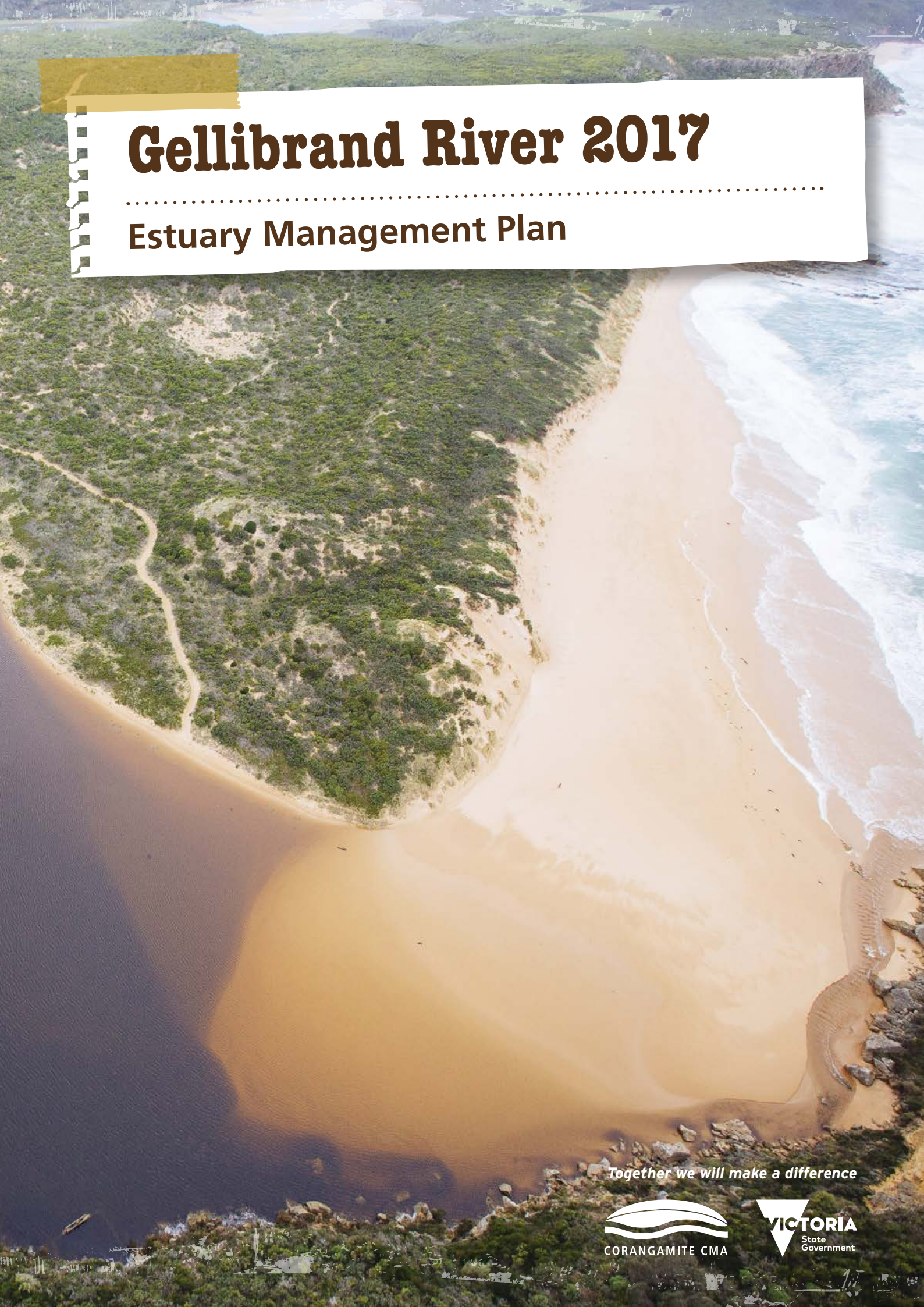
Gellibrand River 2017

Estuary Management Plan



Together we will make a difference

CORANGAMITE CMA

VICTORIA
State Government

Gellibrand River

Total Catchment:	2,346 Ha
River Length:	125 km
Estuary Length:	13.5 km
Location:	38°31'58"S 143°36'27"E

CORANGAMITE CMA

Scale: 1:50,000

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Cover photo courtesy of Gellibrand EstuaryWatch.

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Corangamite Catchment Management Authority (CCMA) Gellibrand River Estuary Management Plan.

Prepared by RM Consulting Group for the Corangamite CMA, Colac, Victoria.

SECTION A

1. Introduction

The Gellibrand River estuary is known for its raw and natural aesthetic, shaped by rugged coastal cliffs and characterised by an expansive floodplain and diverse ecosystems including the Princetown Wetlands. The local community has a deep connection with the estuary and it has long sustained communities both past and present. The resource rich estuary was once an important site for local Indigenous people, and since European settlement, the fertile floodplains have supported productive agriculture.

A number of studies and plans have already been prepared for Gellibrand River estuary, including the first *Gellibrand Estuary Management Plan 2001* which provides a comprehensive account of the main management issues. This Estuary Management Plan (EMP) does not seek to reiterate the information already documented or attempt to address the full suite of management issues; instead it responds to the main concerns identified by the Working Group (refer to Appendix 1), and builds on what has already been achieved. A review of the existing literature occurred as a preliminary piece of work to this EMP, and provides a more detailed account of the main values and threats associated with the estuary, as well as an overview of estuary management in Victoria*.

A whole of catchment management approach has been applied in the preparation of the EMP, recognising that what occurs upstream will ultimately affect downstream. Therefore, this EMP is strongly aligned to, and supports, the *Corangamite Waterway Strategy 2014-2022*. Further, this EMP is not limited to a geographic area defined as the "estuary", given the very dynamic nature of estuarine environments; this is evidenced by a salt wedge that continually moves in response to freshwater and saltwater influences and the nature of the river mouth.

Even though the local community has a special connection to the estuary, how it is valued is not equally shared and community perceptions about what needs to be done to protect and enhance the estuary vary. This presents a complex challenge for both land managers and the local community in achieving an agreed approach to management.

In order to achieve the objectives and goal of this EMP, it is fundamental that we all work together. Government agencies, the local community and industry all have a role to play to ensure the estuary and its environmental values are protected and enhanced, and that the social and economic uses expected by the community can be sustainably supported.

Board walk and viewing platform overlooking the Princetown wetlands

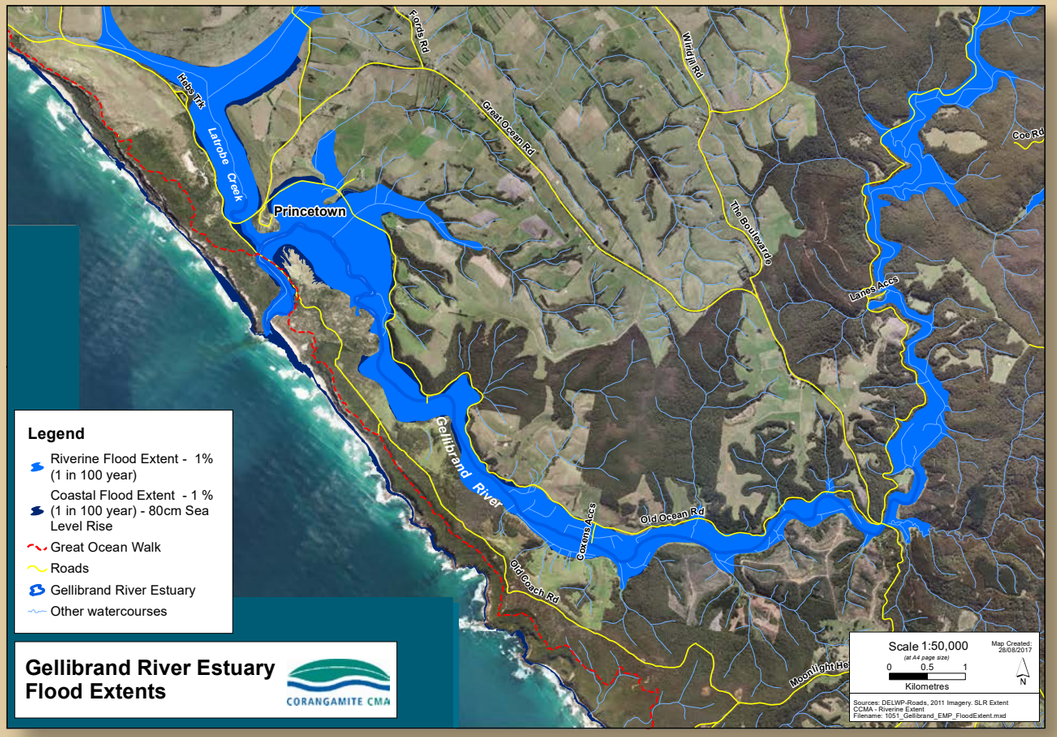
*The *Gellibrand River Literature Review (2016)* can be accessed on the CCMA Knowledge Base www.ccmaknowledgebase.vic.gov.au

2. The Estuary

Located in southwest Victoria, near the township of Princetown, the Gellibrand River rises in the Otway Ranges and enters the coast at the Twelve Apostles Marine National Park. The river and its tributaries have a catchment area of approximately 2346ha (CCMA 2012), and traverse remnant forest, commercial timber plantations and cleared agricultural land.

The tidal and seawater influence of the estuary was originally thought to extend 10.7km upstream, however a 2008 study found a tidal signal as far as 13.6km upstream at the Great Ocean Road bridge (Lloyd et. al. 2008). The estuary has one major tributary, Latrobe Creek approximately 1.25km upstream from the mouth. There are around 320ha of wetlands surrounding the estuary, of which significant areas area listed as Wetlands of National Importance (CCMA 2012).

Figure 1: The 1 in 100 year flood extent of the Gellibrand estuary and river upstream of the Great Ocean Road



3. The Plan

3.1 Scope

The Gellibrand River EMP has been prepared to provide a clear picture of the main management activities required to maintain or improve the condition of the estuary. The EMP has been prepared in consideration of the social, economic and environmental values of the estuary, as well as the current and emerging threats. At the time of preparing this EMP, the guidance from the Victorian Government was for an eight-year plan.

It is intended that the EMP will be used to seek funding, strengthen coordination amongst stakeholders responsible for estuary management and increase community understanding and appreciation for the natural values of the estuary.

The iconic headland at the mouth of the Gellibrand estuary

The Gellibrand River estuary at Old Coach Road

3.2 Planning context

There are two policies that guide estuary management in Victoria, these being the Victorian Coastal Strategy 2014 (VCS) and the Victorian Waterway Management Strategy 2013 (VWMS). Figure 2 outlines the legislative and planning framework for estuary management in Victoria.

The Corangamite CMA will work with the Victorian Government, the Victorian Coastal Council, Coastal Boards and regional partner organisations within the framework of the VWMS and VCS to effectively manage the environmental condition of estuaries within the Corangamite region.

