Sustainable Diversion Limit Adjustment

Phase 2 Assessment

Supply Measure Business Case:
Hattah Lakes North Floodplain Management Project

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 Hattah Lakes North 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.

The Hattah Lakes North site is located on the western bank of the River Murray between Robinvale and Red Cliffs. Situated in the northern most part of the Hattah Lakes floodplain complex, the site is 9,028 ha in area. This floodplain, regarded nationally for its significant environmental values, is comprised of approximately 20 lakes and surrounding woodlands that receive water from the River Murray via Chalka Creek. The Hattah North site is part of the Murray-Kulkyne Park and the Hattah-Kulkyne National Park, which are managed for environmental conservation.

The Hattah Lakes North Floodplain Management Project presents a unique opportunity to complement existing environmental works to deliver a landscape-scale approach to protecting and enhancing an area of national ecological and geomorphological significance. It will reconnect aquatic and terrestrial ecosystems by restoring hydrological function across the floodplain and, in doing so, provide the opportunity to improve the condition of biodiverse habitat for a range of species of state and national significance. This will benefit the broader Hattah Lakes floodplain and connecting ecosystems within the mid Murray region more generally.

Hattah Lakes features wetland habitats that under a more natural water regime were regularly inundated and provided reliable aquatic habitat and refuge during regional droughts. While the site is not within a weir pool, the general impact of river regulation has been to reduce peak flows, change the seasonality of flows and increase minimum flows. The condition of ecological values has declined in response to altered flow regimes. Aquatic habitat is available much less frequently and for shorter periods than under natural unregulated conditions. This decline has been exacerbated by drought and the lakes are less able to provide refuge during extended dry periods and less able to support local populations of aquatic fauna.

Through the construction of two primary regulating structures, supported by supplementary works and track raising[1], this project will enable significantly larger inundation events to the northern Hattah Lakes floodplain. The project provides inundation of up to 1,130 ha of water-dependent habitats including red gum and black box woodlands.

[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.

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 Basin Plan.

The Hattah Lakes North Floodplain Management Project will complement existing environmental infrastructure constructed under The Living Murray program(TLM) by significantly enhancing and extending environmental outcomes across the higher parts of the floodplain (to the north). The project will also provide the flexibility to better manage the frequency and duration of inundation across the whole of the Hattah floodplain system and tailor watering to ecological cues and requirements.

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 Hattah Lakes North project such as 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 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 across the region.

The Hattah Lakes North 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 (DEPI), Parks Victoria and Goulburn-Murray Water (G-MW), 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, 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 total $8,811,408 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	*Aboriginal Heritage Act 2006* (Vic)
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	*Environmental Effects Act 1978* (Vic)
EMP	Environmental Management Plan
EPBC Act 1999	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EVC	Ecological Vegetation Class
EWMP	Environmental Works and Measures Program
FERC	Federal Energy Regulatory Commission
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)
PMBOK	Project Management Body of Knowledge
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
USBR	United States Bureau of Reclamation
VEAC	Victorian Environmental Assessment Council
VEWH	Victorian Environment Water Holder
VMIA	Victorian Managed Insurance Authority
WRP	Water Resource Plan
WTP	Willingness to Pay

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

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
H	Horizontal
mnths	Months
No.	Number
N/A	Not applicable
temp	Temperature
V	Vertical
VIC	Victoria
4WD	Four wheel drive

Units

cm/day	Centimetres per day
EC	Electrical conductivity
GL	Gigalitres
ha	Hectares
km	Kilometres

1. Introduction

1.1 Context

This Business Case for the Hattah Lakes North 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, which are listed below:

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

These sites will work in conjunction with proposed altered river operations and existing environmental infrastructure to deliver environmental outcomes set under the Murray-Darling Basin Plan (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 Site overview

The Hattah Lakes North site is part of the broader Hattah-Kulkyne floodplain, which is nationally recognised for its outstanding environmental values and is located on the western bank of the River Murray between Robinvale and Red Cliffs. The project area comprises the northern most part of the Hattah Lakes floodplain complex and covers 9,028 ha in area. The Hattah Lakes North site provides significant habitat for a suite of plant and animal species of conservation significance, both at a Victorian and national level.

The Hattah Lakes is one of six sites identified as an Icon Site under The Living Murray (TLM) initiative. The proposed works build on the newly constructed works funded through TLM's Environmental Works and Measures Program (EWMP).

