VicRoads

Western Highway Project – Section 3: Ararat to Stawell

Surface Water Impact Assessment Report

November 2012

This Surface Water Impact Assessment Report:

1. *Has been prepared by GHD Pty Ltd ("GHD") for VicRoads;*
2. *May only be used for the purpose of informing the Environment Effects Statement and Planning Scheme Amendment for the Western Highway Project, Ararat to Stawell Project (and must not be used for any other purpose);*
3. *May be provided to the Department of Planning and Community Development for the purpose of public exhibition as part of the Environment Effects Statement and Planning Scheme Amendment for the Western Highway Project, Ararat to Stawell Project;*

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in Section 4 Methodology of this Report.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), as specified in Section 4 Methodology and throughout this Report.

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GHD has prepared the floodplain assessment documented in this report based on information provided by Urban Water Cycle Solutions (UWCS) and TGM for VicRoads, which GHD has not independently verified or checked and takes no liability for, beyond the agreed scope of works.

GHD has not been involved in the preparation of the UWCS/TGM report and has had no contribution to, or review of the UWCS/TGM report. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in or derived from the UWCS/TGM report

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Executive Summary

VicRoads is progressively upgrading the Western Highway as a four-lane divided highway between Ballarat and Stawell (Western Highway Project). The Western Highway Project consists of three sections, to be constructed in stages. Section 3 (Ararat to Stawell) of the Western highway Project (the Project) is the subject of this report.

On 27 October 2010, the Victorian Minister for Planning advised that an Environment Effects Statement (EES) would be required to identify the anticipated environmental effects of the Project. GHD has been commissioned by VicRoads to undertake a Surface Water impact assessment for Section 3 of the Project as part of the EES.

The objective of the surface water assessment was to determine the potential impacts related to surface drainage, water quality, flooding/hydrology and the conditions and river health values of waterways and floodplains.

The overall method for the surface water assessment involved the following assessment stages:

- Existing Conditions Assessment – Existing conditions of the defined study area;
- Options Assessment – Options assessment of the shortlisted alignment options to inform the selection of the preferred Section 3 alignment (note this is not documented within this report); and
- Impact and Risk Assessment – Detailed assessment of the preferred Section 3 alignment in terms of impact on surface water systems.

Existing Conditions Assessment

Among the waterway crossings included in Section 3 are the following main waterways: Concongella Creek and main tributaries including Allanvale Creek, Robinsons Creek, Donald Creek, as well as Pleasant Creek.

The existing conditions were assessed against the key issues to be considered in the impact assessment, including:

- Waterway and river health condition – The identified waterways within the study corridor were assessed, and the status of river health considered. From the assessment the various reaches within the Concongella Creek system, the overall status of the condition of Concongella Creek is moderate. The findings with respect to waterways and river health for existing conditions included for the Concongella Creek system was variable including:
  - Ephemeral waterway with good diversity including in stream pool-riffle features with well vegetated banks and habitat features; and
  - Ephemeral, channelised waterways that are typically highly disturbed with low diversity.
- Floodplain characteristics – The waterway crossings and interaction of the existing highway with the flooding characteristics of the broader study area were assessed. The assessment of floodplain characteristics has been based on interpretation of the flood modelling outputs for a range of events up to the 100 year Average Recurrence Interval (ARI) from the flood investigation undertaken by

Bonacci Water[1] for VicRoads (August 2012) and identifying potential impacts. The existing Western Highway and associated road features are located within complex floodplain environments of Concongella Creek and its tributaries. From the modelling results, at a number of locations the 100 year ARI flood extent behind the highway stretches for several hundred metres, and in some locations property and dwellings are affected. There are a number of crossings where a significant portion of flood flows currently overtop the highway, indicating the level of flood protection for the road is relatively low. For the following locations the existing highway is overtopped in the modelled 100 year ARI flood event (refer to Figure 24 and Appendix C for a map of waterway locations and 100 year ARI flood extents):

– Tributary of Concongella Creek (Crossing WB321)
– Concongella Creek (Crossings WB323) – minor overtopping (significant flow diverted upstream)
– Concongella Creek (Crossings WB325) – overtopping (with significant flow diverted upstream)
– Concongella Creek (Crossings WB325 to WB327) – extensive overtopping of road across a length > 1000 m leading into Great Western from the south
– Concongella Creek (Crossings WB328 – Bests Road)
– Robinsons Creek (WB330).

The existing conditions flooding of the existing highway and the Great Western township is a complex interaction of Concongella Creek and tributaries. Flooding at Great Western is expected to be influenced by:

- Relative timing from the various sub-catchments and tributaries;
- Obstruction to flow paths leading to diversions and breakaway flows; and
- Backwater storage behind existing crossing and road embankments.

Whilst the existing highway is subject to extensive flooding, it also provides some backwater attenuation at various crossing locations, and also causes diversion of flows upstream of crossing locations. The impacts of the proposed highway would need to consider the existing flooding and how any change may impact on flow conditions downstream. The upgraded highway conditions where the road is flood free could potentially affect current flooding characteristics in terms of timing, change in storage characteristic and /or flow distributions.

Impact Assessment

The key outcomes of the impact assessment are summarised below:

River Health - The overall impacts on River Health from the Project to the various waterways is generally low, with exception of the following waterways with site specific impacts from the identified risk pathways:

- direct disturbance by the footprint of the proposed highway embankment at Concongella Creek at Ch. 8200, as well as disturbance where additional crossings are proposed at new locations on the Concongella Creek and Allanvale Creek and the extended crossing of Robinsons Creek s;

[1] As of August 2012 the modelling has been undertaken by Urban Water Solutions (UWCS) with inputs from TGM (by former employees of Bonacci Water). To avoid confusion the terminology has been kept consistent and any reference to “Bonacci Water” subsequent to August 2012 refers to the work of UWCS/TGM .

- fragmentation of river health values at new crossing locations for Concongella Creek and Allanvale Creek; and
- change in Geomorphological conditions at new crossing locations for Concongella Creek and Allanvale Creek.

  For all locations where there are existing crossings of significant waterways (other than Concongella Creek at Ch. 8200 described above) the river health impacts are minor, predominately on the basis of there being an existing crossing already causing a river health impact.

Flooding – The construction of the Western Highway results in changes to the complex flooding characteristics of Concongella Creek, Allanvale Creek and tributaries. The potential impacts at the township of Great Western have been assessed by considering the whole of the Concongella Creek.

The potential impact of the Project (where requirements are for a flood free road during 100 year ARI flood conditions) was considered low for the majority of discrete waterway crossing locations. The potential impacts can be summarised as follows:

- Potential flooding impacts to Great Western township would be Major (given the township scale affected) but can be reduced to Minor subject to detailed flood modelling and detailed design of the road and waterway crossings.
- Potential flooding impacts to rural properties with dwellings at significant crossing locations would be Moderate, but can be reduced to minor subject to detailed flood modelling and detailed design of the road and waterway crossings.
- Potential flooding impacts at rural properties with no dwellings at significant crossing locations are minor.
- Potential impacts to minor waterways crossings were considered to be minor.

All minor crossing locations were considered to be of minor consequence, leading to insignificant risk rating. It is assumed that waterway crossings that provide a minimum flow capacity equivalent to the current crossing would be required. As head loss through a culvert increases with length, slightly larger waterway openings are likely to be necessary to achieve an equivalent flow capacity across the widened road.

Risk Assessment

For the risk assessment it was assumed that standard planning controls (including the VicRoads standard environmental protection measures) were in place. With the application of standard planning control measures, many of the risk items were assigned Low residual risk with the exception of the following risks:

- **Medium -** Construction of Western Highway in disturbance of channel planform, geometry and/or river health values for Concongella Creek at Ch. 8200 where there is a small reach of significant waterway that is directly disturbed by the footprint of the proposed highway embankment, as well as disturbance where additional crossings are proposed at new locations on Concongella Creek and Allanvale Creek.
- **Medium** -Construction of the Western Highway results in fragmentation of river health values at new crossing locations for Concongella and Allanvale Creeks.

- **Medium** -Construction of the Western Highway results in change in Geomorphological conditions at new crossing locations for Concongella Creek and Allanvale Creek.
- **Major** - The Construction of the Western Highway results in changes to floodplain characteristics to the Concongella Creek system leading to potential flooding impacts (including slight increase in flood levels) to the township of Great Western from the complex interaction of Concongella Creek and tributaries and the proposed highway.
- **Medium** - The Construction of the Western Highway results in changes to floodplain characteristics to waterways with identified potential impacts to rural properties at significant crossing locations.

The above medium risks can be mitigated to acceptable risk levels through a combination of the following mitigation measures:

- Construction of bed control and/or bank protection works associated with crossing works so that vulnerable areas are protected within or adjacent to the work area subject to the requirements of the Wimmera Catchment Management Authority (CMA);
- Develop appropriate crossing design configuration and apply appropriate design standards (e.g. culvert sized appropriately and set at bed level of waterway where required), as well as additional design controls may be imposed to design fauna friendly features such as oversizing culvert, providing adequate light penetration to encourage fish passage where applicable and/or providing artificial features (eg culvert baffles);
- Where significant waterways are potentially disturbed or for new crossing locations, large span bridge structures may be imposed with piers set outside of the waterway channel to minimise any disturbance within the waterway footprint;
- Where diversions of significant lengths of waterways are required (as at Concongella Creek, crossing WA323), further investigations are required to be undertaken to develop a design concept for the realignment of the creek which would form part of the works on waterway application and be subject to CMA approval.

For the flooding risks, through preliminary sensitivity modelling, it was identified that there is the potential to mitigate the major flood risk through Great Western. Preliminary hydraulic modelling indicated that impacts of flooding in Great Western including the slight increase in flood levels could be mitigated through appropriate design of crossings. Further hydraulic modelling would need to be undertaken during the detailed design phase to confirm the design arrangements of specific crossings and locations of any flood mitigation measures. From the interpretation of the preliminary modelling results, it can be concluded that the impacts in Great Western can be managed via a combination of the following key design features of the proposed road:

- Design of the complex interchange arrangement and allowance of waterway openings so that there is minimal redistribution of Concongella Creek flows;
- Design of attenuation storage (if required) at select crossing locations upstream of Great Western (e.g. new crossing of Allanvale Creek - subject to not impacting upstream rural properties).

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1. Introduction

1.1 Background

The Western Highway (A8) is being progressively upgraded as a four-lane divided highway for approximately 110 kilometres (km) between Ballarat and Stawell. As the principal road link between Melbourne and Adelaide, the Western Highway serves interstate trade between Victoria and South Australia and is the key transport corridor through Victoria's west, supporting farming, grain production, regional tourism and a range of manufacturing and service activities. Currently, more than 5500 vehicles travel the highway west of Ballarat each day, including 1500 trucks.

The Western Highway Project (here within described as 'the Project') consists of three stages:

- Section 1: Ballarat to Beaufort;
- Section 2: Beaufort to Ararat; and
- Section 3: Ararat to Stawell.

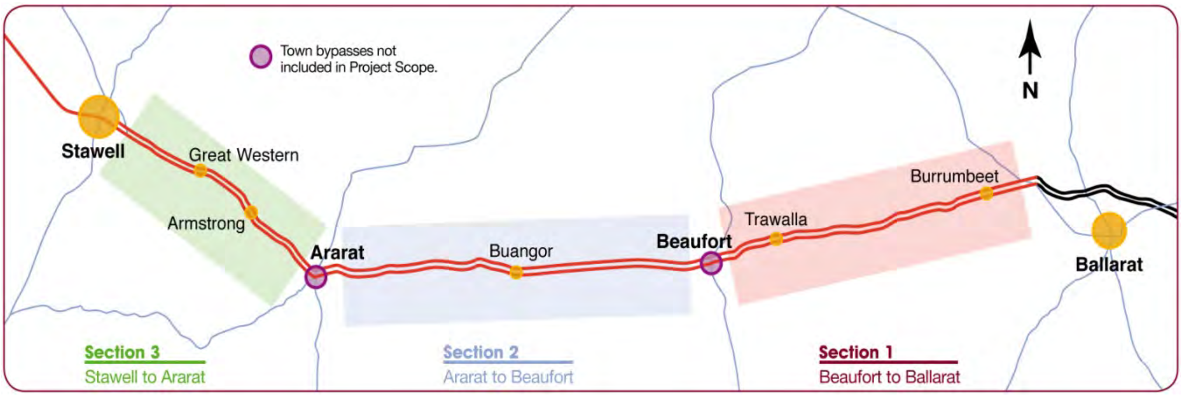


Figure 1: The Western Highway Project

Works on an initial 8 km section between Ballarat and Burrumbeet (Section 1A) commenced in April 2010 and will be completed in 2012. Construction for Section 1B (Burrumbeet to Beaufort-Carngham Road) commenced in early 2012 and is expected to be completed by June 2014. The last 3 km section from Beaufort-Carngham Road to Smiths Lane in Beaufort (Section 1C) commenced in late 2011 and will finish in 2012. Separate Environment Effects Statements (EESs) and Planning Scheme Amendments (PSAs) must be prepared for both Sections 2 and 3. It is expected that Sections 2 and 3 would be completed and opened in stages through to 2016, subject to future funding.

Section 2 of the Project commences immediately west of the railway crossing (near Old Shirley Road), which is west of Beaufort township and extends for a distance of approximately 38 km to Heath Street, Ararat.

Section 3 commences at Pollard Lane, Ararat and extends for approximately 24 km to Gilchrist Road, Stawell.

The EES will focus on assessment of the proposed ultimate upgrade of the Western Highway between Beaufort and Stawell to a freeway standard complying with the road category 1 (freeway) of VicRoads Access Management Policy (AMP1). The project includes a duplicated road to allow for two lanes in each direction separated by a central median.

The EES has also considered a proposed interim upgrade of the Western Highway to a highway standard complying with the VicRoads Access Management Policy AMP3. When required, the final stage of the Project is proposed to be an upgrade to freeway standard complying with AMP1.

To date $505 million has been committed for the Western Highway Project by the Victorian Government and the Australian Government as part of the Nation Building Program.

Highway improvements for the three sections between Ballarat and Stawell will involve:

- Constructing two new traffic lanes adjacent to the existing highway, separated by a central median.
- Upgrade of the Western Highway to a four-lane divided rural highway standard.

In addition to separating the traffic lanes, highway safety would be improved with sealed road shoulders, safety barriers, protected turning lanes, intersection improvements, and service lanes for local access at some locations.

Town bypasses of Beaufort and Ararat are not included in the current proposals. Beyond Stawell to the Victorian border, ongoing Western Highway improvements would continue with shoulder sealing works, new passing lanes and road surface improvements.

The aims/objectives of this Project are to:

- Provide safer conditions for all road users by:
  - Reducing the incidence of head-on and run-off-road crashes;
  - Improving safety at intersections; and
  - Improving safety of access to adjoining properties.
- Improve efficiency of freight by designing for High Productivity Freight Vehicles;
- Provide adequate and improved rest areas;
- Locate alignment to allow for possible future bypasses of Beaufort and Ararat.

1.2 Project and Study Areas

1.2.1 Project Area

The project area was defined for the purposes of characterising the existing conditions for the Project, and to consider alignment alternatives. The project area encompasses a corridor extending generally up to 1500 metres (m) either side (east and west) of the edge of the road reserve, except around Great Western where the project area extends up to 1800 m (encompassing the extent of new alignment possibilities).

1.2.2 Study Area

The study area for this Surface Water assessment is the same as the project area described above. This report details the assessment of the Section 3 stage of works from Ararat to Stawell. The footprint of the study area for Section 3 commences at Pollard Lane, Ararat and extends for approximately 24 km to Gilchrist Road, Stawell. The township of Great Western is located within Section 3.

Waterway crossings included in this Section of the Western Highway Project include the following and associated unnamed tributaries:

- Donald Creek;
- Robinsons Creek;
- Hyde Park Creek;
- Concongella Creek; and
- Allanvale Creek.

Crossings of unnamed tributaries of (but not the creek/river itself):

- Hopkins River; and
- Pleasant Creek.

1.3 Proposed Alignment

A multi-criteria assessment of alignment options was conducted based on information from the existing conditions assessments. The outcome was the selection of a proposed alignment for further consideration in the EES for Section 3. The proposed alignment and associated construction corridor are the subject of the risk and impact assessment presented in this report and are described in more detail in Section 6 of this report. The assessment of alignment options and selection of the proposed alignment is documented in Chapter 5 of the EES, and in the Options Assessment Report (Technical Appendix to the EES).

2. EES Scoping Requirements

2.1 EES draft Evaluation Objectives

For the Surface Water aspects of the Western Highway Project, the relevant draft evaluation objective outlined in the EES Scoping Requirements is:

- *To protect catchment values, surface water and groundwater quality, stream flows and floodway capacity, as well as to avoid impacts on protected beneficial uses.*

2.2 EES Scoping Requirements

The EES Scoping Requirements for Surface Water aspects are as follows:

"The EES needs to assess potential effects related to surface water environments, including on water quality, hydrology and beneficial uses and values. This should be done in the context of the *State Environment Protection Policy (Waters of Victoria),* and other water-related legislation, policies and strategies.

The EES should assess potential effects related to stormwater runoff, as well as the hydrology and water quality of waterways and floodplains in the surrounding area. The level of detail of investigation should take account of the local conditions, the occurrence of surface water in the area, including perennial or ephemeral wetlands, drainage reserves, and sensitivity of the beneficial uses and values of the respective water environments.

Specifically, the EES should:

- *Characterise surface water environments and drainage features (including tributaries, drains and drainage reserves) in the project area in terms of water quality, hydrology and related beneficial uses and values;*
- *Identify and assess potential short- and long-term effects of the construction and operation of the highway on surface water quality and hydrology, surface drainage, flooding, the quantity and quality of surface runoff and river health values of the waterways, tributaries, drains, wetland systems or drainage reserves that may be crossed, including Allanvale Creek, Cobey Creek, Concongella Creek, Donald Creek, Hyde Park Creek and Robinsons Creek. Consideration should also be given to potential effects to the proclaimed special supply catchment areas located near the project area;*
- *Identify measures to avoid, mitigate and manage any potential effects including any relevant design features of the road, preventative techniques for construction and proposed measures to reinstate affected waterways and drains; and*
- *Describe likely residual effects of road construction and operation activities on waterways in the project area, at a level of detail proportionate to the risk to affected assets.*

Of particular relevance to road construction activities, the following must be addressed:

- *Evaluation of the preferred waterway crossing methods and relevant alternatives;*
- *Environmental management practices to be employed at waterway crossings in relation to disturbance of stream beds and banks, construction and removal of temporary barriers and crossings, release of diverted stream flow to watercourse during crossing construction and maintenance of sediment control facilities;*
- *Environmental management practices to be employed generally along the road alignment for activities, especially in disturbed areas within the construction footprint for sediment control and water quality protection; and*
- *Contingency plans, in the event of failure of the proposed control measures (i.e. during heavy rainfall or flooding)."*

3. Legislation and Policy

The following sections provide a brief overview of the legislation and policy documents relevant to surface water investigations. These legislation and policies would need to be adhered to during the preparation of site environmental management plans, planning approvals and design of waterway crossings.

3.1 Water Act 1989

The *Water Act 1989* is intended to ensure that water resources are conserved and properly managed for sustainable use for the benefit of present and future Victorians.

The *Water Act 1989*, in particular Part 10 gives the Catchment Management Authority (CMA) the responsibility for the provision of waterways and drainage services (river health and floodplain management). Through the Water Act responsibilities the CMA administer:

- Waterway function - works and activities associated with designated waterways so that environmental values and health of water ecosystems, including their biodiversity, ecological functions, quality of water and other uses that depend on environmental condition, are protected
- Floodplain function - proposed works or structures within floodplains for land adjoining waterways that may affect flooding in terms of flood levels, flood extent and diversion of floodwaters

3.2 Environment Protection Act 1970

The *Environment Protection Act 1970* empowers the Environment Protection Authority to implement regulations to maintain the State environmental policy, granting works approvals and licenses in the process. Consideration also needs to be given to the relevant state environment protection policies, such as those for groundwater and surface water.

3.2.1 State Environment Protection Policy (Waters of Victoria)

The *State Environment Protection Policy (Waters of Victoria)* aims to provide a coordinated approach for the protection and, where necessary, rehabilitation of the health of Victoria's water environments. The SEPP (WoV) contains objectives for the protection of water quality and biological health that describe the conditions required to protect the beneficial uses of the receiving water bodies. Detailed information is documented for each Catchment Management Authority (CMA) region on the following:

- The SEPP segment and water quality objectives that apply at each water quality site; and
- The SEPP segment and biological objectives that apply at each biological site.

For the purpose of the SEPP, the water quality objectives were incorporated within the segments representing the biological regions in the State Environment Protection Policy (Waters of Victoria). The target objectives for this region are shown in Table 1.

Table 1 SEPP WoV – Water Quality Objectives (Table 1, EPA 2003)

Water Quality Parameter	Objective & Trigger Value Relevant for Upland reaches in the Wimmera, Hopkins, Moorabool, Werribee, Maribyrnong, Campaspe, Loddon and Avoca catchments
Dissolved oxygen saturation	25th percentile: 85; Maximum trigger: 110
Electrical Conductivity at 25ºC	75th percentile: 500 µS cm^{-1}
pH	25th percentile 6.5; 75th percentile 8.3
Turbidity (NTU)	75th percentile 10

The waterways affected by the Western Highway Project would need to be considered under the SEPP WoV. SEPP WoV identifies 'beneficial uses' of waterways and establishes environmental quality objectives at levels that would ensure the protection of these uses. The named waterways within the study area are classified as Waters of Murray and Western Plains in the SEPP WoV Main Schedule (1970). The beneficial uses for these bioregions as identified in SEPP WoV include:

- Maintenance of Aquatic Ecosystems that are slightly to moderately modified;
- Primary contact recreation;
- Secondary contact recreation;
- Aesthetic enjoyment;
- Indigenous cultural and spiritual values;
- Non-indigenous cultural and spiritual values;
- Agriculture and irrigation;
- Aquaculture;
- Industrial and commercial use;
- Human consumption after appropriate treatment; and
- Fish, crustacean and molluscs for human consumption.

These beneficial uses need to be protected from potential impacts resulting from construction and operation of the Project.

3.3 Catchment and Land Protection Act 1994

The *Catchment and Land Protection Act (1994)* has the objective of establishing a framework for the integrated and coordinated management of catchments that will:

- Maintain and enhance long-term land productivity while also conserving the environment; and
- Aim to ensure that the quality of the State's land and water resources and their associated plant and animal life are maintained and enhanced.

The Act established ten Catchment and Land Protection Boards, nine of which have since expanded their roles to become Catchment Management Authorities. The Act provides for the development of Regional Catchment Strategies that must assess the nature, causes, extent and severity of land degradation of the catchments in the region and identify areas for priority attention. Local Planning Schemes must have regard for the Regional Catchment Strategies.

It is noted the catchments for the study area are within Declared Water Supply Catchments (DWSC). Formally known as Proclaimed Water Supply Catchments, DWSCs are the basis for catchment planning and management under the provisions of the Catchment and Land Protection Act, 1994. This process highlights to the community and land managers, the importance of the catchment for water supply purposes. Whilst DWSCs are subject to a Land Use Determination or a Land Use Notice, there are no specific requirements or restrictions for the purpose of the EES.

The Wimmera River Water Supply Catchment is part of the Wimmera River catchment that supplies the Wimmera-Mallee Water Supply System and its headworks. There is currently no management plan for the Wimmera River catchment that stipulates any specific management requirements for the DWSC. It is assumed that the environmental management controls (to be determined in the impact assessment) would be sufficient for meeting the catchment management requirements for the DWSC.

3.3.1 Wimmera Catchment Management Authority

The Wimmera CMA's region covers most of the Section 3 project area.

The Wimmera Waterway Health Strategy has been developed to provide a strategic framework to protect and enhance the high value assets of waterways and terminal lakes within the Wimmera catchment basin. The strategy is aligned with the Wimmera Regional Catchment Strategy five year blue print for improving the health of rivers and creeks within the catchment.

In protecting and improving the region's rivers and creeks, the main objectives of the waterways strategy are to:

- Proactively manage the waterways of the Wimmera, considering environmental, social and economic values;
- Maintain ecologically healthy waterways;
- Achieve an overall improvement in the environmental condition of the region's waterways; and
- Prevent damage to the waterways from future management activities.

The implementation of this strategy is the responsibility of the CMA in partnership with the local community, local government and State Government agencies (Department of Sustainability and Environment, EPA Victoria and Department of Primary Industries).

3.3.2 Glenelg Hopkins Catchment Management Authority

The Glenelg Hopkins CMA region covers a small part of the southern end of the Section 3 project area. The Glenelg Hopkins River Health Strategy (RHS) 2004-2009, provided a five year blue print for improving the health of rivers and creeks within the catchment. In protecting and improving the region's rivers and creeks, the main objectives of the River Health Strategy were to:

- Identify and prioritise actions for river restoration, considering environmental, social and economic values;

- Identify threats to waterway health and assesses the level of risk based on the interaction between threats and values;
- Identify priority actions required to protect and enhance high value river reaches;
- Identify opportunities to actively involve the community in river health; and
- Provide the strategic framework for investment in river health for the five year period.

The implementation of this strategy is the responsibility of GHCMA, in partnership with the local community, local government and State Government agencies (Department of Sustainability and Environment, EPA Victoria and Department of Primary Industries).

Recently, the GHCMA has launched the Regional Catchment Strategy (RCS) 2102-2018. This will be a key planning document for land, water and biodiversity management that will set regional priorities across the Glenelg Hopkins region. The RCS aims to provide focus, coordination and direction for all natural resource management, and in terms of river health management will build on the work from the RHS.

3.3.3 Licensing – Works on Waterway Approval

Victorian Catchment Management Authorities (CMAs) are delegated the function of issuing permits to carry out works on a 'designated' waterway under the *Water Act 1989* (By-Law No. 1). A designated waterway can generally be defined as a river, creek, stream or watercourse; a natural channel in which water regularly flows; and a lake, lagoon, swamp or marsh.

CMAs have the power to enforce alterations or remove works that are not in accordance with the approval conditions or are constructed without a permit or approval. The intent of the permitting system is to ensure that works are performed using environmentally sound methods and to ensure protection of the waterway.

3.4 Planning Schemes

The following provides a brief summary of the planning overlays that apply to the proposed Western Highway Project Section 3 and are of relevance to the surface water assessment. This section of the Project is located in the Rural City of Ararat and Shire of Northern Grampians.

