



## Glenelg River

### Environmental Water Management Plan 2016



Photo: Glenelg River near Harrow

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## Executive summary

The Glenelg River Environmental Water Management Plan (EWMP) sets out objectives for the management of environmental water for priority environmental values of the Glenelg River in the following reaches where environmental water is actively managed:

- **Reach 0 from the headwaters of the Glenelg River to Rocklands Reservoir**
- **Reach 1a from Rocklands Reservoir to the 5-mile outlet**
- **Reach 1b from the 5-mile outlet to the Chetwynd River confluence**
- **Reach 2 from the Chetwynd River confluence to the Wannon River confluence downstream of Casterton.**

The EWMP is an important part of the Victorian Environmental Water Planning Framework. It provides the five to ten year management intentions based on scientific information and stakeholder consultation. The EWMP is used by the Glenelg Hopkins Catchment Management Authority (GHCMA), the Department of Environment, Land, Water and Planning (DELWP), and the Victorian Environmental Water Holder (VEWH) for short and long-term environmental water planning.

### *Catchment context*

The Glenelg River is the largest river in south-west Victoria. Rising in the Grampians National Park it runs for more than 500 km to the Southern Ocean at Nelson and has a catchment area of 12,660 km<sup>2</sup>. The Glenelg River estuary flows through the Lower Glenelg National Park and is a declared a Heritage River under the *Heritage Rivers Act*, 1992. The river supports a wide range of flow dependent environmental values including rare and threatened flora and fauna. This diversity is driven by the range of landforms, climate conditions, connection with the estuary and the largely perennial nature of the river.

The Glenelg River is an integral part of the Wimmera and Glenelg Headworks System with interbasin transfers to the Wimmera occurring from both Moora Moora and Rocklands Reservoirs on the upper Glenelg River (reach 0). The operation of these storages has significantly reduced the volume, duration and magnitude of flows in the Glenelg River and caused significant stress to ecological values. High salinity, low dissolved oxygen and reduced sediment flushing are directly attributable to altered flow regimes.

### *Management focus*

The Glenelg River EWMP informs water delivery to the Glenelg River to support targeted and measurable ecological objectives over a 10 year period. The delivery of these objectives aligns with and contributes to the following management goals of the Glenelg Hopkins Waterways Strategy:

- **Maintain Heritage River values in the Glenelg River**
- **Protect or improve threatened fish populations in the Glenelg River**
- **Maintain or improve waterway dependant species and communities identified as having social or conservation significance**
- **Maintain or improve high value recreational fishing through habitat protection.**

Specific ecological objectives addressed by the EWMP are:

- **to stabilise and increase Glenelg spiny crayfish populations**
- **increase the short-finned eel distribution range to historical extents**
- **increase the tupong distribution range in the freshwater habitat**
- **to stabilise and increase variegated pygmy perch populations**

- **to increase abundance of river blackfish, incorporating integrated river health and watering strategies**
- **to achieve self-sustaining populations of Wimmera bottle brush (two to three recruitment periods in the next 10 years to increase extent and abundance).**

Hydrological requirements to meet these objectives detail the flow components for delivery (as cease to flow, baseflow, freshes, bankful and overbank flows) as well as the period, magnitude, frequency and duration under a range of climatic conditions.

#### *Demonstrating outcomes*

Short-term and long-term intervention monitoring is required to demonstrate that environmental watering regimes are contributing to ecological objectives. Existing long-term monitoring includes fish, water quality, vegetation and physical habitat assessments conducted under the Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) as well as gauged flow and water quality monitoring, stream condition assessments and Judas carp tracking. Current short term monitoring comprises gauged flow and water quality and human observation. In addition to these existing programs the EWMP sets out recommendations for additional short and long term monitoring.

#### *Risks and limitations*

Risks and potential barriers to the delivery of environmental water are assessed and strategies for mitigation detailed. Potential barriers to achieving the ecological objectives as a result of infrastructure or operational constraints are also identified and recommended improvements to reduce the risk documented.

#### *Consultation*

Key stakeholders involved in the development of the Glenelg EWMP include the Glenelg River EWMP Steering Group, Indigenous communities, Angling Clubs, Glenelg Hopkins CMA Advisory Group, Western Region Advisory Group (WRAG) comprising VEWH, Wimmera CMA and GWMWater, DELWP and Parks Victoria.

#### *Knowledge gaps*

The recommendations of the Glenelg EWMP are based on the best available information. A number of knowledge gaps have been identified surrounding the water requirements of the Glenelg estuary and associated wetlands and also reach 0. There is also considerable work to be done to improve understanding of environmental water requirements of individual fish species and the Wimmera River bottlebrush. Knowledge gaps associated with infrastructure include the impacts of the Wannon River diversions and cold water pollution from Rocklands Reservoir. Improving knowledge around management of very low allocations is a priority in light of potential climate change impacts.



## 1 About the plan

The Glenelg River EWMP is a ten-year plan that establishes the long-term environmental water management goals of the Glenelg River system. The Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH) use the EWMP for short and long-term environmental water planning including prioritising water recovery.

The EWMP is informed by scientific information and stakeholder consultation and describes the ecological values present in the river, the priority ecological objectives and recommended flow regime to achieve these objectives.

Environmental flows are crucial for the continued health of the Glenelg River system. Flows deliver ecosystem services through habitat connectivity, maintenance of trophic relationships and provision of essential stimuli for recruitment and development in aquatic faunal and vegetation communities. In addition to environmental benefits, flows support valuable social and economic values for communities along the river and region-wide.

Indicators of successful environmental flow management over the past five years include:

- Recorded numbers of river blackfish (*Gadopsis marmoratus*) have more than doubled (Iervasi, Monk, & Versace, 2015)
- A ten-fold increase in recorded numbers of variegated pygmy perch (*Nannoperca variegata*), listed as critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) (Iervasi, Monk, & Versace, 2015)
- Recorded distribution of estuary perch (*Macquaria colonorum*) extended 130 km upstream from Dartmoor to Harrow (Iervasi, Monk, & Versace, 2015)
- Up to 80% reduction in salinity levels at identified sites threatened by salinity (Department of Environment, Land, Water and Planning, 2015)
- Water for the environment identified as being as important as agricultural use and recreation (Ernst and Young, 2009).
- Water quality improvements may also result in improved growth rates in stock (Aither 2015)



**Photo 1: Glenelg River at Harrow (Photo: Glenelg Hopkins CMA)**

## 1.1 EWMP purpose and scope

The key purposes of the EWMP are to:

- identify long-term objectives and water requirements of high priority values in the Glenelg River as identified in the Glenelg Hopkins Waterways Strategy (GHWS)
- provide a vehicle for community input on long-term objectives and water requirements for the river
- inform the development of seasonal watering proposals and seasonal watering plans.

The scope of this EWMP encompasses the four river reaches where environmental water is actively managed and current flow recommendations exist (see Figure 1):

- Reach 0 from the headwaters of the Glenelg River to Rocklands Reservoir
- Reach 1a from Rocklands Reservoir to the 5-mile outlet
- Reach 1b from the 5-mile outlet to the Chetwynd River confluence
- Reach 2 from the Chetwynd River confluence to the Wannon River confluence downstream of Casterton.

This scope may be expanded to include Reach 3 and the estuary as knowledge increases.

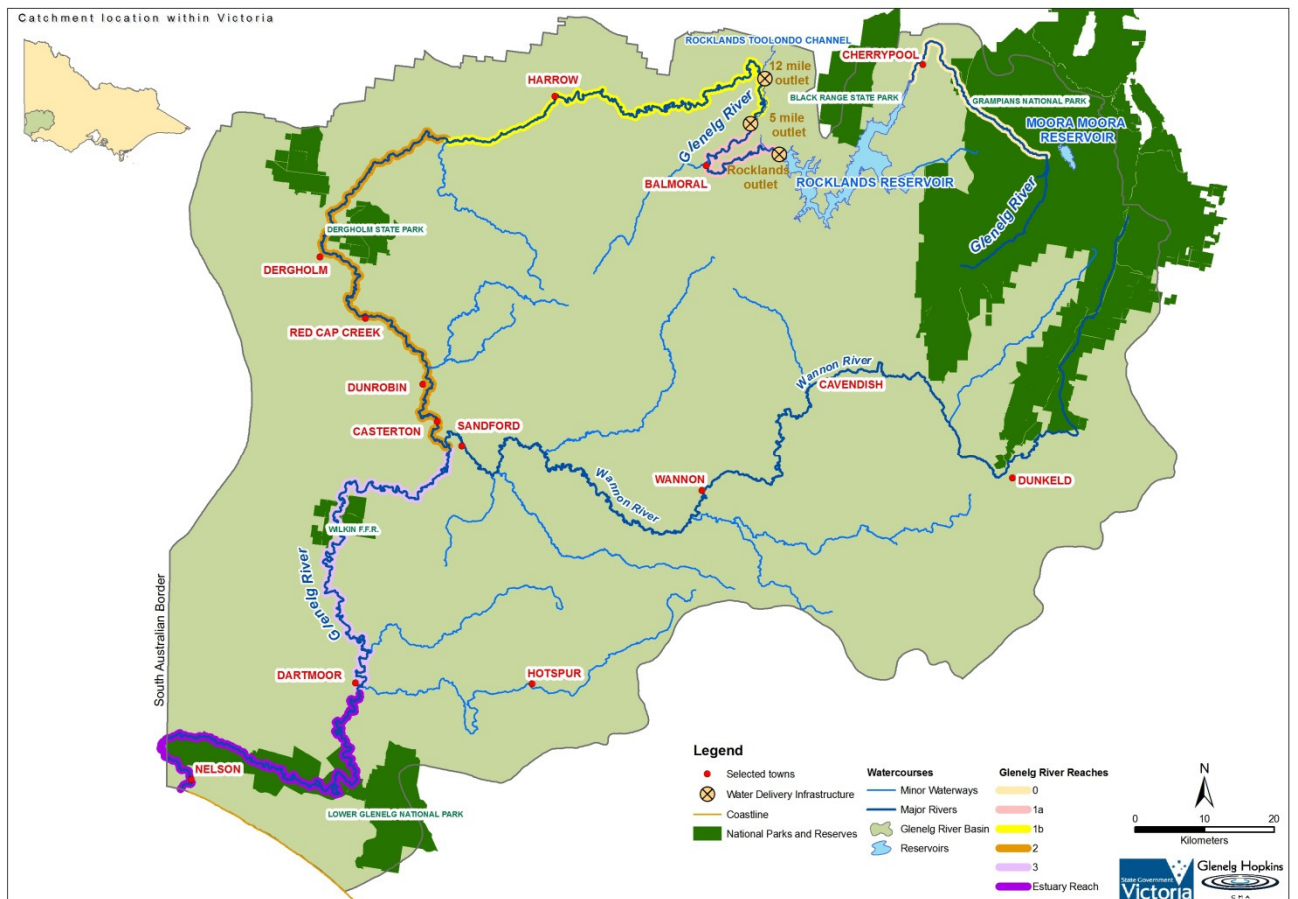


Figure 1: Glenelg River catchment

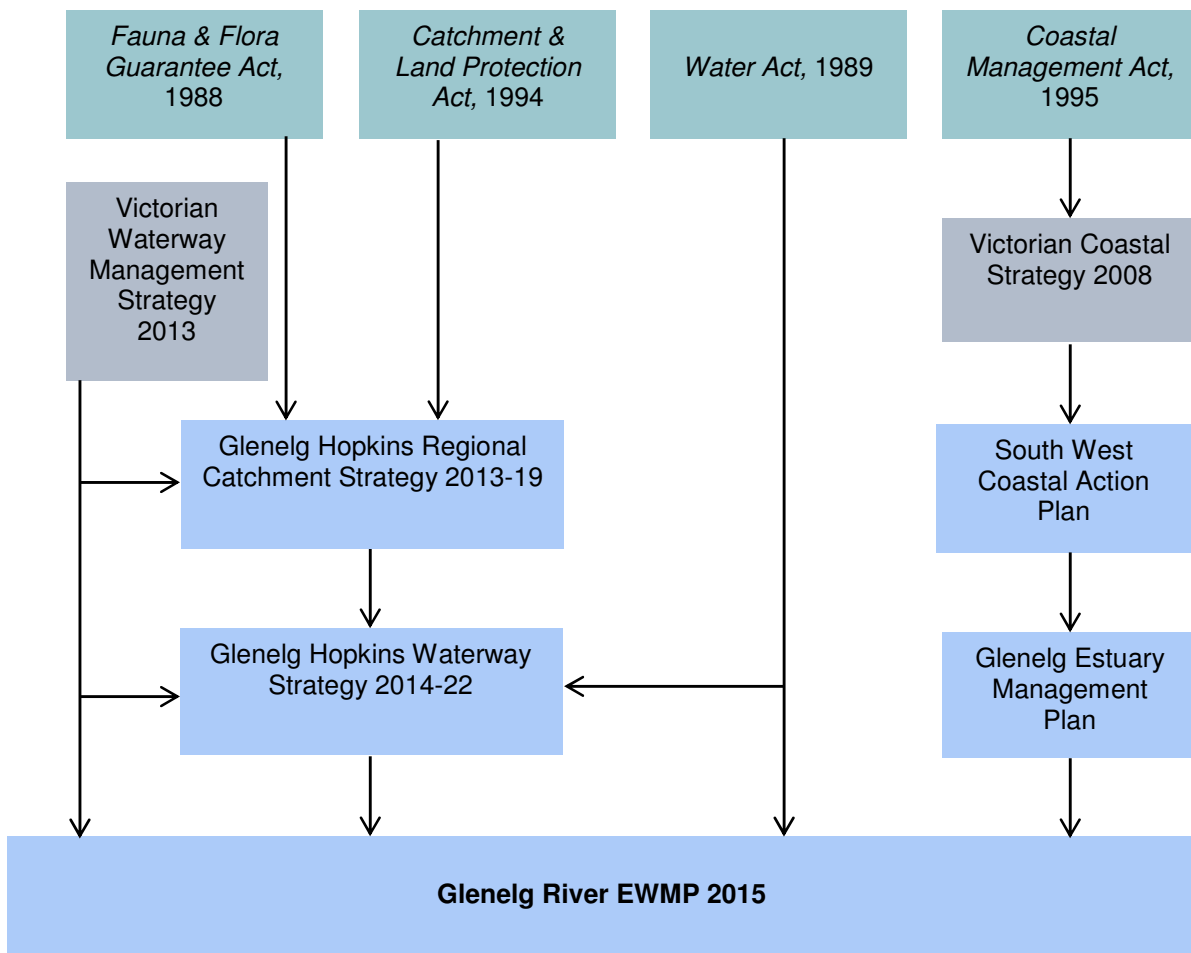
## 1.2 Strategic and legislative context

The Glenelg River EWMP is informed by the Glenelg Hopkins Regional Catchment Strategy (2013-2019) (RCS) and the Glenelg Hopkins Waterway Strategy (2014-22) (GHWS). The RCS is the primary planning document for land, water and biodiversity management within the Glenelg Hopkins region. The GHWS outlines regional goals for waterway management that align with the objectives described in the RCS. The GHWS includes regional priorities for environmental water management and also identifies complementary on-ground management activities required for sites receiving environmental water.

CMAs have specific responsibilities for environmental water management under the *Water Act*, 1989. These responsibilities include:

- **identifying regional priorities for environmental watering and facilitating water delivery**
- **providing input into the water allocation processes.**

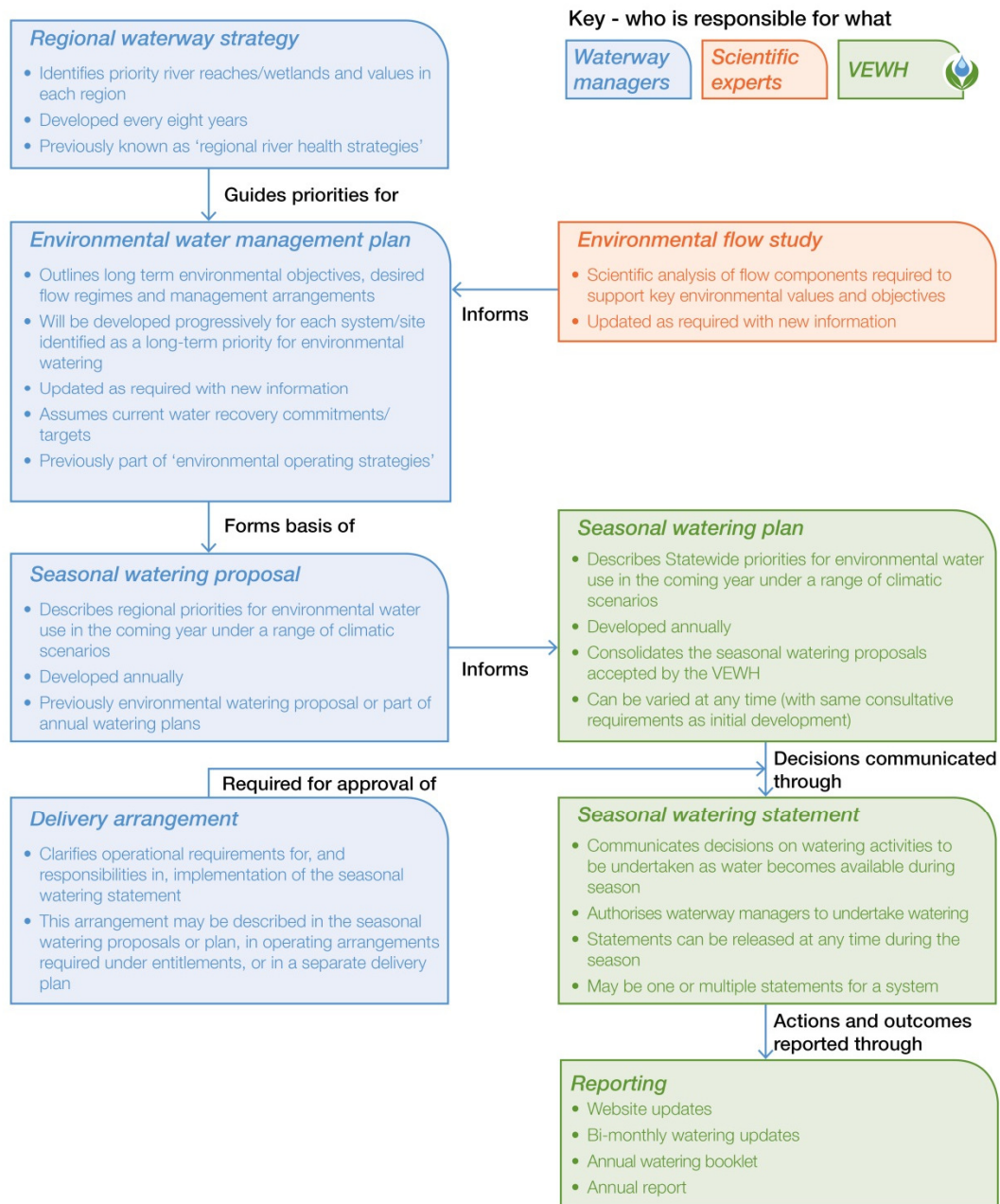
Other key strategic documents and legislation relevant to the EWMP are summarised in Figure 2.



**Figure 2: Key legislation, strategies and plans and their relationships with the Glenelg River EWMP**

### 1.3 Environmental water management

Management of environmental water in Victoria is planned and implemented through a framework of planning and operational strategies informed by scientific knowledge (see Figure 3). In addition, the Wimmera and Glenelg Rivers' Environmental Entitlement (2010) established a range of obligations for waterway managers and the VEWH (see section 4.2.1).



**Figure 3: Strategic framework for environmental water management in Victoria (Department of Environment and Primary Industries, 2013)**

Glenelg Hopkins CMA is the authority responsible for the protection and restoration of waterways throughout the region under Part 10 of the *Water Act*, 1989. To date environmental water regimes in the Glenelg River have focused on in-channel flow events as described in the annual Seasonal Watering Proposal (signed off by GWMWater, Glenelg Hopkins CMA and Wimmera CMA) and Seasonal Watering Statements (issued by the VEWH). Over-bank flows would require additional sign-off from land managers including private landholders, DELWP and Parks Victoria.

## 1.4 Plan Development

The Glenelg River EWMP was developed in collaboration with a range of stakeholders including community groups, Indigenous communities, agencies and water authorities.

The EWMP was informed by existing technical information (Alluvium, 2013) and new scientific data. Technical work completed for the EWMP includes the following studies:

- **A review of the flow requirements for the Glenelg spiny crayfish (Veale, Whiterod, Farrington, & Sweeney, 2014)**
- **Assessing future environmental flow releases from Moora Moora Reservoir to Rocklands Reservoir (Reach 0) (Water Technology, 2015)**
- **Assessment of physical flow constrictions, inundation and risk management below Rocklands Reservoir (Water Technology, 2015).**

Significant community engagement was undertaken during the development of the Victorian Waterway Management Strategy (VWMS), RCS and the GHWS. These documents inform the values described in the Glenelg River EWMP. Additional consultation was undertaken during the development of the EWMP (see Table 1).

**Table 1: Summary of consultation relating to development of the Glenelg River EWMP**

| Who                               | How  | Why  | Outcomes   |
|-----------------------------------|--|--|--|
| Glenelg River EWMP Steering Group | Group meetings and ad hoc communication when required. Stakeholders from Parks Victoria, DELWP, VEWH and GHCMA               | Stakeholder group to provide input to the development of the EWMP                                    | Feedback on stakeholder objectives   |
| Indigenous communities            | Meetings with community leaders from Gunditj Mirring Registered Aboriginal Party (RAP) and a meeting with Barengi Gadjin RAP | Incorporate Indigenous values and knowledge in flow management                                       | Objectives supported. Increased awareness of environmental flows and the links to Aboriginal water |
| Parks Victoria (PV)               | Discussions during development of EWMP   | PV manages parks and reserves along the Glenelg River  | Awareness of flow plan and implications for Parks Victoria sites                                   |
| Angling clubs                     | Regular contact with Balmoral, Casterton and Dartmoor angling clubs.   | Maintain communications and understand issues along the river especially around recreational fishing | Observations about individual flow events and general change in conditions.                        |

|   |   |   |   |
|---|---|---|---|
| Glenelg Hopkins CMA Advisory Group                                    | Advisory group meetings                                 | Broad stakeholder group providing input to CMA projects                         | Feedback on communications and objectives                                   |
| Direct engagement with individual key stakeholders                    | As needs contact with key stakeholders along the river  | Maintain communications and understand issues along the river                   | Observations about individual flow events and general change in conditions. |
| Western Region Advisory Group (WRAG) – VEWH, Wimmera CMA and GWMWater | Meetings of the WRAG as per the annual planning process | Ensure best management practice planning across the Wimmera and Glenelg regions | Collaboration in planning for water use under the shared entitlement        |

## 2 Overview of the Glenelg Catchment

The Glenelg River is the largest river in south-west Victoria. It rises in the Victoria Valley in the Grampians (Gariwerd) National Park and flows for more than 500 km to the Southern Ocean at Nelson with a catchment area of 12,660 km<sup>2</sup>.

The Glenelg River is an integral part of the Wimmera and Glenelg Headworks System with interbasin stock and domestic transfers to the Wimmera occurring from Rocklands Reservoir, a 348,000ML man-made storage on the upper Glenelg River (Reach 0). Moora Reservoir (6,290ML capacity) also diverts water from the headwaters to the Wimmera system.

Downstream of Rocklands Reservoir the river traverses the deeply incised Dundas and Merino Tablelands, and across basalt plains near Hamilton before passing into one of Australia's longest estuarine reaches and to the sea near Nelson (Figure 1). The Glenelg River estuary flows through the Lower Glenelg National Park and is a declared Heritage River under the *Heritage Rivers Act*, 1992. A short stretch of the estuary winds through South Australia before returning to Victoria.

The river flows through the rural townships of Balmoral, Harrow, Dergholm, Casterton, Sandford, Dartmoor and Nelson. The predominant catchment land use is agriculture (largely dryland pasture, with a small percentage of irrigated land). Significant forested areas include the Grampians National Park, Black Range State Park, Dergholm State Park, Lower Glenelg National Park and Wilkin Flora and Fauna Reserve. Blue gum plantations also occur across the catchment. Land tenure for approximately 172 km of river frontage from Rocklands Reservoir to the confluence of the Wannon River is crown land. The majority of this crown frontage is leased to private landholders under Crown Frontage grazing or riparian management licences.

The Glenelg River is valued for its environmental, economic and social attributes. The river supports a wide range of flow dependent environmental values including rare and threatened flora and fauna. This diversity is driven by the range of landforms, climate conditions, connection with the estuary and the largely perennial nature of the river.

The construction of Rocklands Reservoir in the 1950s significantly reduced the volume, duration and magnitude of flows in the Glenelg River. This stressed many of the river's significant values. Despite these hydrological impacts and the effect of a decade of drought (2000–2010), the condition of the Glenelg River continues to recover through the provision of targeted environmental flows (Austral Research and Consulting, 2014). Further details about the regulation of the Glenelg River can be found in section 5.1.

## 3 Goals and Ecological Objectives

In delivering its programs Glenelg Hopkins CMA strives toward:

*“Resilient rivers, estuaries, and wetlands connecting the environment and people and supporting regional communities”* (Glenelg Hopkins CMA, 2014)

This EWMP contributes to this vision by delivering against management goals over a ten year period. Management goals are translated into ecological objectives which describe the intended outcomes of the deployment of environmental water. Hydrological objectives explain the operational rationale for delivering water to meet the ecological objectives.

### 3.1 Management goals

The Glenelg EWMP will provide environmental water to the Glenelg River to achieve targeted and measurable ecological objectives over a 10 year period. The delivery of these objectives aligns with and contributes to the following management goals of the Glenelg Hopkins Waterways Strategy:



- **Maintain Heritage River values in the Glenelg River**
- **Protect or improve threatened fish populations in the Glenelg River**
- **Maintain or improve waterway dependant species and communities identified as having social or conservation significance**
- **Maintain or improve high value recreational fishing through habitat protection.**

### 3.2 Ecological objectives





The ecological objectives listed in Table 2 have been established in consultation with the EWMP steering group and through the consolidation of the Glenelg River FLOWS assessment (Alluvium, 2013), the Glenelg Hopkins Regional Catchment Strategy 2013-19, and the Glenelg Hopkins Waterway Strategy 2014-22.

Ecological objectives describe the intended outcome of the deployment of environmental water. The ecological objectives are measureable outcomes linked to a hydrological regime as either individual or a series of flow components. Ecological objectives contribute to the achievement of management goals.

**Table 2: Ecological objectives for the Glenelg River**

| Objective |   | Justification   |
|-----------|---|---|
| 1         | To stabilise and increase <b>Glenelg spiny crayfish</b> populations           |  <p>Photo: Glenelg Hopkins CMA</p> <p>Iconic species in Glenelg River catchment<br/>Glenelg Hopkins Waterway Strategy priority species<br/>Listed as endangered under the EPBC Act, listed as threatened in Victorian state legislation, FFG Act<br/>Culturally important to Indigenous people</p> |
| 2         | Increase the <b>short-finned eel</b> distribution range to historical extents |  <p>Photo: Queensland Department of Agriculture and Fisheries</p> <p>Iconic species in region<br/>Culturally important to Indigenous people<br/>Riverine life history is relatively well understood</p>  |



| Objective |   | Justification   |
|-----------|---|---|
| 3         | Increase the <b>tupong</b> distribution range in the freshwater habitat   |  <p>Photo: Glenelg Hopkins CMA</p> <p>Species that has a similar water regime to many migratory fish species</p> <p>Strong response to flow observed over recent years (Crook, et al., 2010)</p> <p>Cultural significance to Aboriginal people.</p>  |
| 4         | To stabilise and increase <b>variegated pygmy perch</b> populations.  |  <p>Photo: Saddler et al., 2010</p> <p>Listed as a significant species in the Glenelg Hopkins Waterway Strategy.</p> <p>Listed as vulnerable under the EPBC Act, listed as threatened under the FFG Act</p> <p>Strong response to flow (Alluvium, 2013). Flows provide habitat and promote growth and recruitment.</p>  |
| 5         | To increase abundance of <b>river blackfish</b> , incorporating integrated river health and watering strategies   |  <p>Photo: Queensland Department of Agriculture and Fisheries</p> <p>A species that has a similar water regime to many non-migratory species.</p> <p>Strong response to flows. Flows provide habitat and promote growth and recruitment (Alluvium, 2013)</p>   |
| 6         | To achieve self-sustaining populations of <b>Wimmera bottle brush</b><br><br>Two to three recruitment periods in the next 10 years to increase extent and abundance |  <p>Photo: Glenelg Hopkins CMA</p> <p>Listed as critically endangered under the EPBC Act and listed as a significant species in the Glenelg Hopkins Waterway Strategy.</p> <p>Riparian vegetation species that occurs low on the bank profile (the area that has potential to be influenced by flow management) and dependant on flow for recruitment (Marriott, 2010)</p> |

## 4 Environmental water management

For the purpose of flow management, the Glenelg River has been divided into six FLOWS reaches, as shown in Figure 1. FLOWS reaches are determined as part of environmental flow studies based on biophysical and hydrological features. These reaches are based on different measures to the more widely used Index of Stream Condition (ISC) reaches. FLOWS reaches are listed with the corresponding ISC reaches in Section 8.2. This document focuses on the headwaters of the Grampians to the confluence of the Wannon River (reaches 0, 1a, 1b and 2) as this is where water is currently managed. Further work is needed to understand the role of environmental water deliveries through reach 3 and the estuary.

### 4.1 History of environmental water in the Glenelg system

Concerns about the impacts of regulation on the Glenelg River were expressed during the construction of the Moora Moora system in the 1930s (McIlvena, 2007). These concerns were placated through assurances that the design of diversions would still permit significant flow to continue downstream. During and following construction of Rocklands Reservoir, concerns were raised by downstream communities about the impact of the reservoir on water quality and quantity (Hedditch, 2007). Persistent lobbying by the Glenelg River community resulted in allocation of the Glenelg River Compensation Flow. The intent of this allocation was to support stock and domestic water requirements from Rocklands Reservoir to Harrow while contributing to other social and environmental outcomes through the summer months (Hedditch, 2007). There is now considerable community demand for this allocation to be increased to extend benefits downstream to Casterton.

The inefficient earthen channels of the Northern Mallee stock and domestic supply system were upgraded to a pressurised pipeline system from 1993 to 2004 (Christie, 2007). A portion of the water savings realised by these works were allocated to the environment through the Wimmera and Glenelg Rivers Bulk Entitlement- Flora and Fauna Guarantee 2004. The objective of the original entitlement was to sustain and restore ecological processes and biodiversity of water dependent ecosystems.

The Wimmera Mallee pipeline project commenced in 2006 and over the next four years piped the remainder of the Wimmera Mallee stock and domestic supply system. As savings were achieved through the Wimmera Mallee pipeline project, the volumes were added to entitlements including the environment's bulk entitlement (Christie, 2007). On completion of the project in 2010, all savings were apportioned to investors through an entitlement conversion process. This converted all previous environmental water entitlements into the Wimmera and Glenelg Rivers Environmental Entitlement (2010).

### 4.2 Entitlements

Environmental water is allocated to the Glenelg River under the Wimmera and Glenelg Rivers Environmental Entitlement 2010 and Wimmera and Glenelg Bulk Entitlement (GWMWater) 2010.

Table 3 summarises the water that is available for the Glenelg River downstream of Rocklands Reservoir.

#### **4.2.1 Wimmera and Glenelg Rivers Environmental Entitlement 2010**

Under the Wimmera and Glenelg Rivers Environmental Entitlement 2010 the Glenelg River has access to water via the Wimmera-Mallee pipeline product and Glenelg River passing flows. Environmental water sources are discussed below and summarised in

Table 3. The Wimmera-Glenelg entitlement framework is represented in Figure 4.

### Wimmera–Mallee pipeline product

Under the Wimmera and Glenelg Rivers Environmental Entitlement 2010 the Glenelg River can receive a maximum annual allocation of 40,560 ML with capacity for carryover. This entitlement currently has a modelled reliability of 94.2% (based on percentage of years with greater than 80% entitlement) (GWMWater, 2014).

Water available under the environmental entitlement is shared between the Wimmera and Glenelg systems and the Wimmera–Mallee wetlands. Waterways that receive environmental water include sections of the Glenelg, Wimmera and MacKenzie rivers, Mount William, Burnt and Bungalally creeks. Under the Environmental Entitlement, priority wetlands formerly supplied by the Wimmera–Mallee channel system are supported by a separate 1,000 ML wetlands product which has 92.6% modelled reliability (GWMWater, 2014).

### Glenelg River passing flows

In addition to the volume held in headworks storage, passing flow obligations at Rocklands Reservoir provide up to 25,960 ML between June and November. There are provisions to accumulate passing flows in response to issues such as infrastructure maintenance, prevention of downstream flooding and water quality concerns. Passing flows are dependant on inflows and are subject to restrictions depending on allocations (Glenelg Hopkins CMA, 2014).

## 4.2.2 GWMWater Bulk Entitlement

Under the GWMWater Bulk Entitlement the Glenelg River has access to water via the Glenelg River compensation flow and, by substitution, Commonwealth Environmental Water Holder (CEWH) allocations'

### Glenelg River Compensation Flow

The Glenelg River Compensation Flow (3,300 ML) provides for domestic and stock consumptive requirements downstream of Rocklands Reservoir. Whilst the Glenelg River Compensation Flow indirectly contributes to environmental and other social outcomes it cannot be called on independently for environmental use. The entitlement currently has a modelled reliability of 92.6% (based on percentage of years with greater than 80% entitlement) (GWMWater, 2014) and is held by Grampians Wimmera Mallee Water (GWMWater). Annual delivery planning is undertaken by Glenelg Hopkins CMA in consultation with the VEWH.

## 4.2.3 Commonwealth Environmental Water Holder

The CEWH owns and manages 28,000 ML of regulated entitlement (formerly allocated for irrigation) held under the GWMWater Bulk Entitlement. This water was purchased as part of the Murray Darling Basin Plan. This water is only for use in the Wimmera system, and has low modelled reliability of 90.1%. Experience to date suggests that allocations are unlikely in dry years. Use of CEWH water in the Wimmera system may increase the share of water available to the Glenelg River under the Wimmera and Glenelg Environmental Entitlement.

**Table 3: Summary of environment water sources available for the Glenelg River System**

| Water Entitlement   | Volume (ML)  | Responsible Agency               |
|---|--|----------------------------------|
| Wimmera and Glenelg Rivers Environmental Entitlement 2010 |  |                                  |
| Wimmera–Mallee pipeline product                           | 40,560 ML plus carryover shared between the Wimmera and Glenelg systems<br><br>1,000 ML of regulated entitlement to supply former channel-fed wetlands   | VEWH                             |
| Passing flows obligations at Rocklands Reservoir          | Passing flow rules for the Glenelg River at Rocklands Reservoir:<br><br>June: 100 ML/d or natural<br><br>July and October: 150 ML/d or natural<br><br>August and September: 160 ML/d or natural<br><br>November: 130 ML/d or natural | GMMWater with VEWH               |
| Wimmera and Glenelg Bulk Entitlement 2010                 |  |                                  |
| Glenelg River Compensation Flow                           | 3,300 ML maximum entitlement plus carryover  | Glenelg Hopkins CMA for GMMWater |

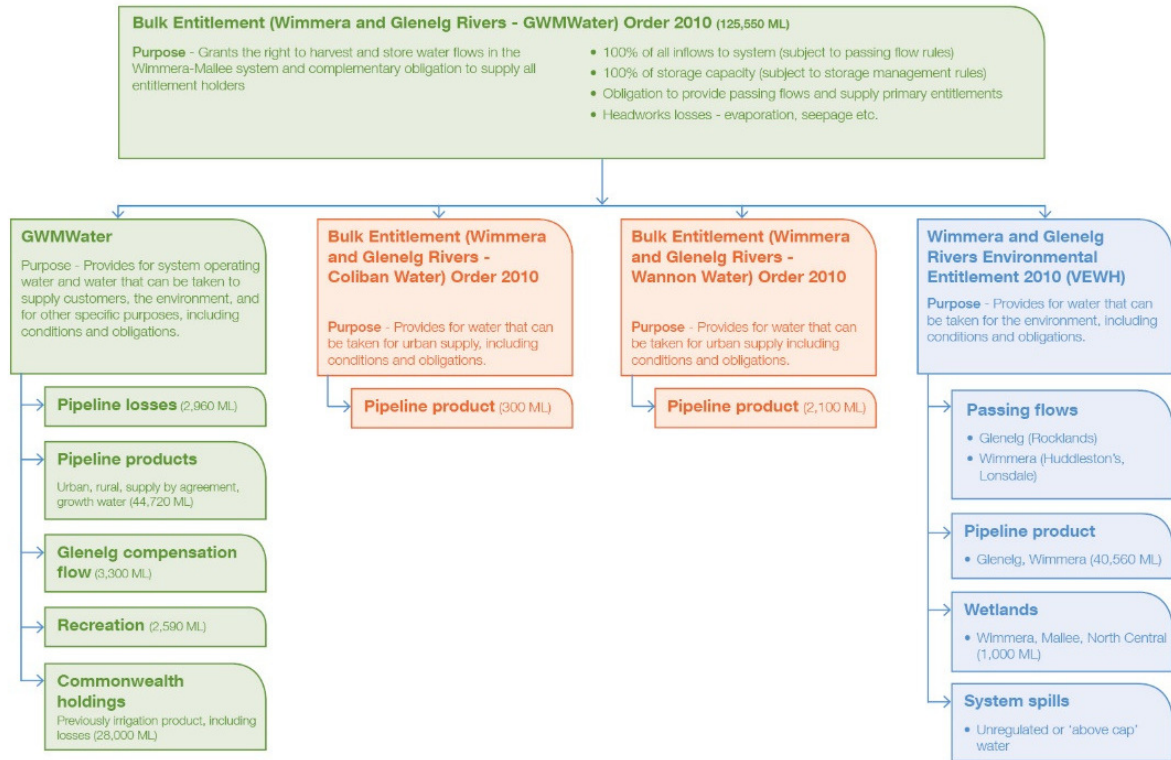


Figure 4: Wimmera-Glenelg entitlement framework (GWMWater, 2014)

### 4.3 Environmental water operations

Section 9 of the Wimmera and Glenelg Rivers Environmental Entitlement (2010) creates an obligation on the VEWH to establish operating arrangements for the entitlement. At the time of writing, operating arrangements are being finalised by the VEWH in partnership with GWMWater, Glenelg Hopkins CMA and Wimmera CMA.

The Western Rivers Advisory Group (WRAG) has been established by the VEWH in partnership with Glenelg Hopkins CMA and Wimmera CMA and with input from GWMWater. The role of the WRAG is to provide advice to the VEWH on environmental watering priorities in the Wimmera and Glenelg systems. This advice is used to inform VEWH decisions regarding the use of environmental entitlements to maximise environmental outcomes across the two systems.

Roles and responsibilities of key parties involved in environmental water management in the Glenelg are summarised in Table 4.

