Transformation of the Latrobe: Pathways for the Latrobe River System

FINAL REPORT

3 August 2022

alluvium

Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to and talking at the meeting places as one nation.

This report has been prepared by Alluvium Consulting Australia Pty Ltd for **West Gippsland Catchment Management Authority** under the contract titled '**Contract – The Latrobe where to from now**'.

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Executive Summary

The Latrobe River system is currently in a period of transition away from coal-fired power generation and attempting to adapt to climate change impacts on the system, including water availability, security and salinity. At present, there is an opportunity to develop management activities and priorities seeking to improve the health and condition of the system, which complement and work in conjunction with other strategies and plans relevant and being developed for this region, including the Central Gippsland Sustainable Waterway Strategy, Water is Life Roadmap, Latrobe Valley Regional Rehabilitation Strategy and others.

This report is intended to inform more detailed planning and decision-making by the West Gippsland Catchment Management Authority (WGCMA), in conjunction with investment partners, stakeholders and communities, to optimise management of the Latrobe River system now and into the future.

In the context of both the broad range of values associated with the Latrobe River system and the continuing and emerging pressures it faces, the report proposes set of principles and long-term goals to guide the future management of the river and its floodplains and wetlands. These are set out below:

Principles for management of the Latrobe River system

i. Management of the Latrobe River system will contribute towards attainment of international, national, state and regional waterway health and biodiversity objectives, community objectives and Gunaikurnai cultural objectives for water and lands on Country

ii. An equitable share of the water resources of the Latrobe River will be provided to meet the objectives of Government environmental delivery partners, the community and the Gunaikurnai, the Traditional Owners of the land and waters

iii. Management of the Latrobe River system and response to threatening processes (including climate change) will ensure there is a net gain in river, floodplain, wetland or estuary health and condition to contribute to broader environmental [cultural, social and economic] objectives across the Gippsland Lakes catchment

iv. Where an adverse impact on the Latrobe River system occurs or a risk to the River system is increased, any accompanying or potential decline in condition will be compensated, to deliver a net gain in the condition of the system

Long-term goals for the Latrobe River system

1. There will be a net gain in the environmental condition of the Latrobe River system, inclusive of the river, floodplains, wetlands and estuary
2. Scientifically determined environmental flow requirements, together with Aboriginal cultural water requirements, will be secured, allocated and provided to the Latrobe River system
3. Sediment and nutrient loads and concentrations in the Latrobe River system will be reduced to levels that do not adversely affect the ecological functioning of the Latrobe River, floodplain wetlands in the Latrobe catchment and the Gippsland Lakes
4. The structure and functioning of the river, floodplains, wetlands and estuary of the Latrobe River system will be conserved to the extent possible, and there will be a net gain in freshwater wetland area and condition.
5. The Latrobe River system will support diverse and resilient populations of native flora and fauna species including, threatened species
6. Riparian corridors will be vegetated with appropriate native species and connected throughout the Latrobe River system
7. There will be continued and increased integration of the Gunaikurnai in alignment with the draft Water is Life: Traditional Owner Access to Water Roadmap (DELWP 2022), and as predetermined by their body corporate, the Gunaikurnai Land and Waters Aboriginal Corporation, in keeping with their priorities and self-determination
8. There will be continued and increased involvement of relevant community, stakeholders and partners in decision making processes, stewardship and management activity.

A package of high-level management options has been developed to improve the condition and health of the Latrobe River system. The recommended management options address salinity and water quality issues, environmental flow deficit as well as improve instream geomorphic complexity and ecological complexity. The recommended management options include:

- Reconfiguration of Lower Latrobe Wetlands inflow and outflow points, comprising new/upgraded constructed inflow points to Heart and Dowd morasses and Sale Common,
- Integrated floodplain and wetland restoration, and constraint management project downstream of Rosedale,
- Re-establish native riparian vegetation through Latrobe System including tributaries and Crown water frontages,
- Removal of barrier to fish passage to re-establish longitudinal connectivity between relevant reaches and tributaries of the Latrobe River,
- Reinstate meanders in sections of the river where meanders have been cut through,
- Opportunistic re-snagging, where practical and cost-effective, by relocating large woody debris from local tree falls,
- Feasibility study into an alternative future for Lake Narracan, which is currently used to deliver water to Yallourn and Loy Yang power stations and for recreational purposes,
- Review passing flow rules for reservoirs and unregulated rivers to better meet environmental needs, through the existing DELWP state-wide program of reviewing passing flow arrangements,
- Relaxation of constraints on the delivery of environmental water. Existing operational flow thresholds constrain releases from Lake Narracan, Moondarra and Blue Rock due to potential for 3rd party flooding impacts,
- Enable storage and release of environmental allocation at Lake Narracan to improve the efficacy of environmental water to reaches downstream from Lake Narracan by enabling more flexibility in Lake Narracan operations and water levels,
- A native fish restocking program,
- Pilot carp control initiative for Lake Wellington and associated catchments,
- The Strzelecki-Alpine Bio-link project, which would seek to re-creating ecological connectivity between the Alps and Strzelecki ranges with a focus on the Morwell River and some surrounding coal mine lands,
- Increase the availability of water to meet identified environmental needs,
- Water quality management initiatives,
- Feasibility study into decommissioning of Yallourn weir
- Investigate options to restore Crown river frontage lease holdings to be managed for improved environmental and community outcomes.

1 Introduction

This report has been prepared for the West Gippsland Catchment Management Authority (WGCMA) to inform decisions aimed at improving the health and condition of the Latrobe River system.

The Latrobe River (Durt-Yowan) system, including its wetlands, floodplains and estuary, supports a wide range of social, environmental, economic and cultural values and assets. Environmental values include native fish populations, vegetation communities, and the internationally significant wetlands of the Gippsland Lakes that are listed under the Ramsar convention (including some of the lower Latrobe wetlands and all of Lake Wellington). The river system also supports a diversity of recreational (e.g., boating and angling) and amenity values.

For the Gunaikurnai as the Traditional Owners of the land and waters of the Country, including the river and its associated tributaries and wetlands, there is much rich cultural heritage connecting the Old People to the present – and if Country and mob are cared for, the future. The Latrobe River is one of the longest rivers on Gunaikurnai country running east across the whole of the Brayakaulung clans area of country from The Great Dividing Range to Lake Wellington. Many of the Latrobe River's tributaries are dendritic flow systems that have great significance as to how the water flows and how people traversed Brayakaulung Country traditionally.

More recently, input from Gunaikurnai Community has reiterated its importance for the cultural heritage it holds, for instance its spiritual connection to the Traditional Owners, the resources it offers, camping, places of connection and story, and knowledge sharing.

Taken together, these values, and the opportunities they present, are becoming increasingly important to the Latrobe valley and its communities.

However, since European settlement, the Latrobe River system has been subjected to significant modification and environmental degradation. Water resources have been developed through dam and weir construction, and diverted for use in agriculture, power generation, industry and urban uses. As a result, the river is hydrologically stressed and its freshwater dependent values – including floodplains and wetlands and the biodiversity they sustain – have been compromised. Riparian vegetation over much of the river system has been cleared and modified, and the structure and habitat values of some river reaches has changed due to historic channel realignment and snag removal. Water quality has also been impacted, mainly by land-based sources of pollution. In the lower Latrobe wetlands, a combination of factors is contributing to rising salinity levels that threaten to change their ecological character.

The rationale for healthy rivers extends well beyond biodiversity outcomes. A healthy river system also provides opportunities to improve individual and community wellbeing, to deliver meaningful reconciliation with Aboriginal people, and to deliver employment, economic development and tourism benefits. A healthy river system contributes toward quadruple bottom line outcomes.

The development and prioritisation of options to provide for river health and associated quadruple bottom-line outcomes, requires an acknowledgement of the significant changes taking place in the Latrobe valley and communities locally and society more broadly:

- The accelerated pace of transition from coal-fired power generation has major socio-economic ramifications for the region.
- Environmentally, both the river system and its communities and industries are exposed to the emerging impacts of climate change, with all projected scenarios pointing to a drier and more variable future. Climate change is also leading to sea level rise, influencing the condition of the lower wetlands and estuary.
- Victorian communities are becoming increasingly attuned to the values of healthy riverine environments, are more likely to take advantage of the recreational and amenity values that they sustain, and are strongly and increasingly advocating for their protection and rehabilitation.
- The Gunaikurnai Community and its Traditional Owners aspire to a more active and meaningful role in land and water management, and these aspirations are gaining traction and support across the wider community and are now embedded in legislation and policy.

The transition from coal-fired power generation requires an approach to the stabilisation and rehabilitation of the final mine voids. As "*a blueprint to progress mine rehabilitation planning for the Latrobe Valley's coal mines*" (DJPR, 2019), the Latrobe Valley Regional Rehabilitation Strategy (LVRRS) canvasses both water-based and non-water-based options for mine void rehabilitation and hence provides an important context for this report and the future of the Latrobe River.

1.1 Project scope and objectives

This report documents the outcomes of a project that sought to:

- Revisit the 2009 Latrobe River 'Business Case' document, including its proposed Principles and Objectives, in the current context of change and transition in the Latrobe Valley
- Identify and prioritise a range of potential management initiatives, appropriate to the current operating environment, for improving the health and condition of the Latrobe River system
- Identify further supporting investigations that may be required (including more detailed options analysis and evaluation).

This report is intended to inform more detailed planning and decision-making by the WGCMA, in conjunction with partners, stakeholders and communities, to optimise management of the Latrobe River system.

The project team included a panel of experts comprising Prof. Ian Rutherfurd, Dr Phil Duncan, Prof. Paul Boon, Jim Binney, and Prof. Barry Hart. It was completed in four phases which are outlined in Figure 1.

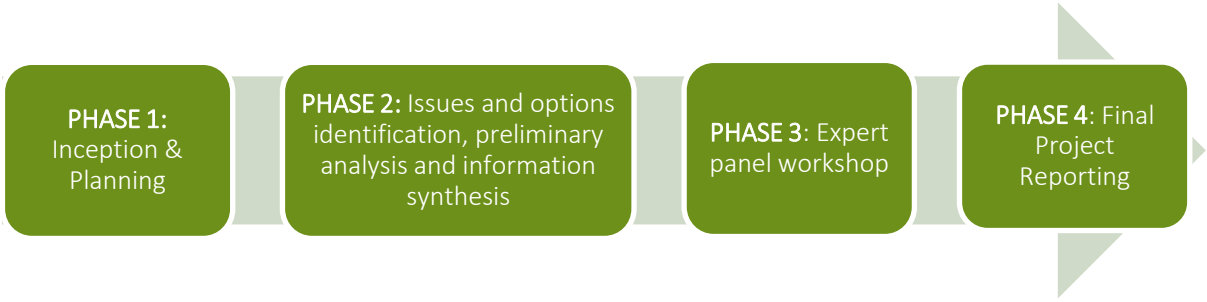

Figure 1. *Project approach*

The **spatial scope** of this project covers the whole of the Latrobe River system, with a focus on

- All regulated reaches of the Latrobe River (Figure 2) and associated floodplains and wetlands, including the Latrobe Wetlands (Dowd Morass, Sale Common and Heart Morass)
- The major regulated and unregulated tributaries of the Latrobe River including the Tyers and Tanjil rivers, the Morwell River, Moe River and Traralgon Creek

Although the Thomson and Macalister Rivers and Gippsland Lakes are not in scope for this project, it is acknowledged that they play an important role in the condition of the lower Latrobe wetlands and estuary.

