Northern Region

Echuca-Moama Bridge EES Soils and Geology Impact Assessment Report

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Document Control

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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.
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.

Term	Definition
Chainage	The distance of a point along a control line, measured from a datum point.
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 preferred alignment 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.
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".

Term	Definition
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.
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.
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.
Higher 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 Vehicles (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 bridge across each waterway.
Interfingering	To grade or pass from one material into another through a series of interpenetrating wedge-shaped layers
Intersection	The place at which two or more roads meet or cross.
Landscape	For the purpose of this EES, the term 'landscape' here refers to the concept of visual and related natural qualities of the area providing an environmental value and a public good. It is distinct from the visual amenity experienced by individuals who have outlooks from their properties towards the RoW and associated infrastructure.
Land use	The type of development permitted in an area whether it be industrial, commercial, residential, 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	The Mid-West Option extends from the Murray Valley Highway

Term	Definition
(Preferred Alignment)	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.
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.
REF	Review of Environmental Factors pursuant to the Environmental Planning and Assessment Act 1979 (NSW) to assess impacts of the Project in NSW.
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.
Right-of-Way	The Right-of-Way is a strip of land the extent of which is reserved under a planning ordinance for the public purposes of a road and, in this case, encompasses sufficient land to construct the Project. The Right-of-Way comprises the sealed

Term	Definition
	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 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.
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 (the 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

Term	Definition
	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.

As part of the EES options assessment, the Mid-West Option was determined to be a 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 is focussed on impacts of the Mid-West Option only and supports its selection as the Preferred Alignment.

This Soils and Geology 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, environmental risk assessment and impact assessment for the ultimate duplication of the Mid-West Option.

From a geotechnical and soils perspective, there are no major impediments to the construction and long term maintenance of the Project and no significant impacts to the geomorphic stability of the proximate sections of the lower Campaspe and Murray Rivers.

The soils and conditions from the two key geological units generally comprise of gravel, sand, silt and clay and may have varying engineering properties due to depositional circumstance, although with standard design and management measures, including further investigations during detailed design, there is considered little potential for significant construction related issues arising from the Mid-West Option.

The key soils and geological risks which may have implications for the design, construction and/or operation of the Project include:

- waste material uncovered during works;
- soil settlement due to poor / soft ground conditions; and
- potential for erosion / sediment generation during and post construction from localised rainfall.

The standard protection measures to mitigate the soils and geology impacts that would arise for the Project include implementation of VicRoads DCI contract specification 177. The specification 177 controls measures related to soil issues. Additional investigations including a suite of intrusive sub-surface investigations and testing would be undertaken during preconstruction to identify soil properties and inform the design and development of any necessary precautions, such as potential for settlement or contaminated materials. The use of insitu and laboratory testing of samples from boreholes and trial pits, or CPT testing, during the detailed design phase would also be undertaken to reduce uncertainty.

There are several additional Project specific controls that have been recommended to avoid, mitigate and manage potential Soils and Geology impacts, thereby reducing initial risks/impacts to an acceptable level (i.e. residual impacts).

A residual impact of the Project is the potential for erosion and sediment generation in the operational phase of the road (post construction) having an impact on the beneficial use of surface water and groundwater. These impacts would only affect surface water and be temporal in nature (i.e. during a high intensity rainfall event) and are considered a minor impact. It is considered a minor impact because during a high intensity rainfall event, gully erosion would occur in the surrounding areas as well, not just on/around the road infrastructure. Therefore, the volume of sediments entering the rivers as a result of the Project would be considered low compared with the total sediments entering the rivers from the surrounding area. Only minimal erosion should occur due to the erosion protection measures put in place during construction (in accordance with contract specification 177). Such erosion would be considered a minor impact.

Geomorphic is defined as 'pertaining to the form of the earth or of its surface features; e.g. a geomorphic province'. The construction of the Project over both the Campaspe and Murray Rivers would have an insignificant effect on the geomorphic stability of the immediate area, provided the proposed single spanned structures are appropriately designed (abutments set back from the river banks which would minimise scour) and erosion control measures are implemented. It is also considered that there is a minor impact on the future geomorphology of the proximate section of both the lower Campaspe and Murray Rivers.

1 Introduction

1.1 Project Overview

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 (Vic) for a decision on whether an assessment under the Environment 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 Soils and Geology Impact Assessment has been prepared to inform the EES. The EES is required to consider the potential effects of the Project on the environment, inform the public and other stakeholders and enable a Minister's Assessment of the Project to inform decision makers.

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 Soils and Geology Impact Assessment report is to document the soils and geology impacts for the ultimate duplication of the Mid-West Option and to outline the methodology, risks and proposed mitigation for the Project within Victoria.

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 freight vehicles used by an increasing proportion of the freight transport industry. Rehabilitation works to upgrade the operational capacity of the existing bridge would require lengthy road closures and would be further complicated by the need for 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 environmental 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 whereby a Western Corridor was 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 proposed

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 (RoW) 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 will 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 comprises the two lanes in both directions and duplicated bridges next to the bridges built during the initial alignment.