**Table 4: Roles and responsibilities for environmental water management in Victoria (Department of Environment and Primary Industries, 2013)**

| Agency/group   | Responsibility/involvement   |
|--|--|
| <p>Department of Environment, Land, Water and Planning (DELWP)</p> | <p>Manage the water allocation and entitlements framework.</p> <p>Develop state policy on water resource management and waterway management.</p> <p>Develop state policy for the management of environmental water in regulated and unregulated systems.</p> <p>Act on behalf of the Minister for Environment and Climate Change to maintain oversight of the VEWH and waterway managers (in their role as environmental water managers).</p>  |
| <p>Victorian Environmental Water Holder (VEWH)</p>                 | <p>Make decisions about the most effective use of water holdings, including use, trade and carryover.</p> <p>Authorise waterway managers to implement watering decisions.</p> <p>Liaise with other water holders to ensure coordinated use of all sources of environmental water.</p> <p>Publicly communicate environmental watering decisions and outcomes.</p> <p>Commission targeted projects to demonstrate ecological outcomes of environmental watering at key sites.</p> <p>Report on management of the water holdings.</p> |
| <p>Commonwealth Environment Water Holder (CEWH)</p>                | <p>Make decisions about the use of Commonwealth water holdings, including providing water to the VEWH for use in Victoria.</p> <p>Liaise with the VEWH to ensure coordinated use of environmental water in Victoria.</p> <p>Report on management of Commonwealth water holdings.</p>   |
| <p>Glenelg Hopkins CMA</p>   | <p>Waterway manager for the Glenelg System.</p> <p>Identify regional priorities for environmental water management in regional waterway strategies.</p> <p>In consultation with the community, assess water regime requirements of priority rivers, estuaries and wetlands to identify environmental watering needs to meet agreed objectives.</p> <p>Propose annual environmental watering actions to the VEWH and implement the VEWH environmental watering decisions.</p>   |

| Agency/group                              | Responsibility/involvement  |
|---|---|
|   | <p>Provide critical input to management of other types of environmental water (passing flows management, above-cap water).</p> <p>Report on environmental water management activities undertaken.</p>   |
| Wimmera CMA                               | <p>Waterway manager for the Wimmera System.</p> <p>Identify regional priorities for environmental water management in regional waterway strategies.</p> <p>In consultation with the community, assess water regime requirements of priority rivers and wetlands to identify environmental watering needs to meet agreed objectives.</p> <p>Propose annual environmental watering actions to the VEWH and implement the VEWH environmental watering decisions.</p> <p>Provide critical input to management of other types of environmental water (passing flows management, above-cap water).</p> <p>Report on environmental water management activities undertaken.</p> |
| Grampians Wimmera Mallee Water (GMMWater) | <p>Rural Water Corporation – storage and infrastructure manager.</p> <p>Work with the VEWH and waterway managers in planning for the delivery of environmental water to maximise environmental outcomes.</p> <p>Operate water supply infrastructure to deliver environmental water.</p> <p>Ensure the provision of passing flows and compliance with management of diversion limits in unregulated and groundwater systems.</p>   |
| Southern Rural Water                      | <p>Rural Water Corporation – resource manager for the Glenelg River downstream of Moree Bridge.</p> <p>Ensure compliance with management of diversion limits in unregulated and groundwater systems.</p>  |
| Parks Victoria                            | <p>Land manager of Grampians (Gariwerd) National Park and Lower Glenelg National Park.</p> <p>Member of Glenelg River EWMP 2014–15 steering group.</p> <p>Participate in the periodic review of relevant EWMPs.</p> <p>Manage and report on other relevant catchment management and risk management actions required due to the implementation of environmental water.</p>  |



| Agency/group  | Responsibility/involvement   |
|---|--|
| Traditional Owners/Registered Aboriginal Parties (RAPs) | Provide input and advice into Glenelg River environmental watering<br>Stewards of traditional water management knowledge.          |
| Gunditj Mirring and Barengi Gadjin RAPs                 | Holders of Native Title rights over crown land (including riparian areas) in areas where Native Title rights have been determined. |

#### 4.3.1 Historic environmental water allocations

Water available annually for the environment is shown in Table 5, along with the amount utilised by the Wimmera and Glenelg systems since 2007.

**Table 5: Historical availability and use of environmental water in the Wimmera and Glenelg systems (GMMWater)**

| Water year           | Environmental water availability in the Wimmera–Glenelg system (ML) |                               |                              | Water use (ML) |                |        |
|----------------------|---|-------------------------------|------------------------------|----------------|----------------|--------|
|                      | Opening allocation  | Total allocation for the year | Carryover from previous year | Glenelg system | Wimmera system | Total  |
| 2007–08 <sup>1</sup> |   |                               |                              | 0              | 2,600          | 2,600  |
| 2008–09              |   |                               |                              | 900            | 500            | 1,400  |
| 2009–10              |   |                               |                              | 3,480          | 5,940          | 9,420  |
| 2010–11              |   |                               |                              | 10,748         | 7,065          | 17,813 |
| 2011–12              | 23,930  | 40,560                        | 19,335                       | 3,562          | 14,183         | 17,745 |
| 2012–13              | 23,363  | 38,800 <sup>2</sup>           | 41,663                       | 19,387         | 30,730         | 50,277 |
| 2013–14              | 8,923   | 32,935                        | 25,795                       | 10,207         | 19,532         | 29,739 |
| 2014–15              | 5,516   | 19,509                        | 24,643                       | 20,668         | 19,007         | 39,675 |

<sup>1</sup> The environment's rights were qualified to secure water supplies for towns in 2007–08, restricting the amount of water available to be used for the environment.

<sup>2</sup> Includes a once-off repayment of 5,532 ML as specified in the Environmental Entitlement.

## 5 Hydrology and geomorphology

Flows in the Glenelg River result from complex interactions between hydrology (the science of water) and geomorphology (the study of geologic forces that shape the landscape). The unique interplay of climate, groundwater, surface water, topography, geologic forces, geology, soil type, animal populations and vegetation within the entire catchment determine the physical characteristics of a waterway including flow and water quality. Human intervention through catchment modification and regulation of waterways has a profound effect on these interactions, resulting in substantial changes to the timing, frequency, duration and magnitude of streamflows, altered channel form and reduced water quality.

### 5.1 River hydrology

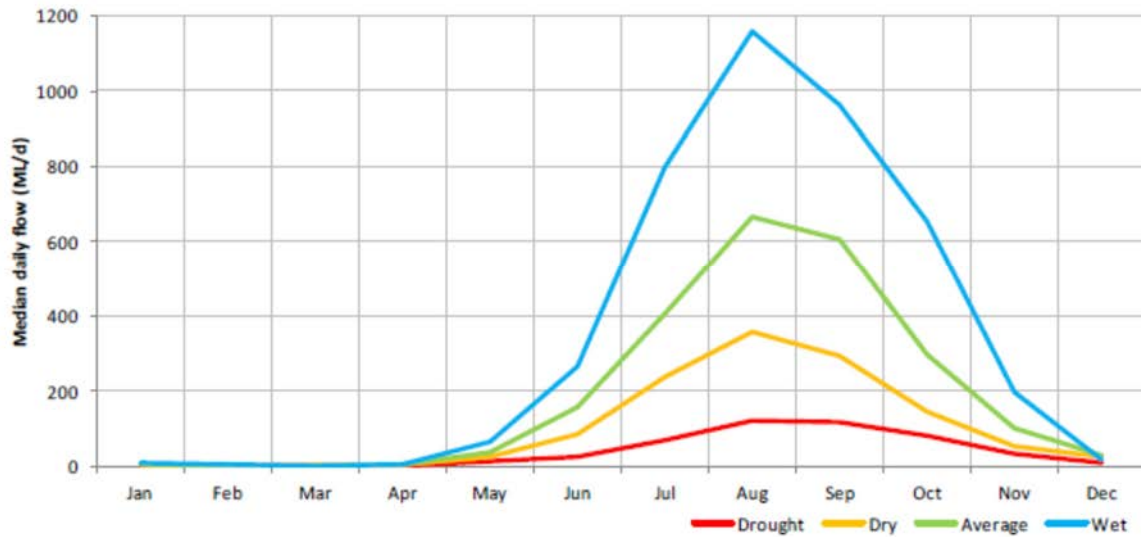
Glenelg River flows are strongly seasonal, reflecting rainfall distribution in the catchment. Mean annual rainfall gradually decreases from around 750 mm near the coast to approximately 550 mm in the middle of the catchment, but rises to over 900 mm in the Grampians (Department of Water Resources, 1989). Streamflow patterns reflect this variation with 70% of average annual flow in the Glenelg River upstream of the Wannon River confluence occurring between August and October. Under natural conditions the Glenelg River at Balmoral would cease to flow between February and April (Godoy, 1996).

The Glenelg River displays a typical temperate seasonal flow pattern characterised by a low flow season, a high flow season and transitional flow seasons (see Table 6)

Both timing and magnitude of flow varies through the transitional months under different seasonal rainfall conditions. During a high rainfall season the high flow period may commence as early as May. In a drier season the low flow period may commence as early as November. Further work to investigate the strength of these trends as a predictive tool may help plan for supply and demand scenarios. Seasonality of flows in the Glenelg River under different seasonal conditions is shown in Figure 5. For the purpose of this analysis, seasonal conditions are defined based on percentage probability of exceeding the annual flow that occurred in each year of the flow record. These probability of exceedance values have been grouped as quartiles with drought defined as >75<sup>th</sup> percentile (75% of years are wetter), dry defined as 75<sup>th</sup> to 50<sup>th</sup> percentile, average is 50<sup>th</sup> to 25<sup>th</sup> percentile and wet is the wettest 25% of years. This coarse delineation limits the ability to manage for drought conditions that occur less frequently than 25 years in 100.

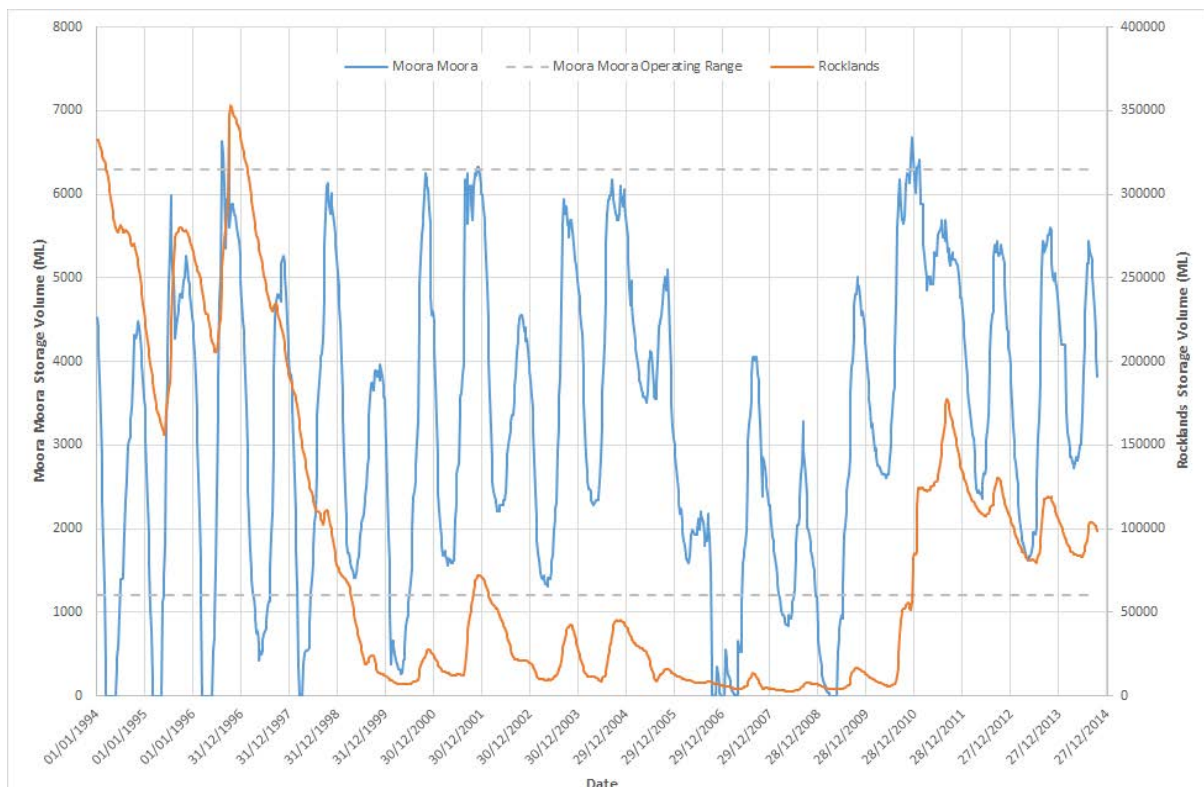
**Table 6: Flow seasons for the Glenelg River (Alluvium, 2013)**

| Flow Season                     | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Low flow season                 |     |     |     |     |     |     |     |     |     |     |     |     |
| Transition season (low to high) |     |     |     |     |     |     |     |     |     |     |     |     |
| High flow season                |     |     |     |     |     |     |     |     |     |     |     |     |
| Transition season (high to low) |     |     |     |     |     |     |     |     |     |     |     |     |



**Figure 5: Seasonality of flow in the Glenelg River. Median monthly flows under different seasonal conditions, unimpacted modelled daily data at Rocklands Reservoir (Alluvium, 2013)**

Water managers use a Resource Allocation Model (REALM) to simulate the operation of water supply systems to make predictions under a range of operating and seasonal conditions including droughts as well as during periods of normal and high streamflows. REALM data calibrated to historic storage levels at Moora Moora and Rocklands Reservoirs (Figure 6) shows almost 90% of Moora Moora Reservoir inflows occur between May and September (Water Technology, 2015). Rocklands Reservoir displays a similar trend, although the majority of inflows are greater later in the season, in the July to October period.



**Figure 6: Moora Moora and Rocklands Reservoirs storage volumes (Water Technology, 2015)**

Eight active streamflow gauges are located along the Glenelg River (Table 7). Two are utilised as compliance points for environmental flows: Glenelg River at Harrow (238210) for Reach 1b and Glenelg River at Dergholm (238211) for Reach 2. Compliance points are gauges that are frequently measured to assess the performance of environmental flows provided to the system. Flow duration curves and hydrographs for both compliance points and gauging for Reach 0 (there is no compliance point for Reach 0) are provided in Appendix 1. There is currently no gauging or compliance point for Reach 1a.

**Table 7: Active Streamflow gauges in the Glenelg River**

| Gauge ID | Location                             | Period of Record | Reach |
|----------|--------------------------------------|------------------|-------|
| 238231   | Glenelg River at Big Cord            | 1968 to present  | 0     |
| 238205   | Glenelg River at Rocklands Reservoir | 1941 to present  | 1a    |
| 238224   | Glenelg River at Fulham Bridge       | 1964 to present  | 1b    |
| 238210   | Glenelg River at Harrow              | 2001 to present  | 1b    |
| 238211   | Glenelg River at Dergholm            | 2004 to present  | 2     |
| 238249   | Glenelg River at Burkes Bridge       | 2001 to present  | 2     |
| 238202   | Glenelg River at Sandford            | 1908 to present  | 3     |
| 238206   | Glenelg River at Dartmoor            | 1948 to present  | 3     |



**Photo 2: Glenelg River at Fulham stream gauge (238224) (photo GHCMA)**

## 5.2 Altered hydrology by regulation

Regulation of water occurs through diversion, extraction, and modification of flow regimes from natural. Flows are considered 'natural' when extractions and diversions are equal to zero and current land use is assumed. Regulation has resulted in flows in the Glenelg River being considerably lower than would have occurred under natural conditions. Land use changes have also impacted on the hydrology of the Glenelg through drainage, clearing of vegetation and the construction of farm dams.

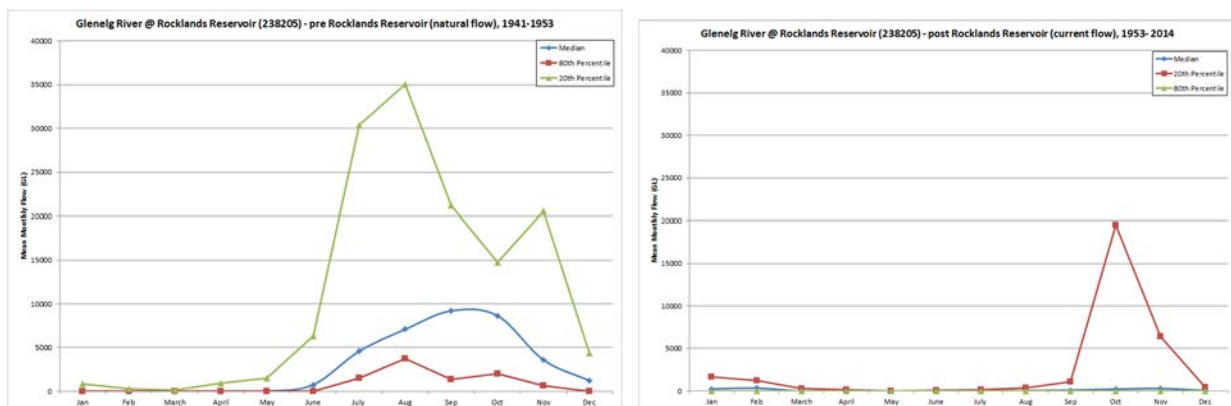
Two storages divert water from the upper Glenelg catchment to the Wimmera: Moora Moora Reservoir and Rocklands Reservoir. Moora Moora was completed in 1933 and has a storage capacity of 6,290ML. Water is diverted to the reservoir from the Glenelg River via the Moora inlet channel (Figure 8). Rocklands Reservoir was constructed on the Glenelg River in 1953 and has a capacity of 348,000ML, approximately three times the average annual inflow. Water is diverted to the Wimmera via the Rocklands outlet channel. Flows to the Glenelg River downstream of the reservoir can be released at three points along the channel; below the dam wall via the Rocklands outlet and further along the channel at the 5-mile and 12-mile outlets (Figure 9). More detail on the regulation of the Glenelg River is provided in section 6.

As a result of these storages, downstream of Rocklands Reservoir mean annual streamflow has decreased from 113,000 ML/year to approximately 43,000 ML/year (SKM, 2003a). As well as drastically reducing the volume of flows, Rocklands Reservoir has reduced the frequency of large flushing flows that occurred under natural conditions during late winter and into September. Reductions in mean monthly flows in the Glenelg River downstream of Rocklands Reservoir are summarised in Table 8 and illustrated in Figure 7.

The effect of regulation is greatest immediately downstream of Rocklands Reservoir (Reach 1a), but continues significantly into Reaches 1b and 2. Downstream of the Wannon River confluence (Reach 3), the impact on peak flow is reduced, although still apparent (SKM, 2003). Studies are currently underway to assess the contribution of environmental flows to the Estuary as the ability to support values in this priority reach is poorly understood.

**Table 8: Glenelg River average mean monthly flows downstream of Rocklands Reservoir (238205), pre and post construction**

| <i>Month</i> | <i>Pre Rocklands Reservoir</i><br>(1941–1952)<br>ML | <i>Post Rocklands Reservoir</i><br>(1953–current)<br>ML |
|--------------|---|---|
| January      | 374.1   | 627.9   |
| February     | 363.0   | 523.5   |
| March        | 3,518.1   | 186.8   |
| April        | 1,249.3   | 104.0   |
| May          | 852.2   | 34.5  |
| June         | 2,614.2   | 443.9   |
| July         | 13,175.5  | 2,910.4   |
| August       | 14,623.9  | 4,912.5   |
| September    | 13,545.3  | 5,456.0   |
| October      | 9,203.5   | 6,667.6   |
| November     | 8,956.1   | 2,889.6   |
| December     | 2,303.0   | 250.0   |



**5.3 Figure 7: Glenelg River at Rocklands Reservoir (280205) pre and post construction Groundwater surface water interaction**

Southern Rural Water and GMMWater manage groundwater resources and issue licences within the Glenelg Basin. The Glenelg Basin contains a large part of the Glenelg Water Supply Protection Area (WSPA) and a small section of the West Wimmera Groundwater Management Area (GMA).

Groundwater contribution to baseflow estimates for the upper Glenelg River from Big Cord (238231) to Dergholm (238211) are relatively low, ranging from 0 to 10,000ML/year (SKM, 2009) and are predominately saline. Analysis shows that there are significant periods of zero flow for gauging stations at Fulham Bridge (reach 1) and Dergholm (reach 2), indicating that groundwater flow contributions in these reaches are ephemeral (Alluvium, 2013). A prominent feature of the upper Glenelg River is the occurrence of deep (2–8 m) saline pools, which are indicative of strong saline groundwater intrusion (Mitchell, Rutherford, Stagnitti, & Merrick, 1996); (SKM, 2003). Saline groundwater intrusion is a threatening process in the upper Glenelg River amplified by reduced natural flow regimes.

The lower Glenelg River (Reach 3 and the estuary) is a baseflow gaining stream, and gains baseflow from the fresher limestone aquifer. Total baseflow increases downstream from Sandford (238202) to Dartmoor (238206). Average annual baseflow gain within the lower Glenelg catchment is in the order of 56,000 ML/year (GHD, 2013). Low salinity groundwater is a sustaining process in the lower Glenelg River.

#### 5.4 River geomorphology

The Glenelg River rises in the Grampians ranges (Gariwerd) at an elevation of approximately 750 metres above sea level. The river then flows north for a short distance through the flat and broad Victoria Valley before heading west, passing across an uplifted, highly erodible palaeoplain (the Dundas Tablelands) that is dissected by a radial drainage network comprising the major upper tributaries of the Glenelg River.

Downstream of Casterton, the river meets its major tributary, the Wannon River, which has a catchment area of 4,000 km<sup>2</sup>. In its downstream reaches (below Casterton) the Glenelg River is unconfined by valley sides or hillslopes, and meanders across broad plains before reaching the head of its estuary, which is a 70 km long limestone gorge (Alluvium, 2013). Geomorphology for each reach is described in detail below.

There are several significant wetland systems within the Upper Glenelg catchment including, Frasers Swamp, Dergholm wetland complex, Beniagh Swamp and Victoria Lagoon. Moora Moora and Rocklands Reservoirs also support significant wetland values in a region where wetlands have been impacted by drainage.

The Glenelg River has been significantly affected by sand slugs generated by sheet and gully erosion of hillslopes and tributaries in granatice areas of the catchment (upper and mid reaches). This erosion has deposited four to eight million cubic metres of sand into the Glenelg River and its tributaries, significantly impacting on instream values (Glenelg Hopkins CMA, 2014). The build-up of sand has smoothed the river bed and made it shallower. Sand impacts have reduced the number and depth of deep holes that provide habitat and refuge for aquatic biota. In some locations sand slugs have effectively dammed the river, creating backwater lakes or online wetlands. In some cases instream vegetation has been smothered further altering the condition of the channel (Alluvium, 2013).

## Reach 0

Extending 39 km between Moora Moora Reservoir and the Rocklands Reservoir pondage, reach 0 is a low energy environment where the flat gradient and the width of the floodplain allow sections of discontinuous and multiple channels to form. Overbank flooding is frequent with shallow flows a common feature across the heavily vegetated floodplain. Fine-grained sediment in the channels, in combination with the complex surface morphology, ensures exchange between surface and subsurface flows that are expected to be significant under low flow conditions (Water Technology, 2015).



**Photo 3: (a) Glenelg River at Big Cord (left) and (b) Serra Road crossing (right) (Photos Water Technology 2015)**

## Reach 1a

Extending 32 km between Rocklands Reservoir and the 5-Mile outlet Reach 1a varies between sections of well-defined single thread channel to flood-out features with ill-defined channel form, to sections with a complex network of channels, islands and back swamps (Alluvium, 2012). These features are highlighted in Photo 4.

Frasers Swamp is located halfway along this reach. The wetland complex is a semi-permanently inundated floodplain that has formed behind a sediment plug at the confluence of the Glenelg River and Yarramylyup Creek. Frasers Swamp provides valuable habitat with a high diversity of plants and animals (Farrington & Bachmann, 2013) and including the growling grass frog listed under the Commonwealth *Environment Protection and Conservation Act*, 1999 and Victorian *Flora and Fauna Guarantee Act*, 1988.





**Photo 4: (a) and (b) Reach 1a approximately 4 km upstream from Balmoral; note the complex network of channels, islands and backswamps – flow direction right to left (Alluvium, 2012). (Photos: Alluvium)**



**Photo 5: Frasers Swamp on the Glenelg River. (Photo: GHCMA)**

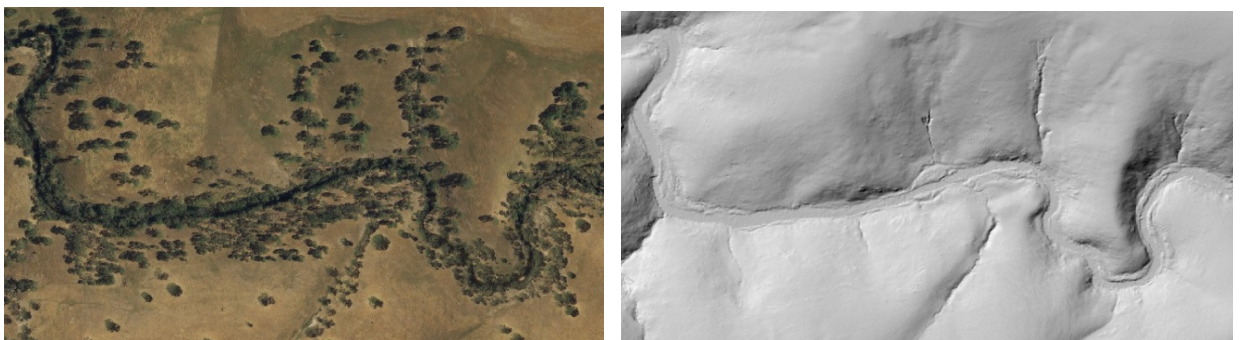
## Reach 1b

This reach extends approximately 133 km between the 5-Mile outlet and the confluence with the Chetwynd River. The geomorphology of the reach includes sections of well-defined channel, flood-out features with ill-defined channel form and sections with a complex network of channels, island and back swamps (Photo 6). Note the transition from a well-defined single thread channel to multiple channels then a flood-out feature before forming a single thread channel again (Alluvium, 2012).

Downstream of Fulham Bridge the river flows through a confining bedrock fracture (Photo 7). Depositional features, including some small floodplain pockets, have formed along the valley margins (Alluvium, 2012). Sand 'slugs' resulting from catchment erosion have a significant impact on habitat complexity and stream continuity in sections of this reach.



**Photo 6: (a) and (b) Section of reach 1b upstream of Fulham Bridge (flow right to left), note the transition between a well-defined channel to multiple channels then a floodout feature with no defined channel before forming a single thread channel again (Alluvium, 2012). (Photos: Alluvium)**



**Photo 7: (a) and (b) Section of reach 1b, which has incised into the bedrock plains leading to valley confinement (flow direction right to left). Note the depositional features at the valley margins (Alluvium, 2012).**

## Reach 2

This reach extends between the Glenelg River - Chetwynd River confluence and the Glenelg River- Wannon River confluence. It consists of a well-defined single thread channel which is more linear than upstream reaches (Photo 8). There are intermittent depositional features throughout the reach however generally morphology is homogenous. Much of this reach is impacted by sand slugs, which reduce bed diversity (Alluvium, 2012).



**Photo 8: (a) and (b) reach 2 section of well-defined single thread channel near Dergholm (flow direction right to left) (Alluvium, 2012).**

## Reach 3

This reach extends from the confluence of the Wannon River to the head of the estuary at Dartmoor. The channel is confined and often wide with some sections deeply incised (up to 10m) with steep, unstable banks formed in sandy loams in the upstream extent of the reach. Around Dartmoor the reach is characterized by pool, run, riffle and glide sequences with streambanks formed in silty loams whilst the streambed is dominated by actively mobile sands (SKM, 2003).



**Photo 9: (a) and (b) Glenelg River Reach 3. (Photo: GHAMA)**

## Estuarine Reach

Extending from Dartmoor to the Southern Ocean, the Glenelg River estuary is the longest estuary in Victoria, is listed under the Victorian *Heritage Rivers Act*, 1992, and as a Wetland of Importance on the Australian Wetlands Database (Environment Australia, 2010). The estuary is confined within limestone gorges formed in a system of dune calcarenite ridges fringing wetlands near the coastline. The mouth of the estuary is shallow and is underlain by a rock bar.



**Photo 10: Estuary reach (Nelson). (Photo: GHCMA)**

## 5.5 Water quality

Water quality is continuously monitored on the Glenelg River. A full summary of monitoring programs is provided in section 14. Monitoring results indicate that salinity, dissolved oxygen and a high sediment load are the parameters most affecting the condition of the Glenelg River (Thiess, 2015). Species may have a range of tolerance for particular water quality parameters depending on the stage of life and physical stresses caused by elevated levels of other parameters.

### 5.5.1 Salinity

Salinity along the Glenelg River is variable. The major sources of salt are saline groundwater intrusion in deep pools where base salinities regularly reach 10,000 EC and inflows from highly saline tributaries which are known to increase salt concentrations in some sections of the Glenelg River (SKM, 2007).

Saline groundwater intrusion is an ongoing threat to the unique ecology of the Glenelg River. Stratification as a result of insufficient dilution and mixing coupled with sand deposition reduces the availability of deep, cool pools as refuge habitat for biota during the warm summer/autumn period.

From December to May environmental flows delivered as ‘freshes’ are critical to improving water quality in deep pools. Fresh events are effective at breaking down stratification and restoring water quality. Summer baseflows assist in maintaining a freshwater lens on the surface of stratified pools providing limited refuge habitat with suitable water quality but baseflows are insufficient to mix or improve condition throughout the water column.

### 5.5.2 Dissolved Oxygen

Deoxygenation of the lower levels of deep pools is an issue throughout the Glenelg River (McGuckin, Anderson, & Gasior, 1991). McGuckin *et. al.* found that deoxygenation is closely associated with the presence of saline pools between Rocklands Reservoir and Fulham Bridge (reach 1b) with pools sampled registering a bottom dissolved oxygen concentration of less than 10% saturation. Pools downstream between Casterton and Dartmoor (reach 3) also recorded low levels with values between 10 – 40% saturation. Elevated salt concentrations and deoxygenation, particularly in deep pools, reduce the quality and quantity of habitats and refuge for aquatic biota (SKM, 2007).

### 5.5.3 High Sediment Load

Significant catchment erosion has delivered high sediment loads (as sand) to the Glenelg River. Sand accumulates in pools where it reduces depth and smothers coarse substrates, woody debris and macrophytes. Flow regulation has reduced the magnitude, frequency and duration of medium to high flows (refer to section 4.2) which has resulted in reduced flushing and scour of deposited sediments. Sediment impacts have reduced channel capacity by 60% between Harrow and Burke's Bridge, 20% between Chetwynd River and Wannon River, and by 10% downstream of the Wannon River confluence. Low flow and sand deposition have promoted excessive growth of the emergent plants *Typha* spp. and *Phragmites australis* in the middle and upper reaches of the Glenelg River, which further impedes flow and increases sediment deposition (SKM, 2007). This is an important process as it entrains a large amount of sediment while also allowing reformation of channel and pool sequences.

### 5.5.4 Thermal Pollution

Rocklands Reservoir is constructed with a fixed low-level outlet. As a result released water can be significantly colder than the receiving river. The impacts of cold water releases can have direct and indirect effects on aquatic ecosystems. Direct effects may include exceeding tolerances for survival or reproduction, while indirect effects may include the exclusion of species based on thermal preference, reduced resilience to other potential stressors, reduced metabolic and physiological abilities and reduced stream productivity overall (Ryan, Webb, Lennie, & Lyon, 2001).

Options to manage this risk have not been explored. Further studies may identify works or operational measures to manage this issue.

## 6 System operations

The Glenelg River is an integral part of the Wimmera and Glenelg Rivers headworks system. The major storages in the Glenelg catchment are Rocklands Reservoir (348,000 ML) and Moora Moora Reservoir (6,300 ML). Environmental water releases are made to the Glenelg River via the Rocklands Reservoir outlet or by using the 5-Mile and 12-Mile outlets along the Rocklands–Toolondo Channel. GWMWater operates all water supply infrastructure within the system.

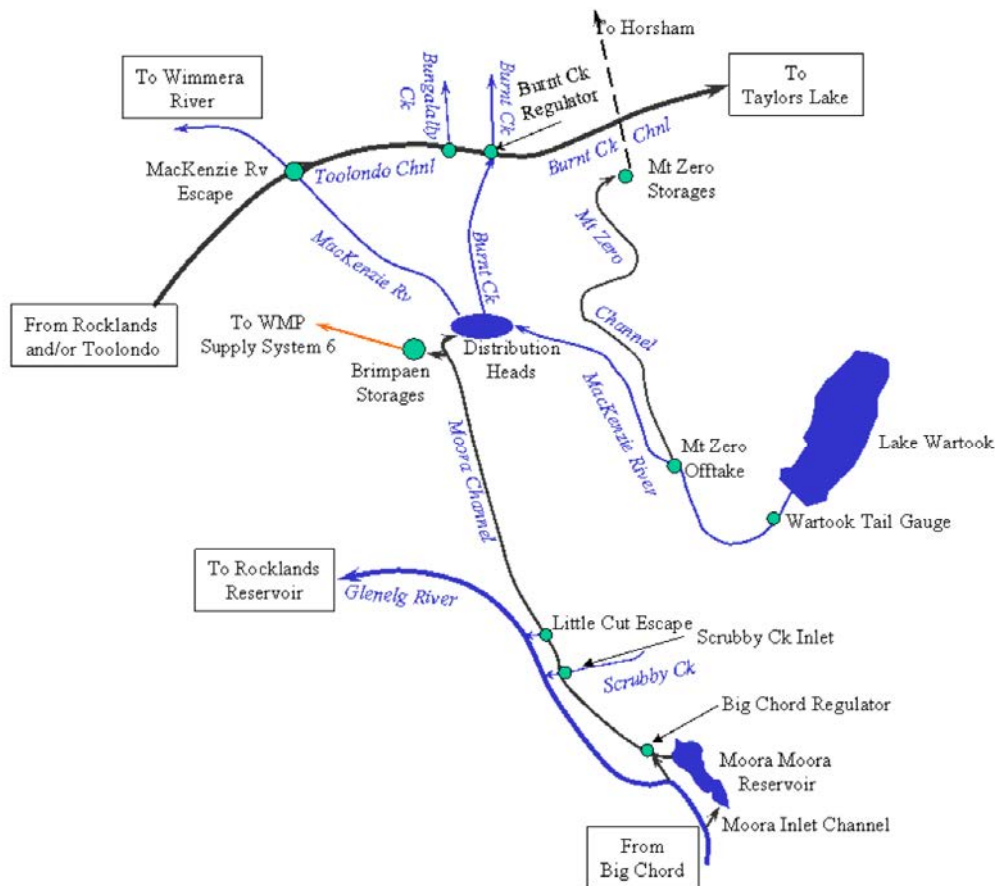
Water is diverted from the Glenelg River to the Wimmera basin at two locations:

- **Via the Moora Moora channel from direct channel pickup and from Moora Moora Reservoir**
- **Via the Rocklands-Toolondo channel from Rocklands Reservoir.**

Water is also harvested from the upper catchment of the Wannon River at three diversion weirs to supply Lake Bellfield in the Wimmera system.

Moora Moora Reservoir and the Moora Channel intercept store and divert a portion of the upper Glenelg catchment runoff (reach 0). The Moora Moora channel was completed in 1931 to supply irrigation waters to the Wimmera system.

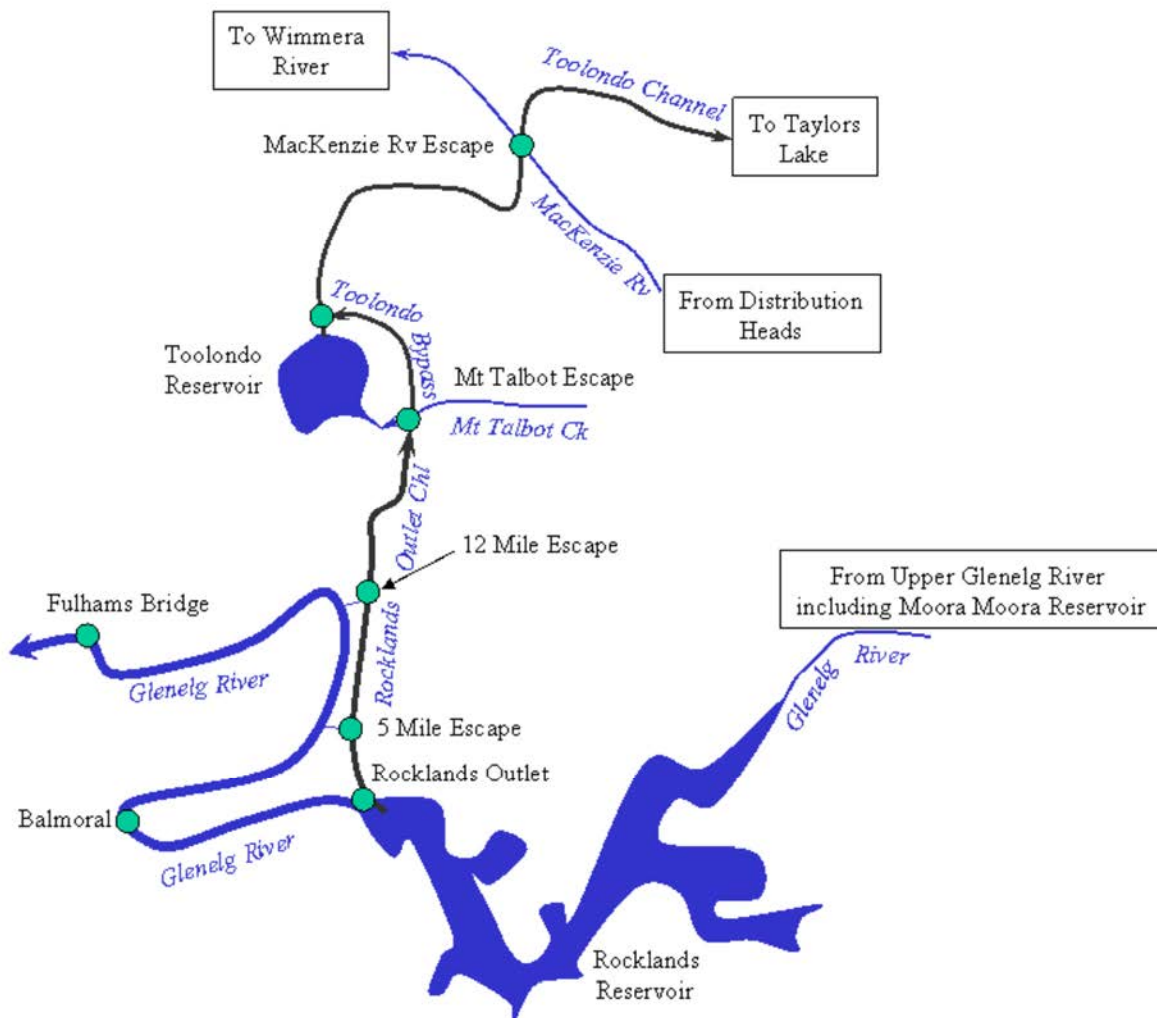
Moora Moora Reservoir was completed in 1933. Water stored in Moora Moora Reservoir can be transferred into the Wimmera system channel or can be discharged to the Glenelg River. However this system is not currently managed for environmental outcomes (Figure 8).



**Figure 8: Water supply infrastructure associated with the delivery of water from Moora Moora Reservoir (GWMWater)**

The Rocklands Reservoir and associated channels were constructed by the State Rivers and Water Supply Commission between 1941 and 1953. Rocklands Reservoir dam wall is approximately 15 km east of Balmoral. The infrastructure was originally constructed to supply the Wimmera–Mallee domestic and stock channel system.

Water releases from Rocklands Reservoir to the Glenelg River can be made directly into the river downstream of the storage into reach 1a. Water can also be delivered into reach 1b using the Rocklands–Toolondo Channel at the 5-Mile and 12-Mile outlets. Reach 2 receives through flows from reach 1a and reach 1b. Figure 9 shows the layout of the Rocklands Reservoir supply infrastructure.



**Figure 9: Water supply infrastructure associated with the delivery of water from Rocklands Reservoir (source: GWMWater)**



**Photo 11: (a) Moora Moora Reservoir (left) and (b) Rocklands Reservoir wall (right). (Photos GWMWater)**

The 5-Mile and 12-Mile outlets were constructed on the Rocklands –Toolondo channel as relief points to prevent uncontrolled channel overflows during large storm events. Both outlets were upgraded in 2007 to increase capacity for environmental flow releases.



**Photo 12: (a) 5-Mile outlet (left) and (b) 12-Mile outlet (right). Photo Glenelg Hopkins CMA**



## 7 Historical context

Historical development of infrastructure and natural drought and flood events have impacted on the condition of the Glenelg River. Figure 10 presents a timeline of significant events that have impacted the Glenelg River catchment. Note that events in red text represent a negative impact on the condition of the Glenelg River from pre-european conditions whilst green text indicates a positive event. Whilst it will never be possible to return to pre-european conditions, these positive events represent a move toward a more balanced and resilient system.

Extensive catchment wide land clearing in the late 1800s and historic agricultural practices have had the most significant influence on the current catchment condition. Riverine flooding has occurred frequently over the last 150 years. In late 2010 and January 2011, the Glenelg River catchment recorded heavy rainfall which resulted in record streamflows and extensive overbank flows.

A key event that contributed substantially to the current condition of the upper Glenelg River was the 2006 Mt Lubra Grampians bushfire. The bushfire was a large-scale and intense fire that profoundly affected the Grampians (Gariwerd) National Park landscape by removing significant amounts of catchment vegetation. This removal of terrestrial and riparian vegetation led to soil destabilisation and facilitated movement of sediment and ash into waterways (Chester, Robson, Johnston, Matthews, & Mitchell, 2014). Fires also occurred in 2013 and January 2014 in Victoria Valley that impacted small tributaries of the upper Glenelg River within the Grampians (Gariwerd) National Park.

**Positive Impacts**

August 1836 Pre European conditions as described by Major Mitchell, August 1836. (The Border Watch, 1936)  
 "We had no difficulty in going down the picturesque river with its limestone cliffs, timbered and festooned. Aquatic birds were numerous – ducks, pelicans, and swans. On the second day, the water was slightly brackish, the river increased in breadth to 101 yards, and in depth to five fathoms. It was, upon the whole, considering the permanent fullness of the stream, the character of its banks, and uniformity of width and depth, the finest body of fresh water I had seen in Australia. On re-entering the river from the open sea, I presented the men with a bottle of whisky with which it was formally named the Glenelg."