Hattah Lakes holds great significance to the local Indigenous community. Aboriginal occupation at the lakes dates back thousands of years and was sustained by the rich productivity of the lakes, which would have provided an abundant and reliable source of food and water for Aboriginal populations (SKM 2007). Many sites of cultural significance have been recorded at Hattah Lakes, including scarred trees, shell middens and burial sites.

The Hattah Lakes are a popular destination for tourists, attracting more than 70,000 visitors annually (DSE, 2003). Common activities include camping, bushwalking, bird watching and when lakes hold water, swimming, kayaking and canoeing.

1.3 Land tenure

The site is part of the Hattah-Kulkyne National Park and adjoining Murray-Kulkyne Park, both of which are managed for environmental conservation outcomes by Parks Victoria.

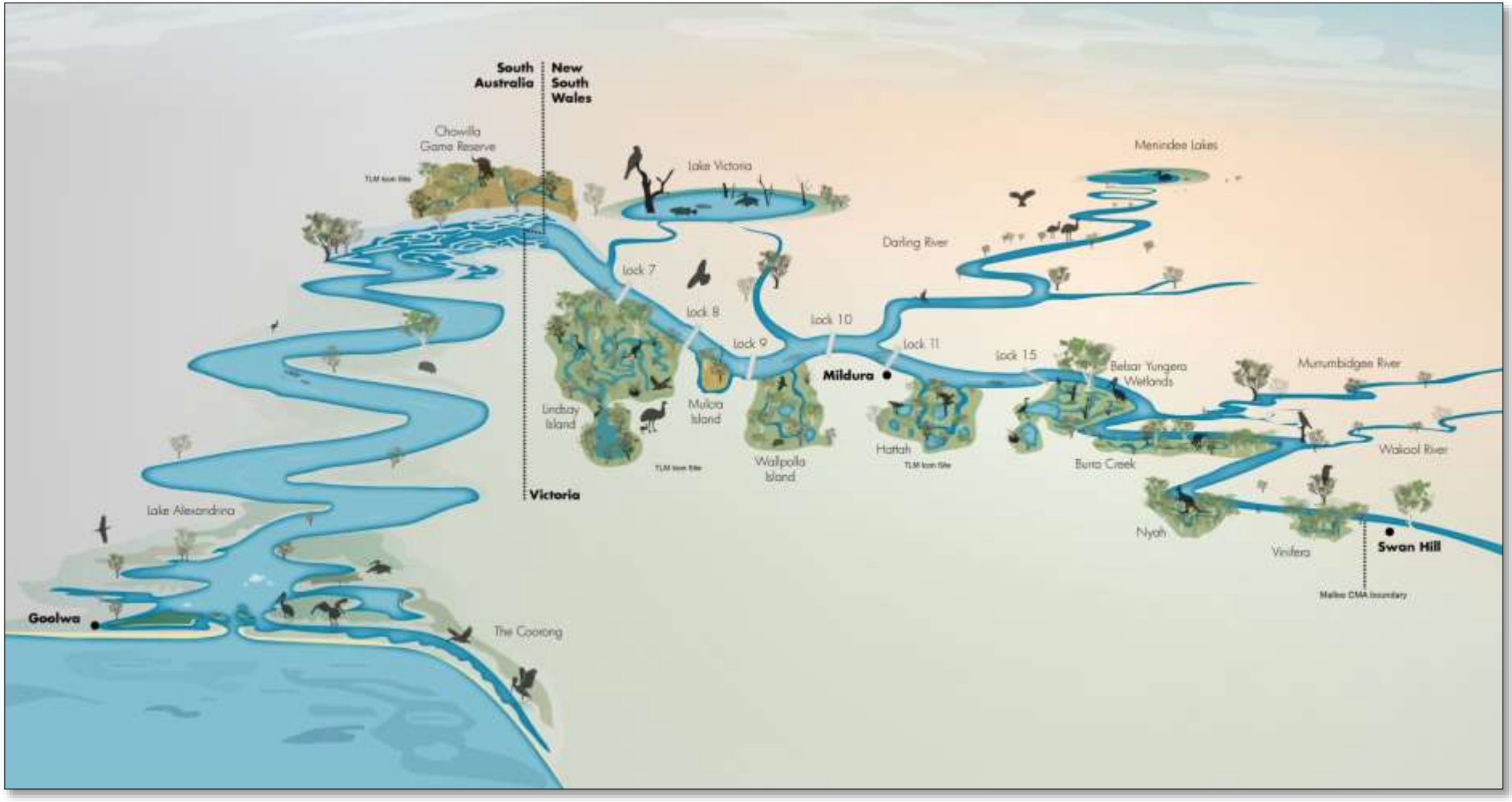


Figure 1-1. Conceptual diagram showing the distribution of sites across the Mallee CMA region and the longitudinal connection to the lower Murray region.

