Sustainable Diversion Limit Adjustment

Phase 2 Assessment

Supply Measure Business Case:

Lindsay Island Floodplain Management Project

State Government Victoria Department of Environment and Primary Industries

mallee catchment management authority

Disclaimer

This business case is one of nine Victorian environmental works projects. It was developed over two years ago and submitted for assessment in early 2015 by the Sustainable Diversion Limit Adjustment Assessment Committee (SDLAAC) in accordance with the inter-jurisdictional governance procedures that pertain to the Murray Darling Basin Plan.

This business case relies on assumptions, estimates and other variables that were considered true, accurate and the best available information at the time of development.

As a result of queries raised during the SDLAAC assessment process, there have been changes to certain elements of some projects, including engineering designs, methods of water supply and future operation. These details have not been incorporated or encapsulated in this or any of the other eight business cases relevant to the Sustainable Diversion Limit Adjustment Mechanism within the Murray Darling Basin Plan.

There has, however, been no material changes to the environmental objectives and outcomes proposed to be achieved through these projects. All nine projects will be revisited for final development once Commonwealth funding is made available.

The detailed cost estimates and other commercial-in-confidence information that originally formed part of this and the other eight business cases have been deliberately omitted from this version of the document. This is in recognition that this detail is no longer relevant given the time that has passed since these business cases were originally developed, new delivery methods are applicable in some cases and to ensure that value for money is achieved when these projects are issued for tender.

Executive Summary

The *Lindsay Island Floodplain Management Project* is a proposed supply measure that is designed to off-set water recovery under the Murray-Darling Basin Plan by achieving equivalent or better environmental outcomes on the ground. The Victorian Government's long standing position is that efficient environmental watering is critical to the long-term success of the Basin Plan.

This view is based on the understanding that engineering works like flow control regulators, pipes and pumps can achieve similar environmental benefits to natural inundation, using a smaller volume of water to replenish greater areas. Works also allow for environmental watering in areas where system constraints prevent overbank flows and, due to the smaller volumes required, can be used to maintain critical refuge habitat during droughts.

This project is one of several proposed by the Victorian Government as having the potential to meet the Basin Plan's environmental objectives through smarter and more efficient use of water.

Lindsay Island is located within the larger lower Murray floodplain, downstream of the junction of the Murray and Darling rivers. This floodplain includes Chowilla, Mulcra and Wallpolla Islands and is nationally recognised for its high environmental and cultural values. The site is part of the Murray-Sunset National Park, which is managed for environmental conservation.

The *Lindsay Island Floodplain Management Project* presents a unique opportunity to protect and enhance an area that is critically important to the biodiversity of the entire lower Murray region. The ecological significance of the Lindsay Island floodplain complex is underpinned by its unique location, providing longitudinal connection to the River Murray and its floodplains, as well as lateral connection into the semi-arid Mallee environment.

The River Murray flow at Lindsay Island has been altered significantly by storages, regulation and diversion upstream on both the Murray and Darling rivers. This has caused a reduction in large winter and spring flow peaks and an increase in low summer flows. Locks and weirs have removed local fluctuations in river levels (Ecological Associates, 2014a).

Through the construction of one major regulating structure, supported by supplementary works and track raising, this project will enable the connection of many parts of the floodplain through tiered watering events, including areas of unique fast-flowing aquatic habitat, through to sections of black box, lignum and onto the higher alluvial terraces. Watering will be able to occur at a landscape scale restoring ecosystem function to 5152 hectares of highly valued floodplain, mimicking flows of 40,000 ML/day to greater than 120,000 ML/day.

This project will achieve vital environmental improvements beyond what is expected to be possible under the anticipated increase in River Murray flows delivered through the implementation of the Murray-Darling Basin Plan. It will complement existing environmental infrastructure to greatly expand the watering options available and provide the flexibility to tailor watering to ecological cues and requirements.

The operation of the proposed Lindsay Island project in conjunction with the Mulcra Island and Chowilla Floodplain infrastructure, weir pool manipulation and other nearby environmental watering events, will dramatically increase and improve available floodplain habitat for flood-dependent fauna beyond that provided by the operation of either project, or Basin Plan flows, in isolation.

The project will provide significant benefit to nationally important species, ecological values, carbon cycling and downstream water quality for Lindsay Island and the lower Murray region more generally.

A broad level of community support exists for this project, which is the result of working directly with key stakeholders and community members to ensure the integration of local knowledge and advice into the project. Stakeholders materially affected by the Lindsay Island project such as Trust for Nature and Parks

Victoria, have provided in-principle support for the progression of the project, along with a number of individuals, groups and organisations central to the project's success, including Lindsay Point Irrigators, adjacent landholders, Aboriginal stakeholders and community groups.

Further confidence in the success of this project can be taken from the extensive knowledge, skills, experience and adaptive management expertise of the agencies involved in the development of this project. This is evidenced by more than a decade of environmental water delivery and successful construction and operation of environmental infrastructure projects that have delivered measurable ecological benefits across the region.

The *Lindsay Island Floodplain Management Project* has been developed by the Mallee Catchment Management Authority (CMA), on behalf of the Victorian Government, and in partnership with the Department of Environment and Primary Industries, Parks Victoria, Goulburn-Murray Water and SA Water, through funding from the Commonwealth Government.

Project risks have been comprehensively analysed and are well known. They can be mitigated through established management controls that have been successfully applied to previous watering projects by the Mallee CMA and partner agencies, as well as the Murray-Darling Basin Authority (MDBA), Commonwealth and Victorian Environmental Water Holders. The adoption of these standard mitigation measures minimise the risks associated with the implementation of this project.

Project costs that will be subject to a request for Commonwealth funding totalling $72,831,526 in 2014 present value terms. Victoria is seeking 100 per cent of these costs from the Commonwealth. In terms of project benefits, the value of water savings is not estimated within this business case.

This business case presents the cost to fully deliver the project (i.e. until all infrastructure is constructed, commissioned and operational), including contingencies. Cost estimates for all components in this proposal are based on current costs, with no calculation undertaken of future cost escalations. To ensure sufficient funding will be available to deliver the project in the event that it is approved by the Murray-Darling Basin Ministerial Council for inclusion in its approved Sustainable Diversion Limit (SDL) Adjustment Package to be submitted to the MDBA by 30 June 2016, cost escalations will be determined in an agreed manner between the proponent and the investor as part of negotiating an investment agreement for this project.

Contents

Acronyms

AEM	Airborne Electromagnetic datasets
AH Act 2006	Victorian *Aboriginal Heritage Act 2006*
ANCOLD	Australian National Committee on Large Dams
ARG	Aboriginal Reference Group
AS/NZS ISO 31000:2009	Australia and New Zealand Risk Management Standard 2009
BSMS	Basin Salinity Management Strategy
CEMP	Construction Environmental Management Plan
CEWH	Commonwealth Environment Water Holder
CFA	Country Fire Authority
CHMP	Cultural Heritage Management Plan
CMA	Catchment Management Authority
CPI	Consumer Price Index
CRG	The Living Murray Community Reference Group
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWA	Country Women's Association
DEPI	Department of Environment and Primary Industries
DO	Dissolved Oxygen
DTF	Department of Treasury and Finance
EE Act 1978	Victorian *Environmental Effects Act 1978*
EMP	Environmental Management Plan
EPBC Act 1999	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EVC	Ecological Vegetation Class
EWMP	Environmental Works and Measures Program
FFG Act 1988	*Flora and Fauna Guarantee Act 1988* (Vic)
G-MW	Goulburn-Murray Water
GST	Goods and Services Tax
IGA	Intergovernmental Agreement on Murray-Darling Basin Water Reform 2014
ISO	International Organisation for Standardisation
LWAC	Land and Water Advisory Committee
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MER	Monitoring, Evaluation and Reporting
MERI	Monitoring, Evaluation, Reporting and Improvement
MLDRIN	Murray Lower Darling Rivers Indigenous Nations
MNES	Matters of National Environmental Significance
NP Act 1975	*National Parks Act 1975* (Vic)
NSW	New South Wales
OPBR	Office of Best Practice Regulation
OH&S	Occupational Health and Safety
O&M	Operations and Maintenance
PCB	Project Control Board
PE Act 1987	*Planning and Environment Act 1987* (Vic)
PPE	Personal Protective Equipment
RGG	Regulatory Governance Group
SA	South Australia
SDL	Sustainable Diversion Limit
TEV	Total Economic Value
TLM	The Living Murray
TSMP	Threatened Species Management Plan

VEAC	Victorian Environmental Assessment Council
VEWH	Victorian Environment Water Holder
WRC	Water Regime Classes
WRP	Water Resource Plan
WTP	Willingness to Pay

Abbreviations

Basin	Murray-Darling Basin
Basin Plan	The Murray-Darling Basin Plan adopted by the Commonwealth Minister under section 44 of the *Water Act* 2007 (Cth) on 22nd November 2012
Guidelines	Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases
No.	Number
N/A	Not applicable
4WD	Four wheel drive

Units

cm/day	Centimetres per day
EC	Electrical conductivity
GL	Gigalitres
ha	Hectares
km	Kilometres
m AHD	Elevation in metres with respect to the Australian Height Datum
m/s	Metres per second
ML	Megalitres
ML/d	Megalitres per day
ha	Hectares
m	Metres
mm	Millimetres
mS/cm	Millisiemens per centimetre
µS/cm	Microsiemens per centimetre
$M	Million dollars

1. Introduction

1.1 Context

This Business Case for the *Lindsay Island Floodplain Management Project* has been developed in accordance with the Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases. This project is one of nine proposed works-based supply measures within Victoria, and one of seven within the Mallee Catchment Management Authority (CMA) region, as listed below:

- Lindsay Island
- Wallpolla Island
- Hattah Lakes North
- Belsar-Yungera Floodplain
- Burra Creek
- Nyah, and
- Vinifera.

These sites will work in conjunction with proposed altered river operations and existing environmental infrastructure to deliver environmental outcomes as set out under the Basin Plan, using less water.

Figure 1-1 provides a conceptual overview of the distribution of sites across the Mallee CMA region and the longitudinal connection to the lower Murray region.

1.2 Forest overview

Lindsay Island is nationally recognised for its outstanding environmental values and significant cultural values. It is located within the larger lower Murray floodplain, downstream of the junction of the River Murray and Darling River. The River Murray and the Lindsay River anabranch enclose Lindsay Island. Lindsay River diverges from the River Murray below Lock 8 and re-joins the river above Lock 6, bypassing Lock 7 (Figure 1-2). The island and its adjacent floodplain encompass 15,000 ha and extends 28 km from east to west (Mallee CMA, 2010).

Lindsay Island is part of the Chowilla Floodplain-Lindsay-Wallpolla Icon Site identified under The Living Murray initiative (TLM). The proposed works complement the existing Upper Lindsay Watercourse Enhancement Project, funded through TLM's Environmental Works and Measures Program (EWMP).

The Lindsay Island site forms part of the Murray-Sunset National Park, managed by Parks Victoria, and also includes a wetland on private land, which is owned by Trust for Nature and managed for conservation.

Lindsay Island holds great significance for the local Indigenous community. Aboriginal occupation at Lindsay Island dates back thousands of years and was sustained by the rich productivity of the floodplain and woodland systems. There is a diverse range of site types and complexes, which appear to be closely associated with floodplain features (SKM, 2004). Shell middens, hearths and culturally scarred trees are found throughout the area (Bell, 2013).

Lindsay Island is a popular recreation site for visitors to the region and local communities in Victoria and South Australia (Aither, 2014). Recreational use of the site includes fishing, camping, boating, canoeing, bird and wildlife watching, photography, motor biking and four-wheel driving.

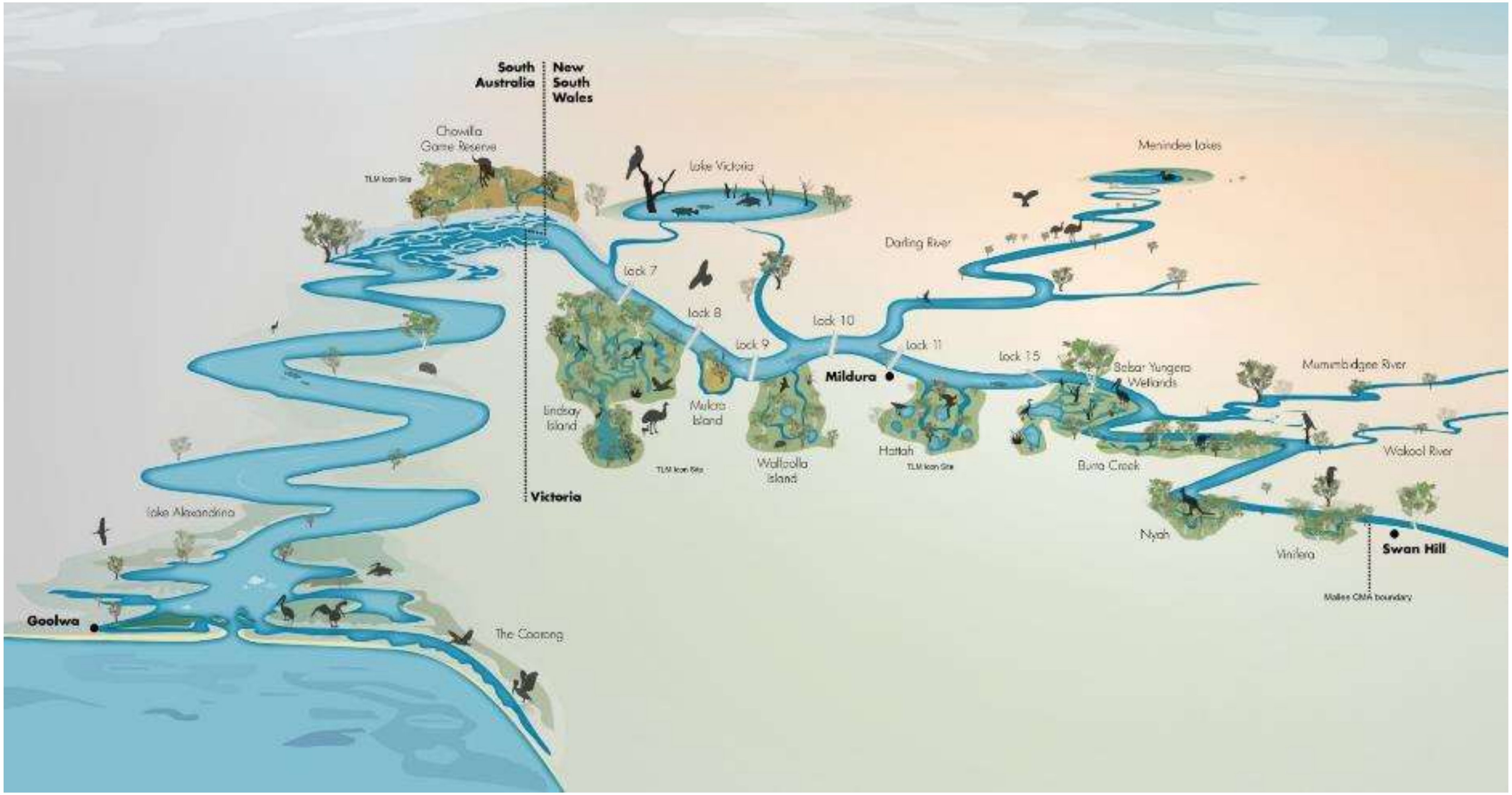


Figure 1-1. Conceptual diagram showing the distribution of proposed supply measure sites across the Mallee CMA region (Vinifera, Nyah, Burra Creek, Belsar-Yungera, Hattah (North), Wallpolla, Lindsay Island), TLM EWMP sites (Hattah Lakes, Mulcra Island, Chowilla Game Reserve and parts of Lindsay Island) and the longitudinal connection to the lower Murray region (note: diagram is not to scale)

Key threats to Lindsay Island and its values include the reduction in the frequency, duration and size of floods, as well as the loss of variability in hydrological regimes, caused by river regulation. Over time, these have resulted in the gradual degradation of the flood-dependent components of the Lindsay Island ecosystem.

1.3 The proposal

This project will improve connectivity across this vast floodplain, restore ecosystem function, and result in environmental benefits beyond those that are expected to be achieved under the Murray-Darling Basin Plan through increased flows alone. The aim is to protect and restore the health of the floodplain ecosystem by increasing the frequency and duration of watering events at this site.

This project provides a unique opportunity to protect and restore landscape condition, which will provide significant benefit to nationally important species, threatened vegetation communities and system carbon cycling. This will benefit both Lindsay Island and the broader lower Murray region more generally.

A range of options have been investigated to address the changes to hydrology to achieve defined ecological objectives. Feasibility, cost-effectiveness and ability to meet objectives have been considered in the analysis of all options. This has resulted in the development of a cost effective package of environmental works and measures that achieves the ecological objectives for Lindsay Island by providing a hydrological regime that meets the requirements of the indigenous fauna and flora.

The Lindsay Island Floodplain Project will inundate 5152 ha and consists of the construction of the Berribee Regulator, one vertical slot fish-way, five containment regulators and 2.6 kilometres of raised tracks[1] to promote widespread inundation. A maximum inundation level of 23.2 m AHD at the Berribee Regulator will inundate 3,546 ha of Lindsay Island Floodplain, river benches and wetlands. This involves the raising of Lock 7. This is referred throughout this document as the Primary Component. The Secondary Component involves the addition of 13 regulators and 4.9 km of raised track and ancillary works at five locations which will be used to inundate an additional 1606 ha of floodplain reusing the water delivered through the Primary option.

For ease of reference, a fold-out map has been included as Appendix A to provide a spatial representation of the planned works discussed in this document.

1.4 Project development

The feasibility study and business case for this proposed project has been developed by the Mallee CMA, on behalf of the Victorian Government and in partnership with the Department of Environment and Primary Industries, Parks Victoria, Goulburn-Murray Water, SA Water, through funding from the Commonwealth Government.

This proposal draws on a decade of collective experience from all project partners in the construction of large-scale environmental works and measures programs and environmental water delivery in the Mallee region. A recent example of collaborative work successfully delivered by this team includes the $32 million Living Murray environmental infrastructure project at Hattah Lakes; a project that delivered environmental water to more than 6000 hectares of Ramsar-listed lakes and floodplain.

1.5 Project stakeholders

The Mallee CMA has worked with key stakeholders and interested community groups to develop the concept for the Lindsay Island project. The project has high visibility among materially affected and adjacent landholders/managers, along with Aboriginal stakeholders and other interested parties. This strong

[1] 'Track raising' is used throughout this business case to refer to the building up of existing tracks to form minor levees to contain water on the floodplain. This method enables duration targets to be met while minimising the construction footprint.

commitment to working directly with project partners and the community will be ongoing throughout the construction and implementation phases of the project, further cementing community support for the Lindsay Island project and ensuring it will continue to be a successful project.

Above: Temporary pumping infrastructure delivering water from Lindsay River to Lake Wallawalla (August, 2010), which had previously been dry for more than a decade. Below: High River Murray flows (flow to SA 84, 306 ML/day) in early 2011 complemented environmental watering to fill Lake Wallawalla. Earlier environmental water delivery is visible as the lighter brown colour in Lake Wallawalla; the darker brown colour is natural flows.

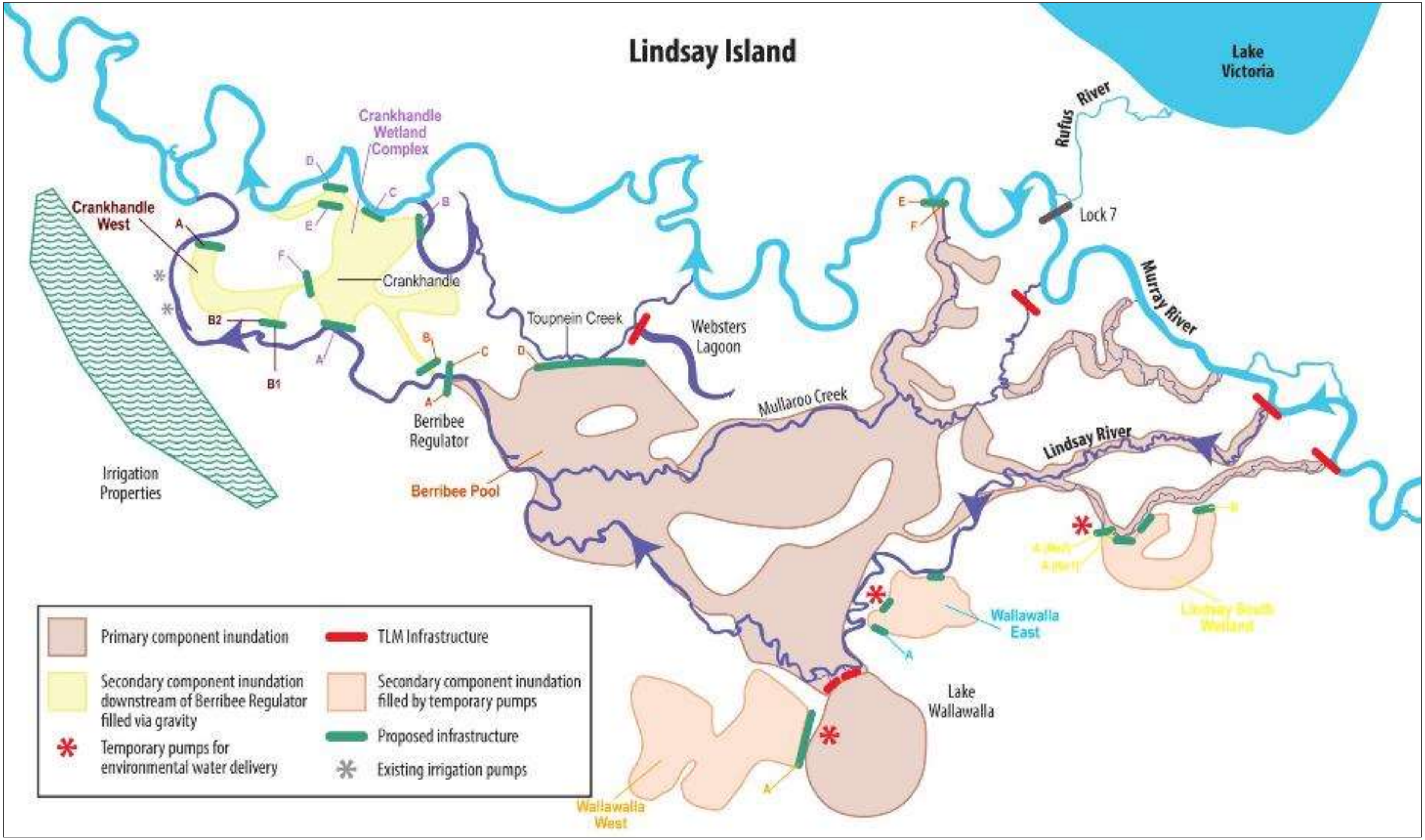


Figure 1-2. Representation of planned works and inundation at the Lindsay Island site. Diagram is not to scale

2. Eligibility (Section 3.4)

Victoria considers that this supply measure meets the relevant eligibility criteria for Commonwealth supply measure funding.

In accordance with the requirements of the Murray-Darling Basin Plan, Victoria confirms this is a new supply measure, additional to those already included in the benchmark assumptions under the Plan.

Pending formal confirmation of off-set potential, the operation of this measure is expected to:

- Increase the quantity of water available for consumptive use
- Provide equivalent environmental outcomes with a lower volume of held environmental water than would otherwise be required under the Basin Plan, and
- Be designed, implemented and operational by 30 June 2024.

This business case demonstrates in detail how each of the criteria (above) is met.

Other than the provision of financial support to develop this business case, this proposal is not a 'pre-existing' Commonwealth funded project, and it has not already been approved for funding by another organisation, either in full or in part.

Mullaroo Creek, critical Murray cod habitat, part of Lindsay Island (2010). Photo courtesy Chris Woods

3. Project Details (Section 4.1)

3.1 Description of proposed measure, including locality map

The *Lindsay Island Floodplain Management Project* is a supply measure project located on the River Murray floodplain, 100 km west of Mildura in northwest Victoria (Figure 3-1). In accordance with the Phase 2 Assessment Guidelines, this project falls within the category of environmental works and measures at point locations. Victoria is seeking 100 per cent of project capital costs that are in scope for Commonwealth Supply or Constraint Measure Funding from the Commonwealth.

The project will restore the integrity and productivity of the aquatic, riparian and floodplain ecosystem by increasing the frequency and duration of floodplain inundation.

The supply measure works at Lindsay Island comprise the Berribee Regulator and vertical-slot fishway, 23 containment regulators, and 7.5 km of raised track to inundate 5,152 ha of Lindsay Island floodplain, wetlands and river benches (Figure 3-2).

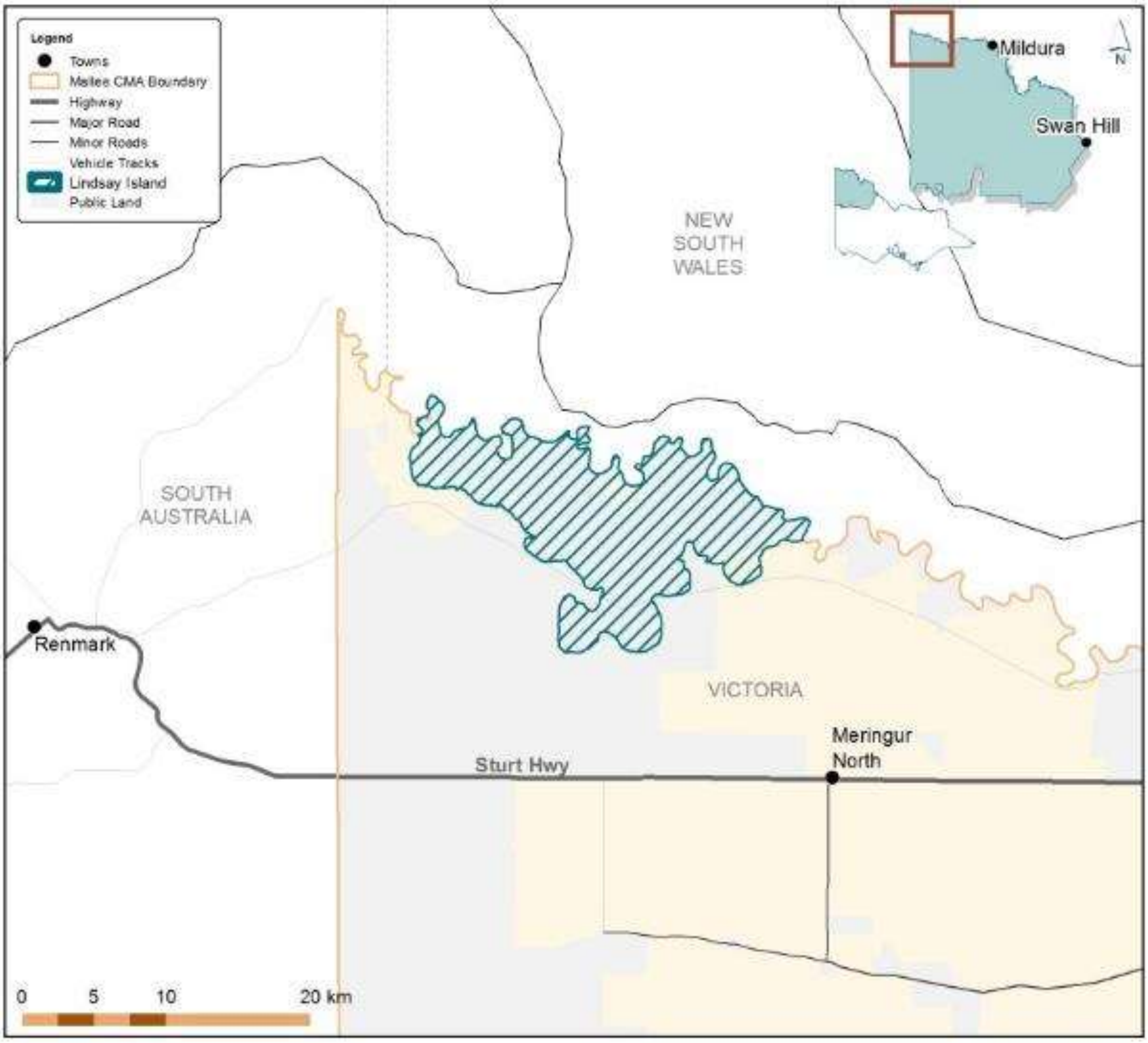


Figure 3-1. Location of the Lindsay Island Floodplain Project

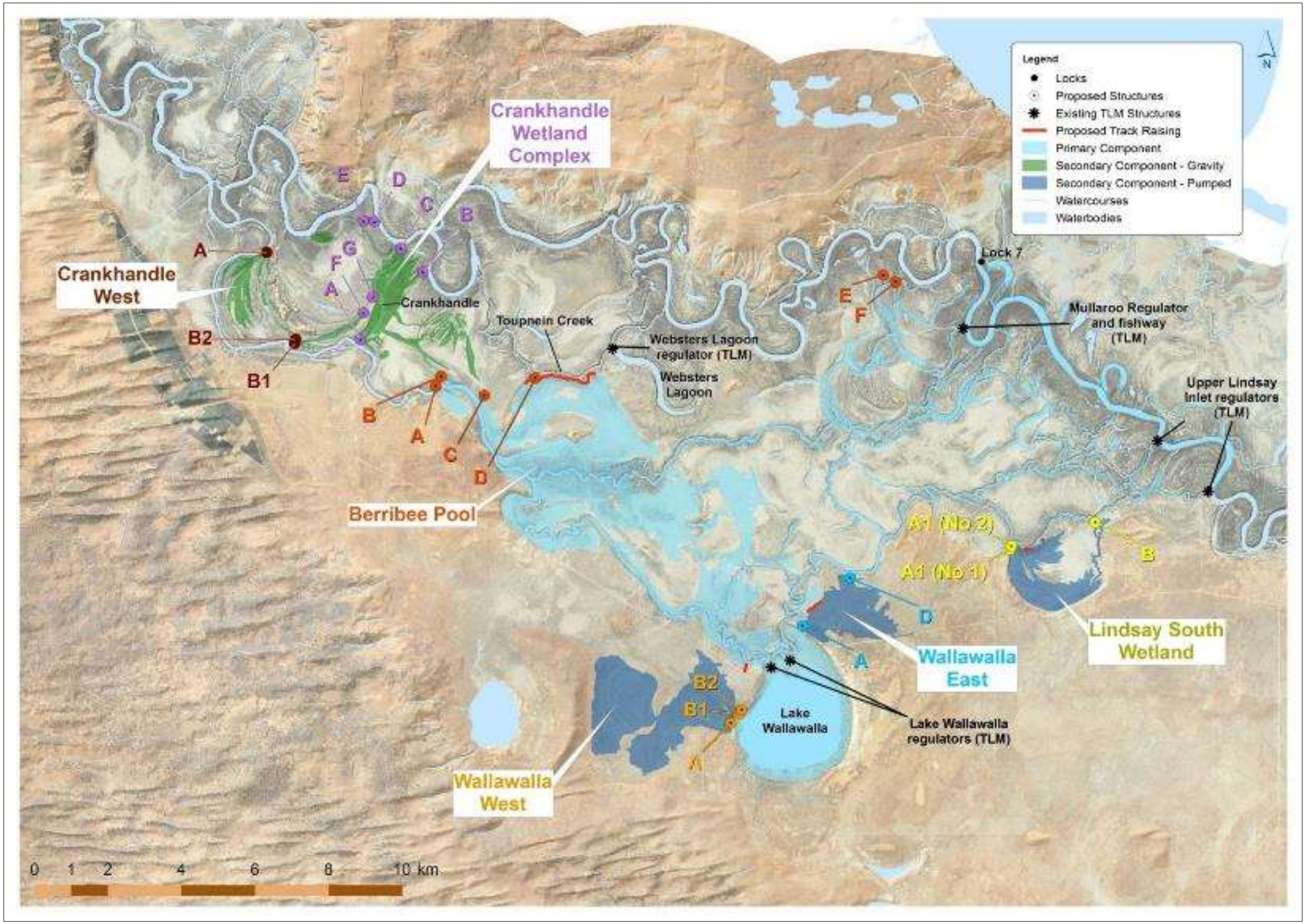


Figure 3-2. Proposed and existing works and inundation extents. Please refer to Appendix A for a large fold out version of this map

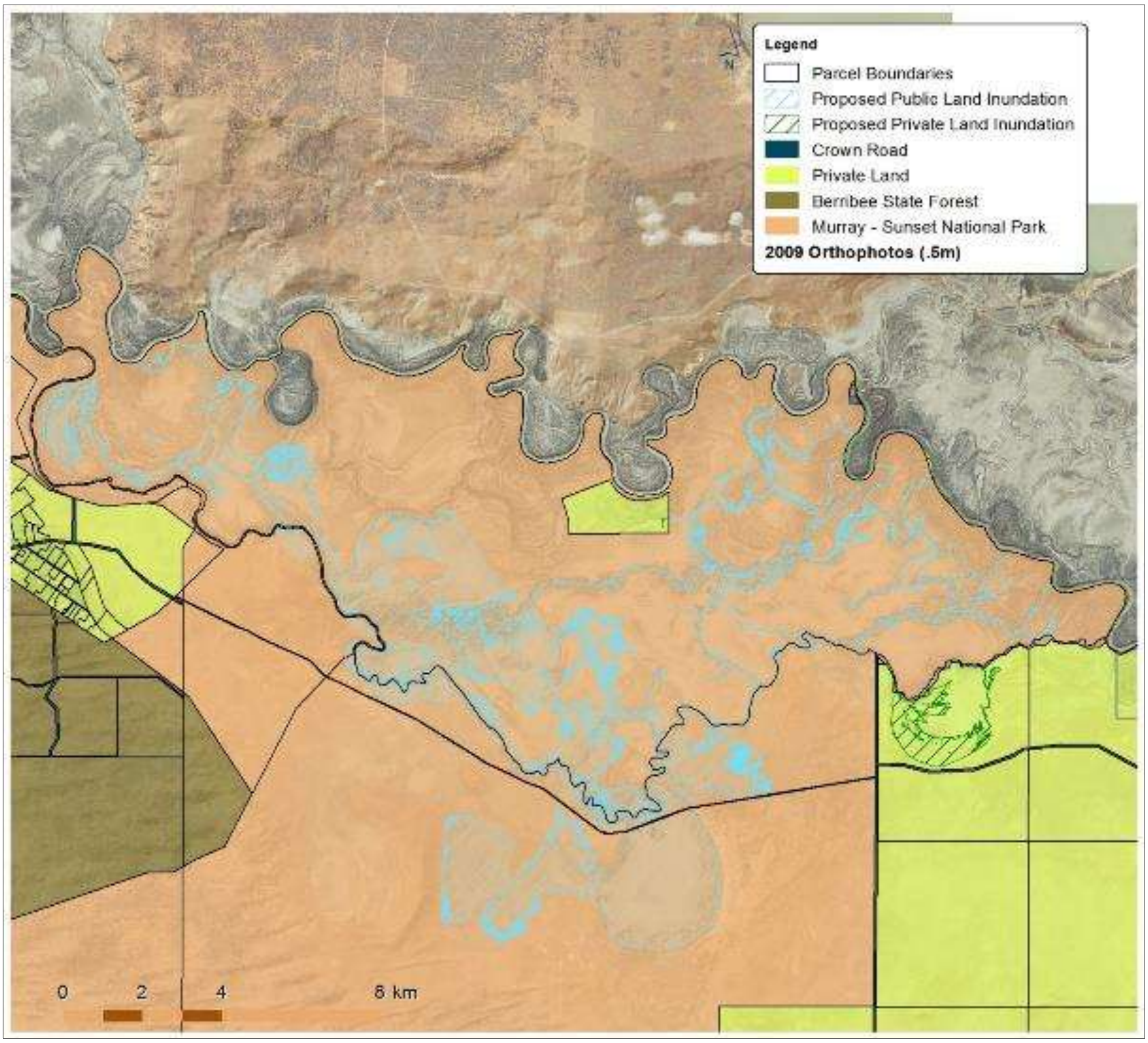


Figure 3-3. Land tenure and proposed inundation extents

3.2 Environmental works and measures at point locations

The *Lindsay Island Floodplain Management Project* consists of a Primary and Secondary Component. The Primary Component utilises the Berribee Regulator and Lock 7 weir pool to inundate the central area of Lindsay Island. The Secondary Component is additional area that can be inundated by delivering water held by the Primary Component, either by temporary pumping or gravity flow. Figure 3-2 outlines the inundation area achieved by the Primary and Secondary Components, while Figure 3-3 shows the inundation area according to land tenure, including 250 ha of private land owned by Trust for Nature and managed for conservation.

Primary Component works

The Primary Component involves the construction of the Berribee Regulator, one vertical slot fish-way, five containment regulators and 2.6 kilometres of raised tracks to promote widespread inundation across much of the floodplain. A maximum inundation level of 23.2 m AHD at the Berribee Regulator will inundate 3,546 ha of Lindsay Island floodplain, river benches and wetlands. Using existing infrastructure, Lock 7 would be surcharged by up to 1.1 m to provide the driving head required to achieve floodplain inundation (GHD, 2014b).

The Upper Lindsay Inlet Regulators Mullaroo Creek Regulator and Fishway, constructed under The Living Murray program, have standalone functionality but were designed as Stage 1 of the *Lindsay Island Floodplain*

Management Project. As such, the existing structures are fully compatible with the proposed works.

The Primary Component targets the mid and upper reaches of Lindsay Island, achieving inundation levels equivalent to a 40,000 ML/d to 90,000 ML/d River Murray flow (Water Technology, 2014). The corresponding area of inundation is shown in Figure 3-2 and is comprised of:

- Lake Wallawalla
- Upper Mullaroo Wetland Complex
- Upper Lindsay Wetland Complex
- Upper Lindsay East Wetland Complex, and
- Lower Lindsay River.