Fish passage improvement (photo GHCMA)



Instream habitat reinstatement (photo GHCMA)

2010 – current Increased environmental water releases resulting from completion of the Wimmera Mallee pipeline and increase in environmental entitlement.

2010 - 2011 Improvements in channel form and water quality following flood events.

2008 Instream habitat improvement. 870 logs inserted along 8.5km of Glenelg River at Casterton.

2004 Environmental water releases commence under the Flora and Fauna Guarantee Bulk Entitlement, 2004

2003 Friends of the Glenelg River formed

2001 – 2013 Six fish barriers removed

2000 CMA Glenelg River Restoration Program commenced (ongoing)

1870 Significant flood event

1906 Largest anecdotally recorded flood.

1946 Significant flood event

1950 – 1983 Soil Conservation Authority constructed erosion control structures

TIME

1836 European colonisation

1860

1885

1910

1935

1960

1985

2010



1946 flooding (photo GHCMA)



1920s – 1940s Severe rabbit plague exacerbating catchment erosion. During World War II the absence of men hunting and actively managing properties allowed rabbit numbers to increase.

1931-1933 Moora Moora diversion channel and reservoir completed. Diversions from Glenelg headwaters commence & continue to today.

1946 High sediment input from catchment erosion during floods

1953 Rocklands Reservoir and associated infrastructure completed. Impoundment and inter-basin transfer severely modified natural flow regime



De-snagging Glenelg River (photo GHCMA)



1960s & 1970s De-snagging of river.

2000 Carp recorded in river. Large population in Rocklands Reservoir, small numbers in river downstream

2004-2008 Millennium drought

2006 High sediment input from Mt Lubra Grampians bushfire

**Negative Impacts**

Figure 10: Timeline of key events that have impacted on the condition of the Glenelg River.

## 8 Water dependent values

### 8.1 Listings and significance

The 2010 Index of Stream Condition (ISC3) recorded waterways within the Glenelg River basin as being in the highest condition for the region (additional information on ISC3 can be found in section 8.2.1). The Glenelg River basin contains more than 150 threatened or near-threatened faunal species and ecological communities and falls within one of 15 recognised 'biodiversity hotspots' in Australia, and one of only two in Victoria (Glenelg Hopkins CMA, 2014).

The Glenelg River estuary and Long Swamp complex are in the process of being nominated for listing under the Ramsar Convention in recognition of the sites international significance as a wetland environment and bird habitat area. The estuarine reach is listed as a Heritage River under the *Heritage Rivers Act*, 1992.

#### 8.1.1 Aquatic Fauna

The Glenelg River supports a variety of aquatic fauna species. Seventy-nine native water dependent species have been recorded in the Glenelg River. Six of these species are listed nationally (EPBC Act) and 24 species are listed at a state level (FFG Act) and/or the Victorian Advisory List) (see Table 9). A full list of aquatic fauna species recorded in the Glenelg River can be found in Appendix 2. The Glenelg River supports a diverse fish community with high conservation significance. Nineteen species of native freshwater fish and 26 estuarine species have been recorded, and the system has a largely intact freshwater fish assemblage (McDowall, 1996).



**Photo 13: (a) Glenelg spiny crayfish (left) photo Glenelg Hopkins CMA; (b) western swamp crayfish (right) (photo: Nature Glenelg Trust)**



**Photo14: (a) Growling grass frog (left); (b) Southern toadlet (right)**

**Table 9: Significant water dependent fauna species recorded in the Glenelg River**

| Common Name            | Scientific name               | Reach |    |    |   | EPBC status | FFG status | Vic advisory list |
|------------------------|-------------------------------|-------|----|----|---|-------------|------------|-------------------|
|                        |                               | 0     | 1a | 1b | 2 |             |            |                   |
| <b>FISH</b>            |                               |       |    |    |   |             |            |                   |
| Yarra pygmy perch      | <i>Nannoperca obscura</i>     |       | √  | √  | √ |             | T          | V                 |
| Dwarf galaxias         | <i>Galaxiella pusilla</i>     | √     | √  | √  |   |             |            | E                 |
| Australian grayling    | <i>Prototroctes maraena</i>   |       |    |    | √ | V           | T          | V                 |
| Variegated pygmy perch | <i>Nannoperca variegata</i>   |       |    |    | √ | V           | T          | V                 |
| <b>INVERTEBRATES</b>   |                               |       |    |    |   |             |            |                   |
| Glenelg spiny crayfish | <i>Euastacus bispinosus</i>   | √     | √  | √  | √ | CE          | T          | E                 |
| Western swamp crayfish | <i>Gramastacus insolitus</i>  | √     |    |    |   |             | T          | E                 |
| <b>WATER BIRDS</b>     |                               |       |    |    |   |             |            |                   |
| Lewin's rail           | <i>Lewinia pectoralis</i>     | √     |    |    |   |             |            | V                 |
| Eastern great egret    | <i>Ardea modesta</i>          | √     | √  | √  | √ |             |            | V                 |
| Musk duck              | <i>Biziura lobata</i>         | √     | √  | √  | √ |             |            | V                 |
| Baillon's crane        | <i>Zapornia pusilla</i>       |       | √  | √  |   |             |            | V                 |
| Australasian bittern   | <i>Botaurus poiciloptilus</i> |       | √  | √  |   | CE          |            | E                 |
| Blue-billed duck       | <i>Oxyura australis</i>       |       | √  | √  |   | V           |            | E                 |
| Hardhead               | <i>Aythya australis</i>       |       | √  | √  |   |             |            | V                 |
| Pied cormorant         | <i>Phalacrocorax varius</i>   |       | √  | √  |   |             |            | NT                |
| Latham's snipe         | <i>Gallinago hardwickii</i>   |       | √  | √  | √ |             |            | NT                |
| Brolga                 | <i>Grus rubicunda</i>         |       |    |    | √ |             | T          | V                 |
| Hardhead               | <i>Aythya australis</i>       |       |    |    | √ |             |            | V                 |

| Common Name   | Scientific name                     | Reach |    |    |   | EPBC status | FFG status | Vic advisory list |
|---|-------------------------------------|-------|----|----|---|-------------|------------|-------------------|
|   |                                     | 0     | 1a | 1b | 2 |             |            |                   |
| Magpie goose  | <i>Anseranas semipalmata</i>        |       |    |    | √ |             |            | NT                |
| Azure kingfisher  | <i>Alcedo azurea</i>                |       |    |    | √ |             |            | NT                |
| Australasian shoveler   | <i>Anas rhynchotis</i>              |       |    |    | √ |             |            | V                 |
| <b>FROGS</b>  |                                     |       |    |    |   |             |            |                   |
| Growing grass frog  | <i>Litoria raniformis</i>           | √     | √  | √  |   | V           | T          | E                 |
| Brown toadlet   | <i>Pseudophryne bibronii</i>        |       | √  | √  |   |             |            | E                 |
| Southern toadlet  | <i>Pseudophryne semimarmorata</i>   | √     |    |    |   |             |            | V                 |
| <b>MAMMALS</b>  |                                     |       |    |    |   |             |            |                   |
| Swamp antechinus  | <i>Antechinus minimus maritimus</i> |       |    |    | √ |             |            | NT                |
| <p>Legend:</p> <p>√ recorded in reach</p> <p>EPBC status: Critically Endangered (CE), Vulnerable (V)</p> <p>FFG status: Threatened (T)</p> <p>Vic advisory list: Endangered (E), Near Threatened (NT), Vulnerable (V), Rare (R)</p> |                                     |       |    |    |   |             |            |                   |

Source: (Department of Environment, Land, Water and Planning, 2015) (Farrington & Bachmann, 2013)

### 8.1.2 Vegetation communities and flora

Water dependant vegetation is vitally important to the ecological structure and function of waterways, providing habitat, food, shade and protection against soil erosion (Water Technology, 2015).

Seventy-three native water dependant flora species have been recorded along the Glenelg River. Four of these species are listed as rare or threatened (see

Table 10), including the critically endangered Wimmera bottle brush listed under the EPBC Act. Wimmera bottle brush was first recorded in 2004 and is endemic to the Glenelg and Wimmera systems. A full list of flora species recorded in the Glenelg River can be found in Appendix 3. Major ecological vegetation classes (EVCs) present in the streamside and riparian zones of the Glenelg River and conservation status are presented in Table 11.

**Table 10: Significant flora species recorded on the Glenelg River**

| Common Name   | Scientific name                                  | Reach |    |    |   | EPBC status | FFG status | Vic advisory list |
|---|--|-------|----|----|---|-------------|------------|-------------------|
|   |  | 0     | 1a | 1b | 2 |             |            |                   |
| Wimmera bottlebrush   | <i>Callistomen wimmerensis</i>                   | √     | √  | √  | √ | CE          |            |                   |
| Lax marsh-flower  | <i>Ornduffia umbricola</i> var. <i>umbricola</i> |       | √  | √  |   |             |            | V                 |
| River leafless bossiaea   | <i>Bossiaea riparia</i>                          |       | √  | √  |   |             |            | R                 |
| Swamp fireweed  | <i>Senecio psilocarpus</i>                       |       |    |    | √ |             |            | V                 |
| <p>Legend:</p> <p>√ recorded in reach</p> <p>EPBC status: Critically Endangered (CE), Vulnerable (V)</p> <p>FFG status: Threatened (T)</p> <p>Vic advisory list: Endangered (E), Near Threatened (NT), Vulnerable (V), Rare (R)</p> |  |       |    |    |   |             |            |                   |

Source: (Department of Environment, Land, Water and Planning, 2015).

**Table 11: Current EVCs of Glenelg River reaches**

| Bioregion          | EVC Name  | EVC #      | Bioregional Conservation Status |
|--------------------|---|------------|---------------------------------|
| Reach 0            |   |            |                                 |
| Greater Grampians  | Floodplain thicket/ Wet heathland thicket             | 280/585    | Least concern                   |
|                    | Seasonally inundated shrubby woodland                 | 195        | Least concern                   |
|                    | Damp heath scrub/ Heath woodland complex              | 165/865    | Least concern                   |
|                    | Sand heathland  | 6          | Least concern                   |
| Dundas Tablelands  | Floodplain thicket                                    | 280        | Vulnerable                      |
|                    | Seasonally inundated shrubby woodland                 | 195        | Depleted                        |
| Reaches 1a and 1 b |   |            |                                 |
| Dundas Tablelands  | Floodplain thicket                                    | 280        | Vulnerable                      |
|                    | Plains grassy woodland/ Plains grassy woodland mosaic | 55/745/752 | Endangered                      |
|                    | Shrubby woodland                                      | 282        | Vulnerable                      |

| Bioregion         | EVC Name                     | EVC # | Bioregional Conservation Status |
|-------------------|------------------------------|-------|---------------------------------|
|                   | Riparian woodland            | 641   | Endangered                      |
|                   | Floodplain riparian woodland | 56    | Vulnerable                      |
|                   | Shallow sands woodland       | 882   | Vulnerable                      |
| River Reach 2     |                              |       |                                 |
| Dundas Tablelands | Floodplain riparian woodland | 56    | Vulnerable                      |
|                   | Riparian woodland            | 641   | Endangered                      |
|                   | Grassy woodland              | 719   | Endangered                      |

### 8.1.3 Terrestrial flora and fauna dependent on riparian habitat

Due to large-scale land clearance downstream of the Grampians (Gariwerd) National Park terrestrial species dependence on the riparian zone is increased. One hundred and thirty native terrestrial fauna species and 421 native terrestrial flora species were recorded within 200 m of the Glenelg River. Of these 18 fauna species and 14 flora species are listed as rare and threatened (see Table 12).

**Table 12: Terrestrial fauna and flora species in the Glenelg River riparian zone**

| Common Name        | Scientific Name                        | Reach |    |    |   | EPBC status | FFG status | Vic advisory list |
|--------------------|--|-------|----|----|---|-------------|------------|-------------------|
|                    |  | 0     | 1a | 1b | 2 |             |            |                   |
| FAUNA              |  |       |    |    |   |             |            |                   |
| Emu                | <i>Dromaius novaehollandiae</i>        | √     | √  | √  |   |             |            | NT                |
| Hooded robin       | <i>Melanodryas cucullata cucullata</i> | √     | √  | √  |   |             |            | NT                |
| Heath mouse        | <i>Pseudomys shortridgei</i>           | √     |    |    |   | V           | L          | NT                |
| Brown treecreeper  | <i>Climacteris picumnus victoriae</i>  | √     | √  | √  | √ |             |            | NT                |
| Malleefowl         | <i>Leipoa ocellata</i>                 | √     |    |    |   | V           | L          | E                 |
| Square-tailed kite | <i>Lophoictinia isura</i>              |       | √  | √  |   |             |            | V                 |
| Speckled warbler   | <i>Chthonicola sagittatus</i>          |       | √  | √  |   |             |            | V                 |
| Pied cormorant     | <i>Phalacrocorax varius</i>            |       | √  | √  |   |             |            | NT                |



| Common Name               | Scientific Name                  | Reach |    |    |   | EPBC status | FFG status | Vic advisory list |
|---------------------------|----------------------------------|-------|----|----|---|-------------|------------|-------------------|
|                           |                                  | 0     | 1a | 1b | 2 |             |            |                   |
| Black-eared cuckoo        | <i>Chrysococcyx osculans</i>     |       | √  | √  | √ |             |            | NT                |
| Diamond firetail          | <i>Stagonopleura guttata</i>     |       | √  | √  |   |             |            | NT                |
| Powerful owl              | <i>Ninox strenua</i>             |       | √  | √  |   |             |            | V                 |
| Masked owl                | <i>Tyto novaehollandiae</i>      |       | √  | √  |   | CE          |            | E                 |
| Red-tailed black Cockatoo | <i>Calyptorhynchus banksii</i>   |       | √  | √  |   | CE          |            | E                 |
| Australasian shoveler     | <i>Anas rhynchotis</i>           |       |    |    | √ |             |            | V                 |
| White-throated needletail | <i>Hirundapus caudacutus</i>     |       |    |    | √ |             |            | V                 |
| Southern brown bandicoot  | <i>Isoodon obesulus obesulus</i> |       |    |    | √ |             |            | NT                |
| Barking owl               | <i>Ninox connivens connivens</i> |       |    |    | √ |             |            | E                 |
| Striped legless lizard    | <i>Delma impar</i>               |       |    |    | √ | V           | L          | E                 |
| FLORA                     |                                  |       |    |    |   |             |            |                   |
| Thready bush-pea          | <i>Pultenaea luehmannii</i>      | √     |    |    |   |             |            | R                 |
| Grampians thryptomene     | <i>Thryptomene calycina</i>      | √     |    |    |   |             |            | R                 |
| Tufted grass-tree         | <i>Xanthorrhoea caespitosa</i>   | √     | √  | √  | √ |             |            | R                 |
| Short-leaf bog-sedge      | <i>Schoenus laevigatus</i>       | √     |    |    |   |             |            |                   |
| Reader's daisy            | <i>Brachyscome readeri</i>       |       | √  | √  |   |             |            | R                 |
| Quinetia                  | <i>Quinetia urvillei</i>         |       | √  | √  |   |             |            | R                 |
| Fringed sun-orchid        | <i>Thelymitra luteocilium</i>    |       | √  | √  |   |             |            | R                 |
| Prickly arrowgrass        | <i>Triglochin mucronata</i>      |       | √  | √  |   |             |            | R                 |

| Common Name             | Scientific Name                       | Reach |    |    |   | EPBC status | FFG status | Vic advisory list |
|-------------------------|---------------------------------------|-------|----|----|---|-------------|------------|-------------------|
|                         |                                       | 0     | 1a | 1b | 2 |             |            |                   |
| Buloke                  | <i>Allocasuarina luehmannii</i>       |       | √  | √  |   |             |            | E                 |
| Clover glycine          | <i>Glycine latrobeana</i>             |       |    |    | √ |             |            | V                 |
| River leafless bossiaea | <i>Bossiaea riparia</i>               |       |    |    | √ |             |            | R                 |
| Parsley xanthosia       | <i>Xanthosia leiophylla</i>           |       |    |    | √ |             |            | R                 |
| Hairy boronia           | <i>Boronia pilosa subsp. torquata</i> |       |    |    | √ |             |            | R                 |
| Ivy flat pea            | <i>Platylobium triangulare</i>        |       |    |    | √ |             |            |                   |

Legend:

√ recorded in reach

EPBC status: Critically Endangered (CE), Vulnerable (V)

FFG status: Threatened (T)

Vic advisory list: Endangered (E), Near Threatened (NT), Vulnerable (V), Rare (R)

Source: (Department of Environment, Land, Water and Planning, 2015) (Farrington & Bachmann, 2013).

## 8.2 Current condition

### 8.2.1 Index of Stream Condition

The Index of Stream Condition (ISC) measures the environmental condition of river reaches. The 2010 ISC assessment (ISC3) sub-indices and trajectories for the Glenelg River are shown in Table 13. It should be noted that due to altered sampling strategies the ISC3 report presents a 'snapshot' and measures should not be used for direct comparison of river health with previous ISC assessments.

#### Hydrology

The ISC3 assessment coincided with a drought period; with conditions impacting on several measures, in particular water quality and hydrology (Glenelg Hopkins CMA, 2014). Streams in the Portland and Glenelg basins were some of the most climate-stressed in Victoria (Department of Environment and Primary Industries, 2011). Flow stress scores from the ISC3 assessment varied significantly along the Glenelg River. Reach 0 within the Grampians (Gariwerd) National Park and downstream of the Wannon River confluence (reach 3) received the poorest scores. This may be due to the variation and duration of the summer baseflow (Department of Environment and Primary Industries, 2011). Reaches 1a and 1b reflected near-natural flow regimes, scoring highly. This section of the river, being downstream of Rocklands and 5-Mile outlet, gains the greatest environmental watering benefit. Prior to environmental water releases, reaches 1a and 1b were severely degraded.

#### Vegetation

The ISC3 vegetation assessment scores relate to the width and continuity of native vegetation in the riparian zone. The lower (moderate) vegetation scores were along reaches 1a, 1b, and 2. The majority of river frontage along these reaches is grazing land.

#### Fish

The ISC3 aquatic life assessment shows the majority of the Glenelg River in moderate to good condition. Reach 0 immediately upstream from Rocklands Reservoir scored poorly.

**Table 13: 2011 Index of Stream Condition sub-indices and trajectories for the Glenelg River (Department of Environment and Primary Industries, 2011).**

| ISC reach No. | E-flow reach | Reach length (km) | Hydrology | Physical form | Streamside zone | Water quality | Aquatic life | Overall ISC score | Condition |
|---------------|--------------|-------------------|-----------|---------------|-----------------|---------------|--------------|-------------------|-----------|
| 13            | 0            | 44.4              | 3         | 5             | 8               | 7             | 6            | 25                | Moderate  |
| 12            | 0            | 22                | 3         | 5             | 9               |               | 3            | 20                | Poor      |
| 11            | 1a           | 52.8              | 8         | 8             | 8               | 6             | 8            | 37                | Good      |
| 10            | 1b           | 57.8              | 8         | 8             | 7               |               | 6            | 34                | Moderate  |
| 9             | 1b/2         | 22                | 8         | 8             | 7               |               | 9            | 39                | Good      |
| 8             | 2            | 36.8              | 4         | 7             | 7               |               | 9            | 31                | Moderate  |

| ISC reach No. | E-flow reach | Reach length (km) | Hydrology | Physical form | Streamside zone | Water quality | Aquatic life | Overall ISC score | Condition |
|---------------|--------------|-------------------|-----------|---------------|-----------------|---------------|--------------|-------------------|-----------|
| 7             | 2            | 33.9              | 4         | 5             | 7               |               | 9            | 27                | Moderate  |
| 6             | 2            | 22.1              | 4         | 5             | 7               | 7             | 9            | 28                | Moderate  |
| 5             | 3            | 20.5              | 2         | 5             | 9               | 6             | 8            | 24                | Moderate  |
| 4             | 3            | 16.7              | 2         | 5             | 9               |               | 8            | 24                | Moderate  |
| 3             | 3            | 60                | 2         | 5             | 8               |               | 9            | 24                | Moderate  |
| 2             | 3            | 17.9              | 3         | 8             | 9               | 8             | 8            | 32                | Moderate  |
| 201           | Estuary      | 47.2              | 3         | 10            | 8               |               |              | 30                | Moderate  |
| 202           | Estuary      | 10.5              | 3         | 10            | 9               |               | 8            | 33                | Moderate  |

### 8.2.2 Victorian Environmental Flow Monitoring and Assessment Program

The Glenelg River has been part of the Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) since 2006. The program involves standardised monitoring of key indicators to test the hypotheses used in developing flow recommendations (refer to Section 0). Fish, vegetation and water quality monitoring undertaken as part of the VEFMAP during 2013–14 and 2014–15 has noted the following:

- **Native fish continue to recolonise the river, with fish community diversity increasing at most sites in recent years**
- **The abundance of key fish species, including recreationally important species continues to increase in the freshwater reaches, particularly river blackfish, estuary perch, black bream and tupong**
- **Migratory species such as eel, bream, estuary perch and tupong have responded strongly following environmental flows delivered as part of a suite of river health works**
- **Since 2011, estuary perch have increased their range in the Glenelg River by around 100 km**
- **Carp numbers remain low**
- **Water quality parameters remain within target ranges as per State Environment Protection Policy (Waters of Victoria) guidelines (Environment Protection Authority, 2003) at all monitoring sites**
- **2015 water quality results demonstrate that a lens of fresh, well oxygenated water was maintained within reach 1b**
- **Widespread flowering of the endangered Wimmera bottlebrush was observed in December 2013**
- **Recruitment of a range of riparian and instream plant species occurred at sites protected from grazing (Glenelg Hopkins CMA, 2014) (Glenelg Hopkins CMA, 2015).**

## Vegetation

VEFMAP vegetation surveys conducted in 2009 along reach 1a to reach 2 recorded 157 native species and 68 exotic weed species. The survey recorded a notable reduction in the shrub layer, and an increase in exotic vegetation along the survey area. Species richness of aquatic and amphibious species was limited. The area with the greatest species richness was identified as Zone C (midway up bank to toe of bank). However, field inspections conducted in March 2013 found an increase in the presence of submerged and semi-emergent aquatic plants. Riparian and floodplain vegetation at a study site on reach 1a (Weaver's Crossing) included a species-rich and apparently healthy mosaic of canopy-layer trees, mostly river red gum, a shrub layer that included *Wimmera* bottlebrush, and a ground layer of native grasses, herbs and forbs (Alluvium, 2013).

## Fish

The 2015 VEFMAP fish survey detected successful recruitment in most fish species. Both river blackfish and variegated pygmy perch have shown a strong spawning response, especially in reach 2. Failure to provide a suitable flow regime will threaten the survival of these ecologically important species.

The 2015 VEFMAP fish surveys captured 1,916 fish, comprising 18 species. Tupong abundance continues to increase along with its geographical distribution throughout the river. River blackfish distribution and abundance remained stable relative to previous years. Approximately 87% of fish captured were native species and the remaining 13% were exotic species. The most abundant native fish recorded were the variegated pygmy perch (36%), flat-headed gudgeon (23%), river blackfish (18%) and carp gudgeon complex (8%) (Austral Research and Consulting, 2014). The improved distribution and abundance of fish species is a positive indicator for the environmental flow and broader river health program.

The majority of exotic fish species were caught in reaches 1 and 2. These species included eastern gambusia, common carp, goldfish, redfin perch and tench.

### **Case study: Tupong abundance and distribution in the Glenelg River based on VEFMAP surveys conducted from 2009–2014** (Austral Research and Consulting, 2014)

A total of 67 tupong were recorded during the annual VEFMAP surveys from 2009 to 2014. The 2014 survey recorded the highest number of individuals (49) and also observed the widest geographical range with captures in reaches 1b, 2 and 3.

Previous surveys had produced sporadic captures of low numbers, with the species confined to reach 3. In 2009 only one individual was recorded, while two were recorded in 2010. Prior to the 2014 survey, the highest number of tupong encountered was 18 in 2013.

Improved water quality and habitat connectivity from environmental watering are likely to have contributed to increased tupong abundance. The Sandford fishway was installed in 2013 and has been shown to assist the upstream movement of tupong (Austral, 2014).

Despite the relatively small numbers recorded, there appears to be an overall trend of increasing numbers. It is likely that increased habitat connectivity through removal of a physical barrier, and improved water quality and connectivity through environmental flows have played a role in assisting this migratory species.

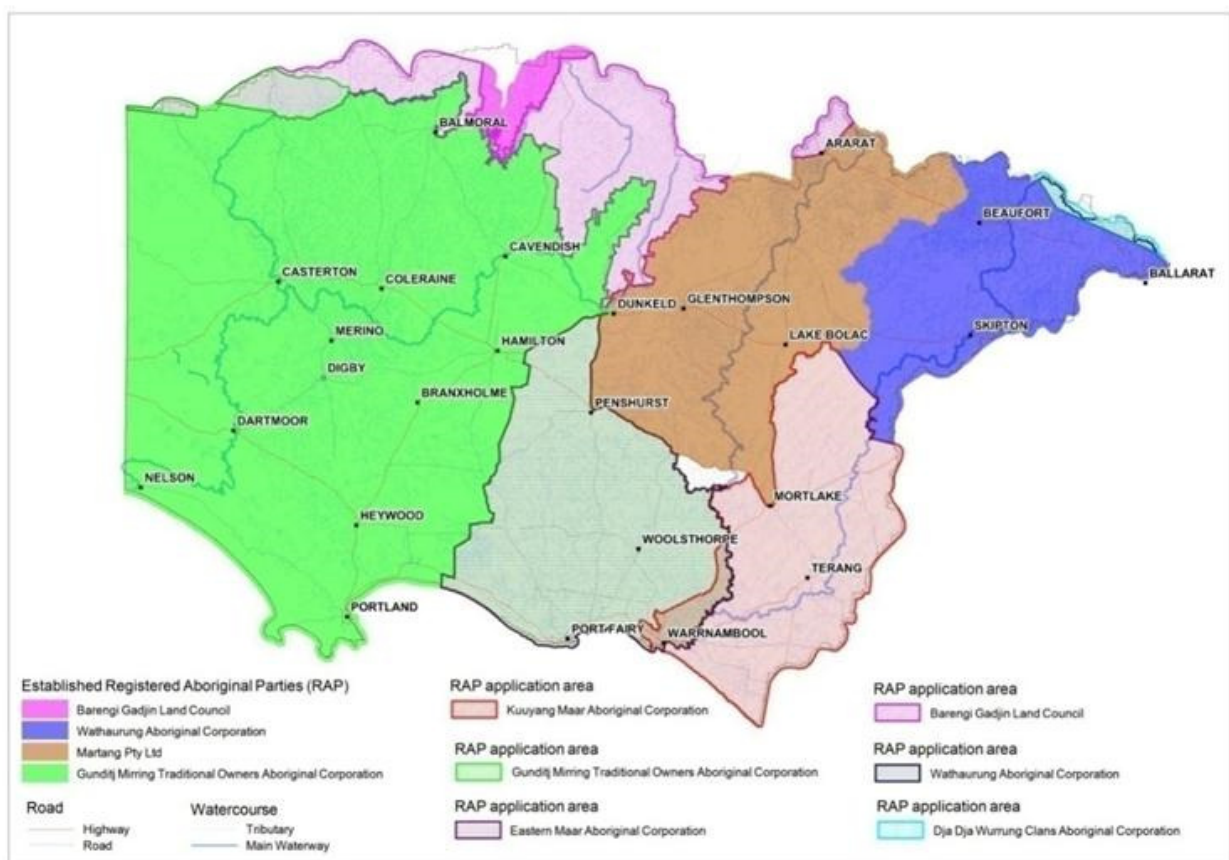


**Photo 15: Tupong (*Pseudaphritis urvillii*) (Photo: Austral)**

## 9 Aboriginal values

Water is the lifeblood of a healthy Country and is intrinsically linked to the cultural and spiritual identity of Aboriginal people. Through their strong connection to country, Aboriginal people feel that the land and water is an integral part of their identity and that they in turn form part of the land and waters (National Cultural Flows Research Project, 2014).

Aboriginal people have sustainably used the waterways in the Glenelg Catchment for at least the past 11,000 years (Glenelg Hopkins CMA, 2014). The Glenelg River and its waters flow through landscapes which are culturally significant to several Traditional Owner groups, who are represented through either the Barengi Gadjin Land Council or Gunditj Mirring RNTBC. Both organisations have been recognised by the Federal Court of Australia as Prescribed Body Corporates under the *Native Title Act*, 1993 and as Registered Aboriginal Parties under the *Aboriginal Heritage Act*, 2006 (Figure 11) .



**Figure 11: Registered Aboriginal Parties (RAPs) and RAP applicants in the Glenelg Hopkins CMA area 2015**

Water is the lifeblood of a healthy country and is intrinsically linked to the cultural and spiritual identity of Aboriginal people. Through their strong connection to Country, Aboriginal people feel that the land and water is an integral part of their identity and that they in turn form part of the land and waters (National Cultural Flows Research Project, 2014).

Access to water and healthy waterways is important for many cultural practices. The region's rivers, estuaries and wetlands have been and continue to be used as sources of food, medicines, fibres and implements. There is physical evidence of historic use in the form of shell middens, oven mounds, stone quarries (important educational sites), fish traps and scarred trees along the Glenelg River (Glenelg Hopkins CMA, 2013). Some sites may have no

observable features but are important for links to places of spiritual or ceremonial significance, resources, trade, travel or stories (Department of Environment and Primary Industries, 2013).

Of some 35,000 Aboriginal places and significant sites recorded on the Aboriginal Heritage Register, 95% occur within 1 km of a waterway or waterbody (Federation of Victorian Traditional Owner Corporations, 2014).

The Glenelg River is very important to the region's Indigenous people, particularly because of its diverse and unique fish assemblage that includes short-finned eel and the federally listed Glenelg spiny crayfish. Customary catch of eels still occurs in some areas. Both the short-finned eel and the Glenelg spiny crayfish are priority species for the environmental watering program. The long-necked tortoise is also an important food source and considered a cultural indicator species for seasonal change for the Barengi Gadjin people (Glenelg Hopkins CMA, 2014).

*Centipeda cunninghamii*, also called old man weed, is an important Indigenous riparian vegetation species due to its healing properties. Old man weed has been recorded along the Glenelg River from Rocklands Reservoir to the estuary. Vigour and growth correspond to inundation and water availability (pers. comm., David Pitts, DELWP, 2015).

### Aboriginal Water Scoping Project June 2015–December 2016

Glenelg Hopkins CMA, in partnership with Gunditj Mirring Traditional Owners Aboriginal Corporation and Barengi Gadjin Land Council, is developing an Aboriginal Water scoping project for the Glenelg River system from June 2015 to December 2016.

Knowledge and information gained through this scoping project will:

- **provide opportunity to conserve traditional water knowledge**
- **establish a shared understanding of Aboriginal water in the Glenelg River**
- **ensure informed management decisions in the implementation of EWMPs**
- **appropriately incorporate Aboriginal values and uses in relation to water resources**
- **build a case to further develop cultural flow objectives and cultural flow requirements along with awareness of the significance of cultural flows.**

## 10 Socio-economic values

Along with achieving environmental targets, environmental flows provide valuable social and economic benefits to communities living along the river and within the region.

### 10.1 Community values

Key recreational uses of the Glenelg River include fishing, hunting, boating, swimming and camping.

Recreational fishing makes an important social and economic contribution to communities in the Glenelg Hopkins region. Recreational fishing is highly dependent on the health of the environment, including availability of suitable habitat, water quality and flow regimes to sustain productive fisheries (Glenelg Hopkins CMA, 2014). With the exception of Rocklands Reservoir which receives recreational fish stockings, all recreational fisheries within the Glenelg River are self-sustaining. The entire length of the Glenelg River has many popular fishing areas and the estuary is considered to be highly valued by recreational fishers year round.

“As an avid angler, I’ve spent countless hours over many years on the Glenelg River. There has been a real and tangible improvement in the health of the river and this is very evident in the stocks and condition of the native fish like estuary perch and black bream as well as waterbirds and the wildlife in and around the river” – Shane Lowery, Administrator, South West Victoria Fishing Reports.

### 10.2 Economic values

The Glenelg River supports a range of enterprises along its length. Some of the key economic values it supports include:

- **A water source for rural towns**
- **Water for dryland stock watering**
- **Businesses associated with tourism and recreational activities.**

The township of Casterton is a centre for retail trade, farming and forestry services, health, education, government and community services for the 4,000 residents in the township and surrounding districts.

“When the river has flow in it the feeling in town is more buoyant and positive than when it’s dry. We’re naturally attracted to water. Water brings people to the town and they spend money with local traders”. – Michael McNamara, President of Casterton Business and Development Association.

Ultimately a healthy and functioning Glenelg River provides a variety of services central to riverside towns and the region’s economic viability and liveability.

A report undertaken by (Aither, 2015) assessed the economic values associated with delivering environmental flows on the Glenelg River. The total benefits were calculated at a conservative \$34.1 million to the Victorian economy.



**Case study: Securing one of Australia's best restoration projects**

In 2013 the Glenelg Hopkins CMA was awarded the Australian Riverprize by the International River Foundation for the Glenelg River Restoration Project.

From 2000, more than 659 individual landholders along with community groups and government agencies have constructed 1,752 km of fencing, planted more than half a million trees and direct-seeded 796 km of waterway frontage. In addition 870 pieces of large wood have been reinstated to the river and 2,784 ha of weed control carried out, totalling more than \$17 million of Government investment in the river. The establishment and delivery of environmental flows have been critical factors in the success of the project.

Environmental flows work together with the improved riparian vegetation and instream structural diversity to create a healthier Glenelg River system. The continued delivery of environmental flows will ensure the benefits of the significant investment are maintained into the future.



*Photo 16: Glenelg River estuary (Photo Glenelg Hopkins CMA)*

## 11 Hydrological requirements to support ecological objectives

Hydrological requirements (environmental flow recommendations) to achieve the ecological objectives listed in Table 2 are summarised in Table 14 to Table 17. Conceptual models for each ecological objective are provided in Appendix 4.



*Photo 17: Glenelg River reach 2 under June–November baseflow conditions (Photo: Glenelg Hopkins CMA)*

Table 14: Hydrological requirements – reach 0, Moora Moora Reservoir to Rocklands Reservoir pondage (Water Technology, 2015)

| Flow component | Period  | Magnitude                          | Condition                   | Frequency   | Duration   | EWMP objectives achieved  | Other objectives achieved   |
|----------------|---|------------------------------------|-----------------------------|---|--|---|---|
| Cease to flow  | Dec–May   | <0.1 ML/d                          | DROUGHT                     | Every year  | < 2 months   |   | None of the environmental objectives require a cease to flow. This recommendation acknowledges that cease to flows naturally occur and provides guidance to ensure that stress on the environmental values is not exacerbated beyond the point of no return                                       |
|                |   |                                    | DRY                         | 2 in 10 years   | < 2 months   |   |   |
|                |   |                                    | AVERAGE                     | Never   | N/A  |   |   |
|                |   |                                    | WET                         |   |  |   |   |
| Jun–Nov        | <0.1 ML/d   | ALL CONDITIONS                     | Never                       | N/A   |  |   |   |
| Baseflow       | Dec–May   | < 1 ML/d at Big Cord               | DROUGHT                     | Continuous (outside of cease to flow periods in dry and drought years)  |  | river blackfish <sup>1,2</sup>  | Edge habitat, pools and shallow water habitat for macroinvertebrates (western swamp cray) and fish and platypus<br><br>Prevent excessive instream terrestrial species growth<br><br>Promote instream vegetation   |
|                |   | <2–3 ML/d downstream of Scrubby Ck | DRY/<br>AVERAGE             |   |  | tupong <sup>3,4</sup>   |   |
|                |   | 3 ML/d at Big Cord                 | WET                         |   |  | short-finned eel <sup>3,4</sup>                                       |   |
|                |   | 6–9 ML/d downstream of Scrubby Ck  |                             |   |  | Glenelg spiny crayfish<br>variegated pygmy perch <sup>5</sup>         |   |
| Jun–Nov        | 10 ML/d at Big Cord<br>20–30 ML/d d/s of Scrubby Ck | ALL                                | Continuous                  | river blackfish <sup>1,2</sup><br>tupong <sup>3,4</sup><br>short-finned eel <sup>3,4</sup><br>Glenelg spiny crayfish<br>variegated pygmy perch <sup>5</sup> | Maintain shallow water availability, water quality and habitat connectivity for macroinvertebrates (freshwater crayfish)<br><br>Maintain water quality in pools, inundating woody debris for egg dispersal and habitat connectivity for fish<br><br>Facilitate annual dispersal of juvenile platypus<br><br>Improves habitat diversity |   |   |
| Freshes        | Dec–May   | 5–10 ML/d at Big Cord              | DROUGHT/<br>DRY/<br>AVERAGE | 3 per season  | 4 to 5 days  | variegated pygmy perch (W and A) <sup>5</sup><br><br>short-finned eel | Flow over wood debris to increase biofilm abundance as a food source to support macroinvertebrates, diverse habitats and water quality<br><br>Facilitate scour of sand for fish habitat<br><br>Maintain condition of emergent vegetation by wetting lower banks<br><br>Wetting high flow channels |
|                |   | 10–30 ML/d d/s of Scrubby Ck       |                             | 1 per season  | 1 week   |   |   |
|                |   | 10–20 ML/d at Big Cord             | WET                         | 4 per season  | 4 to 5 days  |   |   |
|                |   | 20–60 ML/d d/s of Scrubby Ck       |                             | 4 per season  | 1 week   |   |   |
|                | Jun–Nov   | 10–20 ML/d at Big Cord             | DROUGHT                     | 3 to 4 per season   | 1 to 2 weeks   | river blackfish (W and A) <sup>1</sup>                                | Facilitate scour of sand for fish habitat   |

|                       |         |   |                       |   |   |   |  |
|-----------------------|---------|---|-----------------------|---|---|---|--|
|                       |         | 20–60 ML/d d/s of Scrubby Ck                              | DRY<br>AVERAGE<br>WET | In winter–spring season at the Big Cord gauge it seems that 'freshes' are replaced by widespread inundation of the anastomosing floodplain. | tupong <sup>3</sup><br>short-finned eel <sup>3</sup><br>Glenelg spiny crayfish<br>variegated pygmy perch (W and A) <sup>5</sup> | Provide stimulus and opportunity for fish dispersal.<br>Provide stimulus and opportunity for upstream and downstream fish migration <sup>4</sup><br>Improve in-channel diversity by maintaining pools<br>Wet up streamside zone allowing riparian plants to remain watered over winter period, promoting flower, seed and germination |  |
| Bankfull              | Jun–Nov | 30–50 ML/d at Big Cord                                    | DROUGHT/D<br>RY       | 2–3 per<br>season   | 1 week  | Wimmera bottle brush<br>Glenelg spiny crayfish (winter)   | Inundate riparian vegetation to maintain condition and facilitate recruitment<br>Entrain organic debris from the floodplain to support macroinvertebrates (western swamp cray)<br>Maintain structural integrity of channel<br>Provide some disturbance by turning over cobbles and boulders, cleaning accumulated biofilms, uprooting smaller plants, washing propagules downstream etc.<br>2–3 times per decade for Wimmera bottlebrush |
|                       |         | 60–150 ML/d d/s of Scrubby Ck                             | AVERAGE/W<br>ET       | 3 per<br>season   | 1 week  |   |  |
| Overbank <sup>6</sup> | Jun–Nov | > 50 ML/d at Big Cord<br>> 100–150 ML/d d/s of Scrubby Ck | DROUGHT               | 1–2 per<br>season.  | 1 week.   | Wimmera bottle brush<br>Glenelg spiny crayfish (winter)   | Inundate floodplain vegetation to maintain condition and facilitate recruitment<br>Entrain organic debris from the floodplain to support macroinvertebrates.<br>Maintains floodplain geomorphic features<br>2–3 times per decade for Wimmera bottlebrush<br>2–5 times per decade for Tea-tree and Red Gum  |
|                       |         |   | DRY                   | 5–8 per<br>season.  | 40 days total<br>per season.  |   |  |
|                       |         |   | AVERAGE/W<br>ET       | 5–10 per<br>season.   | 50% of the<br>season is<br>overbank.  |   |  |

<sup>1</sup> Priority objective – river blackfish. Second tier objectives – southern pygmy perch, mountain galaxias, flat-headed dudgeon and Australian smelt

<sup>2</sup> Yarra pygmy perch – occurs in slow-moving and still waters (low flows, wetlands and flood-runners)

