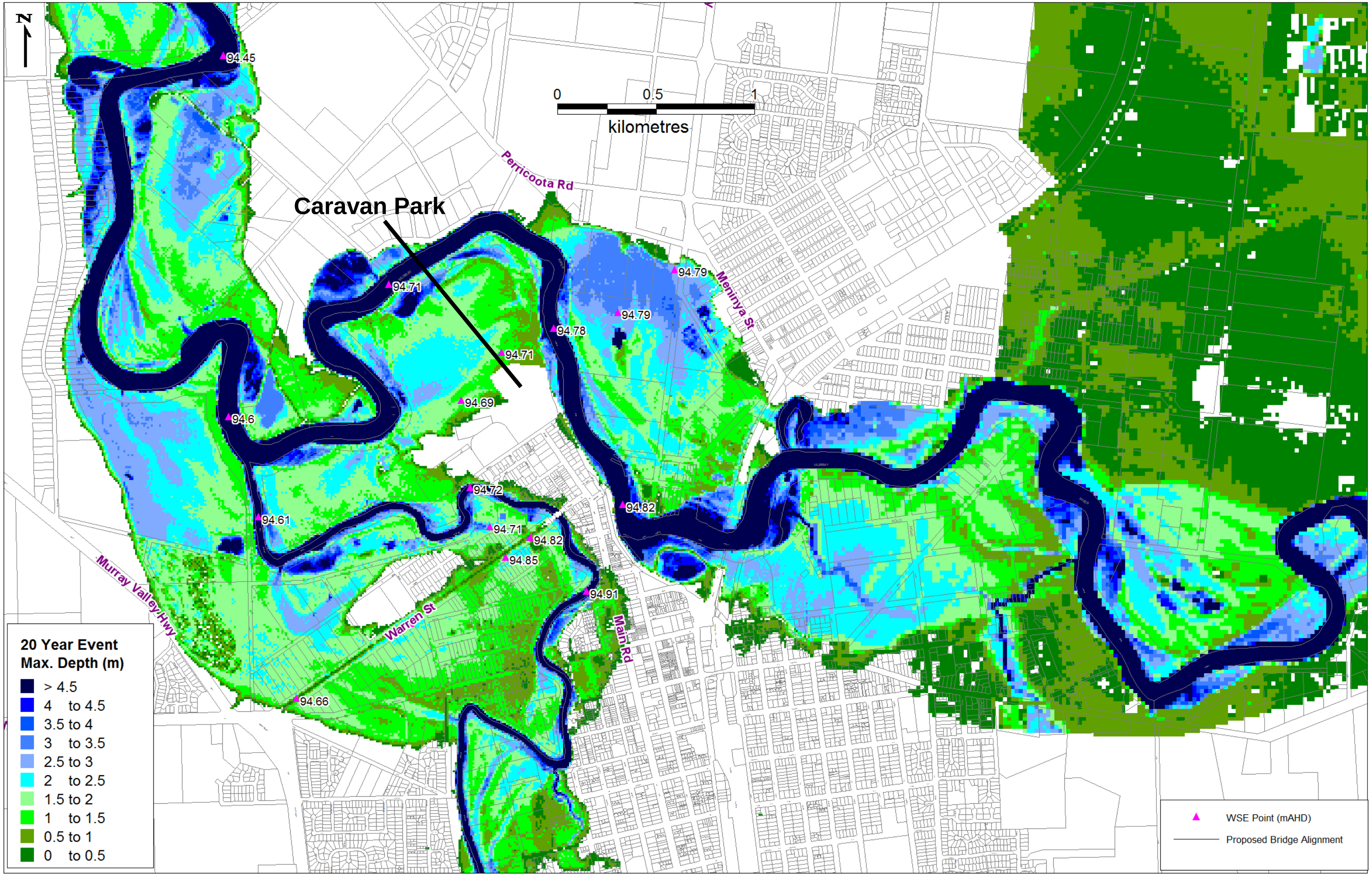

Figure 3 Existing conditions (No Project Option) – 20 year ARI

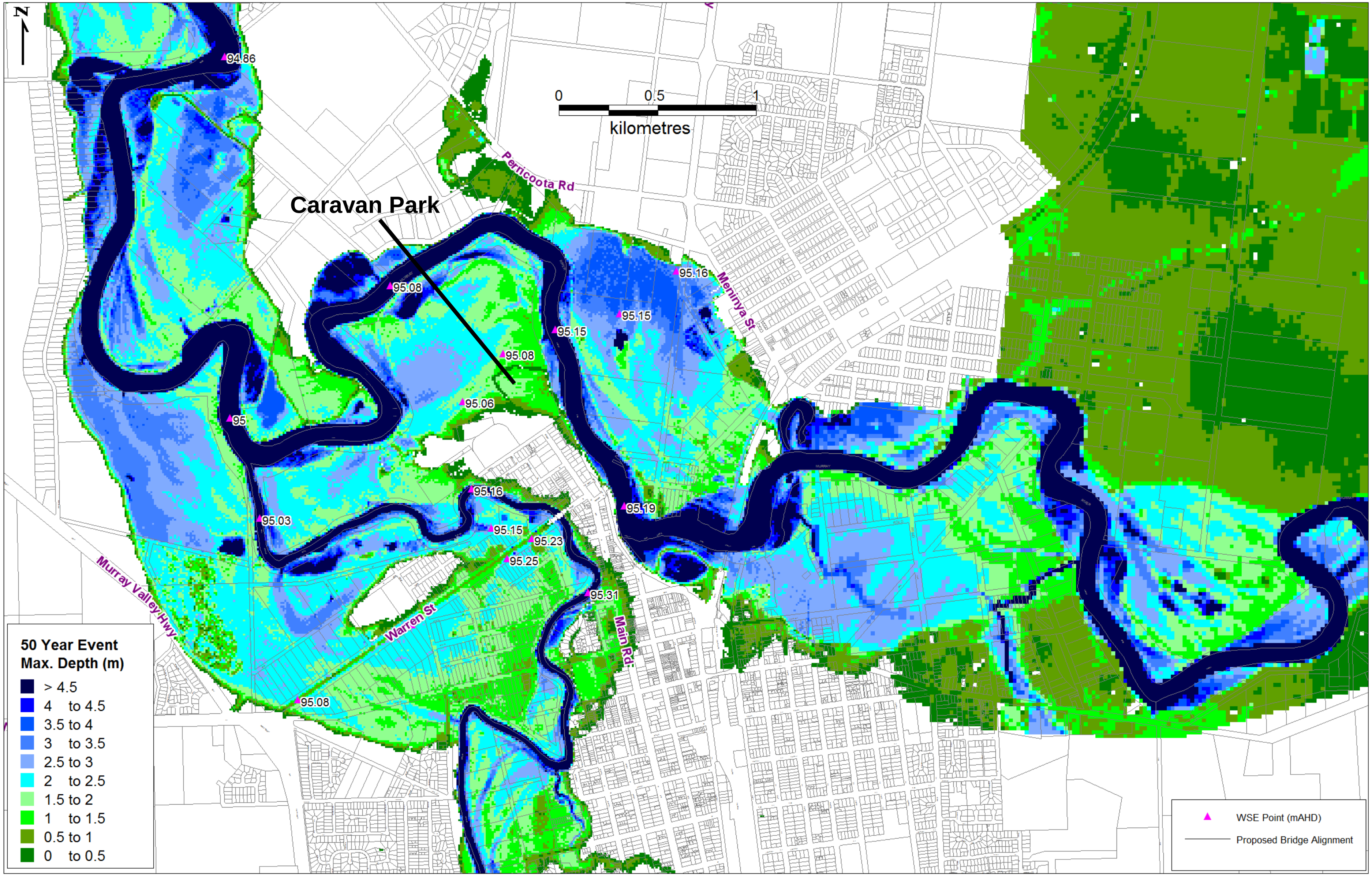

Figure 4 Existing conditions (No Project Option) – 50 year ARI

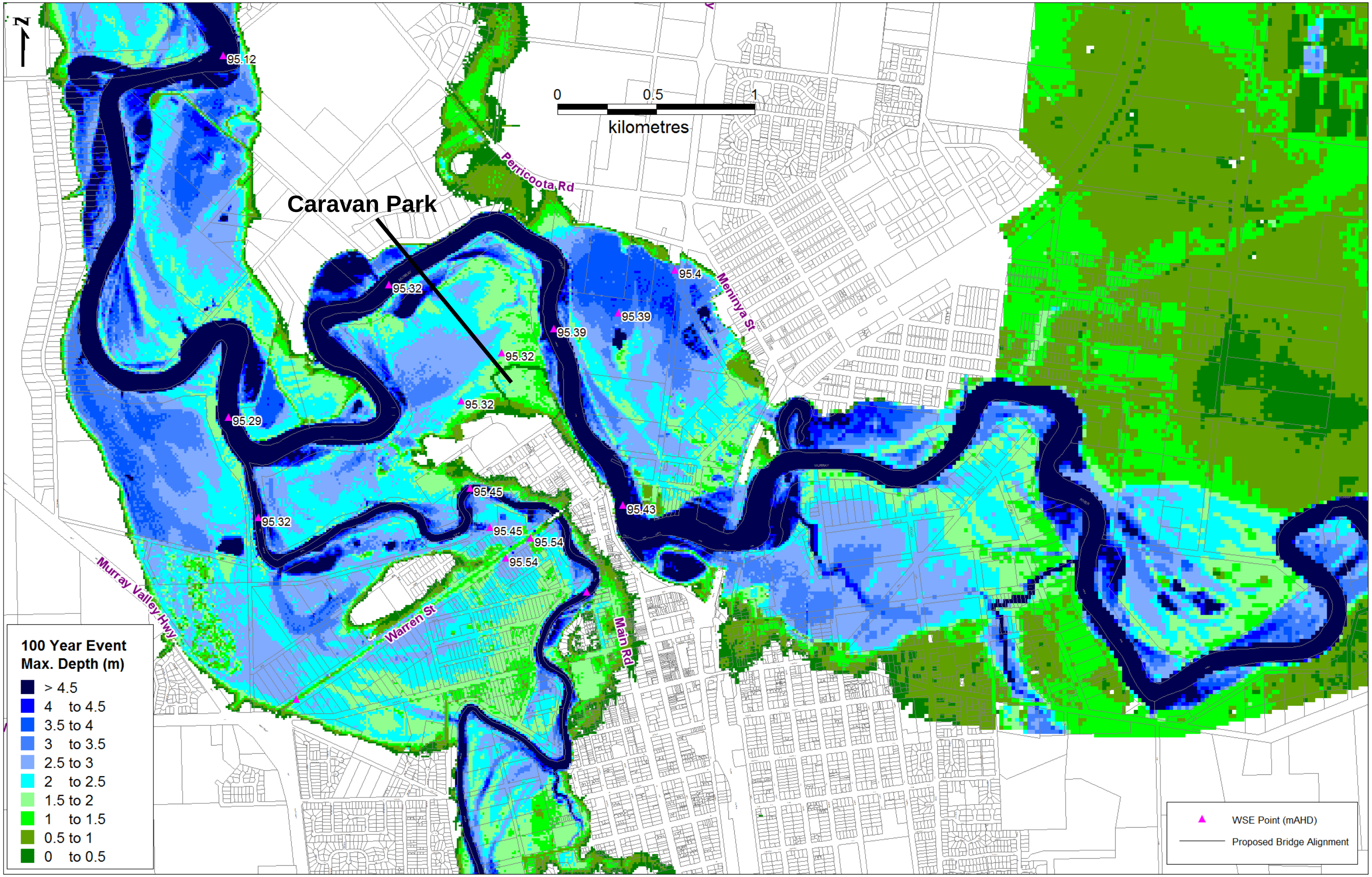

Figure 5 Existing conditions (No Project Option) – 100 year ARI

3.4 Groundwater

Existing conditions (No Project Option) groundwater conditions have not been directly assessed as part of this report. These have been presented within the Soils and Geology (VicRoads 2015) report associated with this EES. Based on records held by the Department of Environment, Land, Water and Planning (formerly the Department of Environment Primary Industries) , the hydrogeology of the Study Area is based upon a number of principal aquifer systems. These include:

- shallow and water table aquifers (Shepparton Formation and Coonambidgal Formation), and
- deep confined aquifers (Renmark Group and Murray Group Calivil Formation, and Basement aquifers).

Within the Geology and Soils Report it is noted that the groundwater (Coonambidgal Formation) has a saline content up to 20000 mg/l TDS. Adjacent to the Campaspe and Murray Rivers the water table is close to the ground surface as this links directly with the water surface levels within the rivers.

3.5 Study Area Characteristics

The existing flood conditions are a combination of the outputs of the three types of dominant event as described in Section 0, and as such define the peak water surface elevations likely to be experienced during the three extreme combinations of events (combination of conditions in the Murray River and Campaspe River) modelled for each ARI.

The current assets, values and uses of the land within the Project Area are known as the ‘existing conditions’. These conditions are the baseline against which the potential impacts of the Project have been assessed. Existing conditions of the broader floodplain are relevant in this instance as the impacts of introducing the Preferred Alignment structure to the floodplain can impact peak flood depths a substantial distance from the structure.

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4 EES Scoping Requirements

4.1 EES Evaluation Objectives

For the hydrology aspects of the Echuca-Moama Bridge, the relevant draft evaluation objective as outlined in the EES Scoping Requirements is based on the overall catchment values with an objective to maintain floodplain functions, hydrology, values of surface water, groundwater and geomorphic stability of proximate sections of the lower Campaspe and Murray Rivers.

4.2 EES Scoping Requirements

The EES Scoping requirements specific to the scope of this Hydrological and Groundwater Impact Assessment are as follows:

Key Issues

- Potential for the Project to have significant effects on the functions, values and beneficial uses of surface water and geomorphic stability of proximate sections of the lower Campaspe and Murray Rivers.
- Potential for the contamination of soils and groundwater from construction and operation activities, including the exposure and disposal of any waste or contaminated soils.

Priorities for characterising the existing environment

- Identify and characterise relevant surface water and floodplain environments, including in terms of the existing drainage functions, geomorphology and behaviour.

Design and mitigation measures

- Identify proposed measures to mitigate any potential effects, including any relevant features or preventative techniques to be employed during construction.