Secondary Component works

The Secondary Component includes 13 regulators and 4.9 km of raised track and ancillary works to inundate an additional 1,606 ha of floodplain, reusing the water delivered through the Primary Component inundation (GHD, 2014b). Temporary pumps would deliver water held by the Primary Component to three higher floodplain terraces, including:

- Wallawalla West
- Wallawalla East, and
- Lindsay South Wetland.

Water may also be released, utilising gravity flow, from the Berribee Regulator pool to inundate the Crankhandle Wetland Complex and Crankhandle West.

Analysis of inundation flow equivalence (Water Technology, 2014) for the secondary component shows that the inundation of Crankhandle Complex and Crankhandle West is equivalent to flows between 50,000 and 80,000 ML/d. Furthermore, the inundation of Wallawalla West, Wallawalla East and Lindsay South Wetland is equivalent to flows exceeding 120,000 ML/d (Water Technology, 2014).

These combined works will provide efficient watering at a large landscape scale producing high ecological benefits that are well above what is expected to be achieved by the planned Basin Plan flows of up to 80,000 ML/d (GHD, 2013). By delivering these outcomes through works, a smaller volume of water will be required.

The proposed primary and secondary component works are listed in Tables 3-1 and 3-2 respectively and areas of inundation are shown in Figure 3-2. Table 3-1 provides detailed information about the Primary Component works, including the Berribee Regulator and its associated support structures. Table 3-2 provides summary information on each of the Secondary Component inundation areas and their associated structures.

These structures will be operated in response to the seasonal flow in the River Murray and ecological cues in order to meet environmental watering targets.

Table 3-1. Primary component works components (GHD 2014b)

Name	Description - Size of structure, function
Berribee Regulator and vertical slot fishway (shown in Figure 3-2 as **Berribee Pool A**)	This regulator is similar to the regulators along the River Murray and includes: a new regulator and associated bridge deck access and abutment works at the Berribee Homestead location; cast in situ base, walls and piers, founding on sheet pile cut offs and concrete piers. 11 No. 6.1 m wide x 7.5 m high bays, using reinforced pre-stressed concrete stop logs lifted with rail tracked excavator with a hydraulic grab. Vertical slot fish way, 1(V):20(H) gradient, with an operating range 4m approx.
Regulator B (shown in Figure 3-2 as **Berribee Pool B**)	Controls the movement of water into Billgoes Billabong. Located on the existing track, upstream of Berribee Regulator. Construction will be: precast or cast in situ base, founding on concrete shear keys; box culverts 2 No. 1200 mm wide x 900 mm high; 80 m long minor regulator / crossing structure on existing flood runner.
Regulator C (shown in Figure 3-2 as **Berribee Pool C**)	Controls the movement of water into a secondary flood runner. Located on the existing track, upstream of Berribee Regulator. Construction will be: precast or cast in situ base, founding on concrete shear keys; box culverts 2 No. 1200 mm wide x 300 mm high; 140 m long minor regulator / crossing structure on existing flood runner.
Track raising D (shown in Figure 3-2 as red line adjacent to **Berribee Pool D**).	Track raising of 2.2 km (approx.) in length, with culverts to maintain the continuity of flow with the Toupnein Creek area. The height of the track raising for the majority of the length is less than 0.5 m, except at defined 3 No. flood runners where 0.75 m diameter pipes are installed.
Regulator D (shown in Figure 3-2 as **Berribee Pool D**)	Construction will be: precast or cast in situ base, founding on concrete shear keys; box culverts 3 No. 1800 mm wide x 1800 mm high x 4.88 m long with drop boards.
Regulator E (shown in Figure 3-2 as **Berribee Pool E**)	Controls the breakout of water to the north, located on the existing track. Construction will be: precast or cast in situ base, founding on concrete shear keys; box culverts 3 No. 1200 mm wide x 300 mm high; 30 m long minor regulator / crossing structure on existing flood runner.
Regulator F (shown in Figure 3-2 as **Berribee Pool F**)	Controls the movement of water into key inlet to the Little Mullaroo Creek. Located on the existing track. Construction will be: precast or cast in situ base, founding on concrete shear keys; box culverts 1 No. 1800 mm wide x 1800 mm high; 175 m long minor regulator/crossing structure on existing flood runner.

Table 3-2. Secondary component works components (GHD 2014b)

Secondary Component Works	
Name	**Description - Size of structure, function**
Wallawalla west (shown in Figure 3-2 as **Wallawalla west**)	A combined track raising and regulator structure is proposed to hold water, which is pumped from the Lindsay River. The proposed raised track structure will incorporate an access track 845 m long, which will provide access to the regulator structure for operational purposes. Regulator A comprises a 1 No. 1800 mm wide x 1800 mm high box culvert, with drop boards. Structure B1 and B2 designates a 400 m long hard stand and a 1 No. 1200 mm wide x 900 mm high road culvert structure, with drop boards.
Wallawalla east (shown in Figure 3-2 as **Wallawalla east**)	Three track raising structures (A – 440 m long, B – 400 m long, C – 140 m long) to contain water to the target height across the floodplain. The raised tracks are to be located along existing tracks and extend across small depression areas. Regulator A comprises a 4 No. 1200 mm wide x 600 mm high box culvert arrangement with provision for drop boards. Structure D designates a 3 m x 6 m compacted crushed rock hard stand.
Crankhandle Wetland Complex (shown in Figure 3-2 as **Crankhandle Wetland Complex**)	Seven track raising structures (A – 120 m long, B – 90 m long, C – 230 m long, D – 100 m long, E – 255 m long, F – 175 m long and H – 20 m long) to contain water on the floodplain to the target height. Regulator A comprises a 2 No. 1800 mm wide x 1800 mm high box culvert arrangement with drop boards. Regulator B comprises a 2 No. 1200 mm wide x 1200 mm high box culvert arrangement with drop boards. Regulator C comprises a 2 No. 1200 mm wide x 1200 mm high box culvert arrangement with drop boards Regulator D comprises a 2 No. 1200 mm wide x 900 mm high box culvert arrangement with drop boards. Regulator E comprises a 2 No. 1200 mm wide x 1200 mm high box culvert arrangement with drop boards Regulator F comprises a 2 No. 1200 mm wide x 900 mm high box culvert arrangement with drop boards Location G comprises a 195 m long channel with of 15 m bed width.
Crankhandle West (shown in Figure 3-2 as **Crankhandle West**)	Four track raising structures (A1 – 180 m long, A2 – 400 m long, B1 – 20 m long, B2 – 29 m long, and C – 29 m long) to contain water to the target height across the floodplain. Regulator A1 comprises a 4 No. 1800 mm wide x 1800 mm high box culvert arrangement with drop boards. Regulator B1 comprises a 2 No. 1800 mm wide x 1800 mm high box culvert arrangement with drop boards. Regulator B2 comprises a 2 No. 1200 mm wide x 600 mm high box culvert arrangement with drop boards.

Lindsay South Wetland (shown in Figure 3-2 as Lindsay South Wetland)	Four track raising structures (A1 – 440 m long, A2 – 400 m long, A3 – 140 m long and B – 29 m long) to contain water on the floodplain to the target height. Regulator A1 comprises two structures of 4 No. 1200 mm wide x 1200 high mm arrangements, both with drop boards Regulator B comprises a 2 No. 1200 mm wide x 750 high box culvert arrangement with drop boards. Structure C designates a 3 m x 6 m compacted crushed rock hard stand.

3.3 Name of proponent and proposed implementing entity

As the project owner, DEPI will have oversight responsibility for project implementation, pending confirmation of construction funding. Further information regarding the proposed governance and project management arrangements for implementation is provided in Section 17.

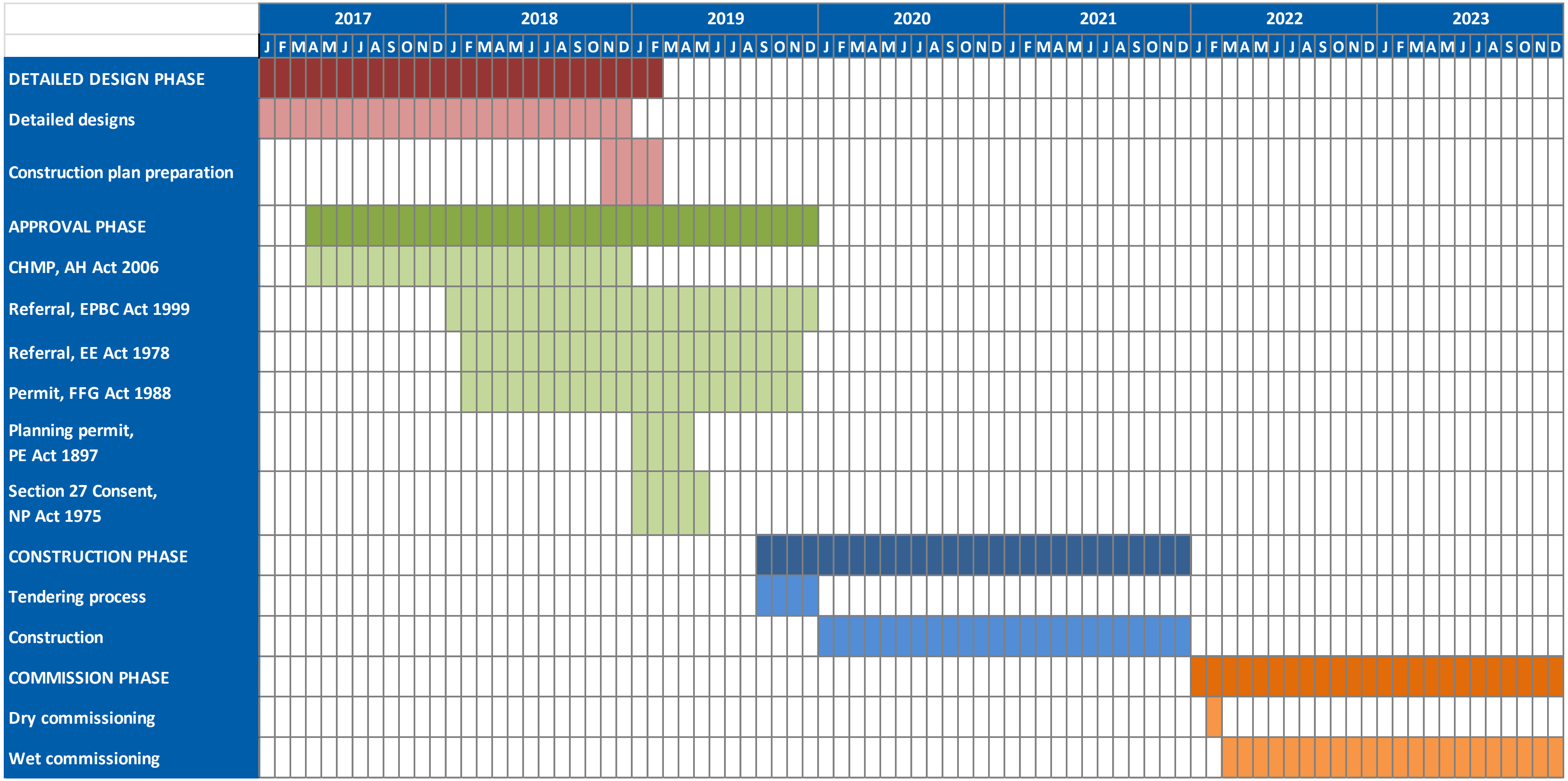
3.4 Summary of estimated costs and proposed schedule

The total cost of the *Lindsay Island Floodplain Management Project* is $72,831,526. This business case presents the cost to fully deliver the project (i.e. until all infrastructure is constructed, commissioned and operational), including contingencies. Cost estimates for all components in this proposal are based on current costs, with no calculation undertaken of future cost escalations. To ensure sufficient funding will be available to deliver the project in the event that it is approved by the MDB Ministerial Council for inclusion in its approved SDL Adjustment Package to be submitted to the MDBA by 30 June 2016, cost escalations will be determined in an agreed manner between the proponent and the investor as part of negotiating an investment agreement for this project. Further details on costs are provided in Section 14.

Table 3-3 outlines a high-level proposed project delivery schedule. The program does not include durations for hold points at project gateways, as these are yet to be confirmed. The works will be fully operational prior to 2024.

The Lake Wallawalla environmental regulator, constructed under The Living Murray program in 2006

Table 3-3. Proposed project delivery schedule. Timelines are indicative only and will depend on finalisation of funding agreements



4. Ecological values of the site (Section 4.2)

4.1 Fauna values

Description of values and features

The ecological significance of the Lindsay Island floodplain complex is underpinned by its unique location, providing longitudinal connection to the River Murray and its floodplains, as well as lateral connection into the semi-arid Mallee environment. The complex is contiguous with the broader Murray-Sunset National Park, which extends 100 km to the south and encompasses 677,000 ha (Parks Victoria, pers. comm. 2014). This provides an essential biodiversity corridor allowing for species to move between environments vital to their life-cycles (Ecological Associates, 2014a). Fauna that regularly use the corridor include regent parrot and Major Mitchell's cockatoo. These birds feed in Mallee vegetation and nest in hollow-bearing trees on the floodplain. Many mammals, reptiles and birds of conservation significance, including fat-tailed dunnart, bats, Giles planigale, carpet python and bush birds, live in both the floodplain and terrestrial landscapes (Ecological Associates, 2014a).

The floodplain incorporates a diverse range of landforms, water bodies and vegetation communities including creeks, temporary anabranches, wetlands, woodlands and grasslands, providing a mosaic of habitat types. This, in turn, supports a vast array of fauna species including three Environmental Protection and Biodiversity Conservation (EPBC) Act-listed species: regent parrot (*Polytelis anthopeplus monarchoides*), growling grass frog (*Litoria raniformis*) and Murray cod (*Maccullochella peelii*); and twenty-seven fauna species listed under Victoria's Flora and Fauna Guarantee Act 1998 (FFG Act); along with a further 52 fauna and 75 flora species of conservation significance (GHD, 2013a).

The site provides important habitat for Murray cod and other native fish species. The Mullaroo Creek currently supports one of the most significant populations of Murray cod in the lower River Murray and Victoria, which exhibits significantly better structure and abundances than populations found in any other Victorian system (Saddlier et al, 2008; Sharpe et al, 2009). It is the robustness of the Mullaroo Creek population that makes it of particular importance to the sustainability of broader regional populations (Sharpe et al., 2009). The creek also provides essential habitat for a number of other native fish including Australian smelt, silver perch (*Bidyanus bidyanus*) and golden perch and, in more recent years, freshwater catfish (*Tandanus tandanus*) (Mallen-Cooper, 2012). Both the silver perch and the freshwater catfish are listed under the FFG Act.

Lindsay Island has a highly diversity of bird fauna with 196 bird species reported from the site, of which 35 have conservation significance at the state and national level and four are protected under international migratory bird agreements. Lindsay Island and Lake Wallawalla are important as habitat for both nomadic and migratory waterbirds, supporting species listed under the Japan-Australia, China-Australia and Republic of Korea-Australia migratory bird agreements. The area provides refuge in times of drought in central and eastern Australia, and important waterbird breeding and feeding habitat during inundation events (Ecological Associates, 2014a). The Chowilla Floodplain-Lindsay-Wallpolla system is ranked in the top ten wetlands in terms of waterbird abundance (Kingsford et al, 2013). A survey of Lake Wallawalla when it was flooded in summer 2012 recorded 17 species of 244 individuals (Henderson et al, 2012).

Spoonbill looking for fish as Lake Wallawalla enters a drying phase (2013). Photo courtesy Chris Woods

Lindsay Island also provides habitat for a range of reptiles and frogs. Twenty-eight reptile species have been reported, including five species of conservation significance. Six frog species occur, including the nationally vulnerable growling grass frog (GHD, 2014, in Ecological Associates, 2014a).

The bat fauna of Lindsay Island is diverse with nine species having been observed at the site (GHD, 2014). The bats are almost entirely insectivorous. Flooding maintains the high levels of canopy and understorey productivity required to attract insect prey while trees provide roosting habitat in bark, crevices and hollows.

Murray cod in Mullaroo Creek (2010)

4.2 Vegetation values

Lindsay Island has a diverse flora assemblage and supports numerous vegetation communities and species of conservation significance. Australian Ecosystems (2013) identified 228 indigenous plant species, of which 44 are floodplain or wetland species that are rare or threatened under the Victorian Advisory List of Threatened Plants (Ecological Associates, 2014a). One species, Striate Spike-sedge (*Eleocharis abicis)*, is classified as vulnerable in Victoria and listed as vulnerable under the Commonwealth EPBC Act. Seven species are listed under the FFG Act.

The island supports intact remnants of river red gum (*Eucalyptus camaldulensis*) forest and woodland associated with the many creeks and anabranches across the island (including Lindsay River, Mullaroo Creek, Little Mullaroo Creek and Toupnein Creek) and large areas of black box (*Eucalyptus largiflorens*) and lignum shrubland communities associated with the higher elevated areas (Ecological Associates, 2014a).

Ecological vegetation classes

The vegetation communities of Lindsay Island are distributed across the floodplain according to hydrological conditions, soil types and salinity gradients. In Victoria vegetation mapping units known as Ecological Vegetation Classes (EVCs) are the standard unit for classifying vegetation types. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and preferred environmental attributes (DEPI, 2014).

A total of 19 EVCs are present at the Lindsay Island site (Figure 4-1). Of the 19 EVCs, 17 are inundation dependent. The EVCs are:

Inundation dependent EVCs

- Alluvial Plains Semi-arid Grassland
- Bare Rock/Ground
- Disused Floodway Shrubby Herbland
- Floodway Pond Herbland
- Grassy Riverine Forest
- Grassy Riverine Forest / Floodway Pond Herbland Complex
- Intermittent Swampy Woodland
- Lake Bed Herbland
- Lignum Shrubland
- Lignum Swamp
- Lignum Swampy Woodland
- Low Chenopod Shrubland
- Riverine Chenopod Woodland
- Shallow Freshwater Marsh
- Shrubby Riverine Woodland
- Sub-saline Depression Shrubland
- Water Body – Fresh

Not Inundation dependent EVCs

- Semi-arid Chenopod Woodland
- Semi-arid Woodland

One EVC, Disused Floodway Shrubby Herbland, is classified as endangered in the Murray Scroll Belt bioregion, and four EVCs are vulnerable: Lake Bed Herbland, Lignum Swamp, Shallow Freshwater Marsh, Alluvial Plains Semi-arid Shrubland and Sub-saline Depression Shrubland (Ecological Associates, 2014a). Lignum Shrubland is the most widespread EVC at the Lindsay Island site.

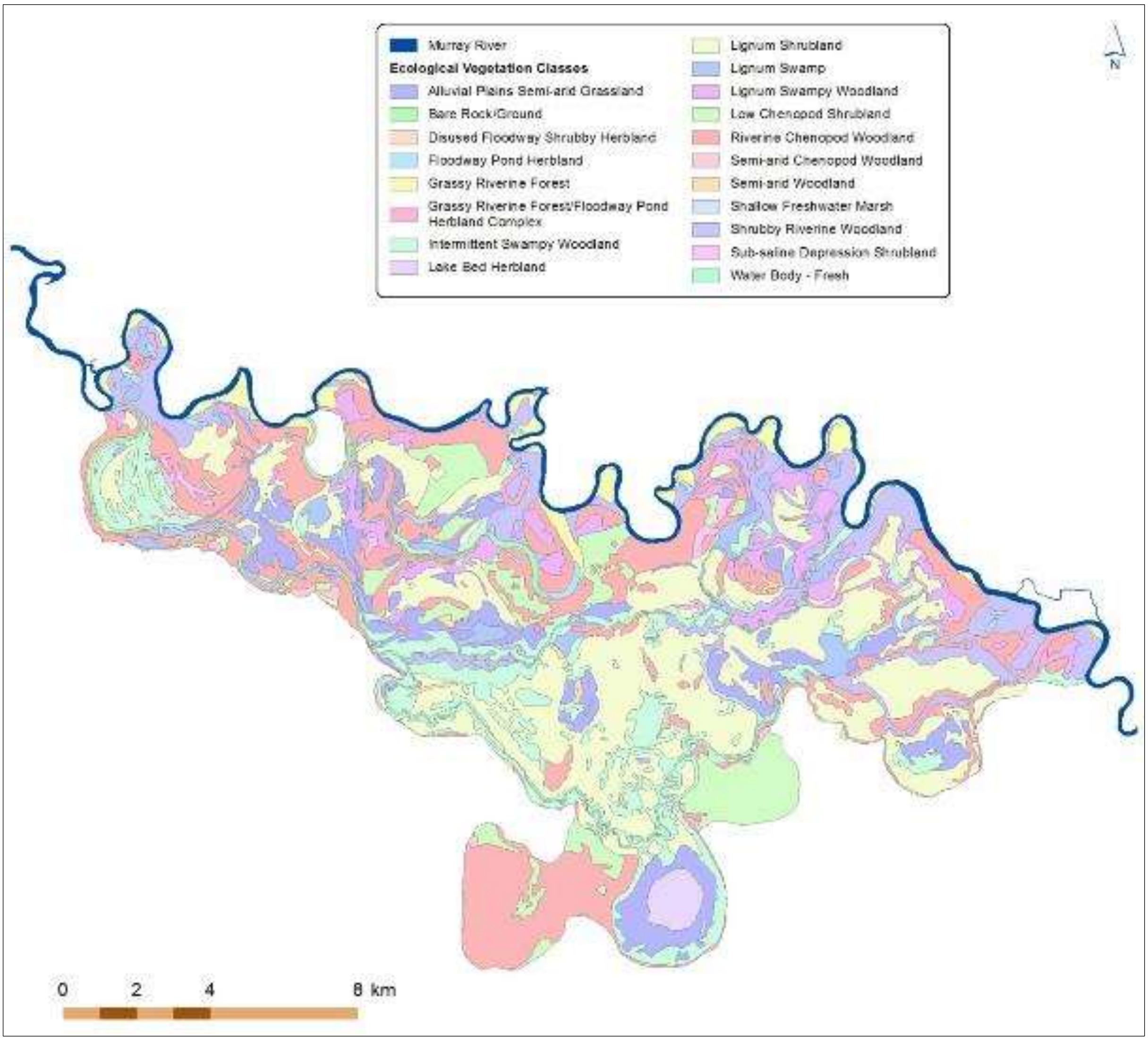


Figure 4-1. Ecological Vegetation Classes present at Lindsay Island

Water regime classes (WRC)

Floodplain ecology is influenced by the duration, depth, frequency and timing of inundation events. Therefore, it is useful to define WRC to establish objectives for the location, extent and condition of components of the floodplain ecosystem.

Plant communities present on Lindsay Island have been described and mapped in detail as EVCs. Possible relationships between EVCs and water regimes were assessed. Using topographic data and information on the known spread of water on a rising hydrograph, EVCs were arranged in the order in which they are likely to be flooded and likely frequency and relative durations of flooding. This environmental gradient was refined by reviewing the EVC descriptions, which set out the species present during flooded and dry phases, their relative abundance and their habitat. Species with known relationships to flooding could be used to rank EVCs from most-likely to least likely to be flooded (Ecological Associates 2007).

EVCs were amalgamated into eight WRC (Figure 4-2). Table 4-1 provides a brief description of the eight water regime classes at Lindsay Island. A more detailed description of the characteristics of these water regime classes is provided in Appendix B.

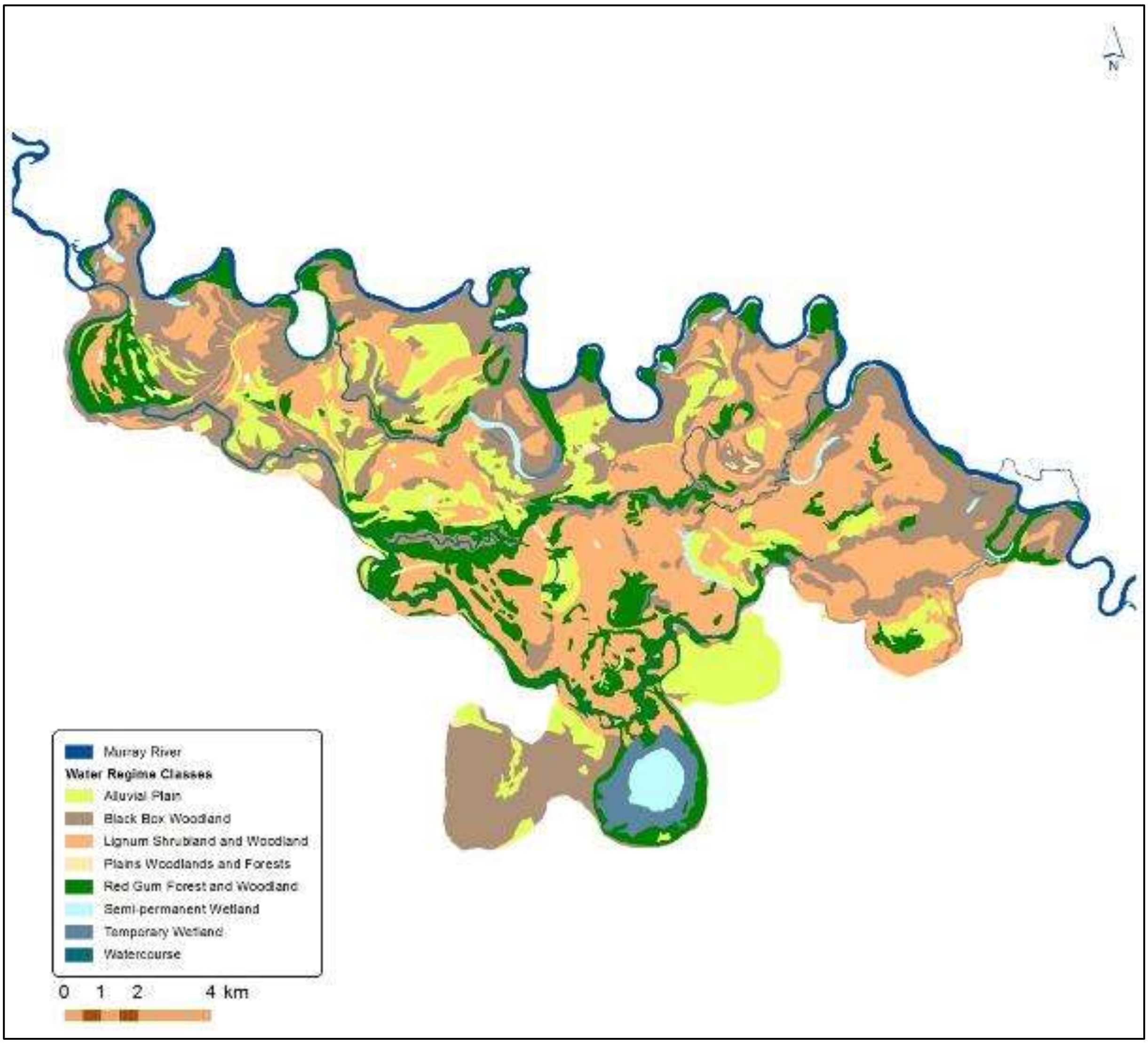


Figure 4-2. Lindsay Island Water Regime Classes (Ecological Associates, 2014a)

Table 4-1. Lindsay Island Water Regime Classes (Ecological Associates, 2014a)

	Area at Lindsay Island (ha)	Area to be watered within this project (ha)	Component Ecological Vegetation Classes
Watercourse	402	223	Bare Rock/Ground Water Body - Fresh
Temporary Wetland	456	365	Alluvial Plains Semi-arid Grassland Disused Floodway Shrubby Herbland Floodway Pond Herbland Shallow Freshwater Marsh Water Body - Fresh
Semi-permanent Wetland	350	254	Bare Rock/Ground Floodway Pond Herbland Lake Bed Herbland Lignum Shrubland Shallow Freshwater Marsh
Red Gum Forest and Woodland	2,935	854	Grassy Riverine Forest / Floodway Pond Herbland Complex Grassy Riverine Forest Intermittent Swampy Woodland
Lignum Shrubland and Woodland	6,851	1,776	Lignum Shrubland Lignum Swamp Lignum Swampy Woodland
Black Box Woodland	6,267	1,030	Riverine Chenopod Woodland Shrubby Riverine Woodland
Alluvial Plain	2,923	607	Alluvial Plains Semi-arid Grassland Sub-saline Depression Shrubland Low Chenopod Shrubland
Plains Woodland and Forest*	181	23	Semi-arid Woodland Semi-arid Chenopod Woodland
Unmapped EVCs**	NA	20	NA
Total	**20,365**	**5,152**	

*Not inundation dependent

**There is a small area on Lindsay Island where EVCs have not been mapped which is due to gaps in spatial data.

4.3 Current condition

The forests and woodlands of the River Murray floodplain have been declining rapidly in condition over the past two decades. The dieback is associated with increasing regulation of the River Murray and extended periods of drought (Cunningham et al, 2011).

During the drought, the condition of lignum communities was poor, while approximately 25% of black box and 80% of red gums were stressed or dying, with little recruitment observed (Henderson et al, 2008; Cunningham et al, 2006).

In 2010, Cunningham et al (2011) found that 79% of river red gum and black box communities in The Living Murray Icon Sites was in a stressed condition. Stands of river red gum and black box in good condition were restricted to the river channel, permanent anabranches, creeks and wetlands; whereas extensive areas of degraded to severely degraded stand condition occurred away from the river (Cunningham et al, 2011).

Exceptionally high rainfall in 2010 (325 mm recorded over summer 2010–11 compared with a long term average of 60 mm at Werrimull) (BOM, 2014, in Henderson et al, 2014) and associated flooding provided some relief to drought stressed plant communities.

There was a significant improvement in the condition of river red gum between 2007–08 and 2011–12, evidenced by a threefold increase in the number of trees assessed as being in good condition, and widespread establishment of river red gum seedlings following flooding in 2010–11 and 2011–12 was recorded (Henderson et al, 2013). While the presence of seedlings and saplings may indicate a successful regeneration event, it is the survival of these juveniles to maturity that may be deemed to constitute successful recruitment. Further, recruitment must keep pace with mortality if populations are to persist. This recruitment is dependent on an ecologically appropriate flooding regime.

There was a substantial improvement in the condition of black box between 2008–09 and 2011–12, followed by a slight decline in 2012–13. The current recruitment rates are insufficient to sustain populations at historic levels. Despite high rainfall events and associated flooding in 2010–11 and 2011–12, there has been no significant seedling establishment (Henderson et al, 2013).

The overall condition of lignum (*Duma florulenta*) has declined substantially since 2006–07. Some improvement in the condition of lignum was recorded in association with flooding and above average rainfall in 2010–11. However, the general condition of lignum is relatively poor with more than half of the plants originally surveyed in 2006–07 recorded as dead in 2013–14, with the expectation that these plants will not be able to regenerate from rootstock (Henderson et al, 2014).

Based on the observed vegetation response to environmental watering and natural floods, it is expected that the ecological condition of Lindsay Island will improve when the water regime better matches its ecological requirements. Benefits of environmental watering are further detailed in Section 6.

Lake Wallawalla before (above; 2010) and after environmental watering (below; 2011)

4.4 Past management activities and actions

From 1848 until the early 1990s, Lindsay Island was managed as a pastoral run and used for grazing of cattle and sheep. In 1991, it became part of Murray-Sunset National Park and was managed for conservation and recreational values, in line with the Mallee Parks Management Plan (1996). Activites included, but were not limited to, management of pest species and fire risk, the preservation of natural values and provision of recreational opportunities.

To prevent catastrophic ecosystem collapse at Lindsay Island, an emergency environmental watering program was initiated in 2003-04 that targeted areas of highly stressed red gums. Over the following six years, environmental water was delivered to low lying wetlands and creek lines via portable pumps and contained with temporary earthen levees.

Bayes et al (2010) concludes that the environmental watering program made a significant contribution to increasing the resilience and therefore long-term viability of the plant communities and populations of threatened species at Lindsay Island. In comparison to un-watered sites, watered wetlands supported a diverse and abundant wetland flora, which often included a diversity of rare and threatened species. The un-watered wetlands were in a stressed condition, with little or no evidence of flood-dependent ground flora and with many either dead or dying structural woody dominants.

It is highly probable that the environmental watering was of considerable benefit for maintenance of local frog populations, as evidenced by the breeding of four of the five frog species located during the survey (Bayes et al, 2010). Successful breeding of some species of the frogs following environmental watering was not just a beneficial outcome for frog populations, but also important to the island's food web. Frogs, their eggs and tadpoles are an important food resource for several other wetland dependent fauna.

Through TLM, long-term environmental water management options were investigated for Lindsay Island. These options involved permanent infrastructure to reinstate an appropriate water regime across large areas of Lindsay Island. However, due to funding constraints the full suite of works was not able to be implemented. To date, TLM has installed five environmental regulators on Lindsay Island: three at Lake Wallawalla and Websters Lagoon in 2006 and two on the Lindsay River inlets in 2013, an additional regulator and fishway will be built in 2015 on Mullaroo Creek.

These works allow for an ecologically appropriate drying cycle of the permanently inundated wetland at Webster's Lagoon. The works also enable the opportunistic watering of Lake Wallawalla to a limited extent. Watering of Lake Wallawalla is only possible during large inundation events and is done by retaining water using the Lake Wallawalla regulators and/or the use of temporary pumps, when conditions permit.

The proposed works build upon early investigations and prior construction to provide infrastructure capable of watering large areas of Lindsay Island, and restoring ecosystem functions and processes.

The vulnerable DeVis' Banded Snake (*Denisonia devisi*) eating a common Spotted Marsh Frog (*Limnodynastes tasmaniensis*) following environmental watering Lindsay Island (2010)

4.5 Other values

In addition to its environmental values, the Lindsay Island Floodplain Complex is recognised for its many social and cultural values. Under the National Parks Act 1975 and the Mallee Parks Management Plan 1996, Lindsay Island is listed as a Special Protection Zone in recognition of its high number of archaeological sites of significance.

Cultural and historical values

Prior to European settlement, Aboriginal people, governed by a distinct system of land ownership, occupied all areas of the Victorian landscape. Aboriginal occupation dates back thousands of years and on Lindsay Island was sustained by the rich productivity of the floodplain and woodland systems. An estimated 800-900 cultural heritage sites exist within the vicinity of Lindsay Island, including scarred trees, artefact scatters, shell middens, hearth features and burial sites (Bell, 2013).

Lindsay Island was gazetted as a pastoral run in 1848 and was grazed by cattle and sheep (Bell, 2013a). Timber cutting, paddle boats and river trade also had an impact on the forests. Lake Wallawalla was part of the Woolwoola pastoral run. Following closer settlement, both runs were managed as a single entity and used for grazing (LCC, 1987 and DCNR, 1996). Remnants of these activities remain providing European heritage values. Later, the properties became the Lindsay Island State Forest and, in 1991, incorporated into the Murray-Sunset National Park. A review in 2008 by the Victorian Environmental Assessment Council saw an expansion of the area of National Park at Lindsay Island.

Social and recreational values

Lindsay Island is a popular recreation site for visitors to the region and local communities in Victoria and South Australia (Aither, 2014). Recreational use of the site includes fishing, camping, boating, canoeing, bird and wildlife watching, photography, motor biking and four-wheel driving.

Lindsay Island attracts campers, especially in spring and autumn. Approximately 80 per cent of visitors to Lindsay Island stay at least one night, mainly due to the site’s remoteness. There are no designated campgrounds or toilet amenities. However, there are approximately 15 sites with picnic tables and fire rings. During Easter every camping site is full and recreational use is estimated at 3000 visitor nights over the four days. Parks Victoria estimates 10,000 to 15,000 visitor days to Lindsay Island per year (Aither, 2014).

Large grinding stone found at Lindsay Island (2014)

5. Ecological objectives and targets (Section 4.3)

Ecological objectives have been developed for the Lindsay Island site drawing on a range of approaches and recommended lines of enquiry including, but not limited to:

- The overarching objectives in Schedule 7 of the Basin Plan
- The Basin-wide Environmental Watering Strategy (MDBA, 2014)
- A review of relevant literature including monitoring data from the TLM initiative (Bayes et al, 2010; Henderson et al, 2012; Henderson et al, 2013; Henderson et al, 2014)
- Desktop and field based flora and fauna surveys (Australian Ecosystems 2013; GHD, 2014)
- Site visits, and
- An ecological objectives workshop with an expert panel comprised of aquatic, wildlife and restoration ecologists and key project stakeholders from DEPI and the Mallee CMA (Ecological Associates, 2014a)

The ecological objectives for the Lindsay Island project were developed with a view to enhance the conservation values of the site with the proposed works, inform the detailed design and operation of the works, and guide monitoring and evaluation.

5.1 Overarching ecological objective

The overarching objective of water management at Lindsay Island is:

*"to **protect and restore** the key species, habitat components and functions of the Lindsay Island ecosystem by providing the hydrological environments required by indigenous plant and animal species and communities"* (Ecological Associates, 2014a).

The *Lindsay Island Floodplain Management Project* will complement previous environmental works and watering (refer to Section 12) by extending the area of floodplain and types of habitat that will be inundated during managed flow events.

The proposed works will provide:

- A mosaic of hydrological regimes and habitat types across Lindsay Island
- Enhanced connectivity between floodplain elements, the floodplain and the river, and
- Continuity of stream-flow and condition through Mullaroo Creek and the mid to lower Lindsay River and to the wider lower Murray floodplain including Chowilla Floodplain (SA), Wallpolla Island (Vic), Mulcra Island (Vic) and Carrs, Capitts and Bunberoo Creek system (NSW) (see Figure 5-1).