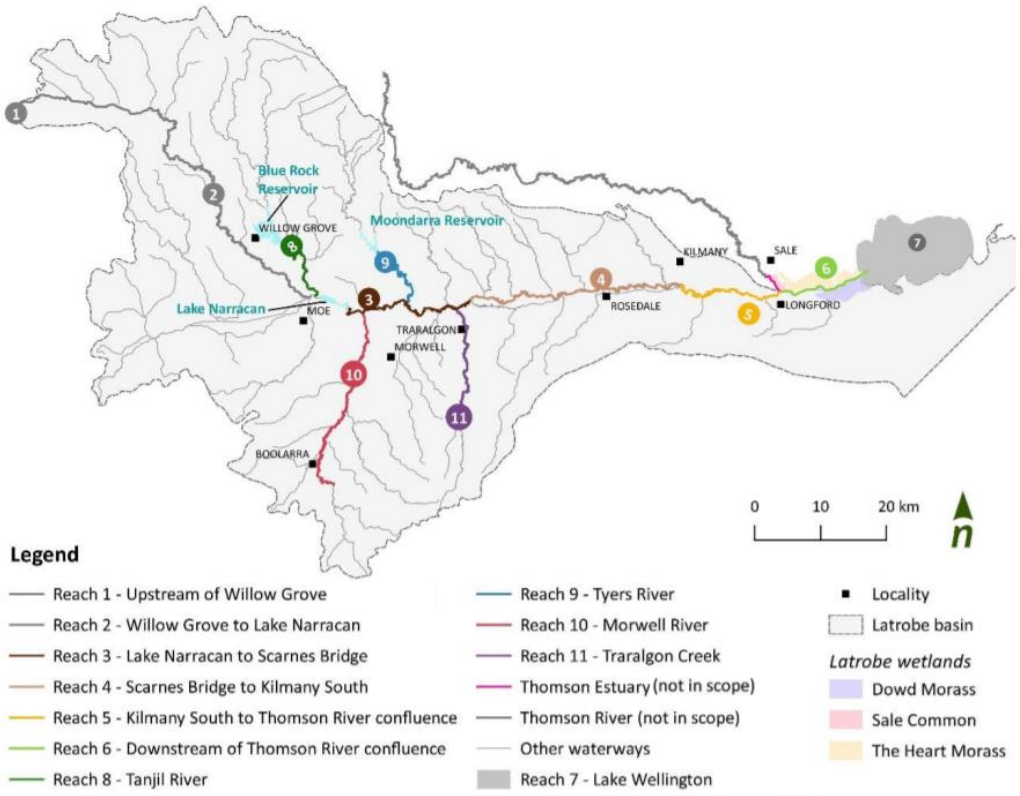

Figure 2. *Study area of Latrobe River System and important tributaries (source: Alluvium, 2020)*

Document review

The project and this report considered relevant work that has been undertaken since the 2009 Business Case was developed. This included:

- The updated FLOWS study (Alluvium, 2020), including a quantitative shortfalls analysis (Alluvium 2021) and the development of interim water recovery targets for consideration in the Central and Gippsland Sustainable Water Strategy discussion draft[1] (DELWP, 2021a)
- Latrobe Valley Regional Water Study – Ecological Effects Assessment (Hale et al., 2020)
- The Latrobe Valley Regional Rehabilitation Strategy (LVRRS) and the associated technical work undertaken for its implementation (DELWP, 2020a; DJPR, 2020a)
- Relevant work that has supported the 2021 Yallourn mine emergency
- The report on changed conditions and likely prognosis for the Ramsar-listed Lake Wellington and its fringing wetlands (Hale & Boon, 2021).

Investigations into the impacts and risks to groundwater and surface were explored, where appropriate.

Stakeholder engagement

In addition to relevant literature, this project was informed by discussions with staff from the West Gippsland Catchment Management (WGCMA), as well as:

- Representatives of the Department of Environment, Land, Water & Planning (DELWP)
- A representative of the Victorian Environmental Water Holder (VEWH), and
- A representative of the Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC)

Semi-structured interviews were conducted with nominated representatives from WGCMA, DELWP, VEWH and GLaWAC, to gauge an understanding of issues, opportunities and options within the catchment. Engagement also included meetings with WGCMA and DEWLP representatives, and a workshop involving WGCMA, DELWP, independent expert Dr Roger Grayson, and the Expert Panel.

[1] Interim waterway recovery targets were reviewed by the West Gippsland Catchment Management Authority and an expert panel, and updated in the final strategy.

2 Background and context

2.1 The Latrobe River System and its current condition

The Latrobe basin is located between the Strzelecki and Baw Baw Ranges in West Gippsland, Victoria. With tributaries originating in the Baw Baw plateau and northern Strzelecki ranges, the Latrobe River flows through a mainly agricultural landscape before merging with the Thomson River (Carran Carran) and flowing into Lake Wellington (Figure 3).

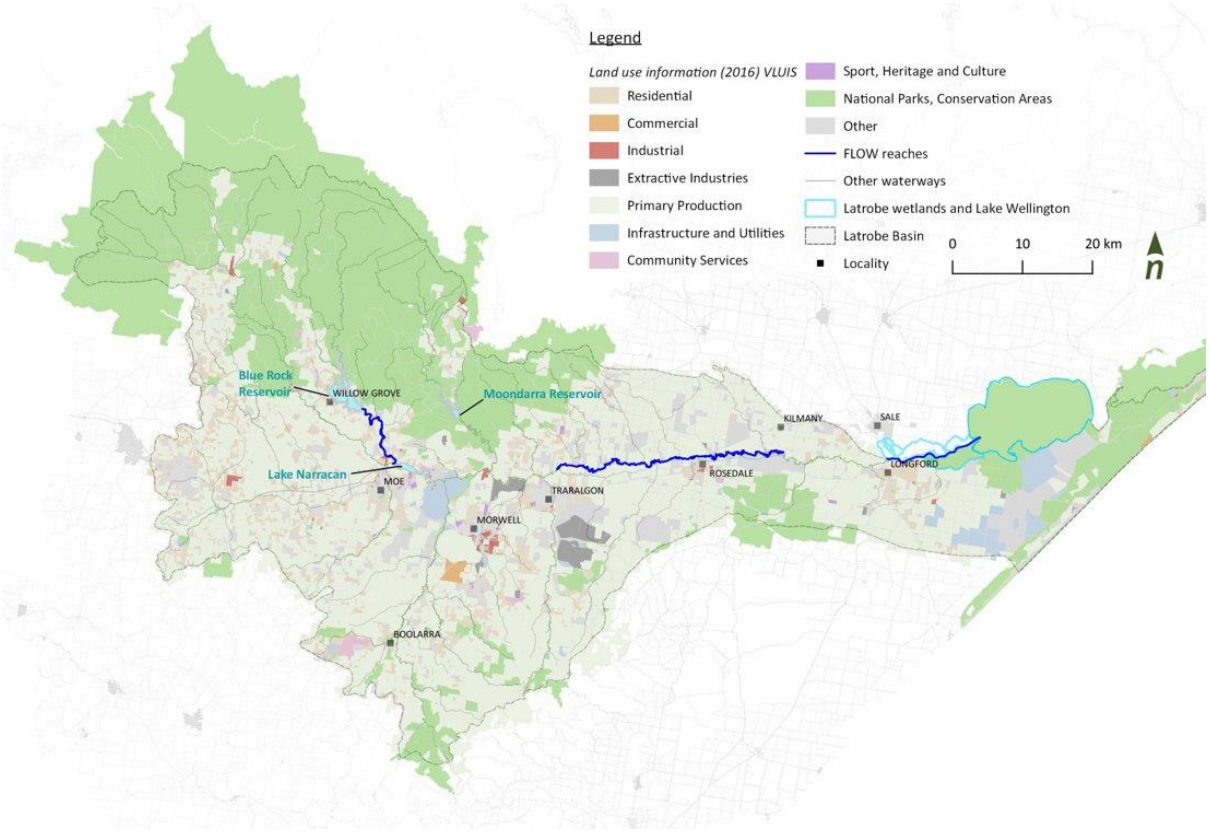

Figure 3. *Land use across the Latrobe River system (source: Alluvium, 2020)*

The Latrobe River system has been substantially modified since European settlement. Some of these modifications, particularly river regulation through dams and weirs, were undertaken to support development of water resources for agriculture, coal mining and related power generation, and industrial and urban uses. The movement of water to meet consumptive demands (other than agricultural demands) is depicted at Figure 4. Previous studies have reported the Latrobe River system as being hydrologically stressed and over-extracted (Alluvium, 2009; Alluvium, 2020; DELWP, 2020c). Development and use of water resources has impacted on the volume and variability of flows in the river system, altering sediment transport dynamics and disconnecting floodplains across the system (EarthTech 2005; Tilleard et al. 2009).