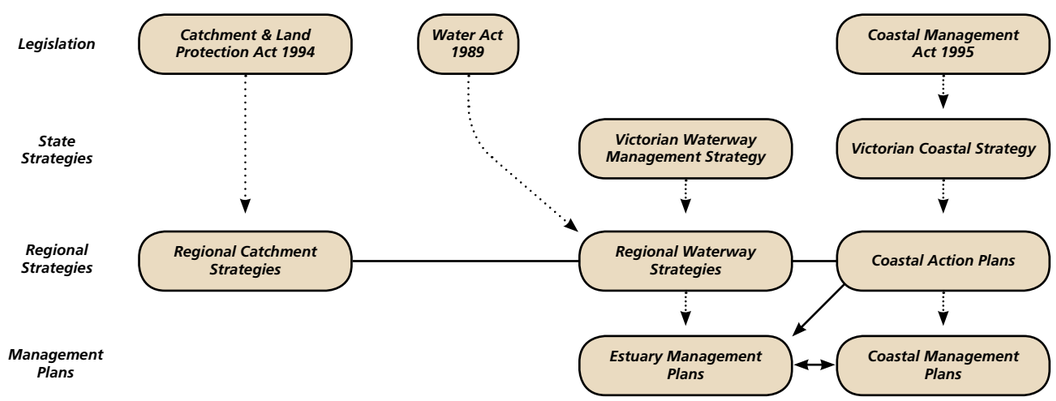
The VCS is the statewide policy for coastal management and planning, prepared in accordance with the *Coastal Management Act 1995**. The VCS and associated plans address use and development issues related to estuaries in Victoria, particularly issues that require planning responses; however, they do not comprehensively include management of the environmental condition of estuaries (DEPI 2014).

The VWMS is the responsible document providing statewide direction on the management of the environmental condition of estuaries. Regional Waterway Strategies translate the statewide direction into regional priorities and the *Corangamite Waterway Strategy 2014-2022* identifies the following approach to estuary management:

EMPs are one tool to prioritise management activity and guide the improvement of environmental condition at the local level. The "review and update of current EMPs" or development of "new plans as required" is identified as an action (Action 13.2) in the VWMS. In response, the *Corangamite Waterway Strategy* identifies the development of the Gellibrand River EMP as a priority management activity.

The Gellibrand River EMP also aligns with the strategic intent of the *Corangamite Regional Catchment Strategy 2013-2019* which is the region's blueprint for catchment health and is recognised in the Corangamite Shire Local Planning Policy Framework.

Figure 2: Key legislation and planning arrangements for estuary management in Victoria (DEPI 2014)



Source: Victorian Waterway Strategy (2013)

*The Coastal Management Act 1995 is to be superseded by a new *Marine and Coastal Act* scheduled for release in 2017.

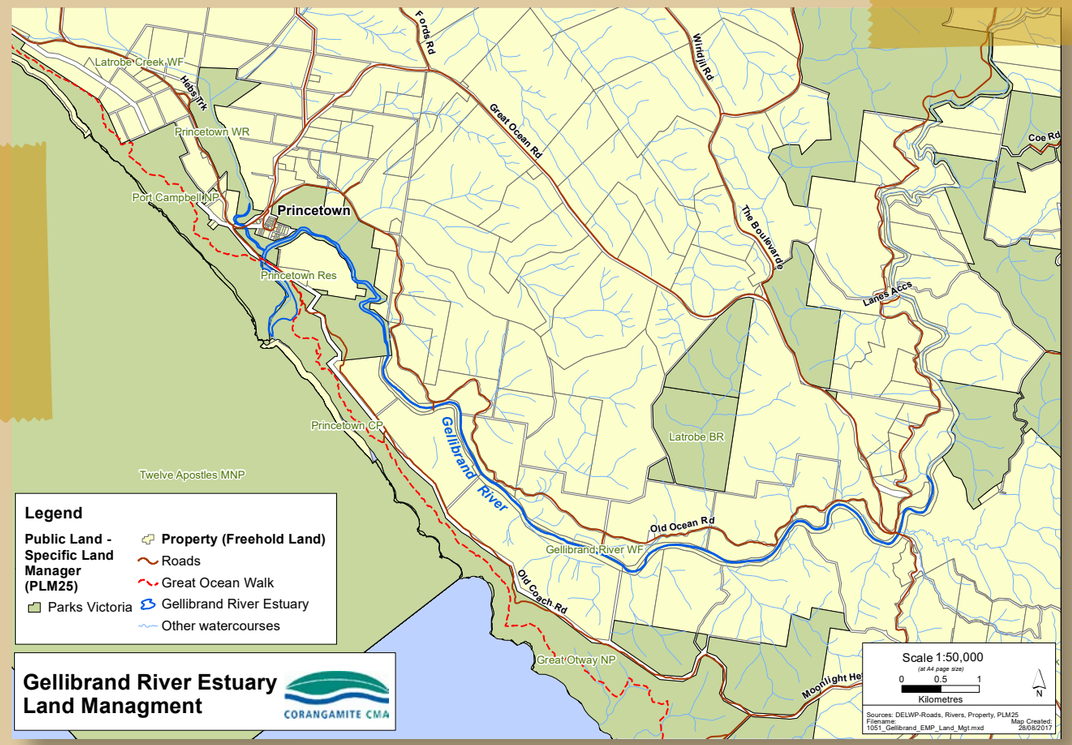
4. Partners and their Roles and Responsibilities

The Corangamite Catchment Management Authority (CCMA) is the responsible authority tasked with the management of waterways, drainage and floodplains under the *Water Act 1989*. Land tenures and management arrangements around estuaries are particularly complex and many other agencies also play a role, as highlighted in Table 1. Figure 3 provides a map of the land management boundaries surrounding the Gellibrand estuary.

Table 1: Responsible groups and agencies at the Gellibrand River estuary

Group or Agency	Regional responsibility
Corangamite Catchment Management Authority (CCMA)	Regional caretaker of water health, including the development of the Corangamite Waterway Strategy and Estuary Management Plans; implementation of waterway work programs; authorisation of works on waterways, including estuary mouth openings, responding to natural disasters and incidents affecting waterways.
Local Government (Colac Otway Shire)	Council has responsibilities under the *Planning and Environment Act 1987* to administer the planning scheme, under the *Road Management Act 2004* to maintain local infrastructure and under the *Emergency Management Act 1986* to coordinate emergency management at a municipal scale. Council also has statutory responsibilities under the *Environmental Protection Act 1970* to regulate septic systems on private land.
Department of Environment, Land, Water and Planning (DELWP)	Development of waterway policy, coordination of regional delivery and prioritisation of government investment in waterways.
Department of Economic Development, Jobs, Transport & Resources (DEDJTR)	To create the conditions to sustainably develop the Victorian economy and grow employment. Fisheries Victoria, which is responsible for the management of fisheries, including recreational fishing, sits within DEDJTR. Agriculture Victoria also sits within DEDJTR.
Parks Victoria (PV)	Management of the Greater Otway National Park, Twelve Apostles Marine Park and the Port Campbell National Park. Holds permit for artificially opening Gellibrand estuary. Issues tour operator licenses for activities associated with parks and reserves managed by Parks Victoria (excluding water-based activities).
Environmental Protection Authority (EPA)	Responsible for the projection and improvement of Victoria's environment by establishing environmental standards, regulating and working with organisations to meet these standards. The EPA also provides guidance on wastewater management to minimise health and environmental risk.
Western Coastal Board	Strategic coastal and marine planning and preparation of regional coastal plans.
Traditional Owners (TOs)	Traditional Owners have rights and interests to lands and waters within their recognised regions, including participation in decision making on how land and/or waters are used. The Eastern Maar Aboriginal Corporation and the Kuuyang Maar Aboriginal Corporation operate in the area around the Gellibrand River estuary.
Water users (Wannon Water, Barwon Water, Southern Rural Water, irrigators and farm dam owners)	Wannon Water is the largest water user in the catchment and provides water to Warrnambool and other townships from the Gellibrand River. Barwon Water operates small storages in the upper catchment that provide water to Colac. Southern Rural Water regulates irrigation, domestic supply and farm dams in the catchment.
Victorian Game Management Authority	Independent statutory authority responsible for the regulation of game hunting in the Princetown (Serpentine Creek) State Game Reserve (62ha). It delivers programs to improve and promote responsible hunting in Victoria.
Maritime Safety Victoria	Enforces regulations regarding Marine Safety. *The Marine Act (1988)* establishes boat speeds for inland waters.
Victorian State Emergency Services	Responsible for the emergency management response related to flooding events including riverine flooding, flash flooding and storm surge.

Figure 3. Land Management Map



4.1 EstuaryWatch

There is an active and engaged volunteer community at the Gellibrand River estuary that make a significant contribution to the protection and enhancement of the environmental values of the estuary. This includes volunteers in the EstuaryWatch program that was established by the Corangamite CMA at the Gellibrand in 2007. EstuaryWatch is a successful citizen science program that supports community members to actively participate in the monitoring of estuary health. The data collected by EstuaryWatch volunteers makes a valuable contribution to informing better estuary management.

Since 2007, the EstuaryWatch group has collected a significant amount of water quality data from seven locations along the Gellibrand River estuary. This has formed the basis of a recent report, which analyses and interprets data collected over the period 2007-2012 (CCMA 2012).

More information about EstuaryWatch can be accessed at: www.estuarywatch.org.au

4.2 Waterwatch

Waterwatch is a national community water monitoring program, supporting local community members to test the quality of their local stream or waterway so action can be taken to maintain or improve the water quality.

There is an active group of volunteers undertaking water quality monitoring at the Gellibrand as part of the Waterwatch program, which is supported by the Corangamite CMA. Monitoring occurs along LaTrobe and Boggy Creeks, which helps keep track of the water quality entering the Gellibrand estuary.

EstuaryWatch volunteers collect valuable water quality data at the Gellibrand estuary

4.3 Landcare

The Heytesbury and District Landcare Network provides overarching support to local Landcare and other community based conservation groups in the district. They support groups to facilitate programs in habitat restoration, pest plant and animal management and environmental education, and work closely with government agencies such as the Corangamite CMA and Corangamite Shire.

The Princetown Landcare Group is the local group occupying the area around the Gellibrand River estuary. Over the years the group, as well as other local landholders, has been active in undertaking restoration works around the river, including riparian revegetation and fencing. In November 2015, the Princetown Landcare Group planted 1,000 native trees along the Gellibrand River estuary (DELWP 2016).

Agricultural land surrounds much of the Gellibrand estuary

SECTION B

5. The Gellibrand River Estuary

5.1 Values

The Gellibrand River estuary is a place of great natural beauty, rich in biodiversity, resources and history that is highly valued by the local community. The abundant resources of the lower Gellibrand River were very important to two Indigenous communities who occupied the area – the Girari Wurrung tribe to the west and the Kaubanuut tribe to the east. In the early 1800's when European's settled the area, the fertile alluvial floodplains were sought out for farming and cultivated to grow crops.

Today, the floodplain continues to support agriculture, predominately dairy and beef grazing while the pristine natural environment remains incredibly important in sustaining significant populations of native flora and fauna species, including some that are rare and threatened. The estuary and the associated Princetown Wetlands provide an important refuge for migratory and non-migratory waterbirds, including the endangered Australian Bittern *(Botaurus poiciloptillus)*.

The endangered Coastal Saltmarsh (EVC 009) vegetation community occurs at the estuary, as well as stands of sea grass meadows and riparian native vegetation providing important habitat for aquatic and semi-aquatic fauna. Significant patches of the vulnerable Swamp Greenhood Orchid *(Pterostylis tenuissima)* occur at the Princetown Wetlands.

The Gellibrand River is among Victoria's more important rivers for the conservation of native fish and carries the largest population of Blackfish *(Gadopsis marmoratus)* and the vulnerable Australian Grayling *(Prototroctes maraena)*, also occurs at the Gellibrand. The estuary is also a popular recreational fishing location and currently supports a commercial eel fishery.