Red kangaroos at Lindsay Island (2014)

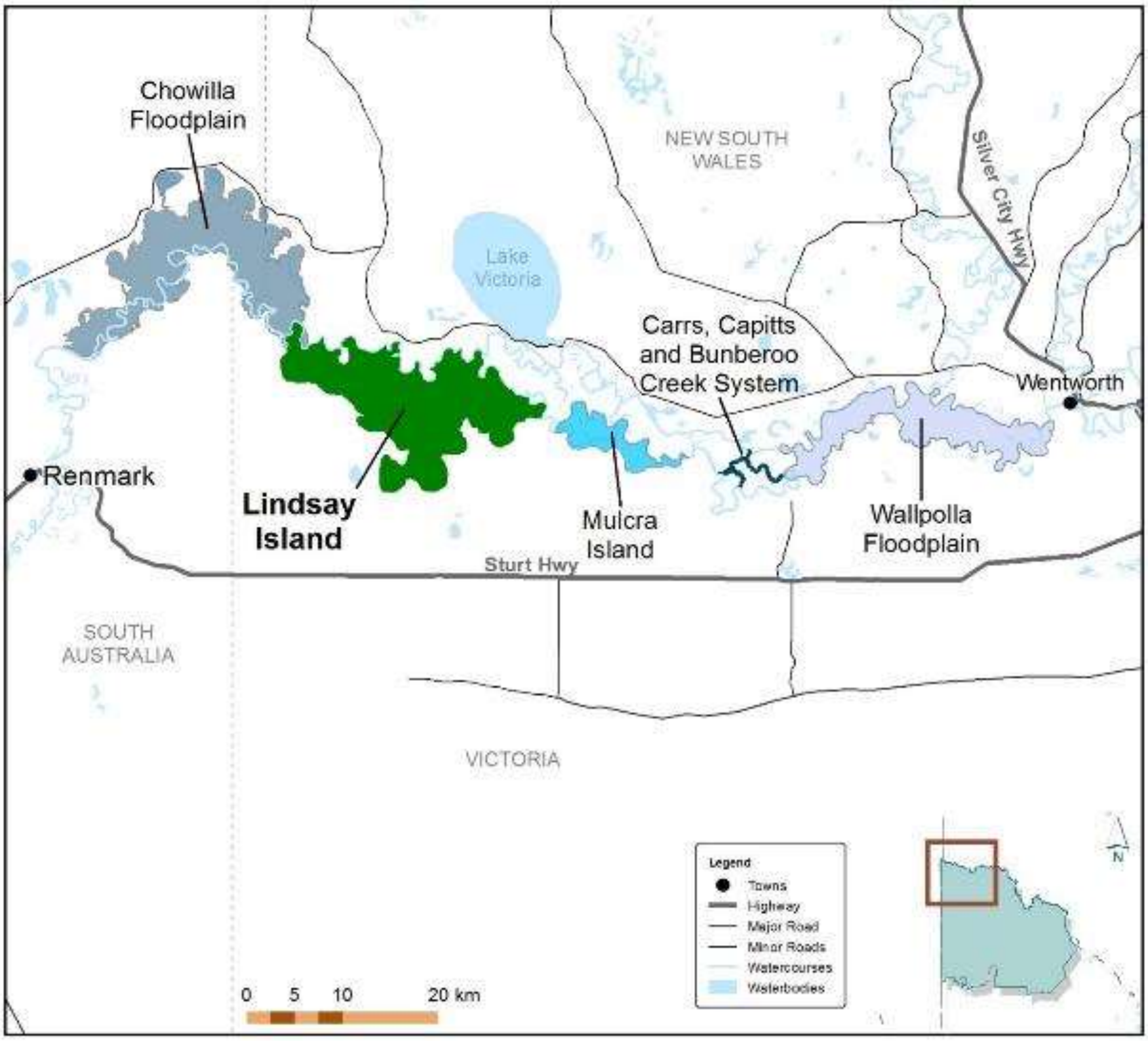


Figure 5-1. The proximity of Lindsay Island to other high-value floodplain systems in Victoria, New South Wales and South Australia

Achieving the overarching objective will be supported by the land management regime of both the private and public land at the Lindsay Island project site. In 2008, recommendations from a Victorian Environmental Assessment Council (VEAC) investigation resulted in the expansion of the area of public land managed as National Park. The *Lindsay Island Floodplain Management Project* will provide the improved hydrological regime needed to restore values within the landscape achieving the recommendations established for the Murray-Sunset National Park (VEAC, 2008).

5.2 Specific objectives and targets

Specific ecological objectives have been developed for the proposed supply measure based on the key water-dependent values of Lindsay Island. The objectives are consistent with those of the Lindsay-Wallpolla Icon Site Environmental Water Management Plan (MDBA, 2012b) and will contribute to achieving the environmental objectives set by the Basin Plan (summarised below and see Table 5-1).

1. *to protect and restore a subset of all water-dependent ecosystems in the Murray-Darling Basin ensuring that:*
   (a) declared Ramsar wetlands that depend on Basin water resources maintain their ecological character: and
   (b) water-dependent ecosystems that depend on Basin water resources and support the lifecycles of species listed under the Bonn Convention, CAMBA, JAMBA or ROKAMBA continue to support those species: and
   (c) water-dependent ecosystems are able to support episodically high ecological productivity and its ecological dispersal.
2. *to protect and restore biodiversity that is dependent on Basin water resources, including by ensuring that: are protected and, if necessary, restored so that they continue to support those life cycles*
   (a) water-dependent ecosystems that:
   - *Depend on Basin water resources: and*
   - *Support the lifecycles of a listed threatened species or listed threatened ecological community, or species treated as threatened or endangered in State or Territory law.*

   (b) representative populations and communities of native biota are protected and if necessary restored.
3. *that the water quality of Basin water resources does not adversely affect water-dependent ecosystems and is consistent with the water quality and salinity management plan.*
4. *to protect and restore connectivity within and between water-dependent ecosystems including by ensuring that:*
   (a) the diversity and dynamics of geomorphic structures, habitats, species and genes are protected and restored; and
   (b) ecological processes depend on hydrologic connectivity longitudinally along rivers, and laterally, between rivers and their floodplains (and associated wetlands) are protected and restored: and
   (c) the Murray Mouth remains open at frequencies, for durations and with passing flows, sufficient to enable the conveyance of salt, nutrients and sediment from the Murray-Darling Basin to the ocean: and
   (d) the Murray Mouth remains open at frequencies, and for durations, sufficient to ensure that the tidal exchanges maintain the Coorong's water quality within the tolerance of the Coorong ecosystems' resilience and
   (e) barriers to the passage of biological resources (including biota, carbon and nutrients) through the Murray Darling Basin are overcome or minimised.
5. *that natural processes that shape landforms (for example, the formation and maintenance of soils) are protected and restored.*
6. *to provide habitat diversity for biota at a range of scales (including, for example, the Murray–Darling Basin, riverine landscape, river reach and asset class).*
7. *to protect and restore food webs that sustain water-dependent ecosystems, including by ensuring that energy, carbon and nutrient dynamics (including primary production and respiration) are protected and restored.*
8. *to protect and restore ecosystem functions of water-dependent ecosystems that maintain populations (for example recruitment, regeneration, dispersal, immigration and emigration) including by ensuring that;*
   (a) flow sequences, and inundation and recession events, meet ecological requirements (for example, cues for migration, germination and breeding); and
   (b) habitat diversity that supports the life cycles of biota of water dependent ecosystems (for example habitats that protect juveniles from predation) is maintained.
9. *to protect and restore ecological community structure and species interactions.*
10. *that water-dependent ecosystems are resilient to climate change, climate variability and disturbances (for example, drought and fire).*
11. *to protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna, including during drought to allow for subsequent re-colonisation beyond the refugia.*
12. *to provide wetting and drying cycles and inundation intervals that do not exceed the tolerance of ecosystem resilience or the threshold of irreversible changes.*
13. *to mitigate human-induced threats (for example, the impact of alien species, water management activities and degraded water quality).*
14. *to minimise habitat fragmentation.*

Table 5-1. Specific objectives and targets established for Lindsay Island (Ecological Associates 2014a), relevant water regime classes and the contribution to Basin Plan objectives

Specific ecological objective	Ecological targets	Water regime class	Associated Basin Plan objective
Enhance Murray cod habitat by improving the productivity of connected riparian zones and wetlands while maintaining fast-flowing habitat	The population of adult Murray cod in Mullaroo Creek and Lindsay River increases by 25% from 2015 levels by 2030. The average lateral extent of aquatic macrophyte vegetation stands on the banks of Mullaroo Creek and Lindsay River increases by 100% from 2015 levels by 2030. The average December projected cover of aquatic macrophytes exceeds 50% in at least 100 ha in wetland habitat in the period between 2025 and 2030.	Semi-permanent Wetlands Watercourses	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14
Maintain resident populations of frogs and small fish in wetlands	At least four native fish species are present in at least five wetland sites throughout the period from 2025 to 2035. At least three frog species are present in at least five wetland sites throughout the period from 2025 to 2035.	Semi-permanent Wetlands	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14
Provide reliable breeding habitat for waterbirds, including colonial nesting species	Any species of waterfowl, crake, rail, waterhen or coot breed every year between 2025 and 2035 in at least five wetland sites. Platform-building waterbirds breed in lignum shrublands on at least three occasions between 2025 and 2035. Cormorants and / or nankeen night heron breed at Lindsay Island on at least three occasions between 2025 and 2035.	Semi-permanent Wetlands RRG Forest and Woodland Lignum Shrubland and Woodland Alluvial Plain	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14
Frequently provide habitat for thousands of waterbirds	The total summer waterbird abundance at Lindsay Island exceeds 3,000 in at least three seasons between 2025 and 2035.	Semi-permanent Wetlands Temporary Wetlands Lignum Shrubland and Woodland Alluvial Plain	1, 2, 3, 4 , 6, 7, 8, 9, 10, 11, 12, 13, 14
Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, insectivorous bats and Giles' planigale	All red gum and black box stands within the project area achieve a health score of moderate or better under Cunningham (2011) tree health monitoring for all years between 2025 and 2035. The total abundance of bats on Lindsay Island increases by 25% from 2015 levels by 2030.	RRG Forest and Woodland Lignum Shrubland and Woodland Black Box Woodland	1, 2, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14
Contribute to the carbon requirements of the River Murray channel ecosystem	The average annual carbon load (dissolved and particulate) to the River Murray from Lindsay Island for the period 2025 to 2035 is double 2015 to 2020 levels.	Temporary Wetlands RRG Forest and Woodland Lignum Shrubland and Woodland Black Box Woodland	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14

Achieving these ecological objectives is dependent on meeting the water requirements of the associated WRCs (see Table 5-1). The water requirements for the WRCs of Lindsay Island are presented in Section 9 with proposed operating scenarios described in Section 10.

Targets have also been developed to measure progress towards the objectives (Table 5-1). It is anticipated that these targets will be tested and refined once the proposed supply measure is operational. The targets describe an ecological outcome or process and are:

- Quantitative and measurable
- Time-bound, and
- Justified by existing site data or scientific knowledge.

The ecological targets compare the current state of the ecosystem (i.e. using 2015 as a baseline) with a future state after the recommended water regimes have been applied, assuming that the proposed works are commissioned in 2020. It will take some time to realise ecological outcomes due to the time required for vegetation to adapt to the new inundation conditions, for floodplain productivity to increase (e.g. for additional energy and nutrients to be distributed through the food web) and for fauna populations to respond. Targets based on relatively stable variables are evaluated in 2030. Targets based on the frequency of an event occurring are evaluated over the period from 2025 to 2035.

Foliated River Red Gum fringing the perimeter of Lake Wallawalla on recession of an environmental watering event, taken March 2013 (photo courtesy Chris Woods)

Photo point monitoring shows river red gum tree condition before environmental watering (above left; 2004) and after environmental watering (above right; 2006)

5.3 Environmental Water Requirements

The works will provide flexibility to deliver a wide range of environmental watering events to meet the above ecological objectives and targets.

The hydrological regime experienced by each WRC has varied from natural due to river regulation and diversions. provides a comparison of the water regime that can be provided by the proposed measure with the following water regimes:

- Natural
- Baseline Condition (current condition) and
- Basin Plan (2750) without the measure.

Basin Plan flows will contribute toward achieving the environmental water requirement of Lindsay Island compared to baseline conditions. The proposed measure is required to bridge the gap between Basin Plan flows and the environmental water requirements of Lindsay Island.

Table 5-2. Comparison of water regimes provided by natural, baseline, Basin Plan and the Lindsay Island measure (natural, baseline and Basin Plan regimes from Gippel, 2014; with measures regime adapted from Ecological Associates, 2014c)

Threshold (ML/d)	WRC	Scenario	Frequency Mean (/100 yrs)	Interval Median (days)	Duration Median (days)	Event start date Median (day of year, 1 Jan = 1)	Prevalence yrs with event %
30,000	Watercourse	With Measure	95	245	120	244	95
		Natural	95.6	168	167	195	95
		Baseline	59.6	302	100	206	59
		Basin Plan 2750 without measure	78.1	270	121	200	76
60,000	Temporary Wetland	With Measure	60	365	90	152	60
		Natural	67.5	305	95	241	72
		Baseline	31.6	631	43	272	39
		Basin Plan 2750 without measure	37.7	607	58	254	39
40,000	Semi-permanent Wetland	With Measure	70	280	90	152	70
		Natural	87.7	237	142	215	89
		Baseline	47.4	338	88	221	48
		Basin Plan 2750 without measure	60.5	297	100	215	59
80,000	Red Gum Forest and Woodland	With Measure	40	670	60	244	40
		Natural	43.9	619	59	260	44
		Baseline	14	1557	48	267	31
		Basin Plan 2750 without measure	16.7	1030	51	270	50
80,000	Lignum Shrubland and Woodland	With Measure	40	850	60	244	40
		Natural	43.9	619	59	260	44
		Baseline	14	1557	48	267	31
		Basin Plan 2750 without measure	16.7	1030	51	270	50
100,000	Black Box Woodland	With Measure	30	850	60	152	30
		Natural	28.1	729	40	273	33
		Baseline	8.8	3532	35	253	27
		Basin Plan 2750 without measure	10.5	1592	34	257	29
120,000	Alluvial Plain	With Measure	20	1795	30	244	20
		Natural	21.1	888	28	288	25
		Baseline	6.1	6462	57	257	5
		Basin Plan 2750 without measure	6.1	5696	60	256	20

6. Anticipated ecological benefits (Section 4.4.1)

6.1 Current condition and management

The creeks, temporary anabranches, wetland and floodplain systems of Lindsay Island support a variety of aquatic and terrestrial ecological communities, including woodlands and grasslands (see Section 4). The condition of ecological values of Lindsay Island and past management activities and actions are outlined in Section 4.3 and 4.4 respectively.

6.2 Ecological benefits of inundation

Inundation maintains the productivity of floodplain habitats and is necessary for the regeneration and successful recruitment of all major canopy species. Dense understorey vegetation maintained by inundation regimes provides the habitat for prey species and the structural habitat components on which the threatened carpet python and lace monitor depend. High levels of insect productivity, derived from both wetland and woodland inundation, contribute to Lindsay Island's nine species of bat fauna (GHD 2014). Organic matter generated on the floodplain is conveyed to the river channel by receding flood water and contributes to the energy requirements of the river ecosystem (Ecological Associates, 2014a).

Flora and fauna surveys completed in 2009 and 2010 (Bayes et al 2010), conclude that the 2009 environmental watering delivery made a significant contribution to increasing the resilience and therefore long-term viability of the plant communities and populations of threatened species at Lindsay Island. In comparison to un-watered sites, watered wetlands supported a more diverse and abundant wetland flora, which often included rare and threatened species. The un-watered wetlands were in a stressed condition, with little to no flood-dependent understory species present, and with many trees either dead or dying. Inundation-dependent threatened species were missing from some areas, suggesting that more frequent inundation would significantly enhance species diversity (Bayes et al. 2010).

The environmental watering was of considerable benefit to local frog populations. Four of the five frog species located during the survey were recorded breeding (Bayes et al, 2010). Frogs, their eggs and tadpoles are an important food resource for other wetland dependent fauna (Bayes et al, 2010).

A trend of improving ecological condition has been recorded since the end of the millennium drought period (Henderson, 2014). These results and findings provide a high level of confidence that the implementation of the proposed supply measure and its associated watering regime will provide the expected ecological benefits.

This project presents a unique opportunity to restore ecosystem functions and processes because of its ability to connect, via watering events, large areas of the floodplain from the unique fast-flowing aquatic habitat to the black box, lignum and higher alluvial floodplain vegetation communities. This can be achieved using low flows (5,000 ML/d) instead of large 120,000 ML/d inundation events.

Photo point monitoring at Lake Wallawalla shows the improvement in vegetation condition in response to environmental watering undertaken in 2010-11 (note the improvement in canopy health and understory diversity). (Left: February 2010; Right: October, 2011)

6.3 Proposed ecological benefits

The proposed supply measure will restore flooding and productivity to extensive areas of red gum woodland, black box woodland and lignum shrubland. It will contribute significantly to the feeding and breeding requirements of platform-building waterbirds that nest in lignum, including colonial nesting species. Frequent flooding of wetlands will maintain wetland habitat for sedgelands and rushlands and support populations of small-bodied fish and cryptic waterbirds such as bitterns, crakes and rails. Large wetlands areas, particularly Lake Wallawalla, provide extensive habitat for benthic herblands which in turn contribute to the habitat requirements of small-bodied fish and a wide variety of waterbirds. The habitat for Murray cod will be promoted by increasing access to physically complex and productive riparian and wetland habitat.

Twelve ecological targets have been developed to provide quantification on the degree of environmental benefit expected by the measure (Table 5-1).

The anticipated ecological benefits that are expected for each water regime class as a result of the project are outlined in Table 6-1.

Table 6-1. Water regime class, strategy, objectives and ecological benefits (Ecological Associates, 2014a)

Water Regime Class	Strategy	Objectives addressed	Ecological benefit, including site ecological targets
Semi-Permanent Wetlands	Protect and restore seasonal inundation and semi-permanent inundation to deep, low-lying wetlands and restore hydraulic connections to riverine habitats.	Enhance Murray cod habitat by improving the productivity of connected riparian and wetland habitat while maintaining fast-flowing habitat Maintain resident populations of frogs and small fish in wetlands Provide reliable breeding habitat for waterbirds, including colonial nesting species Frequently provide habitat for thousands of waterbirds.	Stimulation of seed bank resulting in greater diversity and abundance of wetland flora. This will in turn provide foraging and breeding habitats for wetland birds, fish and frogs Riparian shrubs; will potentially demonstrate increased vigour in species such as lignum, and possibly also exhibit an increase in abundance and diversity Adjacent trees; will likely demonstrate increased vigour and recruitment, therefore leading to an overall improvement in wetland health, maintenance of wetland buffers and maintenance of fauna habitats.
Temporary wetlands	Protect and restore intermittent inundation of floodplain wetlands.	Frequently provide habitat for thousands of waterbirds Contribute to the organic carbon requirements of the River Murray channel ecosystem.	Stimulation of seed bank resulting in greater diversity and abundance of wetland flora. This will in turn provide foraging and breeding habitats for wetland birds, fish and frogs Riparian shrubs; will potentially demonstrate increased vigour in species such as lignum, and possibly also exhibit an increase in abundance and diversity Adjacent trees; will likely demonstrate increased vigour and recruitment, therefore leading to an overall improvement in wetland health, maintenance of wetland buffers and maintenance of fauna habitats
Water courses	Maintain fast flowing habitat in upper Mullaroo Creek Maintain the extent of permanent watercourses Increase the intermittent inundation of temporary watercourses.	Enhance Murray cod habitat by improving the productivity of connected riparian zones and wetlands while maintaining fast-flowing habitat.	In-channel macrophytes; flows convey seeds and propagules into the wetland resulting in an increase in diversity and abundance species. Water quality may also improve Improve native fish diversity and abundance through improved habitat. Bank and channel edge macrophytes; flows convey seeds and propagules Riparian shrubs; will potentially demonstrate increased vigour in species such as lignum, and possibly also exhibit an increase in abundance and diversity Adjacent trees; increased vigour and recruitment, maintenance of

Water Regime Class	Strategy	Objectives addressed	Ecological benefit, including site ecological targets
			wetland buffers and fauna habitats; an increase in diversity and abundance of emergent species. Water quality may improve, wetland banks stabilised.
Red Gum Forest and Woodland	Protect and restore the inundation of red gum forest and woodland.	Provide reliable breeding habitat for waterbirds, including colonial nesting species Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, Insectivorous Bats and Giles' planigale Contribute to the organic carbon requirements of the River Murray channel ecosystem.	Maintenance and enhancement in condition of river red gum communities. Regular inundation events promote aquatic and grassy woodland vegetation, woody debris, submerged aquatic vegetation and other prey habitats (EA 2007). Quality and extent of habitat for a wide range of native species, including threatened species improve. Colonial nesting waterbirds relying on productive flooded river red gum woodlands and shallow wetlands to forage during breeding benefit.
Lignum Shrubland and Woodland	Protect and restore inundation of lignum shrubland.	Provide reliable breeding habitat for waterbirds, including colonial nesting species Frequently provide habitat for thousands of waterbirds Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, Insectivorous Bats and Giles' planigale Contribute to the organic carbon requirements of the River Murray channel ecosystem.	The maintenance and enhancement in condition of lignum shrubland. When inundated, lignum shrubland provides habitat for frog, reptile and fish species (MDBC 2005b), as well as shallow-water feeding waterbirds utilising macrophytes developed in the inter-shrub area. Waterbirds that breed over water, such as ibis and spoonbill may nest over inundated lignum shrubland and regular breeding habitat for waterbirds dependent on lignum, such as Freckled Duck and colonial nesting waterbirds could be provided if 50% of inundation events last three months (EA 2007).
Black Box Woodland	Protect and restore inundation to black box woodland.	Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, Insectivorous Bats and Giles' planigale Contribute to the organic carbon requirements of the River Murray channel ecosystem.	Provide a long-term net benefit through the maintenance and enhancement in condition of floodplain black box woodland communities, including recruitment within the area, maintaining a diverse age structure, including maturation and development of hollows and maintaining habitat in the long-term for native fauna species.
Alluvial Plain	Protect and restore inundation to alluvial plains.	Provide reliable breeding habitat for waterbirds, including colonial nesting species (but only inundating one year in ten) Frequently provide habitat for thousands of waterbirds	Inundation provides opportunistic habitat for floodplain fauna, including feeding habitat for wading birds. Inundation of the alluvial plain will contribute to waterbird breeding events by increasing the availability of food. Extensive inundation may also attract birds and trigger breeding

Water Regime Class	Strategy	Objectives addressed	Ecological benefit, including site ecological targets
		(as above) Contribute to the organic carbon requirements of the River Murray channel ecosystem.	behaviour Alluvial plains should be flooded to complement waterbird breeding objectives in wetland, lignum and woodland habitats Provide important foraging and refuge habitat for floodplain fauna species e.g. chenopod shrubland providing foraging habitat for regent parrot, cracking soils providing refuge habitat for small mammals and reptiles Alluvial plains are also likely to represent refuge for terrestrial fauna species during periods

6.4 Monitoring and evaluation plans (Section 4.4.1)

The effectiveness of the proposed supply measure and its operation will primarily be monitored and reported on through well-established monitoring, evaluation and reporting (MER) strategies and protocols. These strategies and protocols will build upon experience and lessons learned though the ongoing, long-term Living Murray ecological monitoring programs, which include condition and intervention monitoring across several sites in the Mallee. The Mallee CMA has been implementing and coordinating the local Living Murray annual MER process since 2006.

The MER strategies and protocols are linked to overarching State and Victorian Environmental Water Holder frameworks to provide a routine process to:

- Establish a robust program logic to define the correlation between works and other inputs and identified outputs and ecosystem outcomes. This provides the basis for a suite of quantifiable ecological targets that are relevant to the specific site
- Monitor progress against those targets on a regular basis
- Evaluate the implications of the results for the operational parameters of the scheme, and
- Amend and adjust the operational arrangements to optimise performance and outcomes.

Monitoring data is required to plan watering events, to optimise water delivery, to manage risks and to refine ecological objectives. The evaluation process involves analysing collected data and improving operations accordingly.

A detailed monitoring and evaluation plan has been prepared for the Lindsay Island site by Ecological Associates, (2014b). Monitoring and evaluation will focus on the effects of local watering actions and include:

- Evaluating water use
- Measuring ecological outcomes against ecological targets
- Refining conceptual models and improving knowledge, and
- Managing risk.

The Lindsay Island monitoring and evaluation plan identifies the agencies responsible for commissioning, reviewing and acting on monitoring data. The linkages back to decision-making are described in the detailed plan.

Initial monitoring will provide a baseline of the existing status of the ecological objectives and outcome monitoring will measure progress towards these objectives and their targets. This information will inform the ongoing operations at the site. Over time the results of the outcome monitoring will test assumptions and monitoring data will assist with refining conceptual models and ecological objectives. Parameters for monitoring each ecological objective of the supply measure for Lindsay Island are detailed in Appendix C (Ecological Associates, 2014b).

The environmental risks from implementing the proposed water regime are detailed in Section 11 - Operational Risks. Monitoring data will identify emerging hazards and enable operational decisions to minimise risk.

This MER approach will be formalised once funding for the supply measure has been confirmed.

The final MER approach for this supply measure will be informed by broader intergovernmental arrangements for Basin-wide monitoring and evaluation under the Basin Plan. This measure is expected to contribute to the achievement of outcomes under two key Chapters of the Plan, namely: (i) the delivery of ecological outcomes under Chapter 8; and (ii) under Chapter 10, meeting the relevant sustainable diversion limit/s (SDLs), which must be complied with under the state's relevant water resource plan/s (WRPs) from 1 July 2019.

Both Chapter 8 and Chapter 10 of the Basin Plan are captured under the Murray-Darling Basin Authority's (MDBA) own monitoring and evaluation framework. Once specific Basin Plan Chapters commence within a state, the state must report to the MDBA on relevant matters. This will include five yearly reporting on the achievement of environmental outcomes at an asset scale in relation to Chapter 8, and annually reporting on WRP compliance in relation to Chapter 10.

The proponent is satisfied that its participation in the MDBA's reporting and evaluation framework will effectively allow for progress in relation to this supply measure to be monitored, and for success in meeting associated ecological objectives and targets to be assessed.

This approach closely aligns with agreed arrangements under the Basin Plan Implementation Agreement, where implementation tasks are to be as streamlined and cost-efficient as possible.

7. Potential adverse ecological impacts (Section 4.4.2)

This business case has taken into consideration potential adverse ecological impacts of this proposal. It is acknowledged that works that alter floodplain hydraulics and hydrology may threaten the ecological values of the Lindsay Island site, and potentially those of surrounding areas. In order to identify and assess these risks during project development, a comprehensive and rigorous risk assessment was completed (Lloyd Environmental, 2014). This involved identifying potential undesirable outcomes, determining their root causes, assessing likely consequences and significance; and developing relevant mitigation measures to reduce any residual risk to an acceptable level (very low to moderate). Experience gained from previous works and measures, and environmental watering projects of similar scale and complexity, including The Living Murray Program, informed this process.

The methodology described in Section 7.2 was applied to assess the threats to successful project development, delivery and operation, and the potential adverse ecological impacts of the proposed supply measure. It is therefore also relevant to Sections 11 and 17.

The comprehensive approach undertaken to assess potential adverse ecological impacts of the Lindsay Island project ensures risk management strategies can be implemented to ensure management and mitigation of:

- Adverse salinity impacts or water quality outcomes at the site
- The potential to increase pest species
- The potential to favour certain species to the detriment of others or to adversely affect certain species, and
- Adverse impacts on ecological function and connectivity.

The nature of any downstream salinity and/or water quality impacts, and any potential cumulative impacts with other measures, cannot be formally ascertained at this time. This is because such impacts will be influenced by other measures that may be operating upstream of this site, including other supply/efficiency/constraints measures under the SDL adjustment mechanism, and the associated total volume of water that is recovered for the environment.

It is expected that likely or potential downstream/cumulative impacts will become better understood as the full package of adjustment measures is modelled by the MDBA and a final package is agreed to by Basin governments.

7.2 Risk assessment methodology

A risk assessment was completed in line with the requirements of AS/NZS ISO 31000:2009 (Lloyd Environmental 2014). This assessed both the likelihood of an event occurring and the severity of the outcome if that event occurred. The assessment generated a risk matrix in line with the ISO standards and prioritised mitigation strategies and measures. Table 7-1 and Table 7-2 show, respectively, the definitions used for assigning levels of the consequences of threats, and definitions used for assigning levels of the likelihood of threats. Tables 7-3 and 7-4 show, respectively, the risk matrix and definitions used in this risk assessment.

A thorough review of existing literature and a cross-disciplinary expert workshop with the Mallee CMA and key stakeholders was undertaken to complete the risk assessment for the project site (Lloyd Environmental, 2014). In summary, the process included:

- Identification of values, threats to those values and the significance of these threats
- Assessment of the likelihood and consequences of potential impacts for each threat
- Identification of mitigation options, and
- Assessment of the residual risk after mitigation options were identified.

Further work to consolidate the risk assessment was undertaken as the project developed and incorporated into Table 7-5.

Table 7-1. Definitions used for assigning levels of the consequences of threats

	Level	Description
Consequence	Minor (1)	The effects are limited in extent or duration and do not significantly impact on the site values
	Moderate (2)	The effects are moderate in extent or duration and are in conflict with site values or will have minor impacts on offsite values
	Severe (3)	The event significantly undermines site values or moderately impacts on offsite values
	Catastrophic (4)	The event is in significant conflict with the site values or severely impacts offsite values and will result in a serious deterioration of the system

Table 7-2. Definitions used for assigning levels of the likelihood of threats

	Level	Description
Likelihood	Remote (1)	An event which is not expected to occur but may occur under rare, exceptional circumstances
	Unlikely (2)	An event which is not expected to occur as a result of normal activities but may occur
	Possible (3)	An event which is possible and will occasionally occur as a result of normal activities
	Likely (4)	An event which is expected to occur as part of normal activities
	Certain (5)	An event which is expected to occur as a result of the action

Table 7-3. ISO Risk Matrix

	Consequence			
Likelihood	Minor	Moderate	Severe	Catastrophic
Remote	1	2	3	4
Unlikely	2	4	6	8
Possible	3	6	9	12
Likely	4	8	12	16
Certain	5	10	15	20

Table 7-4. Definitions of the levels of risk

	Scores	Risk	Definitions
Risk	1-2	Very Low	There is no reasonable prospect the project objectives will be affected by the event
	3-4	Low	The event is a low priority for management but risk management measures should be considered
	5-8	Moderate	The risk is a moderate priority for management. Risk management measures should be undertaken.
	9-12	High	The risk is a high priority for management. There is a reasonable likelihood it will occur and will have harmful consequences. Risk management is essential.
	15-20	Very High	The risk is a very high priority for management. It is likely to occur and will have very harmful consequences. Risk management is essential.

7.3 Risk assessment outcomes

A summary of the risk assessment and subsequent work undertaken are presented in Table 7-5, including the mitigation measures developed and an assessment of the residual risk after these are applied. Where a residual risk is given a range of ratings, the highest risk category is listed. It is important to note that the majority of the risks identified in this table exist in both an “existing conditions” or “Basin Plan without works” scenario, but are included because the proposed works provide mitigation opportunities.

Table 7-5. Risk of potential adverse ecological impacts with and without mitigation. Adapted from Lloyd Environmental (2014)

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Adverse salinity impacts or water quality outcomes						
Low dissolved oxygen (DO) levels	Low dissolved oxygen (DO) concentrations can occur through a variety of processes, including blackwater events, algal and cyanobacterial blooms, high organic matter loadings and stratification. Low DO can cause the death of aquatic fauna and have negative impacts on the health of wetland communities in general. More frequent inundation (i.e. through managed watering events) will reduce the accumulation of organic matter on the floodplain between inundation events.	Likely	Severe	High	Planning phase: • Monitor antecedent floodplain conditions (i.e. organic matter loads) to assess risk of a hypoxic event occurring. • Consider seasonal conditions (e.g. temperature, algae) prior to watering Operations phase: • Commence watering as early as possible to move organic matter off the floodplain while temperatures are low • Maintain continual flow over Berribee Regulator to prevent the degradation of water quality in the Berribee pool • Maintain through-flow where possible in other areas to maximise exchange rates and movement of organic material. • Monitor DO and water temperature to identify hypoxic areas to inform consequence management (see below). Managing consequences: • Ensure dilution of low DO water by managing outflow rates and river flows • Delay outflows if river flows are too low. • Dispose of hypoxic water by pumping to higher wetlands where possible. • Agitate water using infrastructure to increase aeration.	Moderate

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Poor water quality	Water manipulations may lead to suspension of sediments and/or organic matter causing elevated nutrients, high turbidity and/or low dissolved oxygen (DO) levels. This may impact reduce food sources and possibly toxic algal blooms upon wetland community health, threatened species, fish and other aquatic fauna communities, and waterbird communities (via impacts). The risk assessment for low DO water is presented above.	Possible	Moderate	Moderate	As above.	Low
Inability to discharge poor quality water	Inability to discharge water of poor water quality during a managed flow event, due to downstream impacts (e.g. increases in instream salinity), could result in impacts on floodplain vegetation (due to extended inundation) or formation of blackwater/algal blooms.	Likely	Severe	High	Schedule watering events to make use of dilution flows where possible. Maintain good relationships with other water managers. Integrate water management with other sites in seasonal water planning process. Where possible and useful, water can be disposed within the site (pump to higher wetlands). Continue to undertake water quality monitoring before, during and after watering events to inform adaptive management strategies and real-time operational decision making.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Development of saline mounds under wetlands and displacement of saline groundwater	An increase in groundwater levels may occur in response to project inundation events. Shallow saline groundwater can impact on the health of floodplain vegetation and wetland communities, both at Lindsay Island and downstream. Further details on the salinity impact assessment and mitigation strategies for this proposed supply measure is provided in Section 11.4.	Likely	Severe	High	Avoid watering salinity hot spots identified through the use of AEM datasets (Munday et al. 2008), instream nanoTEM (Telfer et al. 2005a and 2005b, 2007) and other salinity investigations. Monitor the salinity of ground and surface water salinity before, during and after watering events to inform management and ensure sufficient volumes are available for mitigation such as: • Diluting saline groundwater discharge with sufficient river flows. • Diluting saline water on the floodplain by delivering more fresh water to these areas. Reduce the frequency and/or extent of planned watering events if sufficient volumes not available.	Moderate
The potential to increase pest species						
Increased carp populations	Carp will breed in response to both natural and managed floods. High numbers of carp can threaten the health and diversity of wetland vegetation, affecting native fish and other aquatic fauna. This has potential impacts both within the project site and at the reach scale.	Certain	Severe	Very High	Tailor watering regimes to provide a competitive advantage for native fish over carp. Dry wetlands that contain large numbers of carp. Manage the drawdown phase to provide triggers for native fish to move off the floodplain and, where possible, strand carp.	Moderate

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Proliferation of pest plants	Pest plants may be promoted under certain water regimes, potentially impacting the health of all wetland and floodplain vegetation communities. This, in turn, will impact on dependent fauna, including threatened species.	Certain	Severe	Very High	Time water manipulations to drown seedlings, minimise growth, germination and seed set. Time water manipulations to promote native species. Control current populations and eradicate/control new infestations via existing management strategies (e.g. Parks Victoria pest management action plans/strategies). Support partner agencies to seek further funding for targeted weed control programs if necessary.	Low
Increase in pest animals	The reinstatement of more frequent flooding regimes is likely to provide and maintain more favourable conditions for many terrestrial animal pests. In particular, pigs are swamp dwellers and their impacts on watered areas may be more severe than other species.	Likely	Severe	High	Control pest animal populations via existing management strategies (e.g. Parks Victoria pest management action plans/strategies). Support partner agencies to seek further funding for targeted control programs if necessary.	Moderate
Transport or proliferation of invasive weeds due to construction activity	Proliferation of weeds will have impacts on the health of all wetland and floodplain vegetation communities. This, in turn, will impact on dependent fauna, including threatened species.	Likely	Moderate	Moderate	Develop and adhere to an Environmental Management Plan (EMP) that includes hygiene protocols, enforcement and contractor management.	Low
The potential to favour certain species to the detriment of others or to adversely affect certain species						

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Permanent habitat removal or disturbance during construction	Construction of the proposed works will cause disturbance to the floodplain and require the permanent removal of some vegetation/habitat.	Certain	Moderate to Severe	High to Very High	Utilise existing access tracks wherever possible. Design and locate infrastructure/works to avoid and minimise the extent of clearing and disturbance. Ensure clear on-site delineation of construction zones and adequate supervision during works to avoid unauthorized clearance/disturbance.	Moderate
Temporary habitat removal or disturbance during construction	Construction of the proposed works will cause disturbance to the floodplain and require the temporary removal of some vegetation/habitat.	Certain	Moderate	Moderate to Very High	As above. Remediate/revegetate the site once construction activities are complete.	Moderate
Invasion of river red gum in watercourses and open wetlands	Germination of dense thickets of river red gum within watercourses and wetlands, and at the edge of the Berribee Regulator pool may block flow through the system. Obstruction of flows can diminish the effectiveness of future watering events. Prolific germination of seedlings within wetlands will change the habitat structure and the suite of dependent biota.	Certain	Moderate	High	Use of operational strategies to control unwanted germination and establishment, including: • Drowning seedlings. • Timing the recession to avoid optimal conditions for germination in targeted areas (if feasible). Targeted removal of seedling/saplings to remove flow obstructions, if necessary.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Removal of habitat for threatened species created by historic regulation practices	Regulation of the River Murray and Mullaroo Creek has created permanent, fast-flowing habitat in Mullaroo Creek that supports Murray cod and freshwater catfish. Changes to the current, artificial flow regime could affect the suitability of these waterways for these species and could have implications for regional populations.	Likely	Severe	High	Determine flow regime requirements of target species; develop and implement operational arrangements to maintain flow velocities within critical thresholds during watering events. Assess the response of species of concern during and after managed watering events and adjust operational arrangements if required.	Low
Adverse impacts on ecological function and connectivity						
Episodic reduction in hydrodynamic diversity	Installation of regulators within waterways will affect flows and create lentic zones in regulator pools when in operation. This may reduce the extent and variety of aquatic habitat, and change the structure and diversity of wetland and floodplain vegetation communities. In particular, regulator operation is likely to reduce or eliminate fast-flowing habitat that is particularly important for some fish species, including Murray cod.	Likely	Severe	High	Design structures to minimize waterway obstruction and provide through-flow during operations. Develop operational protocols to maintain hydraulic diversity. Assess the response of species of concern during and after managed watering events and adjust operational arrangements if required.	Moderate

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Increase in fire frequency, extent and intensity	The reinstatement of more frequent flooding regimes threat will increase the biomass of floodplain vegetation, increasing the fuel load for bushfires. An increase in the frequency, extent and duration of bushfire could have impacts on ecosystem form and function.	Possible	Moderate	Moderate	No specific mitigating actions have been identified. If a bushfire occurs on Lindsay Island, Parks Victoria and DEPI will respond as usual in such situations.	Moderate
Managed inundation regimes do not match flow requirements for key species	The delivery of an inappropriate water regime may occur through inadequate knowledge of biotic requirements or conflicting requirements of particular species with broader ecological communities. This may lead to adverse ecological outcomes, e.g. failure of waterbird breeding events, lack of spawning response in fish, spawning response but no recruitment.	Possible	Moderate	Moderate	Consider the various requirements of key species/communities when developing operating strategies and planning for watering events. Assess the response of species of concern during and after managed watering events and adjust operational arrangements if required. Update operating strategies to capture new information on the water requirements/ response of key species/communities. Target different taxa at different times (e.g. target vegetation one year and fish the next).	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Prolonged inundation of vegetation within the Berribee Regulator pool	Vegetation in the deepest parts of the Berribee Regulator pool may receive excessive inundation (duration and depth) if the water requirements of vegetation at the perimeter of the pool are met. This is likely to cause localized impacts on vegetation health, possibly death of some less tolerant species.	Possible	Moderate	Moderate	Ensure through-flow when operating structures (including consideration of raising the upstream head via Lock 7) to more closely replicate a more natural hydraulic gradient. Incorporate information on operations, potential impacts and tolerance of inundation regimes and the role of natural floods in ecosystem function into operational plans to minimise the impact.	Low
Inadequate water regime delivered	An inadequate water regime could be delivered through: • Design and construction issues; • Invalid modelling assumptions and/or flow measurement; • Inadequate or incorrect information regarding water requirements and/or system condition; • Errors in planning and calculation of the volumes required; or • An inadequate volume allocated to the event.. This could result in adverse ecological impacts such as drought-stress of vegetation, loss of habitat and limited breeding opportunities for fauna.	Unlikely	Severe	Moderate	Confirm the validity of modelling assumptions during operations to inform future planning and refine the operating arrangements. Design structures for maximum operational flexibility. Ensure adequate measures are in place to measure inflows/outflows. Assess ecosystem response during and after managed watering events and adjust operational arrangements if required. Maintain strong working relationships with river operators, partner agencies and water holders to facilitate timely issue resolution (e.g. allocation of additional water if required).	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Stranding and isolation of fish on floodplains	Stranding can occur through sudden changes in water levels and/or new barriers preventing native fish from escaping drying areas during flood recessions. This may result in the death of a portion of the native fish population.	Possible	Moderate	Moderate	Develop a 'Fish Exit Strategy' to inform regulator operation during the drawdown phase to maintain fish passage for as long as possible and to provide cues for fish to move off the floodplain. Monitor fish movement and adapt operations as required. Continue to build on knowledge and understanding through current studies relating to fish movement in response to environmental watering and cues.	Low
Barriers to fish and other aquatic fauna movement	Installation of regulators in waterways and wetlands creates barriers to the movement of fish and other aquatic fauna. This can reduce access to feeding and breeding habitat, and limit migration or spawning opportunities.	Possible	Moderate	Moderate	Determine fish passage requirements and incorporate into regulator design (as in Hames, 2014). Specific arrangements for this project include: • A vertical slot fishway at Berribee Regulator • Fish-friendly designs to allow passive passage at other regulators. Continue to build on knowledge and understanding through current studies relating to fish movement in response to environmental watering and cues.	Low

7.4 Consideration of significant, threatened or listed species

Throughout project development, significant consideration has been given to the potential impact on significant, threatened or listed species that occur at Lindsay Island (see Section 4). Overall, the project is expected to benefit these species by increasing the frequency, duration and extent of floods of various sizes (see Section 6). However, construction activities will involve physical disturbance to the floodplain and some vegetation clearance is unavoidable. This will result in temporary and permanent vegetation removal and habitat disturbance (see Table 7-5).