<sup>3</sup> Priority objective – tupong and short-finned eel. Second tier objectives – spotted galaxias, climbing galaxias, common galaxias, pouched lamprey, short-headed lamprey, black bream, elongate hardyhead, small-mouthed hardyhead and estuary perch

<sup>4</sup> Australian grayling – lower priority because no confirmed sightings since 1984 and migration to this reach blocked by Rocklands Reservoir

<sup>5</sup> Priority objective – variegated pygmy perch. Second tier objectives – southern pygmy perch, dwarf galaxias

<sup>6</sup> The release capacity of Moora Moora reservoir is 25 ML/d; there is no ability to create overbank flows

W and A: wet and average year

Table 15: Hydrological requirements - reach 1a Glenelg River from Rocklands to 5-mile outfall (Alluvium, 2013)

| Flow component                | Period                          | Magnitude          | Condition           | Frequency                   | Duration  | EWMP objectives achieved  | Other objectives achieved   |        |
|-------------------------------|---------------------------------|--------------------|---------------------|-----------------------------|---|---|---|--------|
| Cease to flow                 | Dec–May                         | 0 ML/d             | DROUGHT             | As infrequently as possible | < 145 days  |   | None of the environmental objectives require a cease to flow. This recommendation acknowledges that cease to flows naturally occur and provides guidance to ensure that stress on the environmental values is not exacerbated beyond the point of no return                                       |        |
|                               |                                 |                    | DRY                 |                             | < 125 days  |   |   |        |
|                               |                                 |                    | AVERAGE             |                             | < 110 days  |   |   |        |
|                               |                                 |                    | WET                 |                             |   |   |   |        |
|                               | Jun–Nov                         | 0 ML/d             | DROUGHT             | As infrequently as possible | < 110 days  |   |   |        |
|                               |                                 |                    | DRY                 |                             | < 55 days   |   |   |        |
|                               |                                 |                    | AVERAGE             |                             | <35 days  |   |   |        |
|                               |                                 |                    | WET                 |                             |   |   |   |        |
| Baseflow                      | Dec–May                         | 10 ML/d or natural | ALL                 | Continuous                  | river blackfish <sup>1,2</sup>  | Edge habitat, pools and shallow water habitat for, macroinvertebrates (western swamp cray) and fish and platypus<br><br>Prevent excessive instream terrestrial species growth<br><br>Promote instream vegetation  |   |        |
|                               |                                 |                    |                     |                             | tupong <sup>3,4</sup>   |   |   |        |
|                               | short-finned eel <sup>3,4</sup> |                    |                     |                             |   |   |   |        |
|                               | Glenelg spiny crayfish          |                    |                     |                             |   |   |   |        |
| Baseflow                      | Jun–Nov                         | 60 ML/d or natural | ALL                 | Continuous                  | variegated pygmy perch <sup>5</sup>   |   |   |        |
|                               |                                 |                    |                     |                             | river blackfish <sup>1,2</sup>  | Maintain shallow water availability, water quality and habitat connectivity for macroinvertebrates (western swamp cray)<br><br>Maintain water quality in pools, inundating woody debris for egg dispersal and habitat connectivity for fish<br><br>Facilitate annual dispersal of juvenile platypus<br><br>Improves habitat diversity |   |        |
|                               | tupong <sup>3,4</sup>           |                    |                     |                             |   |   |   |        |
|                               | short-finned eel <sup>3,4</sup> |                    |                     |                             |   |   |   |        |
| Glenelg spiny crayfish        |                                 |                    |                     |                             |   |   |   |        |
| Freshes                       | Dec–May                         | 60 ML/d            | DROUGHT             | 2 per period                | 2 days  | variegated pygmy perch (W and A) <sup>5</sup>   | Flow over wood debris to increase biofilm abundance as a food source to support macroinvertebrates, diverse habitats and water quality<br><br>Facilitate scour of sand for fish habitat<br><br>Maintain condition of emergent vegetation by wetting lower banks<br><br>Wetting high flow channels |        |
|                               |                                 |                    | DRY                 |                             | 3 days  |   |   |        |
|                               |                                 |                    | AVERAGE             |                             | 3 days  |   |   |        |
|                               |                                 |                    | WET                 |                             | 3 days  |   |   |        |
|                               | Jun–Nov                         | 550 ML/d           | DROUGHT             | 1 per period                | 1 day   | river blackfish (W and A) <sup>1</sup>  |   |        |
|                               |                                 |                    | DRY                 |                             | 2 per period  |   |   | 3 days |
|                               |                                 |                    | AVERAGE             |                             | 3 per period  |   |   | 5 days |
|                               |                                 |                    | tupong <sup>3</sup> |                             | Facilitate scour of sand for fish habitat<br><br>Provide stimulus and opportunity for upstream and downstream fish migration <sup>4</sup><br><br>Improve in-channel diversity by maintaining pools and inundating benches |   |   |        |
| short-finned eel <sup>3</sup> |                                 |                    |                     |                             |   |   |   |        |

|          |         |            |         |                         |        |   |  |
|----------|---------|------------|---------|-------------------------|--------|---|--|
|          |         |            | WET     | 5 per period            | 5 days | Glenelg spiny crayfish<br>variegated pygmy perch (W and A) <sup>5</sup> |  |
| Bankfull | Any     | 1,400 ML/d | DRY     | 1 per year or natural   | 1 day  | Wimmera bottlebrush<br>Glenelg spiny crayfish (winter)                  | Inundate riparian vegetation to maintain condition and facilitate recruitment<br><br>Entrain organic debris from the floodplain to support macroinvertebrates (western swamp cray)<br><br>Maintain structural integrity of channel<br><br>2-3 times per decade for Wimmera bottlebrush |
|          |         |            | AVERAGE |                         | 3 days |   |  |
|          |         |            | WET     |                         | 5 days |   |  |
| Overbank | Aug–Nov | 4,000 ML/d | WET     | 1 per period or natural | 2 days | Wimmera bottlebrush<br>Glenelg spiny crayfish (winter)                  | Inundate floodplain vegetation to maintain condition and facilitate recruitment<br><br>Entrain organic debris from the floodplain to support macroinvertebrates.<br><br>Maintains floodplain geomorphic features<br><br>2-3 times per decade for Wimmera bottlebrush                   |

<sup>1</sup> Priority objective – river blackfish. Second tier objectives – southern pygmy perch, mountain galaxias, flat-headed dudgeon and Australian smelt

<sup>2</sup> Yarra pygmy perch – occurs in slow-moving and still waters (low flows, wetlands and flood-runners)

<sup>3</sup> Priority objective – tupong and short-finned eel. Second tier objectives – spotted galaxias, climbing galaxias, common galaxias, pouched lamprey, short-headed lamprey, black bream, elongate hardyhead, small-mouthed hardyhead and estuary perch

<sup>4</sup> Australian grayling – lower priority because no confirmed sightings since 1984

<sup>5</sup> Priority objective – variegated pygmy perch. Second tier objectives – southern pygmy perch, dwarf galaxias

W and A: wet and average year

**Table 16: Hydrological requirements – Glenelg River reach 1b from 5-Mile outfall to Chetwynd River (Alluvium, 2013)**

| Flow component | Period  | Magnitude          | Condition | Frequency                   | Duration     | EWMP objectives achieved  | Other objectives achieved   |         |
|----------------|---------|--------------------|-----------|-----------------------------|--------------|---|---|---------|
| Cease to flow  | Dec–May | 0 ML/d             | DROUGHT   | As infrequently as possible | < 145 days   | None of the environmental objectives require a cease to flow.   | This recommendation acknowledges that cease to flows naturally occur and provides guidance to ensure that stress on the environmental values is not exacerbated beyond the point of no return                   |         |
|                |         |                    | DRY       |                             | < 125 days   |   |   |         |
|                |         |                    | AVERAGE   |                             | < 110 days   |   |   |         |
|                |         |                    | WET       |                             |              |   |   |         |
|                | Jun–Nov | 0 ML/d             | DROUGHT   | As infrequently as possible | < 110 days   |   |   |         |
|                |         |                    | DRY       |                             | < 55 days    |   |   |         |
|                |         |                    | AVERAGE   |                             | < 35 days    |   |   |         |
|                |         |                    | WET       |                             |              |   |   |         |
| Baseflow       | Dec–May | 15 ML/d or natural | ALL       | Continuous                  |              | river blackfish <sup>1,2</sup><br>tupong <sup>3,4</sup><br>short-finned eel <sup>3,4</sup><br>Glenelg spiny crayfish<br>variegated pygmy perch <sup>5</sup> | Edge habitat, pools and shallow water habitat for platypus, macroinvertebrates and fish<br>Prevent excessive instream terrestrial species growth – entire system<br>Promote instream vegetation – entire system |         |
|                |         |                    |           |                             |              |   |   | Jun–Nov |
|                | Freshes | Dec–May            | 100 ML/d  | DROUGHT                     | 2 per period | 2 days  | variegated pygmy perch (W and A) <sup>5</sup><br>short-finned eel   |         |
|                |         |                    |           | DRY                         | 2 per period | 3 days  |   |         |
| AVERAGE        |         |                    |           | 2 per period                | 3 days       |   |   |         |
| WET            |         |                    |           | 2 per period                | 3 days       |   |   |         |
| Jun–Nov        |         | 250 ML/d           | DROUGHT   | 1 per period                | 1 day        | river blackfish (W and A) <sup>1</sup><br>tupong <sup>3,4</sup>   | Increase the baseflow water depth to provide stimulus for fish movement (not required in drought years, frequently in wet years)<br>Wet low benches and increased habitat to improve diversity of habitat       |         |
|                |         |                    | DRY       | 2 per period                | 3 days       | short-finned eel <sup>3,4</sup>   |   |         |

|          |         |            |         |                         |        |  |  |
|----------|---------|------------|---------|-------------------------|--------|--|--|
|          |         |            | AVERAGE | 3 per period            | 5 days | Glenelg spiny crayfish<br>variegated pygmy perch (W and A) <sup>5</sup>                            |  |
|          |         |            | WET     | 5 per period            | 5 days |  |  |
|          | Jun–Nov | 550 ML/d   | AVERAGE | 1 per period            | 2 days | river blackfish (W and A) <sup>1</sup><br>tupong <sup>3,4</sup><br>short-finned eel <sup>3,4</sup> | Flush surface sediments from hard substrates for macroinvertebrates<br>Wet higher benches and increased edge habitat to improve diversity of habitats  |
|          |         |            | WET     | 2 per period            | 3 days | Glenelg spiny crayfish<br>variegated pygmy perch (W and A) <sup>5</sup>                            |  |
| Bankfull | Any     | 1,000 ML/d | DRY     | 1 per year              | 1 day  |  | Inundate riparian veg to maintain condition and facilitate recruitment   |
|          |         |            | AVERAGE | 1 per year or natural   | 3 days | Wimmera bottlebrush<br>Glenelg spiny crayfish (winter)   | Entrain organic debris in the channel to support macroinvertebrates<br>Maintain structural integrity of channel  |
|          |         |            | WET     | 1 per year              | 5 days |  | 2-3 times per decade for Wimmera bottlebrush   |
| Overbank | Aug–Nov | 6,000 ML/d | WET     | 1 per period or natural | 2 days | Wimmera bottlebrush<br>Glenelg spiny crayfish (winter)   | Inundate floodplain veg to maintain condition and facilitate recruitment<br>Entrain organic debris from the floodplain to support macroinvertebrates<br>Maintains floodplain geomorphic features<br>2-3 times per decade for Wimmera bottlebrush |

<sup>1</sup> Priority objective – river blackfish. Second tier objectives – southern pygmy perch, mountain galaxias, flat-headed dudgeon and Australian smelt

<sup>2</sup> Yarra pygmy perch – occurs in slow-moving and still waters (low flows, wetlands and flood-runners)

<sup>3</sup> Priority objective – tupong and short-finned eel. Second tier objectives – spotted galaxias, climbing galaxias, common galaxias, pouched lamprey, short-headed lamprey, black bream, elongate hardyhead, small-mouthed hardyhead and estuary perch

<sup>4</sup> Australian grayling – lower priority because no confirmed sightings since 1984

<sup>5</sup> Priority objective – variegated pygmy perch. Second tier objectives – southern pygmy perch, dwarf galaxias

W and A: wet and average year



Table 17: Hydrological requirements – Glenelg River reach 2, Chetwynd River to Wannon River (Alluvium, 2013)

| Flow component | Period  | Magnitude           | Condition | Frequency                   | Duration   | EWMP objectives achieved               | Other objectives achieved   | Notes               |
|----------------|---------|---------------------|-----------|-----------------------------|------------|--|---|---------------------|
| Cease to flow  | Dec–May | 0 ML/d              | DROUGHT   | As infrequently as possible | < 145 days |  | None of the environmental objectives require a cease to flow. This recommendation acknowledges that cease to flows naturally occur and provides guidance to ensure that stress on the environmental values is not exacerbated beyond the point of no return | From Alluvium, 2013 |
|                |         |                     | DRY       |                             | < 125 days |  |   |                     |
|                |         |                     | AVERAGE   |                             | < 110 days |  |   |                     |
|                |         |                     | WET       |                             |            |  |   |                     |
|                | Jun–Nov | 0 ML/d              | DROUGHT   | As infrequently as possible | < 110 days |  |   |                     |
|                |         |                     | DRY       |                             | < 55 days  |  |   |                     |
|                |         |                     | AVERAGE   |                             | < 35 days  |  |   |                     |
|                |         |                     | WET       |                             |            |  |   |                     |
| Baseflow       | Dec–May | 25 ML/d or natural  | ALL       | Continuous                  |            | river blackfish <sup>1,2</sup>         | Edge habitat, pools and shallow water habitat for platypus, macroinvertebrates and fish   | From Alluvium, 2013 |
|                |         |                     |           |                             |            | tupong <sup>3,4</sup>                  |   |                     |
|                | Jun–Nov | 160 ML/d or natural | ALL       | Continuous                  |            | short-finned eel <sup>3,4</sup>        | Maintain shallow water availability for macroinvertebrates  |                     |
|                |         |                     |           |                             |            | Glenelg spiny crayfish                 |   |                     |
| Freshes        | Dec–May | 150 ML/d            | DROUGHT   | 2 per period                | 2 days     | variegated pygmy perch                 | Improve condition of emergent veg by wetting lower banks  | From Alluvium, 2013 |
|                |         |                     | DRY       |                             | 3 days     | (W and A) <sup>5</sup>                 |   |                     |
|                |         |                     | AVERAGE   |                             |            | short-finned eel                       |   |                     |
|                |         |                     | WET       |                             |            |  |   |                     |
|                | Jun–Nov | 300 ML/d            | DROUGHT   | 1 per period                | 1 day      | river blackfish (W and A) <sup>1</sup> | Wet benches to improve condition of emergent vegetation and maintain habitat diversity. Increase flow depth for upstream & downstream fish migration to expand populations of native fish   | From Alluvium, 2013 |
|                |         |                     | DRY       | 2 per period                | 3 days     | tupong <sup>3,4</sup>                  |   |                     |
|                |         |                     | AVERAGE   | 3 per period                | 5 days     | short-finned eel <sup>3,4</sup>        |   |                     |
|                |         |                     | WET       | 5 per period                | 5 days     | Glenelg spiny crayfish                 |   |                     |

|          |         |            |         |                         |        |   |  |  |
|----------|---------|------------|---------|-------------------------|--------|---|--|--|
|          |         |            |         |                         |        | variegated pygmy perch<br>(W and A) <sup>5</sup>  |  |  |
|          | Jun–Nov | 1,800 ML/d | AVERAGE | 1 per period            | 2 days | river blackfish (W and A) <sup>1</sup>  | Facilitate scour of pools in sand bed for fish<br>Flush surface substrates from hard substrates to support macroinvertebrates. Wets additional benches   | From Alluvium, 2013                          |
|          |         |            | WET     | 2 per period            | 3 days | tupong <sup>3,4</sup><br>short-finned eel <sup>3,4</sup><br>Glenelg spiny crayfish<br>variegated pygmy perch (W and A) <sup>5</sup> |  |  |
| Bankfull | Any     | 6,000 ML/d | AVERAGE | 1 per year or natural   | 1 day  | Wimmera bottlebrush<br>Glenelg spiny crayfish (winter)  | Inundate riparian vegetation to maintain condition and facilitate recruitment<br>Entrain organic debris in the channel to support macroinvertebrates<br>Maintain structural integrity of channel | 2–3 times per decade for Wimmera bottlebrush |
|          |         |            | WET     |                         | 3 days |   |  |  |
| Overbank | Aug–Nov | 9,000 ML/d | WET     | 1 per period or natural | 5 days | Wimmera bottlebrush<br>Glenelg spiny crayfish (winter)  | Inundate floodplain veg for recruitment and maintain condition.<br>Entrain organic debris to support macroinvertebrates<br>Maintains floodplain geomorphic features                              | 2-3 times per decade for Wimmera bottlebrush |

<sup>1</sup> Priority objective – river blackfish. Second tier objectives – southern pygmy perch, mountain galaxias, flat-headed dudgeon and Australian smelt

<sup>2</sup> Yarra pygmy perch – occurs in slow-moving and still waters (low flows, wetlands and flood-runners)

<sup>3</sup> Priority objective – tupong and short-finned eel. Second tier objectives – spotted galaxias, climbing galaxias, common galaxias, pouched lamprey, short-headed lamprey, black bream, elongate hardyhead, small-mouthed hardyhead and estuary perch

<sup>4</sup> Australian grayling – lower priority because no confirmed sightings since 1984

<sup>5</sup> Priority objective – variegated pygmy perch. Second tier objectives – southern pygmy perch, dwarf galaxias

W and A: wet and average year

## Notes on environmental flow recommendations

Bankfull and overbank flows present specific management challenges. The prescribed overbank flows are possible, but would require significant investigation to understand land tenure and obtain permission from all private landholders. This is also true for bankfull flows, depending on confidence in the hydraulics of the river, and potential to overtop (pers. comm., C.Wiesenfeld, VEWH 2015).

Water Technology has recently completed an assessment of inundation of private and public land and infrastructure downstream of Rocklands Reservoir (refer to section 12). Calibration of the developed hydraulic model would add confidence to the study's results and influence future decisions on overbank and bankfull releases (refer to section 14).



*Photo 18: Glenelg River reach 2 showing complex bench habitat that becomes available during higher flows (Photo: Glenelg Hopkins CMA)*

### 11.1 Conceptualisation of the site

Representations of the broad hydrological and ecological processes occurring at a pool-run sequence in reach 1b near the Fulham gauge are provided in Figure 12 to Figure 14. The pool in the example is typical of the small refuge habitats that persist in most years except during prolonged drought.



### River channel pre - environmental flows

- Inundation area prior to environmental flows in summer
- ➔ Saline groundwater inflow. High salinity and low dissolved oxygen levels in deep pools due to saline groundwater inflows and density stratification. Low velocity flows may not result in dilution or mixing of dense saline water. Freshwater evaporates from top of pool. Groundwater gradient toward the river may be greatest in spring and early summer.
- Some terrestrial plants and grasses occupying the river channel after extended dry period

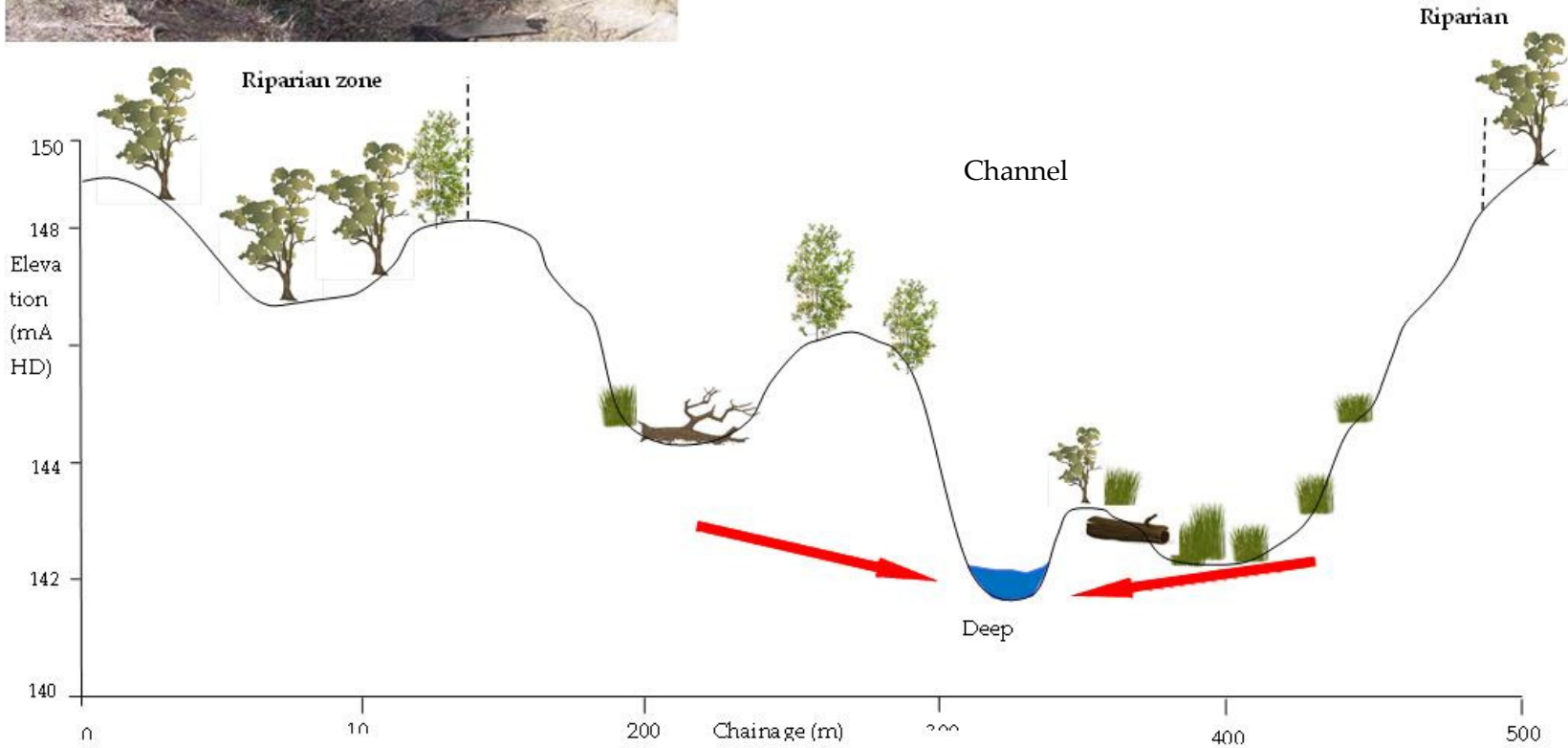










Figure 12: Conceptual model of cease to flow conditions in the Glenelg River



### Summer base flow and freshes

-  Summer/spring base flow
-  Summer/spring fresh flow event
-  Some saline groundwater intrusion. Higher river flows reduce groundwater gradient toward river
-  Hyparheic zone supported by high quality surface water provides moisture for herbs and shrubs on low banks.
-  Connects pools with enough depth for fish to move along the river, increases shallow water habitat along the edge of the pool and improved water quality for macroinvertebrates, vegetation and fish.

-  Baseflow - promotes instream vegetation
-  Freshes - maintain condition of emergent vegetation by wetting lower banks
-  Flow over wood debris to increase biofilm as a food source and support diverse aquatic habitats

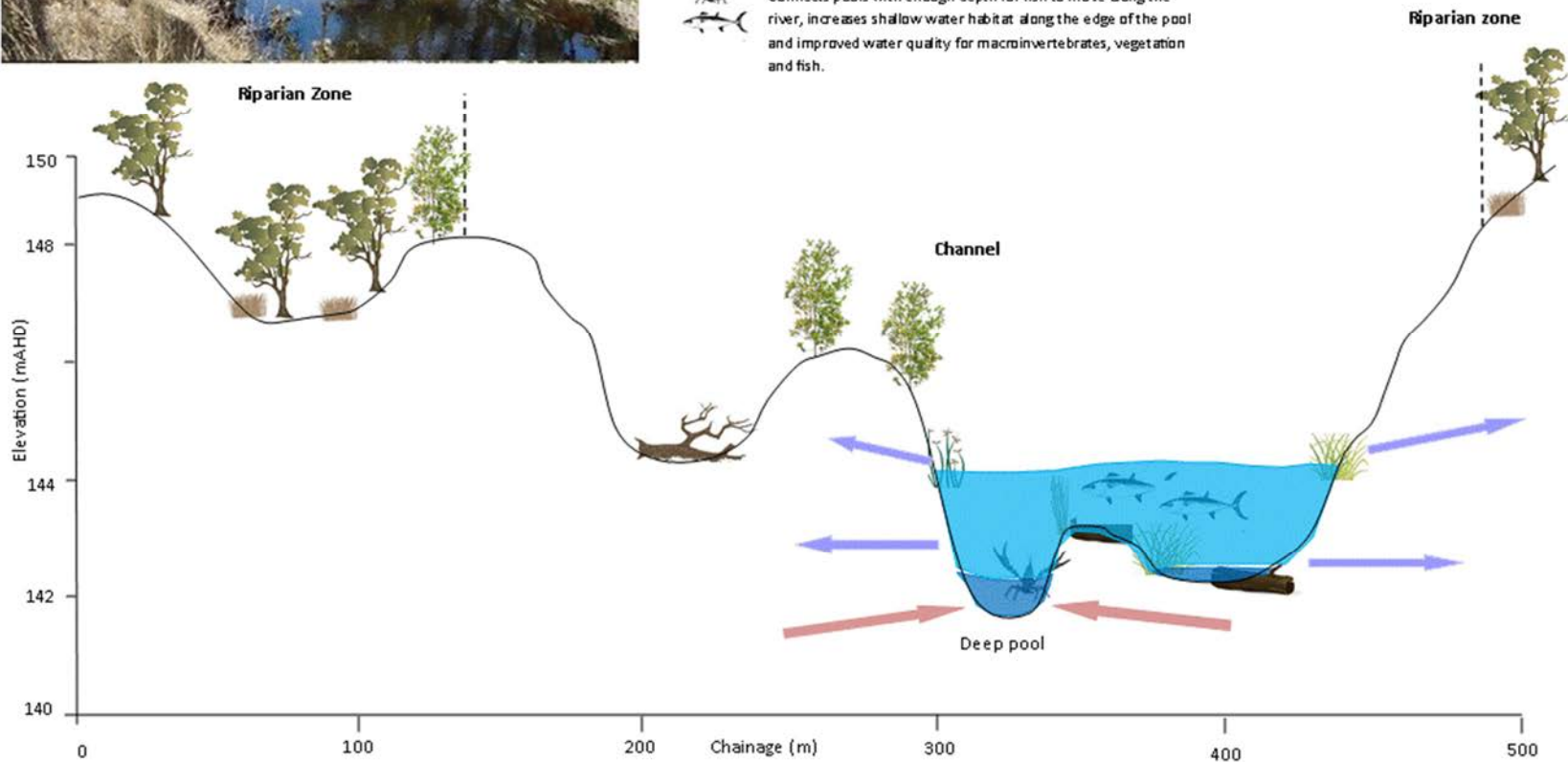










Figure 13: Conceptual model of summer base flows and freshes in the Glenelg River



### Summer base flow and freshes

-  Summer/spring base flow
-  Summer/spring fresh flow event
-  Some saline groundwater intrusion. Higher river flows reduce groundwater gradient toward river
-  Hyparheic zone supported by high quality surface water provides moisture for herbs and shrubs on low banks.
-  Connects pools with enough depth for fish to move along the river, increases shallow water habitat along the edge of the pool and improved water quality for macroinvertebrates, vegetation and fish.
-  Baseflow - promotes instream vegetation
-  Freshes - maintain condition of emergent vegetation by wetting lower banks
-  Flow over wood debris to increase biofilm as a food source and support diverse aquatic habitats

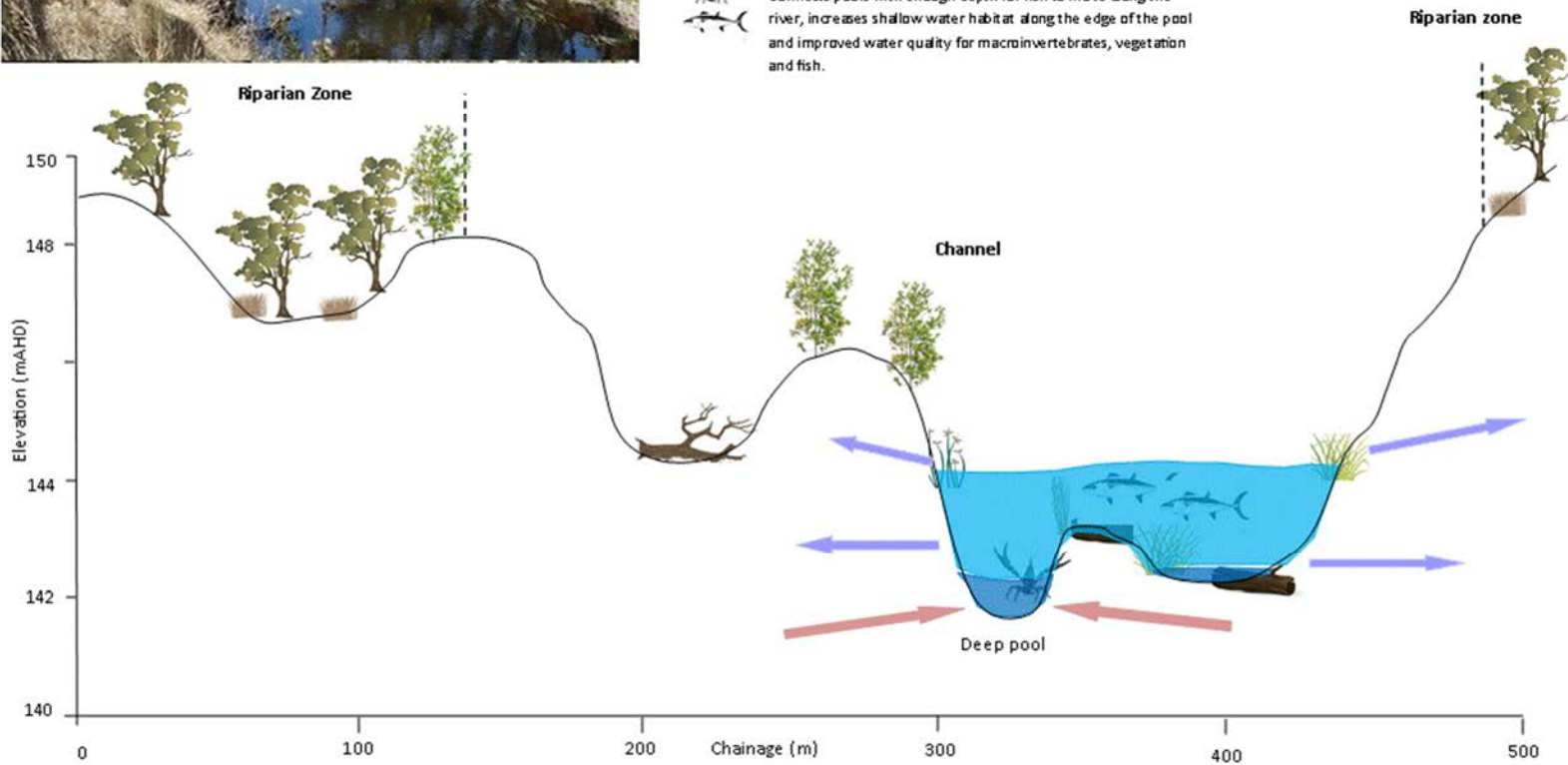


Figure 14: Conceptual model of winter base flow and freshes in the Glenelg River

## 11.2 Prioritising watering actions

Prioritisation of watering actions is necessary to maximise benefits from the limited environmental water available to the Glenelg River. While specific flow components are described through the flow studies, broader principles to guide prioritisation of flow components will assist management. Considerations include maintaining seasonality of flow, providing variability within baseflow components and ensuring a diverse suite of flows. Priority watering actions are developed by the CMA each year and are documented in the Seasonal Watering Proposal.

Section 12.2 of the Ministerial rules relating to the Victorian Environmental Water Holder (Victorian Government, 2014) provides guidance to the VEWH for making decisions in regards to watering actions. Rules focus on achieving significant, efficient and sustainable environmental outcomes along with consideration of the social and economic benefits associated with environmental watering actions. These Ministerial rules are considered when prioritising watering actions in the Glenelg River Seasonal Watering Proposal to ensure regard is given to:

i. **The extent and significance of the environmental benefit expected from the watering action**

When considering the extent of an event, it is important to consider the length of river watered by a watering action.

The length of the targeted reach is a central consideration along with connection with downstream reaches. Non-target reach benefits are important considerations as through flow may contribute to the partial achievement of objectives and other benefits such as providing connectivity between tributaries.

The hydrological significance of a watering action can describe the proportion of gauged flow that is expected to be derived from environmental releases. In summer and autumn, environmental water releases are typically a large proportion of total flow compared with winter and spring.

Significance should also consider the status of species or ecological communities at local, State and Federal scales. As a guide:

- local significance is identified through the Glenelg Hopkins Waterway Strategy 2014-22 and includes species of cultural importance
- State significance is identified through listing for protection through the *Flora and Fauna Guarantee Act* 1988.
- Federal significance is identified through listing for protection through the *Environment Protection and Biodiversity Conservation Act*, 1999.

ii. **The level of certainty of achieving the environmental benefit from the watering action and ability to manage other threats**

Ecological confidence in flow recommendations for the Glenelg River is high following a review and update of the Glenelg River environmental flow study in 2013. This has incorporated available peer reviewed science and the results of monitoring along the Glenelg River. Not all of the scientific certainty in the recommendations documented in the environmental flow study is equal. For some flow objectives, monitoring within the Glenelg River and elsewhere within the state provides a high degree of confidence that recommendations will support objectives. Other objectives have lower confidence because of the lack of research into a particular flow-ecology relationship. Environmental water staff can provide guidance around ecological confidence based on observations and local monitoring results.

Hydrological confidence is an expression of the degree in confidence that a recommended flow rate can be achieved. Analysis of flow gauge data has allowed development of loss factors for watering actions with consideration of seasonal conditions. Loss factors are used when developing release plans to ensure enough water is released to increase certainty that required flow rates are achieved at compliance points. In reaches where compliance points do not exist, consideration should be given to temporary gauging or other measures to understand hydrological certainty.

iii. The ability to provide ongoing benefits at the site at which the watering action is to take place

Permanent environmental water delivery infrastructure is in place to supply the Glenelg River below Rocklands Reservoir. Access to delivery infrastructure downstream of Rocklands Reservoir will be described in operating arrangements being developed by the VEWH.

Pilot releases may be provided to other areas, such as reach 0 with the intention of providing short term benefits where long term benefits in other areas have been secured.

iv. The water requirements of the site at which the watering is to take place, taking into account watering history at that site and the implications of not undertaking the proposed watering action at the site

Hydrological performance in each reach – reviewing flow data (traffic lights green, orange and red) to assess flow performance in order to identify gaps in the flow record and the feasibility of addressing gaps. For example, a flow may become critical if it is not achieved within a period (eg - a spawning flow for a fish that only lives for up to 3 years needs to occur at least once in the preceding 3 year period) this can be used to help guide what watering actions are either targeted or not targeted.

v. The feasibility of the watering action, including flexibility of timing of delivery, operational requirements and constraints, and infrastructure capacity

Operating arrangements have been developed for the Glenelg River. These operating arrangements provide direction around the limitations of environmental water management and flow priorities need to be developed in line with these constraints.

vi. Overall cost effectiveness of the watering action considering the likely benefit to be achieved against the costs of the watering action (including costs associated with delivery, risk management and carryover)

Delivery costs are fixed for the environment across the entire Wimmera-Glenelg supply system and are therefore not a consideration.

Managing the risk of a shortfall of supply for targeted watering actions can be achieved through carry-over or purchase of allocation from another entitlement holder or through increasing the entitlement volume through purchase of growth water. Each of these options has associated costs.

Carryover is subject to a water cost whereby water available at 30 June has a 'carryover allowance' of 15% deducted to allow for evaporation the following year. The decision to carry water over for priority water action requires consideration of this water cost and the opportunity cost of not using the water in the current year.

Purchase of allocation is being explored for the first time in the Wimmera-Glenelg system in 2015-16. There will be a range of transaction costs in addition to the purchase of allocation. There is uncertainty whether the purchased water will retain the characteristics and therefore costs of the parent entitlement or whether it will simply form part of the pool available under the environmental entitlement and be subject to the same delivery costs. If shortfalls are an ongoing issue, purchasing growth water from the pipeline system may be an option.



vii. Opportunities to provide social and economic benefits, after consideration of the above matters

Social and economic aspirations for environmental water are represented in the RWS. Environmental water releases improve the availability and quality of water for domestic and stock use along the river as well as providing aesthetic amenity for towns along its banks. Recreational opportunities for camping, bush walking, fishing and boating are also enhanced through the provision of environmental flows through growth and recruitment of recreational fish species, maintenance of water quality, and access.

### 11.3 Scenario planning

The seasonally adaptive approach to environmental flow management is a flexible way to address short-term climate variability. It considers several potential scenarios to demonstrate the rationale for changing watering actions in response to climate conditions and other drivers (Department of Sustainability and Environment, 2009). These scenarios are based on probability of exceeding (POE) that year's rainfall in any year. In planning for water use in the Wimmera–Glenelg systems, the scenarios for both river basins are drought (95% POE), dry (75% POE), average (50% POE) and wet (25% POE). These scenarios are based on recommended environmental water demand (Alluvium, 2013).

Seasonal rainfall is a key influence on the volume of water allocated in the Wimmera–Glenelg system. Rainfall in the system is highly variable both across years and between the two river basins. Total system storage capacity is relatively large compared with average annual flow, making tools such as system reserve and carryover important considerations (Glenelg Hopkins CMA, 2014).

Seasonal scenarios are assessed and developed each year by the CMA and documented in the Seasonal Watering Proposal. The scenarios present the volumes required to comply with flow recommendations for priority watering actions.

## 12 Managing risks to achieving objectives – risk assessment

Intervening in waterways through environmental flow management has inherent risk. Environmental watering risks have been considered and assessed, and risk management strategies have been identified. The current identified risks are shown in Table 18.

**Table 18: Risk assessment, mitigation and lead agency for environmental water releases in the Glenelg River**

| Risk category | Risk description  | Risk assessment |             |             | Risk mitigation  |               |             |                            |
|---------------|---|-----------------|-------------|-------------|--|---------------|-------------|----------------------------|
|               |   | Likelihood      | Consequence | Risk rating | Mitigation   | Residual Risk | Lead Agency | Timeline for re-assessment |
| Human         | Environmental releases cause personal injury to river users   | Rare            | Moderate    | Low         | Communicate around flow deliveries<br>Avoid large flows during periods of high river use   | Low           | CMA         | Ongoing                    |
|               | Environmental releases cause damage to private or public assets   | Possible        | Minor       | Low         | Identify areas of potential impacts (refer below).<br>Assess specific impacts and work with affected parties to mitigate impacts (refer below)   | Low           | CMA         | Ongoing                    |
|               | Safety risks to system operators when operating structures to make environmental deliveries               | Unlikely        | Extreme     | Extreme     | Avoid using high risk structures<br>Modify structures to increase operator safety<br>Review safe work procedures   | Low           | GWMWater    | Monthly                    |
| Quality       | Organisational relationships deteriorate impacting on effectiveness of the environmental watering program | Possible        | Moderate    | Medium      | Ensure communication occurs between relevant levels of key organisations, formalise documents that support effective management of the system and participate with the joint communications strategy being developed by VEWH | Low           | VEWH        | Ongoing                    |
|               | Low water availability means that priority watering actions are not feasible                              | Likely          | Major       | Extreme     | Revise watering actions, communicate around changed objectives, establish an emergency reserve for emerging problems and identify options to secure additional water for the Glenelg   | Medium        | VEWH        | Monthly                    |
| Environmental | Environmental flow management causes water quality issue  | Possible        | Minor       | Medium      | Adapt flow management based on antecedent conditions and local knowledge   | Low           | CMA         | Prior to release           |

|              |   |                |          |         |   |                |          |          |
|--------------|---|----------------|----------|---------|---|----------------|----------|----------|
|              | Improved conditions for non-endemic species                                     | Possible       | Minor    | Medium  | Continue monitoring regime to understand response (if any) of non-endemic species<br><br>Incorporate latest research into flow management   | Low/<br>Medium | CMA      | Annually |
| Compliance   | Environmental water account is overdrawn  | Possible       | Minor    | Medium  | Monitor water use against volume approved for use through Seasonal Watering Statement.  | Low            | CMA      | Monthly  |
|              | Environmental releases cause flooding of private land                           | Possible       | Minor    | Medium  | Identify areas of potential impacts (refer below)<br><br>Establish landholder agreements for inundation<br><br>If agreement cannot be reached, modify flows to avoid impacts  | Low            | CMA      | Ongoing  |
|              | Environmental release plan not delivered in accordance with agreed release plan | Likely         | Moderate | High    | Maintain close communication between GWMWater and CMA to respond quickly to emerging issues   | Low/<br>Medium | GWMWater | Ongoing  |
| Reputational | Stakeholders are not supportive of environmental watering actions               | Almost certain | Major    | Extreme | Participate in coordinated communications strategy<br><br>Undertake direct engagement with community groups to communicate actions, objectives and benefits<br><br>Identify areas of common interest in the health of the Glenelg River and where appropriate incorporate stakeholder objectives into environmental watering actions. | Medium         | VEWH/CMA | Annually |
|              | Inability to provide evidence that watering actions are achieving objectives    | Likely         | Moderate | High    | Improve monitoring and research programs<br><br>Support publication of research results<br><br>Incorporate emerging knowledge into management   | Low            | CMA/VEWH | Ongoing  |

*Note: The risk management strategies shown in the above table relate only to the risk management approaches of the Glenelg Hopkins CMA and VEW. GWMWater undertakes risk assessments around storage operations in its role as storage manager.*

A risk assessment for inundation of private and public land and infrastructure was undertaken downstream of Rocklands Reservoir (reach 1a to end of reach 2) (Water Technology, 2015). The overall objective of the study was to improve flow management through investigating areas of potential localised inundation, identify physical constrictions and prioritise risk management options to manage risks.