Amongst the local community, the Gellibrand estuary remains highly valued for its natural aesthetic and opportunities for recreation, relaxation and learning. Bird watching, fishing, kayaking, walking and camping are popular pursuits and the 62ha Princetown (Serpentine Creek) State Game Reserve is a popular duck hunting destination. The Gellibrand estuary is on the doorstep of the Great Ocean Road and the internationally renowned Twelve Apostles Marine National Park, Port Campbell National Park and the Great Ocean Walk which crosses the Gellibrand River estuary, with the recreation reserve at Princetown a designated camping site for hikers on the trail. The area forms part of the broader Shipwreck Coast which attracts 2.6 million visitors annually and is forecast to increase (Parks Victoria 2015). Visitation is particularly evident during the peak summer period when Princetown, which has a resident population of approximately 350[1], swells with an influx of people attracted to the estuary and beaches. The *Shipwreck Coast Masterplan 2015* is the current document guiding tourism investment along this stretch of coast over the next 20 years, and the protection and conservation of the coast's natural values is a primary objective of the plan.

The values identified here are consistent with those outlined in the Corangamite Waterway Strategy for the Gellibrand landscape zone, and were also identified by the Working Group during the development of this EMP.

Gellibrand fishing platform

1. 2011 ABS Census data.

5.2 Threats

Estuaries are exposed to pressures from all directions, including from the catchment, the immediate surrounds as well as coastal and marine influences. At the Gellibrand River estuary, catchment based activities have a significant impact on the health of the estuary. The upper Gellibrand River, its associated tributaries and water storages form part of a 'Special Water Supply Catchment' and are a source of potable water for Warrnambool and other townships in the South West. Subsequently, average annual streamflow has been reduced by approximately 16,165ML (~5.4%) from natural conditions, with the greatest reductions occurring in the low flow months of December to May (EarthTech 2005). Climate change and the predicted reduction in annual rainfall is likely to result in even less freshwater inflows reaching the lower river and estuary.

The coastal impacts associated with climate change also pose a significant threat to the Gellibrand estuary. Sea level rise of 0.8-1.1m is forecast by 2100, as well as an increase in storm surge events. According to the *Corangamite NRM Plan for Climate Change* these influences, combined with a reduction in rainfall, create a high climate change risk for the Gellibrand estuary. In recent years, storm surge events have occurred at the Gellibrand estuary providing an insight into the impacts that may be experienced more frequently in the future. Appendices 2 and 3 provide further detail on climate change impacts and opportunities at the Gellibrand estuary.

Livestock access to waterways along the estuary and in the upper Gellibrand River and associated tributaries can erode banks, damage riparian vegetation and reduce water quality through sedimentation and effluent contamination.

Pest plants, such as Blackberry *(Rubus fruticosus spp. agg.)*, Ragwort *(Senecio jacobaea)*, African Box-thorn *(Lycium ferocissimum)* and Ox-eye Daisy *(Leucanthemum vulgare)* pose a threat to the biodiversity of the estuary, through outcompeting and displacing indigenous species and reducing the integrity and extent of habitat for native fauna. The *Corangamite Waterway Strategy* identifies the red fox *(Vulpes vulpes)*, as a significant threat to bird species inhabiting or visiting the estuary and wetlands.

Under natural conditions, the Gellibrand River estuary intermittently opens and closes in response to prevailing conditions such as freshwater inflows, weather changes or tidal movements. Floodplain inundation associated with the closure of the river mouth is a natural process and one that is necessary to support the lifecycle of many species, as well as the cycle of nutrients. Artificial estuary openings now occur to minimise the impact of flooding on adjacent land and infrastructure, however doing so can cause adverse impacts to the natural environment and the species that live there.

Visitation and recreation is popular around the estuary and wetlands. The lower reach of the estuary is a high use area particularly during peak holiday periods, when visitors frequent the estuary to swim, fish, boat, kayak, hike the Great Ocean Walk, camp and surf at the nearby beach. Currently, there is limited infrastructure at the Gellibrand estuary to support the growing number of visitors and ensure access and use of the estuary is environmentally sensitive. The *Shipwreck Coast Masterplan 2015* acknowledges the increasing number of visitors to the broader region, and the strong need to conserve the natural environment while enhancing the visitor experience. Impacts such as littering, trampling of vegetation and habitat disturbance, bank erosion due to inappropriate access, 4-wheel driving and trail bike riding, the introduction and spread of weeds and illegal shooting and camping are present today and may be exacerbated in the future if not carefully planned for and managed.

Many of the threats described here also pose issues for emergency management. Agencies such as the SES and EPA are responsible for responding to natural events (such as riverine flooding, flash flooding, storm surge, landslides and debris resulting from bushfire) and well as other events (such as pollution, boating incidents and drownings). Documents such as the Corangamite Shire *Municipal Emergency Management Plan 2015-2018* and the *Regional Floodplain Management Strategy* (currently under development) provide detail on emergency management and associated risks.

6. Goals, Objectives and Management Actions

6.1 Goal

The environmental condition of the Gellibrand River estuary is maintained or improved, promoting a healthy, rich and diverse wetland and estuarine ecosystem and supporting long-term sustainable use.

6.2 Objectives

Six high level objectives have been identified to help achieve the goal for the Gellibrand River estuary.

They are:

1. The diverse native vegetation communities and wildlife of the estuary are protected and enhanced
2. Water flows support estuary values, and the quality of water entering the estuary improves over time
3. Tourism and recreational use is environmentally sensitive and available for all
4. Indigenous and heritage values are respected and conserved
5. Management of the estuary is coordinated and knowledge gaps addressed
6. Future development has no, or minimal, impact on the variable hydrology of the intermittently open estuary.

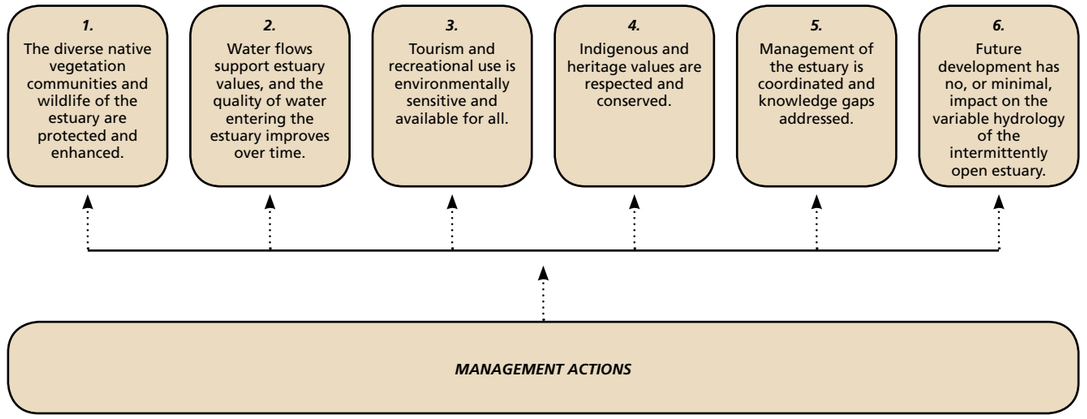
Aerial view of the mouth of the Gellibrand estuary

6.3 Management Actions

The management actions for the Gellibrand River have been informed by existing research and relevant plans, and prepared in consultation with a Working Group of stakeholders including agency representatives and local landholders.

The management actions are presented in Table 2 (over page). Collectively, these actions will contribute towards the achievement of the five high level objectives and ultimately the goal for the Gellibrand River estuary (Figure 4).

Figure 4. Hierarchy of goal, objectives and management actions for the Gellibrand River estuary



Timelines and costing have not been included, to allow the CCMA and other stakeholders flexibility to deliver actions as funding becomes available.

7. Implementation of Actions

This EMP has been written for all stakeholders who have an influence on the Gellibrand River estuary. The Corangamite CMA has taken a lead role in the development of the EMP, although it is only one stakeholder that has a role in the implementation of the actions identified in Table 2. For instance, the CMA has a high level of control and influence in supporting EstuaryWatch and the delivery of river health programs for riparian restoration work in the catchment of the Gellibrand estuary. There are other actions, such as the maintenance and potential upgrade of built infrastructure, where the CMA will play more of a supporting role to other agencies and stakeholders, in this case the Corangamite Shire.

The lead agency, or agencies, has been identified for each action as well as project partners. A Stakeholder Reference Group will be established for the Gellibrand River estuary and will meet annually to oversee the delivery and monitoring of actions.

Another key role of the CMA and the relevant stakeholders will be to seek funding opportunities as they arise to deliver the actions.

Table 2: Management actions for the Gellibrand River estuary

Action	Detail of Action	Lead	Project Partners
Water quality			
1*	Work with landholders to find opportunities to install riparian/wetland fencing to exclude livestock.	CCMA	Landcare, landholders
2	Pilot approaches to riparian fencing for stock exclusion on the floodplain that are flexible and meet the needs of farming systems, whilst providing sound ecological outcomes for the investment.	CCMA	Landcare, landholders
3	Continue to support and encourage riparian restoration works in the Gellibrand River catchment.	CCMA	Landcare, landholders
4	Engage the timber industry in riparian restoration works and sustainable land management practices.	All	Timber companies, CCMA, LG
5	Support and encourage whole-farm planning initiatives with dairy farmers in the Gellibrand River catchment to reduce nutrient runoff to the river and tributaries.	CCMA, DEDJTR	WestVic Dairy, EPA, Landcare, WW
6	Support investigations that consider the impact of domestic and commercial effluent on the water quality of the Gellibrand River estuary.	All	WW, EPA, CCMA
Freshwater flows			
7*	Continue to work to investigate options to improve summer low flows – as identified under Action 7.3 of the Western Regional Sustainable Water Strategy.	WW, CCMA	SRW, DELWP
8	Continue to work in the upper catchment to implement practices that improve the environmental condition of the estuary e.g. in areas such as water extraction and environmental flows.	WW, CCMA	LG, PV, BW, SRW
9	Work with the end users of potable water from the Gellibrand catchment, such as the Warrnambool community, to increase community understanding and encourage more responsible water consumption.	WW, CCMA	LG, SRW, BW, Landcare

*These actions build upon those identified as key management activities for the Gellibrand River estuary and Princetown Wetlands in the *Corangamite Waterway Strategy 2014-2022*.