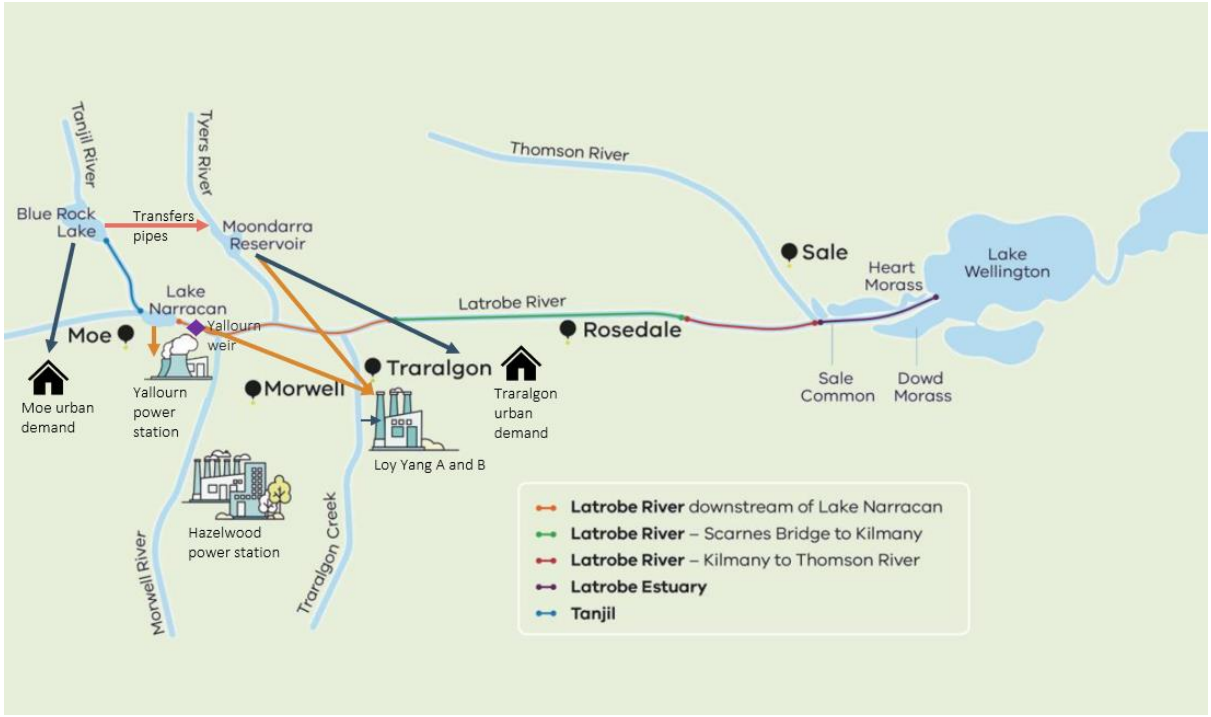

Figure 4. *Schematic representation of the Latrobe River System, where arrows indicate the movement of water from its source to use (source: Alluvium, 2020)*

In water resource terms, the Latrobe is a fully allocated system with several bulk entitlements allocated to Southern Rural Water, Gippsland water and other consumptive uses, as well as two bulk entitlements for environmental purposes. The system includes three water reservoirs: the Blue Rock Lake (Tanjil River), Moondarra reservoir (Tyers River) and Lake Narracan (Latrobe River), with storage capacities of 198 gigalitres (GL), 30 GL and 7 GL, respectively (Figure 4). Below Lake Narracan These storages service urban water supply, irrigated agriculture, power generation, and other industrial and environmental water demands (DELWP, 2021a). Yallourn weir, located directly downstream from Lake Narracan, is another in-stream structure worth noting. In addition to existing consumptive bulk entitlements (BEs), essential service industries, urban users and other entitlement holders can also obtain additional water supplies through the Latrobe Reserve bulk entitlement (established in 2011), which provides up to 37.4 GL from Blue Rock Reservoir during drought periods to help manage such shortfalls (DELWP, 2021a).

Environmental water bulk entitlements cover entitlement held in Blue Rock Reservoir (Blue Rock Environmental Entitlement 2013) and provision for the Lower Latrobe Wetlands (Lower Latrobe Wetlands Entitlement 2010).

Over many decades, Latrobe water resources have supported, and continue to support, significant brown coal-based power production in the Latrobe Valley. In 2019/20, 63.7 GL was used for this purpose (DELWP, 2021b). This power production has been supported by three open-cut coal mines: Hazelwood, Loy Yang (servicing the Loy Yang A and Loy Yang B Power Stations) and Yallourn (Figure 4). The mines are large, each extending over 12 km^2 in total, with a combined void space at closure projected to be 2800 GL (Hale et al., 2020). All of these power stations are scheduled for phased closure over the next 25 years. Hazelwood has ceased power production and is currently in the process of completing an Environmental Effects Statement relating to its mine void rehabilitation plans.

The ecological condition of the Latrobe River system is spatially heterogenous with the upper reaches (e.g., the Upper Latrobe, the Tanjil and Tyers Rivers) in good condition with high quality instream and riparian biodiversity. The condition of the river then deteriorates downstream from the Blue Rock and Moondarra storages. The reach of the Latrobe River between Lake Narracan and Rosedale, as well as the heavily modified lower reach of the Morwell River and Traralgon Creek, support only small remnants of instream and riparian vegetation and limited faunal diversity. They also suffer from poor water quality, and the effects of modifications to channel structure and in-stream habitats and barriers to fish migration. The environmental

condition of the lower reaches of the Latrobe River improves downstream from Rosedale, and again from Kilmany township, where some meanders have been reinstated and extensive remnant floodplain forest and wetlands exist.

Despite these challenges, the Latrobe River retains some natural flow variability, and is relatively stable from a geomorphic perspective. In this regard, considerable scope exists to rehabilitate and improve the ecological condition of the Latrobe River through an integrated suite of waterway management initiatives. The lower reaches of the Latrobe River (downstream of the Rosedale and Kilmany townships) are a prime example demonstrating the recovery potential of the river. The Latrobe Estuary (from Swing Bridge to the delta of Lake Wellington) is classified as a permanently open salt-wedge (Hale et al., 2020) and supports freshwater, estuarine and diadromous fish species and salt-tolerant vegetation communities. Salinity in the estuary is governed by water levels (and salinity) in Lake Wellington and the volumes of freshwater inflows from the Thomson and Latrobe Rivers.

Since the permanent opening and dredging of Lakes Entrance in 1889, the lower Latrobe wetlands and estuary have experienced a long-term trajectory of change. The permanent opening of this entrance, combined with increasing demands on the water resources of the Latrobe and Thomson-Macalister rivers and climate change/vulnerability, has led to rising salinity levels in the Lower Latrobe River and adjoining wetlands including Heart and Dowd morasses. Pre-European settlement, the Lower Latrobe River and wetlands can be described as an intermittently closed and open lagoon system supporting freshwater lacustrine (lake) and palustrine (march/morass) features. This system is now transitioning to an open marine-estuarine system (DSEWPC, 2010). The negative effects of increased salinity on aquatic ecosystems in the Lower Latrobe wetlands has been exacerbated by surface water extraction for resource uses, sea level rise associated with climate change, and land use activities in the mid and upper Latrobe River (Boon et al., 2008; Hale et al., 2021; Raulings et al., 2021). Therefore, Heart Morass and Dowd Morass are now classified to be in a brackish-water wetland condition with some pockets of higher levels of freshwater (Hale & Boon, 2021). Salinity in these wetlands is predicted to increase under future climate conditions as freshwater inflows decrease and sea level rises (DEWLP, 2021a; Hale & Boon, 2021; Jacobs, 2017). Sale Common is the only remaining freshwater wetland in the lower Latrobe wetland complex on public land, and although it is relatively small, it supports high freshwater biodiversity values.

Maintaining the health and condition of the Latrobe River, its tributaries, wetlands and floodplains are important for supporting a diverse range of environmental, economic, social and Aboriginal cultural values (DELWP, 2020b). Identified shortfalls in environmental water and a general decline in water availability due to over extraction of water for urban, electricity and agricultural uses can lead to a loss of biodiversity and decline in environmental values across the Latrobe system. These impacts are predicted to be exacerbated under drier future climate conditions but can be mitigated if more water is made available to maintain minimum environmental flow targets (Alluvium, 2021; DELWP, 2021a). Thus, it is more important than ever both to make best use of water resources available for environmental purposes, and to undertake a range of complementary environmental initiatives, to improve the health of the system and optimise the many different values that it sustains.

In summary, the health and condition of the Latrobe River system continues to be threatened by multiple stressors. Acknowledging that improvements to waterway health may be achieved through increased environmental water and improved flow regimes, there is also considerable scope for other river management initiatives, such as removing barriers to fish passage (Kingfisher Research, 2016) to complement and add value to available environmental water, and to play an important role in achieving waterway health outcomes and improving the character and condition of the Latrobe River system.

2.2 Values of the Latrobe River

The Latrobe River system supports a diverse range of water-dependent environmental, economic, social and Aboriginal cultural values (DELWP, 2020b), the needs of which must be carefully balanced against consumptive demands for water.

Despite a significant decline in the availability of water for the environment, the Latrobe River system continues to sustain a wealth of water-dependent ecological values. These values include:

- The Gippsland Lakes Ramsar site, which includes parts of the Lower Latrobe wetlands, as well as other parts of the wetlands that do not fall within the Ramsar site.
- Ecologically healthy and representative reaches on the Latrobe River above Lake Narracan as well as reach 6 from Noojee to Willow Grove and upstream of Noojee (WGCMA, 2018, Figure 2).
- An assemblage of native fish that includes:
    - Diadromous fish species such as Australian Bass and the nationally threated Australian grayling (Amtstaetter et al., 2016).
    - Threatened non-diadromous fish species including barred galaxias, dwarf galaxias, river blackfish and Australian smelt.
- Numerous waterbird and migratory wader species, including the endangered Australasian bittern. Several migratory species are protected by international treaties and the *Environmental Protection and Biodiversity Conservation Act 1999*.
- Important amphibian species including the vulnerable Green and golden bell frog and Growling grass frog.
- Remnant riparian vegetation, including Red Gum, Swamp Gum, Common Reed, Swamp Paperbark and salt marsh, as well as significant threatened vegetation communities – damp forest, floodplain riparian woodland, wetland formation, swamp riparian woodland, valley heath forest, shrubby foothill forest, riparian forest, riparian scrub complex, wetland formation and South Gippsland Plains grassy forest (WGCMA, 2007).

As discussed in sections 2.1 and 2.6, many of these values are subject to a range of threatening processes.

The Latrobe River system is an integral part of the Country of the Gunaikurnai people, who have managed the land and waters sustainably over many thousands of years. The area is rich in tangible and intangible Gunaikurnai cultural heritage, supporting the many varied cultural values and uses of the original custodians.

As the Traditional Owners of the land and waters of the Country, including the river and its associated tributaries and wetlands, the Gunaikurnai have a rich cultural heritage connecting the Old People to the present – and if Country and mob are cared for, the future. The Latrobe River is one of the longest rivers on Gunaikurnai country, running east across the whole of the Brayakaulung clans area of country from The Great Dividing Range to Lake Wellington. Many of the Latrobe River's tributaries are dendritic flow systems that have great significance as to how the water flows and how people traversed Brayakaulung Country traditionally

The Latrobe also sustains a range of other important values, including:

- Recreational and tourism values such as boating, angling, water-skiing, camping, walking and bird-watching.
- Amenity values important to individual and community wellbeing and to the overall attractions of the region.
- Ecological services such as pollination of agricultural crops, management of insect pests and management of water quality.

Each of these values is important, and moreover, their substantial contribution to the regional and wider Victorian communities can be quantified in economic terms.

Furthermore, by engaging the wider community and involving community members in river management, the Latrobe river serves as a forum for the teaching and acquisition of knowledge, both scientific and traditional, relating to the history, ecology, cultural significance and management of the river system.

In summary, and as articulated in section 1.1, the rationale for initiatives that improve river health and condition extends across the quadruple bottom line of environmental, economic, cultural, and social outcomes.