Infrastructure such as crossings or pump sites were identified and interrogated to identify risk of inundation. The majority of crossings (41 of 59 identified) are considered at low risk of inundation by flows below 600 ML/d. Risks can be minimised for users of 16 of the 18 crossings identified as being at risk of

inundation by utilising nearby crossings or depths that can be driven through under modelled flows. Communication and working with affected parties to mitigate impacts is vital.

There is a significant amount of private land subject to inundation at low flow, however there is not a dramatic increase in private land inundated between 100 and 600 ML/d. The Harrow to Dergholm section has the largest percentage of private land inundated with more private land inundated than public. There were two areas of concern identified; private land near Frasers Swamp and private land near Connewirrecoo Bushland Reserve. As detailed in Table 19, communication with affected parties and establishing landholder agreements for inundation will minimise risks. If agreements cannot be reached, flows could be modified (Water Technology, 2015).

## 13 Environmental water delivery infrastructure

### 13.1 Constraints and infrastructure recommendations

The following table outlines the infrastructure and operational constraints and recommendations to delivering environmental water in the Glenelg River.

**Table 19: Glenelg River environmental water delivery constraints and recommendations**

| Site                    | Reach | Issue and Impact  | Infrastructure Recommendation  |
|-------------------------|-------|---|--|
| Operational constraints | All   | GWMWater has limited resources available for delivery operations at Rocklands Reservoir. Issues arise where not all flows are delivered in line with agreed flow plans. Staff availability, equipment failures and emergencies can impact on flow, resulting in under or over delivery of flows. Good communication between GWMWater and Glenelg Hopkins CMA will aim to develop pragmatic solutions when these issues arise.   | Automation of infrastructure would eliminate OH&S and staffing issues.   |
| Moora Moora Reservoir   | 0     | The availability and tolerance of operators to deliver flows in a remote area.  | As above   |
| Rocklands Reservoir     | 1a    | <p>The outlet capacity at Rocklands Reservoir is 600 ML/d. The carp screens at the outlet also have a limited capacity of 500 ML/d</p> <p>The outlet gates are currently manually operated and the volume delivered to the river is visually estimated. The need to improve measurement of deliveries has been identified through the VEWH metering arrangements</p> <p>Rocklands Reservoir water availability. Glenelg River environmental flows are currently only sourced from Rocklands Reservoir; therefore reservoir levels are critical for supply to the Glenelg system. Some protection is provided through storage management rules (refer to Section 2.4).</p> | Flow metering and automation of the discharge gates at Rocklands. This would provide assurance that environmental water can be delivered through this outlet at the correct rate. Automation of the outlet would eliminate OH&S and staffing issues. |
| 5-Mile outlet           | 1b    | 5-Mile outlet capacity is 250 ML/d, or less if water is going down channel to 12-Mile or Toolondo/Taylor's channel  | Erosion remedial works are required to prevent undermining and the possible failure of the structure. If the structure fails, environmental flow rates will potentially be greatly reduced due to  |

|                |          |   |  |
|----------------|----------|---|--|
|                |          | Erosion remedial works are required to prevent the possible failure of the structure.   | the limited amount of water that can be released upstream at Rocklands wall outlet.  |
| 12-Mile outlet | 1b       | <p>12 Mile outlet capacity is limited to 200 ML/d, or less if water is going down channel to Toolondo/Taylor's channel</p> <p>12-Mile outlet has not been functional for 18 months due to OH&amp;S and staffing issues. This has limited the flexibility of water delivery and decreased the capacity of the delivery system. 12-Mile outlet enables targeted releases to occur at three concurrent points, spreading risks and enhancing ecological opportunities.</p> | Installation of new gates and telemetry at 12-Mile outlet, including safety upgrades. The upgrades will enable flow to be monitored and controlled remotely. Once upgraded, environmental releases can recommence at this location, enabling more efficient and accurate delivery of environmental water to lower reaches of the Glenelg River.  |
| Gauging        | 1a and 0 | <p>There is currently no compliance point or gauge for measuring flow performance in reach 1a. Without a compliance point to understand the flow occurring within the reach, the ecological response to flow cannot be assessed</p> <p>There is currently no compliance point or gauge for measuring flow performance in reach 0.</p>   | <p>Flow gauge/compliance point for reach 1a. A compliance point will enable the CMA to demonstrate outcomes in line with current objectives. The metering will guide efficient use of water and provide critical data for measuring flow outcomes in this reach. During the 2013 FLOWS study, a hydraulic model was established for a representative site within reach 1a. It is proposed that a flow gauge be installed at this site to monitor flow performance</p> <p>Compliance point for reach 0 to enable the CMA to monitor pilot flow release outcomes. (Water Technology, 2015) recommends a monitoring location 2.5 km downstream of the Scrubby Creek confluence.</p> |

## 13.2 Complementary works

Improving the environmental watering regime for the Glenelg River will generate benefits to the environmental values of the river. However, whole system ecological health requires integrated works programs. Table 20 lists complementary works/actions that will enhance the outcomes of delivering environmental water.

**Table 20: Complementary actions to enhance the outcomes for environmental water**

| Activity              | Rationale  | Links to objectives |
|-----------------------|--|---------------------|
| Fencing               | <p>From 2000 to 2015, the Glenelg River basin was the subject of the largest river fencing program in Australia's history. However, stock still have direct access along vast lengths of the Glenelg River and its tributaries. This can cause erosion, sedimentation, damage native vegetation and inhibit the recruitment of native vegetation.</p> <p>Implementation of the 2015 Waterway Action Plan (WAP) is scheduled to begin in Autumn 2015 in the middle-Wannon catchment (major tributary of the Glenelg).</p>     | 1,4,5,6             |
| Carp control          | <p>Glenelg Hopkins CMA is currently operating a carp tracking and controlling program in partnership with VEMCO, South Australian Research and Development Institute (SARDI) Aquatic Sciences and the Arthur Rylah Institute (ARI). The program takes advantage of congregating habits and utilises a tagged fish that provides information on the patterns and distributions of large carp groups, allowing effective targeting and eradication.</p>  | 1,3,4,5             |
| Sand management       | <p>The Glenelg River was severely impacted by sand washing in from the catchment during the 1940s and 1950s. Continued management of sand and erosion is required in the Glenelg River system. Licenced sand extraction and work to stabilise sand is continuing. Mebourne University is about to commence sand monitoring along the Glenelg River to determine future sand management priorities.</p>   | 1,3,4,5             |
| Fish barrier removal  | <p>Six fish barriers have been removed in the Glenelg over the last 10 years at Sandford, Fulham, Dartmoor gauge, Casterton town weir, Iluka pipeline crossing and Les Mutches ford crossing. Other structures in the upper Glenelg River and tributaries (from upstream of Balmoral to Moree) have been identified as potential fish barriers. Funding is required to further assess, and if necessary, plan for works at the identified sites. Barrier removal enables more effective delivery of environmental water.</p> | 2,3,4,5             |
| Erosion control works | <p>Soil Conservation Authority (SCA) constructed many erosion control structures (1950–1983). Structures were intended to reduce sediment input via small tributaries. GHGMA repairs SCA structures and implements new erosion control works when funding is available.</p>  | 1,3,4,5             |

|                                       |   |                |
|---------------------------------------|---|----------------|
| <p>Large wood/habitat improvement</p> | <p>A large wood reinstatement program was completed by the GHCMA in 2008 along the riverbed at both Harrow and Casterton. The key outcome of the resnagging has been re-introducing habitat diversity into sections of the river that were previously a flat sheet of sand. The wood provides direct habitat for many fish species including the river blackfish.</p> | <p>1,3,4,5</p> |
|---------------------------------------|---|----------------|



## 14 Demonstrating outcomes

Monitoring, evaluation and improvement are critical in natural systems where the outcomes from environmental watering can be uncertain. Monitoring is undertaken to assess ecological responses to flow, to ensure water is delivered as planned and to help manage risks (refer to section 12). Intervention monitoring is the primary means for understanding the outcomes from the use of environmental watering. Long-term and short-term (1 year) intervention monitoring is required to demonstrate that watering is achieving environmental outcomes.

### 14.1 Long-term intervention monitoring

Long-term monitoring will provide data on whether the watering regime is causing a change in, or maintaining, the overall condition of the river over a five to ten year period.

#### 14.1.1 Existing monitoring

Currently the principal program for monitoring the ecological responses from the release of environmental water is the VEFMAP program. The VEFMAP program aims to provide a consistent and scientifically defensible framework for monitoring ecological responses to environmental flows. The VEFMAP program began in 2009 and water quality analysis, fish surveys, vegetation and physical form have been undertaken annually (Austral Research and Consulting, 2014). The current VEFMAP and other monitoring programs are detailed in Table 21. The current monitoring regime and monitoring locations on the Glenelg River are shown in Figure 15.

Funding has been confirmed under the VEFMAP program for fish surveys for the next two years up to and including 2016 and vegetation surveys in 2016; however, funding for monitoring beyond 2016 is unconfirmed.

Hydrological performance is monitored at the compliance streamflow gauges in reaches 1b and 2.

#### 14.1.2 Evaluation and reporting

A range of monitoring is undertaken to evaluate the effectiveness of flow regimes in maintaining and improving conditions in the Glenelg River. The current monitoring program is summarised in Table 21 and includes both biological and physico-chemical parameters.

**Table 21: Current monitoring for the Glenelg River**

| Monitoring                  | Objective  | Method or Indicator                                       | Location and frequency                                   |
|-----------------------------|--|---|--|
| Summer fish survey (VEFMAP) | Self-sustaining population of endemic fish                                   | Diversity, number, age, cohorts, recruitment and movement | Annual survey at 20 sites across reaches 1a, 1b, 2 and 3 |
| Water quality (VEFMAP)      | Flows will maintain water quality at suitable levels for aquatic communities | Deep pool logging of salinity and dissolved oxygen        | 3 sites in reach 1b with continuous logging.             |

|   |   |  |   |
|---|---|--|---|
| Aquatic and riparian vegetation (VEFMAP) and physical habitat | Monitor changes in vegetation communities                               | Condition, monitoring and recruitment<br><br>Quantitative transect surveys | 4 sites in reaches 1a, 1b and 2.<br><br>Once every three years              |
| Flow and water quality (partnership)                          | Releases are adequate to achieve the desired flow rate at key locations | Gauged flows<br><br>Surface water quality – EC and temp                    | 5 sites in reaches 1b, 2 and 3.<br><br>Continuous gauging.                  |
| Stream condition  | River conditions will visually improve in response to improved flows    | Photo points   | 5 sites in reaches 1a and 1b.<br><br>Undertaken on an ad hoc basis.         |
| Judas Carp  | Track carp movement and carp control                                    | Tracking devices   | 25 listening stations in Reaches 1a, 1b, 2 and 3.<br><br>Continuous logging |

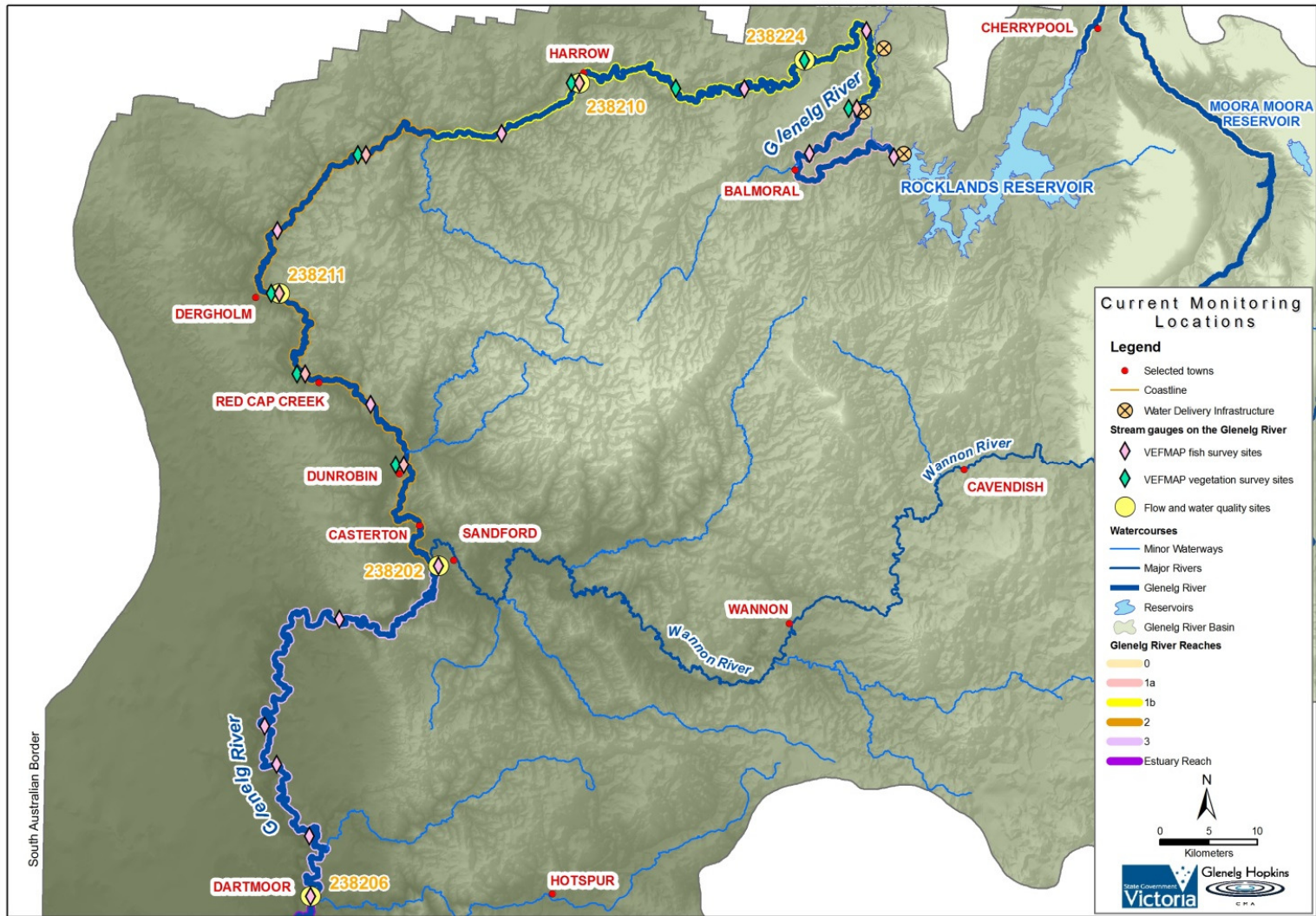


Figure 15: Current monitoring locations on the Glenelg River

### 14.1.3 Additional long-term intervention monitoring

Additional long-term condition monitoring requirements that will assist to demonstrate changes in river condition over time, specifically focusing on the Glenelg River environmental flow delivery program, are shown in Table 22. The monitoring requirements shown are recommended, assuming that the current monitoring continues.

**Table 22: Required long-term intervention monitoring for the Glenelg River**

| Monitoring   | Objective   | Method   | Frequency and location   |
|--|---|--|--|
| Reach 0 – flow and water quality                   | To accurately assess reach hydrology and water quality                                  | Identify a compliance point and install permanent gauging                                | Approximately 2.5 km downstream of Scrubby Creek<br><br>Continuous logging.  |
| Additional winter adult fish survey                | Fish – increase abundance and appropriate age classes                                   | As per current VEFMAP  | Once in winter (additional to current summer sampling)<br><br>20 sites along reach 1a to reach 3 (current VEFMAP monitoring sites) |
| Fish – species presumed lost (Australian Grayling) | To determine if still in system   | Targeted monitoring  | As required  |
| Glenelg Spiny Crayfish                             | Establish baseline numbers and monitor to evaluate progress as per objective (Table 16) | Rapid biological assessment (SKM, 2007)  | Annually<br>All reaches<br><br>20 sites as per VEFMAP monitoring sites   |
| Water quality                                      | Flows will maintain water quality at suitable levels for aquatic communities            | As per current VEFMAP – continuous dissolved oxygen, temperature and salinity monitoring | Reach 1a   |
| Vegetation – undesirable species                   | Effect watering has on extent and abundance of undesirable species                      | Quantitative transect surveys or aerial survey   | 4 sites<br>All reaches<br><br>Every three years.   |
| Vegetation – cumbungi                              | Effect watering has on extent and abundance of cumbungi                                 | Quantitative transect surveys or aerial survey   | 2 sites twice per year (photo points)  |

|  |  |  |                   |
|--|--|--|-------------------|
| Vegetation – Frasers Swamp/Tributary junction plug wetland | To monitor the change in vegetation at Frasers Swamp over time | Quantitative transect surveys or aerial survey | Every three years |
|--|--|--|-------------------|

## 14.2 Short-term intervention monitoring

Short-term monitoring informs flow management over periods of weeks to months. This information can be used for trigger based releases, to monitor seasonal or event based responses that are not detected through long-term monitoring. Additional short-term monitoring may be required for specific purposes such as monitoring particular threats or assessing ecological responses to a flow.

### 14.2.1 Existing short-term monitoring

Flow and water quality monitoring is provided through a webpage for a number of gauged sites along the Glenelg River including Fulham Bridge, Harrow, Derholm, Sandford and Dartmoor. This provides live information that is used to actively monitor conditions in the lead up to, during and after environmental flow releases.

Other sources of short-term monitoring include observations and photos from Glenelg Hopkins CMA staff, landholders and community members along the Glenelg River.

Temporary monitoring has been established for 2015-16 in reach 1a at the Woodlands property. This temporary monitoring is targeted and involves deployment of a portable automated logger to transmit information about river levels and water quality. This logger links through to the website where the permanent gauging site information is accessed.

### 14.2.2 Additional short-term monitoring

The condition monitoring requirements that will assist in demonstrating responses of selected watering actions over the short term are shown in Table 23.

**Table 23: Required short-term intervention monitoring for the Glenelg River**

| Monitoring type                       | Objective  | Method                          | Frequency and location  |
|---------------------------------------|--|---------------------------------|---|
| Reach 0 - Flow and water quality      | To gain a comprehensive understanding of reach hydrology and water quality     | Temporary gauging               | 3 Locations (Serra Road, Moora Inlet Channel, Little Cut)<br><br>Continuous for two seasons |
| Fish movement                         | To observe fish migratory responses to specific flow events                    | To be determined                | Reach 1b, 2, 3 and estuary with frequency dependant on monitoring technique                 |
| Vegetation survey – event based       | To monitor the effects of a large flow event on in-bed and riparian vegetation | Photo points or aerial survey   | Reaches 0, 1a, 1b & 2<br><br>As required  |
| Flow inundation in Reach 1a, 1b and 2 | To calibrate the flow inundation model developed in 2015                       | Water levels after a flow event | Location and frequency as required for calibration purposes                                 |

|  |   |  |                              |
|--|---|--|------------------------------|
| Water quality monitoring after a cease to flow event | To monitor the water quality during a watering event after a cease to flow event                            | Temporary gauging – continuous salinity and dissolved oxygen   | Reaches 1a & 1b<br>4 sites   |
| Monitor the rate of rise and fall of flow events     | Refine rates of rise and fall to increase efficiency beyond the rule based specification in the flow study. | Fish surveys and visual inspection of banks before and after a series of events where rise and fall is important | Reaches 1a and 1b<br>6 sites |

### 14.3 Knowledge gaps and recommendations

The Glenelg River EWMP has been developed using the best available information. However, a number of knowledge gaps may impact on recommendations and/or information presented in the EWMP. These are summarised in Table 24.

**Table 24: Knowledge gaps and recommendations**

| Knowledge gap   | Recommendation   | Who                               |
|---|--|-----------------------------------|
| The water requirements of the Heritage Listed and Ramsar nominated Glenelg River estuary and associated wetland complexes   | Undertake an Estuary FLOWS study to guide delivery of environmental water to protect the environmental values of the Glenelg River estuary. Improving the hydrological regime to support the hydrodynamic processes in this high value system is a significant priority.   | GHCMA/<br>consultant              |
| Further assessment of the flow requirements of Reach 0  | Build on outputs from the 2015 assessment (Water Technology, 2015). Monitoring and assessment is required to verify modelled outputs and ecological impacts.   | GHCMA/<br>GWMWater/<br>consultant |
| Flow requirements for estuary perch and black bream in the Glenelg River. The effect of environmental flows on movement of estuarine species is poorly understood | This project involves understanding flow requirements for estuary perch, black bream and tupong in the Glenelg. These species have recently been recorded well into the freshwater reaches of the Glenelg River. It is believed these migrations have corresponded with environmental flow releases. This project will provide a better understanding of flow requirements and event-based data. | GHCMA/<br>consultant              |
| Flow requirements of the Glenelg spiny crayfish   | Surveying the Glenelg River will provide a better understanding of flow requirements, habitat utilization and population dynamics of adults and juvenile spiny crays. .  | GHCMA/<br>consultant              |
| Flow requirements of Wimmera bottlebrush  | Further investigation is required to identify the distribution and flow requirements in order to tailor environmental watering for the species. Most populations are outside current VEFMAP vegetation survey sites.   | GHCMA/<br>consultant              |

|   |   |  |
|---|---|--|
| Improving understanding of fish populations in reach 0.   | Fish surveys will provide a better understanding of fish populations to determine environmental watering requirements of this reach and establish a monitoring baseline.  | GHCMA/<br>consultant                     |
| Flow requirements for pygmy perch species.<br><br>Initial analysis of the VEFMAP data suggests the three species, (variegated, Yarra, and southern pygmy perches), are responding differently to flows. This behaviour has implications for delivering environmental flows to the Glenelg River | Undertake a scoping study to determine flow requirements for the three species of pygmy perch in the Glenelg River. The Glenelg River is the only regulated Victorian river where the three species coexist. Failure to supply the correct flow requirements for each species could place species at risk of decline. | GHCMA/<br>consultant                     |
| The impacts of the Wannon River diversions. The Wannon River is the largest tributary of the Glenelg River (confluence downstream of Casterton)   | To undertake an investigation of the impacts of the Wannon River diversions.  | GHCMA/<br>Wannon<br>Water/<br>consultant |
| The impacts of cold water releases from Rocklands Reservoir (thermal pollution) on the receiving river and associated biota.  | Understand the impacts and develop options to manage the risk at Rocklands Reservoir to ensure physicochemical parameters of release water meet requirements of biota.  | GHCMA/<br>GWMWater/<br>consultant        |
| Understanding of natural flow conditions in the Glenelg River identified as a limitation of the previous flows study.   | Improve modelling of natural flow in the Glenelg to better inform recommendations on frequency and duration of flow events and provide a better dataset of annual flow.   | GHCMA/<br>GWMWater<br>consultant         |
| Probability of exceedance thresholds for drought, dry, average and wet scenarios require improvement to provide a more realistic basis for management objectives.   | Use improved modelling of natural flows to partition climatic scenarios for drought, dry, average and wet conditions.   | GHCMA/<br>Consultant.                    |

#### 14.4 Document review

The Glenelg River EWMP is intended to remain a living document that is updated over time as new information becomes available. A complete review of the document is likely to coincide with the review of the Glenelg Hopkins Waterway Strategy (subject to funding arrangements).



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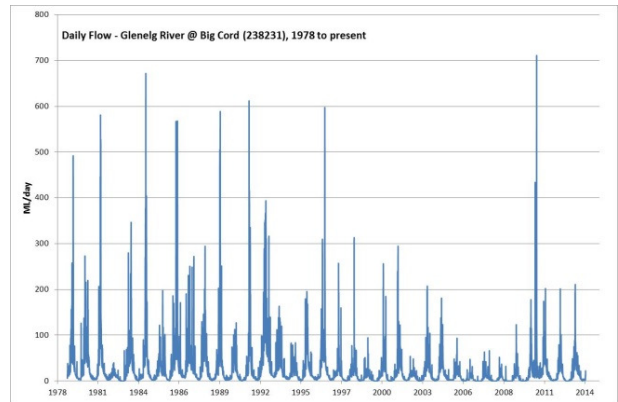
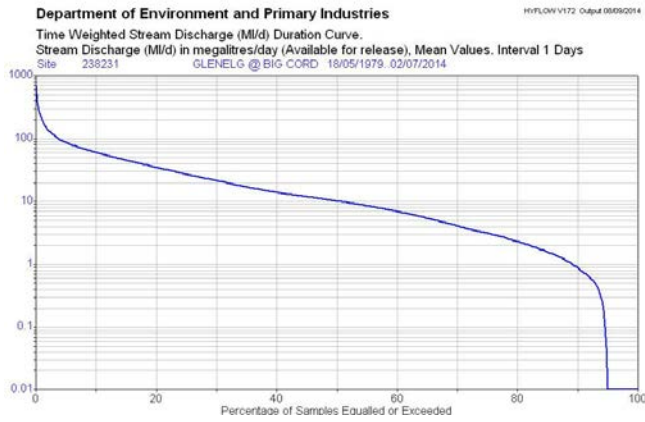
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## Abbreviations and acronyms

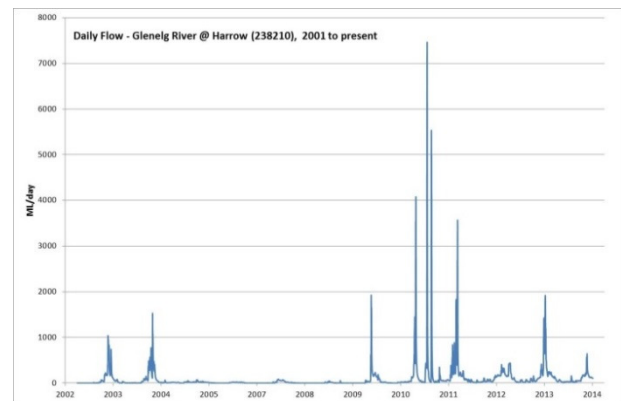
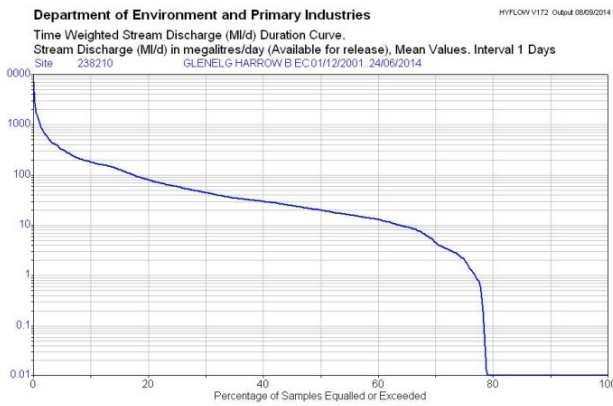
|          |  |
|----------|--|
| BE       | Bulk Entitlement   |
| BONN     | The Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention or CMS) |
| CAMBA    | China–Australia Migratory Bird Agreement   |
| CALP     | Catchment and Land Protection  |
| CEWH     | Commonwealth Environmental Water Holder  |
| CMA      | Catchment Management Authority   |
| DELWP    | Department of Environment, Land, Water and Planning  |
| EC       | Electrical Conductivity  |
| EPBC     | <i>Environment Protection and Biodiversity Conservation Act, 1999 (Cwlth)</i>                                      |
| EVC      | Ecological Vegetation Class  |
| EWMP     | Environmental Water Management Plan  |
| FFG      | <i>Flora and Fauna Guarantee Act, 1988 (Vic)</i>   |
| GL       | Gigalitre (one billion litres)   |
| GIS      | Geographical Information System  |
| GWMWater | Grampians Wimmera Mallee Water   |
| ISC      | Index of Stream Condition  |
| JAMBA    | Japan–Australia Migratory Bird Agreement   |
| MDBA     | Murray–Darling Basin Authority (formerly Murray–Darling Basin Commission, MDBC)                                    |
| ML       | Megalitre (one million litres)   |
| ML/d     | Megalitres per day   |
| POE      | Probability of Exceedance  |
| ROKAMBA  | Republic of Korea–Australia Migratory Bird Agreement   |
| RAP      | Registered Aboriginal Party  |
| RCS      | Regional Catchment Strategy  |
| RWS      | Regional Waterway Strategy   |

|        |   |
|--------|---|
| SWP    | Seasonal Watering Proposal                                      |
| VEFMAP | Victorian Environmental Flows Monitoring and Assessment Program |
| VEWH   | Victorian Environmental Water Holder                            |
| VWMS   | Victorian Waterway Management Strategy                          |
| WSPA   | Water Supply Protection Area                                    |

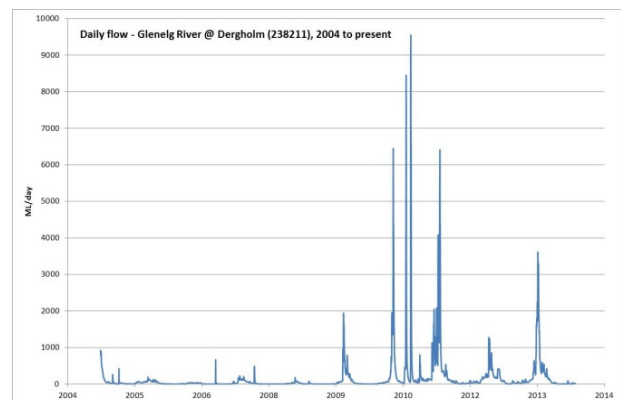
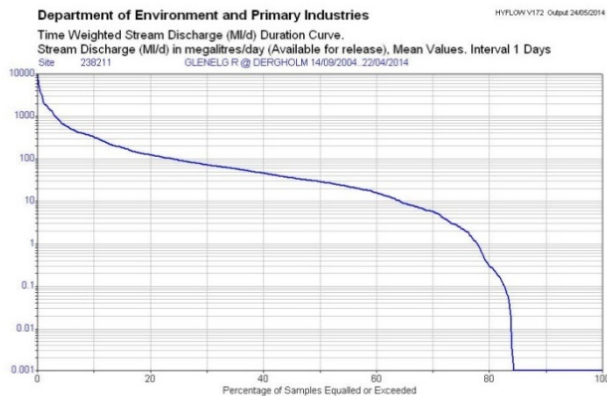
# Appendix 1 – Glenelg River flow duration curves and hydrographs



## Reach 0: Glenelg River @ Big Cord (238231), 1968 to current (catchment area 57 km<sup>2</sup>)



## Reach 1b: Glenelg River @ Harrow (238210), 2001 to present



## Reach 2: Glenelg River @ Dergholm (238211), 2004 to present

## Appendix 2 – Fauna species list

Location accuracy of species recorded in VBA is generally between 200 - 500 m.

| Scientific Name                | Common name             | Reach |    |    |   | EPBC Status | FFG Status | Victorian Advisory List |
|--------------------------------|-------------------------|-------|----|----|---|-------------|------------|-------------------------|
|                                |                         | 0     | 1a | 1b | 2 |             |            |                         |
| Fish native                    |                         |       |    |    |   |             |            |                         |
| <i>Acanthopagrus butcheri</i>  | Black bream             |       |    |    | √ |             |            |                         |
| <i>Aldrichetta forsteri</i>    | Yellow-eye mullet       |       |    |    | √ |             |            |                         |
| <i>Anguilla australis</i>      | Short-finned eel        |       | √  | √  | √ |             |            |                         |
| <i>Anguilla reinhardtii</i>    | Longfinned eel          |       |    |    | √ |             |            |                         |
| <i>Gadopsis marmoratus</i>     | River blackfish         |       | √  | √  | √ |             |            |                         |
| <i>Galaxias maculatus</i>      | Common galaxias         |       | √  | √  | √ |             |            |                         |
| <i>Galaxias olidus</i>         | Mountain galaxias       |       | √  | √  |   |             |            |                         |
| <i>Galaxiella pusilla</i>      | Dwarf galaxias          |       | √  | √  |   |             |            | E                       |
| <i>Geotria australis</i>       | Pouched lamprey         |       |    |    | √ |             |            |                         |
| <i>Macquaria ambigua</i>       | Golden perch            |       |    |    | √ |             |            | NT                      |
| <i>Macquaria australasica</i>  | Macquarie perch         |       |    |    | √ | E           | T          | E                       |
| <i>Macquaria colonorum</i>     | Estuary perch           |       |    | √  | √ |             |            |                         |
| <i>Macquaria novemaculeata</i> | Australian bass         |       | √  | √  |   |             |            |                         |
| <i>Mordacia mordax</i>         | Short-headed lamprey    |       |    |    | √ |             |            |                         |
| <i>Nannoperca australis</i>    | Southern pygmy perch    |       | √  | √  | √ |             |            |                         |
| <i>Nannoperca obscura</i>      | Yarra pygmy perch       |       | √  | √  | √ |             | T          | V                       |
| <i>Nannoperca variegata</i>    | Variiegated pygmy perch |       |    |    | √ | V           | T          | V                       |
| <i>Philypnodon grandiceps</i>  | Flat-headed Gudgeon     |       | √  | √  | √ |             |            |                         |
| <i>Prototroctes maraena</i>    | Australian grayling     |       |    |    | √ | V           | T          | V                       |
| <i>Pseudaphritis urvillii</i>  | Tupong                  |       |    |    | √ |             |            |                         |



|                                   |                                   |   |   |   |   |   |   |    |
|-----------------------------------|-----------------------------------|---|---|---|---|---|---|----|
| <i>Retropinna semoni</i>          | Australian smelt                  |   |   |   | √ |   |   |    |
| Invertebrates                     |                                   |   |   |   |   |   |   |    |
| <i>Cherax destructor</i>          | Common yabby                      | √ | √ | √ | √ |   |   |    |
| <i>Engaeuslyelli sp.</i>          | Land yabby                        | √ | √ | √ | √ |   |   |    |
| <i>Euastacus bispinosus</i>       | Glenelg spiny freshwater crayfish | √ | √ |   | √ | E | T | E  |
| <i>Paratya australiensis</i>      | Freshwater shrimp                 |   | √ |   |   |   |   |    |
| <i>Geocharax falcate</i>          | Western crayfish                  | √ | √ | √ | √ |   |   |    |
| <i>Gramastacus insolitus</i>      | Western swamp crayfish            | √ |   |   |   |   | T | E  |
| Amphibians                        |                                   |   |   |   |   |   |   |    |
| <i>Crinia signifera</i>           | Common froglet                    | √ | √ | √ |   |   |   |    |
| <i>Geocrinia laevis</i>           | Southern smooth froglet           | √ | √ | √ |   |   |   |    |
| <i>Limnodynastes dumerilii</i>    | Southern Bullfrog (spp. Unknown)  |   | √ | √ |   |   |   |    |
| <i>Limnodynastes peronii</i>      | Striped marsh frog                | √ | √ | √ |   |   |   |    |
| <i>Litoria ewingii</i>            | Southern brown tree frog          |   | √ | √ |   |   |   |    |
| <i>Litoria raniformis</i>         | Growling grass frog               | √ | √ | √ |   | V | T | E  |
| <i>Pseudophryne bibronii</i>      | Brown toadlet                     |   | √ | √ |   |   |   | E  |
| <i>Pseudophryne semimarmorata</i> | Southern toadlet                  | √ |   |   |   |   |   | V  |
| <i>Crinia signifera</i>           | Common froglet                    | √ | √ | √ |   |   |   |    |
| Birds water dependant             |                                   |   |   |   |   |   |   |    |
| <i>Acrocephalus stentoreus</i>    | Clamorous reed warbler            | √ | √ | √ |   |   |   |    |
| <i>Alcedo azurea</i>              | Azure kingfisher                  |   |   |   | √ |   |   | NT |
| <i>Anas castanea</i>              | Chestnut teal                     |   | √ | √ |   |   |   |    |
| <i>Anas gracilis</i>              | Grey teal                         |   | √ | √ | √ |   |   |    |
| <i>Anas rhynchotis</i>            | Australasian shoveler             |   |   |   | √ |   |   | V  |
| <i>Anas superciliosa</i>          | Pacific black duck                | √ | √ | √ | √ |   |   |    |

|                                      |                         |   |   |   |   |  |   |    |
|--------------------------------------|-------------------------|---|---|---|---|--|---|----|
| <i>Anhinga novaehollandiae</i>       | Darter                  | √ | √ | √ |   |  |   |    |
| <i>Anseranas semipalmata</i>         | Magpie goose            |   |   |   | √ |  |   | NT |
| <i>Ardea modesta</i>                 | Eastern great egret     | √ | √ | √ | √ |  |   | V  |
| <i>Ardea pacifica</i>                | White-necked heron      | √ | √ | √ | √ |  |   |    |
| <i>Aythya australis</i>              | Hardhead                |   | √ | √ | √ |  |   | V  |
| <i>Biziura lobata</i>                | Musk duck               | √ | √ | √ | √ |  |   | V  |
| <i>Chenonetta jubata</i>             | Australian wood duck    | √ | √ | √ | √ |  |   |    |
| <i>Circus approximans</i>            | Swamp harrier           |   | √ | √ | √ |  |   |    |
| <i>Corcorax melanorhamphos</i>       | White-winged cough      |   | √ | √ |   |  |   |    |
| <i>Cygnus atratus</i>                | Black swan              | √ | √ | √ | √ |  |   |    |
| <i>Egretta novaehollandiae</i>       | White-faced heron       | √ | √ | √ | √ |  |   |    |
| <i>Euseyornis melanops</i>           | Black-fronted dotterel  | √ | √ | √ | √ |  |   |    |
| <i>Fulica atra</i>                   | Eurasian coot           |   | √ | √ | √ |  |   |    |
| <i>Gallinago hardwickii</i>          | Latham's snipe          |   | √ | √ | √ |  |   | NT |
| <i>Gallinula tenebrosa</i>           | Dusky moorhen           | √ | √ | √ | √ |  |   |    |
| <i>Gallinula ventralis</i>           | Black-tailed native-hen |   |   |   | √ |  |   |    |
| <i>Gallirallus philippensis</i>      | Buff-banded rail        |   |   |   | √ |  |   |    |
| <i>Grus rubicunda</i>                | Brolga                  |   |   |   | √ |  | T | V  |
| <i>Lewinia pectoralis pectoralis</i> | Lewin's rail            | √ |   |   | √ |  |   | V  |
| <i>Malacorhynchus membranaceus</i>   | Pink-eared duck         |   |   |   | √ |  |   |    |
| <i>Microcarbo melanoleucos</i>       | Little pied cormorant   | √ | √ | √ | √ |  |   |    |
| <i>Pelecanus conspicillatus</i>      | Australian pelican      |   | √ | √ | √ |  |   |    |
| <i>Phalacrocorax carbo</i>           | Great cormorant         | √ | √ | √ |   |  |   |    |
| <i>Phalacrocorax sulcirostris</i>    | Little black cormorant  | √ | √ | √ | √ |  |   |    |
| <i>Phalacrocorax varius</i>          | Pied cormorant          |   | √ | √ |   |  |   | NT |