Table 2: Management actions for the Gellibrand River estuary (continued)

Action	Detail of Action	Lead	Project Partners
Biodiversity			
10*	Establish terrestrial pest animal control (especially feral cat and fox control) as part of a large scale coordinated program to protect biodiversity values.	DEDJTR	PV, CCMA, Landcare, landholders
11	Work with public and private land managers to implement weed control works on the floodplain.	DEDJTR	PV, CCMA, Landcare, landholders
12*	Establish native indigenous vegetation at the estuary, in accordance with the appropriate Ecological Vegetation Classes (EVCs).	CCMA	DELWP, PV, Landcare, landholders
13	Protect and enhance stands of remnant EVCs on private and public land at the estuary, with a particular focus on those that are threatened e.g. Swamp Scrub (EVC 53).	CCMA	DELWP, PV, Landcare, landholders
14	Utilise research on the Sea Grass Meadows (EVC 845) to increase knowledge about this community and the role it plays in the estuarine ecosystem.	DELWP	Research institutions, CCMA, EstuaryWatch
15	Increase the participation of landholders in the CCMA Coastal Tender and Saltmarsh Tender programs.	CCMA	Landcare, landholders
16	Use existing monitoring of estuary vegetation to inform future management of the estuary.	CCMA	DELWP, PV, Landcare, landholders
17	Build on the existing understanding of habitat requirements for juvenile fish species and aquatic macro invertebrates and consider as part of the future management of the estuary.	CCMA	DELWP, DEDJTR (Fisheries), VRFish, research institutions, Landcare, EstuaryWatch
18	Undertake monitoring and maintenance of in-stream structures established as part of the Gellibrand Fish Habitat Hotspot project.	CCMA	DELWP, ARI, DEDJTR (Fisheries)
19	Increase the extent and protection of habitat for known rare and endangered bird species such as the Australian Bittern.	DELWP	PV, Landcare, landholders, CCMA, GMA
20*	Establish stewardship/management agreements to support landholders to undertake sustainable land management practices.	CCMA	Landholders, DELWP, PV
21	Update existing mapping of high risk Acid Sulphate Soils at the Gellibrand River estuary to inform future management approaches.	DELWP	CCMA, LG
Climate change			
22	Support the PhD research project tilted *'Mitigating Climate Change with Blue Carbon Ecosystems'* and incorporate the findings into the management of the Gellibrand River estuary where appropriate.	CCMA	Deakin University, DELWP, PV, landholders
23	Undertake investigations to further understand the implications of storm surge events and sea level rise on the Gellibrand River estuary and wetlands, in particular the ability for vegetation communities to adapt.	CCMA, LG	DELWP, PV, SES
24	Continue to document case studies on storm surge events, and other extreme climatic events, as they occur.	LG, CCMA	EstuaryWatch, PV, SES
25	Consider local estuary monitoring data alongside Municipal Emergency Response Plans for all flooding events including estuarine and riverine flooding, as well as storm surge events.	SES, LG	EstuaryWatch, BoM, PV, CCMA
26	Support the adaptation responses for the Gellibrand River estuary and wetlands in the *Corangamite Natural Resource Management Plan for Climate Change*, in particular actions that will support the estuary to adapt naturally to the impacts of climate change.	CCMA	DELWP, PV, LG, Landcare, EstuaryWatch, landholders

*These actions build upon those identified as key management activities for the Gellibrand River estuary and Princetown Wetlands in the *Corangamite Waterway Strategy 2014-2022*.

7. Implementation of Actions (continued)

Table 2: Management actions for the Gellibrand River estuary (continued)

Action	Detail of Action	Lead	Project Partners
Artificial estuary openings			
27*	Continue to adopt a risk based approach to estuary mouth opening.	CCMA, PV	LG
28	Prepare a Memorandum of Understanding between the relevant agencies and stakeholders to ensure a coordinated approach to the management of artificial estuary openings.	CCMA, DELWP	DELWP, PV, LG, landholders
29	Ensure EEMSS contains up-to-date information.	CCMA	PV, LG
30	Investigate opportunities for blue carbon projects on the floodplain to support landholders adapt land management to support estuarine inundation.	CCMA	DELWP, landholders, LG, research institutions
31	Assess the costs and benefits of investing in modifications to existing public assets and infrastructure at risk of flooding e.g. Old Ocean Road.	LG, CCMA	DELWP, PV
32	Assess the suitability of local government planning controls e.g. overlays, to ensure they acknowledge the variable inundation regime of intermittently open estuaries.	LG	CCMA, PV
Cultural and European heritage			
33	Ensure future works, planning and strategies consider Indigenous and European heritage values for the Gellibrand River estuary and wetlands.	All	TOs
34	Identify and incorporate cultural risks in EEMSS.	CCMA, PV	TOs, LG, DELWP
Community			
35	Work with, and support, EstuaryWatch and Waterwatch volunteers in the collection and analysis of water quality monitoring data at the Gellibrand River estuary and tributaries e.g. LaTrobe and Boggy Creeks.*	CCMA	EstuaryWatch
36	Support Landcare and EstuaryWatch (e.g. through funding, resource provision and sharing expertise and knowledge) so that they can continue to promote the natural values of the estuary to the wider community.	DELWP, CCMA	Landcare, EstuaryWatch
37	Ensure research and information relating to the management of the estuary is communicated and made accessible to interested community organisations and members.	CCMA All	Landcare, EstuaryWatch, PV
38	Support community education about the impact of upstream land use on the condition of the estuary.	Landcare	CCMA, EstuaryWatch, EPA
Tourism and recreation			
39	Support initiatives arising from relevant tourism strategies that are environmentally sensitive and promote the natural values of the Gellibrand River estuary and wetlands.	LG	PV, CCMA, DELWP
40	Advocate for management approaches that protect and enhance the natural values of the estuary and wetlands, particularly in high use areas.	DELWP, CCMA	PV, LG, GMA, MSV
41	Support research that increases the understanding of the value and impact of recreation (e.g. fishing, boating and camping at the recreation reserve), on the ecology of the estuary.	All	Research institutions, VRFish, DEDJTR, DELWP, PV, CCMA, GMA

*These actions build upon those identified as key management activities for the Gellibrand River estuary and Princetown Wetlands in the *Corangamite Waterway Strategy 2014-2022*.

ARI	Arthur Rylah Institute
BoM	Bureau of Meteorology
BW	Barwon Water
CCMA	Corangamite Catchment Management Authority
DEDJTR	Department of Economic Development, Jobs, Transport & Resources
DELWP	Department of Environment, Land, Water & Planning
EPA	Environment Protection Authority
GMA	Game Management Authority
MSV	Maritime Safety Victoria
LG	Local Government (Corangamite Shire)
PV	Parks Victoria
SRW	Southern Rural Water
TOs	Traditional Owners
VRFish	Victorian Recreational Fishing
WW	Wannon Water

SECTION C

8. Estuarine Processes and Characteristics

8.1 Physical characteristics

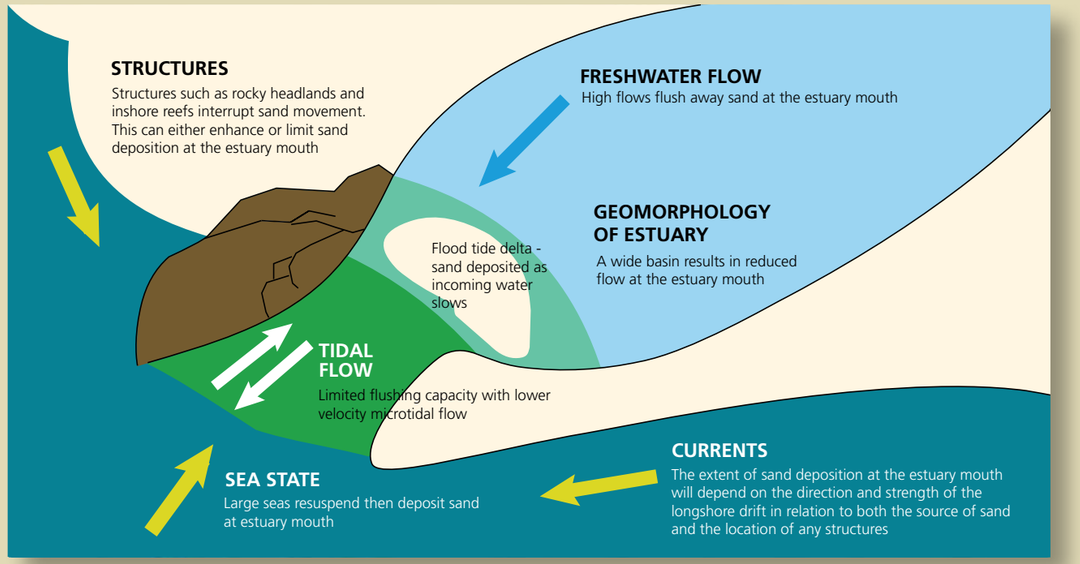
The length of the river is about 125km with a catchment area of 1170km (Barton & Sherwood 2004). The river flows through steep terrain covered with eucalypt forests, agricultural land and across extensive floodplains. Throughout agricultural areas, the river is used extensively for irrigation particularly during summer (Barton & Sherwood 2004).

A complex set of interacting factors influences the characteristics and functioning of an estuary, particularly the formation of the sand bar at the mouth (Figure 5). The key influencing factors are:

- Ocean tides
- Wave activity
- Storm surges
- Freshwater inflow
- Geomorphology e.g. rock headlands.

In the Gellibrand River estuary, the marine influence is low because of a restricted bar at the mouth of the system (EarthTech 2005). Instead, freshwater inflows have the greatest influence on mixing within the estuary. During high flows in winter and spring the estuary becomes totally fresh, while at times of low flow, sea water which enters the estuary as a salt wedge reaches its maximum upstream limit. Flows generally need to be below 750ML/day for the salt wedge to return.

Figure 5: Factors that influence the characteristic and functioning of an estuary, particularly the mouth (Arundell 2006)



8.2 Water quality

EstuaryWatch volunteers have been collecting water quality monitoring data, including dissolved oxygen, salinity, pH, temperature and turbidity (Table 3) across seven sites at the Gellibrand River estuary since 2007. In 2008 the Corangamite CMA and the Victorian Department of Environment and Sustainability installed a HydroShare data logging system to enable real-time monitoring of the estuary.

Table 3: Water quality parameters collected by EstuaryWatch at each monitoring site

Parameter	Unit
Dissolved oxygen (DO)	mg/l & % saturation
Salinity	Parts per thousand (ppt)
Electrical conductivity (EC)	micro Siemens per cm (µS/cm)
pH	pH units
Temperature	Degrees Celsius (°C)
Turbidity	Nephelometric Turbidity Units (NTU)

Many estuarine organisms require water of a particular salinity and with sufficient dissolved oxygen to occur at sites for spawning and egg placement. Adequate winter flows are therefore required to flush deep salty water from the estuary and avoid anoxic conditions from developing.

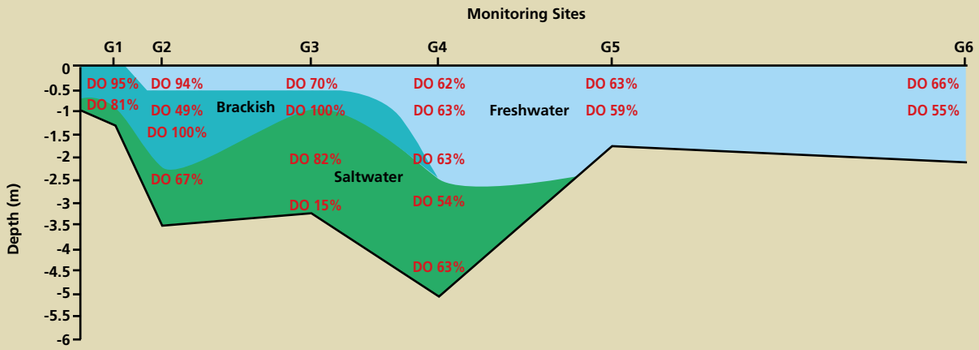
Typically, only 20% of annual inflows occur during summer and autumn in the Gellibrand River estuary. These low flows result in estuary mouth closures and a highly stratified water column, such that dense seawater underlies a layer of freshwater and there is very little mixing between the layers.

Dissolved oxygen (DO) is also influenced by mouth closures and shows the greatest variation when there is stratification of the water column. Measurements of percent saturation of DO will typically range from 0% to 100%, but can exceed 100% at times when plants and algae are producing large amounts of oxygen.

Fluctuations in DO is a natural occurrence in salt wedge estuaries, such as the Gellibrand. Most animals and plants can grow and reproduce unimpaired when DO levels exceed 80%. While some living organisms can become stressed when DO drops to less than 80%, there are other species that have adapted to depleted oxygen conditions. For example, some zooplanktonic estuarine species have been found to occur in the deeper oxygen depleted regions of estuaries (Newton-McKay 1994). Zooplankton are the foundation of the estuarine food web and their ability to survive in low DO conditions is very important and they play a vital role in sustaining a diverse estuarine ecology.