In order to minimise the potential impacts on threatened species, detailed vegetation assessments and further assessment of the impacts on all threatened species will be carried out during the detailed design process, to inform final construction footprints and the development of mitigation measures, where necessary. To date, preliminary locations for infrastructure and works have been chosen to minimise vegetation loss. New access tracks and upgrades of existing tracks will be designed to minimise clearance of large trees and understorey vegetation.

Any losses of native vegetation will be offset in line with current state policy. A program-level approach to offsetting is currently being developed, where the primary offsetting mechanism will be the gains in vegetation condition within the areas watered by the various Victorian works-based supply measures. An assessment of vegetation offset requirements based on preliminary construction footprints indicates that the offsets for this proposed supply measure can be met using this approach.

If funded for construction, this proposed supply measure will be referred under the EPBC Act and Victorian EE Act. Measures to avoid and minimise impacts to threatened species will be a key component of the referrals. Such measures will be consolidated in relevant management plans such as a Construction Environment Management Plan (CEMP) and a Threatened Species Management Plan (TSMP).

Operation of the proposed supply measure could also have adverse impacts on threatened species. The Mullaroo Creek and Lindsay River are widely acknowledged for their significant native fish populations, particularly Murray cod (see Section 4). The protection and, where possible, enhancement of these populations has been a primary consideration during the development of designs and operational scenarios for the proposed works.

The design of minor regulators allows for passive fish passage and a vertical slot fishway that matches the specification of the fishway on the Mullaroo Creek Regulator (under construction through TLM) is proposed at the Berribee Regulator. These design considerations will allow passage for both small and large bodied fish over a range of operating conditions. Additionally, all regulators have been designed to minimise impediments to fish passage when not in use (i.e. when open).

The hydraulic model developed during preparation of the business case will be used to further inform operational plans by ensuring that hydraulic conditions appropriate for fish are maintained during each phase of operation of the works. This approach will mirror that already in place for the recently commissioned Chowilla Floodplan Living Murray works, where fish ecologists have worked in conjunction with hydraulic modellers to develop appropriate operational scenarios.

Monitoring of the response of threatened species to operation (e.g. population abundance, structure and distribution) and the effectiveness of mitigating actions will be critical to inform the planning and management of watering events.

7.5 Risk mitigation and controls

The risk assessment confirms that all identified risks are reduced to acceptable levels (very low to moderate) once well-established risk mitigation controls are implemented. While there are several potential threats could generate high risks to ecological functionality (Table 7-3), these are considered manageable because they:

- Are well known and are unlikely to involve new or unknown challenges
- Can be mitigated through well-established management controls
- Have been successfully managed by the Mallee CMA and project partners (including construction authorities) in previous projects, and
- Result in very low or moderate residual risks after standard mitigation measures are implemented.

As noted in Lloyd Environmental (2014), characterisation of the residual risk must be read within the context of the works creating a substantial improvement in the ecological condition of the site. The improvement will have a very significant role in mitigating many of the impacts. However, these improvements will take time to be realised and therefore the impacts may seem more significant in the short term.

Eight threats retained a residual risk of moderate after implementation of the recommended mitigation strategies (Table 7-6). Further consideration of these threats may assist in further understanding the potential impacts and, in some cases, identifying additional mitigation measures to reduce the residual risk.

7.3 Risk management strategy

A comprehensive risk management strategy will be developed for the proposed supply measure, building on the work completed for this business case. The strategy will cover ecological and socio-economic aspects to provide a structured and coherent approach to risk management for the life of this project (i.e. construction and operation). The strategy will include review processes and timetables for risk assessments, based on new developments or actions taken, and will assign responsible owner/s to individual risks. This will be an important input into the development of operating arrangements for the site.

The risk management strategy will include mitigating measures to address the following potential ecological impacts, as described in Table 7-5:

- Adverse salinity impacts or water quality outcomes either at the site or downstream
- The potential to increase pest species
- The potential to favour certain species to the detriment of others or to adversely affect certain species, and
- Adverse impacts on ecological function and connectivity.

Risk assessment and management is not a static process. Regular monitoring and review of the risk management process is essential to ensure that:

- Mitigation measures are effective and efficient in both design and operation
- Further information is obtained to improve the risk assessment
- Lessons are learnt from events (including near-misses), changes, trends, successes and failures
- Risk treatments and priorities are revised in light of changes in the external and internal context, including changes to risk criteria and the risk itself, and
- Emerging risks are identified.

The risk assessment process will continue throughout the development and implementation of this project. It is anticipated that additional threats will be identified and evaluated as the project progresses, and any new risks incorporated into the risk management strategy.

Table 7-6. High priority risks, mitigation and residual risk

Threat	Risk without mitigation	Residual Risk Rating	Additional considerations (Lloyd Environmental, 2014)	Guiding documents[2]
Enhancing carp recruitment conditions	Very High	Moderate	Additional targeted carp fishdowns, water level manipulations to disrupt the survival of juveniles and the installation of carp cages may all help reduce carp numbers. In addition, future research on carp control may identify new control measures.	*Lindsay Island Floodplain Management Project* Operating Plan (Preliminary) *Fish exit strategy*
Permanent habitat removal or disturbance during construction	High to Very High	Moderate	The risk assessment for these threats will be revised once construction footprints are finalised and detailed vegetation assessments are carried out. If significant species or EVCs are found to be at or close to the site and could be impacted, further actions to reduce the residual risk would include targeted management actions and/or vegetation offsets for the relevant biota.	Basin Plan Environmental Works Program: Regulatory Approvals Strategy (GHD, 2014a) Statutory Approval Requirements (Golsworthy, 2014). *Environmental Management Framework* *Construction Environmental Management Plan* *Offset Strategy* *Threatened Species Management Plan*
Temporary habitat removal or disturbance during construction	Moderate to Very High	Moderate		
Hypoxic blackwater events resulting from watering actions	High	Moderate	The risk assessment has assumed that more frequent inundation will result in more frequent blackwater events than occur currently, and that these events will be of similar magnitude. It is, however, possible that more frequent events may be less intense as tannins and organic material are thought to reduce in subsequent watering events. This is a knowledge gap that could be addressed through ongoing studies.	Assessing the Risk of Hypoxic Blackwater Generation at Proposed SDL Offset Project Sites on the Lower River Murray Floodplain (Ning et al, 2014) *Lindsay Island Floodplain Management Project* Operating Plan (Preliminary)

[2] Documents in italics are yet to be developed

Threat	Risk without mitigation	Residual Risk Rating	Additional considerations (Lloyd Environmental, 2014)	Guiding documents[2]
Development of saline mounds under wetlands and displacement of saline groundwater.	High	Moderate	Implementation of comprehensive monitoring, including additional groundwater monitoring bores, will inform a more detailed analysis of local and downstream salinity impacts. This information should feed into a larger scale investigation covering river operations and environmental watering activities taking place between Lock 9 and Lock 5.	Salinity impact assessment (Preliminary) *Lindsay Island Floodplain Management Project* Operating Plan (Preliminary)
Increase in pest animals	High	Moderate	More intensive culling programs may be needed. Further research into alternative control measures may provide additional control options.	*Lindsay Island Floodplain Management Project* Operating Plan (Preliminary)
Episodic reduction in hydrodynamic diversity	High	Moderate	There remains a knowledge gap in terms of the flora and fauna that may be affected by this threat and this is reflected in the moderate residual risk. Eliminating this knowledge gap may reduce the risk to low or very low. Work is continuing to address this knowledge gap, particular in relation to the impacts on Murray cod and other native fish. Learnings taken from the operation of the Chowilla Floodplain infrastructure and weir pool manipulations undertaken at Locks 8 and 9 will inform operational arrangements. Targeted management plans and/or offsets may also reduce the level of risk.	*Lindsay Island Floodplain Management Project* Operating Plan (Preliminary) Modelling management scenarios for Murray Cod populations in the Mullaroo Creek (Todd et al, 2007) Observations of the movement of Murray Cod under varying flow conditions within Mullaroo Creek (Saddlier et al, 2009) Fish requirements for the proposed Upper Lindsay Watercourse Enhancement Project (Mallen-Cooper et al, 2010) Lindsay Island Fish Requirements (Lloyd Environmental, 2012)
Increase in fire frequency, extent and intensity	Moderate	Moderate	Unavoidable risk that accompanies a project designed to promote growth of native vegetation in the region.	Mallee Fire Operations Plan (DEPI, 2013)

8. Current hydrology and proposed changes (Section 4.5.1)

8.1. Current floodplain hydrology

Lindsay Island is located between Locks 8 and 6, downstream of the River Murray junction with the Darling River. River Murray flows in this reach are influenced by the Murray, Darling, Murrumbidgee, Wakool and Goulburn tributaries, and are typically highest from late winter to early summer. The Darling River, which drains the northern basin, is often influenced by sub-tropical weather systems that generate large flows in summer. Lindsay Island experiences its largest floods when both the Darling and Murray systems are in flood (Ecological Associates, 2014a).

The network of waterways, wetlands and floodplain on Lindsay Island support a hydraulically diverse landscape that, prior to river regulation, would have experienced inundation to varying degrees in almost every year. The intense regulation in this reach of the river now strongly influences the current hydrology of Lindsay Island.

The lower regions of Lindsay River, approximately 30 kilometres upstream of Lock 6, are significantly influenced by the Lock 6 weir pool. This weir has an operating level of 19.25 m AHD and the backwater effect extends beyond the confluence of Mullaroo Creek with the Lindsay River. This ponds water in the channels in the west of the island, particularly affecting the western parts of Lindsay River, Toupnein Creek and lower Mullaroo Creek (Ecological Associates, 2014a).

Lock 7 is located adjacent to Lindsay Island, 2 river kilometres downstream of the Mullaroo Creek inlet. In regulated conditions, Lock 7 maintains a pool level of 22.1 m AHD. This creates a permanent hydraulic gradient across Lindsay Island and increased flow in the Mullaroo Creek (GHD, 2009).

Lake Victoria is a major balancing storage and lies on the New South Wales (NSW) side of the River Murray. The lake stores water diverted from the River Murray above Lock 9 and releases water to the river just downstream of Lock 7. Releases can be up to 9,000 ML/d and can create a significantly higher flow below Lock 7 than above (Ecological Associates, 2014a). This can cause inundation in the west of Lindsay Island (e.g. Webster's Lagoon is a wetland adjacent to Toupnein Creek below Lock 7 and is prone to inundation by small changes in river flow. An existing environmental regulator assists management of the water regime for the lagoon).

The River Murray flow at Lindsay Island has been altered significantly by storages, regulation and diversions on both the Murray and Darling Rivers (Ecological Associates, 2014a). These practices have reduced the occurrence of high flows and created extended periods of low flows, delayed the onset of floods and reduced the frequency and duration of floods (Ecological Associates, 2007; SKM, 2004). Further, it has resulted in a significant change to winter and spring flows as these flows are now captured in upstream storages and gradually released over summer, resulting in a relative continuous flow year round. This is illustrated in Figure 8-1.

Hydraulic modelling of Lindsay Island under current conditions shows that there is connection of waterways and low lying wetlands at 40,000 ML/d (Figure 8-3-1), with extensive wetland inundation and the commencement of floodplain inundation occurring at 60,000 ML/d (Figure 8-3-2). The modelling shows widespread floodplain inundation at 80,000 ML/d (Figure 8-3-3). It should be noted that these hydraulic modelling outputs were derived from steady state conditions that may not reflect operational River Murray hydrographs; smaller inundation areas may be observed during actual floods of this size.

For comparative purposes, the mean frequency and median interval for an 80,000 ML/d flow event is discussed below for a range of scenarios. Prior to regulation, flows of 80,000 ML/d occurred regularly, with a mean frequency of 4.4 events in 10 years. The period between successive 80,000 ML/d flow events was also frequent, with a median interval of 1.7 years (Gippel, 2014).

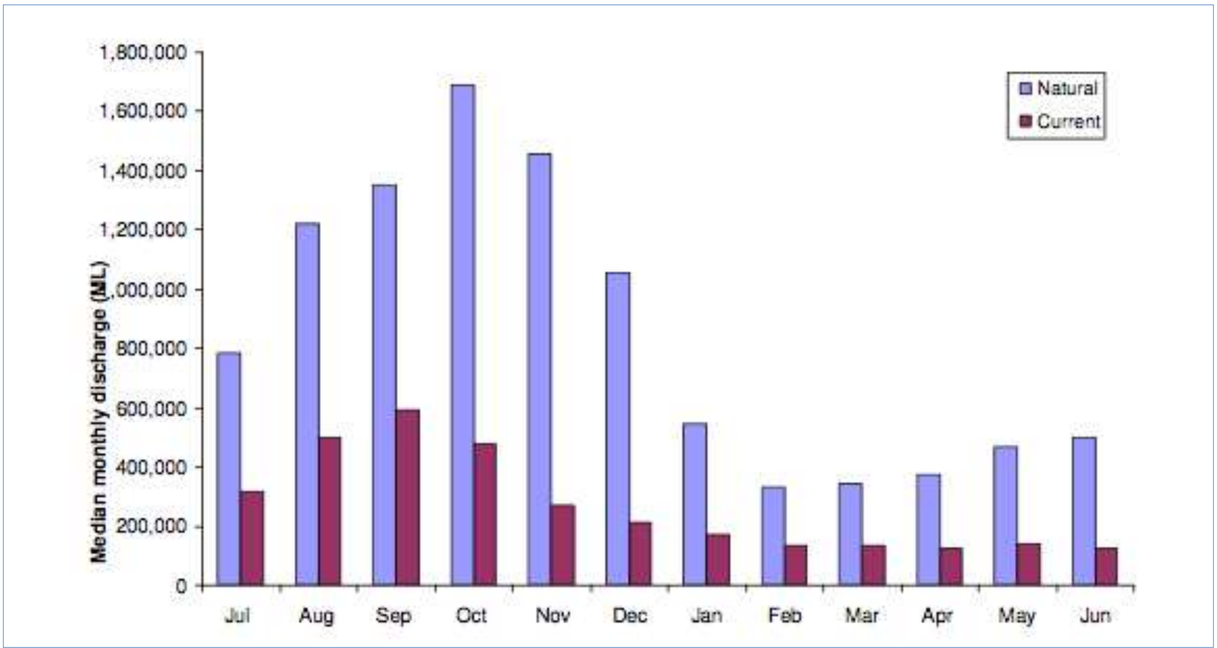


Figure 8-1. Monthly discharge at Lock 8, upstream of Lindsay Island, for modelled natural flows and modelled current system. Based on 115 years of data (1894-2009), provided by the MDBA

For example, the modelled extent shown of 80,000 ML/d in Figure 8-3-3, represents the maximum extent achieved after a steady state flow of 80,000 ML/d over a period of many months.

Regulation has significantly altered the frequency and recurrence interval of 80,000 ML/d flow events at Lindsay Island. The mean frequency of these flows has declined to as much as 31% of natural, (to 1.4 events in 10 years). This has caused a 150 percent increase in the interval between these flow events, resulting in a median recurrence interval of 4.2 years (Gippel, 2014).

Spells analysis of river modelling outputs (Figure 8-2) shows that compared to natural conditions:

- The River Murray now experiences more time at very low flows, less than 10,000 ML/d
- Events that inundate low-lying wetlands, between 40,000 and 60,000 ML/d, now occur at approximately half the frequency of natural conditions. The duration of these events, when they do occur, has also been reduced by approximately 50%
- The frequency of events that inundate black box areas has declined to 20% of natural, and
- The spell timing (represented by start day) was shifted forward by around one month for spells with threshold lower than 80,000 ML/d.

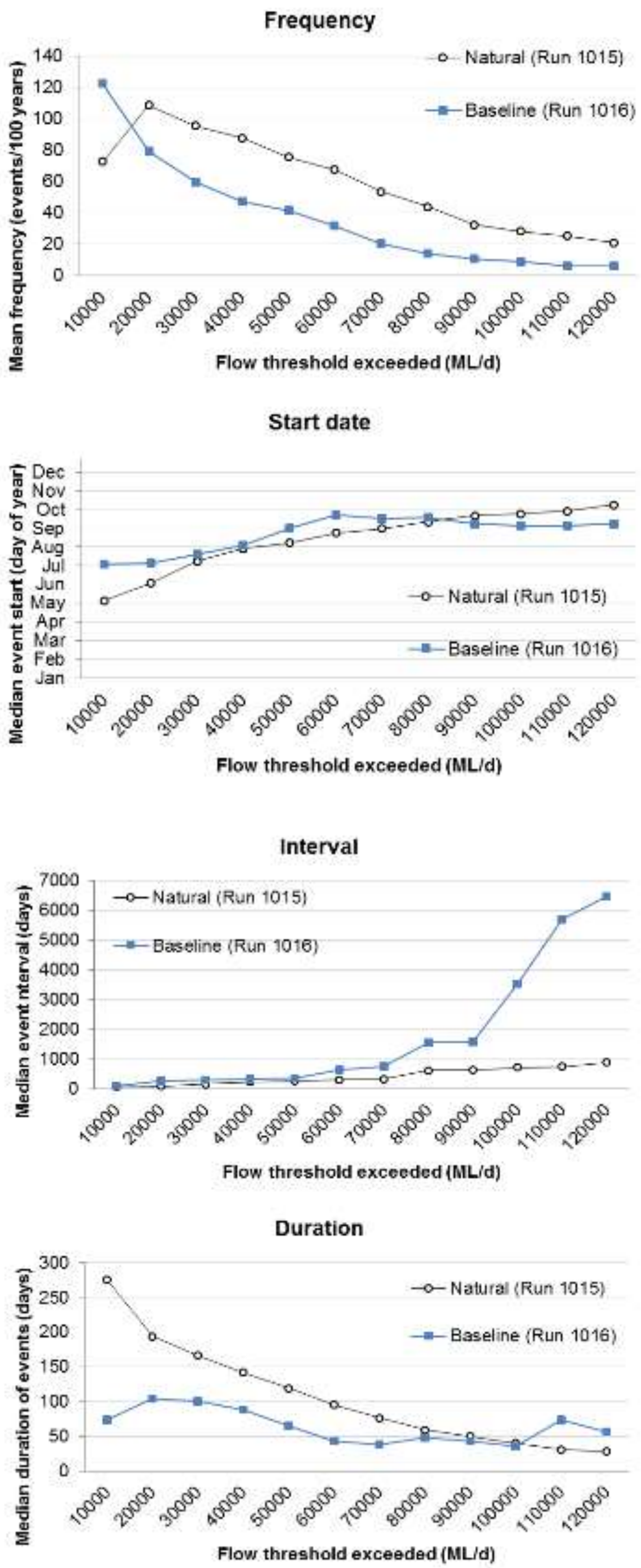
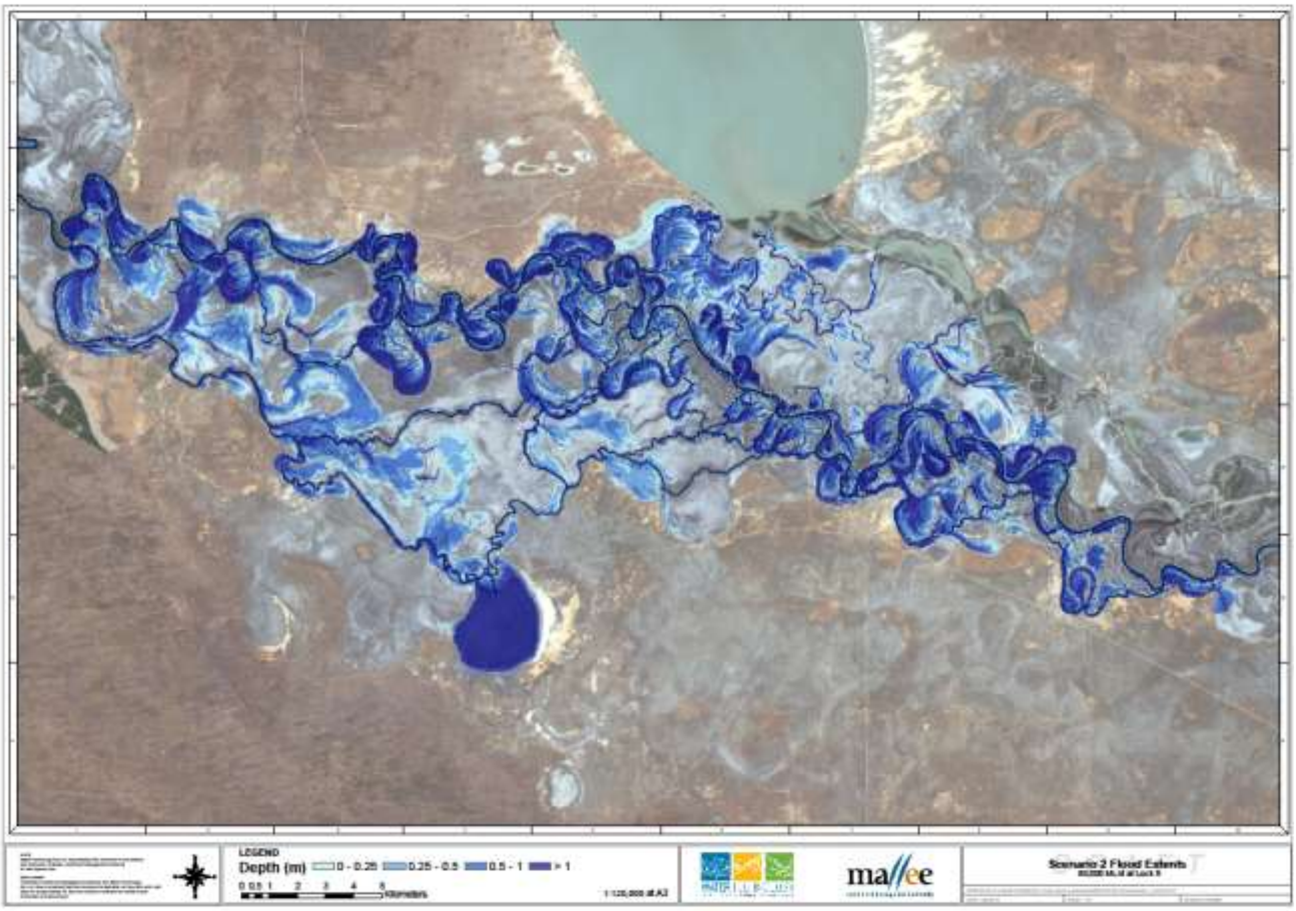


Figure 8-2. Comparison of statistical properties of events at SA Border under Natural and Baseline modelled flow scenarios, over a 114 year modelled period (Gippel, 2014)

Figure 8-3-1. Modelled inundation extent of current conditions at Lindsay Island at flows of 40,000 ML/d (Water Technology, 2014)

Figure 8-3-2 (above) and Figure 8-3-3 (below). Modelled inundation extent of current conditions at Lindsay Island at flows of 60,000 ML/d (above) and 80,000 ML/d (below) (Water Technology, 2014)



8.3 Proposed Changes

Basin Plan flow will contribute toward bridging the gap between natural and baseline conditions as shown in the spells analysis (Figure 8-4) and Table 8-1. Note: Basin Plan 2750 model run number 983 has been used as the basis of this analysis.

The Basin Plan will primarily affect flows less than required for floodplain watering at Lindsay (Table 8-1). For example flows of 40 000 ML/day will occur 4.7 times in 10 years under baseline conditions, 6.1 times under Basin Plan and 8.7 naturally. By comparison flows of 80 000 ML/day will occur 1.4 times in 10 years under baseline, 1.7 times under Basin Plan and 4.4 naturally.

Targeted operation of the works in conjunction with Basin Plan flows will enable mean frequency of inundation equivalent to an 80,000 ML/d flow event to be restored. The mean frequency of inundation will increase from 1.7 to 4 events in 10 years. This will improve the interval between flow events, by reducing the median interval period from 2.8 to 2.3 years (Table 8-1).

In order to further demonstrate the differences in the scenarios described in Table 8-1, hydrographs of the flow regimes are illustrated in Figure 8-5. The flow regimes represent a wetter than average sequence of years (1990s) and an extremely dry sequence of years (2000s).

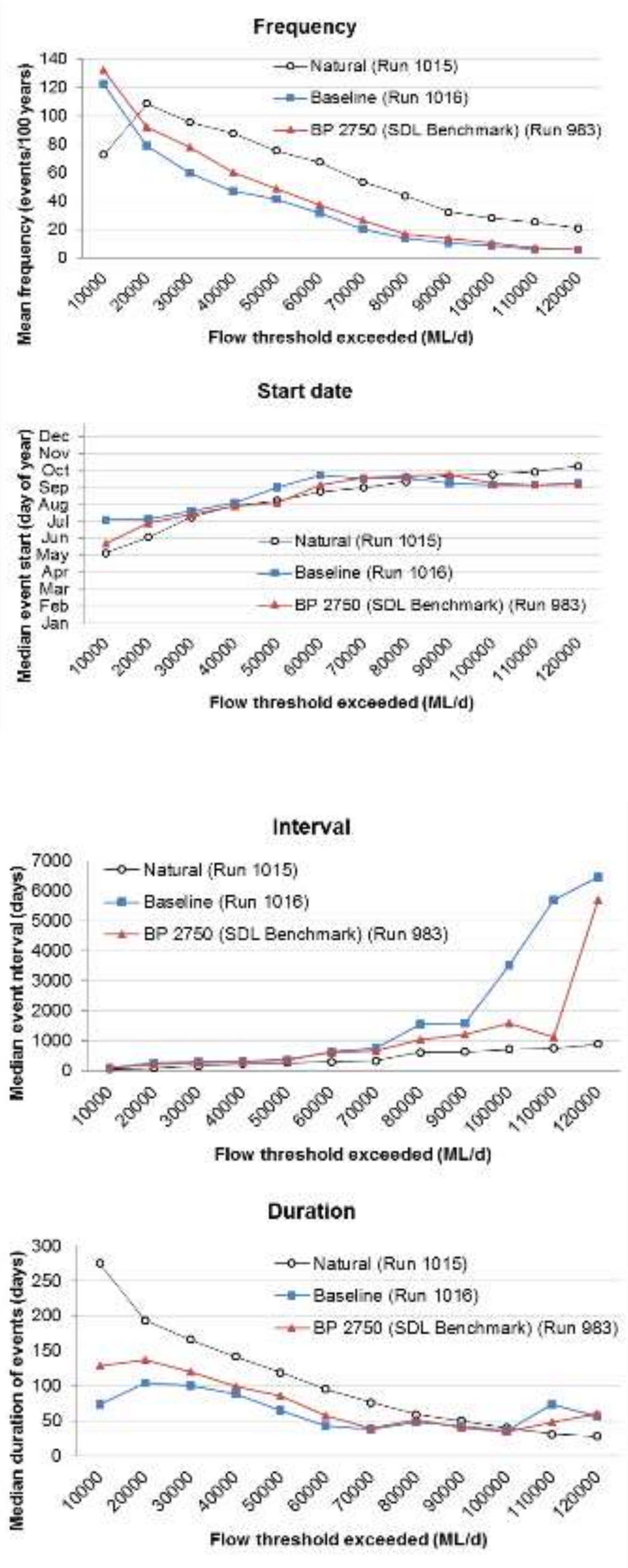


Figure 8-4. Comparison of statistical properties of events at SA Border under the Natural, Baseline and BP 2750 modelled flow scenarios, over a 114 year modelled period

Table 8-1. Comparison of water regimes provided by natural, baseline, Basin Plan and the Lindsay Island measure. Natural, Baseline and Basin Plan flow (Gippel, 2014).

Threshold (ML/d)	WRC	Scenario	Prevalence yrs with event %	Duration Median (days)	Timing	Proposed operations to meet gap	
						Frequency (years in 10)	Duration
30,000	Watercourse	With Measure[1]	95	120	Early spring	2	4 months
		Basin Plan without measure	76	121	Late winter	Additional operations to meet timing requirements may be needed	
40,000	Semi-permanent Wetland	With Measure[1]	70	90	Early winter	1	3 months
		Basin Plan without measure	59	100	Mid to late winter		
60,000	Temporary Wetland	With Measure[1]	60	90	Early winter	2	3 months
		Basin Plan without measure	39	58	Early spring	Additional operations expected to ensure variability in duration of inflows	
80,000	Red Gum Forest and Woodland	With Measure	40	60	Early spring	No additional operations above Basin Plan flows are anticipated	
		Basin Plan without measure	50	51	Early spring		
80,000	Lignum Shrubland and Woodland	With Measure[1]	40	60	Early spring	No additional operations above Basin Plan flows are anticipated	
		Basin Plan without measure	50	51	Early spring		
100,000	Black Box Woodland	With Measure[1]	30	60	Early winter	3	1 month
		Basin Plan without measure	29	34	Early spring		
120,000	Alluvial Plain	With Measure[1]	20	30	Early spring	No additional operations above Basin Plan flows are anticipated	
		Basin Plan without measure	20	60	Early spring		

[1] upon interpretation of the preliminary operations plan adapted from (Ecological Associates 2014c)

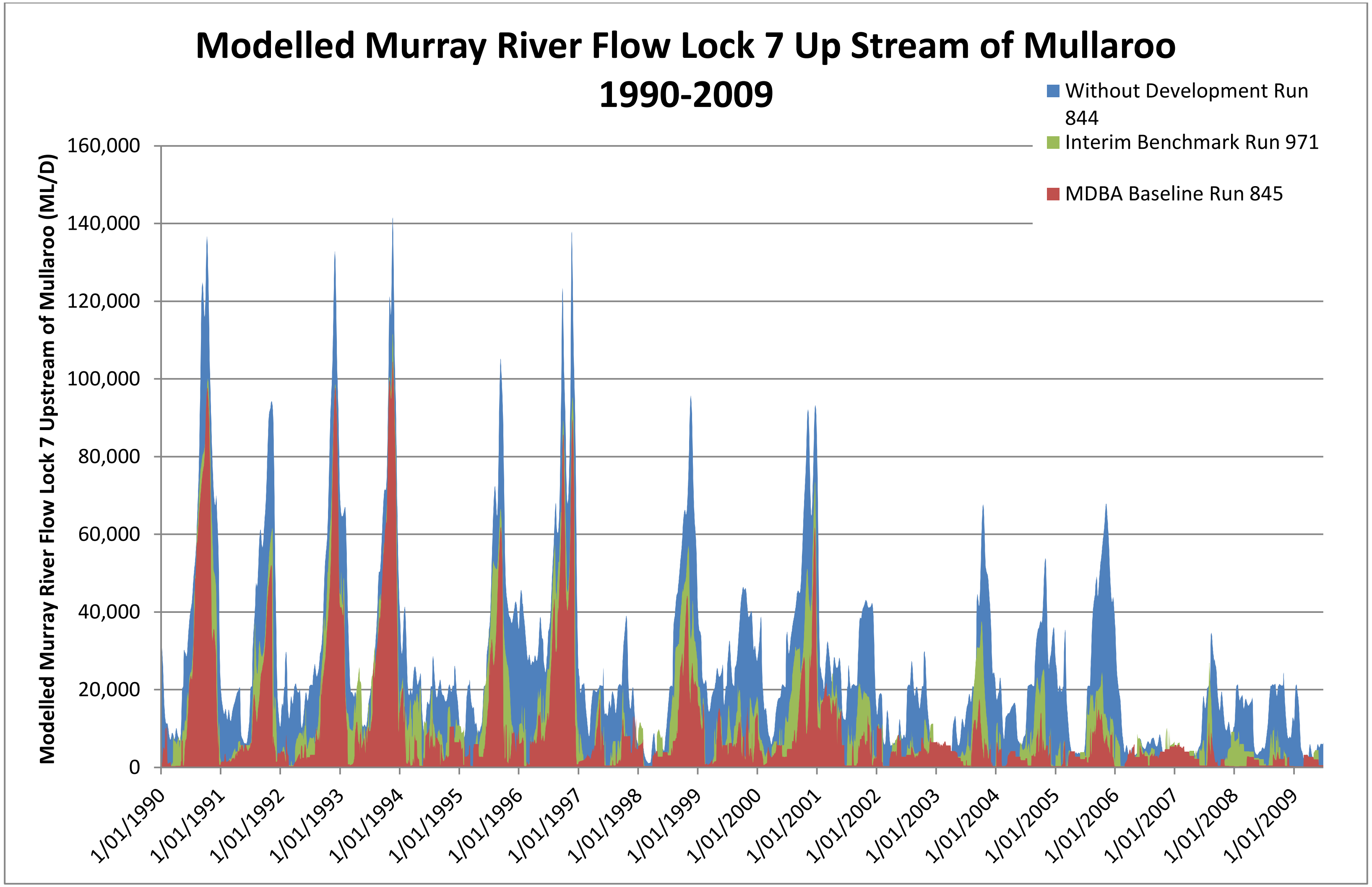


Figure 8-5. Daily Peak Flow by year for different flow regimes at Lock 7 (Data supplied by MDBA, 2014)

9. Environmental water requirements (Section 4.5.2)

Achieving the ecological objectives for the Lindsay Island Floodplain is underpinned by the environmental water requirements for relevant WRCs. These have been identified by analysing relevant hydrographic information, spatial data and scientific literature to generate site-specific water requirements (Ecological Associates, 2014a).

Ecological objectives, associated WRCs and the corresponding environmental water requirements are outlined in Table 9-1. Detailed information on water requirements, including hydrological targets, is provided in Appendix B.

Mechanisms to deliver these environmental water requirements are detailed in Section 10.