2.3 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 with a second flood free crossing between Echuca and Moama;
- enable cross border access for high productivity freight vehicles and oversized vehicles;
- Improve emergency services access between Echuca and Moama during emergency situations and major tourist and flood events
- provide road infrastructure that supports:
    - the local and regional economy of Echuca-Moama; and
    - the state (Vic and NSW) and national economies through improved connectivity of goods and services

2.4 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 for consideration by specialists. The alignment, known as the Mid-West Option was determined to be a 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), 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 Preferred 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 a realigned Meninya Street (the existing Cobb Highway) at a new signalised intersection; and
- Signalisation 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

2.5 Study Area

The Study Area for this Soils and Geology Impact Assessment is along the nominated Preferred Alignment within the RoW as shown in Figure 1 and in Appendix A.

3 Existing Conditions

3.1 Methodology

The existing conditions or "No Project Option" assessment comprised a desktop study of available information and several site inspections. Site inspections have been undertaken by VicRoads Geotechnical Services (VRGS) on several occasions as described in Section 3.2 of this report. The purpose of the site inspections was to gain an appreciation of existing site conditions.

The report 'Geotechnical Desktop Study & Risk Register for the Second Murray River, Echuca-Moama, Report No GRO045-04-01, September 2012' prepared by Adam Farr has been reviewed in the preparation of this Soils and Geology Impact Assessment Report.

The methodology allows for reviews of the documentation throughout the process including comments by VicRoads, VicRoads' advisors, the former DTPLI (now DELWP) and the Technical Reference Group (TRG) on:

- The Existing Conditions assessment;
- The Risk register; and
- The Impact Assessment.

3.2 Existing Conditions

3.2.1 Geology

Inspection of maps and publications of Geoscience Victoria and the Geological Society of Australia has suggested that geological succession most likely to be of concern in the Study Area and design of the Preferred Alignment comprises the Wunghnu Group alluvial deposits of Quaternary age (subdivided into the Coonambidgal Formation and the Shepparton Formation, according to relative depositional environments and ages). Other geological units that may influence design of the Project in the Preferred Alignment are the underlying Palaeocene to Miocene age Murray Group carbonate rocks and Renmark Group lacustrine sandstones, siltstones and coals, and the bedrock strata of undifferentiated Palaeozoic rocks, such as Silurian & Devonian siltstone/sandstone at depth.

The Shepparton Formation of northern Victoria is described by Birch et al. as a set of highly variable sediments of fluviatile, overbank and lacustrine origin, ranging from gravels to clays, and present along the Riverine Plain. The nature of these deposits is typical of complex river systems and produces laterally interfingering, vertically and horizontally variable deposits such as sand channels flanked by layers of fine sandy clay deposited as river levees. The upper part of this deposit consists of a sheet like layer of calcareous clay 1m – 3m thick. Soils developed on the Shepparton Formation are red brown to yellow brown sodic duplex soils.

The Coonambidgal Formation consists of river channel deposits with associated lakes and flood plains. These fluviatile deposits may have an overprint of an Aeolian environment, and are of late Pleistocene age. Modern rivers represent the most recent

set of four such terraces of river deposits. Soils developed on these deposits are generally yellow grey in colour and poorly structured.

An extract from the relevant 1:250,000 scale Geological Survey of Victoria geological map (Sheet SJ55-1, Bendigo) is presented in Appendix A.

The extract includes 2 faults, the Mount William and Corop Fault denoted by the dashed red lines. These faults are well outside the Preferred Alignment and will not be encountered during construction.

3.2.2 Geomorphology

Geomorphology is defined as 'the science that treats the general configuration of the earth's surface, specifically the study of the classification, descriptions, nature, origin, and development of landforms and their relationships to underlying structures, and the history of geologic changes as recorded by these surface features.'

The Preferred Alignment is located in the geomorphic region nominated as the Riverine Plain as described by Birch et al. The Riverine Plain of New South Wales and Victoria is a very extensive and complex alluvial plain associated with the Murray River and its tributaries. It developed following the retreat of the Pliocene sea from the Murray Basin.

Geomorphic is defined as 'pertaining to the form of the earth or of its surface features; e.g. a geomorphic province'.

3.2.3 Site and Topography

Aerial photographs were reviewed from 1971, 2008 and 2013. In addition to the aerial photographs, the current aerial image on Google was also utilised for the assessment. Selected aerial photographs obtained can be found in Appendix B – Site Aerial Photographs.

There are two principal topographic zones in the vicinity of Echuca, the Riverine Plain and the Flood Plain of the Murray River.

The Riverine Plain is a uniform plain that slopes westwards at an average gradient of approximately 0.4m per km. This plain is cut into by a number of creek valleys between 0.6m and 3m below the level of the plain. The creeks themselves are ephemeral in nature, the main permanent watercourses being the Murray River and Campaspe River.

The Study Area on either side of the Murray River is relatively flat lying and mainly consists of semi – cleared undeveloped land with variable tree cover. Remains of some minor earthworks associated with disused older agricultural activities in the area are also present. These consist of disused (and empty) dams and unlined irrigation channels. Some areas of grassland are also present. The land immediately adjacent to the banks of the Murray River has some tree cover. Inspection of aerial photographs dating from the 1970s to the present day suggests that modification of the topography due to human activities over that period was relatively limited.