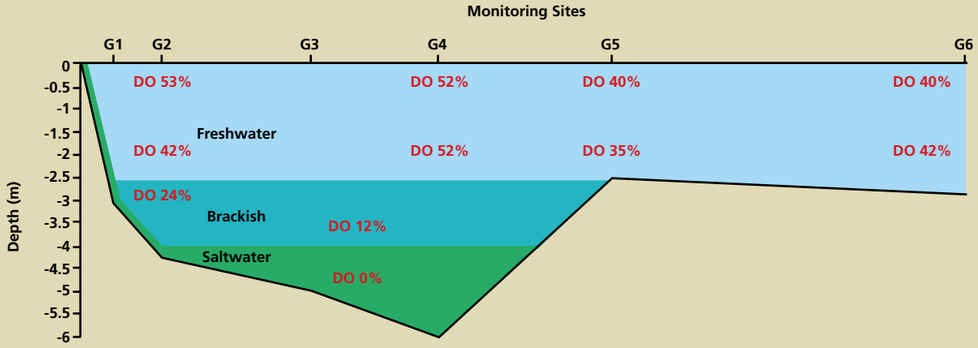
In the Gellibrand River estuary, DO has dropped as low as 0-5% saturation in the bottom layers of the salt wedge. During winter, or periods of high inflows when the mouth is open, DO is more stable with less variation between the top and bottom layers. This is demonstrated in Figure 6 and Figure 7 *(below & opposite page)*.

Figure 6: Stratification and DO levels in the Gellibrand River estuary when the mouth is open (CCMA 2012a)



G1 – is the closest EstuaryWatch monitoring site to the mouth
G6 – is the upper reach of the estuary, 13.6km from the mouth at the Great Ocean Road Bridge.

Figure 7: Stratification and DO levels in the Gellibrand River estuary when the mouth is closed (CCMA 2012a)



G1 – is the closest EstuaryWatch monitoring site to the mouth
G6 – is the upper reach of the estuary, 13.6km from the mouth at the Great Ocean Road Bridge.

Other parameters, including salinity, pH, temperature and turbidity also provide important indicators of water quality.

Salinity in particular plays a major role in the functioning of estuary ecology and salinity dynamics can influence other parameters such as dissolved oxygen, turbidity, pH and colour. Salinity is the amount of salt dissolved in the water and is commonly measured as the units of electrical conductivity (EC) expressed as micro Siemens per centimetre (µS/cm) or parts per thousands (ppt). The overriding influence on salinity in estuaries is from marine inflows; catchment inflows will influence the freshwater surface layer e.g. from geology, urban and agricultural runoff, sewage and industrial effluent and groundwater which can often have very high salt concentrations. Salinity can influence stratification within an estuary, as heavy salt water sinks beneath freshwater causing a tidal salt wedge to move backwards and forwards with the tides (EstuaryWatch Victoria 2012).

Other factors such as wind, geology (depth and width of an estuary), velocity of freshwater and tidal inflows and temperature also influence stratification and mixing in an estuary. Temperature, for example, can change the density of water leading to thermal stratification. Warm water is less dense than cold water, and will therefore float above cold water. The density difference between warm and cold water can inhibit mixing in the same way that salinity does (EstuaryWatch Victoria 2012).

Temperature is also a key factor controlling the rate of biological processes such as algal growth (the rate of growth will increase with temperature increases) and also influences oxygen concentrations (as temperature increases, the amount of oxygen water can hold will decrease).

The pH of water is another important parameter, measuring acidity or alkalinity. Freshwater pH is generally lower than seawater. During high river inflows at the Gellibrand, freshwater will begin to dominate and estuary pH will decrease at the surface; pH during high flows will generally be around 6.5 to 7.5. Bottom water however may remain saline and the pH is likely to be much higher, at least greater than pH 7 and maybe as high as 8.5. A pH lower than 5 may lead to toxic effects (EstuaryWatch Victoria 2012).

Turbidity is a measure of the clarity of water. As suspended particulate matter including clay, silt, detritus and plankton in the water increases, the clarity decreases and the water takes on a muddy appearance. Most of the sediment in an estuary originates from catchment, river, streambed and bank erosion which can be exacerbated by agriculture, forestry and urban developments. Sewerage effluent, industrial and septic tank discharges can also influence the turbidity of an estuary. During periods of high river inflows, turbidity can be very high (as high as 200 NTU for short periods). Turbidity levels in surface waters are generally higher than deeper water with a high salinity (EstuaryWatch Victoria 2012).

Further information relating to water quality monitoring parameters in estuaries, can be found on the EstuaryWatch Portal: www.estuarywatch.org.au

8.3 Condition reporting

Estuaries across Victoria vary greatly. To effectively report on estuary condition, it is important to have a standard set of data to report against.

The Index of Estuary of Condition (IEC), currently under development, is designed to complement the existing Index of Stream Condition (ISC). This provides a consistent statewide assessment of the environmental condition of estuaries that is completed every eight years. The assessment is conducted across six themes:

- Water quality
- Physical form
- Hydrology
- Sediment
- Flora, and
- Fauna.

This enables the condition of the Gellibrand River estuary to be reported at regional, state and national levels, prioritising resource allocation, and providing a way to assess estuary management interventions.

The IEC is only intended to provide a snapshot of condition. Therefore, it is important to have long-term datasets to track condition over time and account for different hydrological states.

The Environment Protection Authority (EPA) water quality guidelines provide a framework and tools for assessing the environmental condition of riverine estuaries. The guideline values describe the condition of quality estuaries, and these can be used as an indicator for assessment of other estuaries.

The Gellibrand estuary and wetlands provide important refuge for birdlife

Marine waters entering the estuary following an opening of the mouth

8.4 Current condition

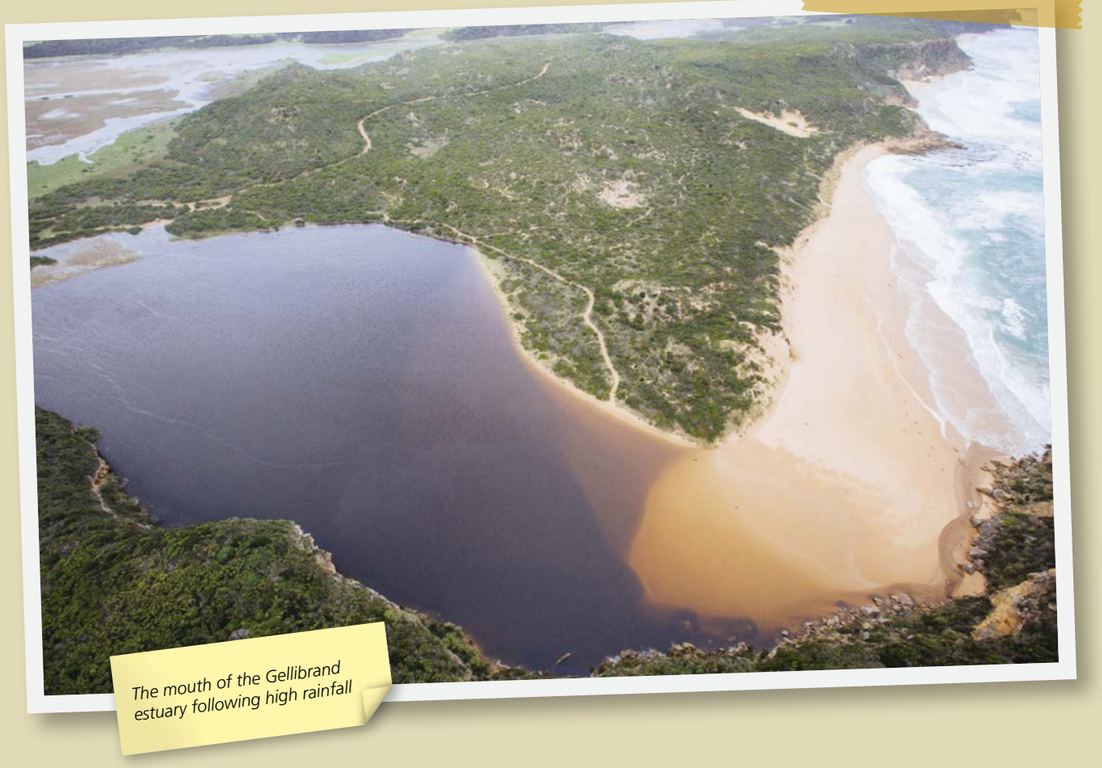
The third ISC report for the Corangamite Region (based on data from 2004-2010), assessed the lower reaches of the Gellibrand River as being in poor to moderate condition, with the condition rating high for physical form and aquatic life (DEPI 2010).

During the development of the EMP, the Working Group discussed the current condition of the estuary. There was consensus that it is a modified system, which over the years has been subject to altered hydrology due to water extractions in the catchment, as well as agricultural and other land use impacts both upstream and on the floodplain. Appendix 4 provides further information relating to water extractions in the Gellibrand catchment.

Even though the estuary has been subject to change, the working group also believed that the wetlands in particular were in relatively good condition compared to other wetlands in Victoria, and continue to provide an important refuge for wildlife.

More information regarding the ISC and studies relating to the condition of the estuary can be located here:

- Corangamite CMA Knowledge Base: www.ccmaknowledgebase.vic.gov.au
- EstuaryWatch Portal: www.estuarywatch.org.au



The mouth of the Gellibrand estuary following high rainfall

9. Estuarine Values

9.1 Fish Species

Fish are managed throughout Victoria for various reasons.

Broadly speaking the *Victorian Guide to Native Fish Management* (Drew et al. 2008) prioritises the following:

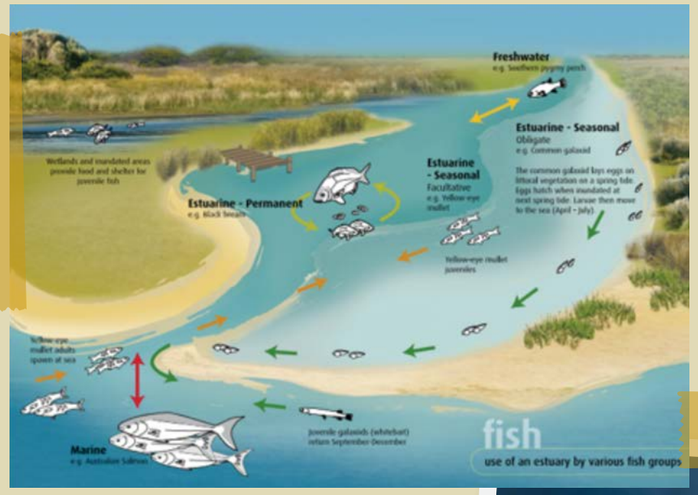
- Freshwater and estuarine species recognised as threatened*
- Freshwater and estuarine species that are targeted by recreational and commercial fishers# or are of cultural significance
- Remaining freshwater species for which we have good knowledge.

Beyond these priority groups, estuarine fish are prioritised according to their level of dependence on estuarine environments, with greater emphasis placed on species heavily reliant on estuarine environments to complete life cycles. Native fish that occur in estuaries are divided into three groups:

- Freshwater species
- Estuarine species usually further divided into permanent or seasonal
- Marine stragglers – visitors to the estuary environment.

Figure 8 shows the variation in how fish groups use and rely on an estuary. This degree of variation is evident at the Gellibrand River estuary, and Lloyd et al. (2008) provide a similar classification for example estuarine fish that occur at the Gellibrand and is included as Appendix 5.

Figure 8. Use of an estuary by various fish groups (Arundell 2006)



Estuary Perch are common in the Gellibrand estuary (Image: Fishes of Australia)

* Listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act (1999)* or *Victorian Flora and Fauna Guarantee Act (1998).*

As determined from information derived from DELWP resources and the Scientific Advisory Panel.