2.3 The 2009 Latrobe 'Business Case' report

In 2009 the West Gippsland Catchment Management Authority (WGCMA) commissioned Alluvium to prepare a report on a Vision for the Latrobe River system, and advice on development of a Business Case for investment in

the Latrobe River (Alluvium, 2009). This work was undertaken as part of the scoping phase for the WGCMA's Latrobe River Health Program (LRHP). The report comprised two parts:

- The 2009 Vision document, which included proposed principles and long-term goals for the ecological functioning of the system and documented a number of key questions for further investigation. It also outlined the next steps required for the development of an investment plan for the river system.
- The Business Case Briefing Paper described the values of the system and its condition. It also mapped a future trajectory of change on a "business as usual" scenario, where anticipated population growth and expansion in coal mining were key assumptions. Finally, it presented a costed suite of management options for the Latrobe (fencing and revegetation; fish passage at Lake Narracan, and meander reinstatement) within the limitations of currently available environmental water.

Since this 2009 work, a number of underpinning assumptions about the Latrobe River system have changed. In particular:

1. Knowledge about future climate change scenarios, (including temperature, rainfall, runoff, sea level rise and extreme weather events) has improved, and there is now much better information on likely reductions in stream flow (DELWP, 2020c; DELWP, 2021a; Jacobs, 2017).
2. Demonstration of the value of water for the environment (including in the Latrobe River and its lower wetlands), and increased community support for improvements in the health of the Latrobe River system.
3. Recent environmental flow studies (Alluvium, 2021) have indicated significant deficits in the volume of water required to sustain healthy aquatic systems associated with the Latrobe River, including in-stream habitats, floodplains and their freshwater wetlands, the lower wetlands and the Latrobe/Thomson estuary. These environmental flow deficits are illustrated at Figure 5.
4. Global and domestic concerns about climate change have dramatically transformed the outlook for brown coal mining and coal-fired power production in Victoria, with the early closure of the Hazelwood mine in 2017 and accelerated plans for the closure of the Yallourn (2028) and Loy Yang (before 2048) mines. This has also brought forward planning for the rehabilitation of mine voids.
5. Australia-wide, Aboriginal people have asserted a strong interest in water resources and waterway management. Chapter 6 of the Water for Victoria policy (DELWP, 2016) sets out a strategy for
    a. recognising Aboriginal values and objectives of water,
    b. including Aboriginal values and traditional ecological knowledge in water planning,
    c. supporting Aboriginal access to water for economic development, and
    d. building capacity to increase Aboriginal participation in water management.

    Proposed approaches to giving effect to these commitments in the Gippsland region are set out in the draft Gippsland and Central Region Sustainable Water Strategy (DELWP, 2021a).

Figure 5: Shortfall assessment of additional environmental flows required to fully achieve recommended flow outcomes (Alluvium, 2021)

2.4 The Latrobe Valley Regional Rehabilitation Strategy

In response to findings from the Hazelwood Mine Fire Inquiry, the Victorian Government commissioned the development of the Latrobe Valley Regional Rehabilitation Strategy (LVRRS) (launched in June 2020) to fill knowledge gaps surrounding the rehabilitation and closure of coal mines (Hazelwood, Yallourn and Loy Yang A and B) in the Latrobe Valley. The LVRRS intended to progress mine rehabilitation planning by guiding mine licensees, government, entitlement holders, stakeholders and the community on a path which aims to transform the existing Latrobe Valley coal mines and adjacent environments into resilient, sustainable and stable landscapes. To help fill existing knowledge gaps, the LVRRS investigated;

- the issues and risks that may arise when planning for and undertaking coal mine rehabilitation, and
- options on how these issues and risks can be mitigated.

Both water-based and non-water-based rehabilitation options to fill mine voids were explored in the LVRRS.

In relation to water-based rehabilitation options, a key consideration in the LVRRS was that planning must account for a drying climate whilst ensuring the rights of existing water users including, urban users, industries, Traditional Owners and the environment are protected and maintained during the mine rehabilitation process. In this regard, the study investigated the projected impacts of climate change on surface water availability in the Latrobe and found that water-based mine rehabilitation under a 'dry climate' scenario could involve adverse water resource impacts on existing water users and the environment (DJPR, 2019).

The LVRRS also investigated the feasibility of using alternative sources, such as desalinated water, recycled water and stormwater, for the purposes of mine rehabilitation, and found that such options are comparatively more expensive and not economically feasible (DJPR, 2019).

The LVRRS established a set of principles to support the realisation of its vision and outcomes in guiding the rehabilitation of the Latrobe Valley coal mines and adjacent lands (DJPR, 2020a). Principles highlighted in the LVRRS are written in context to mine rehabilitation and are not broadly applicable for guiding waterway management across the broader Latrobe region.

Figure 6. *LVRRS principles*

The Hazelwood Rehabilitation Project was initiated following the closure of the Hazelwood mine in 2017, with investments from the ENGIE Group and Mitsui & Co. Ltd to rehabilitate the mine and surrounds, ensuring the future and ongoing useability of the industrial site. An Environmental Effects Statement (EES) has recently commenced for the Hazelwood Rehabilitation Project (2022), and is expected to be shared for public exhibition in 2023.

2.5 Development of the Gippsland and Central Region Sustainable Water Strategy

Concurrent with the preparation of this report is the development of the Gippsland and Central Region Sustainable Water Strategy (SWS) and the consultation draft Water is Life: Traditional Owner Access to Water Roadmap (DELWP, 2022). The draft SWS (DELWP, 2021a) presented a range of draft findings that include:

- proposed increases to environmental water allocations, and
- proposed approaches to protect waterway values through new and upgraded watering infrastructure at the lower wetlands, relaxing environmental water delivery constraints downstream from Rosedale, and removing barriers to fish passage.

Feedback in response to the draft Central and Gippsland SWS has shown overwhelming support for a holistic approach towards waterway management, as well as support for transitioning to manufactured water sources (e.g., desalinated, fit-for-purpose recycled water and stormwater) to satisfy some specific water use requirements in the Latrobe valley, such as agriculture, industries and watering sports fields (DELWP, 2021a). Further, there is overwhelming support from the community and government for environmental flows (water for the environment) and the protection, or rehabilitation of environmental assets in the region. Strong support for change in water use in the Latrobe provides an exciting opportunity to transform the previously characterised "working river" to achieve a healthy river system, meeting the expectations of the community.

The draft Water is Life: Traditional Owner Access to Water Roadmap (DELWP, 2022) is focused on two key parts:

1. The government policy commitments and pathways for increasing Traditional Owner access to water rights and water management
2. A collection of Nation statements written by Traditional Owners across Victoria, detailing their objectives for water.

The draft roadmap represents a commitment of the Victorian Government to work in partnership with Traditional Owners and Aboriginal Victorians to develop a roadmap for access to water for economic development. At present a draft of part 1 (government policy) has been released for public comment. This section of the roadmap outlines the commitments and policy pathways in the short, medium, and long term to increase Traditional Owner access to water and influence in the management of water landscapes under Victorian law. It also includes case studies on how the transfer of a site to sole management could work in practice. Key challenges include:

- Increasing Traditional Owner access to water entitlements
- Increasing Traditional Owner power and resources in water landscapes

2.6 Existing and emerging pressures and trends

Over recent decades, the extraction of water from the Latrobe River for energy, urban, industry and agricultural purposes has impacted flow regimes in the river and decreased the volume of water available for environmental flows. Notwithstanding pressures to accommodate a further increase in consumptive demands on the system's water resources, the projected effects of a drying climate in reducing system water availability increases these risks to the environment (Figure 7).

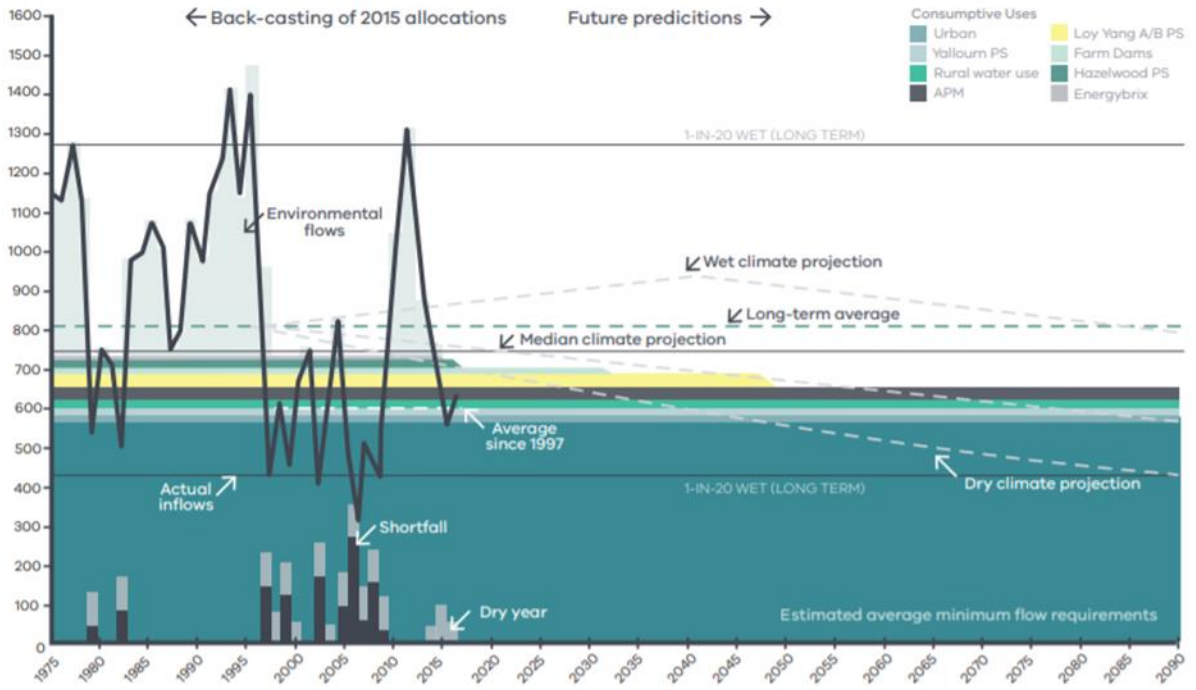

Figure 7. *Available water in the Latrobe River system. This figure specifies how the Latrobe River inflows compare with minimum river flow recommendations and consumptive uses, including power generation and possible future pit lake filling. This graph assumes no change in future demand for non-mining consumptive uses (source: DELWP, 2019).*

According to the recent flows study (Alluvium, 2021) there is a deficit between the volume of environmental water currently allocated for environmental purposes and the volume required to meet environmental requirements of the system. Modified flow regimes are expected to impact the entire Latrobe River system, including its estuaries and wetlands. The combination of a permanent opening of the Gippsland Lakes, the emerging effects of climate change on sea levels and river inflows, climate variability, current consumptive use of water, and constraints on the delivery of large volumes of water have increased salinity in the lower Latrobe River and wetlands, threatening the aquatic ecology and functioning of these previously freshwater wetlands and the values for which they were listed under the Ramsar convention.