Assessment of likely effects

- Identify potential effects on the functions, values and beneficial uses of surface water and geomorphic stability of proximate sections of the lower Campaspe and Murray Rivers.

Approach to manage performance

- Identify any additional measures to manage and monitor effects on catchment values and identify likely residual effects.

5 Legislation, Policies and Guidelines

As part of the Impact Assessment for the Project, it has been necessary to review and consider any relevant legislation, policies or guidelines that apply, including:

- The Water Act (1917) and the water Management Act 2000 (NSW);
- Environment Protection Act 1970, including relevant State Environment Planning Policy (SEPP) guidelines;
- the Water Act 1989 (Victoria);
- the North Central Regional Catchment Strategy 2013-2019;
- Victorian State Planning Policy Framework;
- Campaspe Planning Scheme; and,
- Murray River Local Environment Plan (LEP).

5.1 Commonwealth

There are no relevant Commonwealth legislative requirements for the Hydrological and Groundwater Impact Assessment.

5.2 State

State based legislation forms the framework for many of the local planning controls, however there are some guidelines that provide an overarching guide to the objectives within this study. The issues and implications are summarised with the relevant objective and aim. The aims for both Victoria and NSW are generally aligned in that the aim is to ensure that there is limited impact to existing flooding and to the local environment.

Specific legislation is outlined in Table 3.

Table 3 State based laws and policy

Legislation, Policy or Guideline	Issue	Implication for Project
Water Act 1917 (NSW) & Water Management Act 2000 – Division 5 Floodplain Management (NSW)	Avoid intensifying the impacts of flooding through development of structures in land subject to flooding.	Ensure the Preferred Alignment does not increase or adversely change flooding behaviour.
Water Act 1989 – Section 208 (Vic)	Avoid intensifying the impacts of flooding through development of structures in land subject to flooding.	Ensure the Preferred Alignment does not increase or adversely change flooding behaviour.
Environment Protection Act 1970 (Vic) (EP Act) – Section 38 and 39 (Vic)	The discharge or deposit of wastes into waters of the State of Victoria shall at all times be in accordance with declared State Environment Protection Policy or waste management policy specifying acceptable conditions for the discharge or deposit of wastes into waters in the environment and shall comply with any standards prescribed under the EP Act.	Assess the alignment to avoid impacting the environmental qualities of the waterways.
SEPP (Waters of Victoria)	Guideline targets for water quality for the Murray River floodplain in the Campaspe region. Total Phosphorus 45 μgL^{-1} for the 75^{th} percentile of annual monitoring data sets. Total Nitrogen 900 μgL^{-1} for the 75^{th} percentile of annual monitoring data sets. Dissolved Oxygen saturation should be 80% at the 25^{th} Percentile and 110% maximum. Turbidity should be 30 NTU at the 75^{th} percentile of annual monitoring datasets. Electrical conductivity should be 1500 $\mu S\ cm^{-1}$ at the 75^{th} percentile of annual monitoring datasets. pH should be 6.5/8.3 for the $25^{th}/75^{th}$ percentile respectively of annual monitoring datasets.	Assess releases from the Study Area to ensure these will not prevent the objectives stated for the Murray River floodplain from being met.