From Warren Street to the Campaspe River crossing, the terrain contains small undulations, with relicts of small earthworks present. These probably represent remains of dams and small irrigation channels. The Campaspe River has steep sided banks 4 – 6m in height, which may be subject to erosion where exposed.

Further west along the Preferred Alignment, through Victoria Park, Echuca, the terrain is flat lying with extensive tree cover over dry surface soils.

At the proposed location of the Murray River crossing, the river banks consist of relatively easily eroded material which has been stabilised along short lengths of the western (Victorian) side of the river using retaining structures. The eastern (NSW) side is apparently unmodified, with the principal stabilisation being provided by the root mats of River Red Gum trees.

The location of the Preferred Alignment on the NSW side of the river is generally not accessible to the general public and is fenced off. Observations from the opposite side of the river during the various site inspections of the general terrain indicate it to be much the same as that near the Campaspe River at the southern (Victorian) end of the Preferred Alignment, with small undulations in a generally flat-lying relief and well-developed cover of mature trees. The Murray River bank on the NSW side of the river has the same propensity for erosion as that on the Victorian side. Stability of the river banks and potential for scour to occur is likely to form a consideration for design of the proposed bridge.

There are no known historic land uses that may result in soil contamination within the Study Area.

3.2.4 Groundwater

As indicated in Birch (2003) and in records of the former DEPI (now DELWP), the hydrogeology of the area is based on a number of principal aquifer systems:

Shallow and water table aquifers:

- Shepparton Formation (low yield & moderately saline – 2000mg/l TDS)
- Coonambidgal Formation (highly variable aquifers with variable, up to moderate yield & low to very high salinity – 400 to 20000mg/l TDS)

Deep confined aquifers:

- Renmark Group and Murray Group Calivil Formation; typically contain sheet like aquifers separated by aquitards of coal seams and kaolinitic clays. Encountered at 60m – 130m depth and usually 10m – 100m thick, containing water at moderate to high yields and low to high salinity (400 – 6000mg/l TDS).
- Basement aquifers – siltstones, mudstones, weathered granites and volcanic rocks. Encountered at 10m – 60m depth, containing water at very low yields and low to high salinity (100 – 5000mg/l TDS).

The shallow aquifers are those that are most likely to influence the proposed works for the Project in the Preferred Alignment. Based on the chemistry of water present, appropriate measures, such as specialise concrete mix designs providing protection against aggressive groundwater, may be necessary in terms of structural design for foundation and support structures in saline ground and groundwater. This is a standard construction technique. The need for such measures and the nature of the measures required would depend on the outcome of an adequate geotechnical site investigation along the Preferred Alignment which will be undertaken during the pre-construction phase of the Project.

The measured groundwater salinity levels in the Study Area would pose no risk to the construction of the Project, nor is the Project expected to increase the salinity levels in the aquifers.

The Project is mainly constructed on fill, requiring minimal excavation for piling. During the preconstruction phase, groundwater testing would be undertaken and appropriate construction measures identified. Therefore, the potential to encounter saline soils in any significant quantity is unlikely based on the land formations in the study area and the low volumes of material excavated for piling.

Inspection of the former DEPI (now DELWP) groundwater borehole database indicates the existence of four recorded boreholes within proximity to the Preferred Alignment. The location of these and a tabulated record of monitoring data are shown in Appendix C – DELWP Groundwater Bore Locations Map. These results should be viewed with caution as these laboratory and field results were recorded in the years 1963, 1964, 1966 (majority) and several in 2007 and 2008. The total dissolved solids (TDS) range from 94 to 6077 mg/L. Field results of pH and EC (uS/cm) were obtained with pH results range from 4.5 to 8.5 and EC measured at 4380 uS/cm. Approximate unit conversion of TDS is, 4380 uS/cm becomes 2409 mg/L. The State Protection Policy – 'Groundwater's of Victoria' nominates that the upper measurement of 6077 mg/L is classified as Segment C in the protected beneficial uses of groundwater. Further investigation and testing will be undertaken during the preconstruction phase of the project.

Groundwater is discussed in more detail in the Specialist Hydrology report prepared by Cardno as part of the EES impact assessment, dated May 2015.. The details below have been obtained from Section 6.2.4 of the report,

'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.'.

3.2.5 Material Properties, Emerson Test Results & Potential Acid Sulphate Soils

The term "Soil erodibility potential" is considered to be the likelihood that erosion will occur when soils are exposed to water (and/or wind) during or as a result of land-disturbing activities. Erodibility potential is highest on slopes, and when low plasticity silty soils or fine sands are disturbed.

The term "Soil dispersion potential" is the likelihood that soils will release a cloud of fine clay particles when brought into contact with water and can be measured as the Emerson Class number (a simple semi-quantitative dispersion test). Emerson Class numbers range from 1 to 8, with Class 1 considered the most dispersive and Class 8 the least dispersive.