Since completion of the 2009 'business case' report, knowledge of pressures and trends facing the Latrobe system have improved.

The ongoing pressures on and in the Latrobe River system include the following:

- Despite improvements in provision of water to meet environmental needs, current levels of flow regulation and extraction mean that the river system continues to be hydrologically stressed.
- Constraints on environmental releases, prevent the use of managed environmental flows to reach floodplains and wetlands on private property.
- Barriers to fish migration prevent the migration and critical lifestyle stages of important diadromous species such as Australian grayling and Australian bass.
- The historical legacy from meander removal and de-snagging on in-stream form and habitat diversity remain.
- Similarly, historical clearance of streambank vegetation and weed incursion continues to affect the condition of the river system Land-based sources of pollution continue to have an impact on river health.
- Stability risks associated with extant mine voids remain, including the risk of the Morwell River diversion collapsing into the Yallourn mine void and adversely affecting the Latrobe River and its flows, and
- Drying and more variable climate conditions over the last 20 years.

The new and emerging pressures and trends include:

- Growing knowledge and understanding of the threats posed by climate change, including
    - Projected increased temperatures (increase by 1.2˚C under median projections by 2040 and 2.2˚C by 2065) and increased evapotranspiration (4.5% under median projections by 2040) (Jacobs, 2017). Projected changes to annual rainfall (average decrease by 4.2% under median projections by 2040 and average decrease by 4.5% by 2065) (Jacobs, 2017).
    - Projected changes to surface runoff – by the year 2040; water availability in the Latrobe System is modelled to be 36% lower (under the dry (high) climate change projection) or up to 23% higher (under the wet (low) climate change projection), with a median projection of a 10% decrease in surface water availability (DELWP, 2020a). By the year 2065, this uncertainty expands to range from a 49% decrease to a 10% increase, with a median projection of an 18% decrease in water availability (DELWP, 2020a). Under a high climate change scenario, water availability in the Latrobe System is projected to be ~475 GL/year in 2065 (DELWP, 2021a). This is less than the current surface water availability in the Latrobe System, which has an average of 800—1000 GL/year of available surface water (DELWP, 2021a).
    - Sea level rise – there is a high degree of confidence that this region will experience rise in eustatic sea levels of 0.1 m to 0.27 m above current levels by 2050 (Timbal et al. 2016). Increases in sea level are predicted to increase salinity intrusion into the lower Latrobe Wetlands, threatening the character of the significant Ramsar Listed wetlands (Hale & Boon, 2021) and many significant native flora and aquatic fauna species such as the Australian grayling.
    - Increased frequency and magnitude of extreme events, such as drought and bushfires are also predicted to impact the system – bushfires cause short-term increases in pollutant loads that impact on in-stream biodiversity[2].
- Growth in demand for water for a range of consumptive uses including mine rehabilitation and irrigated agriculture.
- Anticipated growth in plantation forestry associated with the Victorian Government's $110 million Gippsland Plantations Investment Program (DJPR, 2020b), which will result in increased surface water interceptions and reduced river inflows. Based on certain assumptions, it is estimated (refer Appendix A) that new timber plantations in the Latrobe Valley will likely reduce annual surface inflows into the Latrobe River by 9 Gl. These new plantations are expected to become available for harvest from 2050[3].

[2] Shelley, J.J., Raadik, T.A., and Lintermans, M., 2021. Summary of the 2019/20 bushfire impacts on freshwater fish and emergency conservation response in south-eastern Australia. NESP Threatened Species Recovery Hub Project 8.3.6 update report, Brisbane.
[3] https://djpr.vic.gov.au/forestry/forestry-plan

3 Principles and long-term goals proposed for the management of the Latrobe River, floodplains and wetlands

The 2009 Business Case (Alluvium, 2009) developed a set of principles and long-term goals for the management of the Latrobe River system. These principles were intended to inform both the vision for the long-term health of the system and some detailed management objectives. Since 2009, the condition, trends, values, demands on the system and operating environment have changed in ways that pointed to a need to review and update these principles and long-term goals. As part of the review and update exercise, engagement with WGCMA staff and other stakeholders has informed amendments to Principles and Long-term Goals as detailed in the following sections.

3.1 Principles for management of the Latrobe River system

It is proposed that the following principles be adopted for the management of the Latrobe River system

9. Management of the Latrobe River system will contribute towards attainment of international, national, state and regional waterway health and biodiversity objectives, community objectives and Gunaikurnai cultural objectives for water and lands on Country

10. An equitable share of the water resources of the Latrobe River will be provided to meet the objectives of Government environmental delivery partners, the community and the Gunaikurnai, the Traditional Owners of the land and waters

11. Management of the Latrobe River system and response to threatening processes (including climate change) will ensure there is a net gain in river, floodplain, wetland or estuary health and condition to contribute to broader environmental [cultural, social and economic] objectives across the Gippsland Lakes catchment

12. Where an adverse impact on the Latrobe River system occurs or a risk to the River system is increased, any accompanying or potential decline in condition will be compensated, to deliver a net gain in the condition of the system

It is also recognised that more needs to be done to ensure the management of water resources of the Latrobe River System more closely aligns with the objectives and aspirations of the Gunaikurnai people, and consistent with the roadmap articulated in the Water is Life discussion draft document (DELWP, 2022). These revised principles have helped to inform development of long-term goals in section 3.2 below.

3.2 Long-term goals for the Latrobe River system

Consistent with the revised Principles above, Long-term Goals for the management of the Latrobe River system are proposed as follows:

1. There will be a net gain in the environmental condition of the Latrobe River system, inclusive of the river, floodplains, wetlands and estuary

2. Scientifically determined environmental flow requirements, together with Aboriginal cultural water requirements, will be secured, allocated and provided to the Latrobe River system

3. Sediment and nutrient loads and concentrations in the Latrobe River system will be reduced to levels that do not adversely affect the ecological functioning of the Latrobe River, floodplain wetlands in the Latrobe catchment and the Gippsland Lakes

4. The structure and functioning of the river, floodplains, wetlands and estuary of the Latrobe River system will be conserved to the extent possible, and there will be a net gain in freshwater wetland area and condition.

5. The Latrobe River system will support diverse and resilient populations of native flora and fauna species including, threatened species

6. Riparian corridors will be vegetated with appropriate native species and connected throughout the Latrobe River system

7. There will be continued and increased integration of the Gunaikurnai in alignment with the draft Water is Life: Traditional Owner Access to Water Roadmap (DELWP 2022), and as predetermined by their body corporate, the Gunaikurnai Land and Waters Aboriginal Corporation, in keeping with their priorities and self-determination

8. There will be continued and increased involvement of relevant community, stakeholders and partners in decision making processes, stewardship and management activity.

4 Recommended management options

Management options have been developed for the Latrobe River system. These options have been developed in the context of new and existing knowledge, the degrading pressures facing the Latrobe River system (including climate change) and the proposed Principles and Long-term Goals set out at section 3. The options have been identified based on those best suited to improving the environmental condition of the Latrobe River system and the full suite of values and ecosystem services that it provides.

The proposed options are intended to assist the WGCMA in their development of a program of river management investments and associated timeframes, needed to deliver a net improvement in the health and condition of the Latrobe River system (including floodplains, wetlands and estuary) over the medium to long-term.

4.1 Approach to option identification and selection

The process of developing and recommending management options benefited from engagement with those directly involved in managing the Latrobe system, input from other stakeholders, and expert knowledge. Considerations included information on the condition of the Latrobe River system and relevant degrading processes at section 2, as well as a range of new and existing ideas about options with potential to improve the system's health and condition.

Section 2 raised several important contextual matters for the development of the management options presented in this report:

1. A number of changed assumptions relating to the future management of the Latrobe River system, particularly:
    - Recent scientific assessments on the deficits in environmental water required to sustain healthy aquatic systems in the Latrobe River system. *There is a need to increase availability of water to meet environmental needs, and to consider the best ways of optimising the value of limited environmental water.*
    - New and improved knowledge about future climate change scenarios. *Under a low climate change scenario average annual runoff is expected to increase between 2020-2040 and decrease between 2040-2065 (DELWP, 2020d). Alternatively, under a medium and high climate change scenario annual average runoff is projected to decrease between 2020 -2065 (DELWP, 2020d), increasing stressors on the hydrology and natural values of the Latrobe river system. It must be acknowledged that most of the water currently available to the environment is more vulnerable to the effects of a drying climate than water currently managed for consumptive uses. Knowledge is also improving on the contribution sea level rise is having on the degrading forces at work in the Lower Latrobe wetlands.*
    - The dramatically transformed outlook for brown coal mining and coal-fired power production in the Latrobe valley, and associated planning for the rehabilitation of mine voids. *On the one hand, the reduced timeframe for the use of Latrobe surface water resources creates an opportunity to consider whether, and the extent to which, this water can be reallocated to help meet environmental needs. On the other hand, the option of re-purposing this water for the rehabilitation of coal mine voids will, if adopted, represents an opportunity cost to the Latrobe River and its environmental water needs.*
    - Victorian Government policy and commitments regarding the involvement of Aboriginal people in the management of rivers and water resources including the develop of the draft Water is Life roadmap (DELWP, 2022). *This validates current directions within the WGCMA to engage and involve Aboriginal Traditional Owners and representative organisations on many of the management options discussed below.*
2. The findings of the LVRRS. *These findings are particularly relevant to water-based options for mine void rehabilitation and how they might best be delivered, as well as to the Hazelwood EES.*

3. The continuing Central and Gippsland Regional Sustainable Water Strategy (SWS) process. *This process is considering all demands, pressures and opportunities across the Gippsland and Central regions of Victoria, including the Latrobe River system.*

In relation to the WGCMA and its river management responsibilities, this means:

- Existing levels of investment are insufficient to manage the significant environmental values of the Latrobe River System, and the myriad social, cultural and economic values that the system sustains.
- The Latrobe River System is highly vulnerable to the effects of global climate change, and it is important this system is prepared for, and able to adapt to, a changing climate.
- Shortfalls in the availability of water to meet environmental needs exist.

Hence there is a need to focus management actions on

- Approaches to maximising the environmental benefits of existing water available to the environment
- Adaptation measures to prepare the system against current and potential climate changes and associated impacts. This includes ensuring that WGCMA staff possess the necessary knowledge and skills required to address the climate change adaptation challenges.
- Recovery of additional water for the environment of the Latrobe River system; and
- Non-flow, complementary measures capable of delivering significant improvements in river, wetland, floodplain and estuary health and condition

Recommended management options were developed based on:

- A review of the 2009 Draft Vision Statement - Business case for the long-term health of the Latrobe River,
- A review of other relevant literature
- Consideration of current drivers affecting the Latrobe River system and the range of values that it supports (section 2.3),
- Interviews with staff representing the WGCMA, DELWP, VEWH, and GLaWAC
- A workshop conducted with West Gippsland CMA and DELWP staff, Rodger Grayson and the Alluvium Expert Panel, held on 7 February 2022.
- Consideration of the revised and updated Principles and Long-term Goals set out at section 3.