|                                     |                          |   |   |   |   |  |  |  |
|-------------------------------------|--------------------------|---|---|---|---|--|--|--|
| <i>Platalea flavipes</i>            | Yellow-billed spoonbill  | √ | √ | √ | √ |  |  |  |
| <i>Podiceps cristatus</i>           | Great crested grebe      |   | √ | √ |   |  |  |  |
| <i>Poliiocephalus poliocephalus</i> | Hoary-headed grebe       | √ |   |   | √ |  |  |  |
| <i>Porphyrio porphyrio</i>          | Purple swamphen          | √ | √ | √ | √ |  |  |  |
| <i>Porzana fluminea</i>             | Australian spotted crake | √ |   |   |   |  |  |  |
| <i>Porzana tabuensis</i>            | Spotless crake           | √ |   |   |   |  |  |  |
| <i>Tachybaptus novaehollandiae</i>  | Australasian grebe       | √ | √ | √ | √ |  |  |  |
| <i>Tadorna tadornoides</i>          | Australian shelduck      |   | √ | √ | √ |  |  |  |
| <i>Threskiornis molucca</i>         | Australian white ibis    | √ | √ | √ | √ |  |  |  |
| <i>Threskiornis spinicollis</i>     | Straw-necked Ibis        |   | √ | √ | √ |  |  |  |
| <i>Vanellus miles</i>               | Masked lapwing           | √ | √ | √ | √ |  |  |  |
| Birds terrestrial                   |                          |   |   |   |   |  |  |  |
| <i>Acanthiza chrysorrhoa</i>        | Yellow-rumped thornbill  |   | √ | √ | √ |  |  |  |
| <i>Acanthiza lineata</i>            | Striated thornbill       | √ | √ | √ |   |  |  |  |
| <i>Acanthiza nana</i>               | Yellow thornbill         |   | √ | √ |   |  |  |  |
| <i>Acanthiza pusilla</i>            | Brown thornbill          | √ | √ | √ | √ |  |  |  |
| <i>Acanthiza reguloides</i>         | Buff-rumped thornbill    |   | √ | √ |   |  |  |  |
| <i>Acanthorhynchus tenuirostris</i> | Eastern spinebill        | √ | √ | √ |   |  |  |  |
| <i>Accipiter cirrhocephalus</i>     | Collared sparrowhawk     |   | √ | √ | √ |  |  |  |
| <i>Accipiter fasciatus</i>          | Brown goshawk            |   | √ | √ | √ |  |  |  |
| <i>Aegotheles cristatus</i>         | Australian owl-nightjar  |   | √ | √ |   |  |  |  |
| <i>Anthochaera carunculata</i>      | Red wattlebird           | √ | √ | √ | √ |  |  |  |
| <i>Anthochaera chrysoptera</i>      | Little wattlebird        | √ | √ | √ | √ |  |  |  |
| <i>Anthus novaeseelandiae</i>       | Australasian pipit       | √ | √ | √ | √ |  |  |  |

|  |  |   |   |   |   |  |  |    |
|--|--|---|---|---|---|--|--|----|
| <i>Aphelocephala leucopsis</i>         | Southern whiteface                     |   | √ | √ |   |  |  |    |
| <i>Aquila audax</i>                    | Wedge-tailed eagle                     | √ | √ | √ | √ |  |  |    |
| <i>Ardea ibis</i>                      | Cattle egret                           |   |   |   | √ |  |  |    |
| <i>Artamus cyanopterus</i>             | Dusky woodswallow                      | √ | √ | √ | √ |  |  |    |
| <i>Cacatua galerita</i>                | Sulphur-crested Cockatoo               | √ | √ | √ | √ |  |  |    |
| <i>Cacatua sanguinea</i>               | Little corella                         |   | √ | √ |   |  |  |    |
| <i>Cacatua tenuirostris</i>            | Long-billed corella                    | √ | √ | √ | √ |  |  |    |
| <i>Cacomantis flabelliformis</i>       | Fan-tailed cuckoo                      |   | √ | √ |   |  |  |    |
| <i>Callocephalon fimbriatum</i>        | Gang-gang cockatoo                     |   | √ | √ |   |  |  |    |
| <i>Calyptorhynchus funereus</i>        | Yellow-tailed black-cockatoo           |   | √ | √ | √ |  |  |    |
| <i>Chroicocephalus novaehollandiae</i> | Silver gull                            |   | √ | √ | √ |  |  |    |
| <i>Chrysococcyx basalis</i>            | Horsfield's bronze-cuckoo              |   | √ | √ |   |  |  |    |
| <i>Chrysococcyx osculans</i>           | Black-eared cuckoo                     |   | √ | √ | √ |  |  | NT |
| <i>Chthonicola sagittatus</i>          | Speckled warbler                       |   | √ | √ |   |  |  | V  |
| <i>Cincloramphus cruralis</i>          | Brown songlark                         |   |   |   | √ |  |  |    |
| <i>Cincloramphus mathewsi</i>          | Rufous songlark                        |   | √ | √ | √ |  |  |    |
| <i>Climacteris picumnus victoriae</i>  | Brown treecreeper (south-eastern spp.) | √ | √ | √ | √ |  |  | NT |
| <i>Colluricincla harmonica</i>         | Grey Shrike-thrush                     | √ | √ | √ | √ |  |  |    |
| <i>Coracina novaehollandiae</i>        | Black-faced cuckoo-shrike              |   | √ | √ | √ |  |  |    |
| <i>Coracina papuensis</i>              | White-bellied cuckoo-shrike            |   | √ | √ | √ |  |  |    |
| <i>Cormobates leucophaeus</i>          | White-throated treecreeper             | √ | √ | √ |   |  |  |    |

|                                     |                           |   |   |   |   |  |  |    |
|-------------------------------------|---------------------------|---|---|---|---|--|--|----|
| <i>Corvus coronoides</i>            | Australian raven          | √ | √ | √ | √ |  |  |    |
| <i>Corvus mellori</i>               | Little raven              |   | √ | √ | √ |  |  |    |
| <i>Corvus tasmanicus</i>            | Forest raven              |   | √ | √ |   |  |  |    |
| <i>Coturnix pectoralis</i>          | Stubble quail             |   | √ | √ |   |  |  |    |
| <i>Cuculus pallidus</i>             | Pallid cuckoo             |   | √ | √ |   |  |  |    |
| <i>Dacelo novaeguineae</i>          | Laughing kookaburra       | √ | √ | √ | √ |  |  |    |
| <i>Daphoenositta chrysoptera</i>    | Varied sittella           | √ | √ | √ |   |  |  |    |
| <i>Dicaeum hirundinaceum</i>        | Mistletoebird             |   | √ | √ |   |  |  |    |
| <i>Dromaius novaehollandiae</i>     | Emu                       | √ | √ | √ |   |  |  | NT |
| <i>Elanus axillaris</i>             | Black-shouldered kite     |   | √ | √ | √ |  |  |    |
| <i>Eolophus roseicapilla</i>        | Galah                     |   | √ | √ | √ |  |  |    |
| <i>Eopsaltria australis</i>         | Eastern yellow robin      | √ | √ | √ |   |  |  |    |
| <i>Falco berigora</i>               | Brown falcon              |   | √ | √ | √ |  |  |    |
| <i>Falco cenchroides</i>            | Nankeen kestrel           |   |   |   | √ |  |  |    |
| <i>Falco peregrinus</i>             | Peregrine falcon          |   |   |   | √ |  |  |    |
| <i>Falcunculus frontatus</i>        | Crested Shrike-tit        |   | √ | √ | √ |  |  |    |
| <i>Glossopsitta concinna</i>        | Musk lorikeet             | √ | √ | √ | √ |  |  |    |
| <i>Glossopsitta porphyrocephala</i> | Purple-crowned lorikeet   |   | √ | √ |   |  |  |    |
| <i>Glossopsitta pusilla</i>         | Little lorikeet           |   | √ | √ |   |  |  |    |
| <i>Grallina cyanoleuca</i>          | Magpie-lark               | √ | √ | √ | √ |  |  |    |
| <i>Gymnorhina tibicen</i>           | Australian magpie         | √ | √ | √ | √ |  |  |    |
| <i>Haliastur sphenurus</i>          | Whistling kite            | √ | √ | √ | √ |  |  |    |
| <i>Hieraaetus morphnoides</i>       | Little eagle              |   | √ | √ |   |  |  |    |
| <i>Hirundapus caudacutus</i>        | White-throated Needletail |   |   |   | √ |  |  | V  |
| <i>Lalage sueurii</i>               | White-winged triller      |   | √ | √ |   |  |  |    |

|  |                          |   |   |   |   |   |   |    |
|--|--------------------------|---|---|---|---|---|---|----|
| <i>Leipoa ocellata</i>                 | Malleefowl               | √ |   |   |   | V | T | E  |
| <i>Lichenostomus chrysops</i>          | Yellow-faced honeyeater  | √ | √ | √ |   |   |   |    |
| <i>Lichenostomus fuscus</i>            | Fuscous honeyeater       |   | √ | √ |   |   |   |    |
| <i>Lichenostomus leucotis</i>          | White-eared honeyeater   |   | √ | √ | √ |   |   |    |
| <i>Lichenostomus melanops</i>          | Yellow-tufted honeyeater | √ | √ | √ |   |   |   |    |
| <i>Lichenostomus penicillatus</i>      | White-plumed honeyeater  | √ | √ | √ | √ |   |   |    |
| <i>Lophoictinia isura</i>              | Square-tailed kite       |   | √ | √ |   |   |   | V  |
| <i>Malurus cyaneus</i>                 | Superb fairy-wren        | √ | √ | √ | √ |   |   |    |
| <i>Manorina melanocephala</i>          | Noisy miner              | √ | √ | √ |   |   |   |    |
| <i>Megalurus gramineus</i>             | Little grassbird         |   | √ | √ | √ |   |   |    |
| <i>Melanodryas cucullata cucullata</i> | Hooded robin             | √ | √ | √ |   |   |   | NT |
| <i>Melithreptus brevirostris</i>       | Brown-headed honeyeater  |   | √ | √ | √ |   |   |    |
| <i>Melithreptus gularis</i>            | Black-chinned honeyeater |   | √ | √ |   |   |   |    |
| <i>Melithreptus lunatus</i>            | White-naped honeyeater   |   | √ | √ | √ |   |   |    |
| <i>Merops ornatus</i>                  | Rainbow Bee-eater        | √ | √ | √ |   |   |   |    |
| <i>Microeca fascinans</i>              | Jacky winter             | √ | √ | √ |   |   |   |    |
| <i>Myiagra inquieta</i>                | Restless flycatcher      | √ | √ | √ | √ |   |   |    |
| <i>Neochmia temporalis</i>             | Red-browed finch         | √ | √ | √ | √ |   |   |    |
| <i>Neophema chrysostoma</i>            | Blue-winged parrot       |   | √ | √ |   |   |   |    |
| <i>Ninox connivens connivens</i>       | Barking owl              |   |   |   | √ |   |   | E  |
| <i>Ninox novaeseelandiae</i>           | Southern boobook         |   | √ | √ | √ |   |   |    |
| <i>Ocyphaps lophotes</i>               | Crested pigeon           |   | √ | √ |   |   |   |    |
| <i>Oriolus sagittatus</i>              | Olive-backed oriole      |   |   |   | √ |   |   |    |

|                                     |                          |   |   |   |   |  |  |    |
|-------------------------------------|--------------------------|---|---|---|---|--|--|----|
| <i>Pachycephala pectoralis</i>      | Golden whistler          |   | √ | √ | √ |  |  |    |
| <i>Pachycephala rufiventris</i>     | Rufous whistler          | √ | √ | √ | √ |  |  |    |
| <i>Pardalotus punctatus</i>         | Spotted pardalote        | √ | √ | √ |   |  |  |    |
| <i>Pardalotus striatus</i>          | Striated pardalote       | √ | √ | √ | √ |  |  |    |
| <i>Petrochelidon ariel</i>          | Fairy martin             | √ | √ | √ |   |  |  |    |
| <i>Petrochelidon neoxena</i>        | Welcome swallow          | √ | √ | √ | √ |  |  |    |
| <i>Petrochelidon nigricans</i>      | Tree martin              | √ | √ | √ | √ |  |  |    |
| <i>Petroica boodang</i>             | Scarlet robin            | √ | √ | √ | √ |  |  |    |
| <i>Petroica goodenovii</i>          | Red-capped robin         |   | √ | √ |   |  |  |    |
| <i>Phaps chalcoptera</i>            | Common bronzewing        | √ | √ | √ | √ |  |  |    |
| <i>Phylidonyris melanops</i>        | Tawny-crowned honeyeater |   | √ | √ |   |  |  |    |
| <i>Phylidonyris novaehollandiae</i> | New holland honeyeater   | √ | √ | √ | √ |  |  |    |
| <i>Platycercus elegans</i>          | Crimson rosella          | √ | √ | √ | √ |  |  |    |
| <i>Platycercus eximius</i>          | Eastern rosella          | √ | √ | √ | √ |  |  |    |
| <i>Podargus strigoides</i>          | Tawny frogmouth          |   | √ | √ | √ |  |  |    |
| <i>Pomatostomus superciliosus</i>   | White-browed babbler     | √ | √ | √ |   |  |  |    |
| <i>Psephotus haematonotus</i>       | Red-rumped parrot        | √ | √ | √ | √ |  |  |    |
| <i>Rhipidura albiscarpa</i>         | Grey fantail             | √ | √ | √ | √ |  |  |    |
| <i>Rhipidura leucophrys</i>         | Willie wagtail           | √ | √ | √ | √ |  |  |    |
| <i>Sericornis frontalis</i>         | White-browed scrubwren   | √ | √ | √ | √ |  |  |    |
| <i>Smicronis brevirostris</i>       | Weebill                  |   | √ | √ |   |  |  |    |
| <i>Stagonopleura guttata</i>        | Diamond firetail         |   | √ | √ |   |  |  | NT |
| <i>Strepera graculina</i>           | Pied currawong           | √ | √ | √ |   |  |  |    |

|                                     |                            |   |   |   |   |   |   |    |
|-------------------------------------|----------------------------|---|---|---|---|---|---|----|
| <i>Strepera versicolor</i>          | Grey currawong             | √ | √ | √ | √ |   |   |    |
| <i>Todiramphus sanctus</i>          | Sacred kingfisher          | √ | √ | √ |   |   |   |    |
| <i>Trichoglossus haematodus</i>     | Rainbow lorikeet           | √ | √ | √ |   |   |   |    |
| <i>Turnix varia</i>                 | Painted button-quail       |   | √ | √ |   |   |   |    |
| <i>Tyto javanica</i>                | Pacific barn owl           |   |   |   | √ |   |   |    |
| <i>Zosterops lateralis</i>          | Silvereeye                 | √ | √ | √ | √ |   |   |    |
| Mammals water dependant             |                            |   |   |   |   |   |   |    |
| <i>Ornithorhynchus anatinus</i>     | Platypus                   |   |   |   | √ |   |   |    |
| <i>Hydromys chrysogaster</i>        | Water rat                  | √ |   |   |   |   |   |    |
| <i>Antechinus minimus maritimus</i> | Swamp antechinus           |   |   |   | √ |   |   | NT |
| Mammals terrestrial                 |                            |   |   |   |   |   |   |    |
| <i>Antechinus flavipes</i>          | Yellow-footed antechinus   |   | √ | √ | √ |   |   |    |
| <i>Chalinolobus morio</i>           | Chocolate wattled bat      | √ |   |   |   |   |   |    |
| <i>Isoodon obesulus obesulus</i>    | Southern brown bandicoot   |   |   |   | √ |   |   | NT |
| <i>Macropus fuliginosus</i>         | Western grey kangaroo      |   | √ | √ |   |   |   |    |
| <i>Macropus giganteus</i>           | Eastern grey kangaroo      |   | √ | √ | √ |   |   |    |
| <i>Petaurus breviceps</i>           | Sugar glider               |   |   |   | √ |   |   |    |
| <i>Phascolarctos cinereus</i>       | Koala                      |   | √ | √ |   |   |   |    |
| <i>Pseudomys shortridgei</i>        | Heath mouse                | √ |   |   |   | V | T | NT |
| <i>Sminthopsis murina murina</i>    | Common dunnart             | √ |   |   |   |   |   | V  |
| <i>Tadarida australis</i>           | White-striped freetail Bat |   | √ | √ |   |   |   |    |
| <i>Vespadelus vulturnus</i>         | Little forest bat          | √ |   |   |   |   |   |    |
| Reptiles                            |                            |   |   |   |   |   |   |    |
| <i>Delma impar</i>                  | Striped legless lizard     |   |   |   | √ | V | T | E  |



|   |                         |   |   |   |   |  |  |  |
|---|-------------------------|---|---|---|---|--|--|--|
| <i>Diplodactylus vittatus</i>                           | Wood gecko              |   | √ | √ |   |  |  |  |
| <i>Lampropholis guichenoti</i>                          | Garden skink            |   | √ | √ |   |  |  |  |
| <i>Notechis scutatus</i>                                | Tiger snake             |   |   |   | √ |  |  |  |
| <i>Pseudechis porphyriacus</i>                          | Red-bellied black snake | √ |   |   |   |  |  |  |
| <i>Pseudonaja textilis</i>                              | Eastern brown snake     | √ | √ | √ |   |  |  |  |
| <i>Tiliqua rugosa</i>                                   | Stumpy-tailed lizard    |   | √ | √ |   |  |  |  |
| Exotic - fish   |                         |   |   |   |   |  |  |  |
| <i>Carassius auratus</i>                                | Goldfish                |   | √ | √ | √ |  |  |  |
| <i>Cyprinus carpio</i>                                  | Carp                    |   | √ | √ | √ |  |  |  |
| <i>Gambusia holbrooki</i>                               | Eastern gambusia        |   | √ | √ |   |  |  |  |
| <i>Oncorhynchus mykiss</i>                              | Rainbow trout           |   | √ | √ | √ |  |  |  |
| <i>Oncorhynchus tshawytscha</i>                         | Chinook salmon          |   | √ | √ |   |  |  |  |
| <i>Perca fluviatilis</i>                                | Redfin                  |   | √ | √ | √ |  |  |  |
| <i>Salmo trutta</i>                                     | Brown trout             |   | √ | √ | √ |  |  |  |
| Exotic - birds  |                         |   |   |   |   |  |  |  |
| <i>Turdus merula</i>                                    | Common blackbird        | √ | √ | √ | √ |  |  |  |
| <i>Passer domesticus</i>                                | House sparrow           |   | √ | √ | √ |  |  |  |
| <i>Sturnus vulgaris</i>                                 | Common starling         |   | √ | √ | √ |  |  |  |
| <i>Carduelis chloris</i>                                | European greenfinch     |   |   |   | √ |  |  |  |
| <i>Carduelis carduelis</i>                              | European goldfinch      |   | √ | √ |   |  |  |  |
| Exotic mammals  |                         |   |   |   |   |  |  |  |
| <i>Oryctolagus cuniculus</i>                            | European rabbit         |   | √ | √ |   |  |  |  |
| <i>Mus musculus</i>                                     | House mouse             | √ |   |   |   |  |  |  |
| <i>Cervus elaphus</i>                                   | Red deer                | √ | √ | √ |   |  |  |  |
| Legend:   |                         |   |   |   |   |  |  |  |
| √ recorded in reach                                     |                         |   |   |   |   |  |  |  |
| EPBC status: Critically Endangered (CE), Vulnerable (V) |                         |   |   |   |   |  |  |  |

FFG status: Threatened (T)

Vic advisory list: Endangered (E), Near Threatened (NT), Vulnerable (V), Rare (R)

## Appendix 3 – Flora species list

| Scientific Name                                   | Common name                  | Reach |    |    |   | EPBC Status | FFG Status | Victorian Advisory List |
|---|------------------------------|-------|----|----|---|-------------|------------|-------------------------|
|   |                              | 0     | 1a | 1b | 2 |             |            |                         |
| Native water dependant                            |                              |       |    |    |   |             |            |                         |
| <i>Allittia cardiocarpa</i>                       | Swamp daisy                  |       | √  |    |   |             |            |                         |
| <i>Allittia uliginosa</i>                         | Small swamp-daisy            |       | √  |    |   |             |            |                         |
| <i>Amphibromus archeri</i>                        | Pointed swamp Wallaby-grass  |       | √  |    |   |             |            |                         |
| <i>Amphibromus fluitans</i>                       | River swamp Wallaby-grass    |       | √  |    |   |             |            |                         |
| <i>Amphibromus neesii</i>                         | Southern swamp wallaby-grass |       | √  |    |   |             |            |                         |
| <i>Amphibromus recurvatus</i>                     | Dark swamp Wallaby-grass     |       | √  |    |   |             |            |                         |
| <i>Angianthus preissianus</i>                     | Salt angianthus              |       | √  |    |   |             |            |                         |
| <i>Aphelia gracilis</i>                           | Slender aphelia              |       | √  |    |   |             |            |                         |
| <i>Baloskion tetraphyllum subsp. tetraphyllum</i> | Tassel cord-rush             |       | √  |    |   |             |            |                         |
| <i>Baumea arthropphylla</i>                       | Fine twig-sedge              |       | √  |    |   |             |            |                         |
| <i>Baumea articulata</i>                          | Jointed twig-sedge           |       | √  |    |   |             |            |                         |
| <i>Baumea juncea</i>                              | Bare twig-sedge              | √     | √  |    |   |             |            |                         |
| <i>Baumea rubiginosa s.l.</i>                     | Soft twig-rush               |       | √  |    |   |             |            |                         |
| <i>Callitriche spp.</i>                           | Water starwort               |       | √  |    |   |             |            |                         |
| <i>Carex appressa</i>                             | Tall sedge                   |       | √  |    | √ |             |            |                         |
| <i>Carex breviculmis</i>                          | Common grass-sedge           |       | √  |    |   |             |            |                         |
| <i>Carex gaudichaudiana</i>                       | Fen sedge                    |       | √  |    |   |             |            |                         |
| <i>Carex inversa</i>                              | Knob sedge                   |       | √  |    | √ |             |            |                         |
| <i>Carex spp.</i>                                 | Sedge                        |       | √  |    |   |             |            |                         |
| <i>Carex tereticaulis</i>                         | Poong'ort                    |       | √  |    | √ |             |            |                         |

|   |                                  |   |   |  |   |  |  |  |
|---|----------------------------------|---|---|--|---|--|--|--|
| <i>Centipeda cunninghamii</i>               | Common sneezeweed (old man weed) |   | √ |  | √ |  |  |  |
| <i>Characeae spp.</i>                       | Stonewort                        |   | √ |  |   |  |  |  |
| <i>Chorizandra enodis</i>                   | Black bristle-sedge              |   | √ |  |   |  |  |  |
| <i>Cycnogeton alcockiae</i>                 | Southern water-ribbons           |   | √ |  | √ |  |  |  |
| <i>Cycnogeton procerum s.s.</i>             | Common water-ribbons             |   | √ |  | √ |  |  |  |
| <i>Cycnogeton spp.</i>                      | Water ribbons                    |   | √ |  | √ |  |  |  |
| <i>Cyperus gunnii subsp. gunnii</i>         | Flecked flat-sedge               |   | √ |  |   |  |  |  |
| <i>Cyperus lucidus</i>                      | Leafy flat-sedge                 |   | √ |  |   |  |  |  |
| <i>Distichlis distichophylla</i>            | Australian salt-grass            |   | √ |  | √ |  |  |  |
| <i>Eleocharis acuta</i>                     | Common spike-sedge               |   | √ |  | √ |  |  |  |
| <i>Eleocharis pusilla</i>                   | Small spike-sedge                |   | √ |  |   |  |  |  |
| <i>Eleocharis sphacelata</i>                | Tall spike-sedge                 |   | √ |  |   |  |  |  |
| <i>Gahnia filum</i>                         | Chaffy saw-sedge                 |   | √ |  |   |  |  |  |
| <i>Gahnia radula</i>                        | Thatch saw-sedge                 |   | √ |  |   |  |  |  |
| <i>Isolepis cernua var. platycarpa</i>      | Broad-fruit club-sedge           |   | √ |  |   |  |  |  |
| <i>Isolepis fluitans</i>                    | Floating club-sedge              |   | √ |  |   |  |  |  |
| <i>Isotoma fluviatilis subsp. australis</i> | Swamp isotome                    |   | √ |  |   |  |  |  |
| <i>Juncus holoschoenus</i>                  | Joint-leaf rush                  |   | √ |  | √ |  |  |  |
| <i>Juncus kraussii subsp. australiensis</i> | Sea rush                         |   | √ |  |   |  |  |  |
| <i>Juncus pallidus</i>                      | Pale rush                        | √ | √ |  | √ |  |  |  |
| <i>Juncus pauciflorus</i>                   | Loose-flower rush                |   | √ |  |   |  |  |  |
| <i>Juncus sarophorus</i>                    | Broom rush                       |   | √ |  |   |  |  |  |
| <i>Lachnagrostis perennis spp. agg.</i>     | Perennial blown-grass            |   | √ |  |   |  |  |  |

|   |                          |   |   |  |   |  |  |   |
|---|--------------------------|---|---|--|---|--|--|---|
| <i>Landoltia punctata</i>                 | Thin duckweed            |   | √ |  |   |  |  |   |
| <i>Lemna minor s.l.</i>                   | Common duckweed          |   |   |  | √ |  |  |   |
| <i>Lepilaena australis</i>                | Austral water-mat        |   | √ |  |   |  |  |   |
| <i>Lobelia anceps</i>                     | Angled lobelia           |   | √ |  |   |  |  |   |
| <i>Lycopus australis</i>                  | Australian gipsywort     |   |   |  | √ |  |  |   |
| <i>Lythrum hyssopifolia</i>               | Small loosestrife        |   | √ |  | √ |  |  |   |
| <i>Marsilea drummondii</i>                | Common nardoo            |   |   |  | √ |  |  |   |
| <i>Montia australasica</i>                | White purslane           |   | √ |  |   |  |  |   |
| <i>Montia fontana</i>                     | Water blinks             |   | √ |  |   |  |  |   |
| <i>Myriocephalus rhizocephalus</i>        | Woolly-heads             |   | √ |  |   |  |  |   |
| <i>Myriophyllum caput-medusae</i>         | Coarse water-milfoil     |   | √ |  |   |  |  |   |
| <i>Myriophyllum crispatum</i>             | Upright water-milfoil    |   | √ |  |   |  |  |   |
| <i>Myriophyllum integrifolium</i>         | Tiny water-milfoil       |   | √ |  |   |  |  |   |
| <i>Myriophyllum simulans</i>              | Amphibious water-milfoil |   | √ |  |   |  |  |   |
| <i>Myriophyllum spp.</i>                  | Water milfoil            |   |   |  | √ |  |  |   |
| <i>Myriophyllum variifolium</i>           | Varied water-milfoil     |   | √ |  |   |  |  |   |
| <i>Ornduffia reniformis</i>               | Running marsh-flower     | √ | √ |  |   |  |  |   |
| <i>Ornduffia spp.</i>                     | Marsh flower             | √ |   |  |   |  |  |   |
| <i>Ornduffia umbricola var. umbricola</i> | Lax Marsh-flower         |   | √ |  |   |  |  | V |
| <i>Phragmites australis</i>               | Common reed              |   | √ |  | √ |  |  |   |
| <i>Potamogeton ochreatus</i>              | Blunt pondweed           |   | √ |  |   |  |  |   |
| <i>Potamogeton tricarınatus s.l.</i>      | Floating pondweed        |   | √ |  |   |  |  |   |
| <i>Ranunculus amphitrichus</i>            | Small river buttercup    |   | √ |  |   |  |  |   |
| <i>Ranunculus rivularis s.l.</i>          | River buttercup complex  |   | √ |  |   |  |  |   |

|                                |                         |  |   |  |   |  |  |  |
|--------------------------------|-------------------------|--|---|--|---|--|--|--|
| <i>Rumex bidens</i>            | Mud dock                |  | √ |  |   |  |  |  |
| <i>Sonchus hydrophilus</i>     | Native sow-thistle      |  | √ |  |   |  |  |  |
| <i>Stuckenia pectinata</i>     | Fennel pondweed         |  | √ |  |   |  |  |  |
| <i>Typha domingensis</i>       | Narrow-leaf<br>Cumbungi |  | √ |  |   |  |  |  |
| <i>Typha orientalis</i>        | Broad-leaf cumbungi     |  | √ |  |   |  |  |  |
| <i>Vallisneria australis</i>   | Eel grass               |  | √ |  |   |  |  |  |
|                                |                         |  |   |  |   |  |  |  |
| Native terrestrial             |                         |  |   |  |   |  |  |  |
| <i>Acacia acinacea s.l.</i>    | Gold-dust wattle        |  | √ |  |   |  |  |  |
| <i>Acacia brownii</i>          | Heath wattle            |  | √ |  |   |  |  |  |
| <i>Acacia implexa</i>          | Lightwood               |  | √ |  |   |  |  |  |
| <i>Acacia mearnsii</i>         | Black wattle            |  | √ |  | √ |  |  |  |
| <i>Acacia melanoxylon</i>      | Blackwood               |  | √ |  | √ |  |  |  |
| <i>Acacia myrtifolia</i>       | Myrtle wattle           |  | √ |  |   |  |  |  |
| <i>Acacia paradoxa</i>         | Hedge wattle            |  | √ |  |   |  |  |  |
| <i>Acacia pycnantha</i>        | Golden wattle           |  | √ |  |   |  |  |  |
| <i>Acacia ulicifolia</i>       | Juniper wattle          |  | √ |  |   |  |  |  |
| <i>Acacia verniciflua s.l.</i> | Varnish wattle          |  | √ |  | √ |  |  |  |
| <i>Acacia verticillata</i>     | Prickly moses           |  | √ |  | √ |  |  |  |
| <i>Acaena echinata</i>         | Sheep's burr            |  | √ |  | √ |  |  |  |
| <i>Acaena novae-zelandiae</i>  | Bidgee-widgee           |  | √ |  | √ |  |  |  |
| <i>Acaena ovina</i>            | Australian sheep's burr |  | √ |  | √ |  |  |  |
| <i>Acaena ovina</i>            | Australian sheep's burr |  |   |  |   |  |  |  |
| <i>Acaena spp.</i>             | Sheep's burr            |  | √ |  | √ |  |  |  |
| <i>Achrophyllum dentatum</i>   | Toothed mitre-moss      |  |   |  | √ |  |  |  |
| <i>Acrotriche serrulata</i>    | Honey-pots              |  | √ |  |   |  |  |  |
| <i>Adiantum aethiopicum</i>    | Common maidenhair       |  | √ |  |   |  |  |  |

|  |                        |   |   |  |   |  |  |   |
|--|------------------------|---|---|--|---|--|--|---|
| <i>Ajuga australis</i>                                     | Austral bugle          |   | √ |  |   |  |  |   |
| <i>Allocasuarina luehmannii</i>                            | Buloke                 |   | √ |  |   |  |  | E |
| <i>Allocasuarina muelleriana</i> subsp. <i>muelleriana</i> | Slaty sheoak           |   | √ |  |   |  |  |   |
| <i>Allocasuarina verticillata</i>                          | Drooping sheoak        |   | √ |  |   |  |  |   |
| <i>Alternanthera denticulata</i> s.s.                      | Lesser joyweed         |   |   |  | √ |  |  |   |
| <i>Amphipogon strictus</i>                                 | Grey-beard grass       |   | √ |  |   |  |  |   |
| <i>Amyema miquelii</i>                                     | Box mistletoe          |   | √ |  |   |  |  |   |
| <i>Amyema pendula</i>                                      | Drooping mistletoe     |   | √ |  | √ |  |  |   |
| <i>Anogramma leptophylla</i>                               | Annual fern            |   | √ |  |   |  |  |   |
| <i>Anthosachne scabra</i> s.l.                             | Common wheat-grass     |   | √ |  | √ |  |  |   |
| <i>Aphelia</i> spp.  | Aphelia                |   |   |  | √ |  |  |   |
| <i>Apium prostratum</i> subsp. <i>prostratum</i>           | Sea celery             |   | √ |  |   |  |  |   |
| <i>Apodasmia brownii</i>                                   | Coarse twine-rush      |   | √ |  |   |  |  |   |
| <i>Argentipallium obtusifolium</i>                         | Blunt everlasting      | √ |   |  |   |  |  |   |
| <i>Aristida behriana</i>                                   | Brush wire-grass       |   | √ |  |   |  |  |   |
| <i>Aristida ramosa</i>                                     | Cane wire-grass        |   | √ |  |   |  |  |   |
| <i>Arthropodium fimbriatum</i>                             | Nodding chocolate-lily |   | √ |  |   |  |  |   |
| <i>Arthropodium minus</i>                                  | Small vanilla-lily     |   | √ |  |   |  |  |   |
| <i>Arthropodium</i> spp. (s.s.)                            | Vanilla lily           |   | √ |  |   |  |  |   |
| <i>Arthropodium strictum</i> s.l.                          | Chocolate lily         |   | √ |  |   |  |  |   |
| <i>Asperula conferta</i>                                   | Common woodruff        |   | √ |  | √ |  |  |   |
| <i>Astroloma conostephioides</i>                           | Flame heath            |   | √ |  |   |  |  |   |
| <i>Astroloma humifusum</i>                                 | Cranberry heath        |   | √ |  | √ |  |  |   |

|  |                         |  |   |  |   |  |  |   |
|--|-------------------------|--|---|--|---|--|--|---|
| <i>Austrostipa blackii</i>                         | Crested spear-grass     |  | √ |  |   |  |  |   |
| <i>Austrostipa densiflora</i>                      | Dense spear-grass       |  | √ |  |   |  |  |   |
| <i>Austrostipa elegantissima</i>                   | Feather spear-grass     |  | √ |  |   |  |  |   |
| <i>Austrostipa mollis</i>                          | Supple spear-grass      |  | √ |  |   |  |  |   |
| <i>Austrostipa nodosa</i>                          | Knotty spear-grass      |  | √ |  |   |  |  |   |
| <i>Austrostipa pubinodis</i>                       | Tall spear-grass        |  | √ |  |   |  |  |   |
| <i>Austrostipa scabra</i><br><i>subsp. falcata</i> | Rough spear-grass       |  | √ |  |   |  |  |   |
| <i>Austrostipa semibarbata</i>                     | Fibrous spear-grass     |  | √ |  |   |  |  |   |
| <i>Austrostipa spp.</i>                            | Spear grass             |  | √ |  | √ |  |  |   |
| <i>Banksia marginata</i>                           | Silver banksia          |  | √ |  | √ |  |  |   |
| <i>Banksia ornata</i>                              | Desert banksia          |  | √ |  |   |  |  |   |
| <i>Billardiera cymosa</i><br><i>s.l.</i>           | Sweet Apple-berry       |  | √ |  |   |  |  |   |
| <i>Boronia pilosa</i><br><i>subsp. pilosa</i>      | Hairy boronia           |  |   |  | √ |  |  | R |
| <i>Bossiaea prostrata</i>                          | Creeping bossiaea       |  | √ |  |   |  |  |   |
| <i>Bossiaea riparia</i>                            | River leafless bossiaea |  | √ |  | √ |  |  | R |
| <i>Brachyloma ciliatum</i>                         | Fringed brachyloma      |  | √ |  |   |  |  |   |
| <i>Brachyloma daphnoides</i>                       | Daphne heath            |  | √ |  | √ |  |  |   |
| <i>Brachyscome perpusilla</i>                      | Rayless daisy           |  | √ |  |   |  |  |   |
| <i>Brachyscome readeri</i>                         | Reader's daisy          |  | √ |  |   |  |  | R |
| <i>Bromus spp.</i>                                 | Brome                   |  | √ |  |   |  |  |   |
| <i>Brunonia australis</i>                          | Blue pincushion         |  | √ |  |   |  |  |   |
| <i>Bulbine bulbosa</i>                             | Bulbine lily            |  | √ |  |   |  |  |   |
| <i>Bulbine semibarbata</i>                         | Leek lily               |  | √ |  |   |  |  |   |
| <i>Burchardia umbellata</i>                        | Milkmaids               |  | √ |  |   |  |  |   |



|   |                         |   |   |  |   |  |  |  |
|---|-------------------------|---|---|--|---|--|--|--|
| <i>Bursaria spinosa</i><br><i>subsp. spinosa</i>      | Sweet bursaria          |   | √ |  |   |  |  |  |
| <i>Caesia calliantha</i>                              | Blue grass-lily         |   | √ |  |   |  |  |  |
| <i>Caladenia cardiochila</i>                          | Heart-lip spider-orchid |   |   |  | √ |  |  |  |
| <i>Caladenia carnea</i><br><i>s.s.</i>                | Pink fingers            |   | √ |  | √ |  |  |  |
| <i>Caladenia cucullata</i>                            | Hood orchid             |   | √ |  |   |  |  |  |
| <i>Caladenia fuscata</i>                              | Dusky fingers           |   | √ |  |   |  |  |  |
| <i>Caladenia latifolia</i>                            | Pink fairies            |   |   |  | √ |  |  |  |
| <i>Caladenia parva</i>                                | Small spider-orchid     |   | √ |  |   |  |  |  |
| <i>Calandrinia granulifera</i>                        | Pigmy purslane          |   | √ |  |   |  |  |  |
| <i>Callistemon rugulosus</i>                          | Scarlet bottlebrush     |   | √ |  |   |  |  |  |
| <i>Callistomen wimmerensis</i>                        | Wimmera bottlebrush     |   | √ |  |   |  |  |  |
| <i>Callitris gracilis</i>                             | Slender cypress-pine    |   | √ |  |   |  |  |  |
| <i>Calocephalus lacteus</i>                           | Milky beauty-heads      |   | √ |  |   |  |  |  |
| <i>Calochilus robertsonii s.l.</i>                    | Purple Beard-orchid     |   | √ |  |   |  |  |  |
| <i>Calytrix tetragona</i>                             | Common fringe-myrtle    |   | √ |  |   |  |  |  |
| <i>Campylopus introflexus</i>                         | Heath star moss         |   |   |  | √ |  |  |  |
| <i>Cassytha glabella</i>                              | Slender dodder-laurel   |   | √ |  |   |  |  |  |
| <i>Caustis pentandra</i>                              | Thick twist-rush        | √ |   |  |   |  |  |  |
| <i>Centrolepis aristata</i>                           | Pointed centrolepis     | √ | √ |  |   |  |  |  |
| <i>Centrolepis cephaloformis subsp. cephaloformis</i> | Cushion centrolepis     |   | √ |  |   |  |  |  |
| <i>Centrolepis glabra</i>                             | Smooth centrolepis      |   | √ |  |   |  |  |  |
| <i>Centrolepis polygyna</i>                           | Wiry centrolepis        |   | √ |  |   |  |  |  |
| <i>Centrolepis strigosa subsp. strigosa</i>           | Hairy centrolepis       | √ | √ |  |   |  |  |  |

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|---|----------------------|---|---|--|---|--|--|--|
| <i>Chamaescilla corymbosa</i> var. <i>corymbosa</i> | Blue stars           | √ | √ |  |   |  |  |  |
| <i>Cheilanthes austrotenuifolia</i>                 | Green rock-fern      |   | √ |  | √ |  |  |  |
| <i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>    | Narrow rock-fern     |   | √ |  |   |  |  |  |
| <i>Chloris truncata</i>                             | Windmill grass       |   |   |  | √ |  |  |  |
| <i>Chrysocephalum apiculatum</i> s.l.               | Common everlasting   |   | √ |  | √ |  |  |  |
| <i>Comesperma calymega</i>                          | Blue-spike milkwort  |   | √ |  |   |  |  |  |
| <i>Comesperma volubile</i>                          | Love creeper         |   | √ |  |   |  |  |  |
| <i>Convolvulus angustissimus</i>                    | Blushing bindweed    |   | √ |  |   |  |  |  |
| <i>Convolvulus erubescens</i> s.l.                  | Pink bindweed        |   | √ |  |   |  |  |  |
| <i>Coronidium scorpioides</i> s.s.                  | Button everlasting   |   | √ |  |   |  |  |  |
| <i>Correa reflexa</i>                               | Common correa        |   | √ |  |   |  |  |  |
| <i>Corybas incurvus</i>                             | Slaty helmet-orchid  |   | √ |  |   |  |  |  |
| <i>Corybas</i> spp.                                 | Helmet orchid        |   | √ |  |   |  |  |  |
| <i>Cotula australis</i>                             | Common cotula        |   | √ |  |   |  |  |  |
| <i>Craspedia glauca</i> spp. agg.                   | Common billy-buttons |   | √ |  |   |  |  |  |
| <i>Crassula closiana</i>                            | Stalked crassula     |   | √ |  |   |  |  |  |
| <i>Crassula decumbens</i> var. <i>decumbens</i>     | Spreading crassula   |   | √ |  |   |  |  |  |
| <i>Crassula exserta</i>                             | Large-fruit Crassula |   | √ |  |   |  |  |  |
| <i>Crassula helmsii</i>                             | Swamp crassula       |   | √ |  |   |  |  |  |
| <i>Crassula helmsii</i>                             | Swamp crassula       |   |   |  | √ |  |  |  |
| <i>Crassula sieberiana</i> s.l.                     | Sieber crassula      |   | √ |  |   |  |  |  |
| <i>Cymbonotus preissianus</i>                       | Austral bear's-ear   |   | √ |  |   |  |  |  |