The objectives of the following planning scheme overlays for the Rural City of Ararat and Shire of Northern Grampians are consistent with the surface water requirements of the Western Highway Project EES for Section 3.

3.4.1 Land Subject to Inundation Overlay

The purpose of the Land Subject to Inundation Overlay is as follows:

- To identify land in a flood storage or flood fringe area affected by the 1 in 100 year flood or any other area determined by the floodplain management authority;
- To ensure that development maintains the free passage and temporary storage of floodwaters, minimises flood damage, is compatible with the flood hazard and local drainage conditions and will not cause any significant rise in flood level or flow velocity; and

- To protect water quality in accordance with the provisions of relevant State Environment Protection Policies, particularly in accordance with Clauses 33 and 35 of the State Environment Protection Policy (Waters of Victoria).

3.4.2 Environmental Significance Overlay

The purpose of the Environment Significance Overlays is as follows:

- To identify areas where the development of land may be affected by environmental constraints; and
- To ensure that development is compatible with identified environmental values.

Ararat Planning Scheme Schedule 2 to ESO (ESO2 – Watercourses, Waterbody and Wetland Protection Areas).

The objectives to be achieved by this overlay schedule include:

- To maintain and enhance the environment and to maintain the integrity of the ecosystems;
- To prevent pollution and increased turbidity of water in natural watercourses;
- To maintain the biological, physical and chemical quality and quantity of water within the watercourse, water-body or wetland;
- To maintain the ability of streams and watercourses to carry natural flows;
- To prevent erosion of banks, streambeds and adjoining land and the siltation of watercourses, drains and other features;
- To protect and encourage the long term future of fauna and flora habitats along watercourses;
- To ensure development does not occur on land liable to flooding;
- To prevent waste discharge, nutrients and other pollutants from entering watercourses and water-bodies;
- To prevent increased surface runoff or concentration of surface water runoff leading to erosion or siltation of watercourses;
- To conserve existing wildlife habitats close to natural watercourses and encourage regeneration of riparian and fringing vegetation;
- To minimise the potential damage caused to human life, buildings and property by flood waters;
- To restrict the intensity of use and development of land and to activities which are environmentally sensitive and which are compatible with potential drainage or flooding hazards;
- To promote the use and environmental solutions in siting and design in preference to modification of natural systems through technical and engineering measures;
- To minimise the environmental impact on estuarine environments by controls over water releases and sand bar management in line with the established protocols of Wimmera Mallee Water and Southern Rural Water;
- To maintain the natural role of wetlands in filtering nutrients and absorbing soluble pollutants in water. Further loss of wetlands through drainage will be discouraged; and
- To protect and ensure the long term future of fauna and flora habitats in wetland and estuarine areas.

Ararat Planning Scheme Schedule 3 to ESO (ESO3 – Habitat Protection Areas)

The objectives to be achieved by this overlay schedule include:

- To protect rare or threatened species or significant habitats for native flora and fauna;
- To protect and enhance remnant native vegetation including understory and ensure the long term future of fauna and flora habitats;
- To ensure development does not impact on significant habitats;
- To restrict the intensity of use and development of land and to activities which are environmentally sensitive;
- To promote the use of environmentally benign solutions in siting and design in preference to modification of natural systems; and
- To promote the maintenance of ecological processes and generic diversity.

Northern Grampians Planning Scheme Schedule 1 to ESO (ESO1 – Significant Ridge Environs)

The objectives to be achieved by this overlay schedule include:

- To protect significant ridges from development which may accentuate erosion;
- To maintain the natural beauty of the ridge system;
- To protect the remnant native vegetation and to encourage the re-establishment of native communities in degraded areas;
- To prevent erosion of the ridge system; and
- To maintain the landscape qualities of the ridge system especially when viewed from surrounding areas.

3.4.3 Vegetation Protection Overlay

The purpose of the Vegetation Protection Overlay is as follows:

- To protect areas of significant vegetation;
- To ensure that development minimises loss of vegetation;
- To preserve existing trees and other vegetation;
- To recognise vegetation protection areas as locations of special significance, natural beauty, interest and importance;
- To maintain and enhance habitat and habitat corridors for indigenous fauna; and
- To encourage the regeneration of native vegetation.

Ararat Planning Scheme Schedule 1 to VPO (VPO1 – Significant and Remnant Vegetation)

- To protect areas of significant remnant vegetation throughout the municipality.

Ararat Planning Scheme Schedule 2 to VPO (VPO2 – Roadside Vegetation Protection Areas)

- To protect areas of significant remnant vegetation located along roadsides throughout the municipality.

4. Method

The overall surface water assessment method for the Western Highway Project Section 3 EES has involved the following assessment stages:

- Existing Conditions Assessment – Existing conditions of the study area, refined to focus on the preferred alignment is detailed within Section 5 of this report;
- Options Assessment – Options assessment of the shortlisted alignment options in considering the impact on surface water systems to inform the selection of the preferred Section 3 alignment (note this is not documented within this report but in the Options Assessment Report which is a Technical Appendix to the EES); and
- Impact and Risk Assessment – Detailed assessment of the proposed Section 3 alignment in terms of impact on surface water systems with respect to waterway and floodplain management is detailed within Section 6 of this report.

4.1 Existing Conditions

This report summarises the findings of the surface water existing conditions assessment, which forms part of the Western Highway Project EES – Section 3 Ararat to Stawell. The study area for the surface water assessment includes all identified water courses, including rivers, creeks and drainage lines, near or across the highway corridor (approximately 39 crossings of the existing highway). A mapbook showing the proposed alignment of the Western Highway Project Section 3 and location of identified waterways crossings has been included in Appendix A.

The purpose of this assessment is to provide an overview of existing conditions of surface water in the study area. It provided a basis for undertaking the options assessment of the shortlisted alignment options in considering the impact on surface water systems and has informed the determination of the preferred Section 3 alignment.

The existing conditions assessment has been based on a combination of desktop study and field assessment, and included the following tasks:

- Description of the catchment systems that the Project may impact and the catchment characteristics including land use or catchment activities;
- Identification and characterisation of existing watercourses (or “surface water systems”) within the study area that may be impacted from the Project; and
- Identification of the key issues to be assessed against evaluation criteria for an options assessment that has included:
  - Waterway characteristics – number and extent of waterways within the study area as well as considering the status of river health of the catchment system (including downstream receiving waterways) and potential to impact on waterway health and local conditions such as loss of habitat, aquatic invertebrates and riparian vegetation; and
  - Floodplain characteristics – number and extent of waterways within the study area that may impact floodplain characteristics and potential to change the flow hydraulics at waterway crossings as well as encroachment on the floodplain and change of flood flow characteristics. The existing conditions assessment has therefore focused on the hydrologic, floodplain and waterway characteristics.

The following approach and information has been used to inform the existing conditions assessment:

- Hydrologic and floodplain assessment – A concurrent flood study by Bonacci Water/Urban Water Solutions (UWCS)[2]/TGM has been commissioned by VicRoads for the existing Western Highway corridor. The following information from this preliminary investigation has been adopted:
  – The catchment delineation and hydrologic assessment to determine existing conditions design flow rates for the surface water systems at the existing crossing locations; and
  – Output from 2D floodplain hydraulic modelling including 100 year average recurrence interval (ARI) flood extents and depths.
- Waterway assessment – The assessment was based on the current conditions in the Glenelg Hopkins River Health Strategy, Wimmera Waterway Health Strategy and other relevant documents, as well as understanding the long term management objectives and regional significance of the waterways. A desktop condition assessment has also been undertaken using aerial photography and topographical information, as well interpreting other commercially available resources. This has been followed by a field assessment of existing waterway crossings and the field work recording sheets are provided in Appendix B

4.2 Impact and Risk Assessment

The following impact assessment methodology was used to determine the surface water impact pathways and risk ratings for the Project:

1. Determine the impact pathway (how the Project impacts on a given surface water value or issue).
2. Describe the consequences of the impact pathway.
3. Determine the maximum credible 'consequence level' associated with the impact. Table 2, Table 3 and Table 4 provides guidance criteria for assigning the level of consequence. The method for defining these criteria is described in Section 4.2.1.
4. Determine the likelihood of the consequence occurring to the level assigned in step 3. Likelihood descriptors are provided in Table 5 below; and
5. Using the Consequence Level and Likelihood Level in the Risk Matrix in Table 6 to determine the risk rating.

[2] As of August 2012 the modelling has been undertaken by Urban Water Solutions (UWCS) with inputs from TGM (by former employees of Bonacci Water). To avoid confusion the terminology has been kept consistent and any reference to "Bonacci Water" subsequent to August 2012 refers to the work of UWCS/TGM .

Table 2 Surface Water Impacts Consequence Table for physical disruption to waterways.

Insignificant	Minor	Moderate	Major	Catastrophic
Medium level impact to waterway, river health or floodplain function on minor waterway *Low level impact to waterway, river health or floodplain function on significant waterway*	*High level impact to waterway, river health or floodplain function on minor waterway* *Medium level impact to waterway, river health or floodplain function on significant waterway* *Low level impact to waterway, river health or floodplain function on major waterway*	*Severe level impact to waterway, river health or floodplain function on minor waterway* *High level impact to waterway, river health or floodplain function on significant waterway* *Medium level impact to waterway, river health or floodplain function on major waterway*	*Severe level impact to waterway, river health or floodplain function on significant waterway* *High level impact to waterway, river health or floodplain function on major waterway*	*Severe level of impact to a major waterway*

Note: The terms Minor, Significant and Major waterway and Low, Medium, High and Severe impacts are defined in Section 4.2.1 below.

Table 3 Surface Water Impacts Consequence Table for stormwater pollution to waterways.

Insignificant	Minor	Moderate	Major	Catastrophic
Minor increases to stormwater runoff, sediment and or contaminant loading to the waterway.	*Significant increases to stormwater runoff, sediment and or contaminant loading to a minor waterway as described in the impact assessment report.*	*Significant increases to stormwater runoff, sediment and or contaminant loading to a significant waterway as described in the impact assessment report.*	*Significant increases to stormwater runoff, sediment and or contaminant loading to a major waterway as described in the impact assessment report.*	*An uncontained spill of contaminants directly to a major waterway as described in the impact assessment report.*

Note: The terms Minor, Significant and Major waterway and Minor and Severe impacts are defined in Section 4.2.1 below.

Table 4 Surface Water Impacts Consequence Table for flood impacts.

Insignificant	Minor	Moderate	Major	Catastrophic
No additional floodplain impacts to any houses, outbuildings or infrastructure.	*Slight increase in flooding at a rural scale.*	*Medium increase in flooding at a rural scale or slight increase in flooding at a township scale.*	*Significant increase in flooding at a rural scale or medium increase in flooding at a township scale.*	*Significant increase in flooding at a township scale.*

Note: The terms Slight, Medium and Significant increase are defined in Section 4.2.1 below.

Table 5 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 not expected
Rare	The event may occur only in exceptional circumstances

Table 6 Risk 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

4.2.1 Consequence Criteria

Consequence criteria range on a scale of magnitude from “insignificant” to “catastrophic”. Magnitude was considered a function of the size of the impact; the spatial area affected and expected recovery time of the environmental system. Consequence criteria descriptions indicating a minimal impact over a local area, and with a recovery time potential within the range of normal variability were considered to be at the insignificant end of the scale. 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.

Impact - Physical Disruption to Waterways

For the purposes of defining the magnitude of impact resulting from physical disruption to waterways it is necessary to consider the significance of the waterway being impacted. Waterways impacted by the proposed alignment were categorised as minor, significant or major:

- **Minor Waterway** – Refers to undefined tributaries often without permanent water. Many minor tributaries in this area of works are not evident and expected to only flow in significant rainfall events.
- **Significant Waterway** – Refers to waterways with a defined channel, some in-stream vegetation, some sections of permanent water. These waterways include larger waterways that are heavily degraded with low ecological value.
- **Major Waterway** - Well defined channel with permanent water. Moderate to good in-stream vegetation and some stream protection. These waterways include smaller waterways with significant areas of intact vegetation and notable instream features such as deep pools, riffles and/or large woody debris.

The second step in considering the magnitude of the impact resulting from physical disruption was to consider the scale of the impact. Impacts were categorised as low, medium, high or severe by taking into account the size of the area disrupted, the likely extent of impact into adjacent waterway reaches and the expected recovery time for the subject reach.

- **Low** – Perpendicular road crossing with no impact to the adjacent waterway. Recovery could be expected to occur within weeks of completion of construction of the Project.
- **Medium** – Skewed crossings or crossings within interchange structures which impact greater than 100 m of waterway and/or crossings with a potential to impact the waterway immediately adjacent to the crossing location (by increasing the risk of erosion to a downstream bend, for example). Recovery could be expected to occur within months of completion of construction of the Project.
- **High** – Skewed crossings or crossings within interchange structures which impact greater than 200 m of waterway and/or crossings with a potential to impact the whole adjacent reach (by promoting incision of the creek bed level by more than 300 millimetres (mm) for example). Recovery could be expected to occur within years of completion of construction of the Project.
- **Severe –** Skewed crossings or crossings within interchange structures which impact greater than 200 m of waterway and/or crossings with a potential to impact multiple adjacent reaches (by promoting incision of the creek bed level by more than 1000 mm for example). Full recovery may never occur.

These definitions were used in conjunction with Table 2 to determine the appropriate level of consequence for each waterway crossing.

Stormwater Pollution to Waterways

The significance of the waterway being impacted was taken into account using the waterway classifications described in the above section.

Next, stormwater pollution impacts from storm water runoff were categorised as minor or significant.

- **Minor** – As a result of the Project, SEPP(WoV) trigger levels in the reach immediately downstream not exceeded
- **Significant** – As a result of the Project, SEPP(WoV) trigger levels in the reach immediately downstream are exceeded for no more than 6 hours in any one week period during which there occurred a rainfall event greater than the 1 in 3 month ARI but less than the 1 in 2 year ARI (1 in 2 year is the construction phase design storm specified by VicRoads). Or, as a result of the Project, SEPP(WoV) trigger levels in the reach immediately downstream are exceeded for any period of time not as a result of a rainfall event.

These definitions were used in conjunction with Table 3 to determine the appropriate level of consequence for each waterway crossing.

Flood Impacts

The consequence of flood impacts was considered in terms of the significance of the area impacted and the magnitude of the flood level increase. The significance of the area was categorised as either:

- **Rural (no buildings)** – Where no dwellings or farm buildings or local road infrastructure is affected;
- **Rural** – Where a single farm house, a small number of farm buildings or assets and/or a local road is affected; or
- **Township** – Where multiple buildings (residential, commercial premises, etc) forming part of a town and/or a regionally significant road is affected.

The magnitude of increase was categorised as follows:

- **Slight** – Increase in flood levels at buildings where floor levels are already inundated and/or inundation to below the floor level of properties not currently subject to inundation. No additional buildings flooded to above floor level. Partially obstructing but not completely blocking a public thoroughfare.
- **Medium** – Increase in flood levels to above the floor level at a single residential or commercial building or multiple ancillary buildings (i.e. barns, garages, etc). Completely blocking a public thoroughfare without resulting in the isolation of an area also subject to inundation (i.e. blocking a road, but not restricting evacuation of the area via another route).
- **Significant** – Increase in flood levels at multiple residential or commercial buildings resulting in inundation to above the floor level of properties not currently subject to inundation. Completely blocking public thoroughfares resulting in the isolation of an area also subject to inundation (i.e. blocking roads in a manner that restricts safe evacuation of the area).

These definitions were used in conjunction with Table 4 to determine the appropriate level of consequence for each waterway crossing.

The flood extents presented on the maps are based on flood modelling outputs provided by UWCS/TGM on 23 August 2012, which GHD has not independently checked or verified.

The 100 year ARI flood extent outputs presented on the maps are to be used for the purpose of the EES assessment only. They are considered a preliminary representation of the 100 year ARI flood conditions, and may be subject to change with more detailed and refined hydrologic and hydraulic modelling analysis that would be required for preparing a detailed design.

GHD does not accept liability for any error in, omission from, or false or misleading information interpreted in the flood extents provided by UWCS/TGM.

4.3 Limitations

Floodplain assessment

The hydrologic and floodplain assessment portion of this report is largely based on work undertaken by UWCS/TGM , comprising an initial hydraulic analysis in 2011 and subsequent remodeling completed throughout 2012 documented in the Urban Water Cycle Solutions (UWCS)/TGM (August 2012). The assessment by GHD documented in this report is based on findings from the report and the interpretation of the flood modeling outputs provided by UWCS/TGM . We note the following:

- The flood mapping extents from the modeling outputs provided by UWCS/TGM have been inserted on to the GHD prepared GIS base maps.
- The 100 year ARI flood extent outputs presented on the maps were provided by UWCS/TGM on 23 August 2012 and 18 September 2012 and are understood to be a preliminary representation of the 100 year flood conditions prepared for the purpose of the EES assessment only. More detailed and refined hydrologic and hydraulic modeling analysis will be required in preparing a detailed design of the Project.

This report also shares the limitations of the UWCS/TGM report, most notably:

- The data used to derive the topography represented in the Digital Terrain Model (DTM) was from a range of sources that have been combined, but generally includes higher resolution within a 3 km strip along the existing highway; and
- Whilst the initial preliminary TUFLOW modelling used a 10 m grid (which is considered relatively coarse but allows for faster processing), the modelling as documented in this report was based on a 3 m grid in the vicinity of the highway**.**

Vicroads has agreed with the WCMA to undertake the following additional tasks at detailed design as part of a more rigorous analysis:

- Vicroads would extend the catchment modelling to include all subcatchments within the Concongella creek catchment to Concongella Creek at Stawell (Gauge no. 415237)
- Vicroads would incorporate WCMA's most recent LIDAR or other more specific data to further refine the DTM of the hydraulic model;
- Vicroads would include further Flood Frequency analysis at detailed design
- Vicroads would undertake a more detailed and refined hydrologic and hydraulic modeling analysis during the detailed design of the Project

Waterway Assessment

Waterway assessment limitations include:

- The condition assessment undertaken was desktop only, and as such, any waterway features which are not readily apparent from the available photography and topographical information have not been noted in this assessment; and
- The River Health Strategies and Catchment Health Reports used to categorise waterway health are more than five years old, therefore the health of waterways detailed in this report may have improved or declined since these reports were prepared.

5. Existing Conditions Assessment

The existing conditions assessment outlined in this section of the report provides:

- An overview of catchment systems and waterways within the study area (Section 5.1);
- An assessment of the waterway and river health condition of the identified waterways within the study corridor (Section 5.2).
- An assessment of the floodplain characteristics associated with the waterway crossings and interaction of the existing highway with the existing conditions flooding characteristics of the broader study area (Section 5.3)

5.1 Catchment Systems & Waterways

5.1.1 Catchment System Descriptions

Section 3 of Western Highway Project is located within the Glenelg Hopkins CMA and the Wimmera CMA, with the catchment delineation just west of Ararat, as shown in Figure 2.

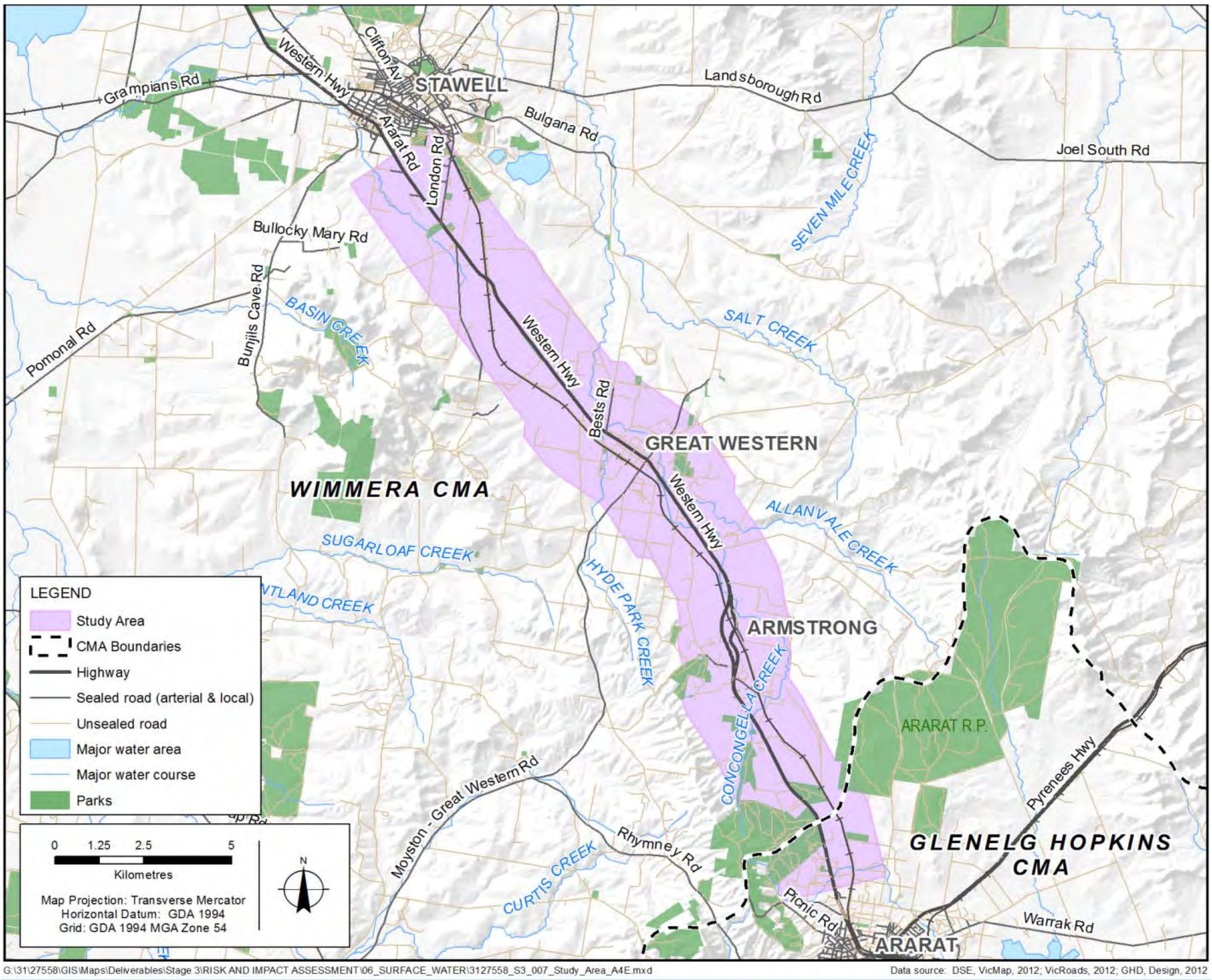


Figure 2: Catchment Management Authorities for Section 3

The alignment interacts with one sub-catchment system (or management unit) within each CMA area, located in the upper catchment areas of each of the CMA regions including:

- Concongella Creek (Wimmera CMA); and
- H5: Upper Hopkins River (Glenelg Hopkins CMA).

Subcatchment - Concongella Creek (Wimmera CMA)

The majority of the section of Western Highway between Stawell and Ararat is located within the Wimmera CMA in the upper Wimmera River Catchment. The main waterway interacting with Section 3 of the Project is Concongella Creek, which drains to the Wimmera River. The Wimmera River and its tributaries flow from the Mt Cole and Pyrenees Ranges to a series of terminal lakes including Lakes Hindmarsh and Albacutya. The region has a semi-arid to temperate climate with average annual rainfall ranging from 400-800 mm/year. Agriculture is the dominant land use in the catchment and most farms operate both cropping and livestock enterprises (SKM 2002).

There are 245 wetlands in the Upper Wimmera River Catchment covering an area of just over 7,000 hectares (Wimmera CMA, 2011). This sub-region includes the upper catchment of the Wimmera River. Many wetlands have high economic value to the region because of the role they play in storing water for urban and rural water supplies. The Concongella Creek Waterway Management Unit is defined separately to the Upper Wimmera WMU in the State of the Streams Report (2007), with the Section 3 Western Highway Project occurring within the Concongella Creek WMU only. The waterway crossings are shown in Appendix A and are detailed in Section 5.2 and Appendix B.

The major waterways and tributaries within this sub-catchment that are within the study corridor include:

- **Concongella Creek** - Concongella Creek is the main waterway intersecting the Western Highway in Section 3, crossing the highway at several locations, as the existing highway runs parallel with the valley over several kilometres. The headwaters of Concongella Creek commence in the Ararat Hills Regional Park and discharge into the Wimmera River upstream of Glenorchy. Concongella Creek is an incised channel with intermittent flows, with a number of permanent pools, sand bars and small islands. Its substrate is coarse sand with some gravel, with deposition of sands forming distinct benching along the length of the reach. Floodplain vegetation is pasture grasses and the riparian zone is open woodland dominated by River Red Gums, other eucalypts, acacias and pasture grasses. The creek crosses the existing Western Highway and proposed project alignment numerous times.
- **Allanvale Creek** - Allanvale Creek is a tributary to the Concongella Creek, with headwaters north of the highway near Armstrong, intersecting with Concongella Creek near Great Western. The creek does not cross the existing highway however it does cross the proposed project alignment immediately south of Great Western.
- **Other Concongella Creek Tributaries** – The smaller tributaries of Donald Creek, Robinsons Creek, Hyde Park Creek and Cobeys Creek commence on the south of the existing highway and converge and cross the highway west of Great Western, discharging into Concongella Creek.
- **Pleasant Creek** - The headwaters of Pleasant Creek are between Great Western and Stawell on the south of the highway and only one minor tributary would be impacted by the proposed project alignment. Pleasant Creek discharges into Anderson Creek prior to Lake Lonsdale.

Subcatchment– H5 Upper Hopkins River (Glenelg Hopkins CMA)

Section 3 of the Western Highway Project commences just within the Glenelg Hopkins CMA, north west of Ararat, within the H5 sub-catchment. The Hopkins River is the major waterway of this sub-catchment, the total Hopkins River length is over 300 km, discharging into the Southern Ocean, with approximately 60 km through this sub-catchment. The average annual rainfall is 500-600 mm and the typical air temperature ranges from 4°C to 26°C.

The major waterway within this sub-catchment, that is within the study area includes:

- **Hopkins River** - The start of Section 3, leaving Ararat, intersects a number of upper tributaries of Hopkins River. The existing Western Highway divides the current land use with upstream of the highway consisting of forest and downstream of the highway cleared land. The tributaries of the upper Hopkins River cross the existing Western Highway at two locations.

5.1.2 Identification of Waterways

This section identifies the waterways likely to be impacted by the Western Highway Project Section 3 study area between Ararat and Stawell. The identification of waterways has been based on a review of the Vicmap Hydro Watercourse dataset (December 2007). Detail on the individual crossings of those waterways is also given. A mapbook showing the location of each waterway crossing has been included as Appendix A.