Proposed supply measure sites include Vinifera, Nyah, Burra Creek, Belsar-Yungera, Hattah Lakes (North), Wallpolla, Lindsay Island. The Living Murray Environmental Works and Measures sites include Hattah, Mulcra Island, Chowilla Game Reserve, and parts of Lindsay Island (diagram is not to scale)

1.4 The proposal

Hattah Lakes features wetland habitats that under a natural water regime were regularly inundated and provided reliable aquatic habitat and refuge during regional droughts. The condition of ecological values has declined in response to altered flow regimes and low flow conditions due to river regulation. Aquatic habitat is available much less frequently and for shorter periods than under natural conditions.

The Hattah Lakes North Floodplain Management Project consists of the construction of two regulators, a causeway across and existing track and 1.7 kilometres of levees on track alignment (Figure 1-2). This project, which builds on infrastructure funded under the TLM initiative, will facilitate significantly larger inundation events to the northern Hattah floodplain and therefore deliver extended ecological benefits beyond those currently achievable. Notably, this business case provides for a greater extent of watering than is possible through existing TLM works and better management of the frequency and duration of inundation across the whole of the Hattah floodplain system. The project provides inundation of up to 1,130 ha of inundation-dependent habitats (GHD, 2012b, Ecological Associates, 2014, GHD, 2013).

This project presents a unique opportunity to reverse the decline in ecological condition of the project site and to improve the condition of biodiverse habitat for a range of species of state and national significance. This will also benefit the broader Hattah Lakes floodplain and connecting ecosystems within the mid Murray region more generally.

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

1.5 Project development

The feasibility study and business case for the proposed Hattah Lakes North Floodplain Management Project have 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 and Goulburn-Murray Water (G-MW), 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 lakes and floodplain.

1.6 Project stakeholders

The Mallee CMA has worked with key stakeholders and interested community groups to develop the concept for the Hattah North project over an extended period of time from 2012 to 2014. Consultation has been undertaken with Aboriginal stakeholder groups, land managers, key partner agencies, and targeted community groups. The project has high visibility among adjacent landholders/managers, along with Aboriginal stakeholders and other interested parties. To ensure the advice and concerns of those involved have been considered and responded to accordingly a detailed Communication and Engagement Strategy has been developed and implemented for this project. 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 for the Hattah Lakes North Floodplain project and ensuring it will continue to be a successful project.

Above: **Lake Mournpall (2009)** Below: **Lake Mournpall after environmental watering (2010 Photo Tom Klein)**