4.2 Package of options to improve the condition and health of the Latrobe River system

Below is a package of high-level management options proposed for the Latrobe River system. Individually, each management option seeks to address one or more of the long-term goals defined in section 3.2, and together contribute towards improving the health and condition of the broader Latrobe River system.. Cost estimates provided with this list were provided by the WGCMA and are based on previous known costings.

Table 1. Short listed options for management

Summary list of proposed management options	Estimated cost	Date of costing	Source of costing
Reconfiguration of Lower Latrobe Wetlands inflow and outflow points	$3.2m	2021	WGCMA
Integrated floodplain and wetland restoration, and constraint management project for Latrobe River between Rosedale and Lower Latrobe wetlands	Un-costed	*Still in scoping phase*	
Re-establish native riparian and floodplain vegetation through Latrobe System	$120.0m	2021	WGCMA
Removal of barriers to fish passage	$10.7m	2021	WGCMA
Reinstate meanders	Un-costed		
Opportunistic re-snagging	Un-costed		
Feasibility study into an alternative future for Lake Narracan and any other redundant infrastructure from coal fired power generation e.g., Yallourn Weir	Un-costed		
Review passing flow rules for reservoirs and unregulated rivers to better meet environmental needs	Existing program		WGCMA
Relaxation of constraints that limit delivery of environmental water, including outlet capacity at Blue Rock and Moondarra reservoirs	Un-costed		
An enhanced native fish restocking program	Un-costed		
Pilot carp control initiative	$75,000 to $100,000	March 2022	VRFish estimate
The Strzelecki-Alpine Bio-link project, with a focus on the Morwell River	Un-costed		
Increase the availability of water to meet identified environmental needs	Un-costed		
Water quality management initiative	Un-costed		
Feasibility study into alternative uses for redundant infrastructure e.g., Yallourn weir	Un-costed		
Investigate options to restore Crown river frontage leaseholdings to the public domain, to be managed for public benefit purposes.	Un-costed		

Many of these short-listed management options have synergies and inter-dependencies with other short-listed management options. This ultimately means that the benefits associated with an integrated package of management options may exceed the sum of benefits that can be ascribed to each individual management option. As a matter of course, new river management initiatives along these lines will need to be accompanied by a properly resourced monitoring, evaluation, reporting and improvement (MERI) plan.

Further details of these management options are set out in Table 2 and Appendix B.

Table 2. Option details

	Management option	Impacts the management option seeks to address
1	Reconfiguration of Lower Latrobe Wetlands inflow and outflow points, comprising new/upgraded constructed inflow points to Heart and Dowd morasses and Sale Common.	For Heart and Dowd morasses, this initiative is intended to assist in reducing/maintaining salinity levels by enabling more freshwater inflows, and countering the adverse effects of saline water ingress, particularly during periods of low flows. This will deliver environmental benefits in terms of: • Slowing the transition of existing freshwater-dependent wetland values to an increasingly saline system, and thereby maintaining the freshwater-based ecological character of the wetlands for as long as possible; and • Buying time to enable some of the system's freshwater wetland values to become re-established in the floodplains and wetlands upstream of the estuary (option #2 refers). Works proposed for Sale Common will help secure an ongoing supply of freshwater by enabling delivery of water from the Thomson River and improved control of water inflow/outflow from the Latrobe River.
2	Integrated floodplain and wetland restoration, and constraint management project downstream of Rosedale, comprising • Engagement with landholders on scope to allow managed overbank flows onto private land • Land &/or easement purchase/ land use agreement • Reinstatement of meanders • Revegetation of floodplains, wetlands and riparian zone • Opportunistic re-snagging • Provision for improved public access • Ongoing management, monitoring and evaluation	Historically, floodplains downstream of Rosedale were largely cleared of their original native vegetation and repurposed to agricultural uses. This was accompanied by river regulation, increased consumptive use of the river's water resources, and straightening of the river channel, all of which reduced the frequency and duration of flooding, as well as lateral flow connectivity of floodplains and wetlands. This project seeks to restore, to the extent possible, the natural ecological functioning and biodiversity values of floodplains and wetlands downstream of Rosedale, consistent with the vision set in the West Gippsland Waterway management strategy 2014-22 (WGCM, 2018). Importantly, this option will also complement Management Option 1 (above), by re-establishing connectivity with the Lower Latrobe Wetlands, and by enabling their freshwater-dependent ecological values and characteristics to progressively shift upstream. In facilitating more over-bank flows, meander reinstatement will maximise the benefits of available environmental water.
3	Re-establish native riparian vegetation through Latrobe System including tributaries and Crown water frontages. In summary, this entails identification of priority sites, site preparation and fencing, revegetation and ongoing maintenance, monitoring and evaluation.	The removal of riparian vegetation along waterways has negative impacts of the ecological and physical functioning of the system, including by reducing bank stability, degrading habitat quality, reducing food resources and preventing migration for some fish species. Removal of riparian vegetation has also contributed to in-stream sediment and nutrient loads. Over time, well-planned and maintained revegetation and fencing of native riparian and floodplain vegetation can restore these ecological values and processes.
4	Removal of barriers to fish passage, by • Removing the disused weir on the Tyers River below Moondarra dam, and • Installing fish ladders at Pump station weir (Tyers River),Lake Narracan and Yallourn weir	This initiative seeks to re-establish longitudinal connectivity between relevant reaches and tributaries of the Latrobe River. This will restore capacity for the migration, breeding and recruitment of diadromous fish species (such as the Australian grayling), as well as restore habitat complexity as more natural flow regimes and sediment deliveries return to the river.
5	Reinstate meanders in sections of the river where meanders have been cut through. (Note there is an overlap with part of the Reach 5 restoration project)	Channel straightening has increased the volume and velocity of in-stream flows, thereby • decreasing the frequency and magnitude of floodplain and wetland inundation, and • changing the structure and diversity of in-stream habitats. This initiative is intended to reverse some of these impacts and improve the ecological functioning of the river and its floodplains and wetlands.
6	Opportunistic re-snagging, where practical and cost-effective, by relocating large woody debris from local tree falls	The Latrobe River has a history of de-snagging dating back to the 1890s, which altered the natural flow behaviour of the river system and decreased the quality and diversity of instream habitat. This management option will explore the opportunity

	Management option	Impacts the management option seeks to address
		of re-snagging the river to reduce flow velocity and increase instream habitat, and food supplies and drought refugia for aquatic fauna.
7	Feasibility study into an alternative future for Lake Narracan, which is currently used to deliver water to Yallourn and Loy Yang power stations and for recreational purposes. This option would explore the feasibility of decommissioning the lake, restoring the lake's footprint to a more natural riverine environment, and relocating water-based recreational pursuits to any coal mine voids rehabilitated by filing with water.	Construction of Lake Narracan has had an adverse environmental impact on the Latrobe River by inundating a section of the riverine environment, presenting a barrier to sediment transport, as well as to fish migration. Subject to feasibility and the views of the local community, decommissioning of Lake Narracan could not only address these impacts, but also establish a new and important public open space and environmental asset for the region. A feasibility study would explore the costs and benefits arising from such a transition across the quadruple bottom-line, and would inform subsequent public consultation.
8	Review passing flow rules for reservoirs and unregulated rivers to better meet environmental needs, through the existing DELWP state-wide program of reviewing passing flow arrangements.	Passing flow rules were not originally conceived or designed to address environmental water needs. Potentially, a review of passing flow requirements could complement, and in some instances augment, the effectiveness of environmental watering undertaken by the VEWH without impacting on consumptive water uses.
9	Relaxation of constraints on the delivery of environmental water. Existing operational and (through structural works) physical flow constraints that limit the capacity to release water from Lake Narracan, Moondarra and Blue Rock to meet environmental objectives. This work would entail • Engagement with landholders on scope to allow managed overbank flows onto private land • Resourcing for land &/or easement purchase &/or land use agreements • Upgrades to storage outlet capacity as required.	The combined effects of river regulation, growth in water abstraction and channel straightening have significantly reduced the frequency and duration of high within bank flows, over-bank flow events, and floodplain inundation Restoration of floodplain and wetland connectivity and condition, particularly in the Latrobe River downstream from Rosedale, is in part dependent on capacity to relax operational and physical constraints.
10	Enable storage and release of environmental allocation at Lake Narracan. This would entail consultation with: • Southern Rural Water, • Latrobe City Council, and • Lake user organisations.	This initiative is intended to improve the efficacy of environmental water to reaches downstream from Lake Narracan by enabling more flexibility in Lake Narracan operations and water levels.
11	An enhanced native fish restocking program - This initiative entails breeding key predatory native fish species such as Australian bass and Estuary perch and restocking the Latrobe with fingerlings to boost fish abundance and diversity, and to increase predation of carp. The program will build upon other restocking programs in the region, including the Australian bass stocking program[4]. Restocking would need to be accompanied by monitoring and evaluation.	This initiative is intended to assist in-stream biodiversity conservation efforts by • increasing the abundance of key native fish populations • restore predator populations and contributing to the restoration of food web dynamics In addition, this initiative can also contribute to supporting Aboriginal cultural values and practices, as well as servicing demand from the regionally important recreational angling community. It is acknowledged that some stocking of native fish valued for recreational purposes is undertaken by the Victorian Fisheries Authority at various rates and locations (e.g. Lake Narracan) around Victoria.
12	Pilot carp control initiative for Lake Wellington and associated catchments – As proposed by VR Fish (Mr Rob Caune), this	Common Carp are a major invasive pest species impacting the freshwater ecology of the Latrobe River System. Increased carp populations in Lake Wellington catchments has seen carp out-compete native species for food resources and refuge, reducing

[4] Victorian Fisheries Authority (2020), *Inaugural Aussie bass stocking for Latrobe River,* Victorian Fisheries Authority. Accessed at https://vfa.vic.gov.au/about/news/inaugural-aussie-bass-stocking-for-latrobe-river