State Planning Policy Framework (SPPF) 13.02-1 Floodplain Management	Avoid intensifying the impacts of flooding through inappropriately located uses and developments.	Ensure the Preferred Alignment does not increase or adversely change flooding behaviour.
State Planning Policy Framework (SPPF) 14.02-1 Catchment Planning and Management	Ensure that works at or near waterways provide for the protection and enhancement of the environmental qualities of waterways and their instream uses. Ensure planning is coordinated with the activities of catchment management authorities. Require the use of appropriate measures to restrict sediment discharges from construction sites.	Assess the alignment to avoid impacting the environmental qualities of the waterways. Ensuring planning is coordinated with the catchment management authority. Ensure that there is no impact due to sediment contamination from the construction.
State Planning Policy Framework (SPPF) 14.02-2 Water Quality	Ensure that land use activities potentially discharging contaminated runoff or wastes to waterways are sited and managed to minimise such discharges and to protect the quality of surface water and groundwater resources, rivers, streams, wetlands, estuaries and marine environments.	Ensure that adequate facilities are in place to manage potential contamination from the Preferred Alignment.

5.3 Local

For the Study Area the local controls are placed around the use of flood prone land and on any impacts to the floodplain. In place are local environmental plans for the Murray River and Local Government Area development controls. The aims for both local Victorian and local NSW policy are generally aligned in that the aim is to ensure that there is limited impact to existing flooding and to the local environment.

The main clauses to be addressed in this study are summarised in Table 4.

Table 4 Local planning controls, laws and policy

Legislation, Policy or Guideline	Issue	Implication for Project
Murray Local Environment Plan 2011 7.8 Flood Planning	Avoid adverse impacts to flood behaviour and is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties.	Ensure the Preferred Alignment does not increase or adversely change flooding behaviour.
Murray Local Environment Plan 2011 7.6 Additional Provisions	To manage and maintain the quality of water in the Murray River, To protect the environmental values and scenic amenity and cultural heritage of those rivers, To protect the stability of the bed and banks of those rivers, to limit the impact of structures in or near those rivers on natural riverine processes and navigability of those rivers.	Ensure the Preferred Alignment does not impact on the quality of the river and does not impact the banks of the Murray River.
Campaspe Planning Scheme 37.03 Urban Flood Zone, 44.03 Floodway Overlay and 44.04 Land Subject to Inundation Overlay	To ensure that any development maintains the free passage and temporary storage of floodwater, minimises flood damage and is compatible with flood hazard, local drainage conditions and the minimisation of soil erosion, sedimentation and silting.	Ensure the Preferred Alignment does not increase or adversely change flooding behaviour.
Campaspe Planning Scheme 37.03 Urban Flood Zone, 44.03 Floodway Overlay and 44.04 Land Subject to Inundation Overlay	To ensure that development maintains or improves river and wetland health, waterway protection and flood plain health.	Ensure the Preferred Alignment does not impact on the quality of the river and groundwater and does not impact the banks of the Murray and Campaspe Rivers.

Campaspe Planning Scheme Schedule 1 to the Environmental Significance Overlay	To promote consistent planning and management along the Murray River corridor. To protect the environs of the Murray River recognising its importance for nature conservation, flooding, economic development, recreation and tourism. To protect and enhance the biodiversity, ecological, and cultural values of waterways. To prevent development of land adjoining the river from degrading water quality.	Ensure the Preferred Alignment does not impact on the function, quality of the river and groundwater and does not impact the banks of the Murray and Campaspe Rivers.

6 Hydrological and Groundwater Impact Assessment

The detailed Hydrological and Groundwater Impact Assessment documented in this report addresses the potential hydrology and groundwater impacts of the construction and operation of the Project.

The impacts of the Project, together with proposed mitigation measures, are considered in detail through the environmental risk assessment process. The details of the risk assessment process undertaken for the Project are outlined in the EES.

Relevant sections of the environmental risk register are provided in this report and the identified impacts of the Mid-West Option are considered in detail in the following sections.

6.1 Benefits and Opportunities

The Preferred Alignment provides a number of benefits to the township of Echuca-Moama. The primary benefits include:

- providing a second flood evacuation route up to the 100 year ARI event for the main township of Echuca. This is particularly important for temporary residents (due to tourism) who may have low flood awareness and preparedness.
- the Preferred Alignment will have spill containment basins from the proposed second bridge to reduce the risk of contaminants from accidents reaching the Campaspe River or Murray River.
- if the recommended mitigation structures are incorporated into the design then the result would be increased flood protection of Warren Street. The upgrades to the mitigation structures under Warren Street would manage more frequent events more efficiently and offer more protection to Warren Street. This is due to the requirement to pass the 100 year ARI event flows. The flood levels are largely unchanged in the 100 year ARI, however in more frequent events (i.e. < 20 year ARI) flood waters are more efficiently conveyed under the roadway.
- potential for reduced economic damages for Warren Street as the road is to be designed to withstand overtopping to improved standards (relative to the current road) which will reduce the likelihood of damage in a flood event. Sections of the road are also raised to above the 100 year ARI event which further reduces the likelihood of flood damage.

6.2 Impacts

The impacts to be addressed as part of the hydrology and groundwater assessment include:

- Flood impacts – ensuring the existing flood conditions are not altered or impacted by the Proposed Alignment.
- Construction impacts – ensure the risks associated with construction are managed appropriately.
- Operation impacts – ensure the risks with the operation of the bridge are managed appropriately.
- Groundwater impacts – ensuring the existing groundwater conditions not altered or impacted by the Proposed Alignment.
- Scour impacts – Ensure that the Proposed Alignment manages the risk for scour during floods.

The Impact Assessment primarily examines the Ultimate Alignment for the impacts as this stage of the alignment is likely to have the highest potential for impact to the Study Area. In particular the Ultimate Alignment is required to be assessed hydrologically to ensure the ultimate duplication does not impact flood behaviour. An assessment of each of the Impact Assessment sections are presented below.

6.2.1 Flood Impacts

The impact to the existing flood levels caused by the introduction of the new bridge structure and raised roads to the floodplain must be mitigated. State based legislation for both NSW and Victoria specify that development within the floodplain must ensure that there is no impact to the floodplain and other properties as a result of the proposed development.

The impacts to the floodplain have been mitigated through the use of bridge spans over the Murray River and Campaspe River, with additional openings within the floodplain. Along Warren Street bridges or culverts are proposed to pass floodwaters and the locations and size of the proposed mitigation are shown in Figure 6. Details of the bridge spans has been summarised in Table 5.

Warren Street is a hydraulic control across the Campaspe River floodplain. The Proposed Alignment results in the section between the link road and the existing Campaspe Bridge being raised above the 100 year ARI level. This results in an increased blockage within the floodplain which requires mitigation in the form of either culverts (or equivalent bridge structure). An assessment of the appropriate mitigation measure has been undertaken and the required culvert arrangement is summarised in Table 6. These culverts sets could equally be replaced by bridge structures with an equivalent waterway area. Bridge structures are less likely to be impacted by blockage but the cost of culverts or bridge structures is similar.

For culvert sets A and B (western culvert sets) it is noted that in the preliminary design supplied by VicRoads (design number SB20436-ECC-DM-0260_CLS) these have not been placed in the low points along Warren Street. It would be preferable if both of these culvert sets were relocated 80 m to the west of their current alignment (see Figure 6). Although the culverts maintain the flood conditions in extreme events in their current alignment, adjusting their location will increase their effectiveness during more frequent lower flow events and in managing localised drainage.

The initial construction of the Mid-West Option would provide one traffic lane in each direction. If required at some future time, the road would be ultimately duplicated. The mitigation options required above are for the Ultimate Duplication, however it should be noted that the initial construction phase would require the same mitigation as the Ultimate Duplication because the mitigation is required primarily due to the blockage of the overland flow path of floodwaters rather than the volumetric displacement of floodwaters due to the fill arrangement. The result of this is that the same mitigation is required for the initial construction phase and the Ultimate Duplication conditions for the Preferred Alignment.