Table 7 provides a summary of the identified waterway crossings along the existing highway and the proposed alignment of the highway. The existing Western Highway has 32 waterway crossings and the proposed alignment has 36 crossings.

Table 7 Summary of Waterway Crossings of Existing and Proposed Highway

	Number of Crossings	Waterway
Existing Highway	32	Concongella Creek (x 5) Donald Creek Robinsons Creek Hyde Park Creek Tributary to Concongella Creek (x 21) Tributary to Pleasant Creek* Tributary to Hopkins River (x 2)
Proposed Alignment	36	Concongella Creek (x 7) Allanvale Creek Donald Creek Robinsons Creek Tributary to Concongella Creek (x 23) Tributary to Pleasant Creek* Tributary to Hopkins River (x 2)

Table 8 provides a summary of the identified waterway crossings. The Project crosses 10 Significant waterways and 26 minor waterways (unnamed tributaries and drainage lines).

Table 8 **Summary of Catchment and Crossings (Proposed Alignment)**

Catchment	Number of Crossings	Waterway
"Major" Waterway		No Major waterways present
"Significant" Waterways	10	◗ Concongella Creek (x7) ◗ Allanvale Creek ◗ Donald Creek ◗ Robinsons Creek
"Minor" Waterways	26	◗ Tributary to Concongella Creek (x23) ◗ Tributary of Pleasant Creek* ◗ Tributary to Hopkins (x2)

* No designated tributary of Pleasant Creek crosses the highway alignment, but there will be local catchment flows that will need to be accommodate

A complete list of waterway crossings identified within the UWCS/TGM hydrologic assessment and those identified from VicMap where they cross the proposed highway alignment can be found in Appendix E. The table lists waterway crossings of both the existing highway and proposed highway. For definition of waterway types see Section 4.2.1.

5.2 Waterway & River Health Assessment

The waterway and river health existing conditions assessment has been undertaken based on a combination of desktop assessments, field assessments and review of various strategies and background documents.

5.2.1 Waterway Characteristics

The following section provides a general description of the waterways and catchments identified in Section 5.1. These waterways are included as part of the south eastern section of the Wimmera Catchment Management Authority (WCMA) region. The WCMA region is divided into 19 Waterway Management Units. The project area for this study lies across the following management units:

- Concongella Creek (Management Unit 4); and
- Upper Mount William Creek (Management Unit 5).

The waterways within the project area are considered to be in moderate ecological condition and of moderate social value according to the WCMA River Health Strategy (WCMA 2006). Under the strategy, Concongella Creek was the only waterway within the project area listed as a priority waterway. Priority waterways are determined based on ecological values, waterway condition and social and economic value.

Although not specified as priority waterways in the WCMA RHS, the other waterways present within the Section 3 study area still need to be considered under the SEPP WoV. SEPP WoV identifies 'beneficial uses' of waterways and establishes environmental quality objectives at levels that will ensure the protection of these uses. The named waterways within the study area are classified as Waters of Murray and Western Plains in the SEPP WoV Main Schedule (1970). The beneficial uses for these bioregions as identified in section 3.2.1.

A summary of the key features of the "significant" and "major" waterways is summarised in Table 9. A set of maps showing the location of each waterway crossing can be found in Appendix A. Note that the proposed alignment in this section also crosses two minor waterways in the Glenelg Hopkins Catchments, which have not been discussed in detail due to their minor nature.

Table 9 Summary of Waterway Characteristics

Waterway Crossing	Waterway	Description	River Health (observation)
Moderate - WB312, WB314, WA323, WB324, WB325, WB327, WB328, WB329 – Moderate	Concongella Creek	Actively eroding waterway with exposed banks and bank slumping in some sections	Low diversity with inhabited by reeds
WB326	Allanvale Creek	A laterally unconfined, sandy waterway with low sinuosity	Some diversity (reeds, sedges)
Existing Highway Only	Hyde Park Creek		
WB330	Robinsons Creek	A low sinuosity, fine grained system with some sandy deposits	Some habitat diversity including; in stream pool-riffles with sedges and reeds, and pockets of woody vegetation
WB331	Donald Creek	A low-sinuosity fine-grained waterway with some bank slumping and smaller sand deposits present within the channel	Some diversity (reeds, sedges)

MAJOR WATERWAYS

There are no "Major" waterways within Section 3.

SIGNIFICANT WATERWAYS

Concongella Creek (WA323)

This crossing of Concongella Creek is located approximately 5 km south east of Great Western. At crossing WA323 the waterway lies within a sinuous channel, approximately 2.3 m high and 8 m wide. The channel is actively eroding by widening at the meander bends. At the existing highway culvert the channel has widened to approximately 25 m.

Erosion of the channel is also occurring through incision, undercutting of the banks and bank slumping. Figure 3 and Figure 4 depict the sandy substrate that makes up the waterway bed and banks. Figure 4 also demonstrates the potential for lateral adjustment of the waterway through erosion of the outside bank, and deposition on the inside bank of the meander bend.

A large floodplain exists upstream of the proposed highway alignment. The floodplain is approximately 200 m wide from either bank. Currently, the railway and existing highway restrict the functionality of the floodplain on both banks.

The Index of Stream Condition (ISC) provides a bench mark of Victorian river conditions for a number of waterways across the State. This section of Concongella Creek is located within ISC reach #51 and has a moderate condition score.

Figure 3: Concongella Creek looking downstream, facing north, directly under proposed alignment of road

Figure 4: Concongella Creek approximately 150 m downstream of existing Highway culverts

Concongella Creek (WB312)

At crossing WB312, which is approximate 8 km north west of Ararat, the waterway lies within a partially confined channel with low sinuosity, approximately 2.5 m high and 10 m wide. The channel has eroding, exposed banks and narrows through a vegetated section downstream of the crossing. Upstream of the highway bridge, a tributary enters Concongella Creek from the northwest. This tributary is shallower and has a low flow channel that is approximately 1 m wide and 0.2 m deep (Figure 5).

Erosion of the channel has historically occurred through incision, undercutting of the banks and bank slumping (Figure 6). Bank stabilisation works may need to be implemented to protect the right bank, downstream of the road bridge where active erosion was observed to be occurring.

Figure 5: Unnamed tributary, looking upstream (facing north west) where it enters Concongella Creek on the left bank upstream of the existing Highway.

Figure 6: Looking upstream (facing south), upstream from the Existing Highway

Concongella Creek (WB324)

At crossing WB324, which is located approximately 4 km south east of Great Western the waterway lies within straight channel, less than 1 m high and 5 m wide. Large sand deposits were observed instream with significantly increased stream bed heights adjacent to the sand deposits (Figure 7). The banks of the waterway at this site are slumping, however there are some large red gums located along the bank margin that are aiding bank stability (Figure 8).

Land use on either bank has been cleared for sheep grazing and the road reserve. The floodplain is partially confined and the left bank of the waterway pushes up against the valley margin upstream of the existing road bridge. Downstream of the road bridge, the floodplain becomes wider on either side of the waterway.

Figure 7: Looking upstream, upper end of reach

Figure 8: Looking downstream, immediately downstream of bridge Highway culverts

Concongella Creek (WB325)

At crossing WB325, which is located approximately 2.5 km south east of Great Western, the waterway lies within a moderately sinuous channel, approximately 2 m deep and 5 m wide upstream of the existing bridge. Downstream, the channel widens and is approximately 15 m wide at the road. Banks were observed during the site visit to be slumping and there was also evidence of undercutting of some sections of bank (Figure 9).

A bank attached sand bar was observed instream and smaller mid-stream sand bars were observed downstream of the existing road bridge (Figure 10). The waterway is unconfined at this site and the land use on the right bank is viticulture.

Figure 9: Exposed banks and some bank slumping observed looking downstream from the existing bridge.

Figure 10: Instream bar observed upstream of the existing highway crossing.

Concongella Creek (WB327)

At crossing WB327, which is located at the south eastern entrance to Great Western, the waterway lies within a moderately sinuous channel, less than 1 m deep and 20 m wide. Instream features observed within the waterway included stone riprap and a very large permanent pool. Instream vegetation is dominated by phragmites and other instream reeds (Figure 11 and Figure 12). The waterway and this site lies within a large floodplain and the creek banks are well vegetated.

Figure 11: Looking upstream from the existing waterway crossing

Figure 12: Looking downstream from the exiting waterway crossing

Concongella Creek (WB328)

At crossing WB328, which is located on Bests Road immediately north west of Great Western, the waterway lies within a relatively straight channel that is up to 20 m wide at the existing bridge crossing. The channel begins to meander approximately 100 m downstream and 250 m upstream. The creek banks are gently sloping and lightly vegetated with some exposed sections. The channel upstream is heavily vegetated with reeds (Figure 13). Sand deposits were observed instream downstream of the existing crossing (Figure 14). Downstream of the existing waterway crossing there is a vegetated island and bank attached sand bar.

Figure 13: Looking upstream from the existing waterway crossing

Figure 14: Looking downstream from the exiting waterway crossing

Concongella Creek (WB329)

At crossing WB339, which is located about 2 km north west of Great Western, the waterway has low sinuosity, is well vegetated and has short but steep banks. At the existing road crossing there are three 1.5 m diameter road culverts (Figure 15). Downstream of the culverts there is a pool of standing water. The floodplain at this site is broad and well treed. The floodplain extends for 70 m to the left bank and 20 m to the right. This crossing is located downstream of a golf course and the surrounding landuse is bushland (Figure 16).

Figure 15: Upstream view of culverts

Figure 16: Looking downstream from the existing road crossing

Allanvale Creek (WB326)

At the crossing of Allanvale Creek, which is located immediately south east of Great Western, the creek is a laterally unconfined, sandy waterway with low sinuosity. The channel is up to 6 m wide and 2 m high. The instream features that make up this reach of the waterway include open pools and narrower vegetated channels (Figure 17). A sandy mid-channel bar lies within the waterway as depicted in Figure 18. The floodplain is approximately 100 m wide on either bank. The existing highway presents a barrier to floodplain functionality on the left bank. Floodplain features observed during field assessments include flood runners that would be engaged during high flows. This section of Allanvale Creek is located within ISC reach #50 and has a moderate condition score.

Figure 17: Allanvale Creek, looking downstream

Figure 18: Allanvale Creek from the right bank looking back upstream, mid-reach.

Robinsons Creek (WB330)

At the crossing of Robinsons Creek, which is located approximately 2 km north west of Great Western, the creek is a low sinuosity, fine grained system with some sandy deposits. The channel is up to 1 m deep and there are instream pools downstream of the road culvert, approximately 10 m wide (Figure 19).

Some undercutting and slumping as occurred along the channel bank as the bank is largely unvegetated (Figure 20). Scour has occurred to the banks and channel bed at the downstream side of the existing highway culvert. The waterway has incised in some sections to expose the underlying bedrock.

The existing highway crossing is made of 3 x 1.2 m square box culvert (Figure 19). Flood debris had been left on the road following a recent flood event where flood waters flowed over the existing highway. Culvert size should be upgraded for the new alignment. This section of Robinsons Creek is located within ISC reach #49 and has a moderate condition score.

Figure 19: Robinsons Creek, looking upstream, north of the road culverts. N.B. scour behind culvert wing walls and the significant different between culvert and channelt invert levels.

Figure 20: Robinsons Creek, looking downstream under the proposed south lane alignment.

Donald Creek (WB331)

At the crossing of Donald Creek, which is located approximately 2.5 km north west of Great Western, the creek is a low-sinuosity, fine-grained waterway with some smaller sand deposits present within the channel. Exposed banks (Figure 21) and active lateral head cuts were observed within the waterway channel during the site visit. There is limited riparian vegetation along the channel which is composed primarily of taller eucalypts. Undercutting of the creek banks has occurred around one of the riparian eucalypts. This has led to the formation of an instream pool. Aquatic vegetation within the waterway is mostly made up of species of reeds and sedges.

The existing highway crossing is made up of three 1.2 m culverts and a larger 2.4 m by 1.5 m box culvert (Figure 22). Storm water runoff from the road is directed into the waterway via a roadside drain made of rockwork. This section of Donald Creek is located within ISC reach #49 and has a moderate condition score.

Figure 21: Donald Creek, upstream of the existing highway culvert.

Figure 22: Donald Creek, looking usptream at the existing highway culvert.

Minor Waterways (Unnamed Tributaries, Drainage Lines or Channels)

Minor Waterways are defined as undefined tributaries often without permanent water. Many minor tributaries in this area of works are not evident and expected to only flow in significant rainfall events. Unlike Significant Waterways which may have some river health values such as instream vegetation or permanent pools, Minor Waterways have limited or no waterway health value, and mainly serve a local drainage purpose. Refer to Appendix E for a complete list of Minor Waterways.

5.2.2 Waterway Health Assessments

The following provides a broad overview of current waterway condition based on information documented in the GHCMA Regional River Health Strategy, Glenelg Hopkins Regional Catchment Strategy, Wimmera CMA Stream Assessment, Concongella Creek Waterway Action Plan and the 2004 Index of Stream Condition. GHD also undertook a desktop assessment of waterway condition at each crossing location.

Wimmera CMA Stream Assessment

Wimmera Waterway Health Strategy (2003), Wimmera State of our Streams assessments in 2006 and 2007, and assessment of the Water Resources of Upper Wimmera (SKM 2002) have identified some of the stream condition and issues relevant to waterways condition in this area.

Congongella Creek is the only waterway assessed relevant to this Project. The Wimmera Waterway Health Strategy identifies the Concongella Creek Waterway Management Unit as the sub-catchment covering this project area, and Concongella Creek as a priority waterway.

The State of our Streams 2006, was a pamphlet produced by Wimmera CMA detailing the results from the 2004 Index of Stream Condition (ISC) survey. The pamphlet highlighted the key findings of the survey relevant to the Wimmera Catchment. The stream condition rating of the Concongella Creek WMU was ‘good’ to ‘moderate’. The surrounding Upper Wimmera sub-catchment was found to have variable stream condition, with generally ‘good’ hydrology assessment, and ‘moderate’ to ‘poor’ physical form and streamside zone classifications. Water quality and aquatic life were both assessed as ‘good’.

Another pamphlet, produced in 2007, based on the same 2004 survey results, described as an annual outline of the health of the waterways including the 2004 results and monitoring undertaken by Wimmera CMA. The State of Our Stream 2007 scores the waterways based on Hydrology, Streamside Zone, Physical Form, Water Quality and Aquatic Life. The Upper Wimmera sub-catchment was rated at C, which is described as having issues with components such as poor water quality, reduced flows, depleted riparian vegetation or channel erosion which are limiting the overall condition of the waterways.

The flow regime was described as unmodified, however the flows have been affected by farm dam development (SKM 2002). The physical forms and streamside zones were rated ‘poor’ to ‘moderate’ due to erosion, vegetation clearing and stock access causing turbidity problems, although improving in the lower reaches. Lack of flows caused by drought conditions severely affected water quality, accounting for the decline in condition between 2006 and 2007.

The in-stream vegetation was fairly natural, with good species diversity. Previously recorded species in Concongella Creek include Mountain Galaxias, Flat Headed Gudgeon, Goldfish and Eastern Gambusia. (SKM 2002). The 2007 State of our Streams biological assessment indicated the condition of macro-invertebrate communities was ‘moderate’.

Glenelg Hopkins Regional Catchment Strategy

The Glenelg Hopkins Regional Catchment Strategy 2012-2018 (RCS), which is currently in draft form, sets the direction for how the region's land, water and biodiversity resources should be managed, by providing a framework for the coordinated management of sub-catchments within the broader Glenelg-Hopkins catchment area.

The RCS provides information on the catchment area, including the assets and their current condition. The assets considered are Community, Rivers and Floodplains, Wetlands, Estuaries, Coasts, Marine, Terrestrial Habitat, Species Populations and Communities and Soil/Land.

The main threats to the environmental, social and economic values of the rivers in the region are listed as:

- stock access to riparian zones;
- land use change to more intense farming practices;
- pest plants and animals;
- flow deviation; and
- barriers to native fish migration.

These threats lead to multiple impacts including bank and bed instability, loss of instream and riparian habitat, reduced water quantity, reduced water quality, and reduced aquatic and terrestrial biodiversity.

Despite these threats, the RCS states that streams within the Hopkins Catchment are generally physically stable, with only minor erosion associated with stock access. Blue-green algal blooms have occurred with increasing frequency in some areas. Other threats impacting on streams and rivers in the Hopkins catchment are clearing of native vegetation and the introduction and spread of exotic species. Poor water quality due to rising salinity, increased sedimentation and nutrient enrichment has been a problem in some areas although this has improved recently with the return of high flows after the drought.

GHCMA Regional River Health Strategy

The Glenelg Hopkins River Health Strategy (GHRHS 2004) provides a five year blue print for improving the health of rivers and creeks in the region. The GHRHS identifies the regional importance of waterways within each catchment area and sets management objectives to improve the current condition of these waterways. The Hopkins Basin catchment vegetation health is detailed as substantially cleared of native vegetation and now supports significant agricultural activity. There are no priority sub-catchments in the Hopkins Basin for restoration activities, however, some reaches are recognised for maintaining high social and economic values.

For Section 3 of the Western Highway Project, only tributaries to Hopkins River intersect with the existing and proposed alignment, just west of Ararat. The Hopkins River is a significant river in the GHCMA, and the RHS assessed the condition in 2004. Overall, it achieved an In Stream Condition rating of Marginal and not an ecologically healthy reach.

Concongella Creek Waterway Action Plan

The Concongella Creek has been identified as a high priority for management by the Wimmera CMA. The Concongella Creek Waterway Action Plan (WAP) was completed in order to facilitate the implementation of management works to the creek. The WAP focuses on four study reaches of

Concongella Creek and also the sub-catchments of Allanvale Creek (located within Western Highway Project study area), Salt Creek, Wattle Creek, Jerrywell Creek and Kirkella Creek.

The Concongella Creek originates from the Great Dividing Range between the townships of Ararat and Great Western. It is a left bank tributary of the Wimmera River, which flows north until it enters the river approximately 18 km upstream of Glenorchy. The surrounding land use of the area is predominantly grazing, however viticulture is an important industry in the upper catchment.

Risks to the Concongella Creek catchment include:

– Initiation of erosion by channel clearing at Great Western;
– Deterioration of riparian vegetation from stock access;
– Increased sediment input from eroding tributaries;
– Smothering of habitat by sediment; and
– Reduced water quality as a result of sedimentation, stock access and saline groundwater.

Actions and opportunities to improve waterway condition within the Concongella catchment include fencing and revegetation of the riparian zone to control sediment movement and restrict stock access.

The WAP divides the Concongella Creek catchment into a number of management reaches and subcatchments. The reaches relevant to this project area are:

– Reach 1 – Upstream from the Great Western Salt Creek Road;
– Reach 2 – Great Western Salt Creek Road to Landsborough Road; and
– Sub-catchment – Allanvale Creek catchment.

The waterways that make up Reach 1 have incised as a result of channel clearing at Great Western. Upstream sections of this reach are well vegetated but further downstream there are only patches along the riparian zone and it is mainly composed of overstory species. Stock access remains a threat to the riparian vegetation within this reach. In-stream habitat within the reach is restricted to pools and dams and water quality is regarded as low due to stock access and nutrient runoff from nearby vineyards. The final condition score for Reach 1 is 10, which implies that it has a low priority for management action works to be undertaken.

Reach 2 contains a natural constriction in the channel form which makes Great Western prone to flooding. The reach has an active sand bed and creek banks are in good condition. The sandy bedload does not appear to have compromised the channel's natural form. Instream habitat has been affected by the sandy bedload as well as stock access at some locations. The reach has a good riparian overstory and understory vegetation is only found at locations where stock access has been restricted. Water quality within Reach 2 is considered satisfactory due to the presence of riparian vegetation. The final condition score for Reach 2 is 23, which means it is a medium priority for management action works to be undertaken.

The Allanvale Creek Catchment has historically undergone incision. Treatment works have been implemented to control many of the erosion heads, however there still remains some active erosion heads. In-stream vegetation including grasses and reeds have been used to stabilise sediments in the waterways. Water quality varies throughout the reach, depending on stock access and riparian vegetation is also in better condition in sections of the reach with restricted stock access. The final condition score for the Allanvale Creek sub-catchment is 17, which means it is a medium priority for management action works to be undertaken. The waterway condition of each reach described above as presented in the WAP is provided in Table 10 below.

Table 10 Condition of River Health relevant WAP Management Reaches

Reach Name	Reach 1	Reach 2	Allanvale Creek catchment
Relevance to Highway	Flowing north west along highway	Flowing north west along highway	Flowing north west across alignment
Length (km)	13	2	1
Physical Form	Moderate	Moderate	Moderate
Riparian Ecology	Moderate	Moderate	Moderate
In-stream Habitat	Poor	Poor	Poor
Water Quality	Poor	Poor	Poor
Final Score	10	23	17

Index of Stream Condition

The Index of Stream Condition (ISC) is a rapid assessment method that was applied statewide in Victoria in 2004 to provide a river condition benchmark. Table 11 presents a summary of the sub index ratings of various ISC key parameters for relevant waterway reaches based on the 2004 assessment, available at Victorian Water Resources Data Warehouse.

Table 11 Condition of River Health of relevant Waterway Reaches 1999 and 2004 Assessment

Reach Name	Concongella Creek -Reach 49	Concongella Creek - Reach 50	Concongella Creek -Reach 51
Relevance to Highway	Flowing north from highway	From headwaters to south of highway	From headwaters to south of highway
Length (km)	23	11	16
Date	2004	2004	2004
Hydrology	8	8	8
Physical Form	4	3	4
Streamside Zone	4	3	5
Overall ISC Score	24	19	25
ISC Condition	Moderate	Moderate	Moderate

From the above overview of the nominated reaches within the Concongella Creek system, the overall status of the condition of Concongella Creek is moderate.

An ecological assessment of Flora and Fauna, including aquatic and riverine species, has been undertaken and a relevant summary for the surface water assessment is provided below.

Ecological Assessment of Waterways

An ecological assessment of Flora and Fauna, including aquatic and riverine species, has been undertaken as part of the EES by Ecology and Heritage Partners.

From their investigation a number of Nationally significant and State significant species are known to potentially exist within the study area associated with the waterways:

- Nationally Significant – Growling Grass Frog, Dwarf Galaxias.
- State Significant – Brown Toadlet, Golden Perch.

As part of the flora and fauna investigations, targeted aquatic surveys were undertaken on the various waterways including in-stream habitat assessments, macro-invertebrate and aquatic (fish) surveys. A summary of the findings documented in the Biodiversity and Habitat report (Ecology and Heritage Partners, 2012) is provided in Table 12. For details regarding site locations refer to maps in Appendix A.

Table 12 Summary of Biodiversity and Habitat findings

EHP Site	Nearest Waterway Crossing	Waterway	In stream Habitat	Macro invertebrate	Aquatic Surveys
Site 1	WB329	Concongella Creek	**Riparian Condition (very poor)** No overhanging vegetation Large Woody Debris (1-10%) Macrophyte Cover (2-50%)	Not Assessed	**No significant species** Common Jolly Tail Flathead Gudgeon
Site 2	WB329	Concongella Creek	**Riparian Condition (very poor)** No overhanging vegetation Large Woody Debris (1-10%) Macrophyte Cover (2-50%)	Not Assessed	**No significant species** Flathead Gudgeon
Site 3	WB237	Concongella Creek	**Riparian Condition (very poor)** No overhanging vegetation Large Woody Debris (1-10%) Macrophyte Cover (2-50%)	Family taxa (18 - high) Key families (15 – moderate) SIGNAL score 4.72 – mild to moderate)	**No significant species** Flathead Gudgeon Yabby
Site 4	WB323	Concongella Creek	**Riparian Condition (poor)** No overhanging vegetation Large Woody Debris (1-10%) Macrophyte Cover (2-50%)	Not Assessed	**No significant species** Redfin (exotic species) Yabby
Site 5	WB323	Concongella Creek	**Riparian Condition (poor)** No overhanging vegetation Large Woody Debris (1-10%) Macrophyte Cover (2-50%)	Not Assessed	**No significant species** Common Jollytail Flathead Gudgeon Tadpole Yabby
Site 6	WA323	Concongella Creek	**Riparian Condition (poor)** No overhanging vegetation Large Woody Debris (1-10%) Macrophyte Cover (2-50%)	F Family taxa (18 - high) Key families (15 – moderate) SIGNAL score 5.67 – average	**No significant species** Flathead Gudgeon Goldfish (exotic species) Redfin (exotic species) Yabby

EHP Site	Nearest Waterway Crossing	Waterway	In stream Habitat	Macro invertebrate	Aquatic Surveys
Site 7	WB324	Concongella Creek	**Riparian Condition (moderate)** Overhanging Vegetation (20%) Large Woody Debris (1-10%) Macrophyte Cover (2-50%)	Not Assessed	**No significant species** Flathead Gudgeon
Site 8	WB331	Donald Creek	**Riparian Condition (very poor)** Overhanging Vegetation (0-10%) Large Woody Debris (1-2%) Macrophyte Cover (1-5%)	Not Assessed	**No significant species** Mosquito Fish (exotic species) Tadpole Yabby
Site 9	WB312	Concongella Creek	**Riparian Condition (poor)** No overhanging vegetation Large Woody Debris (1-10%) Macrophyte Cover (2-50%)	Not Assessed	**No significant species** Southern Brown Tree Frog Yabby
Site 10	WB330	Cobeys Creek	**Riparian Condition (very poor)** Overhanging Vegetation (0-10%) Large Woody Debris (1-2%) Macrophyte Cover (1-5%)	Family taxa (14 - moderate) Key families (13 – low) SIGNAL score 5.29 –moderate)	**No significant species** One tadpole
Site 11	WB331	Donald Creek	**Riparian Condition (very poor)** Overhanging Vegetation (0-10%) Large Woody Debris (1-2%) Macrophyte Cover (1-5%)	Family taxa (11 - low) Key families (9 – low) SIGNAL score 5.36 – moderate)	**No significant species** Mosquito Fish (exotic species) Tadpole Yabby
Site 12	None	Pleasant Creek	**Riparian Condition (poor)** No overhanging vegetation Large Woody Debris (2%)	Family taxa (9 - low) Key families (8 – low) SIGNAL score 5.36 – moderate)	**No significant species** Common Jollytail

5.3 Floodplain Assessment

The floodplain assessment has been based on interpreting the hydrologic modelling and hydraulic modelling outputs undertaken by UWCS/TGM. The interpretation of the modeling outputs has sought to understand the floodplain characteristics associated with the waterway crossings and interaction of the existing highway with the existing conditions flooding of the broader study area. Specifically, modelling outputs have been interpreted from UWCS/TGM from the following analysis:

- Hydrologic Catchment Modeling – A runoff-routing hydrologic model was established to derive the 1 in 100 year design flow hydrographs for the main catchment systems; and
- Floodplain Hydraulic Modeling - A 2-D floodplain hydraulic model was established based on a DTM that represented flood plain features including the existing Western Highway and waterway crossings, with the design flow hydrographs from the hydrologic modeling.