	Management option	Impacts the management option seeks to address
	assumes a subsidised 500 tonne increase in Lake Wellington commercial carp harvesting over (for example) a 5-year period will enable extant juvenile populations of predatory fish to grow to the point where they can control carp numbers and increase native fish populations. A 15c/kg subsidy is required to make his commercially viable.	the diversity and abundance of native fish and other aquatic flora and fauna. Carp also increase turbidity and reduce light penetration to aquatic macrophytes. Given recent strong recruitment of juvenile Sea bass and Estuary perch, this pilot is intended to reducing carp numbers in Lake Wellington and tributaries and contribute to improved aquatic diversity and in-stream health in the Latrobe River system. The key assumption behind this proposal – that reduced carp densities will afford native predatory fish an opportunity to grow to maturity and start to control carp recruitment – requires testing.
13	The Strzelecki-Alpine Bio-link project, which would seek to re-creating ecological connectivity between the Alps and Strzelecki ranges with a focus on the Morwell River and some surrounding coal mine lands. This initiative was first proposed by the Latrobe City Council.	As part of a wider objective of establishing a viable, fenced and revegetated corridor for a range of terrestrial and aquatic wildlife between the Alps and Strzelecki ranges, this initiative would address the currently degraded state of the Morwell River and its riparian zone.
14	Increase the availability of water to meet identified environmental needs. Decisions on environmental water needs should include: • The compounding effects of climate change on the current environmental water deficit, and • The timespan over which additional environmental water can be made available	Currently, the Latrobe River system, including its floodplains and wetlands, is flow stressed, and the amount of water reserved for environmental use is insufficient to meet identified environmental needs. Moreover, the water currently available for environmental purposes is highly vulnerable to the drying effects of climate change on Latrobe River inflows. Improved availability of water for the environment is a fundamental component of any Latrobe River health initiative. Ways in which water for the environment of the Latrobe River system could be increased include: • reallocation of entitlements no longer needed for their intended purpose (e.g. Loy Yang 3-4 bench, Latrobe Reserve); • Reduction in extraction of water from the river through water use efficiency measures and/or new sources of water (e.g. recycled water, stormwater); • Changes to water management rules e.g. passing flows, storage operations • Water trade.
15	Water quality management initiatives. A range of potential water quality improvement projects focussing on hot-spots of land-based sources of pollution and controlling waterway erosion (total suspended sediment loads). Options include working with landholders on leading practices in managing agricultural runoff, detention and retention basins in strategic locations, water sensitive urban design initiatives, revegetation to reduce sediment loads entering the river and grade controls. These initiatives should seek to work in conjunction with other plans, such as the Lake Wellington Land and Water Management[5].	The history of land use change in the Latrobe Valley, particularly agricultural and urban development, have contributed to degradation in river water quality, mainly in the form of elevated nutrient and sediment loads and turbidity.
16	Feasibility study into scope to decommission redundant infrastructure e.g., Yallourn weir	Subject to feasibility and the views of the local community, decommissioning of Yallourn weir could provide environment, economic, recreational and cultural benefits. A feasibility study for each structure would explore the costs and benefits across the quadruple bottom-line, which could then inform public consultation.

[5] West Gippsland Catchment Management Authority (WGCMA) (2018), *Lake Wellington Land and Water Management Plan*, West Gippsland Catchment Management Authority, Traralgon, Victoria. Accessed at https://www.wgcma.vic.gov.au/our-region/projects/9132-2.

	Management option	Impacts the management option seeks to address
17	Investigate options to restore Crown river frontage lease holdings to be managed for improved environmental and community outcomes.	From the 1990s, many areas of Crown river frontage were made available for commercial use under long-term lease arrangements. Since that time, knowledge and understanding of the importance of healthy riparian zones to river health and water quality, as well as their social, Aboriginal and ecosystem service values. This project would entail scoping of options, community and landholder consultation, and detailed options evaluation against quadruple bottom-line criteria. Project options could then inform development of a program of transitioning priority Crown frontages to management for public benefit purposes.

5 Next steps

The next steps for improving the health of the Latrobe River comprise the prioritisation, further development and sequencing of these options for management.

The benefits (relative to the cost) of an integrated river management package are likely to exceed the sum of its parts. However, development of the short-list of options did not entail a rigorous qualitative or quantitative analysis against a consistent set of criteria, and nor did it entail development of cost estimates or benefit-cost analysis.

Further work is therefore required to prioritise and sequence management options, spatially and temporally. This prioritisation process should entail:

- development of cost estimates for currently un-costed options and options where costings may be out of date; and
- Identification of anticipated flow and non-flow environmental outcomes, including for values of national and international significance, and taking account of interdependencies and synergies between different management options
- Opportunities for community and stakeholder buy-in and support
- The nature and extent of social, cultural and economic benefits expected for the region
- Capacity to deliver over time
- An understanding of cost-effectiveness.

For some management options, further feasibility assessment is likely to be required.

Management options that entail meander reinstatement and potentially relaxation of operational flow constraints would benefit from further technical work. Such work would entail hydraulic modelling and mapping to better understand the effects of meander reinstatements in inundating private land, at various flow rates under potential meander restoration and 'constraints easing' scenarios.

6 References

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Appendix A: Estimation of Water use by expansion of plantation forestry

Anticipated growth in plantation forestry associated with the Victorian Government's $110 million Gippsland Plantations Investment Program (DJPR, 2020b), which will result in increased surface water interceptions and reduced river inflows. Based on assumptions as set out below, it has been estimated that new timber plantations in the Latrobe Valley are likely to reduce annual surface inflows into the Latrobe River by ±9 Gl. Assumptions are as follows:

- The Gippsland Plantations Investment Program will lead to the planting of 30 billion trees across the Gippsland region.
- Assuming seeding rates of 1,000 seedlings per Hectare (Ha), the total area of plantations in the wider Gippsland region is 30,000 Ha.
- Approximately 7,500 Ha in plantations can be assumed to be located in the Latrobe valley
- Drawing on Bureau of Meteorology data for various locations across west Gippsland, average annual rainfall varies between approximately 600-1000 mm/yr. On this basis, average annual rainfall for land selected for new plantations is assumed to be 750 mm/yr.
- Drawing on figures used in the Carbon Credits (Carbon Farming Initiative) Regulations 2011 (C'th), plantations in a 700-800 mm rainfall zone can be expected to reduce annual surface runoff by an average of 1.2 ML/ha/year.
- 7,500 Ha X 1.2 ML/year = 9 GL/year in reduced average annual runoff.

Appendix B: Short list option details

Management option	Impacts the management option seeks to address	Relationship to L-T goals *(Long-term Goal# and rationale)*	Implementation
1. Reconfiguration of Lower Latrobe Wetlands inflow and outflow points, comprising • New/upgraded constructed inflow points to Heart and Dowd morasses and Sale Common.	This initiative seeks to address decreased water quality and increased salinity levels in the Lower Latrobe Wetlands, which are threatening the ecological character of the wetlands and Gippsland Lakes Ramsar Site. Further, it seeks to improve volume of freshes reaching the Lower Latrobe wetlands to protect the ecological structure and in-stream diversity as well as better prepare the transition of the system from a fresh to saline wetland environment, through time as sea levels rise.	This measure will improve: 1. Variability in water levels in ways which promote plant recruitment and improve vegetation condition 2. Lower wetlands condition & freshwater character for as long as possible 3. The efficacy of available environmental water in meeting Lower Latrobe wetlands needs. 4. Lower wetlands functioning 5. Capacity to support a diversity of flora and fauna 7. Opportunities for Aboriginal involvement in decision-making 8. Involvement of relevant community partners in decision making processes and management activity	Administered by WGCMA
2. Integrated floodplain and wetland restoration, and constraint management project downstream of Rosedale, comprising Engagement with landholders on scope to allow managed overbank flows onto private land • Land &/or easement purchase/ land use agreement • Reinstatement of meanders • Revegetation • Opportunistic re-snagging • Provision for improved public access	This project will address issues impacting the ecological functioning and biodiversity values downstream of Rosedale (and relevant sections of reaches 6 and 4), including: • fragmentation and habitat loss caused by land clearance for agriculture • changed in-stream hydrology due to historic channel straightening and de-snagging • decreased floodplain and wetlands inundation due to decreased overbank flows. Importantly, this option will also complement Management Option 1 by re-establishing connectivity with the Lower Latrobe Wetlands, and by	These measures will: 1. Deliver a net gain in river condition, including for the freshwater-dependent ecological values and characters of the Lower Latrobe Wetlands. 2. Improve the efficacy of available environmental water in meeting Reach 4 environmental needs. 3. Enhance capacity to reduce instream erosion & provide a buffer to agricultural runoff. 4. Improve reach 5 structure and functioning and lateral connectivity. 5. Build capacity to support more diversity and resilience in flora and fauna 6. Improve the quality and extent of vegetation in floodplains, wetlands and river frontages 7. Improve opportunities for Aboriginal involvement in management and decision-making	Significant funding would be required for this initiative over a sustained period. Potential to deliver in collaboration with GLaWAC Potential for Aboriginal management and use of floodplain lands under an Indigenous Land Use Agreement (S 211 of Native Title Act 1993)

Management option	Impacts the management option seeks to address	Relationship to L-T goals *(Long-term Goal# and rationale)*	Implementation
• Ongoing management, monitoring and evaluation	enabling their freshwater-dependent ecological values and characteristics to progressively shift upstream.	8. Enable involvement of relevant community partners in decision making processes and management activity	
3. Re-establish native riparian vegetation through Latrobe System including tributaries and Crown water frontages. In summary, this entails identification of priority sites, site preparation and fencing, revegetation and ongoing maintenance, monitoring and evaluation.	The removal of riparian vegetation along waterways has had negative impacts of the ecological and physical functioning of the system, including by reducing bank stability, degrading habitat quality, reducing food resources and preventing migration for certain fish species. Removal of riparian vegetation has also contributed to in-stream sediment and nutrient loads and impacted water quality.		Administered by WGCMA, potentially in collaboration Program administered by WGCMA in collaboration with DELWP, GLaWAC and other community partners
4. Removal of barriers to fish passage, by • Removing the disused weir on the Tyers River below Moondarra dam, and • Installing fish ladders at Pump station weir (Tyers River),Lake Narracan and Yallourn weir	This initiative seeks to remove barriers to fish passage, which impact lateral connectivity and natural flow regimes/sediment transport across the river system. Removing fish barriers will address key infrastructure which is impacting the migration, breeding and recruitment of diadromous fish species (such as the Australian grayling) as well as instream morphology.	This measure will: 1. Deliver a net gain in river condition, and improve: 4. The functioning of the river system for fish breeding and recruitment purposes 5. Capacity to support more diversity and resilience in fish communities 7. Opportunities for Aboriginal involvement in management	Works programs administered by WGCMA