Table 5 Proposed bridge span mitigation

Location	Mitigation	Details
NSW Floodplain	45m bridge	100 year ARI level plus freeboard
Murray River crossing	650m bridge	100 year ARI level plus freeboard
Victorian Floodplain near caravan park	65m bridge	100 year ARI level plus freeboard
Campaspe River crossing	300m bridge	100 year ARI level plus freeboard

Table 6 Proposed mitigation for Warren Street

Location	Set	No.	Width x Height	Waterway Width	Waterway Area	Comment
Warren Street culverts	A	40	2.7m x 0.9m	108.0 m	97 m^2	A bridge structure which has the same waterway area could also be used to mitigate the floodwaters
	B	40	2.7m x 0.9m	108.0 m	97 m^2	
	C	21	3.6m x 1.8m	75.6 m	136 m^2	
	D	19	3.6m x 2.4m	68.4 m	164 m^2	

The Ultimate Duplication was assessed using the hydraulic model for the Study Area for the 20, 50 and 100 year ARI event. The peak flood levels were determined from the hydraulic model and compared against the existing levels to determine the impact that the Ultimate Duplication has on the floodplain. The results of this assessment are presented in the form of a difference plot showing the Ultimate Duplication scenario peak water surface elevation less the existing conditions peak water surface elevation. These results are presented in:

- 20 year ARI results (Figure 7);
- 50 year ARI results (Figure 8); and
- 100 year ARI results (Figure 9).

In accordance with relevant Victorian and NSW legislation, the Ultimate Duplication must be approved by the North Central Catchment Management Authority (NCCMA) which is tasked with ensuring that development within the Flood Overlay (FO) and Land Subject to Inundation (LSIO) areas under the Campaspe Planning Scheme is acceptable with regards to flooding.

6.2.1.1 20 year ARI Results

The 20 year ARI results show that the Ultimate Duplication has only a small impact on the peak flood levels around the structure. Near the Murray Valley Highway end of Warren Street there is a reduction in flood depths of up to 6 cm. This reduction is due to the enlarging of the culverts in this area and is a benefit to the floodplain (although there are no properties in this area).

6.2.1.2 50 year ARI Results

The 50 year ARI results show that the peak flood levels under the Ultimate Duplication are largely maintained at current levels. An area near the link road roundabout extending approximately 120m from the roundabout shows increases in flood levels. These levels are all less than a +3 cm increase over existing levels. Properties that are near these increases include:

- 51 Warren Street (near Payne Street) – increase of +2.6 cm
- 279 Campaspe Esp. (the corner of Warren Street and Campaspe Esplanade) – increase of +2.8 cm

The property at 51 Warren Street has an approximate site level of 93.9 mAHD and this building has an elevated floor level (estimated from Google Streetview) of approximately 300 mm above this level. This sets the floor level at approximately 94.2 mAHD. This level is well below the current flood level for the 50 year ARI event at this location of 95.3 mAHD under existing conditions (ie. No Project scenario). The small increase in flood levels (+2.6 cm) is not expected to increase the damage to the property given the location is already severely impacted.

The property at 279 Campaspe Esplanade is built on a raised site set at an average elevation of 94.5 mAHD. The building on this site is not raised and is likely to be slab on ground. As no floor survey exists this is estimated to have a floor level of 94.65 mAHD (surface plus 150 mm for the slab). During the 50 year ARI event the peak flood level reached at this location is 95.2 mAHD under existing conditions (ie. No Project scenario). which is well above the estimated floor level. As such the small increase in flood levels (+ 2.8 cm) is not likely to increase the damage to the property as it is already severely impacted.

6.2.1.3 100 year ARI Results

The 100 year ARI results show that the majority of the peak flood levels are maintained within +/- 2.5 cm from existing levels across the floodplain under the Ultimate Duplication. As with the 50 year ARI results the levels near the proposed link road roundabout show some increases. The maximum increase in peak flood levels in this area are less than 5 cm and the increases extend approximately 300 m from the raised road section of Warren Street. The two properties in the area of increased levels include:

- 51 Warren Street (near Payne Street) – increase of +3.2 cm
- 279 Campaspe Esp. (the corner of Warren Street and Campaspe Esplanade) – increase of +2.8 cm

Further to the discussion about the 50 year ARI results above, these properties are impacted by peak water levels of approximately 95.5 mAHD in the 100 year ARI event. The depths over the floor of the properties exceeds 1m and the increases in flood depths are not expected to change the already severe damage to these properties.

6.2.1.4 Summary

Overall, the flood impacts are mitigated back to existing flood levels and the flood behaviour is not significantly altered across the floodplain, therefore there is no change to beneficial uses resulting from the Project. The predicted impacts of the Preferred Alignment meet the legislative requirements and have been approved by the NCCMA. The Project is expected to have minor flood impacts and no impact on the beneficial uses of surface water.