Testing of materials from previous investigations in the Echuca area has suggested that the local soils have an Emerson class number of between 5 and 8 (VicRoads Geopave report nos. GR00496 (2000) and GR01065 (2001)). This indicates that soils in the Coonambidgal Formation near Echuca have a low potential for dispersion. Tests for a proposed feedlot at Moira Station (24km north of Echuca) gave Emerson class numbers of 1 and 2, suggesting that these materials (Shepparton Formation) are highly dispersive.

Given the Emerson class result, the potential for the development of tunnel and/or gully erosion cannot be discounted. The clays are likely to have variably high and low plasticity. The Plasticity Index is the numerical difference between the Liquid Limit and Plastic Limit for a particular material and indicates the magnitude of the range of moisture contents over which the soil remains plastic. The Plasticity Index generally depends on the amount of clay present. It gives a measure of the cohesive or binding qualities resulting from the clay content.

Observations along the Murray River (Jobson, GeoPave report no. GR01065, 2001) have indicated that only certain types of river bank improvements are satisfactory in producing stabilisation. Rock beaching is not regarded as an effective measure, with

scour occurring at the toe of the beaching, causing undermining and slippage. The root mats of mature River Red Gum trees produce limited stabilisation, but undermining by river scour causes the trees to topple and produce damage due to overturning of the root mat.

An Initial Potential Acid Sulphate Soil (PASS) desktop study completed as part of this report has indicated that the Study Area is not located within the Coastal Acid Sulphate Soil (CASS) area, therefore the risk of encountered PASS is very low and not considered further in this Soils and Geology Assessment.

3.2.6 Site Inspection

Site inspections have been undertaken by VicRoads Geotechnical Services (VRGS) on several dates as nominated below. The purpose of the site inspections was to gain an appreciation of the existing conditions along the Preferred Alignment.

Inspection dates:

- 15 & 16 November 2011
- 15 March 2012 concentrating on the area of the Murray River nominated as Reflection Bend
- A recent site inspection was undertaken on the 12 & 13 June 2014 concentrating on the Preferred Alignement (Mid-West Option).

Site photos are contained in Appendix D – Site Photographs.

Each photograph in Appendix D has a detailed description of the location within the Preferred Alignment.

3.2.7 Post EES

Issues related to soils and geology would be further investigated and managed through the preconstruction phase and construction stages of the Project, including intrusive geotechnical assessments and standard construction management measures. The intrusive sub-surface investigations and testing would be undertaken to identify soil properties and inform the design and development of any necessary precautions and/or construction techniques to deal with settlement or contaminated materials. The investigations would cover the full length and width of the Preferred Alignment, however would focus on identified key geotechnical risks areas, such as, deep embankments, bridges, potential areas of 'unsuitable' or 'soft' materials and other high risk areas.

This approach has been used successfully on other VicRoads projects and is expected to satisfactorily manage key soils and geotechnical risks posed by the Project.

4 EES Scoping Requirements

4.1 EES Evaluation Objectives

For the Soils and Geology aspects of the Project, the relevant draft evaluation objective as outlined in the EES Scoping Requirements is:

"Draft Evaluation 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 Soils and Geology 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 this Soils and Geology Impact Assessment for the Project, it has been necessary to review and consider any relevant legislation, policies or guidelines that apply.

Legislation and guidelines relevant to the management of soils are provided in Table 1.

Table 1: Relevant legislation, policy and guidelines for management of soils

Legislation, Policy	Description	Implication for Project
Environment Protection Act 1970 (Vic) (**EP Act**)	The EP Act enables the Environment Protection Authority (EPA) Victoria to implement the State Environment Protection Policy (SEPP) in regard to contaminated land and the Industrial Waste Management policy for waste. All construction activities must comply with the general performance measures outlined in the legislation. The EP Act is supported by a series of State Environmental Protection Policies (SEPPs) that regulate actions over a range of environmental protection issues. The State Environment Protection Policies (SEPP) are legal documents attached to the EP Act, which prescribe limits for the quality of the natural assets for which they were written. It is incumbent on all proponents of works to ensure that their operations do not contribute to degradation of those natural assets. The relevant SEPPs for geotechnical, groundwater and salinity issues are land and groundwater SEPPs: • Groundwaters of Victoria, 2002 • Prevention and Management of Contamination of Land, 2002.	A works approval will be required from the EPA for any discharges from the Project. Sediment discharge in the rivers from construction activity for the Project may adversely affect the Quality of water. In order to ensure beneficial uses are protected, any proposed discharge concentrations need to be compared with water quality objectives as described in the SEPP Water of Victoria 2002. The land and groundwater SEPPs identify a range of land use categories and a range of protected beneficial uses for each of these categories.
Planning and Environment Act 1987 (Vic)	The Act enables preparation of planning schemes to control the use, development and protection of land in Victoria.	The relevant planning scheme for the Study Area is the Campaspe Planning Scheme.
Campaspe Planning Scheme	Campaspe Planning Scheme covers 3 relevant key environmental risks: 13.03-1 Use of contaminated and potentially contaminated land Objective – '*To ensure that potentially contaminated land is suitable for its intended future use and development, and that contaminated land is used safely'* 13.03-2 Erosion and landslip	*Relevant/key Strategies* 13.03-1, Requires applicants to provide adequate information on the potential for contamination to have adverse effects on the future land use, where the subject land is known to