Table 9-1. Environmental water requirements to achieve ecological objectives (Ecological Associates, 2014a). The maximum interval between events is taken from MDBA (2012), when not specified in Ecological Associates (2014a)

Water Regime Class	Ecological Objectives	Environmental Water Requirements					
		Frequency of inflows	Duration of flooding	Timing	Maximum interval	Area inundated	Equivalent River Murray flow
Semi-permanent Wetlands	• Enhance Murray cod habitat by improving the productivity of connected riparian zones and wetlands while maintaining fast-flowing habitat. • Maintain resident populations of frogs and small fish in wetlands. • Provide reliable breeding habitat for waterbirds, including colonial nesting species. • Frequently provide habitat for thousands of waterbirds.	>8 years in 10	Variable however complete drying is rare (<1 year in 10)	Variable	4 years	254 ha	30,000 ML/d
Temporary Wetlands	• Frequently provide habitat for thousands of waterbirds. • Contribute to the carbon requirements of the River Murray channel ecosystem.	9 years in 10	Variable; filled 3-9 years in 10	Winter – Spring Peak water level between Sep and Dec	4 years	365 ha	60,000 ML/d
Watercourses **(Upper Mullaroo Creek)**	• Enhance Murray cod habitat by improving the productivity of connected riparian zones and wetlands while maintaining fast-flowing habitat.	At all times	Year round	Year round	NA	223 ha	Mullaroo Creek flows: 0.2 - 0.4 m/s
		Annual	6-10 weeks	Spring	2 years		50,000 ML/d
River Red Gum Forest and Woodland	• Provide reliable breeding habitat for waterbirds, including colonial nesting species. • Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, insectivorous bats and Giles' planigale. • Contribute to the carbon requirements of the River Murray	6 years in 10	4-10 weeks	Commence between Sep and Dec	4 years	854 ha	>70,000 ML/d

	channel ecosystem.	5 years in 10	3-6 weeks		7 years		>85,000 ML/d
Lignum Shrubland and Woodland	• Provide reliable breeding habitat for waterbirds, including colonial nesting species • Frequently provide habitat for thousands of waterbirds • Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, insectivorous bats and Giles' planigale • Contribute to the carbon requirements of the River Murray channel ecosystem	6 years in 10	4 -10 weeks	Spring	5 years	1776 ha	>70,000 ML/d
		5 years in 10	3-6 weeks	Spring	5 years		>85,000 ML/d
Black Box Woodland	• Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, insectivorous bats and Giles' planigale • Contribute to the carbon requirements of the River Murray channel ecosystem	3 years in 10	2-6 weeks	Spring	7 years	1030 ha	80,000 – 100,000 ML/d
Alluvial **Plain**	• Provide reliable breeding habitat for waterbirds, including colonial nesting species • Frequently provide habitat for thousands of waterbirds	1 year in 10 (no more than 3 years in 10)	3 -8 weeks	Spring - Summer	NA	607 ha	>100,000 ML/day

10.Operating regime (Section 4.6)

10.1. Role of the structures

The ecological objectives for the site will be achieved by operating the proposed works in conjunction with Lock 7 and existing TLM infrastructure to deliver water to the Lindsay Island floodplain. The proposed works consist of a large environmental regulator (the Berribee Regulator) and a range of supporting structures. Both the MDBA and SA Water have been consulted about the proposed changes to Lock 7 operations, which is considered acceptable under current conditions. This is discussed further in Section 13.2.

The Berribee Regulator will be the primary means of delivering water to the Lindsay Island floodplain, inundating 3546 ha (see Table 10-1). Other infrastructure either constructed through TLM or as part of this proposed supply measure can be operated in combination with or independently of the Berribee Regulator to target other areas of the floodplain (GHD, 2014b).

The proposed works and existing infrastructure are described in Table 10-1. The volumes provided in the table refers to the volume to fill from empty, assuming no losses or return flows. These volumes are based on the depth and area relationships with stage height behind each of the regulators. This information in conjunction with the proposed operating regime will enable the MDBA to model return volumes for the full range of operational scenarios during the Phase 2 assessment process.

Table 10-2. Summary of existing and proposed environmental watering infrastructure on Lindsay Island and its role in the project

Infrastructure	Status	Description	Role	Target area	Inundation area (ha)	Volume (GL)
Lock 7	Existing	River Murray Weir 7.	River Regulation and Navigation.	Whole of Project	N/A	N/A
Mullaroo Regulator and fishway (TLM)	Under construction summer 2014/15	An environmental regulator on the inlet of the Mullaroo Creek, 3 bays with lay flat gates and vertical slot fishway.	It enables Lock 7 to be raised or lowered independent of flow in the Mullaroo Creek. The vertical slot fishway provides upstream and downstream fish passage to the River Murray from Mullaroo Creek.	Whole of project	N/A	N/A
Upper Lindsay inlet regulators (TLM)	Existing	Two environmental regulators on the upstream inlet of Lindsay River fitted with aluminium stop logs.	The environmental regulators enable River Murray flow to enter Lindsay River at lower flow rates and for flow rates to be managed in conjunction with Lock 7 operations.	Whole of project	N/A	N/A
Lake Wallawalla regulators (TLM)	Existing	Two environmental regulators on the inlet to Lake Wallawalla, fitted with dual leaf gates.	The structures enable water to be retained in the Lake for the desired duration from natural and managed flows.	Lake Wallawalla and Wallawalla West	Incorporated in Berribee Regulator area	Incorporated in Berribee Regulator inundation
Webster's Lagoon (TLM)	Existing	Environmental regulator with dual leaf gates.	The regulator manages the wetting and drying regime of the Lagoon by excluding unseasonal flow.	Influences Webster's Lagoon area independently of proposed works	55.8	0.37
Berribee Regulator, fishway and associated works	Proposed	Large environmental regulator, spanning middle Lindsay River, 11 bays with stop logs. Vertical slot fishway. Support structures include track raising and minor regulators fitted with aluminium stop logs.	Enables upstream inundation of Lindsay River and associated floodplain on a large scale via gravity supply from Lock 7 weir pool. To provide containment and direct flow though of the Berribee Regulator pool.	Whole of project	3,546	35.3

Infrastructure	Status	Description	Role	Target area	Inundation area (ha)	Volume (GL)
Lake Wallawalla East and West	Proposed	Track raising and minor regulator fitted with aluminium stop logs.	To provide inundation of high level floodplain via water pumped from the Berribee pool.	Floodplain East and West of Lake Wallawalla	937	3.4
Lindsay South Wetland	Proposed	Track raising and minor regulator fitted with aluminium stop logs.	To provide inundation of high level floodplain via water pumped from the Berribee pool.	Floodplain and wetland south of the Upper Lindsay River	225	1.1
Crankhandle Wetland Complex	Proposed	Track raising and minor regulator fitted with aluminium stop logs.	Provide inundation of Crankhandle wetland and associated floodplain via gravity from the Berribee pool.	Floodplain and wetlands of the Crankhandle Wetland Complex	444	0.90

10.2 Operating scenarios

The Lindsay Island water management works have been designed to provide maximum operational flexibility and will complement Basin Plan flows to deliver additional environmental benefits. Five indicative operating scenarios have been developed to illustrate how these works can be used to achieve environmental outcomes. Actual operation during a watering event is likely to vary somewhat from these scenarios, depending on river flows, antecedent conditions and the condition of the floodplain.

These scenarios include:

- Default
- Seasonal Fresh
- Berribee Intermediate
- Berribee Maximum
- Berribee Maximum and Pumping
- Natural Inundation.

Each of the scenarios align with the water regime classes for Lindsay Island, as illustrated in Table 10-2 below.

Table 10-2: Links between the operating scenarios and water regime classes at Lindsay Island

<table>
<tr><th>Corresponding river flow:</th><th>> 10,0000 ML/d</th><th>30,000 – 50,000 ML/d</th><th>50,000 – 90,000 ML/d</th><th>170,000 ML/day[1]</th></tr>
<tr><td>Watercourse</td><td>Seasonal fresh</td><td rowspan="5">Berribee Intermediate</td><td rowspan="6">Berribee Maximum</td><td rowspan="7">Berribee Maximum and pumping</td></tr>
<tr><td>Semi-permanent Wetlands</td><td rowspan="6"></td></tr>
<tr><td>Temporary wetlands</td></tr>
<tr><td>Red Gum Forest and Woodland</td></tr>
<tr><td>Lignum Shrubland and Woodland</td></tr>
<tr><td>Black Box Woodland</td><td></td></tr>
<tr><td>Alluvial Plain</td><td></td><td></td></tr>
</table>

[1] Corresponding flow threshold for the lakes. The extent of floodplain inundation does not replicate a 170,000 ML/d flow.

Table 10-2 shows that a seasonal fresh meets the water requirements of watercourses. Similarly, a Berribee intermediate operation will meet the requirements of the Red Gum Forest and Woodland, as well as the wetlands and watercourses.

An overview of each of the operational scenarios is provided below.

Default

This scenario represents the default configuration for the Lindsay Island water management infrastructure and Lock 7 during normal regulated flows when environmental watering is not required.

Lock 7 is maintained at normal pool height at 22.1 m AHD, the Mullaroo regulator is set to maintain passing flows of 400 – 800 ML/d, the Southern Lindsay Inlet regulator is closed and the Northern Lindsay Inlet structure is open. All remaining environmental regulators are open.

The only areas of Lindsay Island inundated under this scenario are the permanent watercourses, such as Lindsay River, which provides habitat for a range of generalist aquatic fauna. Fast flowing habitat is maintained in Mullaroo Creek for Murray cod, golden perch and silver perch.

Seasonal Fresh

This scenario targets anabranches, providing a seasonal fresh through the Lindsay River and Mullaroo Creek. It utilises the Upper Lindsay (both North and South are open) and Mullaroo Creek Regulators and will require Lock 7 to be raised to 22.6 m AHD, in the absence of suitable River Murray flow. All other environmental regulators are open.

The scenario fresh scenario aims to stimulate spawning of golden perch, silver perch and Australian smelt. It provides shallow aquatic habitat in the Upper Lindsay effluents for small bodied fish and maintains fast flowing habitat in Mullaroo Creek for Murray cod, golden perch and silver perch. The fresh will also water the river red gums fringing these anabranches.

Berribee Intermediate

This scenario targets the lower floodplain areas, mimicking river flows of between 40,000 and 90,000 ML/day. Lock 7 is raised above normal operating level (22.1 m AHD), the Mullaroo Regulator and Upper Lindsay Inlet Regulators are open, and the Berribee Regulator is closed, whilst maintaining appropriate passing flows. Water can also be passed from the Berribee Regulator pool through to the Crankhandle Wetland Complex and Crankhandle West, where regulators will be operated to pass flow or to maintain desired water levels, as appropriate.

The Berribee Intermediate scenario waters low lying wetlands, fringing red gum and some areas of lignum. This will improve the condition of trees and understory, and provide wetland habitat for small fish, turtles, frogs and waterbirds. Longer and more extensive watering events are likely to provide appropriate conditions for waterbird breeding in flooded red gum and lignum. Fast flowing habitat will maintained in Mullaroo Creek for Murray cod, golden perch and silver perch.

Berribee Maximum

This scenario represents the maximum inundation of Lindsay Island. It mimics river flows of up to 90,000 ML/day and targets the upper floodplain terraces. The Berribee Regulator and Lock 7 will be raised to maximum height; Mullaroo and Upper Lindsay inlet structures will be opened and the Berribee Regulator weirpool will be gradually raised to its maximum level whilst maintaining appropriate passing flows. Water will also be passed from the Berribee Regulator pool through to the Crankhandle Wetland complex where regulators will be set to pass flow or to maintain maximum water levels as appropriate.

The Berribee Maximum scenario will water red gum communities, large areas of lignum and some black box woodland. Extended watering events will provide habitat for waterbird breeding; shorter events will maintain ecosystem structure and productivity. Flow velocities will be managed in Mullaroo Creek for Murray cod, golden perch and silver perch.

Berribee Maximum and Pumping

This scenario is a variation of the Berribee Maximum scenario, utilising temporary pumps to increase the area flooded by more than 1000 ha. In addition to the operations described above, regulators at Wallawalla West, Wallawalla East and the Lindsay South Wetland will be closed and temporary pumps will be used to inundate each of these areas.

This scenario will enable large areas of black box woodland to be watered. This will improve tree recruitment and productivity, improving the habitat available for dependent vertebrate fauna such as bush birds and insectivorous bats.

Natural inundation

In order to minimise the impact of the infrastructure on natural inundation patterns it is proposed that all regulating structures will be open allowing full connectivity between the River Murray, Lindsay River, Mullaroo Creek and the floodplain. The outcomes of this scenario will depend on the magnitude and duration of river flows.

10.3 Transition between operating scenarios

A range of factors may make it necessary to change operational scenarios during the course of a watering event. These factors include:

- Inflows causing increase in environmental water allocations
- Inflows generating natural flooding
- Response to ecological opportunities or to mitigate risks
- Response to operational opportunities or to mitigate risks, and
- Response to water quality risk mitigation requirements.

An operational matrix (Table 10-3) has been developed which summarises how each structure would be operated change from one scenario to another.

For example, to move from the Default to the Berribee Maximum scenario, Lock 7 would need to be raised to its maximum safe operating level and the Upper Lindsay and Mullaroo regulators fully opened. Stop logs would be progressively placed in the Berribee Regulator to raise water levels upstream, while maintaining appropriate passing flows. The Crankhandle regulators would be operated to fill and then maintain water levels within the Crankhandle Wetland Complex and Crankhandle West while maintaining appropriate flow-through.

The matrix shows the status of the structures once each scenario has been established and is in operation. This matrix shows a selection of available operational configurations for the purposes of illustrating the flexibility of the works package.

During transition to the Natural Inundation scenario, stop logs at Lock 7, Berribee and other regulators are progressively removed until tail water and headwater levels are matched. The Berribee Regulator may then be completely stripped to allow unimpeded passage of natural flows.

Table 10-3. Operational matrix

	Scenario To	Default	Seasonal Fresh	Berribee Intermediate	Berribee Maximum	Berribee Maximum and Pumping	Natural inundation
From	Default	Condition During Scenario Lock 7 - set to maintain normal pool height Upper Lindsay and Mullaroo – normal operations** Wallawalla - open Berribee - open Crankhandle - open Upper floodplain structures* – open	Lock 7 – set to 22.6 m AHD Upper Lindsay and Mullaroo – open	Lock 7 – raised to height required to achieve operation objectives (between 22.6 m AHD and maximum operating level) Upper Lindsay and Mullaroo – open Berribee – set to maintain height required to achieve operation objectives, (between open and 23.2 m AHD), with flow through Crankhandle - set to maintain height required to achieve operation objectives (between open and 22.6 m AHD), with flow through where appropriate	Lock 7 – raised to maximum operating level Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate	Lock 7 – raised to maximum operating level Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate Upper floodplain structures* – closed with temporary pumps in operation to fill Wallawalla East and West and Lindsay South	All structures open
From	Seasonal Fresh	Lock 7 - set to maintain normal pool height Upper Lindsay and Mullaroo – normal operations**	Condition During Scenario Lock 7 – set to 22.6 m AHD Upper Lindsay and Mullaroo - open Wallawalla - open Berribee - open Crankhandle - open Upper floodplain structures* – open	Lock 7 – raised to height required to achieve operation objectives (between 22.6 m AHD and maximum operating level) Berribee – set to maintain height required to achieve operation objectives, (between open and 23.2 m AHD), with flow through Crankhandle - set to maintain height required to achieve operation objectives (between open and 22.6 m AHD), with flow through where appropriate	Lock 7 – raised to maximum operating level Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate	Lock 7 – raised to maximum operating level Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate Upper floodplain structures* – closed with temporary pumps in operation to fill Wallawalla East and West and Lindsay South	All structures open
From	Berribee Intermediate	Lock 7 - set to maintain normal pool height Upper Lindsay and Mullaroo – normal operations**	Lock 7 – set to 22.6 m AHD Berribee – open	Condition During Scenario Lock 7 – set to height required to achieve operation objectives (between 22.6 m AHD and maximum operating level) Upper Lindsay and Mullaroo - open Wallawalla - open Berribee – set to maintain height required to achieve operation objectives, (between open and 23.2 m AHD), with flow through Crankhandle - set to maintain height required to achieve operation objectives (between open and 22.6 m AHD), with flow through where appropriate Upper floodplain structures* – open	Lock 7 – raised to maximum operating level Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate	Lock 7 – raised to maximum operating level Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate Upper floodplain structures* – closed with temporary pumps in operation to fill Wallawalla East and West and Lindsay South	All structures open
From	Berribee Maximum	Lock 7 - set to maintain normal pool height Upper Lindsay and Mullaroo – normal operations** Berribee - open Crankhandle - open	Lock 7 – set to 22.6 m AHD Berribee - open Crankhandle - open	Lock 7 – height maintained or lowered to required level to achieve operation objectives (between 22.6 m AHD and maximum operating level) Berribee – set to maintain height required to achieve operation objectives, (between open and 23.2 m AHD), with flow through	Condition During Scenario Lock 7 – set to maximum operating level Upper Lindsay and Mullaroo - open Wallawalla - open Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate Upper floodplain structures* – open	Upper floodplain structures* – closed with temporary pumps in operation to fill Wallawalla East and West and Lindsay South	All structures open

	Scenario To	Default	Seasonal Fresh	Berribee Intermediate	Berribee Maximum	Berribee Maximum and Pumping	Natural inundation
From	Berribee Maximum and Pumping	Lock 7 - set to maintain normal pool height Upper Lindsay and Mullaroo – normal operations** Wallawalla - open Berribee - open Crankhandle - open Upper floodplain structures* – open	Lock 7 – set to 22.6 m AHD Wallawalla - open Berribee - open Crankhandle - open Upper floodplain structures* – open	Lock 7 – height maintained or lowered to required level to achieve operation objectives (between 22.6 m AHD and maximum operating level) Wallawalla - open Berribee – set to maintain height required to achieve operation objectives, (between open and 23.2 m AHD), with flow through Upper floodplain structures* – open	Upper floodplain structures* – open	Condition During Scenario Lock 7 – set to maximum operating level Upper Lindsay and Mullaroo - open Wallawalla - open Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate Upper floodplain structures* – closed with pumps on operation to fill Wallawalla east and west and Lindsay South	All structures open
	Natural Inundation	No change	Lock 7 – set to 22.6 m AHD	Lock 7 – set to height required to achieve operation objectives (between 22.6 m AHD and maximum operating level) Berribee – set to maintain height required to achieve operation objectives, (between open and 23.2 m AHD), with flow through Crankhandle - set to maintain height required to achieve operation objectives (between open and 22.6 m AHD), with flow through where appropriate	Lock 7 – set to maximum operating level Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate	Lock 7 – set to maximum operating level Berribee – set to maintain 23.2 m AHD, (maximum operating height) with flow through Crankhandle – set to maintain 22.6 m AHD, with flow through where appropriate Upper floodplain structures* – closed with pumps on operation to fill Wallawalla east and west and Lindsay South	Condition During Scenario All structures open

*Includes Lake Wallawalla East and West and Lindsay South Wetland

**Normal operations for Mullaroo and Upper Lindsay Structures is Mullaroo regulator set to maintain 400 – 800 ML/d, Southern Lindsay Inlet structure closed, Northern Lindsay structure open

10.3 Timing of Operations and Risk Management

The proposed works provide a high degree of operational flexibility. Ecological Associates (2014c) provides a selection of possible operating scenarios. The decision to initiate an environmental watering event will be based on:

- Water availability
- The floodplain water requirements consistent with the watering regime, ecological objectives and targets
- Operational risks, and
- The regional context (i.e. survival watering, recruitment watering, maintenance watering) and other river operations that may occur within the river reach.

Watering will largely occur in late winter/spring in response to natural flow cues. The optimal timing for events is provided in Table 9-1. Mimicking natural variability will provide a diverse range of inundation events, which will restore a mosaic of vegetation consistent with pre-regulation conditions.

With this in mind, the Mallee CMA will seek to collaborate with the MDBA and other stakeholders to help develop new “real time” river information tools that will better inform operations.

The major irrigation development adjacent to the project site is at Lindsay Point, which is supplied from the Lindsay River. All Lindsay River irrigation off-takes are located downstream of the Berribee Regulator and within the Lock 6 weir pool. Maintenance of passing flows at the Berribee Regulator will enable management of water quality and provision of water resource to these irrigators, allowing for operation of the environmental works to continue without impacting on irrigation demands.

The structures will be operated to manage adverse impacts as per the risk mitigation actions outlined in Sections 7 and 11.

11. Assessment of risks and impacts of the operation of the measure (Section 4.7)

A comprehensive risk assessment of the potential operational impacts of the proposed supply measure has been carried out during development of this business case. It is acknowledged that operation may have a range of impacts, including adverse impacts on cultural heritage, socio-economic values and impacts from operation of structures. This risk assessment process was informed by experience with operating environmental watering projects of similar scale and complexity, including TLM.

11.1 Risk assessment methodology

The risk assessment for the Lindsay Island project was completed in line with the requirements of AS/NZS ISO 31000:2009 (Lloyd Environmental, 2014). This assessed both the likelihood of an event occurring and the severity of the outcome if that event occurred. The assessment generated a risk matrix in line with the ISO standards and prioritised mitigation strategies and measures.

Refer to Section 7, Tables 7-1 to 7-4 to view the risk matrix and definitions used in this risk assessment, and further details on the methodology.

The risk assessment was consolidated as the project developed and additional information incorporated into Table 11-1.

11.2 Risk assessment outcomes

Table 11-1 presents a summary of the assessment and subsequent work undertaken, including mitigation measures developed and an assessment of residual risks after these are applied. It should be noted that where a residual risk is given a range of ratings, the highest risk category is listed.

Table 11-1. Risk assessment – threats and impacts of operation of the measure without mitigation and residual risk rating after mitigation, adapted from Lloyd Environmental (2014)

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Adverse impacts on cultural heritage						
Loss of artefacts via erosion; loss of artefacts via inundation	Lindsay Island is considered an area of high cultural heritage sensitivity. Fluvial processes during watering events could damage cultural sites and places, resulting in the loss of artefacts in-situ on the floodplain. This may damage relationships with Indigenous stakeholders and subsequently affect future operation of the works.	Possible	Moderate	Moderate	Preliminary cultural heritage assessment work has been undertaken through the Lindsay Island Floodplain Due Diligence Assessment (Bell, 2013). A Cultural Heritage Management Plan will be required prior to construction activities and will be developed in partnership with Indigenous stakeholders. This will provide for any further remedial works during/after operations. Implement measures during operations to minimise damage to cultural sites. Proactive engagement with Indigenous stakeholders during operation, which may involve inspection of cultural sites pre and post watering events to monitor and undertake protection works, relocation of artefacts as required, and rehabilitation works.	Low
Damage to relationships with Indigenous stakeholders	This threat could occur through unforeseen impacts on cultural sites during operation, which may damage relationships with Indigenous stakeholders. This could affect the future operation of works and subsequently impact on the site's water-dependent ecological values.	Possible	Moderate	Moderate	As above.	Low
Adverse impacts on socio-economic values						

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Restricted access to public land during watering events	Watering events may inundate roads and bridges, limiting or prohibiting public access. This may reduce opportunities for active and passive recreation, and possibly tourism.	Certain	Minor	Moderate	Improved planning and modelling to predict access limitations during operation. Issue public notifications of access changes/limitations prior to watering events. Close consultation with tourism industry to ensure timely communication around planned events. Upgrade roads to improve access where practical. Provide boat access as an alternative, where relevant.	Moderate
Disturbance of beekeeping and other commercial operations (kayaking, camping, tours etc.)	In addition to restricting access, watering events could inundate vegetation with pollination potential and beehive sites. Watering events could also restrict other commercial operations such as camping and kayaking tours.	Possible	Moderate	Moderate	Engage with the relevant stakeholders (apiarists, licensed tourism operators etc.) to ensure they are aware of the extent of upcoming watering events and can plan accordingly. This will be incorporated into the project stakeholder management strategy.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Rise in river salinity	A key driver to salinity in Lindsay River is discharge of saline groundwater along gaining reaches during a flow recession. Increases in salinity (measured as EC units at Morgan) may breach Basin Salinity Management Strategy requirements and also exceed Basin Plan salinity targets. This may result in poor water quality for downstream users.	Likely	Moderate	High	Avoid watering salinity hot spots identified through the use of AEM datasets (Munday et al. 2008), instream nanoTEM (Telfer et al. 2005a and 2005b, 2007) and other salinity investigations. Provision of dilution flows in the Murray and Lindsay Rivers during and following drawdown. Not operating during high-risk periods. Use regulators to: • Manage flushing of salt load from the Lindsay system to control displacement of in-stream salinity. • Control the level and area of floodplain inundated and control of recession to manage the volume of saline water to be returned to the river. • Enable hold periods to be shortened or lengthened to mitigate impact of release of stored water. • Restrict release from impounded areas to allow evaporation and seepage. • Manage rates of rise within the Berribee Weir Pool to maximise through-flow and dilution. • Manage rates of fall within the Berribee Weir Pool to reduce peak impact and minimise hydraulic gradient between groundwater and surface water. Ongoing monitoring of groundwater and surface water levels and salinity to inform adaptive management and update of Operational Plans.	Moderate

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Increased mosquito populations	Ponding water on the floodplain has the potential to localised increases in mosquito populations. This could lead to human discomfort, disease exposure and eventually to negative perceptions about the project.	Possible	Moderate	Moderate	Active community engagement to improve awareness and encourage people to take precautions. This would be carried out as part of wider communication and engagement activities.	Low
Inundation of NSW land (public and private)	Raising of the Lock 7 weir pool will cause inundation of parks and forests, commercial operations and private land in NSW, and may cause operational changes and/or project delays, threatening the project objectives.	Possible	Moderate	Moderate	Maintain strong working relationships with river operators and NSW partner agencies through regular operation group meetings to ensure affected land managers are aware and prepared for inundation. Extend the use of proven protocols to manage NSW inundation associated with raising Locks 8 and 9 to Lock 7. Develop a detailed Operational Plan and review regularly to implement an adaptive management approach that can respond as necessary.	Low
Adverse impacts resulting from operating structures						
Structural failure of new works during operation	Structures can be vulnerable to inundation flows during operation via processes and attributes such as: inadequate elevation; insufficient protection from scour; insufficient rock armour; flood preparation including strip boards and handrails.	Possible	Severe	High	Provide adequate protection from erosion during and after operation. Ongoing inspection and maintenance of structures for early identification of potential problems during operation. Flood preparation actions written into Operations and Maintenance (O&M) plan including removing structural parts likely to be barriers to flow or large debris.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Unforseen incompatibility with existing infrastructure (e.g. Lock 7)	Interactions with other River Murray management structures including Lake Victoria and Lock 7 will need to be planned and approved. If these requirements cannot be achieved this would cause operational changes or project delays, affecting the ability to operate effectively and achieve the ecological objectives.	Possible	Moderate	Moderate	Identify system constraints and operate within these (or address constraints, where possible), informed by the Constraints Management Strategy (MDBA, 2013). Maintain strong working relationships with river operators, partner agencies (including agencies in NSW, SA and Victoria), through regular operation group meetings to manage all aspects of watering events. Events informed by hydraulic modelling (Water Technology, 2014). Develop a detailed Operational Plan and review regularly to implement an adaptive management approach that can respond as necessary.	Low
Poor design of structures	This could occur through inadequate technical rigour during design or maintenance, causing maintenance issues or reduced effectiveness in operations.	Possible	Moderate	Moderate	Peer review of structure designs. Develop and implement appropriate maintenance programs.	Low
Unsafe operation of built infrastructure	Unsafe operation, such as breaches of OH&S procedures, could threaten human safety.	Unlikely	Catastrophic	Moderate	Ensure appropriate design that incorporates best-practice OH&S provisions. Operate infrastructure in compliance with OH&S requirements. Develop and implement a suitable maintenance program, in conjunction with Operation and Maintenance Plans. Provide safe access provisions and public safety provisions. Provide appropriate induction and training for staff operating infrastructure and equipment. Provide appropriate personal protective equipment (PPE) and equipment for operations.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Adverse impacts on operation, maintenance and management. *Please note: These threats impact operations, but are not caused by the operating regime.*						
Lack of clear understanding of roles and responsibilities of ownership and operation	Lack of clear understanding of roles and responsibilities of ownership and operation could prevent the effective operation of the infrastructure.	Possible	Moderate	Moderate	Establish a MoU between all relevant agencies outlining roles and responsibilities during operation. Facilitate shared knowledge of project objectives among asset owners and operators. Develop all documentation with relevant agencies prior to construction, including production of Operation and Maintenance manuals. Ensure emergency response arrangements are in place. Ensure ongoing maintenance of structures and insurance arrangements. Maintain strong working relationships with river operators, partner agencies (including agencies in NSW, SA and Victoria), and Commonwealth and Victorian water holders through regular operations group meetings. Maintain clear lines of communication during operation and reporting of water accounts/flows (i.e. reporting and accounting arrangements).	Low
Lack of funding for ongoing operation, maintenance and management	Insufficient funding for maintenance activities result in deterioration of structures, increasing the risk of failure. Inability to coordinate/direct operations due to insufficient agency resources.	Possible	Severe	High	Maintain strong relationships with investors/funding bodies to secure long term operational funding. Suspend operations if insufficient resources available to support relevant agencies.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Operational outcomes do not reflect hydrological modelling outputs	On-ground outcomes during operation do not meet expectations due to incorrect assumptions, input data, interpretation or inaccurate models.	Possible	Severe	Moderate	Models developed using best available information. Undertake sensitivity modelling to confirm minor discrepancies in model accuracy do not result in dramatic changes to operational outcomes. Models independently peer-reviewed and determined to be fit for purpose.	Moderate
Community/ stakeholder resistance, backlash or poor perception	Poor communication with project stakeholders and the community can result in misunderstanding of the project's works and ongoing operations. This may limit on the capacity to operate the site as required.	Possible	Moderate	Moderate	Ongoing stakeholder liaison (early and often) guided by a stakeholder engagement plan. Targeted engagement to address identified concerns of key stakeholders.	Low
Inundation of private land without prior agreement	The only private land to be inundated by this project is currently owned by Trust For Nature and managed for conservation. It is possible that ownership could change and the new owner may not permit inundating.	Possible	Moderate	Moderate	Ongoing engagement with landholders regarding planned watering events and outcomes. Negotiate conservation covenants and/or flood/access easements to be registered on title if ownership changes.	Low

11.3 Risk mitigation and controls

The risk assessment confirms that all the risks identified in the risk assessment are reduced to acceptable levels (very low to moderate) once well-established risk mitigation controls are implemented.

While the risk assessment identifies several potential threats that could generate high risks to the operation of the structures (Table 11-1), these risks are considered manageable because they:

- Are well known and are unlikely to involve new or unknown challenges
- Can be mitigated through well-established management controls
- Have been successfully managed by the Mallee CMA and project partners (including construction authorities) in previous projects
- Result in very low or moderate residual risks after standard mitigation measures are implemented

Three risks retained a residual risk of moderate after implementation of the recommended mitigation strategies (Table 11-2). Further consideration of these threats may assist in further understanding the potential impacts and, in some cases, identifying additional mitigation measures to reduce the residual risk.

While downstream and cumulative salinity impacts cannot be formally ascertained at this time (see Section 7), particular consideration has been given to the potential salinity impacts of the project, as described in Section 11.5.

Table 11-2. High priority risks, mitigation and residual risk

Threat	Risk without mitigation	Residual risk rating	Additional considerations (Lloyd Environmental, 2014)
Restricted access to public land during watering events	Moderate	Moderate	Alternative recreational sites could be promoted as a form of ‘offset’ during watering events. New infrastructure could be provided to enhance the most common recreational pursuits (e.g. walking tracks and bird hides, campgrounds for campers)
Rise in river salinity from salt wash off from floodplain soils, mobilisation in stream salt store or via mobilisation of saline groundwater to watercourses	High	Moderate	Implementation of comprehensive monitoring including the installation of additional groundwater monitoring bores during early operations and the use of information obtained will inform a more detailed analysis of local and downstream salinity impacts and adaptive management of the site. This local scale investigation should form part of a larger scale investigation covering river operations and environmental watering activities taking place between Lock 9 and Lock 5.
Operational outcomes do not reflect hydrological modelling outputs	Moderate	Moderate	Opportunities for improvement of models identified for action as more information becomes available. Further refinement of models undertaken as project develops and contextual information is provided regarding Basin Plan flows, detailed designs and initial operations

11.4 Salinity Impact Assessment and Mitigation Strategies

A preliminary salinity impact assessment of the Lindsay Island Floodplain project has been completed which includes analysis of both BSMS considerations and real time salinity impacts. The parameters applied in this assessment are based on historically observed surface and groundwater responses. While the salt mobilisation responses can be identified and estimated, the operating regime of the River Murray under the Basin Plan is largely unknown at this point in time and may affect the observed salinity response. The preliminary salinity impact assessment must be considered in this context.

The Victorian Salt Disposal Working Group provides advice to DEPI about Victoria's compliance and implementation of the BSMS, including the assessment of salinity impacts. The Group comprises representatives from DEPI, Goulburn Broken, Mallee and North Central CMAs, G-MW and Lower Murray Water. The Group has reviewed the preliminary salinity impact assessment for the Lindsay Island Floodplain project and considered the findings of the expert peer review (see Appendix L). The Group endorses the assessment methodology as consistent with the BSMS and fit for purpose to support this business case.

Preliminary Salinity Assessment Approach

The study estimated salt loads to the river system using a combination of approaches (semi-quantitative and qualitative) based on an initial desktop assessment of hydrogeological and salinity information and methods including mass balance, flow nets and groundwater mound calculations. Associated salinity impacts at Morgan were derived using the Ready Reckoner developed specifically for environmental watering projects (Fuller and Telfer 2007).

Real-time salinity estimates by way of in-stream salinity increments have been estimated for the range of proposed operating regimes (river flow rates & discharge volumes/rates/timing and a minimum passing flow through the Berribee Regulator of 400 ML/day) and in consideration of Basin Plan operation targets at Lock 6 (580 µS/cm) and Morgan (830 µS/cm).

The is some uncertainty related to assumptions made in the analysis. Where uncertainty was identified for a given parameter, a conservative value was assumed or upper bound used. This approach is likely to overestimate the salt load magnitude.

The information provided by these assessments can be used to inform analysis of cumulative impacts of the final suite of Supply, Demand and Constraint Management Measures implemented under the Basin Plan. For detailed information please refer to the Preliminary Impact Assessment for Mallee Environmental Watering Projects – Lindsay Island (SKM, 2014; Appendix D).

Preliminary salt estimate

The preliminary salt impact estimate of the proposed Berribee Regulator is 7.12 EC at Morgan (assuming 1 in 2 year frequency of operation) and 1.88 EC at Morgan (assuming 1 in 6 year frequency of operation where pre-drought 1990s groundwater conditions are reinstated as a result of repeated and successive operation). This initial estimate does not account for implementation of mitigation strategies.

The impacts of the other environmental watering options at Lindsay Island are generally not significant in terms of EC impacts at Morgan (i.e. individually less than 0.1 EC). The exceptions are Wallawalla East (0.19 - 0.10 EC) and Lindsay South Effluent (0.28 - 0.14 EC) for the 1 in 2 and 1 in 6 watering frequencies respectively. However, they would be considered cumulatively significant when operated in conjunction with the Berribee Regulator, assuming that such cumulative impact would cause groundwater to rise to similar levels to 1990s conditions.

These estimates were converted to time series salt loads that may be used for more detailed salt impact assessment using the MDBA's MSM BIGMOD river model. Without the mitigation effects of the Mullaroo bypass flow, the real-time salinity impact in the lower reaches of Lindsay River could be quite large. The real time salinity impact assessment has underscored the importance of including a minimum passing flow of 400 ML/d in Mullaroo Creek within future operating scenarios. Adjustment of the passing flow dramatically reduced the salinity response in terms of real-time salinity impact, and provides opportunity to mitigate local effects in the Lower Lindsay.

Key salt mobilisation processes at play

The key driver of the salinity response in the Lindsay River is the rise of the groundwater mound under the floodplain inundation area and displacement of saline groundwater along gaining reaches where groundwater flows back to the river, particularly during flood recession. Another important process is the displacement of the in-stream salt stored in pools along the Lindsay River system. In minor floods, where the natural banks at the upstream end of the Lindsay system are overtopped, water flows in an uncontrolled manner through the Lindsay system. This flow entrains stored salt in these streams and carries it back to the River Murray.

Murray River salinity operational targets at Lock 6 and Morgan were exceeded for the Berribee Regulator (with/without Mullaroo Creek minimum passing flow of 400 ML/day) only when the Murray River salinity was already very close to the targets. The potential to exceed these targets may be minimised and real time impacts significantly lowered by adopting mitigation measures.

Mitigating measures and their feasibility

A balanced approach is required to maximise environmental benefits while at the same time minimising salinity impacts. The level of impact is highly dependent on the magnitude of river flow and the baseline salt load in the river system, which in turn is dependent on whole-of–river operations and priority order for each individual watering project.

The availability of dilution flows and their relative volume, duration and timing of release are important considerations for designing suitable mitigation strategies with more sophisticated control of diversion and release for these projects (SKM 2014). Without further detail on the whole-of–river operations it is not feasible to undertake the myriad of possible modelling scenarios required to determine the most appropriate mitigation strategy.

Mitigation strategies are therefore described below in general terms. More detailed analysis of the potential salinity impacts and risk mitigation strategies is recommended upon approval of this business case, potentially using a daily river operations model. This will most useful when there is greater certainty about the structure specifications and proposed operating regimes of the River Murray. A range of management responses are available and may be appropriate to consider in minimising each salinity process triggered. These include:

- Estimation of salinity thresholds for water users
- Implementing a monitoring regime that informs both the operation of the structures within the nominated thresholds as well as the overall estimation of salinity impacts downstream, and
- Creation of an operations protocol that explicitly connects projected salinity impacts, salinity thresholds for water users and contingency planning.

The proposed Berribee Regulator allows for active salt mitigation strategies to be employed, such as:

- Control of displacement of in-stream salt load: This provides significant benefits of being able to store salt load during lower flow regimes and releasing when river flows and salinity concentrations are able to be accommodated. Specific in stream salinity targets and matching River Murray flow rates will be required.
- Management of the area flooded: By controlling the overall level, different areas of floodplain can be flooded and thus the volume of saline water to be returned to the river can be managed. This measure will need to be considered in the context of the site’s environmental objectives, to ensure that all areas of the floodplain are watered.
- Timing of the “hold” phase: Should river conditions change rapidly, the hold phase can be shortened or lengthened to mitigate the impact of release of stored water. For example, the timing of the end of the hold phase can be actively controlled to minimise overlap with other river needs. This will require timely and pro-active coordination of river operations and can be accommodated by the use of regulating structures.