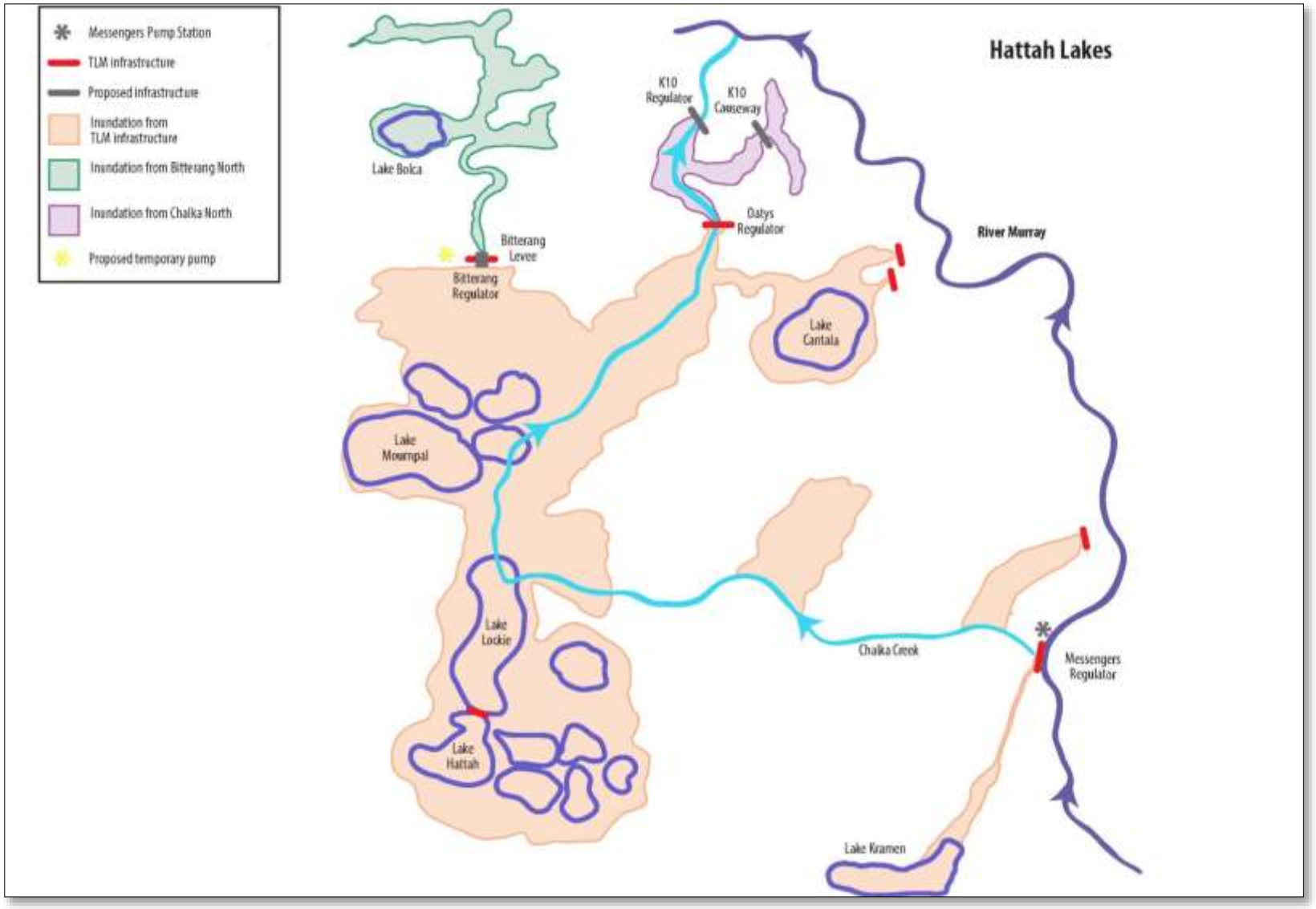


Figure 1-2. Spatial representation of planned works and inundation at the Hattah Lakes North site. Diagram is not to scale

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 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
- 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.

Hattah Lakes provides important habitat for water birds (2014)

3. Project Details (Section 4.1)

3.1 Description of proposed measure, including locality map

The Hattah Lakes North Floodplain Management Project is a proposed supply measure project located on the River Murray floodplain, 60 km south-east of Mildura in north-western 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.

The project will build on previous TLM funded works, and extend the area that can be inundated to include significant habitats in the northern part of the floodplain. This will allow for more flexible management of water during high flow events by allowing water to flow freely to the north of the park and enable the delivery of environmental water to a wider range of water-dependent vegetation and habitat types.

The proposed supply measure works at Hattah Lakes North comprise the construction of two regulators, a causeway across an existing track and 1.7 kilometres of levees on track alignment to inundate 1,130 ha (Figure 3-2). The proposed works are within the Hattah-Kulkyne National Park and adjoin Murray-Kulkyne Park. These areas are referred to as Chalka Creek North and Bitterang North (including the Lake Boolca area) (see Figure 1-2), and described further in Section 3.2.