Legislation, Policy	Description	Implication for Project
	Objective – '*To protect areas prone to erosion, landslip or other land degradation processes'* 13.03-3 Salinity Objective – *'To minimise the impact of salinity and rising water tables on land uses, buildings and infrastructure in rural and urban areas and areas of environmental significance and reduce salt loads in rivers.'* The scheme nominates planning should adopt best practise environmental managements and risk management approach which aims to avoid or minimise environmental degradation and hazards.	have been used for industry, mining or the storage of chemical, gas, wastes or liquid fuel (*may identify sites during investigation)* 13.03-2, Identify areas subject to erosion or instability in planning schemes and when considering the use and development of land. 13.03-3, Promote vegetation retention and replant in aquifer recharge areas contributing to groundwater salinity problems
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 land use and development proposals minimise nutrient contributions to waterways and water bodies and the potential for the development of algal blooms. Require the use of appropriate measures to restrict sediment discharges from construction sites.	Assess the Preferred Alignment to avoid impacting the environmental qualities of the waterways. Ensuring planning is coordinated with the catchment management authority. Ensure that there is only minor 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.
Industrial Waste Management Policy (Waste Acid Sulfate Soils) No S125, 1999	This policy outlines a management framework and specific requirements for the management waste materials in an environmentally responsible manner.	If contamination is encountered during the investigation and/or construction, the policy details specific requirements to address. Require to be included within the Construction Management Plan as part of the contract.

Legislation, Policy	Description	Implication for Project
Catchment and Land Protection Act 1994 (Vic) (**CaLP Act**)	The CaLP Act provides a framework for the integrated and coordinated management of catchments in regard to long-term land productivity and maintenance of the quality of the State's land and water resources	The Study Area is predominately within the North Central Catchment Management Authority. Local planning schemes must have regard to the Regional Catchment Strategy.

6 Impact Assessment

The key soils and geological risks which may have implications for the design, construction and/or operation of the Project include:

- waste material uncovered during works
- soil settlement due to poor / soft ground conditions
- potential for erosion / sediment generation during and post construction from localised rainfall.

The detailed impact assessment documented in this report addresses the potential Soils and Geology impacts of the construction and operation of the Preferred Alignment.

6.1 Waste (contaminated) material

During construction exposure of potentially contaminated soils may occur by uncovering contamination materials during earthworks or through the importation of contaminated fill. With respect to the known historic land use of the Study Area there are no known areas of contamination within the Preferred Alignment.

The discovery of contaminated material in the Study Area during works shall be managed in accordance with VicRoads and EPA Guidelines. These guidelines specify that during the preconstruction works a Phase 1 Environmental Site Assessment (ESA), inclusive of indicative soil contamination testing, will be completed as part of the geotechnical investigation. If contaminated material is located, a Phase 2 Environmental Site Assessment will be undertaken to delineate and classify the contamination. A Phase 2 ESA will only be undertaken if contamination is identified during the Phase 1 ESA. At the completion of Phase 2 ESA it will be possible to alter the design to minimise excavation / ground disturbance within the Preferred Alignment on any defined contaminated sites.

6.2 Imported Fill

There will be a need to import fill for the Project as there is a negative cut/fill balance for this Project, i.e. no specific cut zones, thus a need to import fill for road construction. The approximate volume of fill required to be imported is as follows;

- Earthworks Main Carriageway (Bulk) (including stripping volume and excluding pavement volumes is 325294m^3
- Earthworks Shared Use Path is 22835m^3
- Earthworks Bridge Abutments is 10705m^3

Quantities of various types of Fill, such as Type A, Type B, etc, will be determined during the detailed design phase. Please see below descriptions of various types of Fill Materials from VicRoads Specification for Earthworks 204 that will be utilised:

Fill material includes:

- Type A material – a superior quality material complying with the requirements of Table 204.041 and used principally as capping, selected material, structural material and/or verge material.
- Type B material – a medium quality material that does not meet the requirements of Type A material, and is usually specified with a minimum CBR value.
- Type C material – a lesser quality material that does not meet the requirements of Type A or Type B material, which may be used in Type C material zones of embankments as indicated on the drawings.
- Rock Fill material – a material comprised of larger rock and rock fragments which may be used within Type B and Type C material zones at lower levels of high embankments in accordance with Section 205.
- Permeable Fill material – self draining material, typically sand or aggregate.

Potential sources of fill may be determined during the pre-construction phase, but most likely to be determined during the tender/design phase of the Project. The imported fill will be sourced from VicRoads or RMS accredited quarries or borrow pits and will be required to meet VicRoads specification depending on its proposed use (ie. road base or batters). VicRoads contracts do not allow imported fill to be contaminated or contain inert material, thus excluding the potential for importing contaminated fill onto the RoW.