Following below is a summary of the approach to the Floodplain assessment (both existing conditions and impact assessment) that has involved a combined of modelling work by UWCS/TGM, and detailed interpretation of the modelling outputs by GHD as described below:

Table 13 Summary of Floodplain Assessment

Task	Description	Report Reference
Hydrologic Modeling	Hydrologic Catchment Modeling (using WUFS) to derive the 1 in 100 year design flow hydrographs **(UWCS/TGM)**	5.4.1
Hydrologic Modeling Interpretation	Limited hydrologic outputs were provided for GHD to interpret **(GHD)**	5.4.1
Floodplain Hydraulic Modeling – Existing Conditions	The design flow hydrographs were 2-D floodplain hydraulic model was established and design flow hydrographs to determine 1 in 100 year predicted flow conditions **(UWCS/TGM)**	5.4.3
Interpretation of Existing Conditions Floodplain Hydraulic Modeling	The flood modeling outputs provided included the 1 in 100 year flood extent (including flood depth and flood levels). The existing condition flood assessment focusing on the interaction of existing road and townships and rural properties **(GHD)**	5.4.3
Impact Assessment based on Interpretation of Existing Conditions Floodplain Hydraulic Modeling	The initial impact assessment was based on interpreting the proposed design alignment (assuming that flood criteria would be notionally satisfied) with respect to the existing conditions flood modeling. This was assessed in detail to understand the potential change in flood conditions in order to derive preliminary waterway opening requirements for the proposed highway. GHD subsequently defined proposed condition iterations as modeling scenarios **(GHD)**	6.5.1
Floodplain Hydraulic Modeling – Proposed Conditions Iterations	The following modeling scenarios as defined by GHD were modeled to determined proposed conditions modeling outputs **(UWCS/TGM)**	7.4
Interpretation of Proposed conditions Iterations - Floodplain Hydraulic Modeling	The flood modeling outputs of the defined scenarios were provided, and allowed for comparative assessment of the 1 in 100 year flood extent and flood depth/levels (afflux), focusing on the impacts through the Great Western township and rural properties **(GHD)**	7.4

The hydrologic catchment modeling and floodplain hydraulic modeling have been summarised below in terms of:

- Summary of basis of the modeling undertaken by UWCS/TGM
- Summary of the modeling outputs provided by UWCS/TGM
- Interpretation of the modeling outputs by GHD in terms of understanding the existing conditions assessment
- Interpretation of the modeling outputs by GHD in terms of identifying the potential impacts of the Project (refer to Section 6 - Impact Assessment).

5.3.1 Hydrologic Assessment of Study Area

VicRoads has commissioned UWCS/TGM to complete an analysis of topographic data for use in hydrological and hydraulic assessments relevant to the Western Highway between Beaufort and Stawell. This included determining catchments which impact the project site and preliminary assessment of sections of road impacted by flooding. Some key findings from the Final Report (UWCW, August 2012) are summarised below.

Topographical data used by UWCS/TGM in the assessment included:

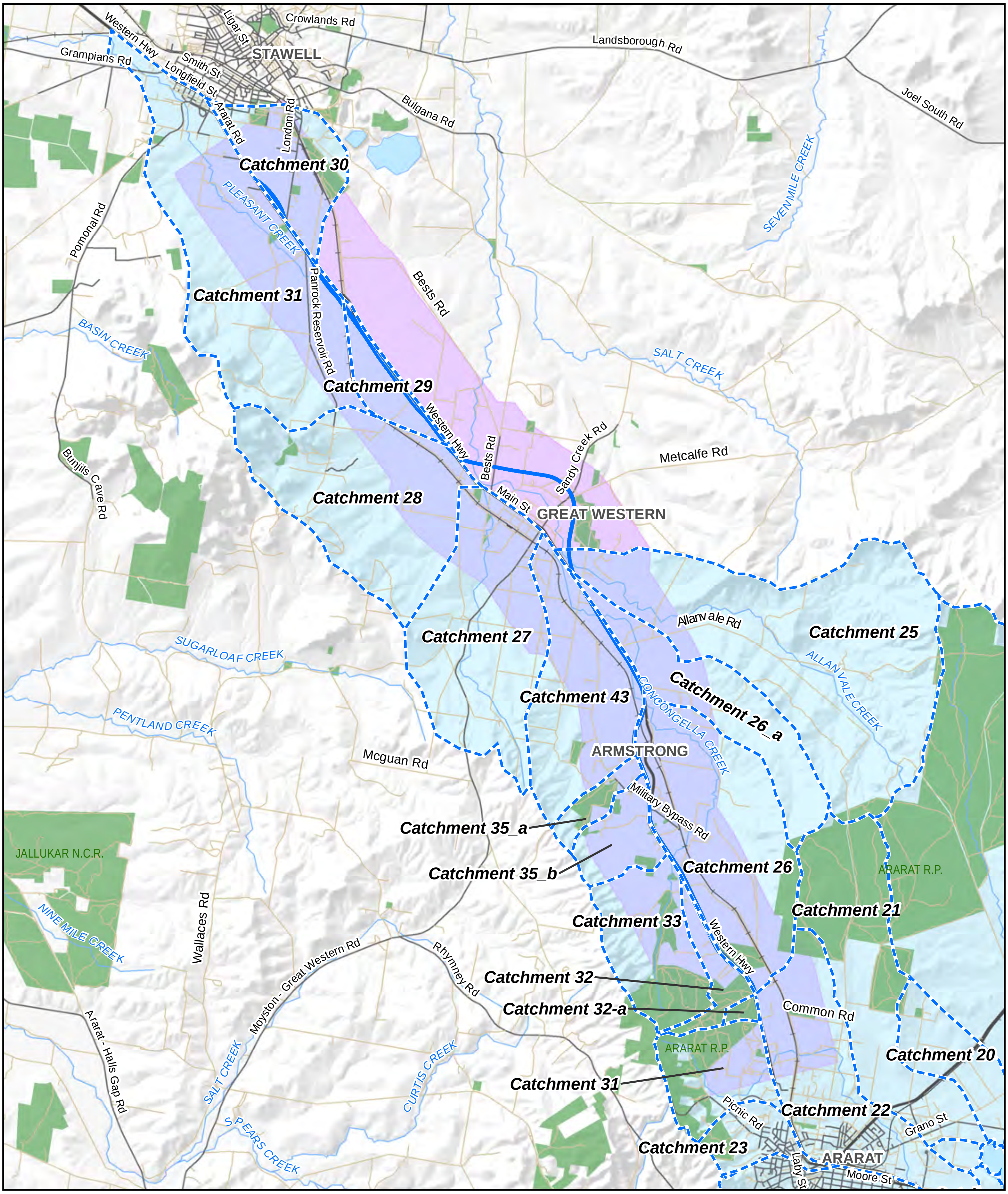
- Light Detection and Ranging (LiDAR) for the 3 km wide strip running the length of the existing highway alignment commissioned by VicRoads, allowing for 1 m contours;
- Contour data from DSE for the entire catchment – 10 m contours;
- Commissioned survey at Green Hill Lake and Ararat Prison; and
- Data collected during field inspections.

UWCS/TGM deemed the existing data to be sufficient for the purpose of flood investigation along the highway alignment, with data gaps in areas south of the alignment not expected to affect the upstream flooding.

UWCS/TGM used rainfall gauges at Ararat and Ararat Prison to estimate the ARI of specific events and long term average annual rainfall of mostly between 400-800 mm within the study area. The stormwater catchments identified as contributing to the existing highway alignment are shown in Figure 23

UWCS/TGM established a Water Urban Flow Simulator (WUFS) hydrology model with design storm parameters from Australian Rainfall and Runoff (IEAust 1987). The model included analysis of the upper Hopkins River, enabling the model to be calibrated and confirmed to recorded flows at a nearby gauging station on the Hopkins River (236219). The data used was from the DSE data warehouse between May 1989 and August 2011. A description of the sub-catchments, their location within the CMA regions and the major waterways are shown in Figure 23 and detailed in Table 14 below.

As part of the UWCS/TGM Flood study, the hydrologic assessment generated flow estimates for the flood modelling. The flood modelling was undertaken for the main flood plain systems and did not extend to each identified crossing location. Many of the minor crossings that are in the upper catchment areas or are associated with minor drainage flow paths were not modelled.



LEGEND

- UWCS Model Catchments
- Proposed Alignment
- Study Area
- Highway
- Sealed road (arterial & local)
- Unsealed road
- Parks

Paper Size A4

0 0.5 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

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GHD

CLIENTS | PEOPLE | PERFORMANCE

vicroads

VicRoads
Western Highway Project
Ararat to Stawell
Study Area and
UWCS Stormwater Catchment

Job Number	31-27558
Revision	B
Date	14 Nov 2012

Figure 23

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

G:\31\27558\GIS\Maps\Deliverables\Stage 3\RISK AND IMPACT ASSESSMENT\06_SURFACE_WATER\3127558_S3_007_Study_Area_A4P.mxd

Data source: DSE, VicMap, 2012; VicRoads, 2011; GHD, Design, 2012; Bonacci, 2012; TGM, 2012. Created by:splaird

Table 14 Sub-catchment Details

Sub Catchment	UWCS/TGM Subcatchment Figure 23	Surface Water System	Interaction with existing Western Highway
GHCMA – H5	**32-a**	Upstream tributaries to Cemetery Creek	Tributaries to Cemetery Creek upstream of Ararat cross highway
WCMA - Concongella Creek	**32**	Concongella Creek	Several small tributaries to Concongella Creek from South/West cross highway
	33	Concongella Creek	Larger tributaries to Concongella Creek from South/West to single existing crossing
	35	Concongella Creek	Larger tributaries to Concongella Creek from South/West to several existing crossings
	26	Concongella Creek	Main Concongella Creek and tributaries from North/East combine with upstream tributaries to main crossing location
	26-a	Concongella Creek	Tributaries to Concongella Creek from North/East combine with main flow path
	25	Allanvale Creek	Allanvale Creek and tributaries from North/East (no existing crossing of highway) combining with Concongella Creek upstream of Great Western
	43	Concongella Creek	Larger tributaries to Concongella Creek from South/West combining with main flow path upstream of existing highway upstream of Great Western
	27	Hyde Park Creek	Hyde Park Creek and tributaries cross existing highway at Great Western (not in study area)
	28	Cobeys Creek, Robinsons Creek, Donald Creek	Cobeys Creek & Robinsons Creek combine upstream of existing highway, and Donald Creek & tributaries combine downstream of existing highway
	29	Concongella Creek	Small tributaries Concongella Creek cross highway downstream of Great Western
	31	Pleasant Creek	Pleasant Creek adjacent to the existing Highway (on south-west side)
	30	Pleasant Creek	Local flowpaths to Pleasant Creek from north west (no designated waterways to formal crossing locations)

Concongella Creek

The interaction of the existing Western Highway and the Concongella Creek system is hydrologically complex. Unlike the waterways for Section 2 of the Western Highway Project, where there are discrete catchment systems to each individual crossing, the Concongella Creek system meanders alongside the existing highway and crosses at several locations. Between Ararat and Great Western, the Concongella Creek and the various tributary systems generally accumulate moving in a north westerly direction with various interactions with the existing Western Highway. The catchment delineation used for the hydrological modelling by UWCS/TGM has been presented in Figure 3.

The hydrological modelling outputs (used for inputs to the hydraulic modelling) are summarised in Table 15 below. The following summarises the peak flows and hydrographs interpreted from the hydrological model (and extracted from the hydraulic model for completeness where indicated). For details regarding the location of each waterway crossing (designators WB321, etc.) refer to Appendix A.

Table 15 Concongella Creek System - Summary of Modelled 100 Year ARI Hydrographs

Hydrograph	Waterway	Peak (m3/s)	Timing (hr)	Comment
Catchment 35 (Inflow)	Concongella Creek tributaries	14.7	2	From Hydrologic model
@(WB321)	Concongella Creek	22.0	1.6	Interpreted from Hydrologic model
Catchment 26+33 (Inflow)	Concongella Creek (upper)	72	2.1	From Hydrologic model
@(WB323)	Concongella Creek	119	3.0	Interpreted from Hydrologic model
@(WB324)	Concongella Creek	119	3.0	Interpreted from Hydrologic model
Catchment 26a (inflow)	Concongella Creek & tributaries	40	2	From Hydrologic model
Catchment 43 (inflow)	Concongella Creek tributaries	152	2.4	From Hydrologic model
@(WB325)	Concongella Creek	154	3.0	Interpreted from Hydrologic model
Catchment 25 (Inflow)	Allanvale Creek	124	2.4	From Hydrologic model
@WB328 (Bests Road)	Concongella Creek	232		Interpreted from Hydraulic model
Catchment 27 (Inflow)	Robinsons Creek	67	2.3	From Hydrologic model

Hydrograph	Waterway	Peak (m3/s)	Timing (hr)	Comment
@WB329 (New Hwy Crossing)	Concongella Creek	270		Interpreted from Hydraulic model
Catchment 28 (Inflow)	Cobey/Robinsons/Donald Creek	39	2	From Hydrologic model

The actual flow at each of the road crossings needs to be interpreted from hydraulic modelling that takes into account floodplain characteristics (including floodplain storage, redistribution of flows etc). The interactions at the various road crossings can be complex and in terms of the total flow at a particular crossing location can be a combination of the following:

- Flow through the culvert (Qc);
- Flow over the road (Qo); and
- Flow diverted away from the crossing location (Q_D).

A breakdown of flows into the categories described in the above list has not yet been determined for most crossing locations. Given this, it was difficult to determine the existing flow through the culverts in the context of the total upstream flow at a particular crossing location. Further modelling would be required at detailed design phase to determine the total flow through each upgraded crossing and achieve flood free conditions.

Minor Waterways - Rational Method Estimation of Flows

Estimation of the 100 year ARI peak discharge at each waterway crossing was calculated using the rural Rational method as specified in the VicRoads Road Design Guidelines (section 7.2.3, June 1992). The catchment area upstream of each waterway crossing was determined. This was then used to calculate a characteristic time representing a typical catchment runoff response to that crossing point. Rainfall intensities for each waterway crossing were obtained from the Bureau of Meteorology website.

5.3.2 January 2011 Flood Event

Modelling Calibration

High intensity rainfall in mid January 2011 caused major flooding across much of the western and central parts of Victoria. The combination of multiple rainfall events falling in succession on an already saturated catchment led to extensive flooding and road closures along the current Western Highway. During the flooding, the Western Highway was closed from Ballarat to Horsham.

Within Section 3 of the Project, major flooding occurred on Concongella Creek near the town of Great Western. There was no hydrological data available for Concongella Creek, however a peak discharge during the flood of 95.9 m^3/s was recorded for the *Hopkins River at Ararat* stream gauge. The storm event that lead to the flooding could be divided into three defined storm bursts that each individually had an ARI of between 20-50 years (UWCS/TGM, 2012).

The storm event that resulted from the combination of these three smaller bursts had an ARI (Rainfall) of 88 years and a duration of 101 hours, and the already saturated catchment conditions also contributed to the extensive flooding that occurred as a result of this storm event (UWCS/TGM, 2012). The observed peak discharge for the Hopkins River gauge (95.9 m^3/s) was used as the primary target for the calibration process of the hydrology model developed by UWCS/TGM (2012). In terms of peak flow, this equates to an event that is similar to a 1 in 100 year flow on the Hopkins River (although this is not explicitly stated in the UWCS/TGM report). It is worth noting that the model verification including Concongella Creek near Great Western, indicates that the 2011 event is comparable to the 1 in 100 year event.

Inputs into the UWCS/TGM hydrologic model adjusted as part of the calibration process included environmental conditions, natural losses, soil conditions and flow characteristics. UWCS/TGM undertook a check of their model by undertaking a comparison between the output hydrograph from the hydrology model at the *Hopkins at Ararat* gauge location for the January 2011 event and the actual Hopkins River gauge recorded hydrograph was made by plotting the two hydrographs. The general shape of the river hydrograph was reproduced by the hydrology model and was accepted by UWCS/TGM (2012) as a reasonable outcome.

The final calibrated model was run to simulate a range of storm events using design storms of different ARI's. The outputs of the hydrologic model were input into the TUFLOW hydraulic model to generate flood extents and depths across the study area. Results from the hydraulic model were then compared against surveyed flood marks, and levels and extents estimated from photographs of the 2011 event and aerial photography in order to verify the model (UWCS/TGM, 2012).

Comparison of January 2011 event and modelled 100 yr ARI

The January 2011 event is an important reference event given the recent memory of the community who may have experienced the flood event and been impacted by it. Whilst the event has provided useful information for the calibration of the hydraulic model, there is some ambiguity in terms of how it compares to the modelled 100 year ARI design event. UWCS/TGM provided some preliminary outputs, and without more detailed assessment of the January 2011 event we are able to interpret the following:

- The January 2011 rainfall event consisted of three defined storm bursts as described above, and was deemed to be a 1 in 88 year rainfall event (UWCS/TGM)
- The peak flows for the modelled 1 in 100 year event are significantly higher than the January 2011 event modelled peak flows (refer to Table 16 below);
- The January 2011 event was a much longer duration that the modelled 1 in 100 year event as summarised by the following:
  - The January 2011 event was considered to be an unusually long duration event made up of three defined storm bursts as described above, peaking at 28 hours with the total duration of the modelled event over 100 hours;
  - The modelled 100 year ARI event that wad a was notionally a 6 hour critical duration event that peaked at between 2-3 hours.
- The January 2011 event is similar in terms of flood extent to the modelled 100 year ARI flood extent, and in some areas was beyond the 1 in 100 year event. This may be due to volumetric effects of the extended duration of the January 2011 event (i.e additional volume filling the floodplain and available floodplain storage)

The modelled hydrologic flows from UWCS/TGM are provided in Table 16, which provides a summary of the comparison of peak flows. Floodplain hydraulics are considered in more detail in section 5.3.

Table 16 Comparison of Flows (Section 3)

Inflow Catchment	Modeled 100 year ARI (m3/s)	Modeled January 2011 event (m3/s)
Catchment 35	14.6	5.6
Catchment 26+33	72	45
Catchment 26a	40	17
Catchment 43	152	70
Catchment 25	124	42
Catchment 27	67	24
Catchment 28	39	15

5.3.3 Floodplain Hydraulic Assessment

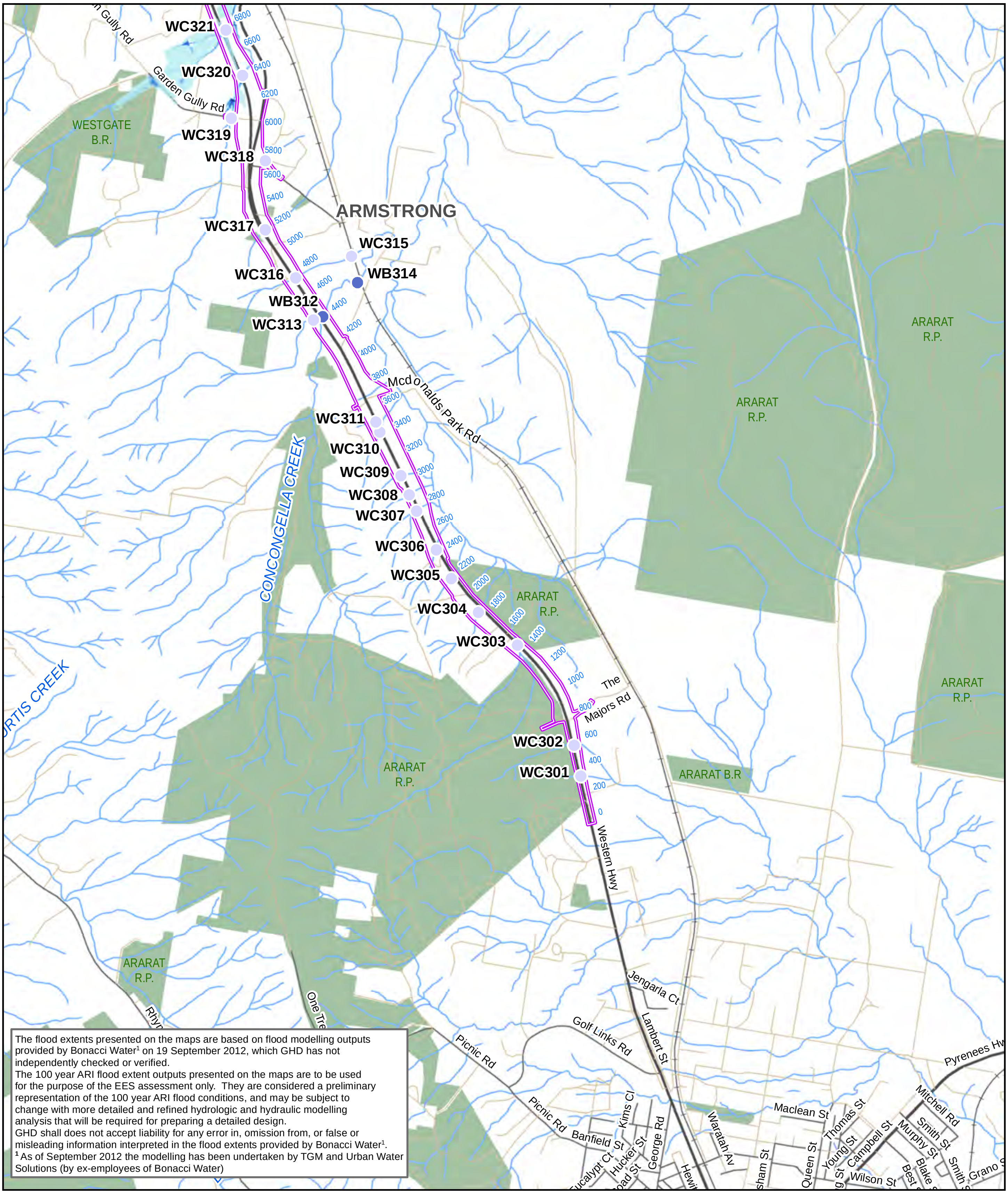
The data assessment undertaken by UWCS/TGM for VicRoads has included a preliminary flood assessment, presented in the Preliminary Report (May 2011) and a final flood investigation and report (August 2012). The impact of flooding along the existing highway was assessed by applying the hydrological model outputs (see Section 5.1.2), with a 2D TUFLOW hydraulic model that used the digital terrain model (DTM) created from the above terrain data.

The preliminary assessment of the 100 year ARI flood extent within the 3 km corridor surrounding the existing Western Highway gave an indication of where the various alignment options would intercept flooding. This initial modelling used a 10 m grid, which is considered large but allows for faster processing. A limitation of the model is the lack of adequate detail for variable terrain or low lying areas including detailed crossing of the highway and assessment of channel flow. Following this preliminary assessment, a number of areas were identified for further, more detailed investigation and these areas were modelled by UWCS/TGM using a TUFLOW model with a smaller 3 m grid. Both hydraulic assessments were only undertaken for the 3 km corridor surrounding the existing highway.

At this stage, the flood mapping provides information on locations of major highway flooding and approximate extents. The outputs from the UWCS/TGM report for Section 3 can be seen in Figure 25 and Figure 26 and a detail of this flood extent on the proposed alignment is shown in Figure 24 and in greater detail in Appendix C. A summary of the separate flood modelled systems is detailed in Table 13.