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|---|---------------------------|---|---|--|---|--|--|--|
| <i>Cynoglossum australe</i>                     | Australian hound's-tongue |   | √ |  |   |  |  |  |
| <i>Cynoglossum suaveolens</i>                   | Sweet hound's-tongue      |   | √ |  |   |  |  |  |
| <i>Danthonia s.l. spp.</i>                      | Wallaby grass             |   | √ |  |   |  |  |  |
| <i>Daucus glochidiatus</i>                      | Australian carrot         |   | √ |  | √ |  |  |  |
| <i>Daviesia arenaria</i>                        | Mallee bitter-pea         |   | √ |  |   |  |  |  |
| <i>Deyeuxia densa</i>                           | Heath bent-grass          | √ |   |  |   |  |  |  |
| <i>Deyeuxia quadriseta</i>                      | Reed bent-grass           |   | √ |  |   |  |  |  |
| <i>Dianella revoluta s.l.</i>                   | Black-anther flax-lily    |   | √ |  | √ |  |  |  |
| <i>Dichelachne crinita</i>                      | Long-hair plume-grass     |   | √ |  | √ |  |  |  |
| <i>Dichelachne spp.</i>                         | Plume grass               |   | √ |  |   |  |  |  |
| <i>Dichondra repens</i>                         | Kidney-weed               |   | √ |  | √ |  |  |  |
| <i>Dillwynia glaberrima</i>                     | Smooth parrot-pea         | √ | √ |  |   |  |  |  |
| <i>Dillwynia hispida</i>                        | Red parrot-pea            |   | √ |  |   |  |  |  |
| <i>Dillwynia sericea</i>                        | Showy parrot-pea          | √ | √ |  |   |  |  |  |
| <i>Dipodium punctatum s.l.</i>                  | Hyacinth orchid           |   | √ |  |   |  |  |  |
| <i>Diuris pardina</i>                           | Leopard orchid            |   | √ |  |   |  |  |  |
| <i>Diuris sulphurea</i>                         | Tiger orchid              |   | √ |  |   |  |  |  |
| <i>Drosera aberrans</i>                         | Scented sundew            |   | √ |  | √ |  |  |  |
| <i>Drosera auriculata</i>                       | Tall sundew               |   | √ |  |   |  |  |  |
| <i>Drosera glanduligera</i>                     | Scarlet sundew            |   | √ |  |   |  |  |  |
| <i>Drosera peltata s.l.</i>                     | Pale sundew               |   | √ |  |   |  |  |  |
| <i>Drosera peltata subsp. peltata spp. agg.</i> | Pale sundew               |   | √ |  |   |  |  |  |
| <i>Drosera pygmaea</i>                          | Tiny sundew               |   | √ |  |   |  |  |  |
| <i>Dysphania pumilio</i>                        | Clammy goosefoot          |   | √ |  |   |  |  |  |
| <i>Einadia nutans</i>                           | Nodding saltbush          |   | √ |  |   |  |  |  |
| <i>Empodisma minus</i>                          | Spreading Rope-rush       | √ |   |  |   |  |  |  |

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| <i>Epilobium billardierianum</i>                               | Variable willow-herb   |   | √ |  |   |  |  |
| <i>Epilobium billardierianum</i> subsp. <i>billardierianum</i> | Smooth willow-herb     |   |   |  | √ |  |  |
| <i>Epilobium billardierianum</i> subsp. <i>cinereum</i>        | Grey willow-herb       |   | √ |  |   |  |  |
| <i>Epilobium billardierianum</i> subsp. <i>intermedium</i>     | Variable willow-herb   |   | √ |  |   |  |  |
| <i>Eragrostis brownii</i>                                      | Common love-grass      |   | √ |  |   |  |  |
| <i>Eryngium ovinum</i>   | Blue devil             |   | √ |  |   |  |  |
| <i>Eryngium vesiculosum</i>                                    | Prickfoot              |   | √ |  |   |  |  |
| <i>Eucalyptus baxteri</i> s.l.                                 | Brown stringybark      |   | √ |  |   |  |  |
| <i>Eucalyptus camaldulensis</i>                                | River red-gum          | √ | √ |  | √ |  |  |
| <i>Eucalyptus camaldulensis</i> var. <i>camaldulensis</i>      | River red-gum          |   | √ |  |   |  |  |
| <i>Eucalyptus leucoxylon</i>                                   | Yellow gum             |   | √ |  |   |  |  |
| <i>Eucalyptus leucoxylon</i> subsp. <i>leucoxylon</i>          | Yellow gum             |   | √ |  |   |  |  |
| <i>Eucalyptus melliodora</i>                                   | Yellow box             |   | √ |  |   |  |  |
| <i>Eucalyptus obliqua</i>                                      | Messmate stringybark   |   | √ |  |   |  |  |
| <i>Eucalyptus ovata</i>  | Swamp gum              |   | √ |  |   |  |  |
| <i>Eucalyptus viminalis</i> subsp. <i>cygnetensis</i>          | Rough-barked Manna-gum | √ | √ |  | √ |  |  |
| <i>Eucalyptus viminalis</i> subsp. <i>viminalis</i>            | Manna gum              |   |   |  | √ |  |  |
| <i>Euchiton involucratus</i> s.l.                              | Common cudweed         |   | √ |  |   |  |  |
| <i>Euchiton involucratus</i> s.s.                              | Star cudweed           |   | √ |  | √ |  |  |

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|--|-------------------------------|---|---|--|---|--|--|---|
| <i>Euchiton japonicus</i><br>s.l.                                      | Clustered/creeping<br>cudweed |   | √ |  |   |  |  |   |
| <i>Euchiton japonicus</i><br>s.s.                                      | Creeping cudweed              |   | √ |  |   |  |  |   |
| <i>Euchiton sphaericus</i>   | Annual cudweed                |   | √ |  |   |  |  |   |
| <i>Exocarpos</i><br><i>cupressiformis</i>                              | Cherry ballart                |   | √ |  |   |  |  |   |
| <i>Exocarpos strictus</i>  | Pale-fruit ballart            |   | √ |  |   |  |  |   |
| <i>Ficinia nodosa</i>  | Knobby club-sedge             |   | √ |  | √ |  |  |   |
| <i>Geranium</i><br><i>potentilloides</i> var.<br><i>potentilloides</i> | Soft crane's-bill             |   | √ |  |   |  |  |   |
| <i>Geranium solanderi</i><br>s.l.                                      | Austral crane's-bill          |   | √ |  | √ |  |  |   |
| <i>Geranium</i> spp.   | Crane's bill                  |   | √ |  |   |  |  |   |
| <i>Geranium</i> spp.   | Crane's bill                  |   |   |  | √ |  |  |   |
| <i>Glossodia major</i>   | Wax-lip orchid                |   | √ |  |   |  |  |   |
| <i>Glycine latrobeana</i>  | Clover glycine                |   |   |  | √ |  |  | V |
| <i>Gnaphalium indutum</i>  | Tiny cudweed                  |   | √ |  |   |  |  |   |
| <i>Gompholobium</i><br><i>huegelii</i>                                 | Common wedge-pea              | √ |   |  |   |  |  |   |
| <i>Gonocarpus elatus</i>   | Tall raspwort                 |   | √ |  |   |  |  |   |
| <i>Gonocarpus</i><br><i>tetragynus</i>                                 | Common raspwort               | √ | √ |  |   |  |  |   |
| <i>Goodenia geniculata</i>   | Bent goodenia                 |   | √ |  |   |  |  |   |
| <i>Goodenia humilis</i>  | Swamp goodenia                |   | √ |  |   |  |  |   |
| <i>Goodenia pinnatifida</i>  | Cut-leaf goodenia             |   | √ |  |   |  |  |   |
| <i>Goodenia</i> spp.   | Goodenia                      |   | √ |  |   |  |  |   |
| <i>Gratiola peruviana</i>  | Austral brooklime             |   |   |  | √ |  |  |   |
| <i>Gratiola pubescens</i>  | Glandular brooklime           |   | √ |  |   |  |  |   |
| <i>Grevillea aquifolium</i>  | Holly grevillea               | √ |   |  |   |  |  |   |
| <i>Hakea mitchellii</i>  | Desert hakea                  |   | √ |  |   |  |  |   |
| <i>Hakea rugosa</i>  | Dwarf hakea                   |   | √ |  |   |  |  |   |

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| <i>Haloragis heterophylla</i>                      | Varied raspwort       |   | √ |  |   |  |  |  |
| <i>Helichrysum luteoalbum</i>                      | Jersey cudweed        |   | √ |  | √ |  |  |  |
| <i>Hemarthria uncinata</i><br><i>var. uncinata</i> | Mat grass             |   | √ |  |   |  |  |  |
| <i>Hibbertia riparia</i>                           | Erect Guinea-flower   |   | √ |  | √ |  |  |  |
| <i>Hibbertia</i> spp.                              | Guinea flower         | √ |   |  |   |  |  |  |
| <i>Hibbertia stricta</i> s.l.                      | Upright Guinea-flower | √ | √ |  |   |  |  |  |
| <i>Hibbertia virgata</i>                           | Twiggy Guinea-flower  | √ | √ |  |   |  |  |  |
| <i>Hovea heterophylla</i>                          | Common hovea          | √ | √ |  |   |  |  |  |
| <i>Hyalosperma demissum</i>                        | Moss sunray           |   | √ |  |   |  |  |  |
| <i>Hydrocotyle callicarpa</i>                      | Small pennywort       |   | √ |  |   |  |  |  |
| <i>Hydrocotyle capillaris</i>                      | Thread pennywort      |   | √ |  |   |  |  |  |
| <i>Hydrocotyle foveolata</i>                       | Yellow pennywort      |   | √ |  |   |  |  |  |
| <i>Hydrocotyle laxiflora</i>                       | Stinking pennywort    |   | √ |  | √ |  |  |  |
| <i>Hydrocotyle</i> spp.                            | Pennywort             |   |   |  | √ |  |  |  |
| <i>Hypericum gramineum</i> spp. agg.               | Small St John's wort  |   | √ |  |   |  |  |  |
| <i>Hypnum cupressiforme</i>                        | Common plait-moss     |   | √ |  |   |  |  |  |
| <i>Hypolaena fastigiata</i>                        | Tassel rope-rush      | √ | √ |  |   |  |  |  |
| <i>Hypoxis glabella</i> var. <i>glabella</i>       | Tiny star             |   | √ |  |   |  |  |  |
| <i>Hypoxis vaginata</i> var. <i>vaginata</i>       | Yellow star           |   | √ |  |   |  |  |  |
| <i>Imperata cylindrica</i>                         | Blady grass           |   | √ |  |   |  |  |  |
| <i>Isoetes drummondii</i>                          | Plain quillwort       |   | √ |  |   |  |  |  |
| <i>Isoetopsis graminifolia</i>                     | Grass cushion         |   | √ |  |   |  |  |  |
| <i>Isolepis inundata</i>                           | Swamp club-sedge      |   | √ |  |   |  |  |  |

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|---|-----------------------|---|---|--|---|--|--|--|
| <i>Isolepis marginata</i>                                 | Little club-sedge     |   | √ |  | √ |  |  |  |
| <i>Isolepis spp.</i>                                      | Club sedge            | √ | √ |  |   |  |  |  |
| <i>Isopogon ceratophyllus</i>                             | Horny cone-bush       |   | √ |  |   |  |  |  |
| <i>Juncus amabilis</i>                                    | Hollow rush           |   | √ |  |   |  |  |  |
| <i>Juncus bufonius</i>                                    | Toad rush             |   | √ |  | √ |  |  |  |
| <i>Juncus flavidus</i>                                    | Gold rush             |   | √ |  |   |  |  |  |
| <i>Juncus homalocaulis</i>                                | Wiry rush             |   | √ |  |   |  |  |  |
| <i>Juncus planifolius</i>                                 | Broad-leaf rush       |   | √ |  | √ |  |  |  |
| <i>Juncus prismatocarpus</i> subsp. <i>prismatocarpus</i> | Branching rush        |   |   |  | √ |  |  |  |
| <i>Juncus spp.</i>  | Rush                  |   | √ |  | √ |  |  |  |
| <i>Juncus subsecundus</i>                                 | Finger rush           |   | √ |  | √ |  |  |  |
| <i>Kennedia prostrata</i>                                 | Running postman       |   | √ |  |   |  |  |  |
| <i>Kunzea ericoides</i> spp. agg.                         | Burgan                |   |   |  | √ |  |  |  |
| <i>Lachnagrostis aemula</i> s.s.                          | Leafy blown-grass     |   |   |  | √ |  |  |  |
| <i>Lachnagrostis filiformis</i> s.l.                      | Common blown-grass    |   | √ |  |   |  |  |  |
| <i>Lachnagrostis filiformis</i> s.s.                      | Common blown-grass    |   | √ |  |   |  |  |  |
| <i>Lachnagrostis spp.</i>                                 | Blown grass           |   | √ |  |   |  |  |  |
| <i>Lagenophora huegelii</i>                               | Coarse bottle-daisy   |   | √ |  |   |  |  |  |
| <i>Lagenophora stipitata</i>                              | Common bottle-daisy   |   | √ |  | √ |  |  |  |
| <i>Lepidium spp.</i>                                      | Peppercress           |   |   |  | √ |  |  |  |
| <i>Lepidobolus drapetocoleus</i>                          | Scale shedder         |   | √ |  |   |  |  |  |
| <i>Lepidosperma carphoides</i>                            | Black rapier-sedge    | √ | √ |  |   |  |  |  |
| <i>Lepidosperma congestum</i>                             | Clustered sword-sedge |   | √ |  |   |  |  |  |

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|-----------------------------------|-----------------------|---|---|--|---|--|--|--|
| <i>Lepidosperma curtisiae</i>     | Little sword-sedge    | √ | √ |  |   |  |  |  |
| <i>Lepidosperma filiforme</i>     | Common rapier-sedge   |   | √ |  |   |  |  |  |
| <i>Lepidosperma laterale</i>      | Variable sword-sedge  | √ | √ |  |   |  |  |  |
| <i>Lepidosperma longitudinale</i> | Pithy sword-sedge     | √ | √ |  |   |  |  |  |
| <i>Lepidosperma semiteres</i>     | Wire rapier-sedge     |   | √ |  |   |  |  |  |
| <i>Lepidosperma viscidum</i>      | Sticky sword-sedge    | √ |   |  |   |  |  |  |
| <i>Leptocarpus tenax</i>          | Slender twine-rush    | √ |   |  |   |  |  |  |
| <i>Leptorhynchos squamatus</i>    | Scaly buttons         |   | √ |  |   |  |  |  |
| <i>Leptospermum continentale</i>  | Prickly tea-tree      |   | √ |  |   |  |  |  |
| <i>Leptospermum myrsinoides</i>   | Heath tea-tree        |   | √ |  | √ |  |  |  |
| <i>Leptospermum obovatum</i>      | River tea-tree        | √ | √ |  | √ |  |  |  |
| <i>Leptospermum scoparium</i>     | Manuka                |   | √ |  |   |  |  |  |
| <i>Leptospermum spp.</i>          | Tea tree              |   |   |  | √ |  |  |  |
| <i>Lepyrodia muelleri</i>         | Common scale-rush     | √ |   |  |   |  |  |  |
| <i>Lepyrodia spp.</i>             | Scale rush            | √ |   |  |   |  |  |  |
| <i>Leucopogon virgatus</i>        | Common beard-heath    |   | √ |  |   |  |  |  |
| <i>Levenhookia dubia</i>          | Hairy stylewort       |   | √ |  |   |  |  |  |
| <i>Lilaeopsis polyantha</i>       | Australian lilaeopsis |   | √ |  |   |  |  |  |
| <i>Lobelia irrigua</i>            | Salt pratia           |   | √ |  |   |  |  |  |
| <i>Lobelia pedunculata s.l.</i>   | Matted pratia         |   | √ |  |   |  |  |  |
| <i>Lobelia pratioides</i>         | Poison lobelia        |   | √ |  | √ |  |  |  |
| <i>Lomandra collina</i>           | Pale mat-rush         |   | √ |  |   |  |  |  |
| <i>Lomandra filiformis</i>        | Wattle mat-rush       |   | √ |  |   |  |  |  |



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|--|------------------------|---|---|--|---|--|--|
| <i>Lomandra filiformis</i><br><i>subsp. coriacea</i>   | Wattle mat-rush        |   | √ |  |   |  |  |
| <i>Lomandra longifolia</i>                             | Spiny-headed mat-rush  |   |   |  | √ |  |  |
| <i>Lomandra micrantha</i><br><i>s.l.</i>               | Small-flower mat-rush  |   | √ |  |   |  |  |
| <i>Lomandra multiflora</i><br><i>subsp. multiflora</i> | Many-flowered mat-rush |   | √ |  |   |  |  |
| <i>Lomandra nana</i>                                   | Dwarf mat-rush         |   | √ |  | √ |  |  |
| <i>Lomandra sororia</i>                                | Small Mat-rush         |   | √ |  |   |  |  |
| <i>Lomandra spp.</i>                                   | Mat-rush               |   | √ |  |   |  |  |
| <i>Luzula meridionalis</i>                             | Common woodrush        |   | √ |  |   |  |  |
| <i>Luzula spp.</i>                                     | Woodrush               |   | √ |  | √ |  |  |
| <i>Lythrum salicaria</i>                               | Purple loosestrife     |   | √ |  |   |  |  |
| <i>Melaleuca brevifolia</i>                            | Mallee honey-myrtle    |   | √ |  |   |  |  |
| <i>Melaleuca decussata</i>                             | Totem-poles            |   | √ |  |   |  |  |
| <i>Melaleuca gibbosa</i>                               | Slender honey-myrtle   | √ | √ |  |   |  |  |
| <i>Melaleuca squamea</i>                               | Swamp honey-myrtle     | √ |   |  |   |  |  |
| <i>Meliccytus dentatus</i><br><i>s.s.</i>              | Tree violet            |   | √ |  | √ |  |  |
| <i>Mentha diemenica</i>                                | Slender mint           |   | √ |  |   |  |  |
| <i>Microlaena stipoides</i><br><i>var. stipoides</i>   | Weeping grass          |   | √ |  | √ |  |  |
| <i>Microseris scapigera</i><br><i>s.l.</i>             | Yam daisy              |   | √ |  |   |  |  |
| <i>Microseris spp.</i>                                 | Yam daisy              |   | √ |  |   |  |  |
| <i>Microtis parviflora</i>                             | Slender onion-orchid   |   | √ |  |   |  |  |
| <i>Microtis spp.</i>                                   | Onion orchid           |   | √ |  |   |  |  |
| <i>Microtis unifolia</i>                               | Common onion-orchid    |   | √ |  |   |  |  |
| <i>Millotia spp.</i>                                   | Millotia               |   | √ |  |   |  |  |
| <i>Millotia tenuifolia</i><br><i>var. tenuifolia</i>   | Soft millotia          |   | √ |  |   |  |  |
| <i>Mimulus repens</i>                                  | Creeping monkey-flower |   | √ |  |   |  |  |

|   |                        |   |   |  |   |    |  |   |
|---|------------------------|---|---|--|---|----|--|---|
| <i>Myoporum parvifolium</i>                           | Creeping myoporum      |   | √ |  |   |    |  |   |
| <i>Myosotis australis</i>                             | Austral forget-me-not  |   | √ |  |   |    |  |   |
| <i>Neurachne alopecuroidea</i>                        | Fox-tail mulga-grass   |   | √ |  |   |    |  |   |
| <i>Opercularia ovata</i>                              | Broad-leaf stinkweed   |   | √ |  |   |    |  |   |
| <i>Opercularia varia</i>                              | Variable stinkweed     |   | √ |  |   |    |  |   |
| <i>Ophioglossum lusitanicum</i>                       | Austral adder's-tongue |   | √ |  |   |    |  |   |
| <i>Ornduffia umbricola</i> var. <i>umbricola</i>      | Lax marsh-flower       |   | √ |  |   | CE |  | V |
| <i>Orthoceras strictum</i>                            | Horned orchid          |   | √ |  |   |    |  |   |
| <i>Oxalis exilis</i>                                  | Shady wood-sorrel      |   | √ |  |   |    |  |   |
| <i>Oxalis perennans</i>                               | Grassland wood-sorrel  |   | √ |  | √ |    |  |   |
| <i>Oxalis</i> spp.                                    | Wood sorrel            |   | √ |  | √ |    |  |   |
| <i>Ozothamnus ferrugineus</i>                         | Tree everlasting       |   |   |  | √ |    |  |   |
| <i>Patersonia fragilis</i>                            | Short purple-flag      | √ |   |  | √ |    |  |   |
| <i>Pelargonium rodneyanum</i>                         | Magenta stork's-bill   |   | √ |  |   |    |  |   |
| <i>Pelargonium</i> spp.                               | Stork's bill           |   | √ |  |   |    |  |   |
| <i>Pentapogon quadrifidus</i> var. <i>quadrifidus</i> | Five-awned spear-grass |   | √ |  |   |    |  |   |
| <i>Persoonia juniperina</i>                           | Prickly geebung        | √ |   |  |   |    |  |   |
| <i>Phyllangium divergens</i>                          | Wiry mitrewort         |   | √ |  |   |    |  |   |
| <i>Phylloglossum drummondii</i>                       | Pygmy clubmoss         |   | √ |  |   |    |  |   |
| <i>Pimelea humilis</i>                                | Common rice-flower     |   | √ |  | √ |    |  |   |
| <i>Plantago gaudichaudii</i>                          | Narrow plantain        |   | √ |  |   |    |  |   |
| <i>Plantago varia</i>                                 | Variable plantain      |   | √ |  | √ |    |  |   |
| <i>Platylobium obtusangulum</i>                       | Common flat-pea        |   | √ |  |   |    |  |   |

|   |                        |   |   |  |   |  |  |   |
|---|------------------------|---|---|--|---|--|--|---|
| <i>Platylobium triangulare</i>                | Ivy flat-pea           |   |   |  | √ |  |  |   |
| <i>Pleurosorus rutifolius s.l.</i>            | Blanket fern           |   | √ |  |   |  |  |   |
| <i>Poa clelandii</i>                          | Noah's ark             |   |   |  | √ |  |  |   |
| <i>Poa labillardierei</i>                     | Common tussock-grass   |   | √ |  |   |  |  |   |
| <i>Poa labillardierei var. labillardierei</i> | Common tussock-grass   |   | √ |  | √ |  |  |   |
| <i>Poa morrisii</i>                           | Soft tussock-grass     |   | √ |  |   |  |  |   |
| <i>Poa sieberiana</i>                         | Grey tussock-grass     |   | √ |  | √ |  |  |   |
| <i>Poa sieberiana var. hirtella</i>           | Grey tussock-grass     |   | √ |  |   |  |  |   |
| <i>Poaceae spp.</i>                           | Grass                  |   | √ |  |   |  |  |   |
| <i>Podolepis jaceoides s.l.</i>               | Showy/basalt podolepis |   | √ |  |   |  |  |   |
| <i>Podotheca angustifolia</i>                 | Sticky long-heads      |   | √ |  |   |  |  |   |
| <i>Pogonolepis muelleriana</i>                | Stiff cup-flower       |   | √ |  |   |  |  |   |
| <i>Polytrichum spp.</i>                       | Haircap                |   | √ |  |   |  |  |   |
| <i>Poranthera microphylla s.l.</i>            | Small poranthera       |   | √ |  |   |  |  |   |
| <i>Prasophyllum elatum</i>                    | Tall leek-orchid       |   | √ |  |   |  |  |   |
| <i>Pteridium esculentum</i>                   | Austral bracken        |   | √ |  | √ |  |  |   |
| <i>Pterostylis curta</i>                      | Blunt greenhood        |   | √ |  |   |  |  |   |
| <i>Pterostylis nana</i>                       | Dwarf greenhood        |   | √ |  |   |  |  |   |
| <i>Pterostylis nutans</i>                     | Nodding greenhood      |   | √ |  |   |  |  |   |
| <i>Pterostylis pedunculata</i>                | Maroonhood             |   | √ |  |   |  |  |   |
| <i>Ptilotus macrocephalus</i>                 | Feather heads          |   | √ |  |   |  |  |   |
| <i>Pultenaea luehmannii</i>                   | Thready bush-pea       | √ |   |  |   |  |  | R |
| <i>Pultenaea luehmannii</i>                   | Thready bush-pea       | √ |   |  |   |  |  | R |

|  |                          |   |   |  |   |  |  |   |
|--|--------------------------|---|---|--|---|--|--|---|
| <i>Pyrrochis nigricans</i>                   | Red-beaks                |   | √ |  |   |  |  |   |
| <i>Quinetia urvillei</i>                     | Quinetia                 |   | √ |  |   |  |  | R |
| <i>Ranunculus robertsonii</i>                | Slender buttercup        |   | √ |  |   |  |  |   |
| <i>Ranunculus scapiger</i>                   | Hairy buttercup          |   | √ |  |   |  |  |   |
| <i>Ranunculus spp.</i>                       | Buttercup                |   | √ |  |   |  |  |   |
| <i>Rosulabryum spp.</i>                      | Thread moss              |   |   |  | √ |  |  |   |
| <i>Rumex brownii</i>                         | Slender dock             |   | √ |  | √ |  |  |   |
| <i>Rytidosperma caespitosum</i>              | Common wallaby-grass     |   | √ |  |   |  |  |   |
| <i>Rytidosperma duttonianum</i>              | Brown-back wallaby-grass |   | √ |  |   |  |  |   |
| <i>Rytidosperma erianthum</i>                | Hill wallaby-grass       |   | √ |  |   |  |  |   |
| <i>Rytidosperma geniculatum</i>              | Kneed wallaby-grass      |   | √ |  | √ |  |  |   |
| <i>Rytidosperma pilosum</i>                  | Velvet wallaby-grass     |   | √ |  |   |  |  |   |
| <i>Rytidosperma racemosum var. racemosum</i> | Slender wallaby-grass    |   | √ |  | √ |  |  |   |
| <i>Rytidosperma semiannulare</i>             | Wetland wallaby-grass    |   | √ |  |   |  |  |   |
| <i>Rytidosperma setaceum</i>                 | Bristly wallaby-grass    |   | √ |  |   |  |  |   |
| <i>Rytidosperma setaceum var. setaceum</i>   | Bristly wallaby-grass    |   | √ |  |   |  |  |   |
| <i>Rytidosperma spp.</i>                     | Wallaby grass            |   | √ |  | √ |  |  |   |
| <i>Rytidosperma tenuius</i>                  | Purplish wallaby-grass   |   | √ |  |   |  |  |   |
| <i>Samolus repens var. repens</i>            | Creeping brookweed       |   | √ |  |   |  |  |   |
| <i>Schoenus apogon</i>                       | Common bog-sedge         | √ | √ |  |   |  |  |   |
| <i>Schoenus breviculmis</i>                  | Matted bog-sedge         | √ | √ |  |   |  |  |   |
| <i>Schoenus laevigatus</i>                   | Short-leaf bog-sedge     | √ |   |  |   |  |  |   |

|                                      |                     |   |   |  |   |  |   |
|--------------------------------------|---------------------|---|---|--|---|--|---|
| <i>Schoenus latelaminatus</i>        | Medusa bog-sedge    |   | √ |  |   |  |   |
| <i>Schoenus nitens</i>               | Shiny bog-sedge     |   | √ |  |   |  |   |
| <i>Schoenus spp.</i>                 | Bog sedge           | √ | √ |  |   |  |   |
| <i>Sebaea albidiflora</i>            | White sebaea        |   | √ |  |   |  |   |
| <i>Sebaea ovata</i>                  | Yellow sebaea       |   | √ |  |   |  |   |
| <i>Selliera radicans</i>             | Shiny swamp-mat     |   | √ |  |   |  |   |
| <i>Sematophyllum homomallum</i>      | Bronze signal-moss  |   |   |  | √ |  |   |
| <i>Senecio glomeratus</i>            | Annual fireweed     |   | √ |  |   |  |   |
| <i>Senecio hispidulus s.l.</i>       | Rough fireweed      |   | √ |  | √ |  |   |
| <i>Senecio minimus</i>               | Shrubby fireweed    |   | √ |  |   |  |   |
| <i>Senecio picridioides</i>          | Hawkbit fireweed    |   | √ |  |   |  |   |
| <i>Senecio pinnatifolius</i>         | Variable groundsel  |   | √ |  |   |  |   |
| <i>Senecio prenanthoides</i>         | Beaked fireweed     |   | √ |  |   |  |   |
| <i>Senecio psilocarpus</i>           | Swamp fireweed      |   |   |  | √ |  | V |
| <i>Senecio quadridentatus</i>        | Cotton fireweed     |   | √ |  | √ |  |   |
| <i>Senecio spp.</i>                  | Groundsel           |   | √ |  | √ |  |   |
| <i>Senecio squarrosus s.l.</i>       | Leafy fireweed      |   | √ |  | √ |  |   |
| <i>Senecio tenuiflorus spp. agg.</i> | Slender fireweed    |   | √ |  | √ |  |   |
| <i>Siloxerus multiflorus</i>         | Small wrinklewort   |   | √ |  |   |  |   |
| <i>Solanum simile</i>                | Oondoroo            | √ | √ |  |   |  |   |
| <i>Solenogyne dominii</i>            | Smooth solenogyne   |   | √ |  | √ |  |   |
| <i>Spergularia media s.l.</i>        | Coast sand-spurrey  |   | √ |  |   |  |   |
| <i>Spergularia sp. 1</i>             | Native sea-spurrey  |   | √ |  |   |  |   |
| <i>Spergularia spp.</i>              | Sand spurrey        |   | √ |  |   |  |   |
| <i>Sphaeromorphaea australis</i>     | Spreading nut-heads |   | √ |  |   |  |   |

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|---|----------------------------|---|---|--|---|--|--|---|
| <i>Spiranthes australis</i><br>s.l.           | Austral ladies'<br>tresses |   |   |  | √ |  |  |   |
| <i>Sporobolus virginicus</i>                  | Salt couch                 |   | √ |  |   |  |  |   |
| <i>Spyridium</i><br><i>vexilliferum</i>       | Winged spyridium           | √ |   |  |   |  |  |   |
| <i>Stackhousia</i><br><i>monogyna</i> s.l.    | Creamy stackhousia         |   | √ |  |   |  |  |   |
| <i>Stellaria</i> spp.                         | Starwort                   |   | √ |  |   |  |  |   |
| <i>Stuartina muelleri</i>                     | Spoon cudweed              |   | √ |  |   |  |  |   |
| <i>Stylidium calcaratum</i><br>spp. agg.      | Book triggerplant          |   | √ |  |   |  |  |   |
| <i>Stylidium despectum</i>                    | Small triggerplant         | √ |   |  |   |  |  |   |
| <i>Stylidium</i><br><i>graminifolium</i> s.l. | Grass triggerplant         |   | √ |  |   |  |  |   |
| <i>Stylidium inundatum</i>                    | Hundreds and<br>thousands  |   | √ |  |   |  |  |   |
| <i>Stylidium</i> spp.                         | Trigger plant              |   | √ |  |   |  |  |   |
| <i>Styphelia</i><br><i>adscendens</i>         | Golden heath               |   |   |  | √ |  |  |   |
| <i>Taraxacum</i> spp.                         | Dandelion                  |   | √ |  |   |  |  |   |
| <i>Tetratheca ciliata</i>                     | Pink-bells                 | √ | √ |  |   |  |  |   |
| <i>Thelymitra</i><br><i>antennifera</i>       | Rabbit ears                |   | √ |  |   |  |  |   |
| <i>Thelymitra carnea</i>                      | Pink sun-orchid            |   | √ |  |   |  |  |   |
| <i>Thelymitra holmesii</i><br>s.l.            | Blue-star sun-orchid       |   | √ |  |   |  |  |   |
| <i>Thelymitra ixioides</i><br>s.l.            | Spotted sun-orchid         |   | √ |  |   |  |  |   |
| <i>Thelymitra</i><br><i>luteocilium</i>       | Fringed sun-orchid         |   | √ |  |   |  |  | R |
| <i>Thelymitra nuda</i>                        | Plain sun-orchid           |   | √ |  |   |  |  |   |
| <i>Thelymitra pauciflora</i><br>s.l.          | Slender sun-orchid         |   | √ |  |   |  |  |   |
| <i>Thelymitra rubra</i>                       | Salmon sun-orchid          |   | √ |  |   |  |  |   |
| <i>Thelymitra</i> spp.                        | Sun orchid                 |   | √ |  | √ |  |  |   |
| <i>Themeda triandra</i>                       | Kangaroo grass             |   | √ |  | √ |  |  |   |

|  |                          |   |   |  |   |  |  |   |
|--|--------------------------|---|---|--|---|--|--|---|
| <i>Thryptomene calycina</i>                | Grampians thryptomene    | √ |   |  |   |  |  | R |
| <i>Thryptomene calycina</i>                | Grampians thryptomene    | √ |   |  |   |  |  | R |
| <i>Thysanotus patersonii</i>               | Twining fringe-lily      |   | √ |  |   |  |  |   |
| <i>Tricoryne elatior</i>                   | Yellow rush-lily         |   | √ |  | √ |  |  |   |
| <i>Tricoryne spp.</i>                      | Rush lily                |   | √ |  |   |  |  |   |
| <i>Triglochin mucronata</i>                | Prickly arrowgrass       |   | √ |  |   |  |  | R |
| <i>Triglochin nana</i>                     | Dwarf arrowgrass         |   | √ |  |   |  |  |   |
| <i>Triglochin striata</i>                  | Streaked arrowgrass      |   | √ |  | √ |  |  |   |
| <i>Triodia scariosa</i>                    | Porcupine grass          |   | √ |  | √ |  |  |   |
| <i>Triptilodiscus pygmaeus</i>             | Common sunray            |   | √ |  |   |  |  |   |
| <i>Utricularia tenella</i>                 | Pink bladderwort         |   | √ |  |   |  |  |   |
| <i>Viminaria juncea</i>                    | Golden spray             | √ | √ |  |   |  |  |   |
| <i>Viola cleistogamoides</i>               | Hidden violet            | √ | √ |  |   |  |  |   |
| <i>Viola sieberiana spp. agg.</i>          | Tiny violet              |   | √ |  |   |  |  |   |
| <i>Vittadinia cuneata var. cuneata</i>     | Fuzzy New Holland daisy  |   | √ |  |   |  |  |   |
| <i>Vittadinia gracilis</i>                 | Woolly New Holland daisy |   | √ |  |   |  |  |   |
| <i>Vittadinia spp.</i>                     | New holland daisy        |   | √ |  |   |  |  |   |
| <i>Wahlenbergia gracilenta s.l.</i>        | Annual bluebell          |   | √ |  |   |  |  |   |
| <i>Wahlenbergia gracilis</i>               | Sprawling bluebell       |   | √ |  | √ |  |  |   |
| <i>Wahlenbergia multicaulis</i>            | Branching bluebell       |   | √ |  |   |  |  |   |
| <i>Wahlenbergia spp.</i>                   | Bluebell                 |   |   |  | √ |  |  |   |
| <i>Wahlenbergia stricta subsp. stricta</i> | Tall bluebell            |   | √ |  |   |  |  |   |
| <i>Wilsonia rotundifolia</i>               | Round-leaf wilsonia      |   | √ |  |   |  |  |   |
| <i>Wurmbea dioica</i>                      | Common early nancy       |   | √ |  |   |  |  |   |

|  |                     |   |   |  |   |  |  |   |
|--|---------------------|---|---|--|---|--|--|---|
| <i>Xanthorrhoea caespitosa</i>                           | Tufted grass-tree   | √ | √ |  | √ |  |  | R |
| <i>Xanthorrhoea minor</i><br><i>subsp. lutea</i>         | Small grass-tree    |   | √ |  |   |  |  |   |
| <i>Xanthosia leiophylla</i>                              | Parsley xanthosia   |   |   |  | √ |  |  | R |
| <i>Xerochrysum leucopsideum</i>                          | Satin everlasting   |   | √ |  |   |  |  |   |
| <i>Zoysia macrantha</i>                                  | Prickly couch       |   | √ |  |   |  |  |   |
|  |                     |   |   |  |   |  |  |   |
| <b>Exotic</b>  |                     |   |   |  |   |  |  |   |
| <i>Acacia baileyana</i>                                  | Cootamundra wattle  |   | √ |  |   |  |  |   |
| <i>Acetosella vulgaris</i>                               | Sheep sorrel        |   | √ |  | √ |  |  |   |
| <i>Agrostis capillaris</i>                               | Brown-top bent      |   |   |  | √ |  |  |   |
| <i>Agrostis stolonifera</i>                              | Creeping bent       |   | √ |  |   |  |  |   |
| <i>Aira caryophyllea</i><br><i>subsp. caryophyllea</i>   | Silvery hair-grass  |   | √ |  |   |  |  |   |
| <i>Aira cupaniana</i>                                    | Quicksilver grass   |   | √ |  |   |  |  |   |
| <i>Aira elegantissima</i>                                | Delicate hair-grass |   | √ |  | √ |  |  |   |
| <i>Aira spp.</i>   | Hair grass          |   | √ |  |   |  |  |   |
| <i>Amaranthus graecizans</i><br><i>subsp. sylvestris</i> | Amaranth            |   |   |  | √ |  |  |   |
| <i>Anthemis arvensis</i>                                 | Field chamomile     |   |   |  | √ |  |  |   |
| <i>Anthoxanthum odoratum</i>                             | Sweet vernal-grass  |   | √ |  | √ |  |  |   |
| <i>Arctotheca calendula</i>                              | Cape weed           |   | √ |  | √ |  |  |   |
| <i>Asparagus asparagoides</i>                            | Bridal creeper      |   | √ |  | √ |  |  |   |
| <i>Asparagus officinalis</i>                             | Asparagus           |   | √ |  |   |  |  |   |
| <i>Asparagus scandens</i>                                | Asparagus fern      |   | √ |  |   |  |  |   |
| <i>Aster subulatus</i>                                   | Aster-weed          |   | √ |  | √ |  |  |   |
| <i>Atriplex prostrata</i>                                | Hastate orache      |   | √ |  |   |  |  |   |
| <i>Avellinia michelii</i>                                | Avellinia           |   | √ |  |   |  |  |   |
| <i>Avena barbata</i>                                     | Bearded oat         |   |   |  | √ |  |  |   |



|  |                              |  |   |  |   |  |  |  |
|--|------------------------------|--|---|--|---|--|--|--|
| <i>Avena fatua</i>                         | Wild oat                     |  | √ |  | √ |  |  |  |
| <i>Avena spp.</i>                          | Oat                          |  |   |  | √ |  |  |  |
| <i>Bellis perennis</i>                     | English daisy                |  |   |  | √ |  |  |  |
| <i>Briza maxima</i>                        | Large quaking-grass          |  | √ |  | √ |  |  |  |
| <i>Briza minor</i>                         | Lesser Quaking-grass         |  | √ |  | √ |  |  |  |
| <i>Bromus alopecuroides</i>                | Mediterranean brome          |  | √ |  |   |  |  |  |
| <i>Bromus diandrus</i>                     | Great brome                  |  | √ |  | √ |  |  |  |
| <i>Bromus hordeaceus subsp. hordeaceus</i> | Soft brome                   |  | √ |  | √ |  |  |  |
| <i>Bromus madritensis</i>                  | Madrid brome                 |  | √ |  |   |  |  |  |
| <i>Bromus rubens</i>                       | Red brome                    |  | √ |  |   |  |  |  |
| <i>Callitriche stagnalis</i>               | Common water-starwort        |  |   |  | √ |  |  |  |
| <i>Carduus pycnocephalus</i>               | Slender thistle              |  | √ |  |   |  |  |  |
| <i>Carduus tenuiflorus</i>                 | Winged slender-thistle       |  | √ |  |   |  |  |  |
| <i>Cenchrus macrourus</i>                  | African feather-grass        |  |   |  | √ |  |  |  |
| <i>Centaurium erythraea</i>                | Common centaury              |  | √ |  | √ |  |  |  |
| <i>Centaurium maritimum</i>                | Sea centaury                 |  | √ |  |   |  |  |  |
| <i>Centaurium spp.</i>                     | Centaury                     |  | √ |  |   |  |  |  |
| <i>Centaurium tenuiflorum</i>              | Slender centaury             |  | √ |  |   |  |  |  |
| <i>Cerastium glomeratum s.l.</i>           | Common mouse-ear Chickweed   |  | √ |  | √ |  |  |  |
| <i>Cerastium pumilum</i>                   | Curtis's mouse-ear Chickweed |  | √ |  |   |  |  |  |
| <i>Chenopodium album</i>                   | Fat hen                      |  | √ |  |   |  |  |  |
| <i>Chenopodium glaucum</i>                 | Glaucous goosefoot           |  | √ |  |   |  |  |  |
| <i>Cicendia filiformis</i>                 | Slender cicendia             |  | √ |  | √ |  |  |  |
| <i>Cirsium arvense</i>                     | Perennial thistle            |  |   |  | √ |  |  |  |