6.3 Soil Settlement

Soft ground conditions can result in ground settlement causing potential impacts to structures, pavement design life and maintenance issues. The construction of embankments over compressible ground may result in consolidation of the materials and thus settlement, both at the time of construction and over time. The laterally and vertically variable nature of the expected geology along the Preferred Alignment, which may include clays and silts, gives a potential for the existence of areas of compressible ground. Areas will be identified during the geotechnical investigation (pre-construction activity).

If soft or compressible ground is determined during the investigation, various construction methods can be undertaken to minimise the impact. Ground improvement options can include:

- Controlled Modulus Column (CMC)
- Surcharge with Wick Drain
- Stone Columns
- Injected piles
- Continuous Flight Auger (CFA)
- Construct fill embankments with lightweight Expanded Polystyrene (EPS)

A list of possible ground improvement options, inclusive of generic details of each option is shown in Appendix E.

Until the actual ground conditions are determined, the selection of which ground improvement option cannot be made. The choice will depend on actual ground conditions encountered, area of soft ground, the rate of predicted settlement and/or cost implications.

No sensitive receptors or community facilities are located within areas that could be subject to soil settlement.

6.4 Erosion

No major soil stability and erosion issues were observed during any of the site inspections along the Preferred Alignment. However, it was noted erosion was observed at the banks of both the Lower Campaspe and Murray River crossings. Any stability and erosion issues that are identified during the preconstruction and construction phases could be managed by reducing slope batters and/or using standard erosion protection measures such as those employed on other VicRoads projects (i.e geofabric matting, appropriate vegetation, tress to be cut at ground level in vicinity of the bank where the proposed river crossings are, etc). Any piling works near the waterways will involve the use of coffer dams to allow construction to occur, as well as minimise sediment entering the waterway. The geomorphic stability adjacent to both the rivers would be maintained by restricting the construction work within the confined zone of the bridge/RoW footprint), also by keeping flood scour velocities to an acceptable level.

The area defined as the 'Sand Hill' near the former Echuca High School, within the Preferred Alignment will have a specific construction methodology to avoid any disturbance of the subsurface material. It is proposed to cover the topsoil in the affected area with a geotextile material and concrete slab prior to construction of the embankment.

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.

6.5 Potential for Spills

The potential for uncontained chemical spills or leaks during operation and construction has been considered as part of the impact assessment.

The risk of chemical spills during the construction or operation of the Project is considered to be low due to established procedures. VicRoads' procedures require the preparation of a Construction Environment Management Plan (CEMP) to manage any potential chemical spills or leaks during construction or operation of the Project. The CEMP would assist in reducing the overall impact from chemical spills from moderate to insignificant during the construction phase of the Project.

It should be noted that during operation, VicRoads' is not responsible for fuel or chemical spills. If there is a spill during the operation of the new road, VicRoads' maintenance contractors are required to have an emergency procedure that details how the spill is to be managed and relevant emergency service agency contacts (including, CFA, police, EPA) are contacted to help manage the spill and implement appropriate traffic control measures.

6.6 Benefits and Opportunities

No direct benefits from a soils and geology perspective would be gained from the construction Project. However, an opportunity to improve erosion control at the sites of the proposed river crossings due to appropriate engineering design and construction may be achieved. This would be considered the only alteration against the "No Project Option".

6.7 Impacts

The residual impact of the Project is the potential for erosion and sediment generation in the operational phase of the road (post construction) having an impact on the beneficial uses of surface water and groundwater. These impacts would only affect surface water and be temporal in nature (i.e. during a high intensity rainfall event) and are considered a minor impact. It is considered a "minor impact", because during a high intensity rainfall event, gully erosion would occur in the surrounding areas of the Preferred Alignment, not just on and adjacent to the aligment, and so the volume of sediments entering the rivers would be considered low as a result of the Project compared with the total sediments entering the rivers. Both rivers are considered to already have a high sediment volume. Only minimal erosion should occur due to the erosion protection measures put in place as part of the construction works. This would also be considered a minor impact.

The construction of the bridges over both the Campaspe and Murray Rivers would have an insignificant effect on the geomorphic stability of the area. With appropriate design of the proposed single spanned structures (abutments set back from the river banks which would minimise scour) and erosion controls measures, it is considered there would be a minor impact on the future geomorphology of the proximate section of both the lower Campaspe and Murray Rivers.

6.8 Risk Assessment

6.8.1 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 4 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 on 18 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.

6.8.2 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". 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 Soils and Geology associated with the Project are outlined in Table 2. The significance of the risks was determined having regard to the Likelihood Guide (Table 3) and Consequence Level (Table 2) as outlined in Table 4.