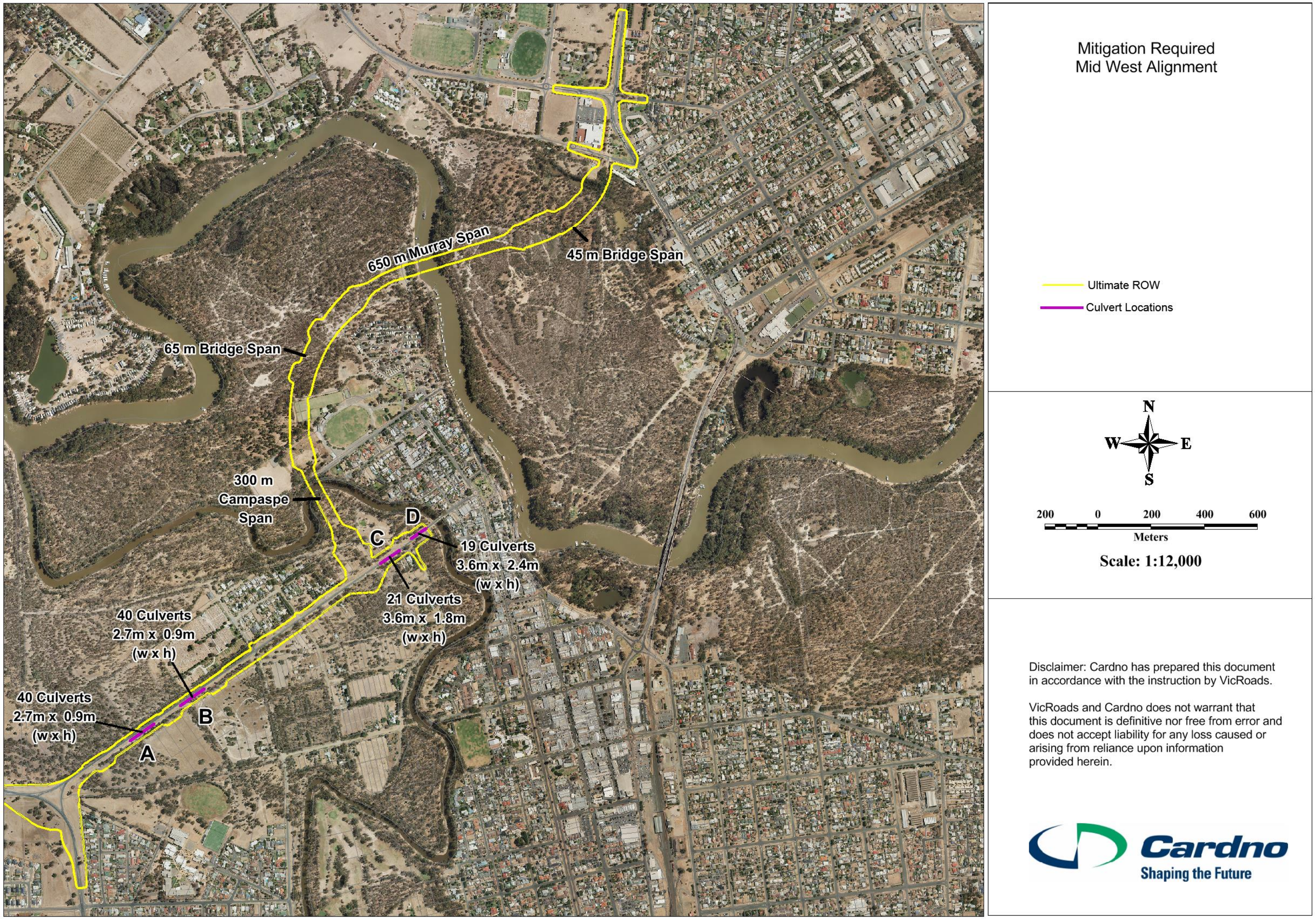

Figure 6 Proposed mitigation for the Preferred Alignment

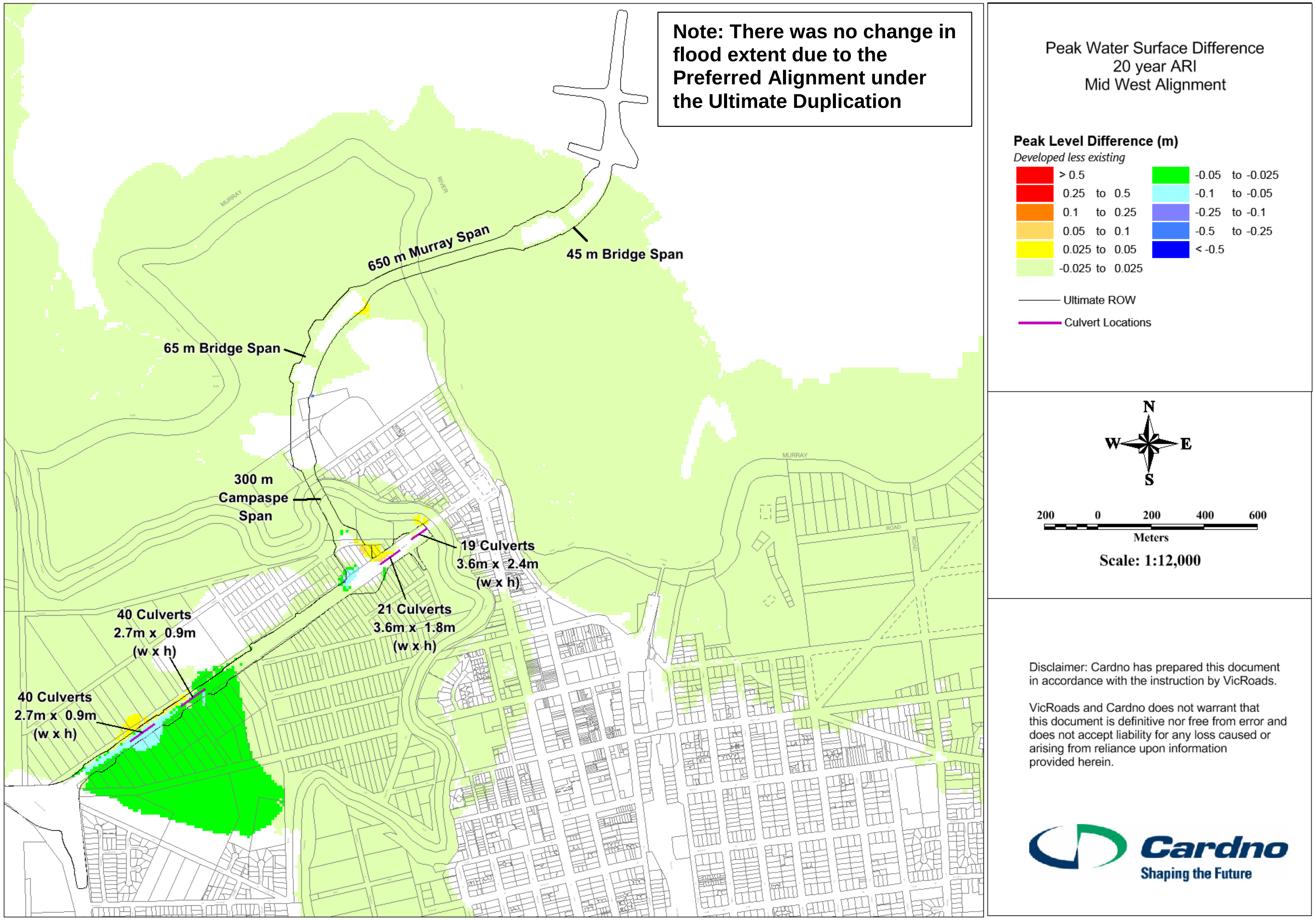

Figure 7 Flood Impact Assessment – 20 year ARI difference plot (Developed versus Existing)

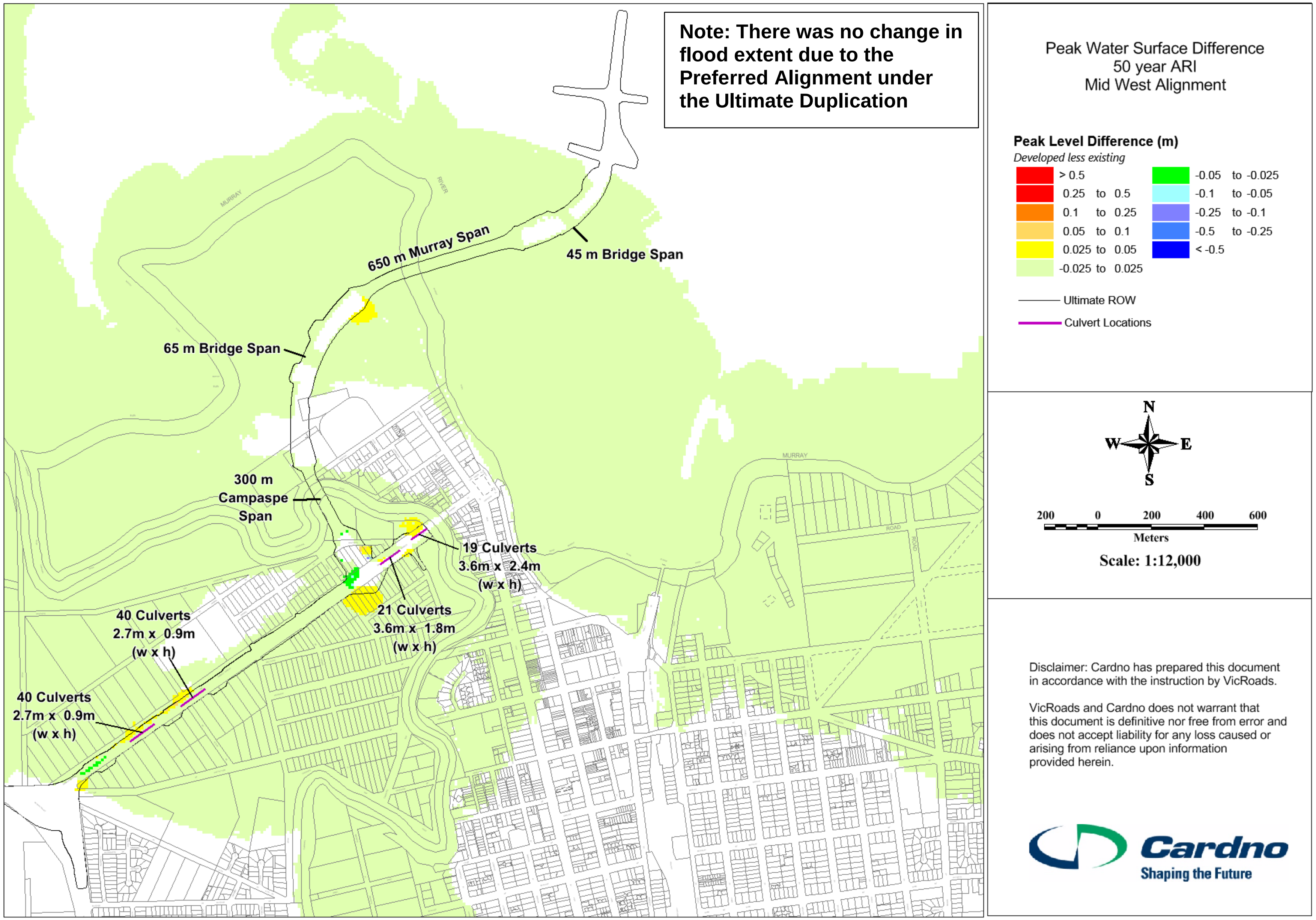

Figure 8 Flood Impact Assessment – 50 year ARI difference plot (Developed versus Existing)