- Control of recession: The rate and volume of stored water that is released into receding river levels can be actively managed. Quick or slow releases can be used to optimise operations to manage salinity impacts in the river and on site.

Monitoring requirements and further analysis

A consultation phase is proposed, once the business case is approved, to determine suitable salinity thresholds in consultation with key stakeholders, including downstream irrigators. This, together with development of detailed construction designs and information on proposed River operation regimes, will assist the development of suitable operating protocols to minimise impacts on downstream users while maximising the environmental gains.

SKM (2014) recommended the implementation of comprehensive monitoring during early operations and the use of this information to inform a more detailed analysis of local and downstream salinity impacts and enable adaptive management of the structures. This local scale investigation should form part of a larger scale investigation covering river operations and environmental watering activities taking place between Lock 9 and Lock 5.

The monitoring program is an important consideration of the business case in gaining a greater understanding of the complex surface water /groundwater interactions and improving the certainty of further modelling. Without this additional information the modelling accuracy will continue to be limited by the current data assumptions and documented areas of uncertainty.

Priority monitoring relies on measurements of salinity, water level from observation wells and fixed surface water monitoring sites. These include:

- Three new bore sites to be drilled to channel sands aquifer to assist with measuring a change at North West and Lindsay South
- Seven data logger sites to capture continuous salinity and water level data – additional sites may be required where inundation activities present access issues
- Monitoring of water level and salinity at 42 existing bores sites before, during and immediately after watering events, and every three months between events, and
- Nine existing surface water sites are nominated to calculate salt load to reaches of flowing anabranches or the River Murray adjacent to floodplain watering.

11.5 Risk management strategy

As noted in Section 7.3, a comprehensive risk management strategy will be developed for the proposed supply measure, building on the work completed for this business case. The strategy will cover ecological and socio-economic aspects to provide a structured and coherent approach to risk management for the life of this project (i.e. construction and operation).

With regard to potential operational impacts, the risk management strategy will focus on the following issues, as described in Table 11-1:

- Potential impacts on socio-economic values, including salinity impacts
- Operation of structures, and
- Maintenance and ongoing management.

Risk assessment and management is not a static process. Regular monitoring and review of the risk management process is essential to ensure that:

- Mitigation measures are effective and efficient in both design and operation
- Further information is obtained to improve the risk assessment
- Lessons are learnt from events (including near-misses), changes, trends, successes and failures
- Risk treatments and priorities are revised in light of changes in the external and internal context, including changes to risk criteria and the risk itself, and
- Emerging risks are identified.

The risk assessment process will continue throughout the development and implementation of this project. It is anticipated that additional threats will be identified and evaluated as the project progresses, and any new risks incorporated into the risk management strategy.

12.Technical feasibility and fitness for purpose (Section 4.8)

12.1 Development of designs

The options selected for the *Lindsay Island Floodplain Management Project* have been developed to complement the delivery of Basin Plan flows. They offer opportunities to provide environmental water to sites during times of water shortage and by allowing delivery of water to higher parts of the floodplain beyond the reach of regulated releases to meet target inundation frequency, extent and duration parameters. In developing options for the project consultants were asked to consider the following:

- Maximising environmental benefit from operation of the proposed works by:
  - Targeting areas that are difficult to reach with run of River Murray flows
  - Considering lifting water from areas flooded by works to higher elevations with temporary pumps
  - Providing the ability to deliver water to high value target areas without requiring large storage releases to generate overbank flow and without relying on removal of system constraints
  - Ensuring that works can be used to magnify the effects of natural flows or regulated releases with minimal additional water use
  - Designing infrastructure which will be flexible in its use to allow implementation of operational strategies developed through adaptive management of the site.
- Maximising cost effectiveness, environmental benefits and water efficiency returns for investors through:
  - Analysis of environmental works in the region and incorporating lessons learned from the construction and operation of these projects
  - Pragmatic analysis of available infrastructure options
  - Striking a balance between capital investment and ongoing operating costs to deliver a cost effective solution.
- Ensuring practical and economic constructability of the project by:
  - Siting structures on existing access tracks and provision of construction access plans
  - Utilisation of locally obtainable construction materials where practical
  - Use of advantageous geological features within the landscape where possible
  - Incorporating information and experience obtained during the construction and operation of nearby works regarding seepage, structure settlement and stability, construction dewatering and downstream erosion control.
- Ensuring compatibility with nearby existing infrastructure and operational practice by:
  - Use of common design features with nearby infrastructure
  - Taking into account operational capabilities of existing infrastructure which is integral to the operation of the proposed works
  - Development of operational access plans
  - Working with SA water during options selection and development of concept designs.

- Minimising negative impacts on the environment and other river users by:
  - Striving to maintain natural flow paths and capacities on the floodplain to minimise impact on natural floods
  - Using existing disturbed footprints where possible
  - Minimising site disturbance and the size of the footprint of any new infrastructure that is required
  - Considering the use of multiple cascading structures to mimic hydraulic gradient and avoid extensive networks of tall levees.

12.2 Design criteria used

In addition to the broad considerations above, specific design criteria have been developed to inform the development of concept designs. These criteria have been developed through reference to current literature and best practice guidelines and through targeted workshops. Detailed descriptions of design rational and criteria are provided in the Appendix E concept design report. A summary of key design criteria is provided below.

Capacity and Flow Conveyance

The general philosophy for sizing the regulators is to consider cost efficiency and maintain a reasonable proportion of the existing waterway area where possible, with consideration of the following (GHD, 2014b):

- Conveyance of a volume of flow into a given area downstream, over an defined period of time
- Velocity of flows through the structure and at entry and exits points
- Minimising allowances for freeboard to reduce the (inundation) height range over which the structure may potential obstruct natural flows, and
- Operability - to provide controlled release of flows and drawdown rates to ensure fish passage and erosion control criteria are being optimised.

Fish Passage

A fish passage workshop was held on the 16 July 2014 involving key fish ecologists, representatives from design consultancies and constructing authorities. All seven of the proposed supply measures within the Mallee CMA region were presented to the workshop and then discussed in detail.

Specific outcomes from the workshop relevant to design of the Lindsay Island works included the following:

- A single vertical slot fishway at Berribee Regulator, designed according to the design criteria established for the Mullaroo Regulator
- Works need to incorporate deep plunge pools where overshot flow is expected
- Works need to consider fish passage for all scenarios of watering events, and
- The velocity through regulators should be minimized where practical.

From this it was determined that, engineering designs, where cost effective, will incorporate appropriate and practical mechanisms to ensure fish passage can occur to and from the River Murray through regulating structures.

The general design philosophy has been to provide explicit fish passage on any structure on a main watercourse (Lindsay River) which requires a continuous passing flow. This has been applied to the Berribee Regulator.

Passive fish passage is to be provided on all minor structures to limit the placement of barriers or encumbrances to fish. For example, on a minor regulator this would mean the use of overshot gates, ensuring optimal natural lighting conditions, etc. (GHD, 2014b).

Gate Design

A gate assessment workshop was held at Berri on 22 August 2014 and included representatives from SA Water operations and major projects as well as from GHD and Mallee CMA. The object of this workshop was to determine appropriate design criteria for each of the regulating structures within the project.

During this workshop the adoption of the concrete stop log system in use at the Chowilla Environmental Regulator and on weirs managed by SA water in the region was confirmed for the Berribee Regulator. This system requires the purchase of a rubber tired excavator equipped with retractable rail wheels and a specially adapted boom for the positioning of stop logs. The design, construction and operation of these structures are well understood by SA Water and adopting this system allows efficiencies in terms of maintenance and commonality of spare parts as well as ensuring that reserve equipment is available in the event of a breakdown.

Design of smaller regulators at the site was standardized to use manually placed 1200 mm or 1800 mm long aluminium stop logs installed on the upstream face of box culvert structures.

Freeboard

The design crest level for each of the structures has been set based upon the design water level (taken as the Top, or Maximum Water Level), and a freeboard allowance.

The freeboard adopted for design of the Berribee Regulator was 500 mm above the maximum operating level.

In setting the levee crest level, the following design freeboard allowances of 300 mm on the impermeable clay core has been adopted.

Defined spillways have been incorporated in structures to direct flow to appropriately protected areas during overtopping events.

Design Life of works

The design life of the concrete and embankment structures within the project is between 80 and 100 years when appropriately maintained. Mechanical components will have a design life of 30 years.

12.3 Concept design drawings

Advanced concept designs have been prepared for both the Primary Component works associated with the Berribee Regulator described in table 12-1 and the secondary components described in Table 12-2.

As part of the design process, concept design drawings for each of these structures have been developed and are provided within the design report attached as Appendix E. Figure 12-1 shows the plan and section view of the proposed Berribee Regulator and fishway. A visual representation of what the regulator would look like is shown in Figure 12-2.

Table 12-1. Description of Primary Component works (GHD 2014b)

Name	Description and function
Berribee Regulator and vertical slot fishway	This regulator is similar to the Chowilla regulator and fishway and includes: a new regulator and associated bridge deck access, abutment works and fishway at the Berribee Homestead location.
Regulator B	Regulator B consists of a two bay box culvert Regulator and 80 m of levee aligned with tracks which controls the movement of water into Billgoes Billabong. Located on the existing track, upstream of Berribee Regulator.
Regulator C	Regulator C consists of a two bay box culvert Regulator and 140 m of levee aligned with tracks which controls the movement of water into a secondary flood runner. Located on the existing track, upstream of Berribee Regulator.
Track raising D	Track raising of 2.2 km (approx.) in length, with culverts to maintain the continuity of flow with the Toupnein Creek area. The height of the track raising for the majority of the length is less than 0.5m, except at defined 3 No. flood runners where 0.75 m diameter pipes are installed.
Regulator D	Regulator D consists of a three bay box culvert regulator within Track raising D described above
Regulator E	Regulator E consists of a three bay box culvert regulator and 30 m of levee along existing track alignments which controls the breakout of water to the north.
Regulator F	Regulator F consists of a single bay box culvert regulator and 175 m of levee along existing track alignments which controls the movement of water into key inlet to the Little Mullaroo Creek.

Table 12-2. Description of Secondary Component works (GHD 2014b)

Name	Description and function
Wallawalla west	A combined track raising and regulator to hold water, which is pumped from the Lindsay River. The proposed raised track structure will incorporate an access track 845 m long and a single bay box culvert regulator. Provision for establishment of a hard stand for temporary pumps.
Wallawalla east	Three track raising structures (A – 440 m long, B – 400 m long, C – 140 m long) to contain water to the target height across the floodplain. The raised tracks are to be located along existing tracks and extend across small depression areas. Regulator A comprises a four bay box culvert Regulator Structure D designates a 3 m x 6 m compacted crushed rock hard stand.
Crankhandle Wetland Complex	Seven track raising structures (A – 120 m long, B – 90 m long, C – 230 m long, D – 100 m long, E – 255 m long, F – 175 m long and H – 20 m long) to contain water on the floodplain to the target height. Regulator A, B, C, D, E and F comprise of a two bay box culvert regulators at each site. Location G comprises a 195 m long channel with of 15 m bed width.
Crankhandle West	Four track raising structures (A1 – 180 m long, A2 – 200 m long, B1 – 20 m long and B2 – 29 m long) to contain water to the target height across the floodplain. Regulator A1 comprises a four bay box culvert structure. Regulator B1 comprises a two bay box culvert structure. Regulator B2 comprises a 2 No. 1200 mm wide x 600 mm high box culvert arrangement with drop boards.
Lindsay South Wetland	Four track raising structures (A1 – 440 m long, A2 – 400 m long, A3 – 140 m long and B – 29 m long) to contain water on the floodplain to the target height. Regulator A1 comprises two four bay box culvert regulator structures Regulator B comprises a two bay box culvert structure. Structure C designates a 3 m x 6 m compacted crushed rock hard stand.

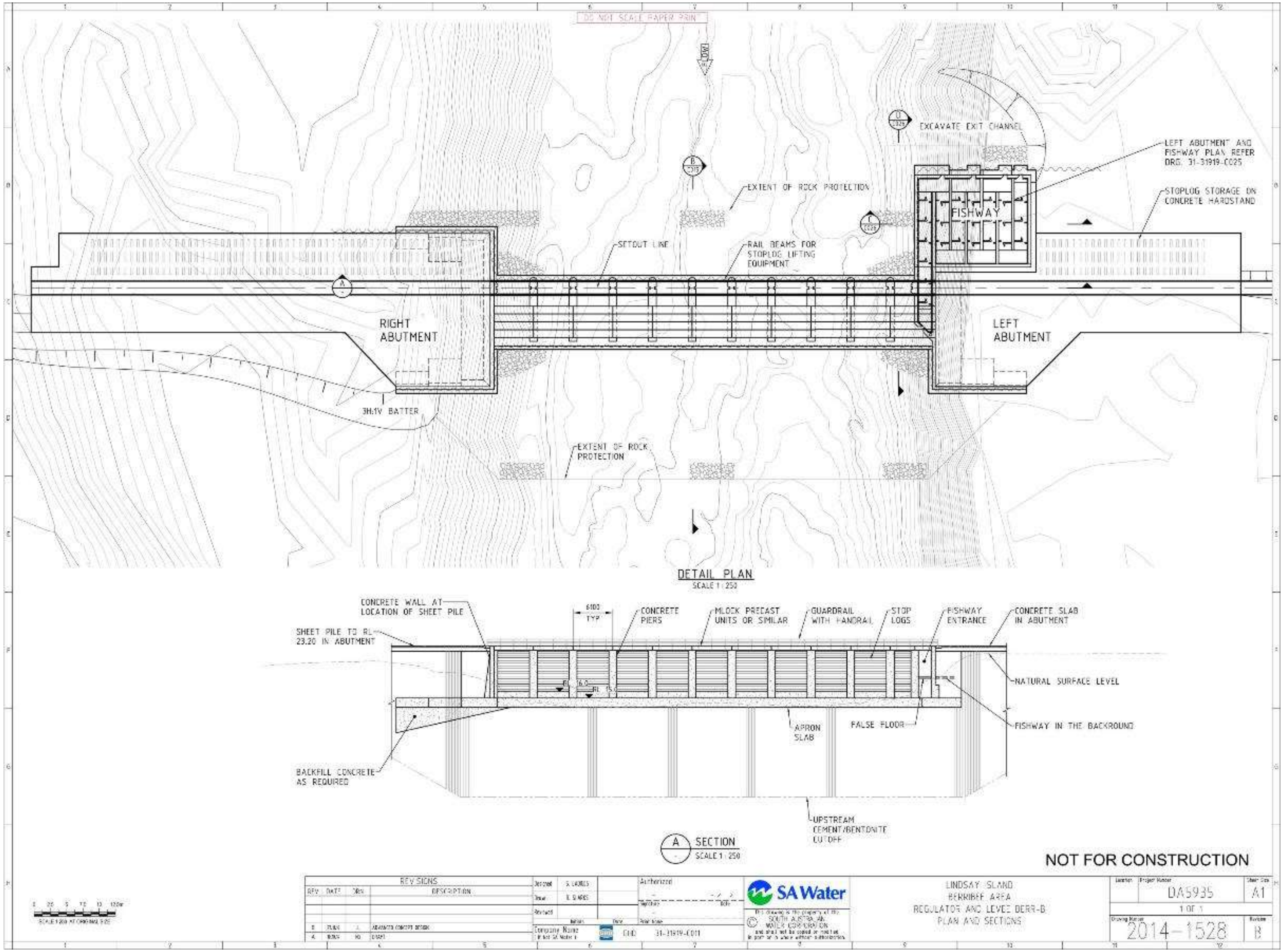


Figure 12-1. Concept design of Primary Component - Berribee Regulator (GHD, 2014)

Figure 12-2. Visual representation of the Berribee Regulator (digitally altered image)

12.4 Location of activities to be undertaken, access routes, footprint area

The location of each structure has been selected to maximize the efficiency of the works whilst minimizing impacts on cultural heritage, native vegetation and the visual or recreational amenity of the park and adjacent landholders. Figure 12.3 shows the location of the works and their associated access tracks. Care has been taken to ensure that access for operational use is provided to allow access from the Mail Route and from Lock 7 during operation. Comprehensive mapping of these access arrangements is provided in GHD 2014b.

Where possible structures have been located on existing tracks or other areas of disturbance. The use of existing disturbed areas minimizes the loss of vegetation and damage to cultural heritage values. Figure 12-4 shows the proposed location of the Berribee Regulator, and its associated support structures as well as the areas set aside for construction activities. This location was selected in order to take advantage of the access tracks and cleared areas associated with the Berribee Homestead and results in reduced disturbance of cultural heritage values and native vegetation over an alternative location upstream.

It is proposed to construct the Berribee Regulator in two stages to provide uninterrupted fish passage and flow through the Lindsay River during construction. This will require construction of temporary coffer dams extending approximately half way across the Lindsay River. On completion of the first half of the regulator the first temporary coffer dam will be removed and a second temporary coffer dam extending from the other bank will be constructed to allow completion of the regulator. Figure 12.5 illustrates the proposed coffer dams in relation to the Berribee Regulator.

Geotechnical investigations at the site have identified dense cemented sand layers on the bed of the Lindsay River at the proposed location. This harder material makes the use of sheet pile coffer dams difficult. As an alternative to sheet pile coffer dams it is proposed that the coffer dams will be embankments constructed from earth filled bulka bags. This method has successfully been used to construct coffer dams by stacking the filled bags in a triangular shape, generally with the wet face vertical, to the required height. The fill material can be a local material, with no specific requirements, although granular material tends to be used as it is easier to place into the bags. The water tightness of the stacked bulker bags can be improved by installing a water proof membrane, such as PVC sheeting on the upstream face. A more detailed justification for selection of this approach and further details of its proposed implementation can be found in GHD2014b.

With the exception of the set down areas associated with the Berribee Regulator and Fishway, specific set down areas, passing bays and construction footprints have not yet been defined for the project. Construction of previous environmental works has shown that the selection of these smaller set down areas and construction footprints is best done as a collaborative exercise between cultural heritage advisors, ecologists and construction engineers during the development of detailed designs and approvals.

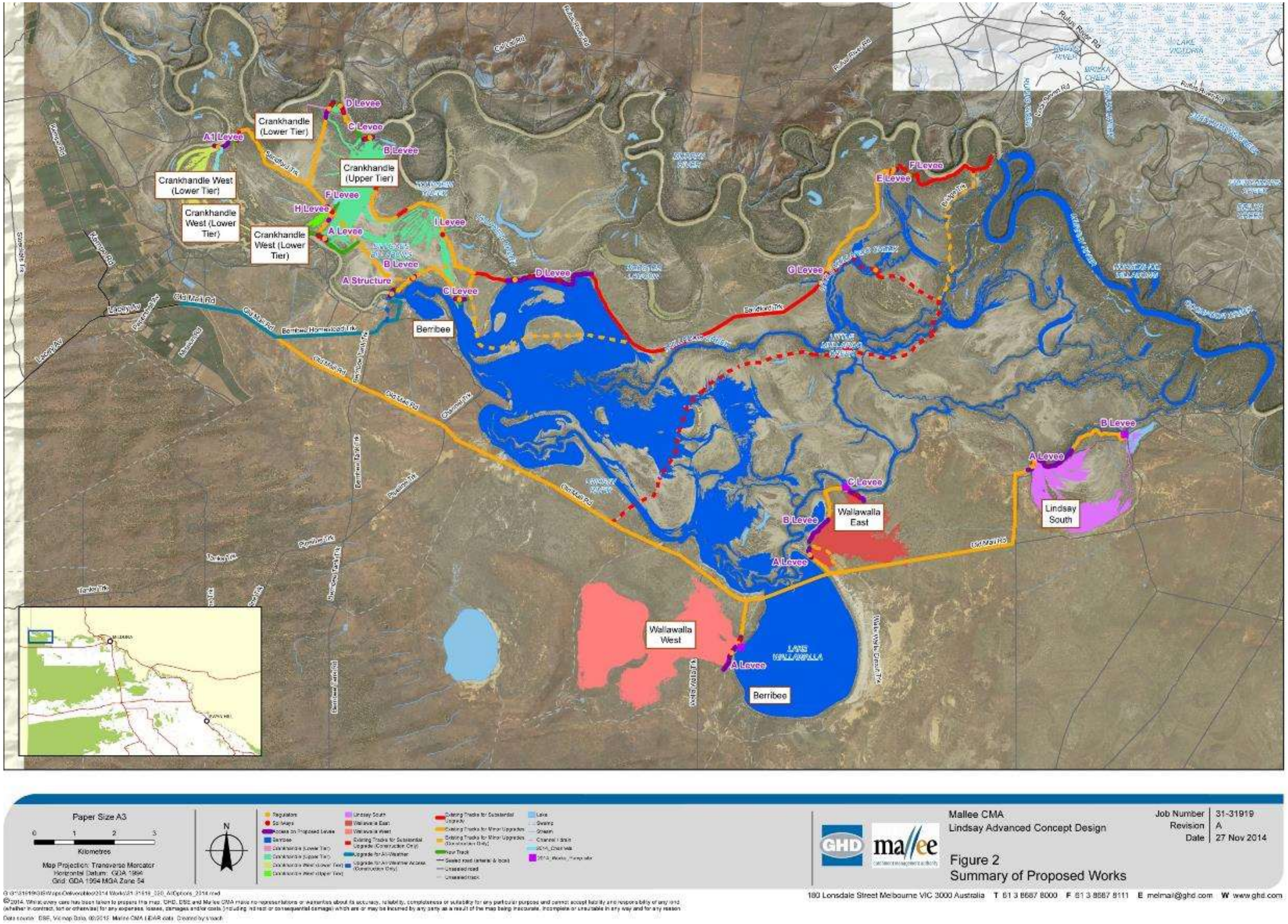


Figure 12-3. Location of structures and access tracks (GHD, 2014b)

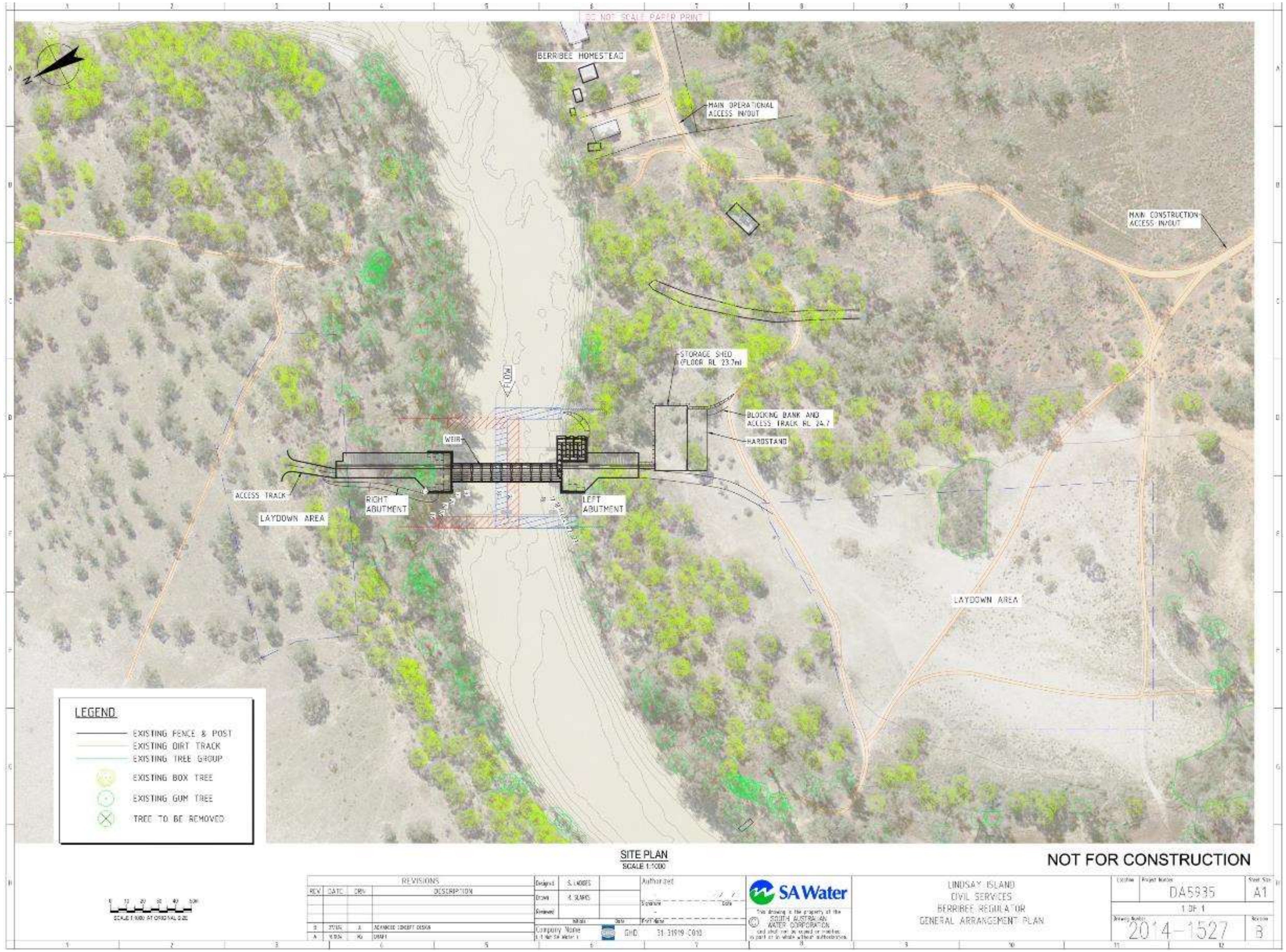


Figure 12.4 Location of the Berribee Regulator, its supporting works and construction set down areas (GHD, 2014b)

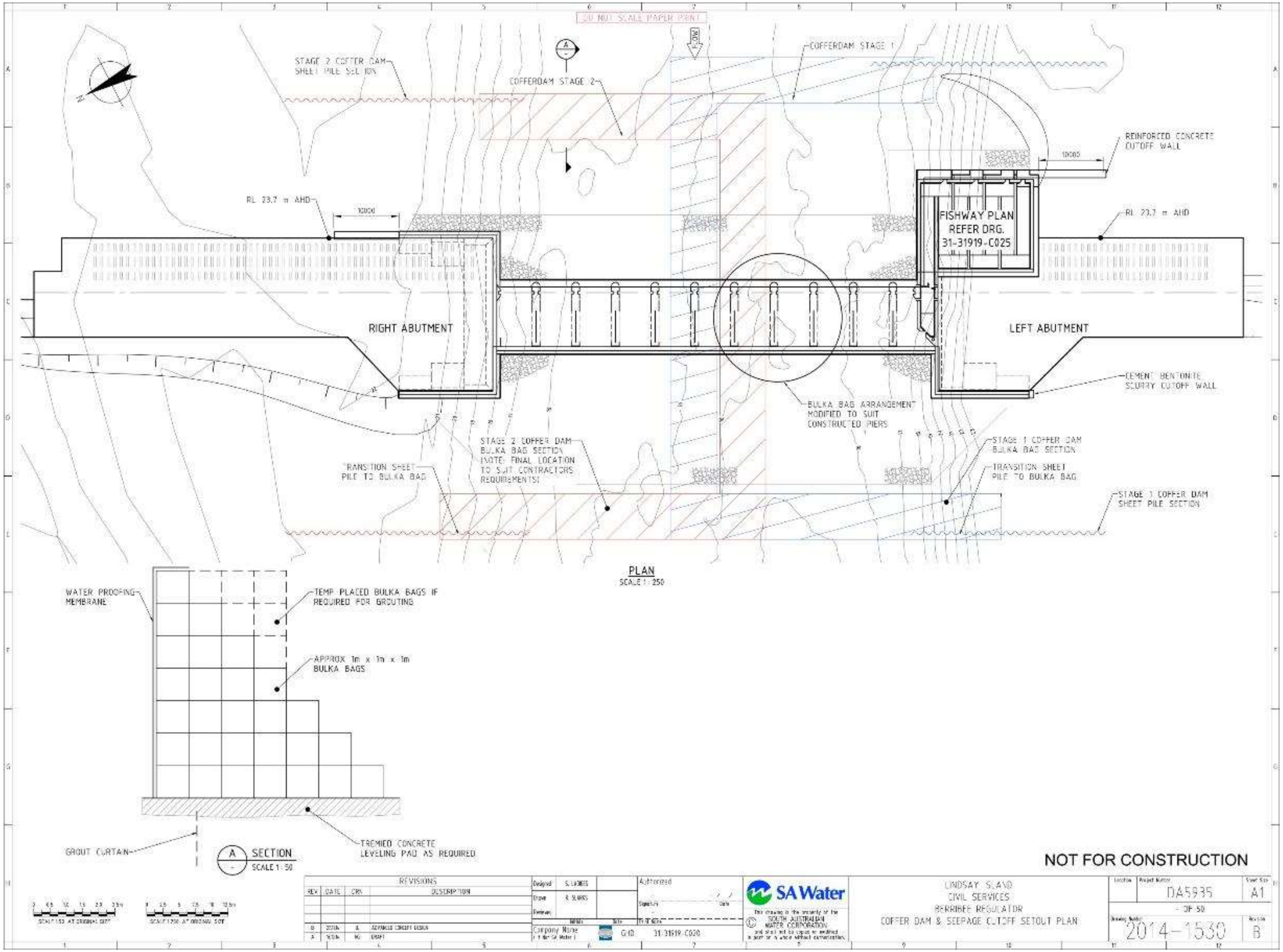


Figure 12.5 Berribee Regulator concept design drawing showing the two stages of coffer dam to enable staged construction

12.5 Geotechnical investigation results

Preliminary geotechnical investigations undertaken by GHD (2012) showed:

- The depth to bedrock material in the project vicinity is very high and beyond the reach of the foundations of the proposed infrastructure.
- Variable alluvial materials typically consisting of very stiff to hard clays likely to be the Coonambidgal or Blanchetown clays overlying dense sands which suggests intercepting the Parilla Sand formation.
- The Parilla Sands are variable and can be highly erosive and may be unfavourable for the installation of water retaining structures. Although in some places localised, strongly cemented sandstone bands provide hard rock conditions within the upper profile of the Parilla Sands.
- There may be a lower strength zone at the transition from clay to sand, commonly associated with the water table.
- Some thin zones of softer silt or clay materials were identified, sometimes containing fibrous organic matter, these are unlikely to cause a structural concern for regulator construction but will require a vertical cut-off.

Bores identified that subsurface conditions generally consist of:

- Aeolian and fluvial sand and silt; overlying
- Quaternary clay deposits and minor sandy silt; overlying
- Dense to very dense sand and fine gravel
- There was significant variability in the depths at which the different units were encountered across the four test borehole sites, and
- The depth to groundwater intersected during drilling was determined to be approximately 4.5 – 5.0 m below existing ground surface level.

A site walkover was completed by GHD geotechnical specialists at the commencement of the advanced concept design investigations in 2014. The aim of the walkover was to assess the geomorphological and geological features at each site and determine any features which should be considered during concept design of proposed structures in lieu of subsurface geotechnical investigation results, and also to assist in determining areas in which geotechnical investigations should be focused. Information on landforms and geology will also aid interpretation of the geotechnical investigation results as they become available.

The following general observations were made regarding the site geology (GHD2014b):

- The surface condition and underlying geology appear to be as expected for the area (clays, silts and sands of the Coonambidgal Formation). A possible outcrop of Blanchetown Clay was observed to the south of Lake Wallawalla.
- The majority of the surficial soil observed at each of the sites was clay, believed to be the Coonambidgal Formation. Zones of extremely dispersive soils were observed. It is anticipated that these soils are associated with abandoned channels on the floodplain where clay soils may have accumulated. These channels are characterised by highly reactive and dispersive clay soils indicated by the cracking and frequent “crabhole” dispersion features.
- Any structures located towards the extreme western end of Lindsey Island (Crankhandle section) may encounter what is believed to be remnant sand dune material sitting on top of the floodplain. This material has been eroded into and moulded by the migrating river channel. There is also a possibility that this sand dune material may predate the floodplain deposits and extend to a deeper level than the more recent Coonambidgal Formation.
- The sand dunes may also be encountered in the Wallawalla west section.

- The Crankhandle West Regulator F and Levee E, of the Kulkurna Cliffs Track, showed fine sand at surface. This may represent a thin overbank sand layer or a deeper sand deposit associated with an abandoned river channel.
- At the Wallawalla Levee B, what it believed to be a thin surficial layer of sand, possibly a dune formation was observed bordering the lake. The thickness of this sand should be determined during geotechnical investigations if construction activities interface with this unit.
- The site of the proposed Wallawalla Regulator A and Levee C was dominated by clay type soils exhibiting cracking and occasional formation of vertical erosion holes due to the dispersive nature of the clay. Some relatively small and isolated stabilised wind blow sands were also observed in the area. Where a levee encounters such a deposit and is confirmed by the geotechnical drilling, the cut-off trench should be extended to below the sand layer.

GHD 2014 b goes on to describe in more detail the geotechnical conditions at the proposed Berribee Regulator location as follows.

The Lindsay River is underlain by the Parilla Sand (Tpp) unit, which forms a hard ferrugineous surface at river bed level and underlies the river banks at depth. The Parilla unit is typically described by the geotechnical boreholes as comprising fine to medium grained quartz sand.

Relative density is typically very dense, with some cementation present. Fine traces of shell fossils were found at in this unit during borehole drilling, confirming a shallow marine depositional origin.

Above the Tpp unit are younger Quaternary aged sediments, which form the banks of the river. These deposits appear to differ between the northern and sides of the river, reflecting migratory changes in the river.

The southern bank of the river is interpreted to comprise Blanchetown Clay (Qb) materials. The upper part of the soil profile consists of clays and sandy clay soil types, which changes to fine to medium sands and silty sands towards the base of formation. The Qb unit directly overlies much denser sands belonging to the Tpp unit.

The northern river bank contains younger strata. On this side of the river the ground has been channelized and infilled by young sediments, reflecting the migratory movement of the river over time. The upper part of the northern river bank appears to comprise fine grained dune sands belonging to the Woorinen Formation (Qw).

The Coonambidgal formation generally presents as mainly fine grained sand and sandy clay with some coarse grained sand and gravel. Being an alluvial deposit, abandoned and infilled channels and creeks are common. Therefore, in such an environment, it is possible for the geology to change significantly over relatively short distances.

The Monoman Formation underlies the Coonambidgal Formation and consists of medium to coarse grained sand and generally has a fine gravel basal layer. In some locations, such as at Chowilla, a horizon of logs and tree stumps is found at the horizon between the Coonambidgal and Monoman interface.

At the Berribee site the interface between the Monoman and Coonambidgal formations is difficult to discern.

Full geotechnical investigations were unable to be carried out prior to this concept review, however as part of this review the previous investigations have been reconsidered in light of the site walkover presented in above, the new ground survey information and the relocation of the Berribee Regulator to the current position downstream of the Berribee homestead.

In the previous geotechnical investigations at the Berribee Regulator site (BHLI-01 and BHLI-02) the suspected interface between the Coonambidgal and Monoman units was intercepted at 4.5 m in BH01 and 11.5 m in BH02. A depression channel was noted in the area of BH02, therefore, it is suspected that BH02 may be located within an infilled river channel. This would explain the presence of more variable and softer sediments within the upper 11 m of BH02 and why there is such a marked difference in the interface level between BH01 and BH02.

At the proposed current location of the Berribee Regulator (downstream of the homestead), a similar depression or “flood runner” has been noted on the northern side of the river. This may suggest that there is an infilled channel in this area and that soils within the upper profile may be soft and variable similar to that seen in BH02. The location and extents of any such channel will need to be investigated during the Geotechnical field investigation.

BH01 is relatively close to the southern abutment of the current proposed location. It is expected that the ground conditions at the southern abutment will be similar to those encountered in BH01. Here approximately 4 to 5 m of Coonambidgal formation overlies the Monoman sands. The upper 4 to 5 m of the Monoman sand presented as being medium dense to dense before becoming very dense with cemented layers at approximately 9.5 m below the surface level.

It is noted that the depth of the very dense and cemented sands roughly coincides with the base level of the Lindsay River in this area. It is expected that the base of the Lindsay River will intercept the Monoman sands. It is speculated that the river depth may be related to the presence of the very dense or cemented sands.

12.6 Alternative designs and specifications

Over the last decade there have been a number of investigations to identify the most effective designs to water the Lindsay Island site. Each study has resulted in the refinement of preferred options to create this business case.

Major options, which were investigated and then ruled out due to high cost, and/or low benefit and/or high risk, include:

- Watering individual wetlands/valuable remnant vegetation patches via pumping (SKM and Roberts, 2003) – limited areas would benefit and the annual cost of pumping is high, with lower ecological benefit than gravity inundation
- Lock 6 raising and lowering – such options were seen to provide little wide-scale benefit to Lindsay Island as they had limited effect on floodplain inundation (Ecological Associates, 2007)
- Lock 8 Bypass – a costly project with potentially significant risks due to the large head differential (Ecological Associates, 2007)
- Lower Lindsay Weir – effectiveness of the weir achieving widespread floodplain inundation in the middle and upper reaches of the Island is limited (Ecological Associates, 2007).

Primary Component options investigated

As the preferred options became clearer, more detailed analysis was carried out on the options (GHD, 2012) outlined in Table 12-3.

While costs were analysed as a part of the assessment of these options they have been omitted from this table to avoid confusion with current cost estimate provided throughout the remainder of this document.