Table 17 Summary of Section 3 Flood Mapping

Sub Catchment	Surface Water System	Flood Extent Mapping
H5 – Upper Hopkins River (GHCMA)	Upper tributaries to Hopkins River	No Mapping
Concongella Creek (Wimmera CMA)	Concongella Creek & main tributaries	Concongella Creek (and main tributaries including Allanvale Creek, Robinsons Creek and Donald Creek)
Pleasant Creek (Wimmera CMA)	Pleasant Creek & tributaries	Pleasant Creek (No crossings of existing highway)



The flood extents presented on the maps are based on flood modelling outputs provided by Bonacci Water[1] on 19 September 2012, which GHD has not independently checked or verified.
The 100 year ARI flood extent outputs presented on the maps are to be used for the purpose of the EES assessment only. They are considered a preliminary representation of the 100 year ARI flood conditions, and may be subject to change with more detailed and refined hydrologic and hydraulic modelling analysis that will be required for preparing a detailed design.
GHD shall does not accept liability for any error in, omission from, or false or misleading information interpreted in the flood extents provided by Bonacci Water[1].
[1] As of September 2012 the modelling has been undertaken by TGM and Urban Water Solutions (by ex-employees of Bonacci Water)

LEGEND

100yr Modelled Flood Depth (m)
- 0 - 0.6
- 0.61 - 1.2
- 1.3 - 1.8
- 1.9 - 2.4
- 2.5 - 3

Waterway Crossings
- Minor
- Moderate
- Major

- Maximum Construction Footprint
- Highway
- Sealed road (arterial & local)
- Unsealed road
- Major water area
- Stream
- Connector
- Parks

Paper Size A4
0 250 500 1,000 1,500
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

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VicRoads
Western Highway Project
Ararat to Stawell
Waterway Crossings & Flood Extents

Sheet 1

Job Number	31-27558
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Date	21 Nov 2012

Figure 24

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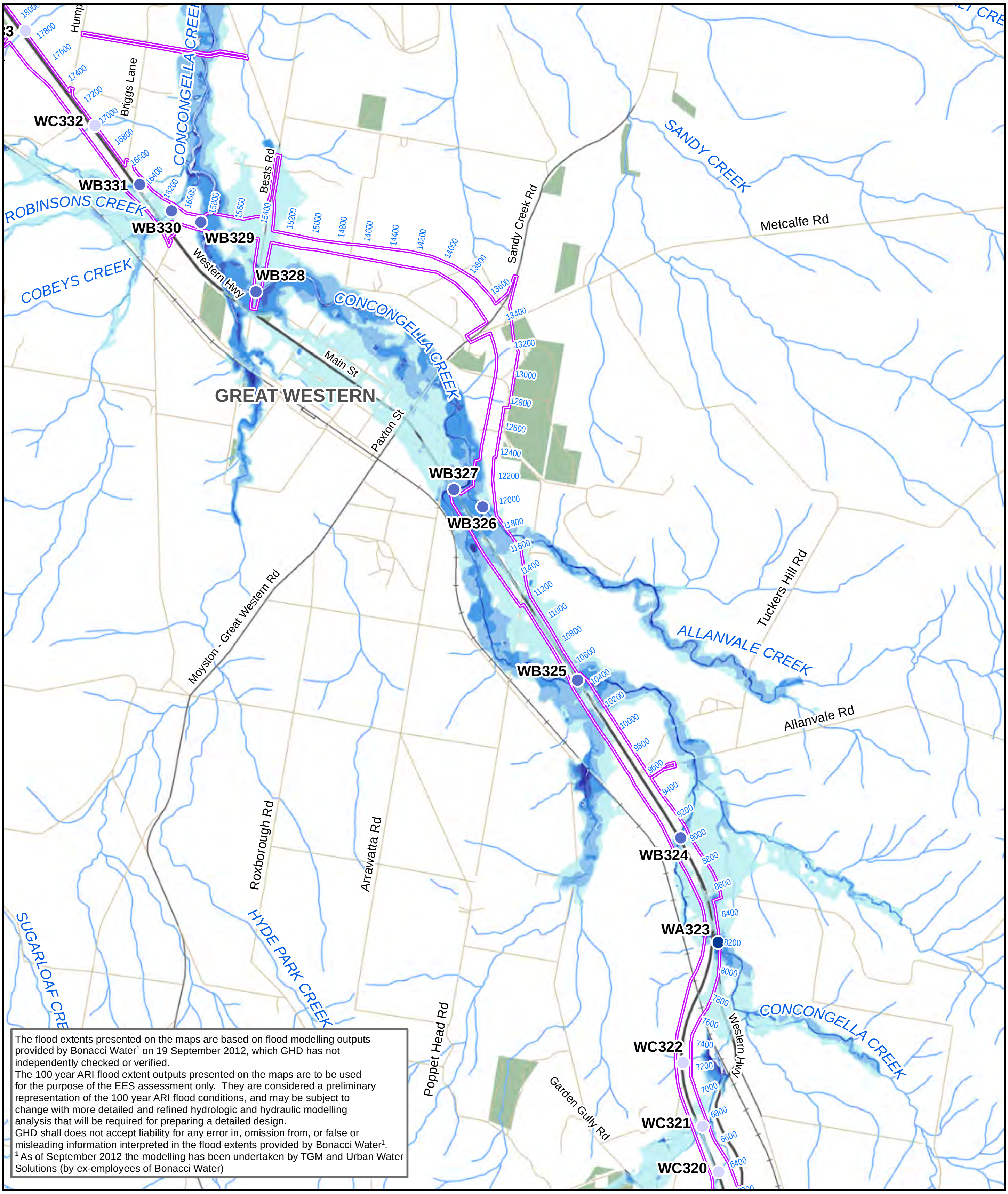
G:\31\27558\GIS\Maps\Deliverables\Stage 3\RISK AND IMPACT ASSESSMENT\06_SURFACE_WATER\3127558_S3_008_Flooding_Extent_A4P_MB_Exist_Flood_Extent_Fig24.mxd

Data source: DSE, VicMap, 2012; VicRoads, 2012; Flooding data: Bonacci, 2012; TGM, 2012. Created by:splaird



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Paper Size A4
0 250 500 1,000 1,500
Metres
Map Projection: Transverse Mercator
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VicRoads
Western Highway Project
Ararat to Stawell
Waterway Crossings & Flood Extents

Sheet 2

Job Number	31-27558
Revision	D
Date	21 Nov 2012

Figure 24

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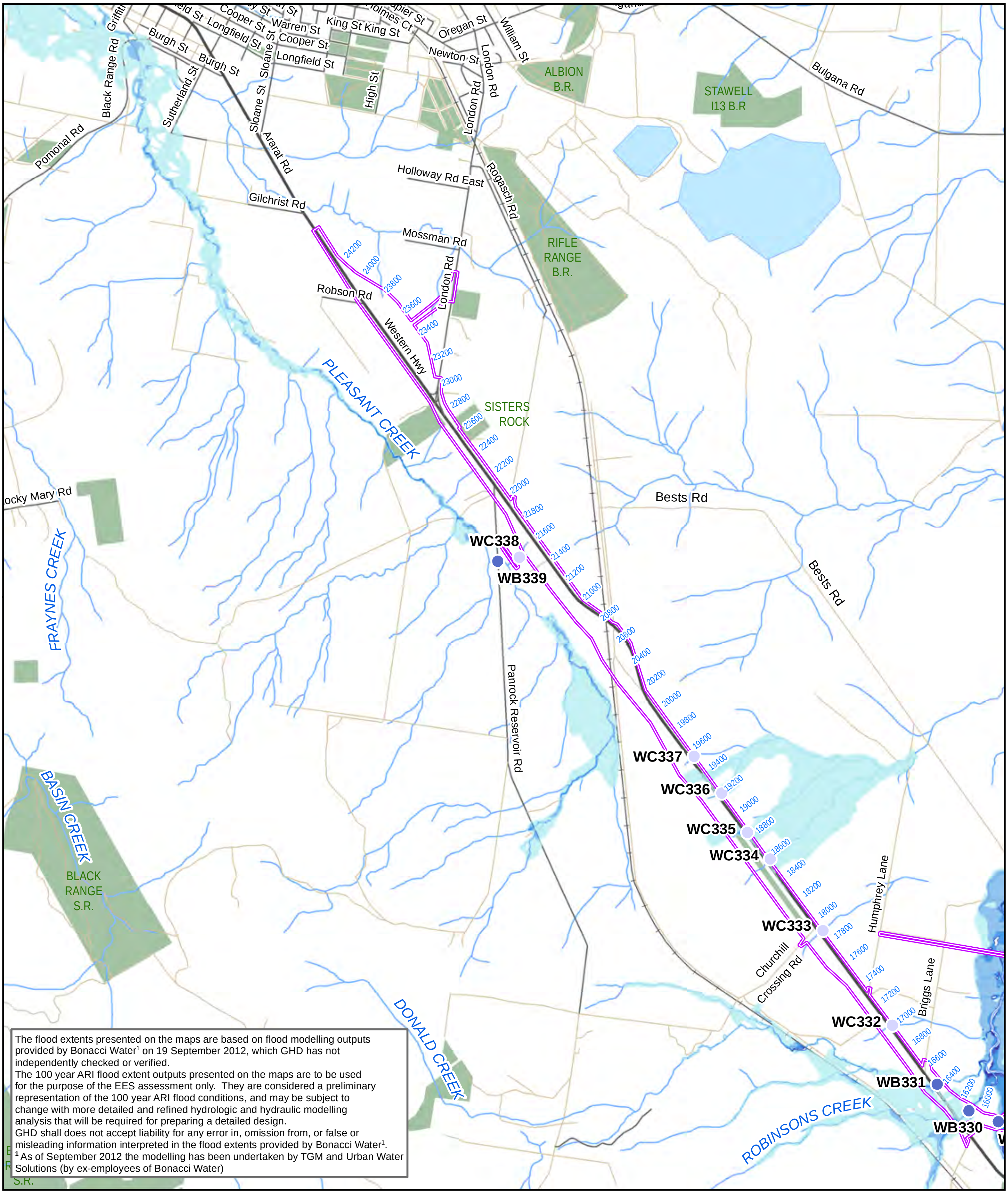
G:\31\27558\GIS\Maps\Deliverables\Stage 3\RISK AND IMPACT ASSESSMENT\06_SURFACE_WATER\3127558_S3_008_Flooding_Extent_A4P_MB_Exist_Flood_Extent_Fig24.mxd

Data source: DSE, VicMap, 2012; VicRoads, 2012; Flooding data: Bonacci, 2012; TGM, 2012. Created by:splaird



The flood extents presented on the maps are based on flood modelling outputs provided by Bonacci Water[1] on 19 September 2012, which GHD has not independently checked or verified.
The 100 year ARI flood extent outputs presented on the maps are to be used for the purpose of the EES assessment only. They are considered a preliminary representation of the 100 year ARI flood conditions, and may be subject to change with more detailed and refined hydrologic and hydraulic modelling analysis that will be required for preparing a detailed design.
GHD shall does not accept liability for any error in, omission from, or false or misleading information interpreted in the flood extents provided by Bonacci Water[1].
[1] As of September 2012 the modelling has been undertaken by TGM and Urban Water Solutions (by ex-employees of Bonacci Water)

LEGEND

100yr Modelled Flood Depth (m)
- 0 - 0.6
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- Maximum Construction Footprint
- Highway
- Sealed road (arterial & local)
- Unsealed road
- Major water area
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Paper Size A4
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Map Projection: Transverse Mercator
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VicRoads
Western Highway Project
Ararat to Stawell
Waterway Crossings & Flood Extents

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Sheet 3

Figure 24

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Data source: DSE, VicMap, 2012; VicRoads, 2012; Flooding data: Bonacci, 2012; TGM, 2012. Created by:splaird

Figure 25: Flood Overlay for Ararat to Stawell section of works, upstream of Great Western (UWCS/TGM, 2012)

Figure 26: Flood Overlay for Stawell section of works at Great Western (UWCS/TGM 2012)

The above Figure 25 and 26 includes the sub-catchments 32, 33, 35, 25, 26, 26a, 43, 27 and 28 and shows the multiple highway crossings of Concongella Creek. In summary, from the available information:

- Concongella Creek (upstream tributaries) – The existing highway interacts with a number of tributary flow paths and confluence of tributaries including localised overtopping of the road;
- Concongella Creek south-east of Great Western – The Concongella Creek and main tributaries interact with the existing Western Highway extensively between Ch. 6000 and Ch. 12000 upstream of the township of Great Western. The convergence of Concongella Creek and several of the main tributaries result in significant flooding of the township of Great Western;

- Allanvale Creek converges with Concongella Creek just north-west of the existing highway at Great Western (CH 12000). Allanvale Creek does not currently cross the existing highway but contributes to backwater flooding of the existing highway near Great Western;
- Hyde Park Creek crosses the existing highway in the township of Great Western and combines with Congcongella Creek at the north end of town; and
- Donald Creek, Robinsons Creek and Cobeys Creek converge near the highway prior to discharge into Concongella Creek downstream of the township of Great Western (Ch. 16200).

There was also modelling undertaken of the Pleasant Creek system that runs parallel to the highway south-east of Stawell. From the available information, there is no flooding of the existing highway indicated by this modelling, and there are no designated tributaries that cross the highway (CH 21600).

The storm event that caused the January 2011 flooding was the largest on record and was used to calibrate the model that was used for the flood mapping in Figure 25 and Figure 26. Photographs taken during the January 2011 flood were used to determine the extent and depth of actual flood levels (UWCS/TGM 2011).

The existing Western Highway and associated road features are located within the complex floodplain environment of Concongella Creek and its tributaries. The UWCS/TGM modelling indicates that at a number of locations the 100 year ARI flood extent upstream of the highway stretches for several hundred metres, and in some locations property and dwellings are affected. There are a number of crossings where a significant portion of flood flows currently overtop the highway, indicating that the level of flood protection for the existing road is relatively low.

For the following locations the existing highway is overtopped in the modelled 100 year ARI flood event:

- Tributary of Concongella Creek (Crossing WB321 at CH 6550 to 6850);
- Concongella Creek (Crossing WB323 at CH 8300 to 8400) – minor overtopping (significant flow diverted upstream);
- Concongella Creek (Crossing WB325 at CH 10400 to 10650) – overtopping (with significant flow diverted upstream);
- Concongella Creek (Crossings WB325 to WB327 at CH 10750 to Ch 12000) – extensive overtopping of road across a length > 1000 m leading into Great Western;
- Concongella Creek (Crossings WB328 – Bests Road at CH 15400); and
- Robinsons Creek (WB330 at CH 16000 to 16400).

For the proposed Western Highway Project in Section 3, various major road features including proposed interchanges are located in areas of complex floodplain structure. Detailed flood extent maps are provided in Appendix C of the various modelled flood extents and the interaction with the existing highway and footprint of the proposed highway. Table 18 contains an outline of the flooding issues interpreted from the 100 year ARI flood mapping.

Table 18 Interpretation of Existing Flood Conditions (100 Year ARI)

Section	Waterway	Crossing ID	Description of Existing Flooding Conditions
Section 3 **Ararat to Stawell**	Concongella Creek	WB312	(removed from current model) Confluence of tributaries upstream (u/s) of existing highway. Previous modelling indicated no overtopping, no attenuation from road.
	Tributary of Concongella Creek	WC320, WC321	Flooding overtops existing road at WC320 due to undersized culverts and diverts along the existing road reserve towards the next crossing location at WC321. Backwater flooding at WC321 influenced by berm u/s of existing accentuated by the diversion from u/s crossing.
	Concongella Creek	WC323	The flow from Concongella Creek appears to be restricted at Western Highway Armstrong Deviation crossing. The flow is split between the crossing (with some overtopping of the road) and breakaway flow upstream of the crossing to the north and where it rejoins the main flow path of Concongella Creek downstream of Crossing WB324.
	Concongella Creek	WC324	Flow at culvert restricted by diversion at upstream crossing. No overtopping, minimal upstream attenuation, no property dwellings near flooding.
	Concongella Creek	WC325	Flow from a main tributary joins Concongella Creek downstream of crossing WB325 leading to significant backwater flooding. Significant overtopping of the existing road as well as diversion of flows on upstream side of highway towards the Allanvale Creek downstream. There is a property on upstream side of highway that is flood affected.
	Allanvale Creek and Concongella Creek	WB327	Allanvale Creek joins Concongella Creek downstream of the Highway bridge crossing of Concongella Creek. There is extensive backwater flooding and interaction with the existing highway flood affected by over 1000 m (between crossing WB325 and WB327). Whilst it subject to significant flood inundation, the existing highway splits the main Concongella Creek flow path and the Allanvale Creek flow path (that combines with the upstream breakaway flows. It is noted an existing property u/s on Allanvale Ck affected by existing flood extent.
	Concongella Creek and Hyde Park Creek	WB328	Hyde Park Creek crosses the existing Highway and joins Concongella Creek immediately downstream. There is an existing crossing (Bests Road) of Concongella Creek with extensive flooding over the road. The two creeks join in the floodplain downstream creating the extensive backwater.
	Robinsons/Cobeys Creek, Donald Creek		Several tributaries flow from the east and converge upstream of the existing Highway including Donald and Robinson Creeks and combine with Concongella Creek downstream. The large backwater associated with the confluence of streams results in the existing highway being flood affected by over 250 m.

6. Impact Assessment

The detailed impact assessment documented in this report addresses the potential impacts of the construction and operation of the proposed alignment of Section 3 of the Project. The alignment assessed is a culmination of progressive deletion of earlier options, refinement of the design and consideration of potential impacts. The process for assessment and rationale for selection of the proposed alignment assessed in the EES is described in the 'Western Highway Project Section 3 Options Assessment Report' (February 2012) (Technical Appendix B of the EES).

The Existing Conditions section (Section 5) of this report covers an area encompassing the long list of alignment options considered for the Project. Potential impacts of each option in the long list of alignments were considered in Phase 1 of the options assessment process, and were used to reduce the initial long list to a short list of alignment options.

The potential impacts of each option in the short list of alignment options were considered in more detail in Phase 2 of the option assessment process. A single proposed alignment was selected for further detailed assessment in the EES. The impacts of the proposed alignment, together with potential mitigation measures, were considered in detail through the environmental risk assessment process. The outcomes of the risk assessment process were used to finalise the alignment assessed in the EES. The environmental risk assessment methodology and complete risk register for all specialist disciplines is presented in 'Western Highway Project Section 3 EES Environmental Risk Assessment' (November 2012) report.

The proposed alignments assessed in this impact assessment report are the outcome of progressive refinement through each phase of the options assessment process. The proposed alignments were also refined following the initial consideration of the environmental risk assessment.

Extracts form the environmental risk register prepared for the EES are provided in this report and the identified impacts of the proposed alignment are considered in detail in the following sections.

6.1 Project Description

The Project provides two lanes in each direction, and associated intersection upgrades to improve road safety and facilitate the efficient movement of traffic. It commences at Pollard Lane, Ararat, and extends northwest for approximately 24 km to Gilchrist Road, Stawell. The upgrade assessed in this impact assessment is a combination of freeway standard (AMP1) and highway standard (AMP3). The first length is proposed to be upgraded to AMP3 from Pollard Lane to the Majors Road. Then the upgrade is proposed to be AMP1 from Pollard Lane to Gilchrist Road on the outskirts of Stawell.

From Ararat the existing carriageway is duplicated to the east, crossing the railway via a new bridge adjacent to the existing Armstrong Deviation bridge. A new dual carriageway highway provides for a north-eastern bypass of Great Western, commencing north-west of Delahoy Road and passing through part of the former Great Western landfill and a quarry, meeting the existing highway alignment again near Briggs Lane. The existing carriageway is duplicated to the east until Harvey Lane. Oddfellows Bridge at Harvey Lane would be upgraded to accommodate one carriageway crossing of the railway, and a second bridge would be constructed for the other carriageway further west.

Overall, the proposed alignment involves two crossings of the Melbourne to Adelaide railway, eight crossings of major waterways and 26 minor waterways (tributaries, drainage lines and irrigation channels), and bypasses of both Armstrong and Great Western townships.

The topography is undulating, and the surrounding land use predominately agricultural (grazing, cropping, viticulture), apart from the forested Ararat Regional Park and other smaller remnants.

Apart from the Melbourne to Adelaide railway line, which carries both freight and passenger services, no State significant infrastructure, such as major pipelines or powerlines, is located within the study area.

The project is predominantly located within the Wimmera CMA region. The alignment is located in the upper catchment areas of the CMA region including the Upper Hopkins River (GHCMA) and Concongella Creek. Maps showing the location of each waterway crossing can be found in Appendix A. It is proposed that the waterway crossing treatments for the existing highway would typically be matched for the duplication. Where there is currently a culvert, a culvert is proposed for the duplicated highway and where there is a bridge, a bridge is proposed for the duplicated highway. The piers of these bridges would be constructed outside of the low flow channel extents. Flood modelling may influence the design of new waterway crossings to differ from existing crossings. The existing highway would also be the subject of the flood modelling. If existing drainage is found to be inadequate then it would also have to be upgraded. In order to prevent exacerbation of flooding it is likely that some existing bridges would require upgrades to accommodate the duplicated crossing.

6.2 Key Issues and Impact Pathways

The key issues are associated with either impacts to river health and water quality of receiving waters, or hydraulic impacts to waterways and floodplains:

- River health and water quality – This includes physical disturbance to existing waterways, fragmentation of waterways and water quality impacts.
- Waterways and floodplain hydraulics – This includes hydraulic conditions of waterway crossings and impacts on flooding.

Construction of the Project would involve replacing or constructing culverts and bridges at most waterway crossings. Construction of these features may involve physical disruption to the waterway as well as works to waterway banks and floodplains and may result in changes to the ecological or geomorphological nature of the waterway as well as floodplain characteristics.

The alignment of the highway upgrade would also intersect a number of waterways and may alter the flood regime and flooding patterns.

The additional traffic volumes may lead to an increase of contamination of storm water runoff from the road which would ultimately end up in the waterways.

Following construction works, there would be opportunities to improve waterway condition and ecological health to beyond the current condition. This can be achieved through revegetation and other waterway stabilisation works.

There may also be opportunities for flood attenuation to be achieved upstream of towns and the highway which could not only mitigate any impacts but could potentially reduce the influence of flooding on the road and local community.

6.3 Impact Pathways

The following section provides an overview of the impacts on each of the waterways associated with the construction and operation of the Project. The impact of the Project on each waterway crossing was assessed and summarised through the risk assessment framework.

In defining Impact Pathways from the key issues the Project may cause impact surface water impacts due to:

- **Construction activities** – Pollution or disturbance as a result of construction activities associated with the Project impact the river health characteristics of the waterways
- The **Construction of the Project (footprint and geometry)** – The Project results in permanent changes to the physical characteristics of the waterways and floodplain
- The **Operation of the Project** - The Project impacts the river health characteristics of the waterways.

The impact pathways have been defined based on the above and applied to each of the waterways. The impact of the Project on each waterway crossing was assessed and summarised through the risk assessment framework.

Impact pathways are replicated for each of the waterways relevant to Section 3 of the Western Highway Project, which include the following:

- Donald Creek;
- Robinsons Creek;
- Hyde Park Creek;
- Concongella Creek; and
- Allanvale Creek.

Crossings of unnamed tributaries of (but not the creek/river itself):

- Hopkins River; and
- Pleasant Creek.

A summary of the identified impact pathways is given in Table 19.

Table 19 Summary of General Impact Pathways, Consequences and Controls

Risk No.	Impact Pathway Description	Description of Consequences	Planned Controls to Manage Risk
SW1	**Construction** activities result in disturbance of channel planform, geometry and/or river health values.	Local destruction or destabilisation of waterway banks and channel profile; reduction of aquatic and terrestrial habitat in the crossing vicinity.	Reinstatement of waterway in accordance with the CMA requirements (channel profile, floodplain revegetation).

Risk No.	Impact Pathway Description	Description of Consequences	Planned Controls to Manage Risk
SW2	**Construction** of Western Highway results in the change in the hydraulic conditions and geomorphologic response at crossing locations..	Increased erosion potential due to concentration of flows/increased velocity through bridge or culvert.	Implement appropriate design standards for bridges and culverts (e.g. adequate culvert sizing or open span bridges), and rock protection to stabilise waterway bed and banks at the crossing location if required).
SW3	**Construction** of Western Highway results in fragmentation of river health values at crossing location.	Restrictions to aquatic and terrestrial fauna movement. Impediments to future waterway and catchment rehabilitation efforts.	Implement appropriate design standards (e.g. culvert sized appropriately and set at bed level of waterway,
SW4	**Construction** activities result in increased sediment and contaminant loadings of waterway.	Degradation of water quality in receiving waters. Impact on aquatic ecosystems.	Implement erosion and sediment control measures. Comply with SEPP WoV requirements. Prompt covering of exposed surfaces, progressive revegetation of the site, avoid unnecessary works in channel/on banks.
SW5	**Operation** of Western Highway road surface results in increased stormwater, sediment and contaminant loadings to waterway.	Increase in quantity of stormwater runoff compared to the existing flow regime. Degradation of water quality in receiving waterways, impact on aquatic ecosystems.	Water Sensitive Road Design measures included in the detailed design phase, as described in VicRoads Integrated Water Management Guidelines (August 2011), and at a minimum best practice pollution reduction targets would be achieved for the additional road surface compared to the existing road surface footprint
SW6	The **Construction** of the Western Highway results in changes to floodplain characteristics to waterway.	Increased afflux and extent of upstream flooding and/or redistribution of flows in increase in flooding at various scales (rural, township, *in situ*).	Implement appropriate design standards to achieve highway flood risk requirements (e.g. adequately sized culverts or bridge spans). (Note: Due to system complexity detailed hydraulic modelling will need to be undertaken to further define the mitigation measures)

Section 6.4 below provides a detailed description of the impacts of the risk pathways for both River Health and Floodplain Management respectively. The impact of the Project on each waterway crossing was assessed and summarised through the risk assessment framework. The expected consequences, likelihood levels and risk ratings for each of the identified risk pathways relevant to surface water investigations is documented in Section 6.6.3. The risk assessment provides an important framework for ensuring all key issues have been identified at each identified waterway and that high-risk pathways receive an appropriate level of consideration in the impact assessment.

Section 7 of this report outlines the management measures proposed to lower risks associated with medium to high risks associated with the impacts to river health and water quality of receiving waters or hydraulic impacts to waterways and floodplains.

6.4 River Health Impacts

The Project may affect river health and water quality characteristics of the various waterways due to the construction of the Project, construction activities during the implementation of the Project, and operation of the Project. The Project would interact with the various waterways as described in Section 5 with potential impacts including physical disturbance to existing waterways, fragmentation of waterways and water quality impacts.

For each River Health impact pathway, detailed descriptions of the potential impacts and level of impact to specific waterways is outlined below. Also, we have described potential opportunities and mitigation beyond standard controls that may need to be considered.

6.4.1 Physical Disturbance to Waterway (Channel Form and River Health)

This is relevant for risk pathway SW1 (refer to Table 19).

Description of Impact - The Construction of the Project would result in local removal of riparian and in-stream vegetation and habitat values at waterway crossing locations. The magnitude of the disturbance is the effective footprint or reach length of waterway disturbed by the Project. Removal of vegetation may impact bed and bank stability and increase the potential for channel erosion.

The loss of native riparian vegetation and decline in vegetation condition can present a threat to the health of surface water systems. A decline in vegetation condition may include increased fragmentation, weed invasion and the loss of vegetation diversity. Loss of riparian vegetation can also lead to an increase in bank erosion and bed degradation.

Bank instabilities threaten remnant riparian vegetation and provide a source of sediment that can have an adverse impact on the waterway. Bed and bank instabilities refers to accelerated rates of erosion associated with either channel enlargement or meander development. These can be the result of direct impacts or more indirect processes such as channel incision. Bank instabilities threaten remnant riparian vegetation and provide a source of sediment that can have an adverse impact on the waterway.

The significance of the impact of the physical disturbance at each waterway crossing location is dependent on the status or value of the waterway, as well as the magnitude or extent of disturbance to the waterway. The status of waterways impacted by the proposed alignment were categorised as minor, significant or major (as defined in section 5.2). The magnitude of the disturbance was categorised as low or high by considering the scale of the impact disrupted (footprint area or reach length of waterway) i.e.

- Where a crossing is a straight perpendicular crossing at an existing crossing location then the scale of disturbance is low; or

- Where a crossing is skewed and/or two new carriageways are being built significant lengths of waterway are potentially disturbed and the scale of disturbance is high.