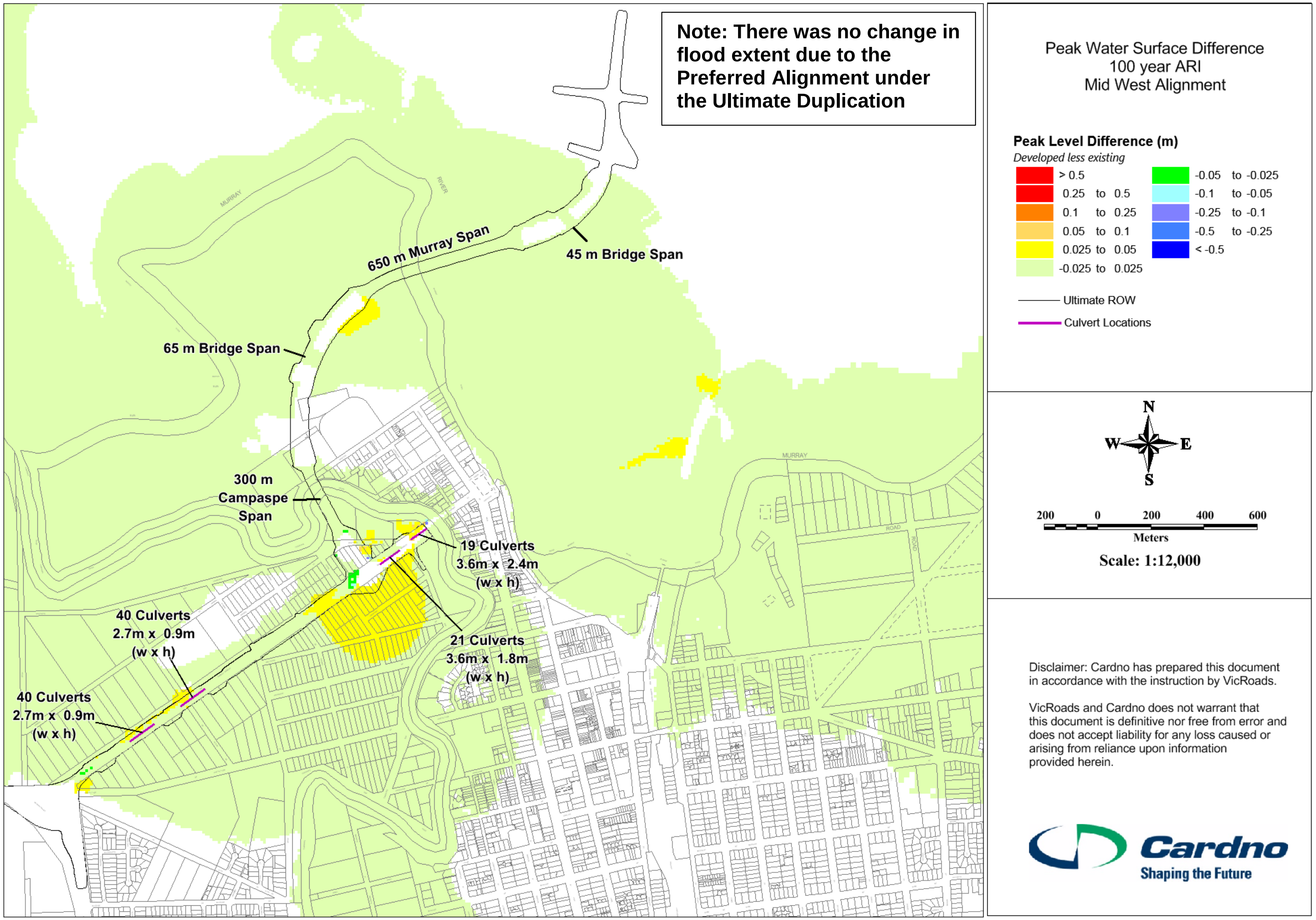

Figure 9 Flood Impact Assessment – 100 year ARI difference plot (Developed versus Existing)

6.2.2 Construction Impacts

The project would involve bridge crossings of the Murray River and Campaspe River. Further bridging and culverts would be provided over low lying flood prone land, providing adequate clearance for movement of flood waters. The piers of the Campaspe and Murray River bridges would be constructed outside of the river channel (summer flow / low water mark extent).

The proposed bridge over the Campaspe River is designed to fully span the river, without support structures in the river channel. At the Campaspe River, bridge piers would be located clear of the river banks to the north and south of the river.

The proposed bridge over the Murray River is designed to span the summer water level river channel, and support structures would not be required within the river channel, but are placed on the river bank above typical baseflow river level. A cantilever structure is proposed over the Murray River, with piers in the river banks supporting a 90-95m clear span over the river channel. The piers would be located above the normal summer flow (summer river water level).

Some construction works may be required on or near the banks of the Murray River. The construction process for Murray River Bridge piers would involve the installation of coffer dams in dry conditions if possible.

During the construction of the Preferred Alignment there is potential for impacting the local water quality and environment. The requirement that water quality is not impacted during construction, this is stated in both the NSW and Victorian based legislation. Specifically the following requirements are stated in both the state based and locally based legislation:

- Ensure that works at or near waterways provide for the protection and enhancement of the environmental qualities of waterways and their instream uses (Environment Protection Act 1970 (Vic), State Planning Policy Framework 14.02-1, Murray Local Environment Plan 2011 7.6, Campaspe Planning Scheme 37.03, 44.03 and 44.04 and Schedule 1 of the Environmental Significance Overlay).
- Ensure planning is coordinated with the activities of catchment management authorities (State Planning Policy Framework (Vic) 14.02-1).
- Require the use of appropriate measures to restrict sediment discharges from construction sites (Environment Protection Act 1970 Section 38 and 39, SEPP (Waters of Victoria), State Planning Policy Framework (Vic) 14.02-1), Murray Local Environment Plan 2011 7.6, Campaspe Planning Scheme 37.03, 44.03 and 44.04 and Schedule 1 of the Environmental Significance Overlay).
- Ensure that land use activities potentially discharging contaminated runoff or wastes to waterways are sited and managed to minimise such discharges and to protect the quality of surface water and groundwater resources, rivers, streams, wetlands, estuaries and marine environments (Environment Protection Act 1970 Section 38 and 39, SEPP (Waters of Victoria), State Planning Policy Framework (Vic) 14.02-1 and 14.02-2), Murray Local Environment Plan 2011 7.6, Campaspe Planning Scheme 37.03, 44.03 and 44.04 and Schedule 1 of the Environmental Significance Overlay).

To control the impacts associated with construction of the Preferred Alignment the planned controls to manage the impacts will be implemented. The VicRoads standard controls include:

- Utilising coffer dams when undertaking construction works in waterways or around the banks of the waterways.
- Construction site runoff is to be captured onsite and treated to SEPP guidelines (see Section 5).
- Ensure cleared vegetation is cut to ground level to stabilise the ground.
- Following works near river banks appropriate stabilisation measures are to be put in place.
- Where works are in, near or over water Environmental Management Plans are to be developed in conjunction with the NCCMA.
- Providing revegetation progressively as the construction is finalised.

The most significant impact is associated with construction activities on the Murray River near the banks. This is required due to the length of the bridge span in this area. The controls as set out above exceed legislative requirements and are in-line with best practise.

One of the other main impacts associated with the construction of the design is introducing sediment to the Murray River or Campaspe River. Both of these systems have a high sediment loading already and as such some localised sediment entering the system due to construction should only have a minor impact. The proposed management measures incorporate strong planned sediment control as part of the construction works and any works near waterways will utilise coffer dams to control sediment impacts in the waterway.

The Project design also includes provision for spill basins to be constructed adjacent to the alignment to capture run-off from the new roadway. The spill basins have been incorporated into the design consistent with discussions with the EPA and allow for the capture and/or treatment of run-off from the road surface and enable removal or release into the flood plain as required. The spill basins would be located as close to the road carriageway as possible to minimise the construction footprint of the Project. On the elevated carriageway from Warren Street in Echuca to Cobb Highway in Moama, the spill basins would be constructed within the batter slope.

The height of the spill basins would be determined during detailed design. The EPA has instructed VicRoads to adopt a risk based approach to spill basin design. This would involve an assessment of construction and maintenance costs, access requirements and public safety, spill risk and effectiveness and reliability of required management measures.

During flood, sediment from construction activities entering the waterway is almost certain. However, the impact of this is minor due to the volume of floodwater associated with flood events along the Campaspe River and Murray River. These river systems already carry a high sediment load and the additional sediment from construction sites during flood would be considered minimal and would not effect on water quality.

During construction of the Preferred Alignment native vegetation will be required to be removed. The amount of vegetation being removed is not sufficient to cause an impact to the local water quality and river health. In addition, the current VicRoads construction guidelines (VicRoads Section 177 – see EES Technical Appendix O) have been assessed and facilitate appropriate guidelines for mitigating these impacts. Revegetation should aim to replace and improve the vegetation following the completion of the Preferred Alignment as per the guidance in the Campaspe Planning Scheme 37.03, 44.03 and 44.04 and Schedule 1 of the Environmental Significance Overlay and the State Planning Policy Framework 14-02-1.

6.2.3 Operation Impacts

During operation of the road under the Preferred Alignment, the impact on water quality following runoff events and due to spill on the roads and bridges is expected to be minor. Both of these impacts are mitigated through the incorporation of spill basins. For the Murray and Campaspe River structures these basins capture all of the runoff and are protected to the 100 year ARI level. The basins should be clay lined to stop infiltration through the base. In the event of a spill they would act as a buffer between the bridge system and the waterway.