Around 30 species of fish are likely to occur in the Gellibrand River estuary at some stage in their lifetime (O'May & Wallace 2001).

The high number of native fish species that occur in the Gellibrand places it among Victoria's more important rivers for the conservation of native fish (Barton & Sherwood 2004). This includes the Australian Grayling *(Prototroctes maraena)*, which is listed as vulnerable under the *Victorian Flora and Fauna Guarantee (FFG) Act 1988* and the *Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999* (CCMA 2012).

The Gellibrand River also carries the largest population of Blackfish *(Gadopsis marmoratus)*, in both number and size of fish, of any river in Victoria and possibly southeast Australia (Tunbridge & Glenane 1988).

The Gellibrand River estuary is a popular fishing location for Estuary perch *(Macquaria colonorum)*, Black bream *(Acanthopagrus butcheri)*, Mullet *(Mugilidae spp.)* and Mulloway *(Argyrosomus japonicus)*.

The Corangamite CMA has worked with the local community, recreational fishers and the Arthur Rylah Institute to improve habitat for fish in the Gellibrand River estuary. The recently completed Gellibrand Fish Habitat Hotspot project focused on rehabilitating instream and riverbank habitat and raising awareness of the importance of healthy, connected waterways to sustain fish populations.

9.2 Birds

A number of significant birds have been recorded at the Gellibrand River estuary.

This includes several that are listed under the *Victorian FFG Act 1988* and the following are nationally recognised under the *Commonwealth EPBC Act 1988*:

- Hooded Plover *(Thinornis rubricollis rubricollis)*
- Fairy Tern *(Sternula nereis nereis)*
- Australasian Bittern *(Botaurus poiciloptilus)*
- Wandering Albatross (Diomedea exulans)
- Blue Petrel (Halobaena caerulea).

A list of the bird species that are recognised at state and national level are included in Appendix 6.

A 2010 survey was conducted at eleven estuaries in the Corangamite region to obtain information on the distribution and abundance of birds, in particular waterbirds and other estuarine specialists.

A total of 1406 individual birds, representing 48 species were identified at the Gellibrand River estuary over the period May-July 2010. This was among the highest numbers recorded across eleven surveyed estuaries in the region (Hansen 2010). It is expected that migratory and transient estuarine bird species occur at the Gellibrand River estuary during late spring through to early autumn (outside the 2010 survey period).

The survey also found that birds used the whole suite of available estuarine habitats, most notably open waterbodies. This pattern of usage was not impacted by changes in hydrology or salinity, suggesting that the presence of inlets, wetlands and lakes is critical to determining the distribution and abundance of estuarine birds.

9.3 Vegetation

Estuarine vegetation plays an important role in filtering sediment, recycling nutrients and providing habitat for a range of invertebrate, fish and bird species. Ecological Vegetation Classes (EVCs) are used to describe and map plant communities across Victoria. An EVC is a component of a vegetation classification system, grouping vegetation communities based on floristic, structural, and ecological features.

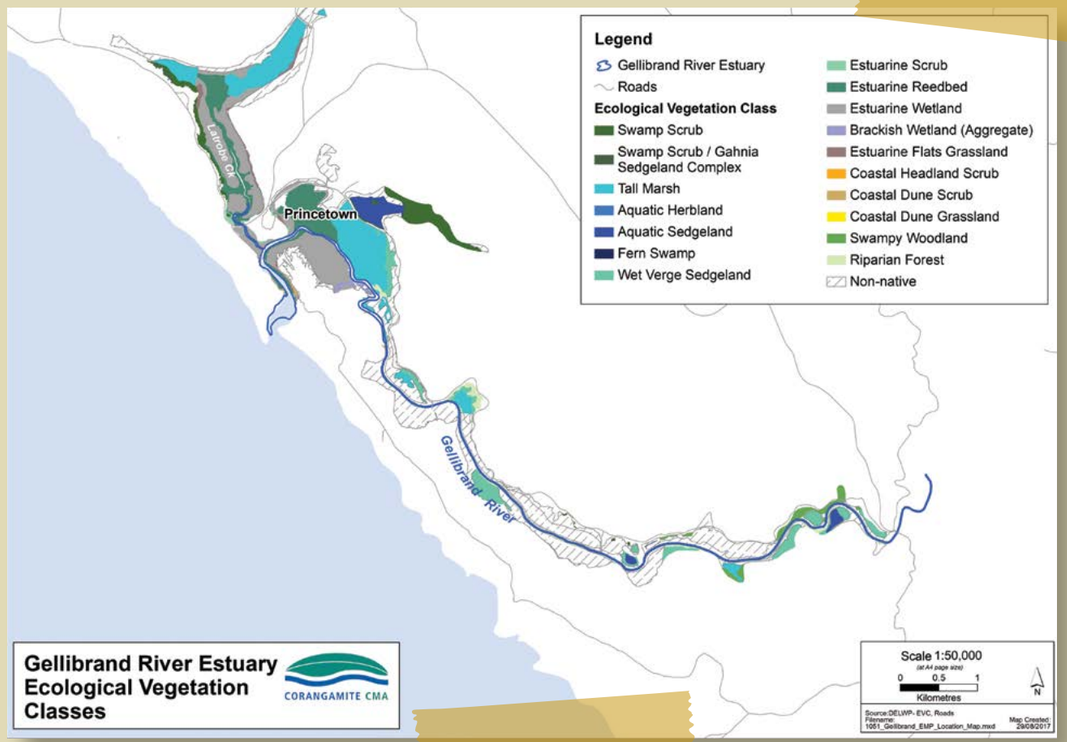
A 2010 study describes 16 EVCs occurring at the Gellibrand River estuary. This includes extensive areas of intact Estuarine Wetland (EVC 10) around Gellibrand River and LaTrobe Creek and a highly significant area of remnant vegetation at Kangaroobie that has not been grazed. According to Osler & Cook (2010), this stand contains a diverse example of Tall Marsh (EVC 821) with significant Swamp Scrub (EVC 53) around the margin. Swamp Scrub has a bioregional conservation status of endangered and would likely have once occurred more along the Gellibrand River.

Important stands of the nationally vulnerable Swamp Greenhood *(Pterostyllis tenuissima)* and Small Sickle Greenhood *(Pterostylis lustra)* occur at both the Gellibrand River and LaTrobe Creek (Osler & Cook 2010). A small population of the nationally threatened Curly Sedge *(Carex tasmanica)* has also been recorded at the estuary (Osler & Cook 2010).

Appendix 7 provides a list of the flora species of conservation significance at the Gellibrand River estuary. Much of the lower Gellibrand River, particularly the floodplain, has been cleared for farming. Grazing and the associated impacts such as pugging, spread of weeds and the reduction in indigenous vegetation cover has been identified as major threat to native vegetation at the estuary. Similarly, the high number of environmental weeds including Wandering Dew *(Tradescantia fluminensis)*, Spiny Rush *(Juncus acutus)* and Willow *(Salix spp.)* also poses a significant threat. There is also the potential activation of acid sulfate soils on the lower floodplain where drains have been dug, which will also adversely impact native vegetation in these locations (Osler & Cook 2010).

Information signage, Gellibrand River

Figure 9. Ecological Vegetation Classes surrounding the Gellibrand River Estuary



9.4 Wetlands

The Princetown Wetlands include both the lower Gellibrand wetlands and Latrobe Creek wetlands.

This complex of wetlands has national recognition in the directory of important Australian wetlands, because of three characteristics:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia
2. It is a wetland that plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex
3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge in adverse conditions such as droughts (Barton & Sherwood 2004).

The Princetown Wetlands are also identified as a priority reach in the *Corangamite Waterway Strategy 2014-2022*.

The main ecological features of the wetlands are the extensive beds of Common Reed *(Phragmites communis)* and meadows dominated by Beaded Glasswort *(Sarcocornia quinqueflora)* that can support large numbers of waterbirds. Significant numbers of the Swamp Greenhood Orchid *(Pterostylis tenuissima)* occur here, growing under dense Woolly Tea-tree *(Leptospermum lanigerum)* groves.

9.5 Socio-economic values

Indigenous communities have had a long association with the Gellibrand River estuary. Two Aboriginal tribes occupied the area around the Gellibrand River estuary. This included the Girai Wurrung tribe who inhabited the coastal region west of Princetown and the Kaubanuut tribe to the east occupied the coast and ranges.

A range of archaeological sites have been recorded in the lower Gellibrand River region, particularly artefact scatters and shell middens along the river and coast.

Since European settlement in the early 1800s, the Gellibrand River estuary has also supported generations of social and economic uses and users. In particular, the fertile floodplains of the lower Gellibrand were sought out by early settlers for farming from the 1860s and were cultivated to grow crops (Figure 10).

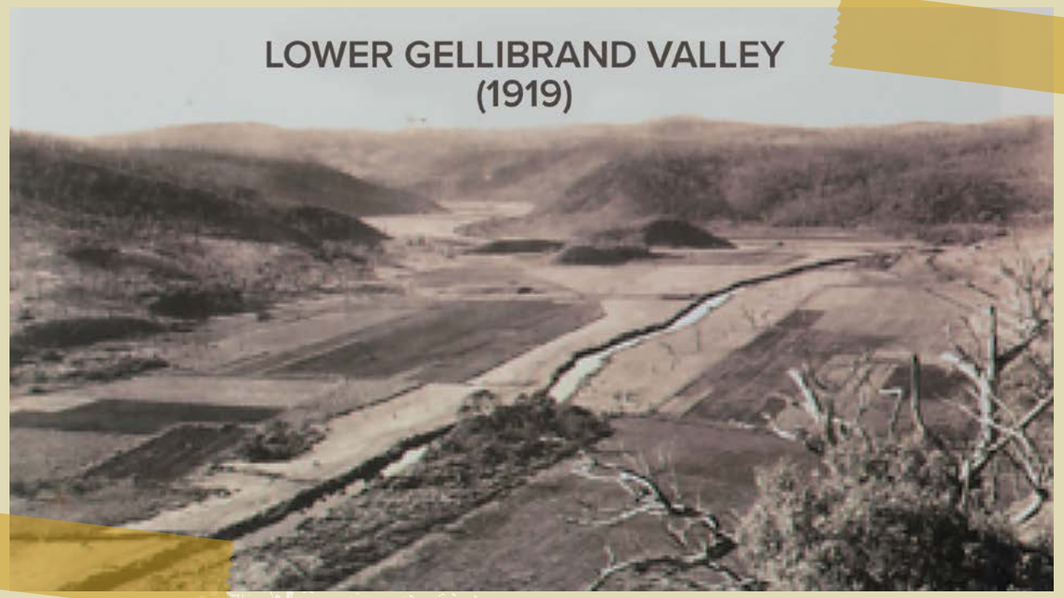
Dairying became a predominate land use on the floodplain and local cheese factory was established on the banks of the Gellibrand River at Lower Gellibrand in the mid 1950s (O'May & Wallace 2001). In recent years the size of the farming community has decreased, however agriculture, predominately dairy and beef grazing, remains the main land use on the floodplain. A relatively reliable rainfall, temperate climate and nutrient rich alluvial soils, contributes to high levels of agricultural productivity in this area.

Tourism plays a large part in the local economy and was introduced early to the area, with holidaymakers attracted to the Gellibrand for fishing, relief from summer heat and the natural charm of the area.