For minor waterways, the significance of the impact is generally low. For the significant and major waterways, the significance of the impact is determined by the magnitude of the disturbance and this is summarised in Table 20 below:

Table 20 Significance of Waterway Impacts ("Significant" waterways)

Waterway Crossing	Waterway (Status)	Magnitude of Disturbance	Significance of Impact
WB312	Concongella Creek (Significant)	Minor skewed crossing of significant waterway and tributary, <200 m footprint disturbed - managed as discrete crossings for each carriageway	Minor
WA323	Concongella Creek (Significant)	>100 m of significant waterway (with good habitat and river health values) directly impacted by the footprint of the project	Moderate
WB324	Concongella Creek (Significant)	Skewed crossing of significant waterway, <200 m footprint disturbed - managed as discrete crossings for each carriageway or realignment of channel	Minor
WB325	Concongella Creek (Significant)	Perpendicular crossing (extension of existing crossing) in significant channel (actively eroding u/s)	Minor
WB326	Allanvale Creek (Significant)	New Highway crossing location of skewed channel alignment of Allanvale Creek	Moderate
WB327	Concongella Creek (Significant)	No disturbance to existing crossing or main creek channel from the footprint of the interchange arrangement	Insignificant
WB328	Concongella Creek (Significant)	Minor disturbace of access road -limited change	Insignificant
WB329	Concongella Creek (Significant)	New crossing - Perpendicular alignment of Concongella Creek (signifcant waterway)	Moderate
WB330	Robinsons Creek (Significant)	Perpendicular, lengthy extension (due to realigned segment of highway merging with existing highway) of existing crossing of significant waterway	Moderate
WB331	Donald Creek (Significant)	Skewed crossing of disturbed waterway, <200 m footprint disturbed - managed as discrete crossings for each carriageway	Minor
WB339	Pleasant Creek (Significant)	No direct crossing (creek alignment parallel) - some local catchment connections not recognised as designated waterways	Insignificant

6.4.2 Water Quality Impacts

This is relevant for risk pathways SW4 and SW5 (refer to Table 19).

Description of Impact - Construction activities on the proposed alignment have the potential to impact water quality due to increased sediment loading resulting. The sediment load can be generated from general construction activities from the overall footprint of works (typically managed within an

Environmental Management Plan) prior to discharge to receiving waterways. Water quality impacts associated with direct disturbance of bed and bank from works within the waterways at crossing locations is covered by risk pathway SW1. The degradation of water quality in receiving waterways can impact on aquatic ecosystems. A greater level of concern or impact would occur to higher value waterways that have high value aquatic ecosystems (eg.in particular where Dwarf Galaxias may exist however no Dwarf Galaxias were observed in Section 3). Any construction activities around the waterways would be required to maintain water quality parameters within the SEPP WOV objectives.

The operation of the Project has the potential to impact water quality due to increased contaminants from the additional road surface being discharged to receiving waterways, including particulate matter, nutrients (nitrogen and phosphorous), heavy metals, petroleum based products, organic compounds and rubber products.

Water quality decline is an adverse change in water parameters such as water temperature, pH, dissolved oxygen, turbidity, pathogens, nutrients, pesticides, chemicals and heavy metals. Changes to water quality outside the bounds of natural variability for the waterway can reduce river health values by adversely impacting aquatic life and vegetation.

The significance of the impact of water quality degradation to each receiving waterway is dependent on the status or value of the waterway, as well as the level of water quality pollution to the waterway. The status of waterways impacted by the proposed alignment were categorised as minor, significant or major (as defined in section 5.2). For all locations the level of water quality pollution was categorised as Low assuming that standard controls are in place i.e.

- Construction Phase - appropriate environmental management controls for construction phase; and
- Operation Phase - appropriate WSRD measures are implemented as part of the works for the managing runoff from the road in operation).

Benefits & Opportunities – For the existing road there is currently no formal stormwater quality treatment measures in place or WSRD. The previous road was built prior to there being a requirement to address stormwater quality from road runoff. As there is a requirement for the new road to manage water quality from runoff from the road, there is an opportunity to provide WSRD treatments for all hardstand areas (including where the existing carriageway is being retained as a carriageway or maintained as a service road or local road). The WSRD elements could be located and sized to treat the whole surface footprint of hardstand road surfaces.

Mitigation Measures – Where the magnitude of water quality degradation of the Significant/Major waterways leads to a Medium impact or greater there would be mitigation required. This may be in the form of a construction wetland that provides habitat value as described above in the potential opportunities.

6.4.3 Change in Geomorphologic Response (Stream Bed Degradation and Aggradation)

This is relevant for risk pathway SW2 (refer to Table 19).

Description of Impact – The footprint of the Project has the potential to increase sediment loading to the downstream waterway in the short term, as a result of channel disturbance and removal of stabilising bed and bank vegetation. The construction of culvert crossings also has the potential to accelerate stream bed degradation and aggradation (sediment accumulation) processes due to the change in hydraulic conditions (i.e. increased scour potential downstream of the culvert) and discontinuity of sediment transport processes.

Stream bed degradation refers to the lowering of the stream bed elevation through ongoing erosion processes. Most often the erosion is headward progressing (i.e. moving in an upstream direction) associated with the movement of nick points or head cuts. This can impact waterway health through the loss of existing instream features and can result in destabilisation and the production of sediment that may have adverse downstream impacts.

Stream bed aggradation is a process of net sediment deposition within a stream channel that results in the ongoing rise in bed elevation. This can lead to the decline in waterway health by smothering of bed forms and associated loss of bed diversity including pools, riffles and instream structure. Ongoing aggradation can accelerate channel avulsion (i.e. stream process where a new channel formation occurs and abandonment of the old stream channel) and the creation of a new one.

The significance of the impact of the geomorphologic response for each waterway crossing location is dependent on the geomorphologic status or current stability of the waterway (Significant and Major), as well as the magnitude or extent of disturbance caused by the change to the waterway. The geomorphologic status of the waterways that are impacted by the proposed alignment were considered to be showing signs of actively eroding throughout the systems. The magnitude of the disturbance to the waterway is assumed to be low given the presence of existing culverts that may already be exacerbating the issue. Nonetheless, there would be requirements to size culverts to reduce velocities and provide appropriate protection to bed and banks as part of the works. Therefore, for all existing waterway crossings the significance of the impact is generally low. For the proposed new crossing at Concongella Creek and Allanvale Creek the higher impact may warrant further design considerations.

Benefits & Opportunities – For any disturbed waterway where there is an existing crossing there is an opportunity to address the downstream condition with stabilisation works. It is noted there were no sites observed that required stabilisation works.

Mitigation Measures – For locations where there are existing crossings there is no requirement for mitigation beyond the standard controls (i.e. appropriately sized waterway openings and downstream bed and bank protection works), and for the proposed new crossings at Concongella Creek and Allanvale Creek there may be specified design requirements (eg. oversize waterway opening, limit disturbance to creek bed).

6.4.4 Fragmentation of River Health values

This is relevant for risk pathway SW3 (refer to Table 19).

Description of Impact - The Project could lead to fragmentation of River Health values in the form of instream barriers at the waterway crossings that could prevent the passage of instream sediments, detritus, macroinvertebrates and fish. Examples of instream barriers include weirs, road culverts and causeways. Such barriers can halt ongoing stream processes downstream of the barrier, prevent the recolonisation of stream reaches with species following disturbance, result in the isolation of fish populations and prevent completion of fish breeding cycles. The barrier to fish migration can result in the loss of fish populations from waterways and potential loss of species. Furthermore, the fragmentation not only leads to restrictions for aquatic and terrestrial fauna movement, but impediments to future waterway and catchment rehabilitation efforts.

Culvert crossings constructed as a result of the Project may create instream barriers that isolate or restrict the movement of native fish populations, and interfere with or prevent fish spawning.

The significance of the impact of the fragmentation for each waterway crossing location is dependent on the status of the waterway reach near the location of the crossing (Significant and Major), as well as the magnitude of the discontinuity to the waterway. The magnitude of the discontinuity to the waterway would vary from low (eg where there is an `existing crossing at a straight perpendicular location) to potentially more significant at deviation locations where there is a new crossing proposed. The standard requirements for crossing include sizing culverts to reduce velocities, and arranging culverts so that invert levels match bed levels, and provide appropriate protection to bed and banks as part of the works. Therefore, for all waterways except for the proposed new crossing of Concongella Creek and Allanvale Creek, the significance of the impact is generally low with application of standard controls. The proposed new crossing at Concongella Creek and Allanvale Creek is considered a higher impact and may warrant further design considerations to reduce the impacts (e.g. open span bridge).

Benefits & Opportunities – For any disturbed waterway where there is an existing crossing causing fragmentation (eg restrictive culvert, bed level discontinuity) there is an opportunity to address the fragmentation caused by the existing crossing. Where waterway crossings are being upgraded then this may reduce the level of fragmentation. There may be opportunities to retrofit existing culverts (eg. with baffles to reduce low flow velocities - subject to capacity) to improve connectivity.

Mitigation Measures – Where a new crossing is proposed the standard mitigation controls would apply (i.e. culvert sized appropriately and set at bed level of waterway). In some cases where impacts are considered medium to high more specific design requirements (i.e. fauna friendly features such as provision of adequate light penetration) or stringent design requirements may be imposed (an open span bridge) where required.

6.4.5 Overall Assessment of River Health Impacts

The overall impacts on River Health from the Project to the various waterways is generally low. However, the impacts described at the following specific locations are medium or higher and warrant additional mitigation or management measures:

- Construction of Western Highway in disturbance of channel planform, geometry and/or river health values for Concongella Creek at Ch. 8200 where there is a small reach of significant waterway that is directly disturbed by the footprint of the proposed highway embankment, as well as disturbance where additional crossings are proposed at new locations on Concongella Creek and Allanvale Creek;
- Construction of Western Highway results in fragmentation of river health values at new crossing location for Concongella Creek and Allanvale Creek; and
- Construction of Western Highway results in change in Geomorphological conditions at new crossing locations for Concongella Creek and Allanvale Creek.

For all locations where there are existing crossings of significant waterways (other than Concongella Creek at Ch. 8200 described above) the river health impacts are minor, predominately on the basis of there being an existing crossing already causing a river health impact.

The Project would provide opportunities to improve existing conditions of reaches within the vicinity of the works, as well as improve discontinuities and provide water quality treatment outcomes that are better than existing conditions.

6.5 Floodplain Management Impacts

The Project may affect the hydraulic behaviour of the waterways and associated floodplains and may cause obstruction to flow paths leading to increase in flood levels and/or redistribution of flood flows. The Project would impact the flood extent and flow paths of the various waterway systems and associated floodplains as described in Section 5.3, with potential impacts on flood levels and/or redistribution of flood flows.

6.5.1 Afflux and Floodplain Function

This is relevant for risk pathway SW6 (refer to Table 19)

Afflux refers to the rise in water level (above existing) on the upstream side of a bridge or obstruction, such as a culvert. Afflux results when the effective flow area at the obstruction is less than the natural width of the stream immediately upstream of the obstruction. The construction of the Project has the potential to result in afflux in areas upstream of new culvert and bridge crossings during peak flow events, i.e. increase in flood levels. The impact of this would vary depending on catchment land uses.

Flooding is defined as the inundation of land that is not normally covered by water, and occurs when the channel of a waterway is unable to contain the volume of water flowing from the catchment. At these times, the waterway and its associated floodplain form an integrated system for the passage of flood flows. Floodplains augment the capacity of a waterway to discharge floods by providing additional flow capacity to reduce the flood height and flow velocities. Floodplains also provide temporary storage of floodwaters, attenuating the peak flows and reducing the extent of flooding. As the fringe between land and water based ecosystems, floodplains are a key element in the natural environment due to their support of both terrestrial and aquatic communities.

Construction of the Project may result in changes in floodplain characteristics. This has the potential to impact floodplain function and flow conveyance, particularly during peak events.

The proposed road for the Western Highway Project is either duplication along the existing alignment or a deviation for new dual carriageways where a new waterway crossing location may be required. For the majority of the proposed road it is a duplication of the existing highway, and therefore waterway crossings become an extension or duplication of existing crossings. At a minimum, the proposed road design includes two 2-lane carriageways and potentially, access ramps and/or services roads. The existing road may be used as either of the carriageways or may become an access road or service road where the current flood standard would be maintained. The only significant deviation of the proposed road is around the township of Great Western, and this would result in the need for three additional or new crossing locations.

The significance of flood impacts was considered in terms of the status of the area impacted and the magnitude of the flood level increase. The significance of the area was categorised as described in Section 4.2.1 of the report, with categories for Rural (no buildings), Rural and Township flooding impacts. The magnitude of the flood level increase where there is Rural or Township impacts is required to be reduced to zero.

For township flooding of Great Western there is widespread flooding under existing conditions, which is confirmed in the flood modelling outputs. There are potential impacts of the Project on flooding in Great Western, and the minimum requirements would be to demonstrate no worsening of the existing flood conditions. The potential to improve local conditions in Great Western, if local attenuation is allowed upstream, would be explored at detailed design.

The impact assessment was based on interpreting the proposed design alignment (assuming that flood criteria would be notionally satisfied) with respect to the existing conditions flood modelling. This was assessed in detail to understand the potential change in flood conditions. This was subsequently used to derive preliminary waterway opening requirements for the iterative modelling undertaken for the proposed highway (refer to Section 7.4).

Table 21 and Figure 24 provides a summary of the potential flooding impacts of the Project as interpreted from the existing conditions flood conditions as presented in the detailed flood extent maps in Appendix C.

Table 21 Potential Flooding Impacts of Proposed Highway Conditions

Waterway	Waterway Crossing	Description of Potential Flooding Impacts – Proposed highway Conditions
Concongella Creek	**WB312**	**Duplication**: No change required to highway level and waterway opening to be marginally increased to minimise afflux.
Concongella Creek	**WB320, WB321**	**Duplication**: Raising of existing highway level and increase of waterway opening required. Nearby property not expected to be impacted flood extent.
Concongella Creek	**WA323**	**Duplication**: Minor raising of existing highway and additional waterway area for the main flow path and culvert openings (or direct additional flow north of the highway). No properties in the vicinity of the upstream flood extent.
Concongella Creek	**WB324**	**Duplication**: No change required to highway level and waterway opening – Based on upstream flow at WB323 diverted to the north of the highway. No properties in the vicinity of the upstream flood extent.
Concongella Creek	**WB325**	**Duplication**: Significant raising of existing highway and increase in bridge opening required for the main flow path to maintain existing flow distributions. The backwater and breakaway flow on the upstream side of the highway towards the north currently impacts a property (adjacent to road Ch. 10600). Any change in distribution of flow at this location may have implications on the flooding behavior in the township of Great Western and rural property upstream.
Allanvale Creek & Concongella Creek	**WB326, WB327**	**Deviation**: Proposed Highway deviation and interchange is within the backwater and intersects the floodplain by over 1000 m extending back to crossing WB325. A new major bridge crossing would be required of Allanvale Creek main flow path as part of the deviation and road interchange arrangement. There would also need to be significant openings provided in the backwater area of the existing carriageways as well as for the exit ramps and service roads. Any change in distribution of flow at this complex interchange location may have implications on the flooding behavior in the township of Great Western. For Allanvale Creek, a nearby property upstream is not expected to be impacted flood extent.

Waterway	Waterway Crossing	Description of Potential Flooding Impacts – Proposed highway Conditions
Concongella Creek	**WB328, WB329**	**Deviation**: Some raising of road at Bests Road crossing would be required (depending on upgraded design standard). Bests Road is currently inundated by the backwater of Concongella Creek. There is potential for a significant increase in backwater flooding depths locally along Concongella Creek as a result of fill works for the Bests Road overpass and new highway crossing. Proposed Highway would require a new major crossing structure at WC329 which crosses an existing flood extent width of 200 m.
Robinsons Creek and Donald Creek	**WB330, WB331**	**Deviation/Duplication**: The proposed highway would require a new crossing of Robinsons Creek 100 m downstream of the existing highway and an upgrade of the existing crossing and proposed service road. Raising of the road and an upsized crossing would be required at the duplication of the existing crossing of Donald Creek.
Pleasant Creek		No crossing of Western Highway (other than local catchment flow paths).

The existing conditions flooding of the existing highway and the Great Western township is a complex interaction of Concongella Creek and tributaries. Flooding at Great Western is expected to be influenced by:

- Relative timing of flows from the various sub-catchments and tributaries;
- Obstruction to flow paths leading to diversions and breakaway flows; and
- Backwater storage behind existing crossing and road embankments.

Whilst the existing highway is subject to extensive flooding, it also provides some backwater attenuation at various crossing locations, and also causes diversion of flows upstream of crossing locations. Existing flooding characteristics are influenced by the existing highway conditions, and any change may impact flow conditions both upstream and downstream. The upgraded highway conditions where the road is flood free could potentially affect current flooding characteristics in terms of timing, change in storage characteristic and /or flow distributions.

The impacts of the Project have been considered in the context of potential impacts in the township of Great Western, as well as potential localised impacts where there are dwellings on rural properties. The following summarises the interaction of the Project and existing conditions flooding based on the interpretation of existing conditions flooding.

- The existing highway is flood affected in two locations in the upper Concongella Creek and tributaries – *These can be addressed by raising the road and increasing waterway openings as required (without any expected change in distribution of flows).*
- The existing highway is significantly flood effected in the 2 km section of road upstream of Great Western at crossings and between crossings from the complex interaction of Concongella Creek, breakway flows from Concongella Creek and Allanvale Creek - *Constructing the new highway to be flood free and cause no afflux with result in increased flood levels through Great Western (estimated to be in the order of a 100 mm increase)*.

- The flooding through the township of Great Western is extensive and the existing highway is flood affected throughout the township. The existing road becomes an access exit/entry road for the proposed highway. – *Changes to the existing highway within the town are minor and are not expected to have any significant implications on flooding.*
- The new alignment is a deviation from the existing highway (around the township of Great Western), and there would be a requirement for three new crossing locations – *The new crossings would be designed as flood free crossings with no allowable increase in flood levels.*
- The existing highway and Bests Road at the northern end of town are affected by flooding at the confluence of Hyde Park Creek and Concongella Creek. Changes at this location are minor and are not expected to increase flood levels within the town - *Changes to the access road (Bests Road) within the town are unlikely to result in any significant increase in flood levels.*
- The existing highway downstream of Great Western is flood affected from Robinsons Creek and Donald Creek upstream of the confluence with Concongella Creek - *This can be addressed by raising the road and increasing waterway openings as required without significant change in the distribution and timing of flows.*

Where the new alignment is a duplication there would be significant lengthening of the represented waterway crossing to include all carriageways and ancillary roads. Where there is currently no overtopping of the road, it is assumed that crossing arrangements can be readily determined that have no or minimal adverse impact on upstream flooding (i.e.by sizing relative to existing waterways areas).

The Concongella Creek and complex interaction with the Western Highway and change in conditions due to the proposed highway have been assessed in the hydraulic modelling. Iterative modelling analysis has been undertaken with the intent of providing sufficient information to enable an assessment of flooding impacts outlined in section 7.4

Overall Assessment of Impact - The Construction of the Western Highway results in changes to the complex flooding characteristics of Concongella Creek and tributaries. The potential impacts at the township of Great Western have been assessed by considering the whole of the Concongella Creek system and major tributaries. The potential impacts can be summarised as follows:

- Potential impacts to Great Western township from increased flooding of Concongella Creek as a result of changes to floodplain characteristics on Congongella Creek and Allanvalle Creek upstream of the town– Major potential impact;
- Potential impacts to rural properties at significant crossing locations as a result of increased flooding from Robinsons Creek (WB330) and Congongella Creek (WB325)– Moderate potential impact; and
- Potential impacts at significant crossing locations (farmland only) as a result of increased flooding at Unnamed Tributaries of Concongella Creek (WC320 and WC321), and Donald Creek (WB331) – Minor potential impact.

All minor crossing locations were considered to be of minor consequence, leading to insignificant risk rating. It is assumed that waterway crossings that provide a minimum flow capacity equivalent to the current crossing would be required. As head loss through a culvert increases with length, slightly larger waterway openings are likely to be necessary to achieve an equivalent flow capacity across the widened road.

6.6 Risk Assessment

6.6.1 Planned Controls - VicRoads

VicRoads has a standard set of environmental protection measures which are typically incorporated into its construction contracts for road works and bridge works. These are described in *VicRoads Contract Shell DC1: Design & Construct, April 2012*, hereafter referred to as the "VicRoads standard environmental protection measures". These measures have been used as the starting point for the impact assessment. Those that are relevant to surface water are included in the "planned controls" column of the risk assessment (Table 22).

As a result of the initial risk assessment, in some cases additional Project specific controls have been proposed to reduce risks. These are outlined in the "additional controls" column of the risk assessment in Table 22, and are described in more detail in Section 7.

Both the VicRoads standard environmental protection measures and the additional Project specific controls have been included in the Environmental Management Framework for the Project.

- 1200.03 Environmental Management Plans (EMP).

Environmental Management Plans shall be prepared taking into account:

  - the Site's environmental features;
  - the nature of the works to be undertaken;
  - any potential environmental impacts as identified in VicRoads Project Environment Protection Strategy;
  - any permits and/or approvals and related conditions;
  - the findings of environmental investigations; and
  - the results of any environmental investigations undertaken by the Contractor.

- 1200.04 Water.

The quality of water in existing drainage infrastructure after acceptance of runoff/discharge from the Site shall not be detrimentally impacted by runoff from the site.

- 1200.08 Erosion and Sediment Control.
  - All exposed surfaces shall be free of erosion.
  - Soil conservation measures shall include but are not limited to:
    - minimising the amount of exposed erodable surfaces during construction - this may include staging of works;
    - installation and maintenance of erosion and sedimentation controls, established in accordance with EPA best practice guidelines for the treatment of sediment laden run-off resulting from construction activities;
    - installation and maintenance of catch drains to divert and segregate water runoff from catchments outside the construction site from water exposed to the construction site and to adequately control and route runoff within the construction site to the appropriate sedimentation control installation;
    - treatment of open drains to prevent erosion before adjacent ground is disturbed and excavation is commenced;

- prompt covering of exposed surfaces (including batters and stockpiles) that would otherwise remain bare for more than 28: days - cover may include mulch, erosion control mat or seeding with sterile grass;
    - minimising the timing between clearing and stripping of the Site and covering of erodible surfaces; and
    - where trees are required to be removed more than two months in advance of any construction works, remove only that part of the tree that is above ground level and where possible allow the roots to remain intact beneath the ground surface to assist with erosion control.
- Works shall be programmed and managed so as to avoid work in waters. Where work in waters is unavoidable, procedures shall be developed and implemented to satisfy the requirements of VicRoads standard environmental protection measures and as required by any permits from the responsible authority(s) (refer to Section 3).
- Where construction activities are undertaken in, near or over waters, Environmental Management Plan(s) shall be prepared to protect beneficial uses in accordance with any permit, the State Environment Protection Policy (Waters of Victoria), its schedules and best practice guidelines.

In addition to the VicRoads standard environmental protection measures, it is planned that the Project would be designed in accordance with VicRoads Water Sensitive Road Design Guidelines. The VicRoads document *Integrated Water Management Guidelines* (VicRoads, 2011), which replaces *Applying Water Sensitive Road Design Guidelines* (VicRoads, 2007), is designed to provide a general overview of the principles of Water Sensitive Road Design and a framework for applying to road projects.

Water Sensitive Road Design is the application of the principles of Water Sensitive Urban Design (WSUD) relevant to the road network. It seeks to minimise the extent of impervious surfaces and mitigate changes to the natural water balance. Specifically, WSUD (and WSRD) attempts to manage the impacts of:

- Reduced quality of stormwater run-off;
- Increased peak and total stormwater flows; and
- Decreased base flows, due to increase catchment imperviousness.

Further discussion on WSRD is in Appendix D.

6.6.2 Planned Controls – Other

As mentioned above, the VicRoads standard environmental protection measures specify that, “where work in waters is unavoidable, procedures shall be developed and implemented to satisfy the requirements of VicRoads standard environmental protection measures and as required by any permits from the responsible authority(s)”.

As mentioned in Section 3, WCMA and GHCMA, as caretakers for waterways under the *Catchment and Land Protection Act 1994,* are responsible for issuing permits for works on waterways and their permission would need to be sought prior to undertaking the works on waterways for this project.

For the proposed works a Works on Waterways application would need to be submitted to WCMA or GHCMA for assessment. The key issues to address in a Works on Waterway application are under the following headings:

- Environmental Management Plan;
- Water Quality and Water Sensitive Road Design; and
- Effect of works on floodplain function.

Waterway crossing locations would require reinstatement following construction works associated with the Project. Works should be undertaken in accordance with the CMA's specific requirements with reference to the *Technical Guidelines for Waterway Management (DSE, 2007*).

The Technical Guidelines for Waterway Management represent current best management practice and incorporate advances in environmental and technical practice for river health restoration and protection.

In order to achieve the most effective beneficial river health outcomes for the resources and effort invested, program implementation should be in accordance with best management practice and in recognition of the underlying geomorphologic and ecological processes operating within the waterway.

In conducting this interpretation it has been assumed that the ultimate road design will be to the following standards (as per the Section 1 specification):

- Traffic lanes to be one metre above the 100 year ARI flood level;
- No increase in afflux above existing conditions; and
- No significant change in downstream flow distribution leading to increase in downstream flooding.

6.6.3 Risk Assessment Outcomes

Table 22 below summarises the outcomes of the risk assessment process.