Management option	Impacts the management option seeks to address	Relationship to L-T goals *(Long-term Goal# and rationale)*	Implementation
5. Reinstate meanders, including engagement with landholders and potential easement purchase or other form of enduring land use agreement.	Channel straightening has increased the volume and velocity of in-stream flows, thereby • decreasing the frequency and magnitude of floodplain and wetland inundation, • altering the natural volume and variability in flow and sediment transport regimes, and • changing the structure and diversity of in-stream habitats. • Reinstating meanders seeks to address impacts created by channel straightening .	This measure will: 1. Deliver a net gain in river condition, and improve: 2. The efficacy of available environmental water in meeting environmental needs. 3. Capacity to reduce instream erosion and movement of sediments. 4. River structure and functioning and lateral connectivity 5. Capacity to support more diversity and resilience in flora and fauna 7. Opportunities for Aboriginal involvement in planning and management 8. Involvement of relevant community partners in decision making processes and management activity And aligns with the West Gippsland Waterway Strategy	Works program administered by WGCMA
6. Opportunistic re-snagging, where practical and cost-effective, by relocating large woody debris from local tree falls.	Historic de-snagging has had detrimental impacts to the Latrobe Rivers condition by increasing flow velocities, reducing in-stream habitat complexity and diversity as well as decreasing the number of available in-stream habitats required for native fish, macro and macroinvertebrates to complete lifestyle stage or seek refuge.	This option could: 1. Deliver a net gain in river condition, and improve: 4. The structure and functioning of river channels 5. Capacity to support more diversity and resilience in flora and fauna 7. Opportunities for Aboriginal involvement in planning and management 8. Involvement of relevant community partners in decision making processes and management activity	Works program administered by WGCMA
7. Feasibility study into an alternative future for Lake Narracan, which is currently used to convey water to Yallourn and Loy Yang power stations and for	Construction of Lake Narracan has had an adverse environmental impact on the Latrobe River by inundating a section of the riverine environment, presenting a barrier to fish movement and migration.	*Potentially*, this measure could lead to a rehabilitation plan that delivers: 1. A net gain in river condition, and improve	Independent analysis commissioned by WGCMA, potentially in

Management option	Impacts the management option seeks to address	Relationship to L-T goals *(Long-term Goal# and rationale)*	Implementation
recreational purposes. This option would explore the feasibility of decommissioning the lake, restoring the lake's footprint to a more natural riverine environment, and relocating water-based recreational pursuits to coal mine voids rehabilitated by filing with water.		3. Capacity to manage inflows of nutrients, sediments and other pollutants. 4. River structure and functioning at the Narracan site through river, floodplain and wetland restoration works and removal of a key barrier to fish passage 5. Diversity and resilience in flora and fauna 6. The quality and extent of vegetation by creating a new asset supporting significant natural and amenity values 7. Opportunities for Aboriginal involvement in planning and management 8. Involvement of relevant community partners in decision making processes and management activity	collaboration with Latrobe City Council
8. Review passing flow rules for reservoirs and unregulated rivers to better meet environmental needs, through the existing DELWP state-wide program of reviewing passing flow arrangements	Passing flow rules were not originally conceived or designed to address environmental water needs. This initiative seeks to review passing flow requirements to improve the flow-related environmental condition of the Latrobe River as well as water quality.	This option will: 1. Deliver a net gain in river condition, and improve: 2. Attainment of identified environmental flow needs. 3. Capacity to dilute sediment and nutrient concentrations. 4. River, floodplain wetland and estuary functioning and connectivity 5. Capacity to support more diversity and resilience in flora and fauna 7. Opportunities for Aboriginal involvement in planning, management and decision-making 8. Involvement of relevant community partners in decision making processes and management activity	Via existing DELWP state-wide review of passing flows

Management option	Impacts the management option seeks to address	Relationship to L-T goals *(Long-term Goal# and rationale)*	Implementation
9. Relaxation of constraints on the delivery of environmental water. Existing operational and (through structural works) physical flow constraints that limit the capacity to release water from Lake Narracan, Moondarra and Blue Rock to meet environmental objectives. This work would entail • Engagement with landholders on scope to allow managed overbank flows onto private land • Resourcing for land &/or easement purchase &/or land use agreements • Upgrades to storage outlet capacity as required.	The combined effects of river regulation, growth in water abstraction and channel straightening have significantly reduced the frequency and duration of high within bank flows, over-bank flow events, and floodplain inundation Restoration of floodplain and wetland connectivity and condition, particularly in the Latrobe River downstream from Rosedale, is in part dependent on capacity to relax operational and physical constraints.	These options could: 1. Deliver a net gain in river condition, and improve: 2. The efficacy of available environmental water in meeting instream, floodplain and wetland needs. 4. Riverine structure and functioning and lateral connectivity 5. Capacity to support more diversity and resilience in flora and fauna 6. The condition of floodplain and wetland vegetation 7. Opportunities for Aboriginal involvement in planning, management and decision-making 8. Involvement of relevant community partners in decision making processes and management activity	Program administered by WGCMA in collaboration with DELWP and Southern Rural Water
10. Enable storage and release of environmental allocation at Lake Narracan. This would entail consultation with: • Southern Rural Water • Latrobe City Council • Lake user organisations	Address changed river, floodplain and wetland hydrology in reaches 4, 5 and 6.	This option could: 1. Deliver a net gain in river condition, and improve: 2. The efficacy of available environmental water in meeting Reach 4, 5 and 6, including Lower Wetlands environmental needs. 4. River, floodplain and wetland functioning and connectivity 5. Capacity to support more diversity and resilience in flora and fauna 7. Opportunities for Aboriginal involvement in planning, management and decision-making 8. Involvement of relevant community partners in decision making processes and management activity	Program administered by WGCMA in collaboration with DELWP and Southern Rural Water

Management option	Impacts the management option seeks to address	Relationship to L-T goals *(Long-term Goal# and rationale)*	Implementation
11. A native fish restocking program - This initiative entails breeding key predatory native fish species such as Australian bass and Estuary perch and restocking the Latrobe with fingerlings to boost fish abundance and diversity, and to increase predation of carp.	This initiative is intended to assist in-stream biodiversity conservation efforts by increasing the abundance of key native fish populations restore predator populations and contribute to the restoration of food web dynamics In addition, this initiative can also contribute to supporting Aboriginal cultural values and practices, and service demand recreational angling demand.	This option could: 1. Deliver a net gain in river condition, and improve: 2. The efficacy of available environmental water in meeting Reach 4, 5 and Lower Wetlands environmental needs. 4. River, floodplain and wetland functioning and connectivity 5. Capacity to support more diversity and resilience in flora and fauna 7. Opportunities for Aboriginal involvement in planning, management and decision-making 8. Involvement of relevant community partners in decision making processes and management activity	Program likely best administered by DELWP
12. Pilot carp control initiative for Lake Wellington and associated catchments – As proposed by VR Fish (Mr Rob Caune), this assumes a subsidised 500 tonne increase in Lake Wellington commercial carp harvesting over (for example) a 5-year period will enable extant juvenile populations of predatory fish to grow to the point where they can control carp numbers and increase native fish populations. A 15c/kg subsidy is required to make his commercially viable.	Increased carp populations in Lake Wellington catchments has seen carp out-compete native species for food resources and refuge, reducing the diversity and abundance of native fish and other aquatic flora and fauna. Carp also increase turbidity and reduce light penetration to aquatic macrophytes.	This option could: 1. Deliver a net gain in river condition, and improve: 5. Capacity to support more diversity and resilience in flora and fauna 8. Involvement of relevant community partners in decision making processes and management activity	Program administered by WGCMA in consultation with DELWP, VR Fish and commercial fishers
13. Re-creating ecological connectivity between the Alps and Strzelecki ranges with a focus on the Morwell River and some surrounding mine lands.	The main impacts this project will address concern the currently degraded state of the Morwell River and its riparian zone.	This option could: 1. Deliver a net gain in river condition, and improve: 4. River, floodplain and wetland functioning and connectivity 5. Capacity to support more diversity and resilience in flora and fauna	Program administered by WGCMA, potentially in collaboration with

Management option	Impacts the management option seeks to address	Relationship to L-T goals *(Long-term Goal# and rationale)*	Implementation
		7. Opportunities for Aboriginal involvement in planning, management and decision-making 8. Involvement of relevant community partners in decision making processes and management activity	DELWP, GLaWAC and other community partners
14. Increase the availability of water to meet identified environmental needs. Considerations for pending decisions on environmental water needs should include: • The compounding effects of climate change on the current environmental water deficit, & • The timespan over which additional environmental; water can be made available	Currently, the Latrobe River system, including its floodplains and wetlands, is flow stressed, and the amount of water reserved for environmental use is insufficient to meet identified environmental needs. Moreover, the water currently available for environmental purposes is highly vulnerable to the drying effects of climate change on Latrobe River inflows.	This option will: 1. Deliver a net gain in river condition, and improve: 2. Support attainment of identified environmental flow needs. 3. Improve capacity to dilute sediment and nutrient concentrations. 4. Enhance river, floodplain wetland and estuary functioning and connectivity 5. Support more diversity and resilience in flora and fauna 7. Improve opportunities for Aboriginal involvement in planning, management and decision-making	Issues are currently under consideration in the Central and Gippsland Regional Sustainable Water Strategy process.
15. Water quality management initiatives A range of potential water quality improvement projects focussing on hot-spots of land-based sources of pollution and controlling waterway erosion (total suspended sediment loads). Options include working with landholders on leading practices in managing agricultural runoff, detention and retention basins in strategic locations, water sensitive urban design initiatives, revegetation to reduce sediment loads entering the river and grade	The history of land use change in the Latrobe value, particularly agricultural and urban development, have contributed to degradation in river water quality, mainly in the form of elevated nutrient and sediment loads and turbidity.	This option could: 1. Deliver a net gain in river condition, 5. Improve capacity to support more diversity and resilience in flora and fauna 7. Improve opportunities for Aboriginal involvement in planning, management and decision-making 8. Improve the involvement of relevant community partners in decision making processes and management activity	Program administered by WGCMA in collaboration with local community partners and GLaWAC.

Management option	Impacts the management option seeks to address	Relationship to L-T goals *(Long-term Goal# and rationale)*	Implementation
controls. These initiatives should seek to work in conjunction with other plans, such as the Lake Wellington Land and Water Management			
16. Construct a pipeline between available water sources to the Latrobe Valley, particularly a pipeline from Blue Rock Reservoir to the Latrobe Valley	Optimising water delivery and supply across the broader Latrobe River system	This measure will: 1. Deliver a net gain in river condition, and improve 3. Capacity to manage inflows of nutrients, sediments and other pollutants. 7. Opportunities for Aboriginal involvement in planning and management 8. Involvement of relevant community partners in decision making processes and management activity	Program administered by WGCMA, potentially in collaboration with DELWP, GLaWAC and other community partners
17. Feasibility study into alternative uses for redundant infrastructure e.g., Yallourn weir	Subject to feasibility and the views of the local community, repurposing redundant infrastructure could provide environment, economic, recreational and cultural benefits, through re-establishing fish passage and natural flow regimes.	*Potentially*, this measure could lead to a rehabilitation plan that delivers: 1. A net gain in river condition, and improve 3. Capacity to manage inflows of nutrients, sediments and other pollutants. 4. River structure and functioning at Yallourn weir through river and floodplain restoration works and removal of a key barrier to fish passage 5. Diversity and resilience in flora and fauna 6. The quality and extent of vegetation by creating a new asset supporting significant natural and amenity values 7. Opportunities for Aboriginal involvement in planning and management 8. Involvement of relevant community partners in decision making processes and management activity	Independent analysis commissioned by WGCMA, potentially in collaboration with Latrobe City Council