Today the Gellibrand River estuary and surrounding area continues to attract a wide range of visitors, particularly to the nearby 12 Apostles Marine National Park, Port Campbell National Park and the Great Ocean Walk. The lower reaches of the Gellibrand River is a high priority for the social values it provides. Popular activities at the estuary include fishing, boating, sightseeing, bird watching, camping, walking, cycling, swimming, duck hunting, horse riding, four-wheel driving and trail bikes.

Local residents are also a main user of the estuary. A 2005 study of 618 residents along the Great Ocean Road, found that the main reason they visited local estuaries included walking or bushwalking (55%), relaxing or to unwind (34%), fishing (29%), sightseeing (22%), swimming (21%), to have a picnic/BBQ (13%), a family outing (12%) or to watch birds (10%) (Nexus Research 2005).

Figure 10. Agriculture on the Gellibrand floodplain, 1919 (G. Gracie Collection)



10. Estuary Entrance Management Support System (EEMSS)

Parks Victoria manages all artificial estuary openings at the Gellibrand River. Parks Victoria and the Corangamite CMA use the Estuary Entrance Management Support System (EEMSS) at times when there is the threat of flooding due to estuary mouth closure. The EEMSS provides estuary managers with a tool for assessing the likely impacts of artificially opening, or not opening, an estuary. This includes consideration of the environmental, social and economic impacts.

The EEMSS also contains important baseline data such as records of estuary openings, water levels, water quality data and species lists. Agricultural data has been recently collected and will be incorporated into the EEMSS for the Gellibrand River estuary. Collection of this data involved consultation with local landholders to understand their assets and threats in relation to the estuary water level for particular times of the year.

Originally the EEMSS was developed as a database in 2006, but has since been redeveloped as a web-based tool and can be accessed at: www.victorianestuaries.com.au

Appendix 8 provides an historical account of artificial estuary openings at the Gellibrand River.

An artificial opening, 2008 (Judy Spafford)

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12. Glossary

Acid: Water with a pH lower than 7.

AHD: Australian Height Datum is the standard measure for height with zero being a mean sea level.

Alkaline: Water with a pH higher than 7.

Anaerobic: Living or active in an environment where oxygen is absent.

Anoxic: Areas of marine or freshwater that are depleted of dissolved oxygen.

Asset Values Identified and Risk Assessment (AVIRA): A spatial tool for assessing the values and threats to river reaches, wetlands and estuaries.

Bathymetry: The terrain beneath the water's surface, which could be marine, riverine or wetland.

Berm: The sand accumulated at the mouth of a waterway (river or creek).

Catchment: An extent of land where water from precipitation drains into a waterway.

Dissolved Oxygen: Oxygen dissolved in water. Usually measured in milligrams per litre (mg/l or ppm) but can also be presented as percent saturation.

Ecological Vegetation Class (EVC): A component of a vegetation classification system, grouping vegetation communities based on floristic, structural, and ecological features.

Electrical conductivity (EC): A measure of how well a material accommodates the transport of electrical charge. EC is used to estimate the concentration of dissolved salts.

Estuary: Semi-enclosed body of water where salt from the sea mixes with freshwater flowing from the land.

Estuary Management Support System (EEMSS): A decision support database tool to inform artificial estuary mouth openings by considering the risks to social, environmental and economic assets or values.

EstuaryWatch: A community based estuarine monitoring program administered by the Corangamite CMA.

Estuary Water Level (EWL): Refers to the surface height of water within the estuary.

Freshwater: Looking at estuaries, water with a low salinity. Not necessarily potable or clear.

Halocline: An area of transition from lower to higher salinity with increasing depth.

Hydraulic: Operated by, moved by, or employing water or other liquids in motion. Studying the hydraulics of the estuary will explain where the water moves and the way it does within the estuary.

Hydrodynamics: The branch of science concerned with the hydraulic properties of water and in this context, how the water within the estuary moves based upon the physical boundaries within the system such as bank steepness and roughness, depth (bathymetry) and bank width.

Index of Stream Condition (ISC): Standard measure of river health in Victoria reported every six years.

Index of Estuary Condition (IEC): Still at draft stage the IEC will have a similar statewide measure of estuary health as that for wetlands (IWC) and rivers (ISC).

Land Subject to Inundation Overlay (LSIO): A flood related town planning control.

Longshore sediment transport: The general direction of sand and sediment transport along the Victorian coastline in west to east.

Marine: Of or pertaining to the sea; existing in or produced by the sea.

µS/cm: micro Siemens per cm – the unit of measurement for electrical conductivity (salinity). mS/cm gives an indication of the salt content in a solution; the more salt there is in a solution, the easier it is for an electric current to flow.

NTU: Nephelometric Turbidity Units – the unit of measurement for turbidity. Turbidity is normally measured by an instrument called a Nephelometer, which determines the scattering of light and is measured in standard NTUs.

Parameters: The different types of qualities that estuary water is tested for can be termed parameters.

pH: A measure of how many H+ and OH- ions are in solution giving a measure of acidity or alkalinity on a scale of 1-14, where less than 7 is acid, 7 is neutral, and greater that 7 is alkaline.

Terrestrial: Belonging to the land rather than the sea or air living or growing on land.

Saline: Water containing significant content of salt.

Salt wedge: The physical separation of marine and riverine water within an estuary with the denser salty marine water sitting beneath the riverine water and forming a wedge.

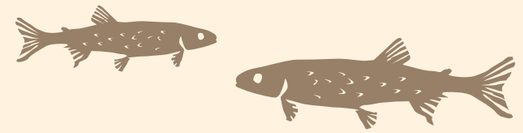
Stratification: Water stratification occurs when water masses with different properties such as salinity (halocline), oxygen (chemocline), density (pycnocline) temperature (thermocline) form layers that act as barriers to water mixing.

Threats: Something which may do harm to a value or asset.

Turbidity: Visible cloudiness due to suspended material in water causing a reduction in the transmission of light.

Tributary: A stream that flows to a larger stream or other body of water.

Values: Things important to the community and stakeholders.



APPENDICES

Appendix 1: Working Group

A Working Group was established to guide the development of the Gellibrand River Estuary Management Plan. The following organisations were represented (or invited to participate) on the Working Group:

- Corangamite Catchment Management Authority
- Corangamite Shire
- Parks Victoria
- Department of Environment, Land, Water and Planning
- Department of Economic Development, Jobs, Transport and Resources
- Victorian Recreational Fishing
- Eastern Maar Aboriginal Corporation
- Kuuyang Maar Aboriginal Corporation
- Guli-Gad Aboriginal Corporation
- Wannon Water
- State Emergency Services
- Game Management Authority
- Great Ocean Road Tourism Committee
- Western Coastal Board
- Heytesbury District Landcare Network
- Princetown Landcare Group
- EstuaryWatch
- Timboon Field Naturalists
- Friends of the Gellibrand River, estuary and wetlands
- Private industry
- Local business operators.

View of Old Coach Road bridge, EstuaryWatch site G2

Appendix 2: Adapting to climate change

The Corangamite CMA has prepared the *Corangamite Natural Resource Management Plan for Climate Change*, which provides the background, current information and detailed processes required to enable the impact of climate change to be considered in managing the region's natural assets.

The plan:

- Provides regional information on the projected changes in climate and its likely impact on the region's natural assets
- Provides guidance to the Corangamite CMA and other regional NRM agencies in developing adaptation and mitigation actions to address the impact of climate change on the region's natural ecosystems
- Identifies priority landscapes for carbon plantings and other carbon sequestration methods, as well as strategies to build landscape integrity
- Provides guidance for regional decision-making, community engagement and research methods to improve understanding of the impact of climate change, and how those impacts can be managed.

The plan also includes a web portal with relevant climate change data and information, with the ability to include new data as it becomes available. The portal can be accessed at: www.swclimatechange.com.au

What will the climate in Corangamite look like in the future?

RAINFALL	• Less rainfall in the cool season – up to less than 25% in winter and 45% in spring by 2090, under high emissions. • Changes to summer and autumn rainfall are possible, but less clear. • Increased intensity of extreme rainfall events is projected. • Time spent in drought is predicted to increase over the century.
TEMPERATURE	• Average temperature will continue to increase in all seasons, with more hot days and warm spells and fewer frosts. • By 2030, average annual warming is expected to be around 0.4 - 1.1°C. • By 2090, under high emissions warming is expected to be 2.4 - 3.8°C and under an intermediate emissions scenario 1.1 - 1.9°C.
MARINE & COAST	• By 2030, sea level is projected to rise by 0.08 - 0.18m. • By 2090, sea level is projected to rise by 0.29 - 0.64m under an intermediate emissions scenario and by 0.39 - 0.84m under high emissions. • Sea surface temperature is expected to increase in the range of 1.6 - 3.4°C by 2090 under high emissions. • An increase in the frequency and height of extreme sea level events. • The oceans are predicted to become more acidic.
OTHER	• There is likely to be a harsher fire-weather climate in the future. • Potential evapotranspiration is projected to increase in all seasons. • An increase in solar radiation and a decrease in relative humidity are projected in the cool season.

Appendix 2:
Climate change impacts to estuaries

Estuaries are exposed to climate change impacts arising in both the catchment and the coast. The predicted reduction in rainfall, and subsequent freshwater inflows, coupled with coastal and marine influences such as sea level rise and storm surge events will have a major impact on estuaries. It is important that future management of the Gellibrand River estuary considers the impacts of climate change on the system, that new information is incorporated as it becomes available and adaptation responses are prepared.

Gellibrand River estuary storm surge event

Images of the May 2015 storm surge event at the Gellibrand River estuary

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During May 2015, extended periods of large swells and high tides hit the southwest Victorian coastline, causing a number of storm surge events at estuaries along the coast, including the Gellibrand River estuary. During this period, the Gellibrand River estuary reached a maximum height of 2.026mAHD on 15 May 2015.

Conductivity (uS/cm) readings from the period 5 – 16 May revealed a conductivity equivalent to seawater at particular times, confirming the event was a storm surge event as opposed to riverine flooding.

The water was still brackish at times, suggesting there was still some mixing taking place with the tidal exchange in the estuary. The estuary mouth naturally opened on 14 May at a water level height of 1.98mAHD.

On this occasion, EstuaryWatch volunteers recorded flooding on all roads in the area, including the Great Ocean Road. Boardwalks were also underwater and the campground at the Princetown Recreation Reserve also experienced localised flooding. The flood markers at the Old Ocean Road were also observed to be at 0.8m.

This event provides an insight into the likely impacts that are expected under a changing climate at the Gellibrand River estuary. The extent of flooding that occurred during this event closely mirrors the modelled storm tide extent expected under a sea level rise of 0.82m by 2100. Had the estuary mouth been closed at the time with greater catchment flows coinciding with the storm surge event, there may have been much more serious impacts. There is a challenge for land managers to plan for, and adapt to, the likely climate change impacts at the Gellibrand River estuary.

Further information: Climate Change and Victoria, DELWP: www.climatechange.vic.gov.au/understand
Corangamite CMA: www.ccma.vic.gov.au/What-we-do/Climate.aspx

Appendix 3: Blue Carbon

Saltmarsh, mangroves and seagrass meadows are collectively known Blue Carbon habitats. They have recently been identified as one of the most effective carbon sinks on the planet, burying carbon at a rate 35-57 times faster than tropical rainforests and storing it for thousands of years. These features make vegetation coastal habitats ideal candidates for carbon offset programs and nature-based climate mitigation initiatives.