Table 2: Consequence Criteria

ASPECT	CONSEQUENCE CRITERIA				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Potential for erosion, scouring / sediment generation	No potential for erosion, scouring or sediment generation	Potential for erosion, scouring and sediment mobilisation in small isolated locations along the alignment	Potential for erosion, scouring and sediment mobilisation in multiple locations along the alignment	Potential for erosion, scouring and significant mobilisation of sediment along sections of the alignment	Potential significant erosion, scouring, widespread sediment mobilisation and instability along the majority of the alignment
Land contamination (encountering historic, or causing or permitting contamination during construction or operation of the road)	No potential for encountering land contamination with no risk to sensitive receivers.	Potential for minor land contamination , but minimal risk to sensitive receivers	Potential for moderate land contamination , some risk to sensitive receivers	Potential for gross land contamination , confined to a localised area. Significant risk to sensitive receivers	Potential for gross and widespread land contamination . Significant risk to sensitive receivers
Soil settlement due to poor ground conditions	No potential for soil settlement	Potential for some soil settlement in small isolated locations along the alignment	Potential for significant soil settlement in isolated locations along the alignment	Potential for significant soil settlement along multiple locations of the alignment	Potential for significant soil settlement for the majority of the alignment

Table 3: 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 4: 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

6.8.3 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 Alignment). 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 NSW Roads and Maritime Services.

Initial discussions at the workshop were held regarding the suggested consequence criteria developed for each of the relevant specialist's disciplines for the Project. This was followed by review of environmental risks.

The workshop included review of the Extreme, High and Medium initial risks. As part of the workshop, it was agreed that the consequence criteria or likelihood of some of the initial Medium, High and Extreme risks could be revised. The risk ratings were revised within the workshop and specialists were asked to review the updated risk register as part of their impact assessment to confirm or recommend if any further changes would be required. Table 5 outlines the Soils and Geology risks identified for the preferred alignment.

Table 5: Soils and Geology Risk Register

Risk No.	Impact pathway	Description of consequences	Linkages	VR Contract Specification Section 177 Reference	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
SG 1	Waste material uncovered during works	Exposure of potentially contaminated soils.	Hydrology, Biodiversity & Habitat	177E1.	The discovery of contaminated material on the site during works shall be managed in accordance with VicRoads and EPA Guidelines. Undertake Phase 1 Environmental Site Assessment (ESA) and indicative soil contamination testing as part of the geotechnical investigation during the pre-construction works.	*Moderate*	*Unlikely*	*Medium*	Phase 2 environmental site assessment to delineate any contamination if contamination encountered. Design to minimise excavation / ground disturbance within the corridor.	*Minor*	*Unlikely*	*Low*
SG 2	Soil settlement due to poor / soft ground conditions	Ground settlement, potential impacts to structures, pavement design life and maintenance issues	Social		Undertake adequate geotechnical investigations including Cone penetration testing and consolidation testing of undisturbed soil samples obtained from borehole drilling. If soft ground encountered, undertake additional investigations to allow design to minimise settlement	*Moderate*	*Likely*	*High*	Ground stabilisation/improvement techniques if required prior to construction. Contractor to utilise best practice techniques for batter construction.	*Minor*	*Unlikely*	*Low*

Risk No.	Impact pathway	Description of consequences	Linkages	VR Contract Specification Section 177 Reference	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
SG 3	Potential for erosion / sediment generation during construction from localised rainfall.	Batter instability, maintenance issues and sediment impacts within drainage paths and waterways	Hydrology, Biodiversity & Habitat	Clause 177D	Sediment control measures (e.g. sedimentation basins) to be setback from banks of waterways where possible. Where construction activities are undertaken in, near or over waters, EMPs shall be prepared to protect beneficial users in accordance with any permit, the *State Environmental Planning Policy (Waters of Victoria)* its schedules and best practice guidelines.	*Minor*	*Possible*	*Low*		*Minor*	*Possible*	*Low*
SG 4	Potential for erosion / sediment generation post construction	Batter instability, maintenance issues and sediment impacts within drainage paths and waterways	Hydrology, Biodiversity & Habitat	Clause 177D	Regular maintenance and established management measures, such as sedimentation basins, silt fences, batter protection (appropriate vegetation, geofabric matting, etc)	*Minor*	*Possible*	*Low*	Additional erosion management measures if pre-existing measures implemented not performing to requirements. Measures may include remulching, inserted erosion control mats or seeding with grass (hydroseeding). Undertake surveillance to monitor.	*Minor*	*Unlikely*	*Low*

Risk No.	Impact pathway	Description of consequences	Linkages	VR Contract Specification Section 177 Reference	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
SG 5	Potential for uncontained spills or leaks during construction or operation	Groundwater, soil and/or surface water contamination impacts on water resources, flora, fauna, and/or human health.	Hydrology, Biodiversity & Habitat	Clause 177.G1	Environmental Management Plan (EMP) shall include specific procedures to minimise spillage of any fuels or chemicals and mitigate the effect in the event that leakages and spillages occur. Fuel, chemical and equipment storage areas shall be visually monitored at intervals of not more than 7 days to mitigate contamination in a timely manner.	*Moderate*	*Rare*	*Low*	EMP to include: - Appropriate procedures for containing spills and leaks - Appropriate methods for cleaning up spills and leaks where safe to do so.	*Insignificant*	*Rare*	*Negligible*

6.9 Mitigation Measures

In order to mitigate the risks for the Project, standard VicRoads and Roads and Maritime environmental protection measures and some additional project specific measures 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 Environmental Management Plan (EMP).