Table 12-3. Primary Component options that were subject to detailed analysis (GHD, 2012)

Options		Details	Area Inundated	Cost ($/ha)
Option 1	Lindsay River Environmental Regulator, Lower	Targets an inundation level of 23.2m AHD and comprises major regulating structure in the Lindsay River adjacent to Berribee Homestead with vertical slot fishway. Includes other works to manage breakouts such as: • 4 No. regulator and crossing combination structures • 1 No. regulator structure • 1 No. levee, mostly shallow (0.55 m deep), 2.3 km long	3,520 ha	$9,000
Option 2	Lindsay River Environmental Regulator, Middle	Targets an inundation level of 23.2 m AHD and comprises major regulating structure on the Lindsay River north of the Channel Track (Red Rock) with vertical slot fishway. Includes other works to manage breakouts such as: • 2 No. regulator and crossing combination structures • 1 No. regulator structure • 1 No. levee, 1.1 to 0.5 m deep, 1 km long • 1 No. levee, mostly shallow (0.55 m deep), 2.3 km long	3,360 ha	$8,000
Option 3	Lindsay River Environmental Regulator, Upper	Targets an inundation level of 23.2 m AHD and comprises major regulating structure on the Lindsay River (mid-island) and another structure of the Mullaroo Creek, both with vertical slot fishways. Includes other works to manage breakouts such as: • 2 No. regulator and crossing combination structures • 1 No. regulator structure • 1 No. levee, average 0.3 m deep, 2.3 km long	1,960 ha	$21,000
Option 4	Upper Lindsay and Mullaroo Flood Complex	Targets an inundation level of 24.0 m AHD and comprises major regulating structure on the Lindsay River (upper Lindsay Island) and another structure on the Mullaroo Creek (downstream of the confluence of Mullaroo and Little Mullaroo Creek), both with vertical slot fishways. Includes other works to manage breakouts such as: • 2 No. regulator and crossing combination structures • 13 No. regulator structure • 8 No. levee, minor only	1,480 ha.	$24,000

Given the proposed total area to be inundated, Option 1 offered the greatest potential ecological benefits for the estimated project cost and risks as estimated during the 2012 option assessment:

- Option 1 is ranked first for area inundated. It is likely to achieve the greatest direct and indirect benefits for fish, based upon the total area inundated and provides a lower level of risk for isolation and stranding of fish on the floodplain during managed flood recession due to a smaller number of in-channel structures.
- Option 2 is similar cost to option 1 in terms of cost, area of inundation and expected benefits. However it is located within an area of particularly high cultural heritage significance.
- Option 3 resulted in a comparatively smaller area of flooding at almost twice the cost of options 1 and 2. requires major structures on both anabranches of Lindsay Island.
- Option 4 was dismissed on the basis of cost and area inundated.

Table 12-4 lists the secondary component options that were investigated and whether they are dependent upon Options 1, 2 and 3 (above), independent of them or complementary.

Secondary Component options investigated

Table 12-4. Secondary Component options that were subject to detailed analysis (GHD, 2012)

Area	Option Dependency	Top Water Level (m AHD)	Inundation Area (ha)	Details of structures
Crankhandle Wetland Complex	Complementary	22.6	472	5 regulators, 5 levees
Crankhandle West, Lower Area	Independent (all three)	21.6	41	1 regulator, 1 levee
Crankhandle West, Middle Area	Independent	21.1	33	1 regulator, 1 levee
Crankhandle West, Upper Area	Independent	22.4	261	2 regulators, 1 levee
Toupnein Creek Area	Dependent (Option 1, 2)	23.2	528	3 large regulators, 2 small regulators, 3 levees
North of Toupnein Creek	Dependent (Option 1, 2)	23.2	361	Pipe, 1 regulator, 4 levees
Toupnein Wetland Complex	Dependent (Option 1, 2) or Independent	22.7	63	4 regulators
Webster's Lagoon	Dependent (Option 1, 2)	23.2	280	1 large regulators, 3 small regulators, 3 levees, 1 channel
Combined Toupnein Creek and Webster's Lagoon	Dependent (Option 1, 2)	23.2	807	2 large regulators, 5 small regulators, 4 levees
Lower Lindsay River, Southern Pocket, West	Dependent (Option 1, 2)	23.2	43	1 regulator, 1 channel
Lower Lindsay River, Southern Pocket, East	Dependent (Option 1, 2)	23.2	9	1 regulator, 1 channel
Lake Wallawalla	Dependent (Option 1, 2, 3)	23.2	804	-
Lake Wallawalla West	Independent	25	923	1 regulator, 3 long levees, 1 open channel, 1 hard stand, 1 regulator/crossing
Lake Wallawalla East	Independent	25.5	479	1 regulator, 3 long levees

Area	Option Dependency	Top Water Level (m AHD)	Inundation Area (ha)	Details of structures
Lindsay South Effluent, Southern Wetland	Independent	25	481	4 regulators, 3 levees
Lindsay South Effluent, Northern Wetland	Independent	24.5	333	2 regulators, 4 levees
Upper Lindsay Wetland Complex*	Independent	23.2	19	3 regulators
Upper Lindsay East Wetland Complex*	Independent	23.2	20	3 regulators
Upper Mullaroo Wetland Complex, Original*	Independent	23.2	59	4 regulators
Upper Mullaroo Wetland Complex, Extended*	Independent	23.2	93	2 regulators, 1 levee, 1 regulator/crossing
Wetland 33*	Independent	22.9	19	1 regulator, 1 levee
Upper North Mullaroo Wetland*	Independent	23.2	28	1 regulator, 1 channel excavation
North West Area**	Independent	22.3	730	3 regulators, 2 levees

*Provides the same coverage as Options 1, 2 or 3, however, allows for independent operation as well as dependent.

**Information based on estimates only, limited by LIDAR coverage

Secondary component options were prioritised by GHD (2012) based on cost effectiveness (measured as capital cost per hectare of inundation) and ecological impact (measured using components; area inundated, current condition, and impacts on fish ecology) as estimated during the 2012 option assessment. Wetland areas were then ranked in relation to the capital cost per hectare and an overall ecological score.

Based on this prioritization, the following works were identified as the optimum arrangement (Table 12-5).

Table 12-5. Final options selected (GHD 2013) (note that areas for each option were revised during development of advanced concept designs 2014)

Option	Total Area of Inundation (ha)	Volume (GL)
Option 1 – Berribee Regulator	3,782	35.3
Wallawalla West	702	2.8
Wallawalla East	240	0.6
Crankhandle Wetland Complex	335	0.6
Crankhandle West (Upper)	147	0.31
Lindsay South Effluent (Southern Wetland)	225	1.0
Total	**5,431**	**40.61**

Development of advanced concept designs

A number of alterations to the concepts proposed by GHD (2013) have occurred during the development of advanced concept designs GHD (2014). The main revisions relate to the Berribee Regulator and are summarised below:

Location

The structure was relocated approximately 400m downstream from the previous site (GHD 2013) due to:

- cultural heritage considerations
- geotechnical conditions in the bed of the Creek, and
- access to the works site during construction and proximity of available land for laydown areas.

Following results from preliminary geotechnical conditions which identified hard bed conditions, alternative sites within 1km upstream and downstream of the current site were also examined. As geotechnical conditions were found to be reasonably uniform over the assessed reach, the proposed site represents the shallowest.

Fishway

The earlier concepts (GHD 2013) were modified to include a vertical slot fishway in the structure following confirmation it is a project requirement and refinement of the configuration of the fishway design.

Temporary works and permanent cutoffs

A major review of the foundation requirements, temporary works and permanent cutoff arrangements was undertaken following completion of the preliminary geotechnical investigations.

Further details on the assessment of temporary works and cutoff arrangements as well as other amendments to the 2013 concept designs are provided in (GHD 2014b).

12.7 Ongoing operational monitoring and record keeping arrangements

Operational monitoring and record keeping

The operational monitoring regime will form a key component of the operating plan developed for the site and will assign roles and responsibilities for agencies tasked with undertaking this monitoring. Critical areas of operational monitoring include those associated with water accounting and water quality which are likely to be the responsibility of SA Water, as the MDBA's water resource manager for this part of the river.

The project team has many years of experience in river and asset management and maintenance on the River Murray floodplain including the construction and operation of works at Chowilla and Mulcra Island. Along with this experience comes the necessary organisational capacity including data management and asset management systems required to maintain and operate large works including those subject to ANCOLD regulation. The team also has systems in place to manage data generated by operations including water accounting and water quality monitoring data.

Surface water flow and water quality monitoring will be implemented to ensure the water volume used and the water quality impacts of the project are recorded to appropriate standards and that this informs management and operations.

Groundwater monitoring will also be implemented to ensure salinity risks are appropriately managed.

An Operations Plan will describe how the infrastructure is to be operated for maximum environmental benefit while carefully managing risks. It will describe procedures for operating all infrastructure and interactions with the Lock 7 Weir Pool, River Murray levels and floods.

12.8 Peer review of concept designs

Prior to the commencement of the advanced concept designs a workshop was held including representatives from GHD, SA Water, G-MW and an independent expert reviewer engaged by DEPI to provide advice regarding specific areas to be addressed during further design work. The outcomes of this review were provided to GHD as input into the Advanced Concept Design.

GHD have undertaken internal reviews of material during development of designs as well as incorporating feedback provided by G-MW and the Mallee CMA on draft reports.

During the development of concept designs, draft material including geotechnical investigation specifications and design documentation have also been provided to independent experts engaged by DEPI. The expert peer reviewers engaged were Phillip Cummins Shane McGrath.

The outcomes of the expert review process are provided in Appendix L.

13.Complementary actions and interdependencies (Section 4.9)

The proposed *Lindsay Island Floodplain Management Project* supply measure will affect the Victorian Murray (SS2) surface water sustainable diversion limit (SDL) water resource unit. This SDL resource unit is anticipated to be affected by this supply measure through an adjustment to the SDL, pending confirmation of a final off-set amount by the Murray-Darling Basin Authority (MDBA).

Any potential inter-dependencies for this supply measure and its associated SDL resource unit, in terms of other measures, cannot be formally ascertained at this time. This is because such inter-dependencies will be influenced by other factors that may be operating in connection with this site, including other supply/efficiency/constraints measures under the SDL adjustment mechanism, and the total volume of water that is recovered for the environment.

It is expected that all likely linkages and inter-dependencies for this measure and its associated SDL resource unit, particularly with any constraints measures, will become better understood as the full adjustment package is modelled by the MDBA and a final package is agreed to by Basin governments.

Similarly, a fully comprehensive assessment of the likely risks for this supply measure and its SDL resource unit cannot be completed until the full package of adjustment measures has been modelled by the MDBA, and a final package has been agreed between Basin governments.

The operation of the proposed works is dependent on the ability to raise Lock 7 above its normal operating levels. SA Water has confirmed the weir at Lock 7 will be within safe operating parameters at the proposed increased operating level according to the Lock and Weirs 1-10 Safe Operation Tables For Stability (URS 2014). The process of operating weirs at elevated weir pool levels is well understood by SA Water and other stakeholders in the region and in recent times has become an annual event at locks 8 and 9. The Upper Lindsay and Mullaroo Inlet Regulators constructed under TLM will provide increased flow in the Lindsay River and Mullaroo Creek, allowing filling of the Berribee Regulator pool and appropriate through-flow to maintain flowing habitat for fish and to manage water quality.

Under current arrangements, the operation of the existing Lock 7 and TLM infrastructure is undertaken by SA water at the request of MDBA River operators, following advice from the Lindsay, Mulcra and Wallpolla Operating Group, which is chaired by the Mallee CMA. This arrangement ensures local requests for the operation of the TLM works are integrated into broader river operations and provides a proven model for the operational governance of the proposed works.

Complementary actions beyond water management will include pest plant and animal control programs and other NRM activities funded by state and federal programs delivered by local agencies as per current arrangements.

13.1 Cumulative impacts of operation of existing and proposed works

The operation of the proposed works in conjunction with Basin Plan flows, constraints management measures, operating rule changes and other proposed or existing environmental works will have both positive and negative cumulative impacts on the system and river users.

The benefits of integrating the operation of works along the River Murray and the delivery of Basin Plan flows and natural cues will include water efficiencies and the provision of appropriate ecological cues across multiple river reaches. Potential negative impacts may include cumulative salinity and other water quality impacts; however water quality impacts will be substantially offset due to increased Basin Plan flows in the River Murray.

River scale benefits will include provision of nursery habitat for fish larvae and juvenile fish spawned upstream during elevated flows or operation of environmental works. These fish will return to the river as the water is drawn down from the floodplain contributing to the fish stocks of the River Murray.

On a local scale, the cumulative impacts of the proposed Lindsay and Wallpolla Island projects and the existing Mulcra Island and Chowilla Floodplain Management Projects on downstream salinity and dissolved oxygen levels for river users and operation of downstream environmental works such as Pike and Katarapco Creeks will need to be managed carefully through use of appropriate dilution flows. The effectiveness of this dilution approach has been demonstrated during the recent successful operation of the Chowilla works. It is expected that Basin Plan flows will more than meet dilution flow requirements of proposed and existing works as well as delivering environmental and water quality benefits along the full length of the river.

The operation of the proposed Lindsay and Wallpolla Island projects in conjunction with the Mulcra Island and Chowilla Floodplain infrastructure, weir pool manipulation and other nearby environmental watering events, will dramatically increase and improve available floodplain habitat for valued flood-dependent fauna beyond that provided by the operation of any individual project, or Basin Plan flows, in isolation.

Holistic planning across the Basin will be required to mitigate potential negative impacts and maximise the social and ecological contribution of the Lindsay Island project to the outcomes of the Basin Plan.

14.Costs, benefits and funding arrangements (Section 4.10)

14.1 Introduction

Consistent with the guidance given on page 26 of the Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases, a formal cost benefit analysis has not been undertaken as yet for this project because the main benefit of the project (in this case, the SDL adjustment) cannot be reliably estimated in time to inform this business case.

However from a qualitative perspective, Victoria considers that, on balance, the benefits of this project will significantly outweigh its costs. The rationale for this assertion is that a broad range of enduring social, economic and environmental benefits can be pre-emptively assumed to arise from this project.

These include:

- The social and economic benefits that will accrue for local and regional communities and businesses associated with its construction and operation
- The increased social and environmental amenity at this site arising from improved environmental health, increasing its attraction for tourism and recreational activities, and
- The broader regional economic benefit of taking less water out of productive use as a consequence of undertaking this project and being credited with an SDL Offset.

It must also be recognised that these immediate benefits can be assumed to have a range of positive secondary and tertiary benefits through the ‘multiplier effect’. For example, the investment committed to construction of the project will benefit local businesses and families through jobs, materials purchase and normal every day expenditure.

A similar positive impact can be anticipated as a consequence of the increase in tourism and recreation generated by the project and its environmental amenity dividend over its lifetime.

There is evidence that the quantum of visitor numbers to sites such as this, are closely related to inundation, with tourists more attracted to visit when water is present. As an illustrative example of this effect, whilst formal visitor statistics are not available, anecdotal evidence from Parks Victoria staff indicate that visitor numbers at the Hattah Lakes site have increased significantly (up to 50%) since environmental water was first pumped into the lakes (B. Rodgers, 2009, pers comm).

It is accepted that there will be some disbenefits to account for; but these will be minor and transient. Construction will involve unavoidable physical disturbance that has the potential to impact on native vegetation and wildlife, and cultural heritage sites and places. These impacts will be avoided where possible by careful planning and adherence to relevant state and Commonwealth legislation, regulations and guidelines.

Any unavoidable impacts will be minimised through the implementation of a rigorous environmental management framework during construction.

It is also acknowledged that access will be compromised to some extent during the construction phase; but this is temporary. This may impact on activities such as fishing, recreational boating, camping, tourism and commercial operators. Access for recreational activities will also be limited during managed inundation events; however this would also occur during natural floods.

In addition, given the relative remoteness of the site from populated areas, there is also unlikely to be any significant loss of social amenity to surrounding communities due to the noise and nuisance that will be encountered during construction.

Drawing an overall conclusion from the matters described above, it can be assumed that more than any other factor over the long term, the local and regional communities located close to this site will significantly benefit from the environmental amenity dividend generated by this project over its lifetime.

By contrast, it is difficult to envisage any significant social, economic and environmental disbenefit arising from direct operation of this asset in the manner described in this business case.

The Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases require that business cases identify benefits and costs that support a compelling case for investment, including a detailed estimate of financial cost and advice on proposed funding arrangements.

This chapter provides this information on the following:

- Capital cost estimates
- Operating and maintenance costs
- Funding sought and co-contributions
- Ownership of assets, and
- Project benefits.

These costs and benefits are outlined both in undiscounted terms in the year in which they occur, and in 'present value' terms, discounted to 2014 dollars by a central real discount rate of 7%. This discount rate is suggested by the Victorian Department of Treasury and Finance (DTF) for projects of this kind, and is also consistent with the Commonwealth Office of Best Practice Regulation (OPBR) advice on the choice of discount rate. A project timeframe of 30 years is used for the analysis, as per Victorian DTF guidelines for Economic Evaluation for Business Cases. Year 1 of this time period is 2016 when design costs are incurred.

14.2 Cost estimates

The total cost to implement the *Lindsay Island Floodplain Management Project*, is $72,831,526 (Present Value 2014 dollars).

This business case presents the cost to fully deliver the project (i.e. until all infrastructure is constructed, commissioned and operational), including contingencies. Cost estimates for all components in this proposal are based on current costs, with no calculation of cost escalation either accounting for the taken from estimating the cost to the time for construction to commence or for escalation during execution of the project. To ensure sufficient funding will be available to deliver the project in the event that it is approved by the MDB Ministerial Council for inclusion in its approved SDL Adjustment Package to be submitted to the MDBA by 30 June 2016, cost escalations will be determined in an agreed manner between the proponent and the investor as part of negotiating an investment agreement for this project.

Total capital costs (including contingencies but excluding design costs) in Present Value 2014 dollars are $63,262,361. This figure is based on a P90[3] cost estimate provided by SA Water using data from the concept design report. The cost of individual structures estimated by the design engineers is presented in Table 14-1. Capital cost estimates have been developed using real-world costs from recently constructed environmental infrastructure projects in the area (e.g. Hattah Lakes, Mulcra Island, Upper Lindsay River Watercourse Enhancement Project, Chowilla Floodplain), in conjunction with agencies involved in these and other projects. These cost estimates have been peer reviewed by the Expert Review Panel, comprised of recognised experts (as described in Section 17).

Contingencies form 30 percent of the total capital costs. In additional to these contingency specifically costed risks including, inundation from flooding, wet weather delays and delays due to approvals during construction have been included. This reflects the current level of development of designs and incorporates, but is not limited to, contingencies associated with geotechnical uncertainty.

[3] P90 Estimate: An estimate with a 90% confidence of not being exceeded at project completion, while not being overly conservative.

Project implementation costs that are in scope for Commonwealth Supply or Constraint Measure Funding are summarised by project stage in Table 14-2. Only forward looking costs have been included (that is, costs already incurred are not included in the table). The P90 capital cost estimate has been used in Table 14.2.

Note that Table 14-2 does not include funding to coordinate the delivery of the final package of works-based supply measures; this will be determined as part of negotiating an investment agreement for this project.

Costs incurred for monitoring related to verifying the performance and integrity of newly constructed infrastructure have been included as commissioning costs.

Costs expressed in this document are present day values and investors will need to consider indexation and cost variations as appropriate. The costs presented here relate to the implementation of this project in isolation.

[redacted]

[redacted]

14.3 Operating and maintenance costs

A full estimate of ongoing costs can only be developed after this proposal is built into Basin-scale modelling of post-SDL adjustment operations and the likely frequency of operation estimated. In order to provide a conservative estimate of ongoing costs, it has been assumed the proposed works will be operated according to appropriate scenarios (as detailed in Section 10) in 50 percent of years.

Operating and maintenance costs for the project are summarised in Table 14-3. As the precise operating procedures of the project will be detailed subsequent to this business case, Table 14-3 outlines the operating costs as an average annual cost and maximum annual cost to reflect the environmental water delivery via temporary pumping. Operation and maintenance costs (supplied by SA Water) based on a 30 year timeframe and does not include asset renewal.

[redacted]

14.4 Projects seeking Commonwealth Supply or Constraint Measure Funding (funding sought and co-contributions)

Victoria will be seeking 100 per cent of project funding for this supply measure proposal from the Commonwealth. The funding requested will ensure the proposed supply measure is construction ready, built in accordance with all regulatory approval requirements and conditions, and fully commissioned once construction is completed.

Co-contributions

No co-contributions are provided for project capital costs.

14.5 Ownership of assets

To inform an eventual decision on proposed financial responsibility for ongoing asset ownership costs, and the preferred agency to undertake this role, the Department of Environment and Primary Industries convened a workshop with the key delivery partners for Victoria's proposed supply measures. Attendees at the workshop included representatives from:

- Mallee CMA

- North Central CMA
- DEPI
- Parks Victoria, and
- Goulburn-Murray Water.

The workshop was convened as a theoretical scoping exercise to draw on pre-existing expertise to evaluate the set of criteria that an agency would need to possess in order to effectively own, operate and maintain an asset like this proposed supply measure. Key criteria evaluated included:

- Access to capability to perform the required functions, either directly or under contract
- Access to suitable resources which can be deployed in a timely, efficient manner
- Sufficient powers conferred under legislation to enable services to be provided
- Demonstrable benefit or linkage to primary business mission or activities
- Ability to collaborate and co-ordinate effectively with multiple parties, and
- Risks are allocated to those best placed to manage them.

Participants at the workshop were collectively of the view that while a number of Victorian agencies possessed many of the key criteria needed to perform this role, more information was needed before a conclusive decision could be made on which agency was overall the best fit. This included a more determinative sense of the full suite of adjustment measures that were likely to be agreed to across the Basin, and their spatial distribution, so that opportunities to capitalise on economies of scale could be more fully investigated.

On this basis, DEPI advises that the delegation of asset ownership and operation, including any associated proposed financial responsibility, cannot be formally ascertained at this time. Such decisions are generally whole-of-Victorian government, and sufficient information is not currently available to enable a formal position on this matter to be clarified.

In line with good financial practice, any long-term arrangements for asset ownership, operation and maintenance should maximise cost-efficiencies where they can be found. This includes options to ‘package up’ ongoing ownership, operation and maintenance where this is deemed the most cost-effective approach.

DEPI will be in a position to provide more formal advice on the state’s preferred long-term arrangements for this supply measure once the full suite of Victorian proposals under the SDL adjustment mechanism has been more definitely scoped. This is anticipated to occur during the course of 2015, pending receipt of advice from the MDBA on likely adjustment outcomes.

14.6 Project benefits

The main benefit of this project (SDL adjustment) will be calculated after submission of this business case, and cannot be included in this document. However, the project will also produce additional significant environmental, social and economic benefits to the region, driven by the environmental improvement generated by the project. A study was commissioned into the quantifiable benefits of the project other than water savings (attached as Appendix F), which drew on a Total Economic Value (TEV) framework and involved the ‘benefit transfer’ method of transferring unit values from original studies in a similar context.

The quantified economic values produced by the project reflect the broader Victorian community’s willingness to pay (WTP) for specific types of environmental improvement, as well as an estimate of the consumer surplus associated with increased recreation produced by this environmental improvement. Specific benefits include (Aither, 2014):

- Improved healthy native vegetation: studies have shown that the Victorian community values improvements to the health of native vegetation, specifically River Murray red gum forests[4]. Values were conservatively applied to 1,000 hectares of the project area (total project area is 20,000 hectares)

- Improved native fish populations: the same studies reveal a community WTP for improvement in native fish populations, calculated at an estimated 1% increase in native fish populations in the river produced by the project[5]
- Increased frequency of colonial water bird breeding: previous analysis reveals a community WTP for an increase in the frequency of water bird breeding in the River Murray ($12 per year per household)[6]. Under the assumption that Lindsay Island (as one of the seven icon sites identified in the Basin Plan) represents 5% of this River Murray value, a value for increased water bird breeding to the Victorian community was developed
- Increased recreation: workshops with Mallee CMA and Parks Victoria staff revealed that the Lindsay Island project was estimated to double the net annual tourist visitor days to the site[7]. Using previous studies that estimated the economic value of a visitor day ($134 per visitor day[8]), the economic value of an increase of 10,000 visitor days was estimated, and
- Improved access to Lock 7. Currently, access is cut when River Murray flows reach 20,000 ML/day; however, under the proposed works access will be maintained in excess of 60,000ML/day.

The economic value of these four[9] quantified economic benefits associated with the Lindsay Island project are presented in Table 14-3. The 'present value' estimates assume benefits start accruing in the year of commissioning (shown as 2021 on proposed project schedule in Table 3-3) and continue annually for the remaining years of the analysis timeframe (30 years). They are discounted to 2014 using a 7% discount rate.

Table 14-3. Economic benefits produced by the project ($2014) (Aither, 2014)[10]

	Annual value ($M)	Present value ($M)[11]
Healthy native vegetation	$1.9	$17.7
Native fish population	$1.2	$11.2
Frequency of colonial water-bird breeding	$0.9	$8.4
Recreation	$1.6	$14.8
Total	**$5.68 million**	**$51.97 million**

A number of unquantified benefits are also identified for the project, namely:

[5] Bennett et al (2007) found that annual household value for this change was estimated at $0.97 per Melbourne household, $1.43 per 'rest of Victoria' household, and $1.00 per 'local region' household. We adjust these values with CPI from 2007 to 2014

[6] We adjust for CPI from 2011 to 2014. Please note that this was not undertaken in the Aither report.

[7] Some minor negative impacts in visitor numbers were expected during inundation events, but these were expected to be offset by significant increases in visitor numbers over time, producing a net doubling of annual visitor numbers.

[8] We account for CPI from the source study in 2007 to 2014.

[9] Please note that the value for changes to healthy native vegetation, native fish population and frequency of colonial water-bird breeding may constitute a 'double-count' of environmental value, depending upon how the CSIRO SDL Adjustment Ecological Elements Method is employed. How this method will be employed is unknown at the time of this business case submission.

[10] Please note that all data in this table is adjusted for CPI from the source year (2007 for vegetation, fish and recreation; 2011 for bird breeding). This was not undertaken in the Aither analysis.

[11] $2014, discount rate of 7% over 30 years. Please note that the 'present value' estimates in the Aither document differ from numbers reported here, as Aither estimated 30 years of benefit whereas in this project benefits commence in the 4th year of the 30 year analysis period, producing only 26 years of benefit.

- Cultural heritage: 800-900 cultural heritage sites exist within the vicinity of Lindsay Island, including scarred trees, artefact scatters, shell middens, hearth features and burial sites. The scarred trees may benefit from improved environmental conditions, while other cultural sites (e.g. hearths) may benefit from increased protection works undertaken through the Cultural Heritage Management Plan developed for this project.
- Apiarists: the beehives that currently exist on Lindsay Island depend on seasonal flowering of river red gum forests, which will increase in regularity and reliability due to the project. This should increase the number of hives at each site, and the number of active sites. This value is not quantified.

In terms of impacts on the local community of the project, Compelling Economics developed a REMPLAN input-output model of the Mildura-Wentworth region. Using this model, the impact of the proposed works at Lindsay Island can be estimated in terms of employment, output, wages and salary, and industry value added.

During the two year construction phase of the proposed works, the additional expenditure will result in $47.7 million per year of gross output and 114 jobs. After this construction phase, tourism expenditure and annual operations and maintenance expenditure will result in output of $4.37 million per annum and 11 additional jobs (Aither, 2014)[12]. These numbers illustrate the regional benefits of the project but are not proposed to be included in the cost-benefit analysis.

Living culturally scarred tree at Lindsay Island (2014)

[12] Present value figures reported in this document may differ from the source due to different assumptions on assessment period.

15. Stakeholder management strategy (Section 4.11.1)

The Mallee CMA has worked with key stakeholders and interested community groups to develop the concept for the Lindsay Island project from 2012 to 2014. Communication and engagement activities conducted throughout the Business Case phase have included:

- More than 125 face-to-face briefing sessions, meetings, presentations and on-site visits, engaging more than 450 people, which is reflective of the wide range of project stakeholders, and
- Fact sheets, media releases, electronic communication (website, emails, newsletters), brochures and correspondence.

This direct approach to engagement has helped ensure the views and local knowledge of key stakeholders and community members have been directly integrated into the project, resulting in broad community support for the proposed works at Lindsay Island, as evidenced by the receipt of letters of support from:

- Materially-affected land managers such as Trust for Nature and Parks Victoria
- Irrigators at Lindsay Point
- Adjacent private landholders (including NSW landholders)
- Aboriginal stakeholders
- Local government (Mildura Rural City Council)
- Regional Development Australia and Regional Development Victoria – Loddon Mallee
- Industry groups
- Tourism operators, and
- Community groups such as the Lindsay Point Landcare Group and Sunraysia Riverwatch.

A full list of the letters of support received for this project is provided in Appendix G.

Broad community support for this proposed project is further evidenced by the sustained interest in the proposal as illustrated by on-going requests from key stakeholders to provide briefings, presentations and updates.

15.1 Communication and engagement strategy

A detailed Communication and Engagement Strategy has been developed for this project and key stakeholders identified. This strategy has helped to ensure those who are materially affected by the project and the broader community have been consulted and their views adequately considered and responded to by the Mallee CMA (RMCG, 2014).

This strategy reflects the intent of the *Principles to be applied in environmental watering* outlined in the Basin Plan (MDBA, 2012a), aligns with the directions of the Victorian Government's Environmental Partnerships policy (Victorian Government, 2012) and is consistent with the principles of the Community Engagement and Partnerships Framework for Victoria's Catchment Management Authorities (Community Engagement and Partnership Working Group 2012) (RMCG, 2014).

The Communication and Engagement Strategy includes:

- Identification of key stakeholders of the Lindsay Island project
- Detailed analysis of the stakeholders, which have been divided into three groups according to their level of interest in and influence on the project
- Analysis of stakeholders' issues and sensitivities
- Clearly articulated objectives and engagement approaches designed to meet the needs of different stakeholder groups, and
- Communication and engagement activities for both the Business Case and implementation phases of the project.

An overview of the Lindsay Island Communications and Engagement Strategy and the outcomes from the Business Case phase are provided in the following sections. The full strategy is provided in Appendix H.

15.2 Identification of key stakeholders and engagement approaches

Stakeholders have been characterised into three groups relating to their interest and influence on the project outcomes. Relative to each other, Stakeholder Group 1 has the highest level of interest in and influence on the project outcomes, Stakeholder Group 2 has a moderate level of interest in and influence on the project outcomes and Stakeholder Group 3 has a lower level of interest in and influence on the project outcomes (RMCG, 2014).

Stakeholder Group 1 has been further defined into two key types; project partners and project stakeholders. Project partners are differentiated from project stakeholders for the purposes of defining appropriate communication and engagement approaches as they have a direct role in the design and development of the project (i.e. as investors, land managers, construction or operational managers) (RMCG, 2014).

The engagement approach for Stakeholder Group 1 can be described as high intensity, targeted and tailored to the needs of each individual stakeholder. On the iap2 public participation spectrum, the aim of the engagement approach for project partners is to COLLABORATE in the planning, construction and operation phases of the Lindsay Island project. For project stakeholders, the aim is to INVOLVE stakeholders in all phases of the Lindsay Island project (RMCG, 2014).

The engagement approach for Stakeholder Group 2 is of moderate intensity, targeted and more generic in nature in comparison to Stakeholder Group 1. On the iap2 public participation spectrum, the aim of the engagement approach for Stakeholder Group 2 is to CONSULT stakeholders on the planning, construction and operation phases of the Lindsay Island project (RMCG, 2014).

The engagement approach for Stakeholder Group 3 is of lower intensity, publicly accessible and generic in nature. On the iap2 public participation spectrum, the aim of the engagement approach for Stakeholder Group 3 is to INFORM stakeholders on the planning, construction and operation phases of the Lindsay Island project.

Table 15-1 provides a list of stakeholders and a summary of the issues and sensitivities of each of the three Stakeholder Groups (RMCG, 2014).

Table 15-1. Stakeholders of the Lindsay Island Floodplain Management Project and summary of the issues and sensitivities

Stakeholder group	Stakeholder	Summary of issues and sensitivities
Group 1a: Project partners	DEPI Parks Victoria Trust for Nature MDBA G-MW SA Water	Land inundation Restoring the natural ecology Consistency with Basin Plan Environmental water responsibilities Managing impacts of works on visitors and recreation Responsibility for construction/operations Impacts of water volume on river flow Appropriate infrastructure to maximise the impact of environmental watering Ensuring projects are delivered in a way that both benefits the environment and respects Indigenous culture
Group 1b: Project stakeholders	**Indigenous community:** Ngintait, Latji Latji Mumthelang Aboriginal Corporation Lindsay Point Irrigators Adjacent freehold landholders **Local community**: townships of Lake Cullulleraine, Werrimull and Lindsay Point **Mallee CMA Community Committees:** Land and Water Advisory Committee (LWAC), Aboriginal Reference Group (ARG), The Living Murray Community Reference Group (CRG) (Hattah Lakes and Lindsay-Wallpolla Icon Sites) **Local Government:** Mildura Rural City Council Commonwealth Environmental Water Holder (CEWH) Victorian Environmental Water Holders (VEWH)	Impact to cultural heritage and indigenous values Future environmental health of country Land inundation Restoring the natural ecology Continuity and quality of irrigation water supply Local knowledge, history and a sense of ownership of the areas involved Impact to local amenity, recreation, economy and environment Impacts of water volume on river flow Appropriate infrastructure to maximise the impact of environmental watering Ensuring projects are delivered in a way that both benefits the environment and respects Indigenous culture Ensuring that proposed activities and outcomes are acceptable to the wider community Consistency with planning scheme
Group 2	**Other environmental organisations:** Murray-Darling Freshwater Research Centre, Murray Darling Association, Environment Victoria, Australian Conservation Foundation, Lower Murray Water **Community-based environment groups:** Lindsay Point Landcare Group, Millewa-	Impact to local amenity, recreation, economy and environment Ensuring projects are delivered in a way that both benefits the environment and respects Indigenous culture

Stakeholder group	Stakeholder	Summary of issues and sensitivities
	Carwarp Landcare Group, Birdlife Australia (Mildura Branch), River Watch, Sunraysia Field Naturalists Club, Sporting Shooters Association of Australia (Nhill), Murray-Darling Wetlands Working Group, Victorian National Parks Association **Indigenous organisations/groups:** North West Native Title Claimants, Murray Lower Darling Rivers Indigenous Nations (MLDRIN) **Other community groups/businesses:** Regional Development Victoria – Loddon Mallee, 4WD clubs, angling clubs, tourism businesses, license holders (firewood, bee keeping, fishing), Rotary, Probus, Progress associations, CWA, Lions **Park users/visitors:** Murray-Sunset National Park	
Group 3	**Wider community:** Mallee region, Victoria, Murray Darling Basin	As above

15.3 Outcomes of consultation undertaken during the Business Case phase

The overall response to engagement activities undertaken to date has been positive. Engagement activities were tailored to the stakeholder's interest in the project and provided the opportunity to identify issues/sensitivities and reach agreed outcomes.

For all communication and engagement activities completed through the Business Case phase, Mallee CMA has kept a detailed record of:

- Who has been consulted and the outcomes
- How consultation outcomes have been considered and responded to by the Mallee CMA, and
- The extent of stakeholder and community support for the project.

The outcomes of consultation undertaken during the business case phase will directly inform the communication and engagement strategy for the implementation phase of this project.

An overview of the communication and engagement approaches and main outcomes from the consultation by stakeholder group is provided in Table 15-2.

A more detailed analysis of the approaches is provided in the Lindsay Island Communication and Engagement Strategy (Appendix H: Section 3-4, pp. 9-25).

Table 15-2. Summary of consultation outcomes from the Business Case phase

Stakeholder group	Communication/engagement approach	Focus of consultation	Summary of consultation outcomes (Mallee CMA response)	Evidence of support for the project
Group 1: Project partners	Intensive engagement through: Sustainable Diversion Limits Offset Projects Steering Committee: Lindsay-Wallpolla Islands meetings (monthly) Design team meetings Negotiations regarding roles and responsibilities One-on-one discussions as required	Siting of proposed infrastructure Design parameters of proposed infrastructure Downstream water quality impacts Adjustments/clarifications to technical information and/or presentation of information in business case Monitoring and management of salinity and turbidity during operation of proposed infrastructure	Adjusted structure location to reflect stakeholder advice Designs developed in accordance with stakeholder preferences/requirements Operational scenarios for proposed infrastructure investigated to minimise water quality impacts Business case adjusted in accordance with feedback received Salinity investigations undertaken, monitoring and management strategies considered Planned ongoing engagement with project partners	Letters of support for the project from partner agencies such as Parks Victoria, Trust for Nature, Goulburn-Murray Water Sustained, consistent high-level involvement in project development throughout business case phase
Group 1: Project stakeholders	Small group (face-to-face) briefing sessions with Mallee CMA, including on-site visits Face-to-face engagement and on-site visits with Aboriginal stakeholders Presentations conducted by Mallee CMA	Inundation of private land Minimisation of harm to sites of cultural heritage, in line with legislative requirements Monitoring and management of salinity and turbidity during operation of proposed infrastructure	Specific control mechanisms included in project proposal to include/exclude private land inundation in line with stakeholder preference Works proposed for existing tracks/disturbed areas where possible to minimise harm to sites of cultural heritage Preliminary cultural heritage assessment completed to inform project development Salinity investigations undertaken, monitoring and management strategies considered Planned ongoing engagement with	Letters of support from Aboriginal stakeholders, Lindsay Point irrigators, adjacent freehold landholders (including NSW landholders), Mallee CMA community committees and local government (Mildura Rural City Council) On-going discussions/preliminary approval processes completed with Mildura Rural City Council, resulting in a strong working relationship. Sustained interest in the project as illustrated by on-going requests from key stakeholders to provide briefings, presentations and updates.

			project stakeholders	
Group 2	Teleconference briefing sessions with Mallee CMA staff Presentations conducted by Mallee CMA staff	Social (e.g. public access) and economic (e.g. financial investment in region) challenges/opportunities Impact on apiary operations.	Operational scenarios for proposed infrastructure investigated to minimise restrictions to public access. Clear and accessible information provided regarding proposed project Consideration of apiary requirements in planning operation of infrastructure Planned ongoing engagement with project stakeholders	Letters of support from tourism operators, as well as key organisations and community groups such as Regional Development Australia and Regional Development Victoria – Loddon Mallee, the Lindsay Point Landcare Group, Meringur Pioneer Settlement, Sunraysia Branch Victorian Apiarists Association Sustained interest in the project as illustrated by on-going requests from key stakeholders to provide briefings, presentations and updates.
Group 3	Information accessed through the Mallee CMA website	Impacts on water quality during operation of proposed infrastructure.	Operational scenarios for proposed infrastructure investigated to minimise water quality impacts. Planned ongoing engagement with project stakeholders	Letters of support Sustained interest in the project as illustrated by on-going requests from key stakeholders to provide briefings, presentations and updates.
All stakeholders	Information package accessed on the Mallee CMA website (fact sheets, case studies, photos, contact information) Project up-dates	As above	As above	Letters of support Sustained interest in the project as illustrated by on-going requests from key stakeholders to provide briefings, presentations and updates.