Basins on Warren Street are required by the EPA but do not need flood protection up to the 100 year ARI level. The spill basins in this area have been specified by the EPA as requiring a 20 year ARI flood protection commensurate with the flood protection of Warren Street. Warren Street is not being raised for the majority of the length and introducing spill basins is an improvement over the No Project Scenario road conditions (no spill basins exist for Warren Street under the No Project Scenario).

The spill basins are required under legislation to ensure that water running off the roads is captured and treated to meet the guidelines as stated in Section 5 and to ensure that any spills are detained for treatment and do not enter the local waterways.

6.2.4 Groundwater Impacts

Due to the proximity of the Preferred Alignment to the Murray River and Campaspe River the groundwater table is located very close to the existing ground surface. The construction and ongoing operation of the Preferred Alignment is not likely to impact groundwater levels as these are controlled by the river levels in the area rather than from groundwater recharge via infiltration. Details of the existing groundwater conditions are discussed in the Soils and Geology EES report.

The structure is mainly to be constructed on fill and as such there is no direct interaction with the groundwater due to excavation. However, during construction the proposed second bridge is to be constructed using piles supported by piers. The piers would interact with the groundwater during their construction, however the impact to the groundwater is likely to be minor. When piling, suitable sedimentation controls are assumed to be in place in accordance with the standard VicRoads environmental protection measures (VicRoads Section 177 – see EES Technical Appendix O). If this is the case, there is not likely to be impacts on the Murray River or Campaspe Rivers.

The overall impact to the groundwater in the region for the construction and ongoing operation of the Preferred Alignment is minor provided that the standard construction and operation guidelines utilised by VicRoads (VicRoads Section 177 – see EES Technical Appendix O) are implemented. No additional controls are required to manage the impacts associated with the interactions of groundwater as the interaction with the groundwater and resulting impacts are minor.

For the Preferred Alignment it is not expected that the Initial Alignment or Ultimate Duplication will impact the groundwater conditions for the Study Area.

6.2.5 Scour and Over Topping Impacts

During floods large volumes of water are flowing through the floodplain and floodwater velocities increase during these events. If velocities increase sufficiently then scour around piers and structures can occur. Due to the width of the Murray River and Campaspe River floodplain the velocities associated with events up to the 100 year ARI are less than 1.5 m/s. Standard scour protection for piers, bridge abutments and culverts should be included in the design to resist erosion associated with this. Using standard scour protection design will result in scour having an insignificant impact on the Preferred Alignment.

In pier design the 1 in 2000 year ARI event is an important metric for determining if there is likely to be any scour and to design adequate protection. For the Murray River and Campaspe River floodplains Cardno have assessed the 2000 year ARI event in previous studies using the current model (Addendum: Detailed Hydrology Study for the Echuca-Moama Bridge Planning Study – LJ5598 / RM2277 Final v1.0 (Cardno, 2010)). This report found that the peak velocity adjacent to pier locations was 1.4 m/s. Geotechnical assessment and design should be undertaken on the piers during the detailed design of the bridge abutments to adequately assess and design for scour protection.

The 2000 year ARI run shows that the velocities are not high within the floodplain and the detailed design will be able to mitigate the impacts of scour through standard design.

Warren Street is currently at a level that is typically overtopped during a 20 year ARI flood event. As a result any events of this magnitude or larger will overtop the road in the future. As this may be overtopped in future flood events this road should be designed to withstand overtopping forces and resists hydrostatic forces such as lifting of the road surface. Suitable design will mitigate the impacts of overtopping of the road resulting in the impact of overtopping to be minor.

6.3 Risk Assessment

6.3.1 Methodology

The risk assessment for the Project included identification and management of Project risks and Environmental risks. Project risks were identified by VicRoads before an environmental risk assessment was undertaken with key specialists. A summary of the Project risk assessment is outlined in Chapter 6 of the EES.

The environmental risk assessment developed for the EES included the development of impact pathways and mitigation measures that could reduce the impact of the Preferred Alignment.

A quantitative risk assessment was undertaken with key specialists. VicRoads and key members of the Project team developed a risk register based upon a detailed understanding of the Project and the Preferred Alignment. The risk register was sent to key specialists for review and consideration prior to attendance at a workshop held on the 18th September 2014 to:

- review the consequence criteria developed;
- review the risks identified;
- identify any additional risks that need to be addressed; and
- develop detailed mitigation measures.

6.3.2 Risk Significance

The significance of risks were identified having regard to the Consequence Criteria and Likelihood Guide.

Consequence criteria was developed by VicRoads and reviewed by project specialists to define a scale of magnitude from “insignificant” to “catastrophic” risks. The scale of magnitude was based on the spatial area affected and expected recovery time of the value impacted. Accordingly, insignificant consequences were generally situated within a localised area with a recovery time potential within the range of normal variability. Conversely, catastrophic consequence criteria describe scenarios involving a very high magnitude event, affecting a State-wide area, or requiring over a decade to reach functional recovery.

The Consequence criteria for the hydrology and groundwater impacts associated with the Project are outlined in Table 8.

The significance of the risks were determined having regard to the Likelihood Guide (Table 7) and the Consequence Criteria (Table 8). Table 9 outlines the risk significance as a result of the likelihood and consequence.

Table 7 Likelihood Guide

Descriptor	Explanation
Almost Certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Possible	The event could occur
Unlikely	The event could occur but is not expected
Rare	The event may occur only in exceptional circumstances

Table 8 Consequence Criteria

	Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Surface Water	Construction impacts on water quality	Applicable water quality standards met across the region	Isolated and minor exceedance of water quality standards that are short lived	Minor exceedance of applicable water quality standards in a localised area	Major exceedance of applicable water quality standards in a number of local areas	Widespread exceedance of applicable water quality standards across the region
	Operational impacts on water quality	Applicable water quality standards met across the region	Isolated and minor exceedance of water quality standards that are short lived	Minor exceedance of applicable water quality standards in a localised area	Major exceedance of applicable water quality standards in a number of local areas	Widespread exceedance of applicable water quality standards across the region
	Changes to water and flow regime	Negligible change to waterway, river health and flow regime	Changes to waterway, river health or flow regime with minor implications in the immediate area	Changes to waterway, river health or floodplain function with moderate implications in the immediate area	Waterway, floodplain function or river health significantly compromised over a wider area	Extensive impact to waterway or floodplain function, river health irreversibly disturbed
	Changes to the floodplain characteristics	No additional floodplain impacts to any dwellings or infrastructure	Slight increase in flooding of non-urban areas	Medium increase in flooding at a non-urban scale or slight increase in flooding at an urban scale	Significant increase in flooding at a non-urban scale or medium increase in flooding at an urban scale	Significant increase in flooding at an urban scale
Groundwater	Construction impacts on groundwater	Negligible change to groundwater regime, quality and availability	Temporary changes to groundwater regime, quality and availability but no significant implications	Changes to groundwater regime, quality and availability with minor groundwater implications for a localised area	Groundwater regime, quality or availability significantly compromised.	Widespread groundwater resource depletion, contamination or subsidence
	Operational impacts on groundwater	Negligible change to groundwater regime, quality and availability	Changes to groundwater regime, quality and availability but no significant implications	Changes to groundwater regime, quality and availability with minor groundwater implications for a localised area	Groundwater regime, quality or availability significantly compromised.	Widespread groundwater resource depletion, contamination or subsidence

Table 9 Risk Significance Matrix

Likelihood	Consequence Level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Negligible	Low	Medium	High	High
Unlikely	Negligible	Low	Medium	Medium	High
Rare	Negligible	Negligible	Low	Medium	Medium

6.3.3 Risk Workshop

The Environmental Risk Assessment Workshop was held on 18 September 2014 to consider the risks and mitigation measures that would apply to the Preferred Alignment (Mid-West Option). The risk workshop was attended by the flora and fauna, cultural heritage, hydrology, noise, aquatic, traffic and geology specialists. The workshop also included representatives of VicRoads and the NSW Department of Roads and Maritime Services. The purpose of the workshop was to identify the most significant risks associated with each aspect of the project and assess potential risk-mitigation measures. For the transport elements of the project, construction and longer-term operational risks were considered.

Table 10 outlines the hydrology and groundwater risks identified for the Preferred Alignment.