Standard protection measures for the Soils and Geology impacts that would be adopted for this Project include Clauses of the VicRoads DCI contract specification 177. Section 177 specifies the standard environmental management obligations for meeting 'best practice' and VicRoads legislative obligations. The clauses include control measures related to soils and geology issues. Please see EES Technical Appendix O – VicRoads Specification, SECTION 177 – ENVIRONMENTAL MANAGEMENT (Major) for specific details of the specification which nominates the standard protection measures. Specifically please refer to the following parts of the specification:

- Part B – Water Quality
- Part D – Erosion and Sediment Control
- Part E – Contaminated Soils and Materials

A suite of intrusive sub-surface investigations and testing would be undertaken during preconstruction to identify soil properties and inform the design and development of any necessary precautions, such as potential for settlement or contaminated materials. The laterally and vertically variable nature of the geology, which may include clays and silts, gives a potential for the existence of areas of compressible ground. The use of insitu and laboratory testing of samples from boreholes and trial pits, or CPT testing, will allow design to mitigate the risks.

These nominated investigations would cover the full Preferred Alignment. However, the investigations would focus on identified key geotechnical risks areas, such as, deep embankments, bridges, potential areas of 'unsuitable' or 'soft' materials and other high risk areas.

It should be noted that groundwater risks have been considered as part of the Specialist Hydrology Report by Cardno (May 2015).

There are several additional Project specific controls that have been recommended to avoid, mitigate and manage potential Soils and Geology effects, reducing residual risks/impacts to an acceptable level. These additional controls and the responsibility for implementing them are outlined in Table 6.

Table 6: Environmental Management Measures

Risk No.	Risk Description	Management Measures	Responsibility
SG1	Waste or contaminated material uncovered during works	Phase 2 environmental site assessment to delineate any contamination if contamination encountered. Design to minimise excavation / ground disturbance within the alignment on any defined contaminated sites.	VicRoads VicRoads & Contractor
SG2	Soil settlement due to poor/soft ground conditions	Ground stabilisation &/or improvement techniques if required prior to construction. Contractor to utilise best practice techniques for batter construction.	VicRoads (contract specific clauses in specification) & Contractor
SG4	Potential for erosion/sediment generation post construction	Additional erosion management measures if pre-existing measures implemented not performing to requirements. Measures may include remulching, inserted erosion control mats or seeding with grass (hydroseeding). Undertake surveillance to monitor.	VicRoads & Contractor (defects liability period, approximately 2 years)
SG5	Potential for uncontained spills or leaks during construction or operation	EMP to include - Appropriate procedures for containing spills and leaks - Appropriate methods for cleaning up spills and leaks where safe to do so.	VicRoads & Contractor

7 Summary of Impacts

From a geotechnical and soils impacts perspective, there are no major impediments to the construction and long term maintenance of the Project.

The soils and conditions from the two key geological units which generally will comprise of gravel, sand, silt and clay and may have varying engineering properties due to depositional circumstance, although with standard design and management measures, including further investigations during detailed design, it is considered that there is little potential for significant soil issues arising from the Mid-West Option.

The construction of the roadway over both the Campaspe and Murray Rivers would have an insignificant effect on the geomorphic stability of the area, unless there is an occurrence of flooding of those rivers in which case, this would be assessed through specialised detailed hydrology modelling. With appropriate design of the proposed single spanned structures (abutments set back from the river banks which would minimise scour) and erosion controls measures it is considered there is an insignificant effect on the future geomorphology of the proximate sections of both the lower Campaspe and Murray Rivers.

8 Assumptions and Limitations

Disclaimer

This document has been prepared in response to the client's brief with all due care and skill by competent personnel, as defined in Technical Services quality system, and is a true record of the investigations and tests conducted at the date and time conducted. This document is not intended to be a complete and exhaustive statement of all conditions present.

This document has been prepared solely for the specific client, for this specific project and for a specific use in response to the client's brief. The use of this document is not appropriate where there has been any change in the nature of the project or its intended use, or in the site resulting from natural or man-made events or the passing of time or in the specific needs of the user.

This document should only be used as a whole. This document has been prepared for interpretation and use as a single entity, with qualifications being made where appropriate on information presented herein. No responsibility or liability is accepted where any part of the document is used in isolation, and without consideration of the total document.

Surface and sub-surface conditions are variable. Where investigations have been conducted, these investigations relate only to the specific sites tested as shown in this document. While due care and judgement have been used, such investigations are far less exact than other design disciplines.

Sub-surface conditions, especially, may vary between test sites, at depths below which testing has been carried out, and with climatic conditions. Actual conditions may only be revealed during further work at the site. Technical Services recommends that further advice be obtained where any variances in conditions differ from those identified in this document.

Visual inspections. Where the client has requested visual inspections only without sub-surface investigations, sampling or testing, the information presented is considered to be a true record of visible conditions as observed by an experienced and competent person present at that time, date and under the climatic conditions experienced. A visual inspection cannot be deemed as a comprehensive review of existing conditions.

Testing of materials supplied by others. No responsibility or liability is accepted for the condition of materials or apparatus as received from the client, or for the suitability of the test method where it has been specified by the client.

9 References

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