Table 22 Surface Water Risk Assessment

Risk No.	Impact Pathway Description (how the project interacts with assets, values and uses)	Description of consequences	Planned Controls to Manage Risk (as per Project Description, and VicRoads Contract Shell DC1: Design & Construct (April 2012)).	Initial Risk			Additional Controls Recommended to Reduce Risk	Residual Risk		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
SW1A	Construction activities on Significant crossing of Concongella Creek (Ch. 8200, WB 323) resulting in disturbance of channel planform, geometry and river health values.	Destruction of >100 m of waterway banks, channel profile and pools. Reduction in aquatic and terrestrial habitat value in the vicinity of the crossing location.	Reinstatement of waterway in accordance with WCMA requirements (channel profile, floodplain revegetation).	Moderate	Likely	High	Realignment of waterway to follow eastern boundary of old highway, including bed control structures, bank stabilisation using a combination of rock, vegetation and erosion matting, creation of meanders, reintroduction of large woody debris, synthesis of existing pool and riffles, relocation of old highway bridge and construction of a new bridge on the new carriageway.	Minor	Possible	Low
SW1B	Construction activities for new or extended Significant crossings on Allanvale Creek (Ch.12000, WB326), Concongella Creek (Ch. 16000, WB329), and Robinsons Creek (Ch. 16200, WB 331) resulting in disturbance of channel planform, geometry and river health values.	Local destabilisation of >100 m of waterway banks, channel profile and pools. Reduction in aquatic and terrestrial habitat value in the vicinity of the crossing location.	Reinstatement of waterway in accordance with WCMA requirements (channel profile, floodplain revegetation); avoid unnecessary work in channel.	Moderate	Likely	High	Partial realignment of waterway to limit the length of waterway beneath carriageways or construction of longer bridge spans to protect the existing waterway bed and banks.	Minor	Possible	Low

Risk No.	Impact Pathway Description (how the project interacts with assets, values and uses)	Description of consequences	Planned Controls to Manage Risk (as per Project Description, and VicRoads Contract Shell DC1: Design & Construct (April 2012)).	Initial Risk			Additional Controls Recommended to Reduce Risk	Residual Risk		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
SW1C	Construction activities on other Significant crossings of Concongella Creek and tributaries (Ch. 4400, WB 312), (Ch 6450, WB 320), (Ch 6750, WC 321), (Ch. 9100, WB 324), (Ch. 10550, WB325) and Donald Creek (Ch. 16500, WB 331) resulting in disturbance of channel planform, geometry and river health values.	Local destabilisation of waterway banks, channel profile and pools. Reduction in aquatic and terrestrial habitat value in the vicinity of the crossing location.	Reinstatement of waterway in accordance with WCMA requirements (channel profile, floodplain revegetation); avoid unnecessary work in channel.	Minor	Likely	Medium	Construction of bed control and/or bank protection works to protect vulnerable areas within or adjacent to the work area.	Insignificant	Likely	Low
SW1D	Construction activities on side roads at (SR6100, WC 319), Concongella Creek (SR12150, WB327), (SR15400, WB328) and Pleasant Creek (SR21700, WB339) resulting in disturbance of channel planform, geometry and/or river health values.	Local disturbance to waterway banks (minor change to existing structure), channel profile and pools. Reduction in aquatic and terrestrial habitat value in the vicinity of the crossing location	Reinstatement of waterway in accordance with WCMA requirements (channel profile, floodplain revegetation); avoid unnecessary work in channel.	Insignificant	Possible	Low	.	Insignificant	Possible	Low
SW1E	Construction activities on all other Minor waterways resulting in disturbance of channel planform, geometry and/or river health values.	Local disturbance or destabilisation of waterway banks and channel profile. Reduction in aquatic and terrestrial habitat value in the vicinity of the crossing location.	Reinstatement of waterway in accordance with WCMA and GHCMA requirements (channel profile, floodplain revegetation); avoid unnecessary work in channel.	Insignificant	Possible	Low		Insignificant	Possible	Low
SW2A	Construction of the Western Highway at **new** crossing locations results in the change in the hydraulic conditions and geomorphologic response at crossing locations.	Increased erosion potential downstream/increase sedimentation upstream due to the constriction of flow through a culvert or beneath a bridge.	Appropriate design standards (e.g. adequately sized culverts, rock protection to stabilise waterway bed and banks at the crossing location if required).	Moderate	Possible	Medium	Construction of oversized culvert crossings and/or limit disturbance to existing creek bed (i.e. impose bridge span crossing to minimise change to the existing waterway)	Minor	Possible	Low

Risk No.	Impact Pathway Description (how the project interacts with assets, values and uses)	Description of consequences	Planned Controls to Manage Risk (as per Project Description, and VicRoads Contract Shell DC1: Design & Construct (April 2012)).	Initial Risk: Consequence	Initial Risk: Likelihood	Initial Risk: Risk Rating	Additional Controls Recommended to Reduce Risk	Residual Risk: Consequence	Residual Risk: Likelihood	Residual Risk: Risk Rating
SW2B	Construction of the Western Highway at **existing** crossing locations results in the change in the hydraulic conditions and geomorphologic response at crossing locations.	Some increased erosion potential downstream/increase sedimentation upstream due to the constriction of flow through a culvert or beneath a bridge (limited impact given existing crossing) .	Appropriate design standards (e.g. adequately sized culverts, rock protection to stabilise waterway bed and banks at the crossing location if required).	Minor	Possible	Low		Minor	Possible	Low
SW3A	Construction of the Western Highway at **new** crossing locations results in fragmentation of river health values at crossing locations.	Restrictions to aquatic and terrestrial fauna movement, impediments to future waterway and catchment rehabilitation efforts.	Appropriate design standards (e.g. culvert sized appropriately and set at bed level of waterway or span bridge where required,	Moderate	Possible	Medium	Include additional design control features such as adequate light penetration to encourage fish passage or impose construction of longer bridge spans to protect the existing waterway	Minor	Possible	Low
SW3B	Construction of the Western Highway at **existing** crossing locations results in fragmentation of river health values at crossing locations.	Restrictions to aquatic and terrestrial fauna movement, impediments to future waterway and catchment rehabilitation efforts (limited impact given existing crossing).	Appropriate design standards (e.g. culvert sized appropriately and set at bed level of waterway or span bridge where required	Minor	Possible	Low		Minor	Possible	Low
SW4A	Construction activities result in increased sediment and contaminant loadings to all Significant waterways.	Degradation of water quality in receiving waterways, impact on aquatic ecosystems.	Implement Erosion and Sediment Control Measures and SEPP requirements for receiving waterways through an EMP, including but not limited to: minimising the amount of exposed erodible surfaces, installation of erosion and sedimentation control, prompt covering of exposed surfaces, progressive revegetation of the site, management of stockpiles and co-ordination to avoid works near watercourses.	Minor	Possible	Low		Minor	Possible	Low

Risk No.	Impact Pathway Description (how the project interacts with assets, values and uses)	Description of consequences	Planned Controls to Manage Risk (as per Project Description, and VicRoads Contract Shell DC1: Design & Construct (April 2012)).	Initial Risk Consequence	Initial Risk Likelihood	Initial Risk Risk Rating	Additional Controls Recommended to Reduce Risk	Residual Risk Consequence	Residual Risk Likelihood	Residual Risk Risk Rating
SW4B	Construction activities result in increased sediment and contaminant loadings to all other (Minor) waterways.	Degradation of water quality in receiving waterways, impact on aquatic ecosystems.	Implement Erosion and Sediment Control Measures and SEPP requirements for receiving waterways through an EMP, including but not limited to: minimising the amount of exposed erodible surfaces, installation of erosion and sedimentation control, prompt covering of exposed surfaces, progressive revegetation of the site, management of stockpiles and co-ordination to avoid works near watercourses.	Insignificant	Possible	Negligible		Insignificant	Possible	Negligible
SW5A	Operation of the Western Highway road surface results in increased stormwater, sediment and contaminant loadings to all Significant waterways.	Increase in quantity of stormwater runoff compared to the existing flow regime. Degradation of water quality in receiving waterways, impact on aquatic ecosystems.	Water Sensitive Road Design measures would be evaluated for inclusion in the detailed design phase, as described in VicRoads Integrated Water Management Guidelines (August 2011), and at a minimum best practice pollution reduction targets would be achieved for the additional road surface compared to the existing road surface footprint..	Minor	Possible	Low		Minor	Possible	Low
SW5B	Operation of the Western Highway road surface results in increased stormwater, sediment and contaminant loadings to all other waterways.	Increase in quantity of stormwater runoff compared to the existing flow regime. Degradation of water quality in receiving waterways, impact on aquatic ecosystems.	Water Sensitive Road Design measures would be evaluated for inclusion in the detailed design phase, as described in VicRoads Integrated Water Management Guidelines (August 2011), and at a minimum best practice pollution reduction targets would be achieved for the additional road surface compared to the existing road surface footprint.	Insignificant	Possible	Negligible		Insignificant	Possible	Negligible

Risk No.	Impact Pathway Description (how the project interacts with assets, values and uses)	Description of consequences	Planned Controls to Manage Risk (as per Project Description, and VicRoads Contract Shell DC1: Design & Construct (April 2012)).	Initial Risk			Additional Controls Recommended to Reduce Risk	Residual Risk		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
SW6A	Construction of the Western Highway results in changes to the floodplain characteristics and flooding characteristics in the township of Great Western from Concongella Creek and tributaries	Increased afflux and extent of upstream flooding and/or redistribution of flows results in medium increase in flooding at a township scale.	Appropriate design standards to achieve highway flood risk requirements (e.g. adequately sized culverts or bridge spans where required).	Major	Possible	High	Further hydraulic modelling would need to be undertaken during the detailed design phase to minimise the risk of increased flooding, and to demonstrate that the flood risk has been satisfactorily mitigated.	Moderate	Possible	Medium
SW6B-1	Construction of the Western Highway results in changes to the floodplain characteristics for Concongella Creek and tributaries where rural properties are impacted	Increased afflux and extent of upstream flooding and/or redistribution of flows or local drainage results in a medium increase in flooding at a rural scale	Appropriate design standards to achieve highway flood risk requirements (e.g. adequately sized culverts or bridge spans where required).	Moderate	Possible	Medium	Further hydraulic modelling would need to be undertaken during the detailed design phase to minimise the risk of increased flooding. Note: meeting requirements for individual crossings may have implications for SW6A.	Minor	Unlikely	Low
SW6B-2	Construction of the Western Highway results in changes to the floodplain characteristics for Concongella Creek and tributaries (where no rural properties are impacted)	Increased afflux and extent of upstream flooding and/or redistribution of flows or local drainage results in a slight increase in flooding at a rural scale.	Appropriate design standards to achieve highway flood risk requirements (e.g. adequately sized culverts or bridge spans where required).	Minor	Possible	Low	Further hydraulic modelling would need to be undertaken during the detailed design phase to minimise the risk of increased flooding. Note: meeting requirements for individual crossings may have implications for SW6A.	Insignificant	Unlikely	Negligible
SW6C	Construction of the Western Highway results in changes to the floodplain characteristics for all other waterways.	Increased afflux and extent of upstream flooding and/or redistribution of flows or local drainage results in a slight increase in flooding at a rural scale.	Appropriate design standards to achieve highway flood risk requirements (e.g. adequately sized culverts or bridge spans where required).	Insignificant	Unlikely	Negligible		Insignificant	Unlikely	Negligible

6.6.4 Discussion on Risk Ratings

The following section documents the assigning of risk ratings to the pathways identified in Table 22. As mentioned previously, any works near to a designated waterway or any works resulting in direct connections to the waterway for drainage purposes would require approval by the relevant CMA. A number of the risks identified below would need to be addressed in works on waterway applications under the *Water Act 1989*.

Construction activities result in disturbance of channel planform, geometry and/or river health values (impact pathway SW1)

For assessment against this impact pathway, the waterways in Section 3 were separated into three groups. The groups related to the value of the reach being crossed and the level of impact expected once the planned controls were taken into account.

The additional controls “Construction of bed control and/or bank protection works to protect vulnerable areas within or adjacent to the work area” was recommended for all waterways as this is a common approach for road and waterway protection even when not specified explicitly in contract documents or CMA requirements. This control helped to reduce residual risks in all groups.

The main risk expected from this pathway is at the crossing of Concongella Creek at Armstrong (Ch. 8200). At this location a carriageway would be built overlying 140 m of the creek, necessitating the realignment of the creek through the adjacent paddock. The section of creek to be relocated has established vegetation and instream features such as large woody debris, riffles and persistent pools. Detailed design of the realigned section would be required for installation of bed control structures, bank stabilisation, revegetation and recreation of natural features such as pool and riffle sequences. With appropriate detailed design as per the additional controls, the consequence of this impact can be mitigated from moderate to minor. The likelihood remains almost certain. WCMA may require some form of offset for the realignment of this creek.

The crossing of Allanvale Creek (Ch. 12000) was also separately assessed due to the skewed angle at which the crossing is proposed. The presence of an interchange in the Allanvale Creek floodplain further threatens river health values at this location. Partial realignment of the waterway and/or increased bridge spans would be required to mitigate the risk from minor to insignificant.

Several other waterways showed signs of active erosion in the vicinity of the proposed crossings. These waterways were grouped together as they would require extra attention to bed and/or bank erosion control works in order to mitigate likelihood of worsening erosion from almost certain to possible (in the case of freeway crossings) and from possible to unlikely (in the case of side road / ramp crossings).

A summary of the specific impacts to significant waterways associated with the proposed Western Highway Project is provided in Table 23.

Table 23 Key Waterway Impacts of the "significant" waterways

Waterway Crossing	Waterway (Status)	Description of Impact	Consequence Rating
WB312	Concongella Creek (Significant)	Minor skewed crossing of significant waterway and tributary, <200 m footprint disturbed - managed as discrete crossings for each carriageway	Minor
WA323	Concongella Creek (Significant)	>100 m of significant waterway (with good habitat and river health values) directly impacted by the footprint of the project	Moderate
WB324	Concongella Creek (Significant)	Skewed crossing of significant waterway, <200 m footprint disturbed - managed as discrete crossings for each carriageway or realignment of channel	Minor
WB325	Concongella Creek (Significant)	Perpendicular crossing (extension of existing crossing) in significant channel (actively eroding u/s)	Minor
WB326	Allanvale Creek (Significant)	New Highway crossing location of skewed channel alignment of Allanvale Creek	Moderate
WB327	Concongella Creek (Significant)	No disturbance to existing crossing or main creek channel from the footprint of the interchange arrangement	Insignificant
WB328	Concongella Creek (Significant)	Minor disturbance of access road - limited change	Insignificant
WB329	Concongella Creek (Significant)	New crossing - Perpendicular alignment of Concongella Creek (significant waterway)	Moderate
WB330	Robinsons Creek (Significant))	Perpendicular, lengthy extension (due to realigned segment of highway merging with existing highway) of existing crossing of significant waterway	Moderate
WB331	Donald Creek (Significant)	Skewed crossing of disturbed waterway, <200 m footprint disturbed - managed as discrete crossings for each carriageway	Minor
WB339	Pleasant Creek (Significant)	No direct crossing (creek alignment parallel) - some local catchment connections not recognised as designated waterways	Insignificant

Typically, where the consequence rating is minor, through application of waterway management works to the CMA requirements within the existing footprint of the channel, the risks can be managed to low. Where the consequence is moderate, this is due to higher value waterways being affected and/or the need for more significant waterway management works such as diversions. These would require more specific works to be developed to meet waterway and river health objectives subject to the CMA requirements.

Construction of the Project results in the reduction in the hydraulic capacity at crossing locations on waterways (impact pathway SW2)

Where flow is concentrated through a culvert or a bridge there is increased erosion potential. As flow constrictions (culvert or bridge) already exist at each waterway crossing, a low residual risk rating for all waterway crossings has been assigned.

If, during detailed design, it is determined that erosion and incision of the waterway through the concentration of flow is an issue then additional culvert capacity or open span bridge could be considered to reduce the risk associated with the concentration of flows through the road embankment. Consideration could also be given to energy dissipation, such as rock beaching, downstream of the culverts.

Construction of the Project results in fragmentation of river health values in the local catchment (impact pathway SW3)

For named waterways the bridges would be designed so that the piers are not placed in the low flow channel of the creek bed. At the minor waterway crossings, where culverts are intended, the culverts would be placed at or slightly below the bed level, therefore minimising the fragmentation of the waterway. The ephemeral nature of many of the waterways implies there are natural stream flow barriers to aquatic movement through a number of the catchments already. As a result, a low residual risk rating has been assigned.

Construction activities result in increased sediment and contaminant loading to waterways (impact pathway SW4)

The Construction Environmental Management Plan (CEMP) would include sediment control measures such as silt fences and sediment traps and the contractor would need to demonstrate competence and suitable experience in environmental management in a construction environment. Relevant personnel may be required to have successfully completed a nationally accredited training course which addresses management practices for erosion and sediment control.

Due to the presence of deep permanent pools at Concongella Creek at Armstrong (Ch. 8200) an additional mitigation measure is proposed; increasing the design standard for erosion control measures from 1 in 2 year ARI to 1 in 10 year ARI reduces the residual risk rating to low.

A low residual risk rating has been assigned for all other named waterway crossings as their habitat quality is lower in the vicinity of the proposed works. A negligible residual risk rating has been assigned to all remaining waterways as they have little or no quality habitat in the vicinity of the proposed works.

Construction of the additional road surface results in increased stormwater runoff to waterways (impact pathway SW5)

The road area generating surface runoff to each of the waterways is generally less than 1% of the total catchment area upstream of the discharge location. In the case of a number of very small catchments (less than 10 ha) this proportion could be as high as 5%, however these small catchments are generally highly modified with dams, unfenced grazing access etc. The proportional increase in stormwater runoff from the construction would be relatively small. The peak flows from the road would be expected to coincide with the rising arm of the main catchment hydrograph (rather than the peak) and therefore the magnitude of the peak flow events would not increase.

In addition, Water Sensitive Road Design measures would be evaluated for inclusion in the detailed design and SEPP (WoV) water quality objectives would be required to be met. On this basis, a low residual risk rating has been assigned for Concongella Creek at Armstrong (Ch. 8200) where deep pools persist and a negligible residual risk rating has been assigned to all other waterways.

Construction of the Project results in changes to the floodplain characteristics of waterways (impact pathway SW6)

A summary of the specific potential flooding impacts associated with the proposed Western Highway Project alignment is provided in Table 24.

Table 24 Specific Potential Flooding Impacts associated with the proposed Western Highway Project

Waterway Crossing	Waterway	Description of Potential Impact	Consequence Rating
Great Western Township (all Significant crossings as a whole system)	Concongella Creek & main tributaries	Great Western township affected by changes to Proposed Highway in the context of the Concongella Creek system as a whole	Major
WB330	Robinsons Creek	Upstream property affected	Moderate
WB325	Concongella Creek	Upstream property affected	Moderate
All other Significant Crossings	Concongella Creek & main tributaries	No identified properties affected at specific locations	Minor
All minor crossings	Concongella Creek tributaries, Pleasant Creek tributaries	Local impacts can be readily managed – No properties identified upstream	Insignificant

The potential impacts of the Project on Great Western are considered “Major”, and combined with the “possible” likelihood leads to a high risk. The potential impacts at each crossing vary from “Moderate” (where rural property may be affected) to “Minor” where there are no identified rural properties. Therefore, the assessment has been considered in the context of potential impacts in the township of Great Western in assessing the system as a whole, as well as potential localised impacts to rural properties assessing each crossing individually.

It is noted all other crossing locations were considered to be of insignificant consequence, leading to low risk rating. It is assumed that waterway crossings that provide a minimum flow capacity equivalent to the current crossing would be required. Where the road is a duplication of the existing highway, this is likely to result in slightly larger waterway openings (to account for losses of the extended length of crossings). It is noted all crossing locations would need to be modelled and sized in the development of the detailed design of the Project.

6.7 Benefits and Opportunities

This section identifies key potential benefits or opportunities to surface water that the Project could provide, rates the significance of these, and outlines measures to enhance and capture these benefits.

There is considered to be the following potential benefits:

- **Improvement to waterway condition (*minor to significant benefits at a local level*)** - Following construction works, as part of rehabilitation there would be opportunities to improve waterway condition and ecological health to beyond the current condition. This can be achieved through revegetation and other waterway stabilisation works; and
- **Improvement to local flood conditions (moderate benefit at a regional level) -** There is opportunity for improving flood conditions at specific locations throughout the study area. For example, by reducing upstream flood levels through increasing current waterway openings or reducing downstream impacts (on Great Western for example) by selectively detaining flows upstream of the new highway.

Benefit ratings are described in Table 25.

Table 25 Benefit Ratings

Rating	Potential Project benefits
Very well	Significant benefit to the State Superior benefit to the region Policy consistency with superior positive impact
Well	Moderate benefit to the State Significant befit to the region Superior benefit to the locality Policy consistency with significant positive impact
Moderately well	Moderate benefits to the region Significant benefit to the locality Policy consistency with moderate positive impact
Partial	Minor benefits as a local level or significant benefits for a small number of individuals
Negligible	Minimal benefit at any level

7. Mitigation Measures

7.1 Construction

VicRoads would require the construction contractor to develop and implement a Construction Environmental Management Plan (CEMP) for the Project. VicRoads standard environmental protection measures and some additional Project specific controls identified below have been incorporated into the Environmental Management Framework for the Project which is documented in the Project Environment Protection Strategy (PEPS). The PEPS is a VicRoads Document that details the environmental management arrangements for the design, construction and operation of the Project. VicRoads would require the construction contractor to incorporate all of these measures into the CEMP. Refer to Chapter 21 of the EES for further explanation of the environmental management framework and documentation proposed for the project

The VicRoads standard environmental protection measures for surface water that would be adopted for this Project include:

- Waters shall be monitored for the parameters identified in Table 1200.041 during all stages of construction to ensure that the water quality in the receiving waters:
  - does not deteriorate between the upstream and downstream limits of the work site during the construction period (where upstream results become the background limits); or
  - is as agreed between the Contractor, the Superintendent and EPA.
- The Contractor shall provide and maintain equipment capable of providing instantaneous monitoring of parameters as required in Table 1200.041 and have such equipment available on-site at all times. All equipment associated with monitoring shall be maintained and calibrated in accordance with the manufacturer's or equipment supplier's requirements.
- Table 1200.041 Construction Monitoring

Parameter	Method
Turbidity (Turb) – NTU	Measure with on-site meter
Electrical Conductivity (EC) – µS/cm	Measure with on-site meter
pH	Measure with on-site meter
Dissolved oxygen (DO) – mg/L	Measure with on-site meter
Temperature (°C)	Measure with on-site meter
Suspended Solids (SS) – mg/L	Measure with on-site meter
Litter (definition, including solid inert waste)	Visual (prevent litter from entering waters and drainage systems)
Oils and Greases	Visual (No visible free oil or greases)

All exposed surfaces shall be free of erosion.

Soil conservation measures shall include but are not limited to:

- minimising the amount of exposed erodable surfaces during construction - this may include staging of works;
- installation and maintenance of erosion and sedimentation controls, established in accordance with EPA best practice guidelines for the treatment of sediment laden run-off resulting from construction activities;
- prompt temporary and/or permanent progressive revegetation of the Site as work proceeds;
- installation and maintenance of catch drains to divert and segregate water runoff from catchments outside the construction site from water exposed to the construction site and to adequately control and route runoff within the construction site to the appropriate sedimentation control installation;
- treatment of open drains to prevent erosion before adjacent ground is disturbed and excavation is commenced;
- prompt covering of exposed surfaces (including batters and stockpiles) that would otherwise remain bare for more than 28 days - cover may include mulch, erosion control mat or seeding with sterile grass;
- minimising the timing between clearing and stripping of the Site and covering of erodable surfaces; and
- where trees are required to be removed more than two months in advance of any construction works, remove only that part of the tree that is above ground level and where possible allow the roots to remain intact beneath the ground surface to assist with erosion control.

- Works shall be programmed and managed so as to avoid work in waters. Where work in waters is unavoidable, procedures shall be developed and implemented to satisfy the requirements of this Clause 1200 and as required by any permits from the responsible authority(s).
- Where construction activities are undertaken in, near or over waters, Environmental Management Plan(s) shall be prepared to protect beneficial uses in accordance with any permit, the State Environment Protection Policy (Waters of Victoria), its schedules and best practice guidelines.
- Sedimentation basins shall be modelled and sized to manage rainfall intensities and soil characteristics specific to the region shall be used. The sizing and modelling of sedimentation basin(s) shall consider the expected works and associated area of disturbance within catchment areas(s) within the site.
- The sizing and modelling of temporary sedimentation basins shall be undertaken utilising recognised ‘best practice’ modelling techniques or by utilising ‘VicRoads Temporary Sedimentation Basin Design Tool’.
- Spillways or bypass systems (installations that divert all clean surface flows around a works site) shall be designed for an event having an Average Recurrence Interval of 5 years.
- Sedimentation basins shall be cleaned out whenever the accumulated sediment has reduced the capacity of the basin by 30 percent or more, or whenever the sediment has built up to a point where it is less than 500 mm below the spillway crest, whichever occurs earlier.
- The waterway at bridge and culvert structures shall be sufficient to prevent scour and to limit afflux to not exceed the pre-existing afflux conditions.
- Existing drainage catchments and flow patterns shall be maintained where practicable and drainage flows shall not cause damage or nuisance to landowner’s access, facilities and/or properties

including crown land. The Contractor shall not permit re-direction, concentration or diversion of drainage flows for the Works except with the written consent of the responsible drainage authority and any other affected parties.

- Drainage systems including culverts, drainage networks, kerb and channel and open drains shall cater for the design storm event (1 in 100 year ARI) and shall have sufficient capacity to accommodate the design drainage flow in accordance with the drainage condition requirements and without causing damage or nuisance to landowner's access, facilities and/or properties including crown land.
- Ground surfaces upstream and downstream of drainage structures, bridge and culvert structures including spillways inlets, outlets, and including swales, open drains and watercourse, WSRD elements and water treatment structures shall be protected from scour. Appropriate measures shall be in place to prevent scour for flows of not less than the design drainage flow. Such measures shall include, but are not limited to, beaching, provision of rip rap, erosion matting and control of flow velocities as appropriate.
- The Contractor shall design and construct water quality treatment measures to collect and treat runoff from all pavement areas to the required levels prior to discharging into surrounding drainage networks and / or waterways.
- Stormwater runoff from the road pavement discharged both directly and indirectly into any surrounding waterways and /or drainage network, shall meet the water quality performance criteria requirements of the State Environmental Protection Policy (Waters of Victoria) 2003, Australian Runoff Quality Guidelines, this Specification and requirements of any relevant authority.
- The Contractor shall undertake the Works in such a manner that the completed Works do not have a detrimental impact on the beneficial uses of the waterways as defined in the State Environmental Protection Policy, WSUD Engineering Procedures: Stormwater and the Australian Runoff Quality Guidelines.
- The following treatment objectives, in terms of pollutant load reductions for storm water runoff shall be achieved:
  - Suspended Solids 80% retention of the typical urban annual load;
  - Total Phosphorus 45% retention of the typical urban annual load;
  - Total Nitrogen 45% retention of the typical urban annual load; and
  - Litter 70% retention of the typical urban annual load.

Additional, Project specific controls are also proposed to reduce risks to surface water include:

- Compliance with all requirements of the relevant waterway manager, being either Wimmera CMA or Glenelg Hopkins CMA.
- Realignment of waterway where required to maintain hydraulic capacity and allow appropriate reinstatement of waterway values. Associated works could include bed control structures, bank stabilisation using a combination of rock, vegetation and biodegradable erosion matting, creation of meanders, reintroduction of large woody debris and creation of pool and riffle arrangements.
- Construction of bridge spans longer than required for flow conveyance in order to bridge areas of high river health value.
- Construction of bank and/or bank protection works using a combination of rock, vegetation and biodegradable erosion control matting to protect vulnerable areas within or adjacent to the work area.

- Increasing the design standard for temporary erosion control measures such as sediment ponds from 1 in 2 year ARI to 1 in 10 year ARI.
- Compensation works for loss of flood plain storage where required due to a risk of increasing flood levels.
- Where a waterway has the potential to offer passage of aquatic fauna the road crossing would be designed in a manner that would not discourage fauna passage.