Table 10 Risk Register

Risk No.	Discipline	Impact Pathway	Description of consequences	Linkages	VicRoads Contract Specification Section 177 Reference (see EES Technical Appendix O)	Planned Controls to Manage Risk (as per Section 177 and Project Description)	Initial Risk			Additional Controls Recommended to Reduce Risk	Residual Risk		
							Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
H1	Surface water	Construction at Murray River impacts on bank form, habitat or waterway health	Localised bank destabilisation and scour at waterway crossings and detrimental impact on riparian habitat	Aquatic	177 B1 177 D1	Coffer dams to be implemented and significant vegetation to be cut to ground level. The quality of water in waterways shall not be detrimentally impacted by runoff from the site. Works shall be programmed and managed to avoid works in waters. Where work in waters is unavoidable, procedures shall be developed and implemented to satisfy the requirements of the specification and as required by any permits from the responsible authority(s). Where construction activities are undertaken in, near or over waters, EMPs shall be prepared to protect beneficial use in accordance with any permit, the SEPP (waters of Victoria) its schedules and best practice guidelines.	*Minor*	*Almost Certain*	*Medium*	-	*Minor*	*Almost Certain*	*Medium*
H2	Surface water	Proposed works result in change to hydraulic conditions above acceptable levels	Potential for local disturbance to waterway banks, channels and flow. Potential for reduced aquatic habitat	Aquatic Biodiversity and Habitat		Structures within waterways to be sized and sited to minimise any afflux consistent with NCCMA & MDB Authority requirements Undertake waterway improvements / bank stabilisation works to allow for any changes to flow characteristics	*Minor*	*Unlikely*	*Low*	-	*Minor*	*Unlikely*	*Low*
H3	Surface water	Construction at Campaspe River impacts on bank form, habitat or waterway health	Localised bank destabilisation and waterway crossings and detrimental impact on existing habitat	Aquatic	177 B1 177 D1	The quality of water in waterways shall not be detrimentally impacted by runoff from the site. Works shall be programmed and managed to avoid works in waters. Where work in waters is unavoidable, procedures shall be developed and implemented to satisfy the requirements of the specification and as required by any permits from the responsible authority(s). Where construction activities are undertaken in, near or over waters, EMPs shall be prepared to protect beneficial use in accordance with any permit, the SEPP (waters of Victoria) its schedules and best practice guidelines. To manage disturbance of the banks and river no piers are being placed within the main river channel.	*Minor*	*Unlikely*	*Low*		*Minor*	*Unlikely*	*Low*

H4		Construction risk of sediment from disturbed areas may impact the waterways	Accumulation of sediment in the waterways during construction	Aquatic	177 B1 177 D1	Prompt temporary and/or permanent progressive revegetation of the site as work proceeds. Prompt covering of exposed surfaces (including batters and stockpiles) that would otherwise remain bare for more than 28 days. Installation, stabilisation and maintenance of catch and diversion drains that segregate water runoff from catchments outside of the construction site from water exposed to the construction site.	***Minor***	***Possible***	***Low***	-	***Minor***	***Possible***	***Low***
H5		Operational risk of pollutants in stormwater runoff may affect the water quality in the local waterways	Increase of sediment / pollutants in the waterways over time, reducing in water quality and potential impacts on waterway health	Biodiversity and Habitat	177 D1	Drainage design shall be modelled and sized to manage rainfall intensities and soil characteristics specific to the region. This risk is an operational risk following construction of the system.	***Minor***	***Unlikely***	***Low***	Incorporate spill basins into design as required capture pollutants	***Minor***	***Rare***	***Negligible***
H6		Construction risk of impact on the floodplain function during a flood event	Modification of the behaviour of the floodplain during construction	Biodiversity and Habitat		Monitor weather and flood warnings and establish plans at each stage of construction to minimise damage and impact to the waterway. If flood warnings arise clear equipment and blockages within the floodplain as much as possible.	***Minor***	***Rare***	***Negligible***	-	***Minor***	***Rare***	***Negligible***
GW1	**Groundwater**	Construction and/or operation impacts on existing groundwater levels	Potential for localised reduction in groundwater levels resulting in either land subsidence or impact to beneficial users	Social / landuse	177 B2	The Contractor shall consider the beneficial uses, quality and quantity of groundwater when determining the ongoing management of groundwater. Such consideration shall be completed prior to the completion of related design and prior to commencement / continuation of related construction activities. Incorporate management practices or design solutions in consultation with the NCCMA	***Minor***	***Unlikely***	***Low***	-	***Minor***	***Unlikely***	***Low***
GW2		Intersected groundwater discharges into waterways and impacts on surface water quality	Potential discharge of groundwater into Campaspe or Murray Rivers	Aquatic Hydrology	177 B1, B2	The quality of water in waterways shall not be detrimentally impacted by runoff from the site. Where groundwater is unexpectedly encountered, a management plan shall be developed and implemented to manage the groundwater and protect beneficial uses in accordance with the requirements of the EPA and/or relevant authority. Groundwater encountered on site shall be assessed for the opportunity for reuse as a non-potable water source for the duration of the Contract if no higher fit for purpose use can be identified. Incorporate management practices or design solutions in consultation with the NCCMA.	***Minor***	***Unlikely***	***Low***	-	***Minor***	***Unlikely***	***Low***

6.4 Mitigation Measures

In order to mitigate the risks for the Project, standard VicRoads and Roads and Maritime Services environmental protection measures and some additional project specific have been identified for incorporation into the Environmental Management Framework (EMF). VicRoads, as the responsible proponent for the construction of the Project, would require the construction contractor to incorporate all of these measures from the Environmental Management Framework into the Construction Environmental Management Plan (CEMP).

Standard protection measures for the hydrology impact that would be adopted for this Project include the following Clauses of the VicRoads Section 177 Environmental Management specifications (see EES Technical Appendix O for details) standard requirements:

- 177B1;
- 177B2; and,
- 177D1.

The details of the planned controls to manage risk which are to be implemented for the project are included in Table 10.

From the risk register only one risk falls in the “Medium” category and this was H1 - Construction at Murray River impacts on bank form, habitat or waterway health. This risk is unavoidable due to the proximity of the construction activities to the banks of the Murray River. The likelihood of this occurring is almost certain, however the impact due to the risk is minor. A range of planned controls (VicRoads Section 177 – see EES Technical Appendix O) are to be implemented to manage the impacts of this risk. The risk cannot be avoided but can be effectively managed.

There are additional project specific controls that have been recommended to avoid, mitigate and manage potential hydrology effects, reducing residual risks to an acceptable level. These additional controls and the responsibility for implementing them are outlined in Table 11. It should be noted that these are the measures that exceed the existing guidelines (VicRoads Section 177 – see EES Technical Appendix O) being utilised for the design, construction and operation of the Project.

Table 11 Additional Controls Recommended to Reduce Risk

Risk No.	Risk Description	Management Measures	Responsibility
H5	Pollutants in stormwater runoff may affect the water quality in the local waterways	Incorporate spill basins into design as required capture pollutants	VicRoads

7 Summary of Impacts

This detailed Hydrology and Groundwater Impact Assessment has been prepared in response to the EES Scoping Requirements with an objective to maintain floodplain functions, hydrology, values of surface water, groundwater and geomorphic stability of proximate sections of the lower Campaspe and Murray Rivers. This assessment has demonstrated that the planned controls for the Project have resulted in a Project that:

- would not have a significant effect on the function, values and beneficial uses of surface water for the lower Campaspe River and Murray River.
- would not contaminate the soil and groundwater from construction and operation activities.

The Project also provides a range of benefits to the townships of Echuca-Moama by:

- providing a second route across the Campaspe River and Murray River.
- providing a second flood evacuation route up to the 100 year ARI event for the main townships of Echuca and Moama.
- increased flood protection of Warren Street as this now has additional culverts and mitigation structures proposed which reduce the frequency of the road overtopping. The road is also to be designed to withstand overtopping to improved standards which would reduce the likelihood of damage in a flood event. Sections of the road are also to be raised above the 100 year ARI event which further reduces the likelihood of flood damage.

The residual risks following the implementation of the planned controls are no greater than the existing conditions (under the “No Project” scenario) and in some instances reduced. The impact of flooding is maintained at existing levels in line with the required legislation and policy. The inclusion of the additional flood free evacuation route has decreased the risk to community in that area.

8 References

Cardno 2009, Detailed Hydrology Study for the Echuca-Moama Bridge Planning Study, prepared for VicRoads, Vic.

Cardno 2010, Addendum: Detailed Hydrology Study for the Echuca-Moama Bridge Planning Study, prepared for VicRoads, Vic.

Cardno 2013, Detailed Hydrology Study for the Echuca-Moama Bridge Planning Study – Mid-West 2 Alignment, prepared for VicRoads, Vic.

North Central Catchment Management Authority 2015, Campaspe River, available from http://www.nccma.vic.gov.au/Water/Rivers/Campaspe_River/

SKM 1997, Moama-Echuca Flood Study, Department of Land and Water Conservation, NSW and the Department of Conservation and Natural Resources, Vic.

VicRoads 2015, Echuca Moama Bridge EES, Specialist Soils and Geology Report, prepared for VicRoads, Vic.