The main benefits of blue carbon habitats include:

- They sequester nearly equivalent quantities of organic carbon as terrestrial vegetation, despite comparatively limited biomass (0.05% of terrestrial plant biomass).
- The ability to store carbon at around 40 times the rate of terrestrial systems. The anaerobic soils prevent organic carbon remineralisation, helping to achieve long-term sequestration.
- Carbon in these habitats can be stored for centuries to millennia.
- The ability to produce and store their own carbon, but also trap carbon produced from other locations.
- Their ability to trap particles and suspended sediments means they may appropriate large quantities of carbon that originates from adjacent habitats, both terrestrial and marine. This is of particular importance in the Corangamite region where a majority of waterways filter through coastal saltmarsh before entering the sea.
- The provision of a range of other ecosystem services including nursery habitat for fish species and shoreline stabilisation.

While blue carbon habitats are excellent at accumulating carbon, degradation and loss of vegetated coastal habitats could shift them from carbon sinks to carbon sources, releasing atmospheric CO_2. Impacts include land clearing, changes to tidal influences and stock grazing.

The Corangamite CMA has identified the protection, and improvement of blue carbon habitats as a priority for the region. During 2014, the CMA commissioned Deakin University to conduct a blue carbon stock assessment across the region.

The study found that the majority of the region's blue carbon stock comprises mostly saltmarsh (62%) and seagrass (37%), and mangroves contributing <1%. Estuaries in particular were found to have higher carbon stocks than other coastal environments.

The Gellibrand River estuary has been identified as an area with potential blue carbon habitat areas worthy of further research for carbon sequestration purposes. The CMA, in conjunction with Deakin University, has sponsored a PhD research into the effectiveness of blue carbon habitats in Corangamite and potential carbon sequestration opportunities. Knowledge and opportunities in this area will continue to evolve and should be considered in the overall management of the Gellibrand River estuary.

Reference:

Corangamite CMA (2016) *Corangamite Natural Resource Management Plan for Climate Change*. Corangamite Catchment Management Authority, Colac, Victoria.

Potential blue carbon habitat has been identified at the Gellibrand estuary

Appendix 4:
Water extraction on the Gellibrand River

There are multiple water users on the Gellibrand River, including water authorities (Wannon Water and Barwon Water), Southern Rural Water, irrigators and farm dam owners.

Wannon Water is the largest water user on the Gellibrand River and operate diversions at the North and South Otway Pump Stations, to supply domestic water to major surrounding townships. This accounts for an average annual streamflow reduction of approximately 16,165ML (~5.4%) from natural conditions, with the greatest reductions occurring in the low flow months of December to May (EarthTech 2005).

Agricultural irrigation occurs throughout the catchment, particularly during the summer months. Extraction of flows for domestic and irrigation supply reduces the amount of water reaching the estuary, particularly during warmer, drier months (Baron & Sherwood 2004). Farm dams are predominant throughout the catchment and also have a significant impact on low flows in river.

A body of work exists on the flow requirements to sustain the environmental condition of the Gellibrand river and estuary (Tunbridge & Glenane 1988; Earth Tech 2005-07; Lloyd et. al. 2008) and is the subject of ongoing investigation. Wannon Water, in conjunction with the Corangamite CMA, is currently investigating opportunities to increase freshwater inflows to the system, in particular to support artificial estuary openings.

A recent analysis of estuarine data for the period 2007-2012, found that freshwater inflows, particularly over the summer/autumn period, are the main factor influencing water quality and the overall condition of the Gellibrand River estuary.

The 2007-2012 analysis concluded that at the Gellibrand River estuary the mouth threatens to close if flows are maintained at low levels, there are times that if the flows drop below 100ML/day, even if for only a short period, the mouth may close, and if flows are below 150ML/day for an extended period the estuary mouth may also close.

When berm growth is at 0.9m this appears to be the time when the estuary is the most susceptible to closure, if flows are low. Upon closure of the estuary mouth, if there is a moderate rainfall event that produces a flow of >300ML/day, this is likely to open the estuary mouth. If the flow is below 300ML/day and depending on the length of closure and potential increase in berm development, flows may not be sufficient to open the estuary mouth (CCMA 2012).

Low flows upstream in the Gellibrand River, 2011 (Judy Spafford)

Low water levels near the Old Coach Road boat launch and EstuaryWatch site G2, August 2011 (Judy Spafford)

Appendix 5:
Fish groups at the Gellibrand River estuary

The following table categorises a list of example fish species known to occur at the Gellibrand River estuary, according to their use of the estuarine environment at some stage in their lifecycle.

The fish groups are classified as:

- **Estuarine residents** – specialised fish that complete their entire lifecycle in the estuary; these fish may tolerate variable salinities.
- **Estuarine dependent** – these fish are dependent of the estuary to complete one part of their lifecycle such as spawning, shelter, feeding or as a nursery for their young. These fish may be marine or freshwater species for most of their lives.
- **Estuarine opportunists** – these fish may be freshwater or marine species that use the estuary to exploit the estuary's resources and are likely to visit the estuary on a regular basis.

Table 4. Fish groups in the Gellibrand River estuary (Lloyd et. al. 2008)

Estuary Fish Group	Sub-Types	Example Species present in Gellibrand
A: Estuarine Residents	n/a	Estuary Perch [C,R] Black Bream [C,R] Blue Spot Goby Tamar Goby
B: Estuarine Dependent	Marine Derived (Anadromous)	Congolli (Tupong) [C,R] King George Whiting [C,R] Smallmouth Hardyhead Elongate Hardyhead Mulloway [C,R] Pouched Lamprey Short-headed Lamprey
	Freshwater Derived (Catadromous)	Short-finned Eel [C,R] Australian Grayling# Common Jollytail Climbing Galaxias Spotted Galaxias
C: Estuarine Opportunists	Marine Derived	Long-snout Flounder [C,R] Australian Herring (tommy rough) [C,R] Australian Salmon [C,R] Smooth Toadfish Sea Mullet [C,R] Yellow-Eyed Mullet [C,R] Long-snouted Flounder [C,R] Luderick [C,R] Silver Trevally [C,R]
	Freshwater Derived	Big-headed Gudgeons [C,R] Australian Smelt Brown Trout [R] River Blackfish [R] Southern Pigmy Perch

\# Australian Grayling is listed as vulnerable under the *Victorian FFG Act* and the *Australian Government's EPBC Act.*

C These species have commercial fisheries value.

R These species have recreational fisheries value.

Appendix 6:
Bird species of conservation significance

The following table identifies bird species occurring at the Gellibrand River estuary that have conservation significance under either, or both, of the *Victorian Flora and Fauna Guarantee Act 1988* and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

Table 5. Bird species of conservation significance at state *(FFG Act 1988)* and/or federal *(EPBC Act 1999)* level (DELWP 2016)

Scientific name	Common name	FFG	EPBC
Passerine Birds			
Dasyornis broadbenti	Rufous Bristlebird	L	
Dasyornis broadbenti caryochrous	Rufous Bristlebird (Otway)	L	
Wader Birds			
Thinornis rubricollis rubricollis	Hooded Plover	L	VU
Sternula nereis nereis	Fairy Tern	L	VU
Non-Passerine Birds			
Egretta garzetta nigripes	Little Egret	L	
Ardea modesta	Eastern Great Egret	L	
Botaurus poiciloptilus	Australasian Bittern	L	EN
Lewinia pectoralis pectoralis	Lewin's Rail	L	
Accipiter novaehollandiae novaehollandiae	Grey Goshawk	L	
Marine Birds			
Diomedea exulans	Wandering Albatross	L	VU
Halobaena caerulea	Blue Petrel		VU

L = Listed
VU = Vulnerable
EN = Endangered
CR = Critically Endangered
EX = Extinct

Appendix 7:
Flora species of conservation significance

The following table provides a list of the threatened flora species occurring at the Gellibrand River estuary, including those have conservation significance under the *Victorian Flora and Fauna Guarantee Act 1988* and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

Table 6. Threatened flora species at the Gellibrand River estuary (DELWP 2016)

Scientific name	Common name	Victorian Advisory List	FFG	EPBC
Lachnagrostis rudis subsp. rudis	Rough Blown-grass	Rare		
Baumea laxa	Lax Twig-sedge	Rare		
Cladium procerum	Leafy Twig-sedge	Rare		
Exocarpos syrticola	Coast Ballart	Rare		
Pterostylis tenuissima	Swamp Greenhood	Vulnerable		VU
Pterostylis lustra	Small Sickle Greenhood	Endangered	L	
Eucalyptus ovata subsp. grandiflora	West-coast Swamp-gum	Rare		
Eucalyptus falciformis	Western Peppermint	Rare		
Eucalyptus kitsoniana	Bog Gum	Rare		
Acacia verticillata subsp. ruscifolia	Broad-leaf Prickly Moses	Rare		
Carex tasmanica	Curly Sedge	Vulnerable	L	
Correa alba var. pannosa	Velvet White Correa	Rare		
Stackhousia spathulata	Coast Stackhousia	Poorly known		
Zygophyllum billardierei	Coast Twin-leaf	Rare		
Asplenium appendiculatum subsp. appendiculatum	Ground Spleenwort	Rare		
Cardamine tenuifolia	Slender Bitter-cress			
Olearia sp. 2	Peninsula Dairy-bush	Rare		
Euryomyrtus ramosissima subsp. prostrate	Nodding Baeckea	Rare		

L = Listed
VU = Vulnerable
EN = Endangered
CR = Critically Endangered
EX = Extinct

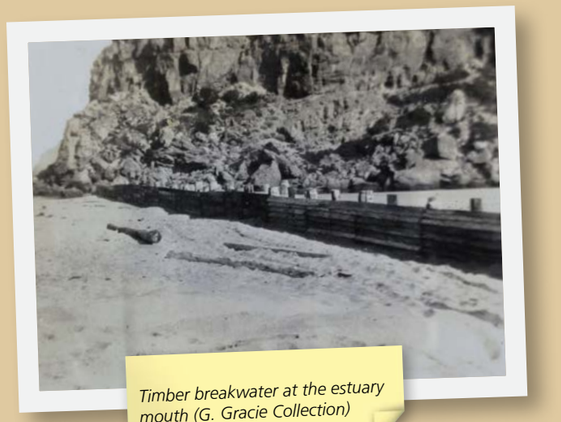
Appendix 8: History of artificial openings

The mouth of the Gellibrand River naturally opens and closes in response to prevailing conditions such as freshwater inflows, weather changes or tidal movements. Periodically a sand bar forms at the mouth of the Gellibrand River causing trapped water to inundate the floodplain. For generations landholders have utilised the floodplains as part of their farming operations, particularly over the summer and autumn months when the fertile floodplains provide valuable grazing pastures.

Over the years there have been several attempts to drain water off the floodplain. Around 1909, a tunnel was built through the headland in an attempt to direct river water unimpeded to the ocean, however it quickly silted up and became inoperable. A timber breakwater was subsequently constructed at the mouth in about 1912, and local landholders suggest this kept the mouth open for 30 years.

Around the 1950s until the early 2000s, landholders would manually open the estuary mouth, initially with shovels then later tractors, using their local knowledge to determine the best opening time which generally coincided with a calm sea, waning tide, good weather and suitable river flows (O'May & Wallace 2001). In 2001 the responsibility for authorising works on waterways at the Gellibrand River estuary was vested with the Corangamite CMA. A permit to manage the opening of the Gellibrand River mouth has since been issued to Parks Victoria.

In 2013 the release of the *Victorian Waterway Management Strategy* required waterway managers to develop a Memorandum of Understanding (MoU) to identify the roles and responsibilities and the process for artificial estuary openings. Work is currently underway to prepare a MoU for the Gellibrand River estuary.



Timber breakwater at the estuary mouth (G. Gracie Collection)

Early estuary openings (D. Lawson) and a more recent opening in 2013 (EstuaryWatch)

Cover: *Gellibrand River estuary entrance*

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