7.2 Operation

During operation VicRoads would comply with Water Sensitive Road Design practices, including regular maintenance of design features intended to capture and treat stormwater run-off from the road. VicRoads would also regularly maintain all culverts and bridge openings ensuring that they remain free of debris and other blockages and can adequately pass their design flows.

7.3 Reducing Water River Health Impacts

Where significant aquatic values are potentially disturbed at new crossing locations, large span bridge structures may be imposed to minimise any disturbance within the waterway footprint. It is assumed at crossing Ch. 12000 (Allanvale Creek) and Ch. 16000 (Concongella Creek) for the new highway alignment, the type of bridge crossing imposed would be a large span bridge structure.

Also, where diversions of significant lengths of waterways are required, further investigations are required to be undertaken to develop a design concept for the realignment of the creek which would form part of the works on waterway application to the CMA's. In particular, crossing at Ch. 8200 would require a detailed concept plan.

The concept plan would include consideration of the following:

- Natural channel design in terms of planform and shape;
- Stable longitudinal gradients with possible grade control structures;
- Varying bank slopes to a maximum of 1:3;
- Additional protection of bank toes at bends;
- Vegetated and protected banks with appropriate species selection;
- Creation of habitat values (e.g. placement of pools and riffles); and
- Include planting of trees to provide shading and habitat benefit.

7.4 Reducing Flood Risk

The initial impact assessment and risk assessment (documented in Section 6) was based on interpreting the proposed design alignment with respect to the existing conditions flood modelling outputs. In this process the potential impacts of the Project were identified without being modelled. The impacts were considered assuming the proposed road notionally meets flood criteria of not overtopping the road in the 100 year flood conditions.

To better understand the magnitude of the impacts there was need to undertake preliminary hydraulic modelling representing the proposed road conditions. The potential change in flood conditions was interpreted in order to estimate preliminary waterway opening requirements for the proposed highway.

To meet the required flood criteria with proposed road gradelines and crossing configurations there is a significant change to interaction of the proposed highway and the floodplain, with the potential change to the floodplain characteristics (i.e. flood storage, timing of peak flows and distribution of flows) that may impact downstream environments including the township of Great Western. The complex interaction of Concongella Creek with the Western Highway and change in conditions due to the proposed highway was modelled to assess the impacts and determine preliminary crossing configurations. Iterative modelling analysis was undertaken by UWCS/TGM (2012) with the intent of providing sufficient information to enable an assessment of flooding impacts (and potential benefits).

Therefore additional preliminary modelling was undertaken to assess:

- Whether the following flood criteria can be readily met
    - 100 year Flood free road; and
    - Zero afflux at crossing locations (to rural properties)
- The potential impacts in Great Western of meeting the flood criteria (Iteration 2A)
- The potential to mitigate the impacts in Great Western (Iteration 2B)

Subsequently the following proposed condition iterations (as modelling scenarios) were defined to be modelled to assess the potential impacts in more detail.

- Iteration 2A – Representation of the proposed alignment and gradeline to demonstrate no overtopping of new road and minimise upstream afflux at each crossing (in accordance with VicRoads design requirements); and
- Iteration 2B – Sensitivity modelling scenario to test the potential to reduce flood peaks/flood levels through Great Western by restricting openings at selective locations (ignoring the VicRoads afflux criteria)

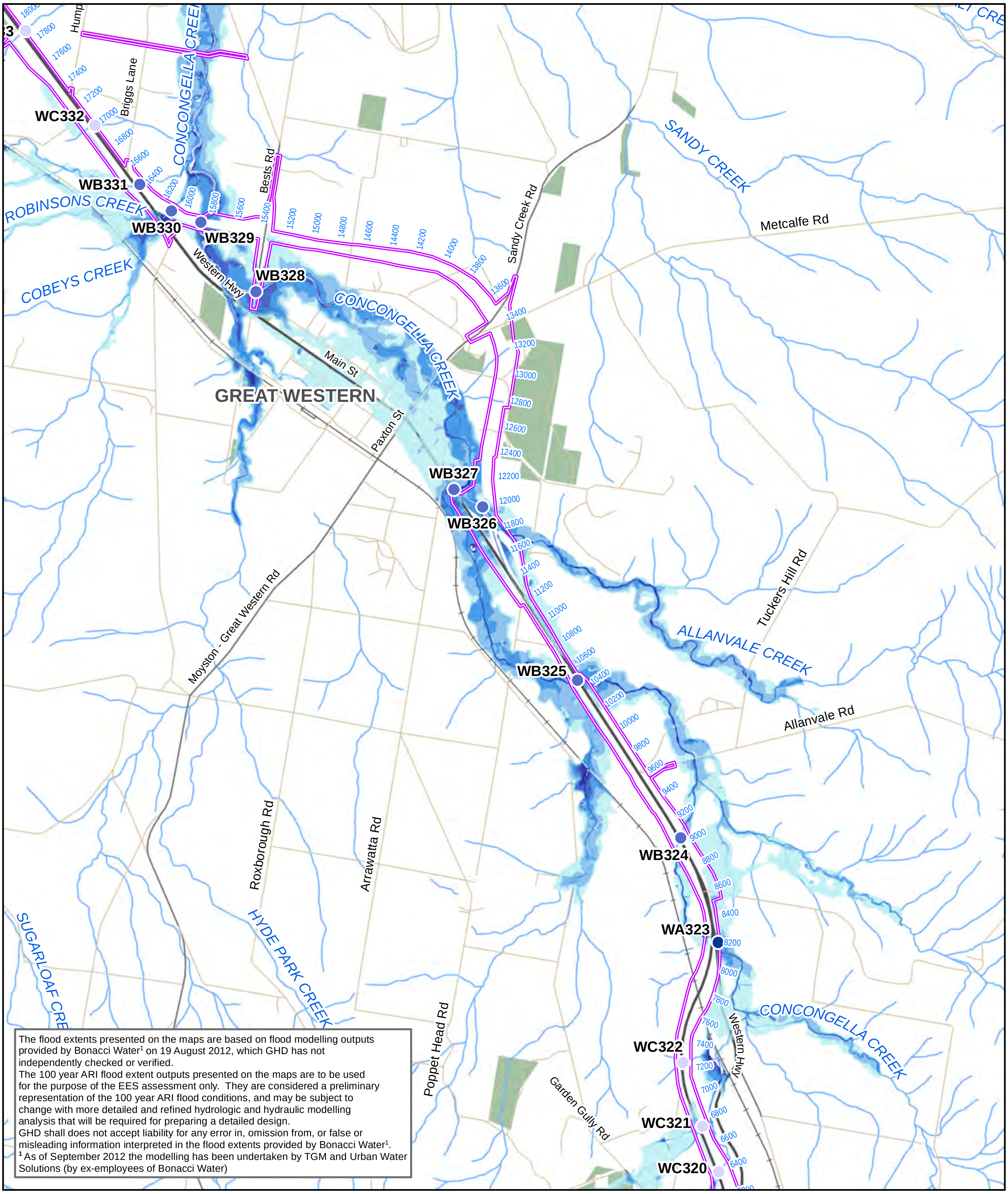
The results of this preliminary modelling assessment are documented in a memo from TGM dated September 2012 provided in Appendix F, and the interpretation of the modelling scenarios are discussed briefly below.

7.4.1 Iteration 2A

The intent of Iteration 2A was to represent the proposed alignment and gradeline (with waterway opening sized to demonstrate no overtopping of new road and minimise upstream afflux at each crossing), as well as understand the potential implications in Great Western township.

The additional and modified waterway crossing openings for Iteration 2A are summarised in Table F1 in Appendix F.

The flood modelling outputs of this scenario were provided by UWCS/Bonacci, and allowed for comparative assessment of the 1 in 100 year flood extent and flood depth/levels (afflux), Whilst there were some unresolved anomalies in the modelling, from the information we were able to interpret the relative impacts through the Great Western township and for rural properties. The flood extent for Iteration 2A is presented in Figure 27.



The flood extents presented on the maps are based on flood modelling outputs provided by Bonacci Water[1] on 19 August 2012, which GHD has not independently checked or verified.
The 100 year ARI flood extent outputs presented on the maps are to be used for the purpose of the EES assessment only. They are considered a preliminary representation of the 100 year ARI flood conditions, and may be subject to change with more detailed and refined hydrologic and hydraulic modelling analysis that will be required for preparing a detailed design.
GHD shall does not accept liability for any error in, omission from, or false or misleading information interpreted in the flood extents provided by Bonacci Water[1].
[1] As of September 2012 the modelling has been undertaken by TGM and Urban Water Solutions (by ex-employees of Bonacci Water)

LEGEND

100yr Modelled Flood Depth (m)		Waterway Crossings		
0 - 0.6	1.3 - 1.8	Minor	Maximum Construction Footprint	Major water area
0.61 - 1.2	1.9 - 2.4	Moderate	Highway	Stream
	2.5 - 3	Major	Sealed road (arterial & local)	Connector
			Unsealed road	Parks

Paper Size A4
0 250 500 1,000 1,500
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

CLIENTS | PEOPLE | PERFORMANCE

VicRoads
Western Highway Project

Ararat to Stawell
Iteration 2A Flood Extent

Job Number 31-27558
Revision D
Date 21 Nov 2012

Figure 27

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com
G:\31\27558\GIS\Maps\Deliverables\Stage 3\RISK AND IMPACT ASSESSMENT\06_SURFACE_WATER\3127558_S3_009_Flooding_Extent_A4P_MB_Iteration2A_Fig25.mxd

Data source: DSE, VicMap, 2012; VicRoads, 2012; Flooding data: Bonacci, 2012; TGM, 2012. Created by:splaird

In summary, the Preliminary modelling indicates:

- The individual crossing locations on Concongella Creek upstream of Great Western (WB321, WB323, WB324 & WB325) can be designed to achieve minimal afflux and therefore not impact identified rural properties;
- The change to the upstream crossing locations (WB321, WB323, WB324 & WB325) results in minor change to flow distributions and flood levels downstream;
- The change associated with complex interchange arrangement of the proposed highway (near the confluence of Allanvale Creek) appears to be causing the most significant redistribution of flows that may be impacting Great Western. This complex arrangement consists of the following components:
  - New Road Deviation (New Bridge Crossing of Allanvale Creek)
  - New Entry road ramps
  - Exit road based on modifying existing highway gradeline
  - New Service Road
  - Delahoys Road

In conclusion the representation of Iteration 2A results in minor increases in flood level in parts of Great Western that can be attributed to the following:

- Change in upstream crossing configurations leading to minor changes flow distributions and flood levels downstream (relatively minor);
- Change in flow distributions due to the complex interchange configuration immediately upstream of Great Western township (more significant).

7.4.2 Iteration 2B

The intent of Iteration 2B was to test the potential to manage the predicted impacts from Iteration 2A and the potential to reduce flood peaks/flood levels through Great Western by restricting openings at selective locations.

For Iteration 2B, there were two structural changes to the model from Iteration 2A in terms of the restriction of waterway openings at the following locations:

- WB 326 – New crossing of Allanvale Creek (to provide attenuation by restricting flow through the crossing of the New Road Deviation)
- WB 325 – Modify crossing of Concongella Creek (to restrict flow downstream)

Whilst there were some unresolved anomalies in the modelling, the information provides an indication of the how the impacts through the Great Western township can be managed. From the interpretation of the results, it can be concluded that the impacts in Great Western can be managed via a combination of the following in the design of the proposed road:

- Design of the complex interchange arrangement and allowance of waterway openings so that there is minimal redistribution of Concongella Creek flows;
- Design of the new crossing of Allanvale Creek (as part of this complex interchange) to provide some attenuation (subject to not impacting upstream rural properties)
- Design of attenuation at select crossing locations upstream (If required)

From the preliminary modelling, the extent of upstream attenuation and the specific locations for attenuation were not able to be confirmed as further assessment was required. However the modelling has confirmed that the impacts can be managed through these means as described above.

7.4.3 Detailed Modelling Approach

The preliminary modelling as described above is considered sufficient for undertaking the impact assessment, however it is not sufficient for determining detail design components required to manage predicted impacts.

The preliminary modelling has indicated that in meeting the typical design criteria, there are slight increases in flood level in parts of Great Western. The preliminary modelling has also indicated that the slight impacts could be managed. The current preliminary modelling is useful for determining relative impacts but is not suitable for informing the detail design of the proposed alignment or waterway crossing configurations. Further modelling is required to determine the extent and nature for flood mitigation measures and their exact location. The selection of appropriate waterway openings/culvert sizing for the whole system needs to be based on more detailed flood modelling. VicRoads intends to undertake more detailed hydraulic assessments at the waterway crossings to inform detailed design of the Project.

The approach to the detailed flood modelling investigation and design would involve the following:

- *Survey and baseline information* -Detailed survey of the road level, waterway crossings and the floor levels of houses in potentially affected areas;
- *Model Structure Refinement* - Refine both the hydrologic and hydraulic model structure (as identified in the limitations section and agreed with by Vicroads) in terms of the following:
  - Catchment model to include all subcatchments within the Concongella creek catchment to Concongella Creek at Stawell (Gauge no. 415237), and inclusion of a flood frequency analysis in determining design flows
  - Hydraulic model DTM to incorporate WCMA's most recent LIDAR or other more specific data to represent existing conditions (eg. representation of waterway openings and upstream and downstream waterways)
- *Design Event Modelling (Existing Conditions)* – Undertake rigorous modelling analysis in terms of modelling a range of design event ARI's and durations in the hydraulic model and to determine the flood extent envelope for the 1 in 100 year ARI event.
- *Design Event Modelling (Iterative Analysis with detailed design)* - Further hydraulic assessments of waterway crossings and iterative flood modelling to inform the optimal design of the system as a whole meet the project criteria. This would involve the developing the detailed design of carriageways and waterway crossing configurations, and in particular design of the following:
  - Design of the complex interchange arrangement and allowance of waterway openings so that there is minimal redistribution of Concongella Creek flows;
  - Design of attenuation storage (if required) at select crossing locations upstream of Great Western (e.g. new crossing of Allanvale Creek - subject to not impacting upstream rural properties).
  - Consideration of runoff and the stormwater system within Great Western; and
- *Consultation* - Ongoing consultation with the Catchment Management Authority, local Council and potentially affected landowners.

7.5 Summary

Table 26 presents a summary of the mitigation measures that have been identified to avoid, reduce or minimise the risk of adverse impacts. The measures comprise both relevant requirements of the VicRoads standard environmental protection measures as well as the additional measures identified by this impact assessment. The aim to achieve the relevant EES Objective described in Section 2.

Table 26 Environmental Management Measures

Risk No.	Risk Description	Management Measures	Responsibility
SW1	Construction activities could result in disturbance to channel planform, geometry and river health values.	Reinstatement of waterway in accordance with WCMA requirements (channel profile, floodplain revegetation) and avoid unnecessary works in the channel. Construction of bed control and/or bank protection works to protect vulnerable areas within or adjacent to the work area. Where there are diversions of significant lengths of waterways required, a design concept for the realignment of the creek which would form part of the works on waterway application and be subject to CMA approval. For new crossings this may lead to partial realignment of the waterway to limit the length of waterway beneath carriageways and/or construction of longer bridge spans to protect the existing waterway bed and banks.	Designer Contractor
SW2	Construction of Western Highway results in the change in the hydraulic conditions and geomorphologic response at crossing locations.	Appropriate design standards (e.g. adequately sized culverts, rock protection to stabilise waterway bed and banks at the crossing location if required). Construction of oversized culvert crossings to minimise hydraulic change and/or limit disturbance to existing creek bed (i.e. impose bridge crossing with piers set outside the main flow channel)	Designer

Risk No.	Risk Description	Management Measures	Responsibility
SW3	Restrictions to aquatic and terrestrial fauna movement, impediments to future waterway and catchment rehabilitation efforts.	Where a waterway has the potential to offer passage of aquatic fauna the road crossing would be designed in a manner that would not discourage fauna passage. At a minimum this would involve appropriate design standards (e.g. culvert sized appropriately and set at bed level of waterway where required). Some additional design controls may be imposed to design fauna friendly features such as oversizing culvert, providing adequate light penetration to encourage fish passage where applicable and/or providing artificial features (eg culvert baffles). Alternatively, construction of open bridge spans (with piers located outside of waterway channel riparian zones) may be imposed.	Designer
SW4	Degradation of water quality in receiving waterway and impact on aquatic ecosystem as a result of increased sediment and contaminant loadings during construction of the road.	Implement Erosion and Sediment Control Measures and SEPP requirements for receiving waterways through an EMP, including but not limited to: ◗ Water quality upstream and downstream of works would be monitored. ◗ Soil conservation measures would be employed on site to minimise the amount of sediment mobilised. ◗ Works would be scheduled to avoid working in flowing waterways where possible. ◗ Sediment basins would be designed to 'best practice' standard and sized specifically for each site. ◗ Water quality treatment measures would collect and treat runoff from all pavement areas to the required levels prior to discharging into surrounding drainage networks and / or waterways.	Contractor

Risk No.	Risk Description	Management Measures	Responsibility
SW5	Degradation of water quality in receiving waterway and impact on aquatic ecosystem as a result of increased sediment and contaminant loadings during the operation of the road.	Water Sensitive Road Design measures would be evaluated for inclusion in the detailed design phase, as described in VicRoads Integrated Water Management Guidelines (August 2011), and at a minimum best practice pollution reduction targets achieved for the additional road surface compared to the existing road surface footprint. During operation VicRoads would comply with Water Sensitive Road Design practices, including regular maintenance of design features intended to capture and treat stormwater run-off from the road.	Designer VicRoads
SW6	Increased afflux and extent of upstream flooding and/or redistribution of flows results in an increase in flooding.	Preliminary hydraulic modelling indicated that impacts of flooding in Great Western could be mitigated. Further hydraulic modelling would need to be undertaken during the detailed design phase to confirm the design arrangements of specific crossings and locations of any flood mitigation measures. From the interpretation of the preliminary modelling results, it can be concluded that the impacts in Great Western can be managed via a combination of the following in the design of the proposed road: ◗ Design of the complex interchange arrangement and allowance of waterway openings so that there is minimal redistribution of Concongella Creek flows; ◗ Design of attenuation storage (if required) at select crossing locations upstream of Great Western (e.g. new crossing of Allanvale Creek - subject to not impacting upstream rural properties).	Designer

8. Conclusion

The objective of the surface water assessment was to determine the potential impacts related to surface drainage, water quality, flooding/hydrology, and the conditions and river health values of waterways and floodplains. The waterway crossings in Section 3 include the following main waterways and/or associated unnamed tributaries: Concongella Creek and main tributaries including Allanvale Creek, Robinsons Creek, Donald Creek, and separately Pleasant Creek.

The potential waterway impacts due to construction and operation of the Project were used as a basis for determining the risk pathways in the risk assessment. The key issues are associated with either impacts to river health and water quality of receiving waters or hydraulic impacts to waterways and floodplains:

- River health and water quality – This includes physical disturbance to existing waterways, fragmentation of waterways and water quality impacts; and
- Waterways and floodplain hydraulics – This includes of the Project in terms of the effect of road embankments and waterway crossings on flooding characteristics.

The potential waterway impacts due to construction and operation of the Project were considered under the following six risk pathways for each of the waterway systems:

- Construction activities result in disturbance of channel planform, geometry and/or river health values;
- Construction of Western Highway Project results in change in the hydraulic conditions and geomorphologic response at crossing locations;
- Construction of Western Highway Project results in fragmentation of river health values at crossing location;
- Construction activities result in increased sediment and contaminant loadings within the waterway;
- Operation of the new Western Highway road surface results in increased stormwater, sediment and contaminant loadings to waterway; and
- The construction of the Western Highway Project results in changes to floodplain characteristics of the waterway.

The key outcomes of the impact assessment are summarised below:

River Health - The overall impacts on River Health from the Project to the various waterways is generally low, with exception of the following waterways with site specific impacts from the identified risk pathways:

  - direct disturbance by the footprint of the proposed highway embankment at Concongella Creek at Ch. 8200, as well as disturbance where additional crossings are proposed at new locations on Concongella Creek and Allanvale Creek and the extended crossing of Robinsons Creek;
  - fragmentation of river health values at new crossing location for Concongella Creek and Allanvale Creek; and
  - change in Geomorphological conditions at new crossing locations for Concongella Creek and Allanvale Creek.

For all locations where there are existing crossings of significant waterways (other than Concongella Creek at Ch. 8200 described above) the river health impacts are minor, predominately on the basis of there being an existing crossing already causing a river health impact.

Flooding – The construction of the Western Highway results in changes to the complex flooding characteristics of Concongella Creek and tributaries. The potential impacts at the township of Great Western have been assessed by considering the whole of the Concongella Creek system.

The impact of the Project (where requirements are for a flood free road during 100 year ARI flood conditions) was considered low for the majority of discrete waterway crossing locations. However in consideration of the system as a whole, the potential impacts can be summarised as follows:

- Potential flooding impacts to Great Western township would be Major (given the township scale affected) but can be reduced to Minor subject to detailed flood modelling and detailed design of the road and waterway crossings.
- Potential flooding impacts to rural properties with dwellings at significant crossing locations would be Moderate, but can be reduced to minor subject to detailed flood modelling and detailed design of the road and waterway crossings.
- Potential flooding impacts at rural properties with no dwellings at significant crossing locations are minor.
- Potential impacts to minor waterways crossings were considered to be minor.

All minor crossing locations were considered to be of minor consequence, leading to insignificant risk rating. It is assumed that waterway crossings that provide a minimum flow capacity equivalent to the current crossing would be required. This is likely to result in slightly larger waterway openings (to account for losses of the extended length of crossings).

For the risk assessment it was assumed that standard planning controls (including the VicRoads standard environmental protection measures) were in place. With the application of standard planning control measures, many of the risk items were assigned Low residual risk with the exception of the following risks:

- **Medium -** Construction of the Western Highway in disturbance of channel planform, geometry and/or river health values for Concongella Creek at Ch. 8200 where there is a small reach of significant waterway that is directly disturbed by the footprint of the proposed highway embankment, as well as disturbance where additional crossings are proposed at new locations on Concongella Creek and Allanvale Creek and the extended crossing of Robinsons Creek;
- **Medium** -Construction of the Western Highway results in fragmentation of river health values at new crossing location for Concongella and Allanvale Creeks;
- **Medium** -Construction of the Western Highway results in change in Geomorphological conditions at new crossing locations for Concongella Creek and Allanvale Creek;
- **Major** - The Construction of the Western Highway results in changes to floodplain characteristics to the Concongella Creek system leading to potential flooding impacts (including slight increase in flood levels) to the township of Great Western from the complex interaction of Concongella Creek and tributaries and the proposed highway; and
- **Medium** - The Construction of the Western Highway results in changes to floodplain characteristics to waterways with identified potential impacts to rural properties at Significant crossing locations.

For River Health issues, the above medium risks can be mitigated to acceptable risk levels through a combination of the following mitigation measures:

- Construction of bed control and/or bank protection works associated with crossing works so that vulnerable areas are protected within or adjacent to the work area subject to the requirements of the CMA;
- Develop appropriate crossing design configuration and apply appropriate design standards (e.g. culvert sized appropriately and set at bed level of waterway where required), as well as additional design controls may be imposed to design fauna friendly features such as oversizing culvert, providing adequate light penetration to encourage fish passage where applicable and/or providing artificial features (eg culvert baffles).
- Where significant or major waterways are potentially disturbed or for new crossing locations, large span bridge structures may be imposed with piers set outside of the waterway channel to minimise any disturbance within the waterway footprint; and
- Where diversions of significant lengths of waterways are required, further investigations are required to be undertaken to develop a design concept for the realignment of the creek which would form part of the works on waterway application and be subject to CMA approval.

The Project would provide opportunities to improve existing conditions of waterway reaches within the vicinity of the works, as well as improve existing fragmentation caused by the existing highway by redesigning crossings (eg by redesigning waterway crossings), and the opportunity to provide water quality treatment outcomes that are better than existing conditions.

For the flooding risks, through preliminary sensitivity modelling, it was identified that there is the potential to mitigate the major flood risk through Great Western. Preliminary hydraulic modelling indicated that impacts of flooding in Great Western, including the slight increase in flood levels, could be mitigated through appropriate design of crossings. Further hydraulic modelling would need to be undertaken during the detailed design phase to confirm the design arrangements of specific crossings and locations of any flood mitigation measures. From the interpretation of the preliminary modelling results, it can be concluded that the impacts in Great Western can be managed via a combination of the following key design features of the proposed road:

- Design of the complex interchange arrangement and allowance of waterway openings so that there is minimal redistribution of Concongella Creek flows;
- Design of attenuation storage (if required) at select crossing locations upstream of Great Western (e.g. new crossing of Allanvale Creek - subject to not impacting upstream rural properties).

9. References

EPA Victoria Publications

- Biological Objectives for Rivers and Streams – Ecosystem Protection (March 2004), Information Bulletin – Publication Number 793.2
- Nutrient Objectives for Rivers and Streams – Ecosystem Protection (June 2003), Information Bulletin – Publication Number 792.1
- Water Quality Objectives for Rivers and Streams – Ecosystem Protection (June 2003), Information Bulletin – Publication Number 791.1)

Australian Rainfall & Runoff: A Guide to Flood Estimation (1987), Institute of Engineers, Australia

Catchment Management Authorities

Glenelg Hopkins CMA, 2004, River Health Strategy 2004-2009.

SKM 2002, Upper Wimmera Water Resources Management Plan - Environmental Flow Study, September 2002.

Wimmera CMA, 2007, State of our streams Report, 2007.

Wimmera CMA, 2006, State of our streams, the Wimmera (fact sheet).

Wimmera CMA & EPA Victoria, 2008, The heath of streams in the Wimmera, June 2008.

Wimmera CMA, 2004, Wimmera Regional Catchment Strategy

Wimmera CMA, 2007, Wimmera Waterway Health Strategy.

Wimmera CMA, 2011, Wimmera Wetlands Asset Strategy.

Project Specific Reports

UWCS/TGM 2012, VicRoads Western Highway Duplication Project: Flood Investigation, Projects 320 1203 and 320 1204, Version 4.

UWCS/TGM 2012, VicRoads Western Highway Duplication Project: Flood Investigation of Sector 2 alignments – Summary Report

TGM, 2012, VicRoads Western Highway Duplication Project: Flood Modelling – Section 3 (Iteration 2A & 2B) – Existing Flood Extent vs. Design Flood Extent (Memo provided 18 September 2012).