15.4 Proposed consultation approaches for the implementation phase

A proposed communication and engagement strategy has also been prepared for each Stakeholder Group for the implementation phase of the Lindsay Island project. This strategy has been directly informed by the outcomes of the consultation activities undertaken during the business case phase of the project.

An overview of the planned communication and engagement approaches is provided in Table 15-3. A more detailed analysis of the approaches is provided in the Lindsay Island Communication and Engagement Strategy (Appendix H: Section 3-4, pp. 9-25).

A large effort has been invested in the communication and engagement activities in order to develop broad community support for the Lindsay Island project. The project has high visibility among materially affected and adjacent landholders/managers, along with Aboriginal stakeholders and other interested parties, ensuring the advice and concerns of those involved have been considered and responded to accordingly. This strong commitment to working directly with project partners and the community will be ongoing throughout the construction and implementation phases of the project, further cementing community support and ensuring success for the Lindsay Island project.

Table 15-3. Communication and engagement strategy for the implementation phase

Stakeholder group	Engagement approach	iap2 level of engagement	Number / timing
Group 1: Project partners	Intensive engagement throughout project planning and development including design and construction meetings, on-site visits and other engagement methods as relevant	Collaborate	Ongoing
Group 1: Project stakeholders	Tailored events (e.g. site tours, funding announcement, commencement of construction)	Involve	Funding announcement/commencement of construction Site tours as required
Group 2	Teleconference briefing sessions with Mallee CMA staff Presentations conducted by Mallee CMA staff	Consult	Ongoing as required Throughout implementation phase
Group 3	Videos accessed through the Mallee CMA website Information package accessed on the Mallee CMA website (fact sheets, case studies, photos, contact information)	Inform	Accessible throughout implementation phase As soon as possible after funding is confirmed Updated and accessible throughout implementation phase
All stakeholders	Project up-dates accessed through the Mallee CMA website and social media channels (e.g. e-newsletter, Twitter and other social media)	Inform	Regularly throughout implementation phase
	Media communication (e.g. media releases, newspaper articles, radio interviews, television interviews)	Inform	As required throughout construction and operation One media release associated with each watering event

16.Legal and regulatory requirements (Section 4.11.2)

Obtaining statutory approvals is an essential consideration for the *Lindsay Island Floodplain Management Project*. The process of obtaining the necessary approvals can be complex and can present risks to the timeline, budget and delivery of the project.

Early identification of statutory approvals required, background investigations required to complete the approvals, interdependencies between approvals as well as timeframes associated with both the preparation and assessment/consideration of submissions have been identified as important elements critical to the timely delivery of environmental watering projects (Golsworthy, 2014).

In order to guide the approvals process, DEPI and the Mallee CMA commissioned management strategies (GHD, 2014a; Golsworthy 2014). The strategies provide a clear understanding of the current relevant legislation as well as the approvals required, based on the type and location of planned works, the cultural heritage, flora and fauna values present within the works footprint, and the past experience of the Mallee CMA and partner agencies in completing approvals for large, infrastructure-based projects within National Parks.

16.1 Regulatory approvals

GHD, 2014a (Appendix I) and Golsworthy, 2014 (Appendix J) have identified the approvals, permits and licences likely to be required prior to the commencement of construction. An assessment of relevant issues based on the proposed construction footprint at Lindsay Island has indicated the need to obtain several approvals under local government, State and Commonwealth legislation.

Approvals refers to all environmental and planning consents, endorsements and agreements required from Government agencies by legislative or other statutory obligations to conduct works (GHD, 2014a).

The approvals required for Lindsay Island are listed in Table 16-1.

Table 16-1. Regulatory approvals anticipated for Lindsay Island (GHD, 2014a). This table includes potential species of national environmental significance

Approvals required	Description
Commonwealth legislation	
Environmental Protection & Biodiversity Conservation Act 1999 **Referral**	A number of potentially affected "matters of national environmental significance" (MNES) are present at Lindsay Island: • Upstream from Banrock, Coorong and Riverland Ramsar sites • Seven migratory waterbird species • 18 nationally threatened species • 1 nationally threatened ecological community community
Victorian legislation	
Environmental Effects Act 1978 **Referral**	Relevant to three of the six referral criteria for individual potential effects i.e. Potential clearing of 10 ha or more of native vegetation from an area that: • Is of an is of an Ecological Vegetation Class identified as endangered by the Department of Sustainability and Environment (in accordance with Appendix 2 of Victoria's Native Vegetation Management Framework), or • Is, or is likely to be, of very high conservation significance (as defined in accordance with Appendix 3 of Victoria's Native Vegetation Management Framework), and • Is not authorised under an approved Forest Management Plan or Fire Protection Plan Potential long-term change to the ecological character of a wetland listed under the Ramsar Convention or in 'A Directory of Important Wetlands in Australia' Potential extensive or major effects on the health or biodiversity of aquatic, estuarine or marine ecosystems, over the long term.
Planning & Environment Act 1987 **Planning permit** **Public Land Managers Consent**	Applicant to request permission from public land manager to apply for a planning permit for works on public land A planning permit application is then submitted with supporting documentation including an: • Offset strategy • Threatened species management plan Local Council refers applications and plans to appropriate authorities for advice.
Aboriginal Heritage Act 2006 **Cultural Heritage Management Plan**	A CHMP is required when a listed high impact activity will cause significant ground disturbance and is in an area of cultural heritage sensitivity as defined by the Aboriginal Heritage Regulations 2007 (Part 2, Division 5). Relevant high impact activities include: (xxiii) a utility installation, other than a telecommunications facility, if the works are a linear project with a length exceeding 100 metres (other than the construction of an overhead power line or a pipeline with a pipe diameter not exceeding 150 millimetres). To be prepared by an approved Cultural Heritage Advisor.
Water Act 1989 **Works on waterways permit**	Application for a licence to construct and operate works on a waterway.
National Parks Act 1975 **Section 27 consent**	Approval for a public authority to carry out its functions in a national park.

Flora & Fauna Guarantee Act 1988	Application for approval to remove protected flora within public land for non-commercial purposes.
Protected flora licence or permit	Will need to include targeted surveys for threatened/protected species considered likely to be present at the site and impacted by proposed works.

The following supporting documents will be required and likely to be requested through referral decisions on planning permit conditions (GHD, 2014a):

- An offset strategy for native vegetation losses
- An environmental management framework
- A threatened species management plan, and
- A cultural heritage management plan.

The application process for each approval, the responsible agency, timing of submissions and timeframe for decisions are outlined in the Regulatory Approvals Strategy (GHD, 2014a). The Strategy includes an indicative program for effecting regulatory approvals that predicts a minimum 31-week period to obtain all required approvals. This timeframe assumes that an Environmental Effects Statement is not required, all applications (including supporting documentation) are already prepared and that there are no significant delays during the assessment process. The Strategy also notes that there are a number of linkages and dependencies between approvals, where for example, some approvals cannot be issued until another is approved e.g. a planning permit cannot be granted until there is an approved CHMP.

A Regulatory Governance Group (RGG) is supporting the delivery of business case requirements related to regulatory approvals by providing a mechanism for high-level engagement with responsible agencies at an early stage to streamline the regulatory approvals process. The RGG provides advice to the Project Control Board (PCB) regarding the regulatory approvals needed for Victorian projects, the resolution of associated issues and develop a program-level strategy to obtain approvals.

16.2 Legislative and policy amendments and inter-jurisdictional agreements

At the state level, a legislative change may be needed to address the requirement to secure native vegetation offsets prior to clearing. As the primary offsetting mechanism is expected to be the gains in vegetation condition within the areas watered by the various Victorian works-based supply measures, i.e. the outcomes of the measures once operational, this requirement cannot be met. DEPI will investigate a suite of options to address this issue during the detailed design for this measure, including the potential for a planning scheme amendment. Note that the other options to be investigated do not require legislative changes.

Matters related to other regulatory approvals necessary for the implementation of this supply measure are discussed elsewhere in this Business Case.

No other amendments to state legislation or policy are anticipated. This includes any formal amendments to state water sharing frameworks, or river operations rules or practices.

Further to this, no changes to the Murray-Darling Basin Agreement 2008 are required to implement this measure, nor do any new agreements need to be created either with other jurisdictions or water holders in the Basin.

16.3 Cultural heritage assessment

An Archaeological Due Diligence Assessment Report (Bell, 2013, Appendix K) has been completed for the project. A desktop assessment showed that within 100m of proposed structures there were a total of five recorded Aboriginal Cultural Heritage places. Field inspections identified a total of 73 previously unrecorded Aboriginal cultural heritage places. Under the *Aboriginal Heritage Act 2006* Lindsay Island is specified as an area of cultural heritage sensitivity in accordance with several categories and a Cultural Heritage Management Plan will be undertaken prior to any work being undertaken.

17.Governance and project management (Section 4.11.3)

Appropriate governance and project management arrangements have been put in place to minimise risks to investors and other parties from the proposed supply measure. The sections below describe the governance arrangements during business case development and proposed arrangements during project implementation.

17.1 Governance arrangements during business case development

A Project Control Board (PCB) was convened by DEPI to oversee the development of business cases for the nine Victorian works-based supply measures. The PCB is comprised of senior executives from DEPI, the Mallee and North Central CMAs, G-MW and Parks Victoria. This has ensured high level engagement of responsible agencies and has assisted in identifying and resolving program-level issues during development of business cases. The PCB's role has been to ensure that:

- All business cases meet the requirements set out in the Phase 2 Guidelines (reference),
- All business cases are of a high and consistent standard, and delivered within specified timelines,
- The technical basis of each business case is robust, credible and fit for purpose, and
- That appropriate consultation with stakeholder agencies, affected persons and the community was carried out during business case development.

The PCB has been supported by an Expert Review Panel and Regulatory Governance Group, and project-specific governance arrangements set up by the North Central and Mallee CMAs (see Figure 17-1).

The *Lindsay Island Floodplain Management Project* business case has been endorsed by the PCB as part of the final package of Victorian business cases to be submitted for assessment under Phase 2 of the SDL adjustment mechanism.

Expert Review Panel

An Expert Review Panel ('the Panel') was set up to examine the critical elements of each business case at key stages and assess quality, credibility and whether the element is fit for purpose. The Panel was chaired by David Dole and comprised of experts in engineering (including geotechnical, structural, hydraulic and water system operations), hydrology and ecology. Its members include:

- Phillip Cummins (engineering)
- Shane McGrath (engineering)
- Dr Chris Gippel (hydrology)
- Andrew Telfer (salinity), and
- Professor Terry Hillman (ecology).

The following evaluations were carried out during the development of this business case:

- Engineering: Review of concept engineering designs (hydraulics and structures), the scoping of geotechnical investigations to support water management structure design and construction costs
- Hydrology: Review of hydrodynamic and hydrological models, data, modelled scenarios and outputs,
- Salinity: review of assessments of potential salinity impacts of works and measures projects; and
- Ecology: Review of the descriptions of ecological values, the ecological objectives and targets, and environmental water requirements, and the descriptions of anticipated ecological outcomes and environmental water requirements.

The expert review process has concluded that the underlying feasibility and outcome investigations have provided a soundly based proposal which is fit for purpose (see Appendix L).

Regulatory Governance Group

The Regulatory Governance Group (RGG) was established to support the delivery of business case requirements related to regulatory approvals. The RGG was comprised of relevant staff from Victorian approvals agencies, including DEPI, Parks Victoria and Aboriginal Affairs Victoria. The RGG provided advice to the PCB regarding the regulatory approvals needed for Victorian projects, the resolution of associated issues and develop a program-level strategy to obtain approvals (Appendix I).

Setting up the RGG has provided a mechanism for high-level engagement with responsible agencies at an early stage to streamline the regulatory approvals process for proposed supply measures. While the RGG ceased operation when all business cases were finalised for submission (December 2014), the Group may be reconvened by the PCB as required.

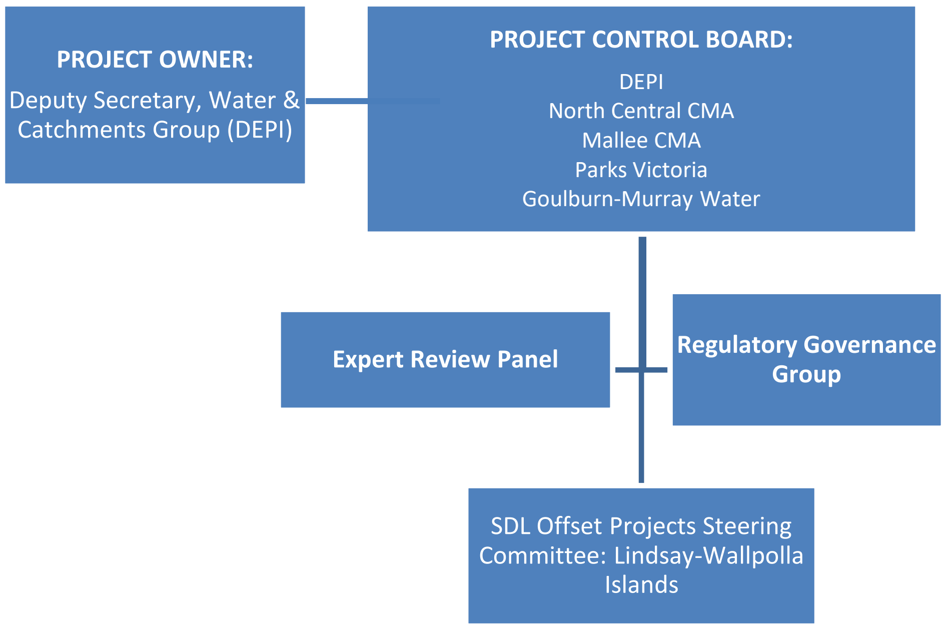


Figure 17-1. Governance arrangements during business case development

SDL Offset Projects Steering Committee: Lindsay-Wallpolla Islands

At the project level, development of the business case for the *Lindsay Island Floodplain Management Project* was overseen by the SDL Offset Projects (Lindsay-Wallpolla Islands) Steering Committee (Mallee CMA, 2014a). The committee's role was to ensure the business cases developed for these sites are of a high quality, consistent standard, and that they meet the requirements of the Commonwealth (Mallee CMA, 2014a).

Specifically the committee was responsible for the following functions in the development and delivery of the relevant SDL project business cases (Mallee CMA, 2014a):

- Provision of advice on the development and proposed delivery of SDL projects from a technical perspective
- Ensuring projects developed and the supporting business cases produced are technically rigorous and sound
- Providing guidance to resolve project-specific issues
- Monitoring the development of business cases to ensure a consistent approach and that required information is provided, in accordance with the Phase 2 Guidelines for Supply and Constraint Measure Business Cases provided by the Commonwealth, and
- Providing advice on project procurement from a technical perspective.

The committee was comprised of the following members (Mallee CMA, 2014a):

- Chief Executive Officer, Mallee CMA
- The Living Murray Coordinator, Mallee CMA
- Manager Water, Mallee CMA
- Parks Victoria representative/s (land manager representative)
- Department of Environment and Primary Industries (DEPI) representative/s (land manager representative and coordinator of regional environmental advice and approvals)
- Goulburn-Murray Water (G-MW) representative/s
- SA Water representative/s
- Murray-Darling Basin Authority representative/s.

The Steering Committee met monthly, with extraordinary meetings scheduled as necessary. The committee ceased operation when all business cases were finalised for submission (December 2014) (Mallee CMA, 2014a).

17.2 Governance arrangements during project implementation

To ensure that this proposed supply measure is delivered on time, arrangements will be put in place that ensure appropriate senior oversight of project governance and delivery. This will allow for the successful completion and operation of the measure as part of the SDL adjustment mechanism.

These arrangements will be predominantly based around those that were used to deliver the four Living Murray Environmental Works and Measures Program (EWMP) projects within Victoria, complemented by existing state government frameworks, which together will underpin a set of robust and thorough processes for procurement and project management. Key aspects of the proposed governance and project management for this supply measure will include:

Project management structure and team

The project management structure and team will be overseen by the project owner, currently anticipated to be DEPI. In line with the governance arrangements that have underpinned the Business Case preparation for this proposed supply measure, DEPI will be supported by a PCB, comprised of senior executives from DEPI, the relevant Victorian CMAs, the relevant constructing authorities (e.g. G-MW; SA Water), Parks Victoria and the Commonwealth.

It is expected that the PCB will be comprised of appropriate senior management representation from each of the participating agencies, who will have the required decision-making authority to oversee all elements of implementation. In line with the successful governance arrangements that were utilised during the Living Murray EWMP and the outcomes of the workshop on ongoing asset management arrangements (see Section 14.5), the relevant constructing authority (SA Water) would be well placed to undertake the construction of the supply measure, supported by the relevant CMA.

Procurement strategy

As the primary delivery agency, the relevant constructing authority would be expected to manage procurement during the construction of the supply measure, operating under the high-level oversight of the PCB. Supporting this, the relevant CMA will play a critical role by assisting in the development of a procurement strategy, which would be approved by the PCB. More specific details of the preferred approach for procurement will be detailed in the construction proposal.

Project Steering Committees or related governance mechanisms

In line with good governance practice, and again drawing on the experience of the Living Murray, it is expected that the PCB would meet regularly throughout the construction of this proposed supply measure to ensure that milestones and timelines are met, and to resolve any potential arising issues.

As noted above, it is expected that PCB members would have the required decision-making authority to address any emerging risks, including the following:

- Identifying and resolving issues, including those that might impact timelines/budget
- Providing guidance to resolve project-specific issues
- Ensuring appropriate consultation with key stakeholder agencies and the community
- Closely monitoring implementation to ensure timelines and budgets are met, and
- Making recommendations to DEPI on any issues that may arise during construction.

Monitoring and reporting during implementation

It is anticipated that the PCB would be the key conduit for monitoring and reporting during the implementation of this proposed supply measure. This would include:

- The relevant constructing authority providing regular implementation updates at each PCB meeting, and
- Consideration of any milestone or payment reporting that is likely to be required under all contractual funding arrangements associated with this supply measure.

Design and implementation plan with timelines

As noted, the PCB will meet regularly throughout the construction phase of this proposed supply measure to ensure milestones and timelines are met, to review designs, and to resolve any arising issues. The relevant CMA will play a critical supporting role by assisting the constructing authority with statutory approvals and the development of the construction proposal, as well as managing discrete projects to support detailed designs and the implementation/construction of the supply measure.

A detailed work plan will document the key tasks and the agency responsible, associated resources and timelines for the implementation of the supply measure.

Refer to Table 3-3 for a proposed project delivery schedule outlining timelines for the implementation of this project.

Operations Group

An Operations Group will be established to assist and advise on the commissioning and operation of this proposed supply measure. This Group will provide a forum to involve project partners in the decision-making process, to consider broader system operations (e.g. of the River Murray and other environmental watering events) during planning and operations, and to inform stakeholders of operations and progress. This model has proven highly successful for the TLM environmental works and measures program.

For the Lindsay Island site, the Operations Group membership will consist of partners and stakeholders, including the Murray-Darling Basin Authority, the Victorian Department of Environment and Primary Industries, SA Water, NSW Office of Water, Lower Murray Water, Parks Victoria, the Commonwealth Environmental Water Holder and the Victorian Environmental Water Holder. Other agencies and organisations may be invited to participate as guests or observers.

The key responsibilities of the Operations Group will be to ensure the necessary planning, monitoring, communication and reporting arrangements are established prior to and during events and to identify and monitor any event risks or issues. This allows for safe and effective operation of the works, real time response and adaptive management when necessary.

17.3 Governance expertise of partner agencies

Implementation of the project at Lindsay Island will be a partnership between four agencies: Mallee CMA, DEPI, Parks Victoria and SA Water.

Mallee CMA

The primary responsibility of the Mallee CMA is to ensure that natural resources in the region are managed in an integrated and ecologically sustainable way. The Mallee CMA's work is based on rigorous science and delivered through meaningful partnerships with government agencies, industry, environmental organisations, private land managers, Indigenous stakeholders and the broader community. All delivery arrangements are formalised through a range of mechanisms including operating agreements, service level agreements and landholder incentive / tender management agreements, the application of comprehensive MERI frameworks; and the application and interpretation of complex spatial data.

The Mallee CMA have a proven track record in successfully delivering a vast range of environmental projects which have varied in complexity, monetary value (up to multi-million dollar projects); and in spatial extent (from concentrated focal points to landscape scale programs).

Operating within policies and controls approved and overseen by the Mallee CMA Board ensures transparent and accountable governance systems that embody performance and continuous improvement. These governance arrangements include a quality management approach to project management, with policies and procedures for project management, contractual arrangements, procurement and risk management.

DEPI

The primary responsibility of DEPI in regard to this project is to act as its sponsor through the project assessment process established by the Intergovernmental Agreement on Murray-Darling Basin Water Reform 2014 (IGA). As part of this process, DEPI will represent the State of Victoria in negotiations with Commonwealth Government agencies to secure funding for the project, consistent with the commitments and arrangements outlined in the above mentioned IGA.

Once a funding agreement is reached for this project, DEPI will then assume an oversight role for the rollout of the project consistent with the terms of the funding agreement. As indicated previously, this oversight will be applied through the establishment of a PCB for the purposes of this project and any others that secure Commonwealth Government funding. It is envisaged that this PCB will be chaired and operated by DEPI. Its primary focus will be to ensure that milestones and timelines are met and where necessary, to resolve any emerging issues that present a material risk to the conduct and/or completion of this project.

Over the past decade, DEPI has had considerable experience in undertaking such oversight roles to a high standard for major Commonwealth funded water infrastructure projects in Victoria. Notable examples in this regard include the Living Murray Environmental Works and Measures projects at Gunbower, Hattah Lakes, Mulcra and Lindsay Islands, the G-MW Connections Program and the Lake Mokoan project.

Parks Victoria

Parks Victoria is a statutory authority, created by the *Parks Victoria Act 1998* and reporting to the Minister for Environment and Climate Change. Parks Victoria is responsible for managing an expanding and diverse estate covering more than 4 million hectares, or about 17 per cent, of Victoria.

Parks Victoria is committed to delivering works on the ground across Victoria's park network to protect and enhance park values. Parks Victoria's primary responsibility to ensure parks are healthy and resilient for current and future generations and manage parks in the context of their surrounding landscape and in partnership with Traditional Owners.

Parks Victoria works in partnership with other government and non-government organisations and community groups such as DEPI, CMAs, private land owners, Friends groups, volunteers, licensed tour operators, lessees, research institutes and the broader community.

Health Parks Healthy People is at the core of everything Parks Victoria does. Parks and nature are an important part of improving and maintaining health, both for individuals and the community. Parks Victoria has a clear role to play in connecting people and communities with parks.

South Australia Water

SA Water has a history of delivering large and complex civil water retaining structures such as:

- The Chowilla Regulator on behalf of the Murray Darling Basin Authority, ($58M)
- The South and Little Para Dam upgrades (South Australia), ($22M)
- The River Murray Locks and Weirs Upgrades, ($67M)
- Murtho Salt Interception Scheme, ($30M)
- Kangaroo Creek Dam Safety Upgrade, in delivery, ($82M)

SA Water has gathered significant experience in this field due largely to its existing capital plan in excess of $300M per annum, which will ensure this project moves forward and delivers the outcomes for the state / national client in a consistent manner that addresses risk and opportunity throughout the life of the project.

SA Water will also deliver significant benefits to the project by leveraging existing procurement frameworks, panel relationships and senior support in the form of its Board and Senior Executive team.

This project’s outcomes will be delivered in accordance with SA Water’s Corporate Project Management Methodology. This methodology provides for governance, delivery and risk management in line with the recognised national standards and is based on the Australian Business Excellence Framework and Project Management Body of Knowledge. The projects delivery framework will also be consistent with the Australia/New Zealand Risk Management Standard AS/NZS ISO 4360.

18.Risk assessment of project development and construction (Section 4.11.4)

A comprehensive risk assessment of the project development and construction phases has been carried out. A number of threats to successful project delivery were identified, as described in Table 18-1. The risk assessment process was informed by the past experience of the project team in the development and construction of environmental watering projects of similar scale and complexity, including TLM.

18.1 Risk assessment methodology

The risk assessment for the Lindsay Island project was completed in line with the requirements of AS/NZS ISO 31000:2009 (Lloyd Environmental, 2014). This assessed both the likelihood of an event occurring and the severity of the outcome if that event occurred. The assessment generated a risk matrix in line with the ISO standards and prioritised mitigation strategies and measures.

Refer to Section 7, Tables 7-1 to 7-4 to view the risk matrix and definitions used in this risk assessment, and further details on the methodology.

The risk assessment was consolidated as the project developed and additional information incorporated into Table 18-1.

18.2 Risk assessment outcomes

Table 18-1 presents a summary of the assessment and subsequent work undertaken, including mitigation measures developed and an assessment of residual risks after these are applied. It should be noted that where a residual risk is given a range of ratings, the highest risk category is listed.

Table 18-1. Risk assessment – Potential impacts to project delivery and construction without mitigation and residual risk rating with mitigation, adapted from Lloyd Environmental (2014)

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Unexpected delays in obtaining statutory approvals	The high environmental and cultural values of Lindsay Island may result in a lengthy regulatory approvals process, due to requests for additional information to clarify the potential impacts and proposed mitigation measures. Numerous conditions could also be placed on permits and approvals to ensure appropriate controls are in place during construction to minimise impacts.	Certain	Moderate	High	General: • CEMP developed and implemented; monitoring during construction to ensure compliance. • Site-based approvals group convened to engage with the relevant regulatory authorities • Project delivery timelines informed by Regulatory Approvals Strategy to minimise unexpected delays. Cultural heritage: • Preliminary assessment to inform structure design and location • A CHMP will be developed in consultation with Indigenous stakeholders and implemented during construction to minimise impacts on cultural values.	Low
Delays to construction planning and completion	Time and cost overruns could occur if the time required to obtain all necessary approvals is not embedded in the project planning and delivery timeframe.	Certain	Moderate	High	As above, and: Maintain strong working relationships with partner agencies (including agencies in NSW, SA and Victoria) through regular design and construction group meetings. Incorporate potential for delays into contractual arrangements.	Low
Weather related delays	Adverse weather (such as storms, heat waves) may create short-term delays to works through limitations to site access due to poor track conditions, OH&S and fire safety considerations.	Certain	Moderate	High	Consider weather conditions and medium to long-term forecasts when sequencing site works to minimise impacts and inform program scheduling to accommodate extreme weather events. Incorporate potential for delays into contractual arrangements, including appropriate terminology and clauses to	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
					ensure the principal and client are not put at undue risk for natural events.	
Floods	Natural floods may inundate the site and restrict access during construction, leading to cost increases and delays. These issues may be compounded by local weather conditions preventing demobilisation at the site.	Possible	Severe	High	Physically managing flows, as far as practical, through river operations. Utilise long-range weather forecasts, flow forecasts and general flow data (travel time, historical/predictive flows) to provide advance warning of floods to ensure sufficient lead time for demobilisation. Maintain strong working relationships with partner agencies (including agencies in NSW, SA and Victoria) through regular design and construction group meetings to assist timely issue resolution. Incorporate potential for delays into contractual arrangements, including appropriate terminology and clauses to ensure the principal and client are not put at undue risk for natural events. Contingency planning for inundation events. Obtain insurance covering inundation events.	Moderate
Fire	Equipment that can create sparks, such as angle grinders and welding equipment, can cause fires that threaten worker safety and require site evacuation. Bushfires (other causes) can have similar outcomes. Depending on the size and severity, fires can cause project delays and increase costs.	Unlikely	Severe	Moderate	Include safety provisions for relevant equipment in the CEMP and the site safety plan. Ensure comprehensive fire management plans are in place prior to construction that include: • Training and equipment requirements for on-ground	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
					personnel. • Site access/equipment restrictions that apply on fire danger days. • Emergency response (including evacuation) if a fire does occur. Monitor bushfire danger by liaising with DEPI, CFA, BOM and other relevant authorities. Contractual arrangements that accommodate changes resulting from fire incidents. Appropriate insurance for contractors, equipment and liability.	
Poor contractual arrangements	Ambiguous contractual arrangements may lead to confusion regarding the scope of work to be delivered and/or multiple contract variation requests. This can delay construction and have significant financial impacts.	Possible	Moderate	Moderate	Seek expert/legal advice on contractual arrangements. Ongoing supervision of contractors.	Very Low
Poor engineering design	Poor engineering design can create a number of issues, including: • Design not fit for purpose • Difficulties in operation • Increased maintenance costs • Reduced design life	Possible	Moderate	Moderate	Detailed designs and construction drawings peer reviewed before they are finalised. Early engagement of contractors and operators to provide feedback on design practicalities/constructability.	Very Low
Inadequate geotechnical information	Unforeseen geotechnical conditions encountered during construction may require significant alteration to existing designs or relocation of infrastructure causing project delays and additional expense.	Possible	Severe	High	Appropriate geotechnical investigations conducted carried out during the design phase to reduce uncertainty. Conservative design of structures to allow for variations to geotechnical conditions.	Moderate
Unclear roles and responsibilities	Unclear roles and responsibilities could hinder effective project development and	Possible	Moderate	Moderate	Establish a MoU between all relevant agencies outlining roles and	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
	construction.				responsibilities during project development and construction. Ensure appropriate contractual arrangements are in place between the project owner and the agencies responsible for construction management, approvals preparation, etc. Maintain strong working relationships with river operators, partner agencies (including agencies in NSW, SA and Victoria), and Commonwealth and Victorian water holders through regular design and construction group meetings. Maintain clear lines of communication with all partner agencies and project stakeholders during project development and delivery.	
Insufficient resourcing	Insufficient resourcing available for agency staff and equipment. This will impact on the ability to deliver the project within agreed timelines and budget.	Possible	Moderate	Moderate	Clear identification of roles, responsibilities, associated activities and resourcing requirements; funding agreements negotiated on the basis of these requirements. Maintain strong relationships with investors/funding bodies to secure adequate resources for project development and delivery.	Low

18.3 Risk mitigation and controls

While the risk assessment identifies several potential threats that could generate high risks to construction (Table 18-1), these risks are considered manageable because they:

- Are well known and are unlikely to involve new or unknown challenges
- Can be mitigated through well-established management controls
- Have been successfully managed by the project team (including construction authorities) in previous projects, and
- Result in very low or moderate residual risks after standard mitigation measures are implemented.

The risk assessment confirms that all risks are reduced to acceptable levels (moderate or lower) once well-established risk mitigation controls are implemented. Two threats retained a residual risk of moderate after implementation of the recommended mitigation strategies (18-2). Additional considerations may assist in further understanding, and in some cases reducing, the residual risk rating.

Table 18-2. High priority risks, mitigation and residual risk

Threat	Risk without mitigation	Residual risk rating	Additional considerations
Inadequate geotechnical information	High	Moderate	Obtaining peer review of designs and geotechnical information prior to engagement of contractors.
Floods	High	Moderate	The risk of a flood occurring is unpredictable and mitigation options are limited. Flood risks must be adequately considered in project costs. This is reflected in the inclusion of explicit costing for flood risk in the cost estimates for this business case.

18.4 Risk management strategy

As noted in Section 7.3, a comprehensive risk management strategy will be developed for the proposed supply measure, building on the work completed for this business case. The strategy will provide a structured and coherent approach to risk management for the life of this project (i.e. construction and operation). With regard to the potential threats to project development and construction, the risk management strategy will focus on the following issues, as described in Table 18-1:

- Ability to complete construction
- Project development and delivery

Risk assessment and management is not a static process. Regular monitoring and review of the risk management process is essential to ensure that:

- Mitigation measures are effective and efficient in both design and operation
- Further information is obtained to improve the risk assessment
- Lessons are learnt from events (including near-misses), changes, trends, successes and failures
- Risk treatments and priorities are revised in light of changes in the external and internal context, including changes to risk criteria and the risk itself, and
- Emerging risks are identified.

The risk assessment process will continue throughout the development and implementation of this project. It is anticipated that additional threats will be identified and evaluated as the project progresses, and any new risks incorporated into the risk management strategy.

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20. Appendices

Appendix A: Lindsay Island proposed works and inundation extents.

Appendix B: Ecological Associates 2014a. SDL Floodplain Watering Projects: Rationale and Outcomes, Report AL040-1-D. Report for the Mallee CMA.

Appendix C: Ecological Associates 2014b. SDL Floodplain Watering Projects: Monitoring and Evaluation. Report AL045-1-B. Report for the Mallee CMA

Appendix D: SKM 2014. Preliminary Salinity Impact Assessment for Mallee Environmental Watering Projects – Lindsay Island. Report for the Mallee CMA.

Appendix E: GHD 2014b. Basin Plan Sustainable Diversion Limits Offset Projects on Lindsay Island, Advanced Concept Design. Report for SA Water.

Appendix F: Aither 2014. Lindsay Island Water Management Works, Benefits for the Basin Plan Sustainable Diversion Limits offset program business case. Report for the Mallee CMA.

Appendix G: Lindsay Island letters of support.

Appendix H: RMCG 2014. Lindsay Island Sustainable Diversion Limits Offset Project, Final Communication and Engagement Strategy. Report for the Mallee CMA.

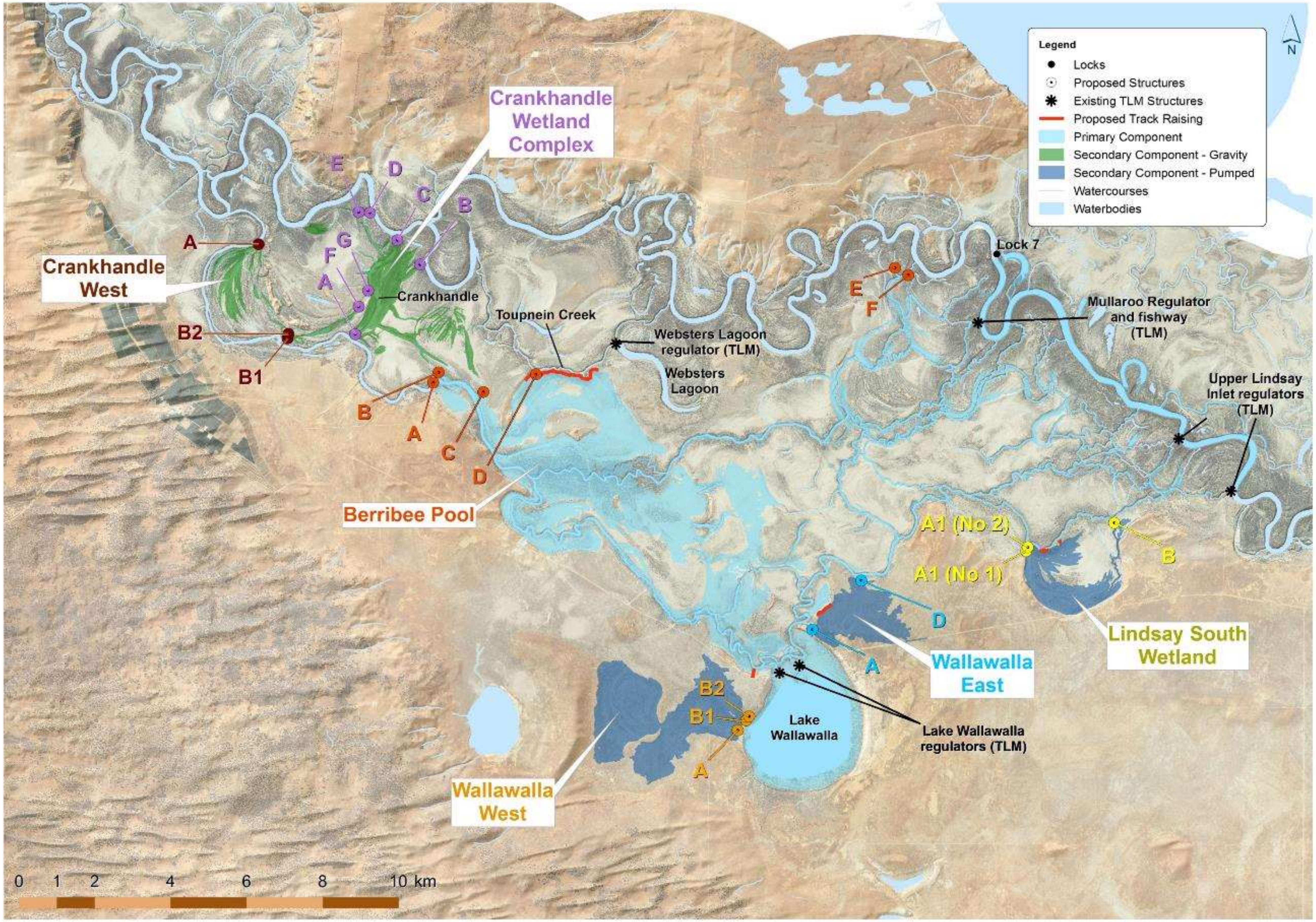
Appendix I: GHD 2014a. Basin Plan Environmental Works Program: Approvals Strategy. Report for the Department of Environment and Primary Industries.

Appendix J: James Goldsworthy Consulting 2014. SDL Offsets Projects, Statutory Approval Requirements, Belsar, Burra, Hattah, Lindsay, Nyah, Vinifera and Wallpolla. Report for the Mallee CMA.

Appendix K: Bell, J. 2013. Lindsay Island Floodplain, Northwest Victoria Due Diligence Assessment. Report for the Mallee CMA.

Appendix L: Expert Review Panel Reports.

Appendix A: Proposed works and inundation extents



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