|   |                       |  |   |  |   |  |  |  |
|---|-----------------------|--|---|--|---|--|--|--|
| <i>Cirsium spp.</i>                           | Thistle               |  |   |  | √ |  |  |  |
| <i>Cirsium vulgare</i>                        | Spear thistle         |  | √ |  | √ |  |  |  |
| <i>Claytonia perfoliata subsp. perfoliata</i> | Miner's lettuce       |  |   |  | √ |  |  |  |
| <i>Conyza bonariensis</i>                     | Flaxleaf fleabane     |  |   |  | √ |  |  |  |
| <i>Conyza spp.</i>                            | Fleabane              |  |   |  | √ |  |  |  |
| <i>Cortaderia selloana</i>                    | Pampas grass          |  | √ |  |   |  |  |  |
| <i>Cotula coronopifolia</i>                   | Water buttons         |  | √ |  | √ |  |  |  |
| <i>Crassula alata var. alata</i>              | Three-part crassula   |  | √ |  |   |  |  |  |
| <i>Crassula natans var. minus</i>             | Water crassula        |  | √ |  |   |  |  |  |
| <i>Crepis vesicaria subsp. taraxacifolia</i>  | Bladder hawksbeard    |  | √ |  |   |  |  |  |
| <i>Cucumis myriocarpus subsp. leptodermis</i> | Paddy melon           |  | √ |  |   |  |  |  |
| <i>Cynodon dactylon</i>                       | Couch                 |  |   |  | √ |  |  |  |
| <i>Cynosurus echinatus</i>                    | Rough dog's-tail      |  | √ |  | √ |  |  |  |
| <i>Dactylis glomerata</i>                     | Cocksfoot             |  |   |  | √ |  |  |  |
| <i>Disa bracteata</i>                         | South african orchid  |  | √ |  |   |  |  |  |
| <i>Dittrichia graveolens</i>                  | Stinkwort             |  | √ |  |   |  |  |  |
| <i>Echium plantagineum</i>                    | Paterson's curse      |  |   |  | √ |  |  |  |
| <i>Ehrharta calycina</i>                      | Perennial veldt-grass |  | √ |  |   |  |  |  |
| <i>Ehrharta longiflora</i>                    | Annual veldt-grass    |  | √ |  |   |  |  |  |
| <i>Erodium cicutarium</i>                     | Common heron's-bill   |  | √ |  |   |  |  |  |
| <i>Galium divaricatum</i>                     | Slender bedstraw      |  | √ |  |   |  |  |  |
| <i>Galium murale</i>                          | Small goosegrass      |  | √ |  |   |  |  |  |
| <i>Gamochaeta purpurea s.l.</i>               | Purple cudweed        |  | √ |  |   |  |  |  |
| <i>Genista monspessulana</i>                  | Montpellier broom     |  | √ |  |   |  |  |  |
| <i>Gladiolus spp.</i>                         | Gladiolus             |  | √ |  |   |  |  |  |

|   |                        |  |   |  |   |  |  |
|---|------------------------|--|---|--|---|--|--|
| <i>Gladiolus undulatus</i>                                  | Wild gladiolus         |  | √ |  |   |  |  |
| <i>Helminthotheca echioides</i>                             | Ox-tongue              |  | √ |  |   |  |  |
| <i>Holcus annuus</i>  | Annual fog             |  | √ |  |   |  |  |
| <i>Holcus lanatus</i>                                       | Yorkshire fog          |  | √ |  | √ |  |  |
| <i>Hordeum marinum</i>                                      |                        |  | √ |  |   |  |  |
| <i>Hordeum murinum</i><br>s.l.                              | Barley-grass           |  | √ |  | √ |  |  |
| <i>Hypericum perforatum</i> subsp.<br><i>veronense</i>      | St john's wort         |  | √ |  |   |  |  |
| <i>Hypochaeris glabra</i>                                   | Smooth cat's-ear       |  | √ |  | √ |  |  |
| <i>Hypochaeris radicata</i>                                 | Flatweed               |  | √ |  | √ |  |  |
| <i>Isolepis hystrix</i>                                     | Awned club-sedge       |  | √ |  |   |  |  |
| <i>Isolepis levynsiana</i>                                  | Tiny flat-sedge        |  | √ |  | √ |  |  |
| <i>Isolepis prolifera</i>                                   | Proliferous club-sedge |  |   |  | √ |  |  |
| <i>Juncus acutus</i> subsp.<br><i>acutus</i>                | Spiny rush             |  | √ |  | √ |  |  |
| <i>Juncus articulatus</i> subsp.<br><i>articulatus</i>      | Jointed rush           |  | √ |  |   |  |  |
| <i>Juncus bufonius</i>                                      | Toad rush              |  | √ |  | √ |  |  |
| <i>Juncus bulbosus</i>                                      | Bulbous rush           |  | √ |  |   |  |  |
| <i>Juncus capitatus</i>                                     | Capitate rush          |  | √ |  |   |  |  |
| <i>Lactuca saligna</i>                                      | Willow-leaf lettuce    |  | √ |  |   |  |  |
| <i>Lactuca spp.</i>   | Lettuce                |  |   |  | √ |  |  |
| <i>Lagurus ovatus</i>                                       | Hare's-tail grass      |  |   |  | √ |  |  |
| <i>Leontodon taraxacoides</i> subsp.<br><i>taraxacoides</i> | Hairy hawkbit          |  | √ |  | √ |  |  |
| <i>Lolium perenne</i>                                       | Perennial rye-grass    |  | √ |  | √ |  |  |
| <i>Lolium rigidum</i>                                       | Wimmera rye-grass      |  | √ |  |   |  |  |
| <i>Lycium ferocissimum</i>                                  | African box-thorn      |  | √ |  |   |  |  |
| <i>Lysimachia arvensis</i>                                  | Pimpernel              |  | √ |  | √ |  |  |

|   |                        |  |   |  |   |  |  |
|---|------------------------|--|---|--|---|--|--|
| <i>Lysimachia arvensis</i><br>(Blue-flowered variant) | Blue pimpernel         |  | √ |  |   |  |  |
| <i>Lysimachia arvensis</i><br>(Red-flowered variant)  | Scarlet pimpernel      |  | √ |  | √ |  |  |
| <i>Lysimachia minima</i>                              | Chaffweed              |  | √ |  |   |  |  |
| <i>Medicago lupulina</i>                              | Black medic            |  | √ |  |   |  |  |
| <i>Medicago polymorpha</i>                            | Burr medic             |  | √ |  |   |  |  |
| <i>Medicago spp.</i>                                  | Medic                  |  |   |  | √ |  |  |
| <i>Mentha pulegium</i>                                | Pennyroyal             |  | √ |  |   |  |  |
| <i>Modiola caroliniana</i>                            | Red-flower mallow      |  |   |  | √ |  |  |
| <i>Moenchia erecta</i>                                | Erect chickweed        |  | √ |  |   |  |  |
| <i>Moraea flaccida</i>                                | One-leaf cape-tulip    |  | √ |  | √ |  |  |
| <i>Moraea spp.</i>                                    | Moraea                 |  | √ |  |   |  |  |
| <i>Oxalis corniculata s.l.</i>                        | Yellow wood-sorrel     |  | √ |  | √ |  |  |
| <i>Oxalis pes-caprae</i>                              | Soursob                |  |   |  | √ |  |  |
| <i>Panicum capillare</i>                              | Common millet          |  | √ |  |   |  |  |
| <i>Panicum hillmanii</i>                              | Witch panic            |  |   |  | √ |  |  |
| <i>Parapholis incurva</i>                             | Coast barb-grass       |  | √ |  |   |  |  |
| <i>Parentucellia latifolia</i>                        | Red bartsia            |  | √ |  |   |  |  |
| <i>Paspalum dilatatum</i>                             | Paspalum               |  |   |  | √ |  |  |
| <i>Pentameris airoides</i><br>subsp. <i>airoides</i>  | False hair-grass       |  | √ |  |   |  |  |
| <i>Petrorhagia dubia</i>                              | Velvety pink           |  | √ |  |   |  |  |
| <i>Phalaris aquatica</i>                              | Toowoomba canary-grass |  | √ |  | √ |  |  |
| <i>Picnomon acarna</i>                                | Soldier thistle        |  |   |  | √ |  |  |
| <i>Plantago bellardii</i>                             | Silky plantain         |  | √ |  |   |  |  |
| <i>Plantago coronopus</i>                             | Buck's-horn plantain   |  | √ |  |   |  |  |
| <i>Plantago lanceolata</i>                            | Ribwort                |  | √ |  |   |  |  |
| <i>Plantago lanceolata</i>                            | Ribwort                |  |   |  | √ |  |  |

|   |                     |  |   |  |   |  |  |  |
|---|---------------------|--|---|--|---|--|--|--|
| <i>Plantago major</i>                         | Greater plantain    |  |   |  | √ |  |  |  |
| <i>Poa annua</i>                              | Annual meadow-grass |  | √ |  |   |  |  |  |
| <i>Polycarpon tetraphyllum</i>                | Four-leaved allseed |  | √ |  | √ |  |  |  |
| <i>Polypogon maritimus var. subspathaceus</i> | Coast beard-grass   |  | √ |  |   |  |  |  |
| <i>Polypogon monspeliensis</i>                | Annual beard-grass  |  | √ |  | √ |  |  |  |
| <i>Raphanus sativus</i>                       | Common radish       |  |   |  | √ |  |  |  |
| <i>Romulea rosea</i>                          | Onion grass         |  | √ |  | √ |  |  |  |
| <i>Rosa rubiginosa</i>                        | Sweet briar         |  | √ |  | √ |  |  |  |
| <i>Rubus fruticosus spp. agg.</i>             | Blackberry          |  |   |  | √ |  |  |  |
| <i>Rubus polyanthemus</i>                     | Forest blackberry   |  |   |  | √ |  |  |  |
| <i>Rumex conglomeratus</i>                    | Clustered dock      |  | √ |  | √ |  |  |  |
| <i>Rumex crispus</i>                          | Curled dock         |  | √ |  | √ |  |  |  |
| <i>Rumex pulcher subsp. pulcher</i>           | Fiddle dock         |  |   |  | √ |  |  |  |
| <i>Rumex spp.</i>                             | Dock                |  |   |  | √ |  |  |  |
| <i>Scabiosa atropurpurea</i>                  | Pincushion          |  |   |  | √ |  |  |  |
| <i>Schinus molle</i>                          | Pepper tree         |  | √ |  |   |  |  |  |
| <i>Sherardia arvensis</i>                     | Field madder        |  | √ |  |   |  |  |  |
| <i>Silene gallica</i>                         | French catchfly     |  | √ |  |   |  |  |  |
| <i>Silybum marianum</i>                       | Variegated thistle  |  |   |  | √ |  |  |  |
| <i>Sisyrinchium iridifolium</i>               | Striped rush-leaf   |  | √ |  |   |  |  |  |
| <i>Solanum nigrum s.l.</i>                    | Black nightshade    |  | √ |  | √ |  |  |  |
| <i>Soliva sessilis</i>                        | Jo Jo               |  | √ |  |   |  |  |  |
| <i>Sonchus asper s.l.</i>                     | Rough sow-thistle   |  | √ |  | √ |  |  |  |
| <i>Sonchus oleraceus</i>                      | Common sow-thistle  |  | √ |  | √ |  |  |  |
| <i>Sparaxis bulbifera</i>                     | Harlequin flower    |  | √ |  |   |  |  |  |

|   |                           |  |   |  |   |  |  |
|---|---------------------------|--|---|--|---|--|--|
| <i>Spergularia rubra s.l.</i>   | Red sand-spurrey          |  | √ |  |   |  |  |
| <i>Stellaria media</i>  | Chickweed                 |  | √ |  |   |  |  |
| <i>Stellaria pallida</i>  | Lesser chickweed          |  | √ |  |   |  |  |
| <i>Taraxacum officinale</i><br><i>spp. agg.</i>                       | Garden dandelion          |  | √ |  | √ |  |  |
| <i>Tolpis barbata</i>   | Yellow hawkweed           |  | √ |  |   |  |  |
| <i>Tribolium acutiflorum</i><br><i>s.l.</i>                           | Desmazeria                |  | √ |  |   |  |  |
| <i>Trifolium</i><br><i>angustifolium var.</i><br><i>angustifolium</i> | Narrow-leaf clover        |  | √ |  |   |  |  |
| <i>Trifolium campestre</i><br><i>var. campestre</i>                   | Hop clover                |  | √ |  |   |  |  |
| <i>Trifolium cernuum</i>  | Drooping-flower<br>clover |  | √ |  |   |  |  |
| <i>Trifolium dubium</i>   | Suckling clover           |  | √ |  |   |  |  |
| <i>Trifolium glomeratum</i>   | Cluster clover            |  | √ |  |   |  |  |
| <i>Trifolium</i><br><i>ornithopodioides</i>                           | Birdsfoot clover          |  | √ |  |   |  |  |
| <i>Trifolium repens var.</i><br><i>repens</i>                         | White clover              |  | √ |  | √ |  |  |
| <i>Trifolium scabrum</i>  | Rough clover              |  | √ |  |   |  |  |
| <i>Trifolium spp.</i>   | Clover                    |  | √ |  | √ |  |  |
| <i>Trifolium</i><br><i>subterraneum</i>                               | Subterranean clover       |  | √ |  |   |  |  |
| <i>Trifolium</i><br><i>tomentosum var.</i><br><i>tomentosum</i>       | Woolly clover             |  | √ |  | √ |  |  |
| <i>Vellereophyton</i><br><i>dealbatum</i>                             | White cudweed             |  | √ |  |   |  |  |
| <i>Verbascum virgatum</i>   | Twiggy mullein            |  | √ |  |   |  |  |
| <i>Vicia sativa</i>   | Common vetch              |  |   |  | √ |  |  |
| <i>Vulpia bromoides</i>   | Squirrel-tail fescue      |  | √ |  | √ |  |  |
| <i>Vulpia myuros</i>  | Rat's-tail fescue         |  | √ |  | √ |  |  |
| <i>Vulpia spp.</i>  | Fescue                    |  | √ |  |   |  |  |

|                                |                 |  |  |  |   |  |  |  |
|--------------------------------|-----------------|--|--|--|---|--|--|--|
| <i>Zantedeschia aethiopica</i> | White arum-lily |  |  |  | √ |  |  |  |
|--------------------------------|-----------------|--|--|--|---|--|--|--|

Legend:

EPBC status: endangered, vulnerable

FFG status: listed as threatened

DEPI advisory list: vulnerable, rare

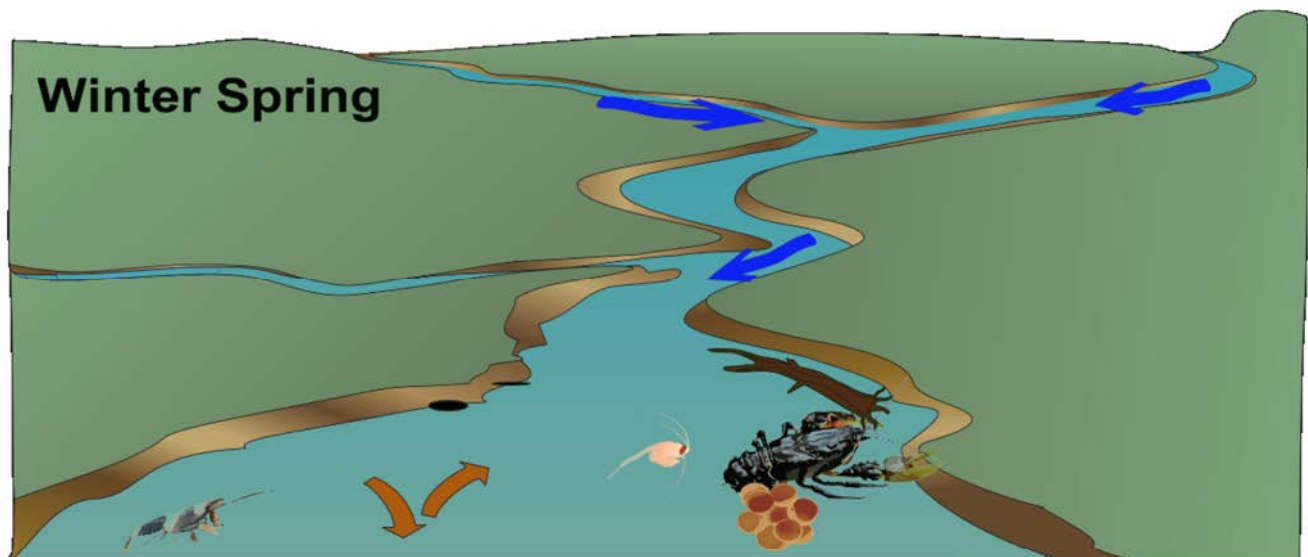
## Appendix 4 – Ecological objectives conceptual models

### Glenelg Spiny Crayfish *Euastacus bispinosus*

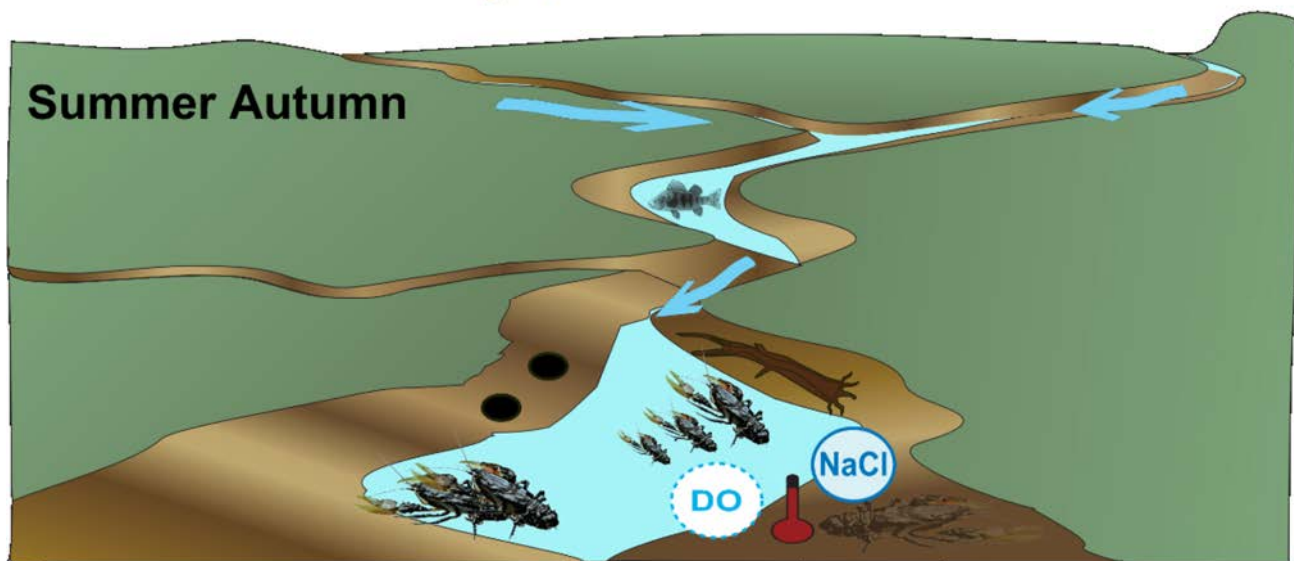
|  |   |
|--|---|
| Where/when value occurs                | Lowland/slopes<br>Reaches 0, 1a, 1b, 2, 3   |
| Required habitat                       | <p>Glenelg spiny crayfish require cool, shaded flowing habitats with good water quality and intact riparian vegetation. Crayfish utilise undercut banks, woody debris, rock boulders and cobbled river beds as refuges (Honan 2004; Johnston and Robson 2009).</p> <p>Preferably shelter or refuge from extreme physical conditions and predation, particularly juveniles and during moulting (Veale, Whiterod, Farrington, &amp; Sweeney, 2014).</p> <p>Deep pools (Glenelg River groundwater fed pools are <math>\geq 3\text{m}</math>) with groundwater inflows providing important refuge when water temperature increases (preferred water temperature 8-22°C), flow declines and stratification may (Honan, 2004).</p>  |
| Threats                                | <p>Reduced flows can lead to a reduction in water quality, including low dissolved oxygen (preferred DO 7.7–13.0 mg/l), high turbidity (preferred turbidity 7.3–19 units) and high salinity (preferred conductivity 1500–5000 <math>\mu\text{S/cm}</math>). Most vulnerable to poor water quality during hatching (Nov–Dec) and moulting (Jan–May) (Honan, 2004).</p> <p>Habitat destruction from snag removal, vegetation clearance and stock access.</p> <p>Groundwater extraction leading to decreased stream baseflow.</p> <p>Fire – reduced water quality, reduction in woody debris, bank collapse and smothering of instream vegetation by sediment.</p>   |
| Conservation status                    | Listed as endangered under the federal EPBC Act and threatened under State FFG Act.   |
| Desired status                         | Protect, maintain and enhance populations.  |
| Species with similar flow requirements | Tupong, spotted galaxias, climbing galaxias, common galaxias, pouched lamprey, short-headed lamprey, black bream, elongate hardyhead, small-mouthed hardyhead, estuary perch.   |
| Water dependence /requirements         | <p>Baseflows in summer and autumn are required to maintain habitat extent and quality by:</p> <ul style="list-style-type: none"> <li>• Maintaining aquatic refuge habitat (deep pools)</li> <li>• Ensuring salinity is less than 6000 <math>\mu\text{S/cm}</math> at critical locations during moulting (May)</li> <li>• Ensuring that dissolved oxygen is more than <math>&gt;4\text{ mg/L}</math> at critical locations (Honan, 2004)</li> <li>• Allowing movement between pools.</li> </ul> <p>Baseflows and freshes in winter and spring are required to promote growth and recruitment by:</p> <ul style="list-style-type: none"> <li>• Optimising water quality for incubation of eggs</li> <li>• Providing access to bench and bank habitat</li> <li>• Connecting habitats to promote dispersal</li> <li>• Maintaining water levels along bank margins to avoid drying burrows.</li> </ul> <p>Bankfull or overbank flows are required in winter and spring to scour the channel bed and maintain channel form.</p> <p>High flows during summer increase connectivity for predators in refuge sites (Veale, Whiterod, Farrington, &amp; Sweeney, 2014).</p> |










|  |   |
|--|---|
| Flow requirement   | <ul style="list-style-type: none"> <li>• Summer and autumn baseflow releases are to exceed 15 ML/d at Fulham gauge and 25 ML/d at Dergholm gauge continuously between December and May</li> <li>• Winter and spring baseflow are to exceed 100 ML/d at Fulham gauge and 160 ML/d at Dergholm gauge continuously between June and November</li> <li>• Winter and spring freshes of more than 250 ML/d at Fulham gauge and 300 ML/d at Dergholm gauge lasting 1–5 days are required on 1 to 5 occasions between June and November</li> <li>• Bankfull flows of more than 1,000 ML/d at Fulham gauge and 6,000 ML/d at Dergholm lasting 1–5 days are required once per period</li> <li>• Overbank flows of more than 6,000 ML/d at Fulham gauge and 9,000 ML/d at Dergholm lasting 2–5 days are required once per year.</li> </ul> |
| <p>Evidence of abundance &amp; distribution increasing with flows</p> <p>Information not available as population surveys have not been undertaken since EPBC Act listing</p> |   |



High flows  coincide with unregulated tributary inflows to optimise water quality for incubation of eggs  and increased water levels, providing access to bank habitat  and structure  for release of juveniles . Winter high and overbank flows facilitate scouring  and greater access to shallow habitat for juveniles  during spring and early summer.



Low flows  help to prevent development of negative water quality conditions i.e low dissolved oxygen , high salinity , high temperatures  and crayfish mortality . Maintenance of water quality is important for moulting  and the onset of breeding in late autumn. Flow magnitude needs to be optimised to offset water quality deterioration but also minimise connectivity with other pools containing predators .

*Conceptual model of the anticipated links between flow and Glenelg spiny freshwater crayfish *Euastacus bispinosus* (Veale, Whiterod, Farrington, & Sweeney, 2014)*

## Variegated pygmy perch *Nannoperca varigata*

|   |  |
|---|--|
| Where/when value occurs                           | Habitat: lowland/slopes (Alluvium, 2013)<br><br>Reaches 0, 1b, 2, 3  |
| Required habitat                                  | <p>Relatively shallow freshwater streams with moderate to high water flow. Usually occur in small groups, often mixed with Southern pygmy perch and Yarra pygmy perch, although the Variegated pygmy perch prefers faster water velocities than the other two pygmy perch species (Kuitert &amp; Allen, 1986). (Saddler &amp; Hammer, 2010).</p> <p>Variegated pygmy perch are associated with dense aquatic vegetation and substrates of gravel, cobble or boulder in the absence of silt (Koehn &amp; O'Connor, 1990) (Kuitert, Humphries, &amp; Arthington, 1996)1996). They can be found in freshwater and slightly brackish water with a preferred temperature range of 14–26°C (Saddler &amp; Hammer, 2010).</p> <p>Flows to allow pygmy perch to move between habitats for spawning or colonise areas will have a direct benefit. Flows play a critical role in these movements, in some cases acting as a trigger for movement, and in others ensuring that any potential barriers are inundated (Alluvium, 2013).</p> <p>Ensuring a variable flow regime to promote phytoplankton and zooplankton production is important to the survival of Variegated pygmy perch (Alluvium, 2013).</p> |
| Threats   | <ul style="list-style-type: none"> <li>• Changes to rivers and creeks that reduces connectivity: <ul style="list-style-type: none"> <li>○ Altered hydrology impacting on longitudinal and lateral connectivity to wetlands</li> <li>○ barriers to fish passage</li> </ul> </li> <li>• Waterway habitat alteration and reduced inflows due to groundwater extraction</li> <li>• Reduction in instream and riparian vegetation (e.g. by stock grazing)</li> <li>• Alteration to temperature regimes (cold water pollution downstream of Rocklands wall)</li> <li>• Sediment input to streams</li> <li>• Invasive species that are competitors and predators (Department of Sustainability and Environment, 1993) (Saddler &amp; Hammer, 2010).</li> </ul>  |
| Conservation status                               | L Listed as vulnerable under the EPBC Act and listed as threatened under the FFG Act.  |
| Desired status                                    | The long-term objective of recovery is to minimise the probability of extinction and ensure long-term survival of Variegated pygmy perch in the wild and to increase the probability of important populations becoming self-sustaining in the long term (Saddler & Hammer, 2010).  |
| Species/objectives with similar flow requirements | <p>Non-migratory fish species including:</p> <ul style="list-style-type: none"> <li>• Southern pygmy perch</li> <li>• River blackfish</li> <li>• Mountain galaxias</li> <li>• Flat-head gudgeon</li> <li>• Dwarf galaxias.</li> </ul>  |
| Water dependence /requirements                    | <p>Baseflows in summer and autumn are required to maintaining habitat extent and quality by maintaining aquatic refuge habitat</p> <p>Baseflows and freshes in winter and spring are required to promote growth and recruitment by:</p> <ul style="list-style-type: none"> <li>• Providing access to spawning habitat in flooded riparian vegetation</li> <li>• Connecting habitats to promote dispersal</li> <li>• Displace fine sediment from channel bed to maintain habitat quality</li> <li>• Scouring the channel bed to maintain deep holes</li> </ul>  |

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|  | Bankfull flows are required in winter and spring to scour the channel bed to maintain deep holes.   |
| Flow requirement   | <ul style="list-style-type: none"> <li>• Summer and autumn baseflow releases are to exceed 15 ML/d at Fulham gauge and 25 ML/d at Dergholm gauge continuously between December and May.</li> <li>• Winter and spring baseflow are to exceed 100 ML/d at Fulham gauge and 160 ML/d at Dergholm gauge continuously between June and November.</li> <li>• Winter and spring freshes of more than 250 ML/d at Fulham gauge and 300 ML/d at Dergholm gauge lasting 1–5 days are required on 1 to 5 occasions between June and November.</li> <li>• Bankfull flows of more than 1000 ML/d at Fulham gauge and 6000 ML/d at Dergholm lasting 1–5 days are required once per period.</li> </ul> |
| Evidence of abundance & distribution increase with flows | <p>Increase in abundance from 2013 and distribution since 2011 (Iervasi et al. 2014).</p> <p>Low numbers of variegated pygmy perch were caught in Reach 1 at two sites and were widely distributed throughout reaches 2 and 3 (Iervasi, Monk, &amp; Versace, 2015).</p>   |

## River blackfish *Gadopsis marmoratus*

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| Where/when value occurs                           | Habitat: slopes (Alluvium, 2013)<br><br>Reaches 0, 1a, 1b, 2, 3   |
| Required habitat                                  | River blackfish inhabit a variety of stream types, preferably with abundant cover such as snags and vegetation (Koehn & O'Connor, 1990).<br><br>Susceptible to increased sediment loads in streams and degradation of natural riparian vegetation (Doeg & Koehn, 1994).<br><br>Spawning time: Oct–Dec (Allen, Midgely, & Allen, 2002).  |
| Threats   | River blackfish are very susceptible to siltation due to their preference for upland streams. Its abundance may also have declined due to snag removal lowering availability of habitat and spawning sites. Other key threats are: <ul style="list-style-type: none"> <li>• Loss or degradation of watercourse habitat</li> <li>• Altered flow regimes, delayed onset of seasonal flows and the occurrence of unnatural cycles of drying, which may impede movement between riparian areas (likely to become more pronounced with climate change)</li> <li>• Reduction in water quality, including increased sediment and salinity</li> <li>• Loss or degradation of streamside vegetation and silting of watercourses, e.g. impact of livestock</li> <li>• Major barriers or disruptions to dispersal due to instream structures, such as dams, weirs and crossings</li> <li>• Predation by and competition from introduced fish species.</li> </ul> |
| Current status of value                           | Common  |
| Desired status                                    | Build and maintain population   |
| Species/objectives with similar flow requirements | Non-migratory fish species including: <ul style="list-style-type: none"> <li>• Southern pygmy perch</li> <li>• Variegated pygmy perch</li> <li>• Mountain galaxias</li> <li>• Flat-headed gudgeon</li> <li>• Dwarf galaxias.</li> </ul>   |
| Water dependence /requirements                    | Baseflows in summer and autumn are required to maintain habitat extent and quality by: <ul style="list-style-type: none"> <li>• Maintaining aquatic refuge habitat in pools of more than 1.5 m depth</li> <li>• Maintaining inundation of priority shallow riffles to a depth of more than 0.1 m</li> <li>• Inundating potential barriers.</li> </ul> Baseflows and freshes in winter and spring are required to promote growth and recruitment by: <ul style="list-style-type: none"> <li>• Inundating woody debris to support reproduction and egg survival</li> <li>• Connecting habitats to promote dispersal</li> <li>• Displacing fine sediment from channel bed to maintain habitat quality</li> <li>• Scouring the channel bed to maintain deep holes</li> <li>• Inundating potential barriers.</li> </ul>  |
| Flow requirement                                  | <ul style="list-style-type: none"> <li>• Summer and autumn baseflow releases are to exceed 15 ML/d at Fulham gauge and 25 ML/d at Dergholm gauge continuously between December and May</li> <li>• Winter and spring baseflow are to exceed 100 ML/d at Fulham gauge and 160 ML/d at Dergholm gauge continuously between June and November</li> </ul>  |

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|   | <ul style="list-style-type: none"> <li>• Winter and spring freshes of more than 250 ML/d at Fulham gauge and 300 ML/d at Dergholm gauge lasting 1–5days are required on 1 to 5 occasions between June and November.</li> </ul> |
| Evidence of abundance & distribution increase | Increase in abundance and distribution – see table below (Iervasi, Monk, & Versace, 2015).   |

**Tupong *Pseudaphritis urvilli***

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| Where/when value occurs                 | Habitat: lowland/slopes<br><br>Reaches 1b, 2, 3  |
| Required habitat                        | <p>Tupong typically inhabit the beds of slow-flowing streams and often remain partly buried among rocks and logs (Andrews, 1996).</p> <p>Adults migrate downstream to estuary for breeding April to July. Juveniles migrate upstream Oct–Feb (Lloyd Environmental, 2012).</p> <p>Spawning time: May – Aug (Crook, et al., 2010).</p> <p>Life span: greater than 5 years.</p> <p>Flows for tupong to move between habitats for spawning or to colonise areas. Flow play a critical role in these movements, in some cases acting as a trigger for movement, and in others ensuring that any potential barriers are inundated. For example, (Crook, et al., 2010) showed that movement of female tupong in the Glenelg River was frequently associated with flow pulses above the median daily flow (Alluvium, 2013).</p>            |
| Threats                                 | <ul style="list-style-type: none"> <li>• Loss of flows allowing movement between available habitat sites</li> <li>• Construction of dams, drains or crossings which alter the direction, velocity and timing of flows, and can impede spawning migrations of adults, and/or the migration of juveniles</li> <li>• Aquatic pest species that can out-compete, predate or displace</li> <li>• Reduction in fresh water quantity (environmental flows)</li> <li>• Destruction of instream habitat and loss and degradation of riparian vegetation (which reduces habitat for feeding and sheltering, destabilises streams and river banks, and changes channels)</li> <li>• Climate change – in particular reduced freshwater river flows caused by reduced rainfall and increased diversion of river water for human use.</li> </ul> |
| Current status of value                 | Common   |
| Desired status                          | Build and maintain population  |
| Species with similar flow requirements: | Short-finned eel, spotted galaxias, climbing galaxias, common galaxias, pouched lamprey, short-headed lamprey, black bream, elongate hardyhead, small-mouthed hardyhead, estuary perch.  |
| Water dependence /requirements          | <p>Baseflows in summer and autumn are required to maintain habitat extent and quality by:</p> <ul style="list-style-type: none"> <li>• Maintaining aquatic refuge habitat in pools of more than 1.5 m depth</li> <li>• Maintaining water quality in pools; adequate DO &gt;5 mg/l, conductivity &lt; 1500 µs/cm @ 25°C (Environment Protection Authority, 2003) (Iervasi, Monk, &amp; Versace, 2015).</li> </ul> <p>Baseflows and high flow freshes in winter and spring are required to promote growth and migration by:</p> <ul style="list-style-type: none"> <li>• Maintaining water quality in pools; adequate DO &gt;5 mg/l, conductivity &lt; 1,500 µs/cm @ 25°C (Environment Protection Authority, 2003) (Iervasi, Monk, &amp; Versace, 2015)</li> </ul>   |

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|   | <ul style="list-style-type: none"> <li>• Providing stimulus and opportunity for downstream migration between June and August at least one time every year for 2 to 5 days with a minimum depth of 0.2 m over barriers</li> <li>• Providing stimulus and opportunity for upstream migration between October and November at least once per year with a minimum depth of 0.2 m over barriers</li> <li>• Connecting habitats to promote dispersal within the river system.</li> </ul> <p>Require the longitudinal continuity of flow events be protected, especially those relating to fish movement (Alluvium, 2013).</p> |
| Flow requirement                              | <ul style="list-style-type: none"> <li>• Summer and autumn baseflow releases are to exceed 15ML/d at Fulham gauge and 25ML/d at Dergholm gauge continuously between December to May</li> <li>• Winter and spring baseflow are to exceed 100 ML/d at Fulham gauge and 160 ML/d at Dergholm gauge continuously between June to November</li> <li>• Winter and spring freshes of more than 250 ML/d at Fulham gauge and 300 ML/d at Dergholm gauge lasting 1–5 days are required on 1 to 5 occasions between June and November.</li> </ul>   |
| Evidence of abundance & distribution increase | <p>Tupong abundance increased as did its geographical distribution through the river, see table below (Iervasi, Monk, &amp; Versace, 2015).</p> <p>It is likely that increased habitat connectivity through removal of a key physical barrier to movement at the Sandford weir, and improved water quality and connectivity through environmental flows has played a role in assisting this migratory species (Iervasi, Monk, &amp; Versace, 2015).</p>   |

## Short-finned eel *Anguilla australis*

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| Where/when value occurs                 | Habitat: lowland/slopes<br>Reaches 1a, 1b, 2 and 3  |
| Required habitat                        | Occupy a variety of habitats including rivers, creeks and wetlands.<br>Adults migrate to sea during summer and autumn and elvers return into estuaries Jan–Feb and migrate upstream in subsequent years (Lloyd Environmental, 2012).<br>Spawning season: June–Mar (Lloyd Environmental, 2012).<br>Life span: 32 years.<br>Flow pulses Dec–March. Peak downstream spawning migration occurs Dec–March and is triggered by high flow events. DSE data from western Vic indicated eel movement is positively correlated with the hydrograph (Crook, et al., 2008).   |
| Current status of value                 | Not listed as threatened.<br>The Glenelg basin population is at the western extent of the short-finned eel Australian range with only a few cross over to South Australia to Eight Mile Creek.  |
| Desired status                          | Protect, maintain and enhance populations.  |
| Threats                                 | <ul style="list-style-type: none"> <li>• Major barriers or disruptions to dispersal and migration due to instream structures, such as dams, weirs, drains or crossings</li> <li>• Invasive species that are competitors and predators</li> <li>• Commercial harvesting .</li> </ul>   |
| Species with similar flow requirements: | Tupong, spotted galaxais, climbing galaxais, common galaxais, pouched lamprey, short-headed lamprey, black bream, elongate hardyhead, small-mouthed hardyhead, estuary perch.   |
| Water dependence /requirements          | Baseflows in summer and autumn are required to maintain habitat extent and quality by maintaining aquatic refuge habitat in pools of more than 1.5 m depth.<br>Fishes in summer and autumn are required to provide stimulus for downstream spawning migration between December and March.<br>Baseflows and freshes in winter and spring are required to promote growth and migration by: <ul style="list-style-type: none"> <li>• Providing stimulus and opportunity for upstream migration between October and November at least once per year with a minimum depth of 0.2 m over barriers</li> <li>• Connecting habitats to promote dispersal within the river system</li> <li>• Displacing fine sediment from channel bed to maintain habitat quality</li> <li>• Scouring the channel bed to maintain deep holes.</li> </ul> |
| Flow Requirement                        | <ul style="list-style-type: none"> <li>• Summer and autumn baseflow releases are to exceed 15 ML/d at Fulham gauge and 25 ML/d at Dergholm gauge continuously between December and May</li> <li>• Winter and spring baseflow are to exceed 100 ML/d at Fulham gauge and 160 ML/d at Dergholm gauge continuously between June and November</li> <li>• Summer and autumn freshes of more than 100 ML/d at Fulham gauge and 150 ML/d at Dergholm lasting 2–3 days are required on 2 occasions per period</li> <li>• Winter and spring freshes of more than 250 ML/d at Fulham gauge and 300 ML/d at Dergholm gauge lasting 1–5days are required on 1 to 5 occasions between June and November.</li> </ul>  |



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| Evidence of abundance & distribution increase with flows | Downstream migration of tagged eels was strongly correlated with periods of increased river discharge. Positive associations between downstream migration and river discharge have been reported previously for <i>A. australis</i> (Crook, et al., 2014) |
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**Wimmera bottlebrush *Callistemon wimmerensis***

|   |  |
|---|--|
| <p>Where/when value occurs</p>                    | <p>Reaches 0, 1a, 1b and 2</p> <p>Occurs on river banks and floodplain within the upper reaches of the Glenelg River and the lower Mackenzie River (Wimmera CMA). Low population base and limited distribution.</p> <p>Occurs low in the hydrological profile.</p> <p>Regular yearly winter/ spring flows are essential for the long-term health and survival (Marriott, 2010).</p> <p>Large natural, or regular large environmental flows will result in the recovery of the population (Marriott, 2010).</p> |
| <p>Threats</p>                                    | <p>Weeds and other 'out of balance' plant species</p> <p>Grazing pressure</p> <p>Fire</p> <p>Recreational activities (trail bikes)</p> <p>Reduction in fresh water quantity (flow diversions)</p> <p>Climate change – in particular reduced freshwater river flows caused by reduced rainfall and increased diversion of river water for human use.</p>  |
| <p>Current status of value</p>                    | <p>Listed as critically endangered under the EPBC Act.</p>   |
| <p>Desired status</p>                             | <p>Maintain, protect and enhance populations.</p>  |
| <p>Water dependence /requirements</p>             | <p>Regular winter–spring baseflows for long-term health.</p> <p>Winter/ spring bankfull and overbank for flowering and seedling recruitment.</p>   |
| <p>Flow requirement</p>                           | <p>Inundate riparian zone (bankfull) and floodplain (overbank) in order to maintain condition of adults and facilitate sexual recruitment.</p> <p>Bankfull, spring–summer, 2–5 times per decade (pers. comm., Neil Marriott).</p> <p>Overbank, winter spring, 2-5 times per decade (pers. comm., Neil Marriott).</p>   |
| <p>Response if water requirements are not met</p> | <p>Significant decline of <i>Callistemon</i> population ( (Marriott, 2010).</p> <p>'Absence of an environmental flow for the majority of the population 2005–2008 combined with the ongoing severe drought resulted in the death of 30% of the population in the MacKenzie system' (Marriott, 2010).</p>   |