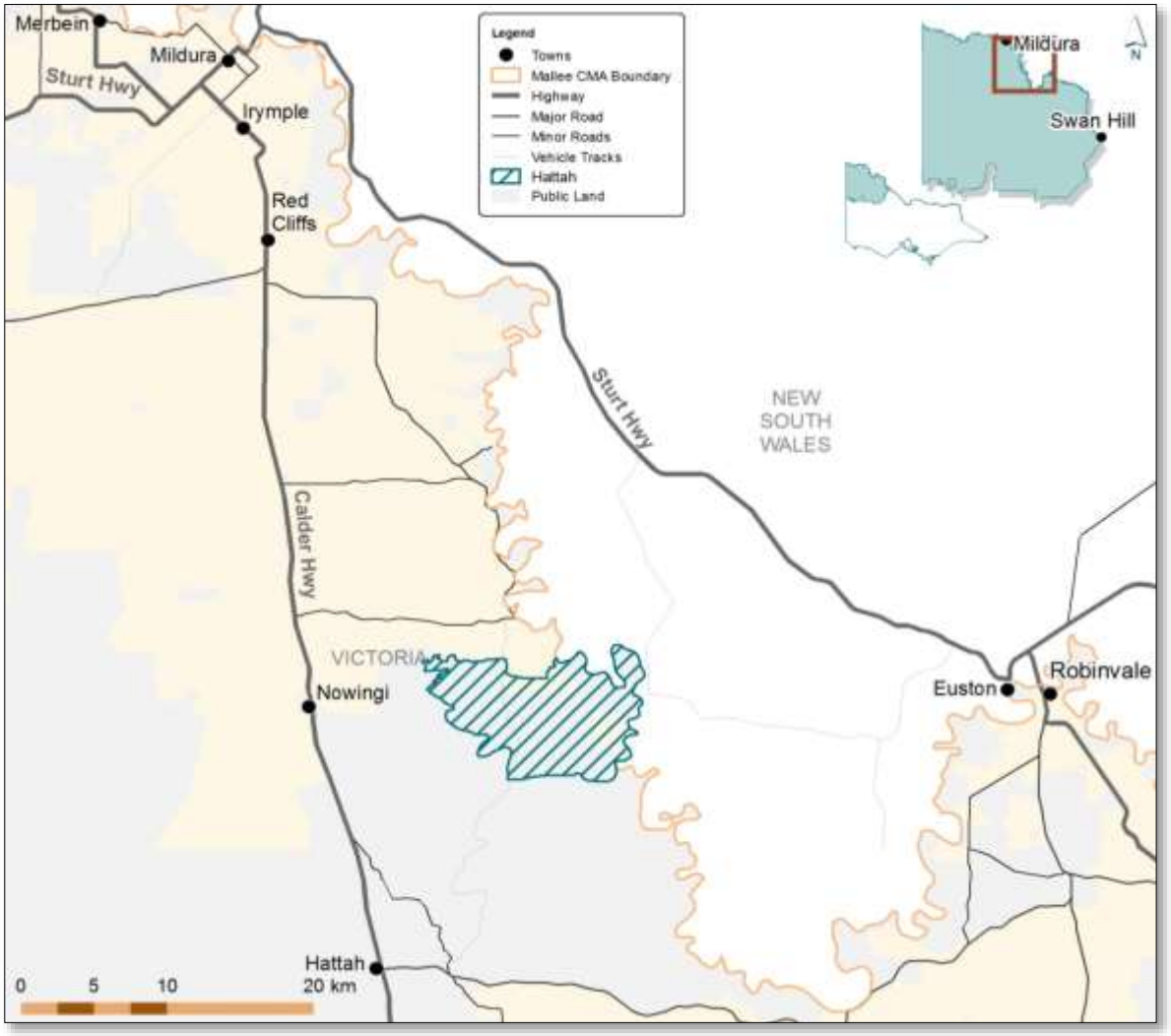


Figure 3-1. Location of the Hattah Lakes North Floodplain Management Project

3.2 Environmental works and measures at point locations

Existing TLM works at Hattah Lakes have been designed to operate to extend the benefit of natural flows or, in their absence, provide inundation through use of a permanent pumping station located at the southern end of Chalka Creek. These works are able to replicate inundation extents of floods up to 90,000 ML/d in the central lakes area and in excess of 150,000 ML/d at Lake Kramen. A detailed description of the existing infrastructure and its operation is provided in Section 8.

The proposed Hattah Lakes North works have been designed to ensure compatibility with the existing Hattah Lakes TLM infrastructure. Operation of the proposed works is dependent on the operation of the existing TLM infrastructure, with new works proposed for two areas: Chalka Creek North and Bitterang North.

For Chalka Creek North, it is proposed to employ the K10 regulator and K10 River Track causeway to enable inundation of 420 ha (Figure 3-2). At Bitterang North, the Bitterang Regulator will allow natural and managed floods to flow north from Lake Bitterang, inundating up to 300 ha via gravity and a further 410 ha via the use of temporary pumps to pump water over the Bitterang Levee (Figure 3-2). The Bitterang Levee, a TLM program construction, currently blocks this flow path. Figure 3-3 illustrates the proposed inundation according to land tenure. It should be noted regulators on the K10 River Track Causeway provide the ability to control inundation of the private land on the eastern side of the map (approximately 75 ha at Kulkyne Station). Inundation of private land at the northern end of the map (approximately 37 ha of land under a conservation covenant) can be managed by altering the duration of pumping over the Bitterang Levee.

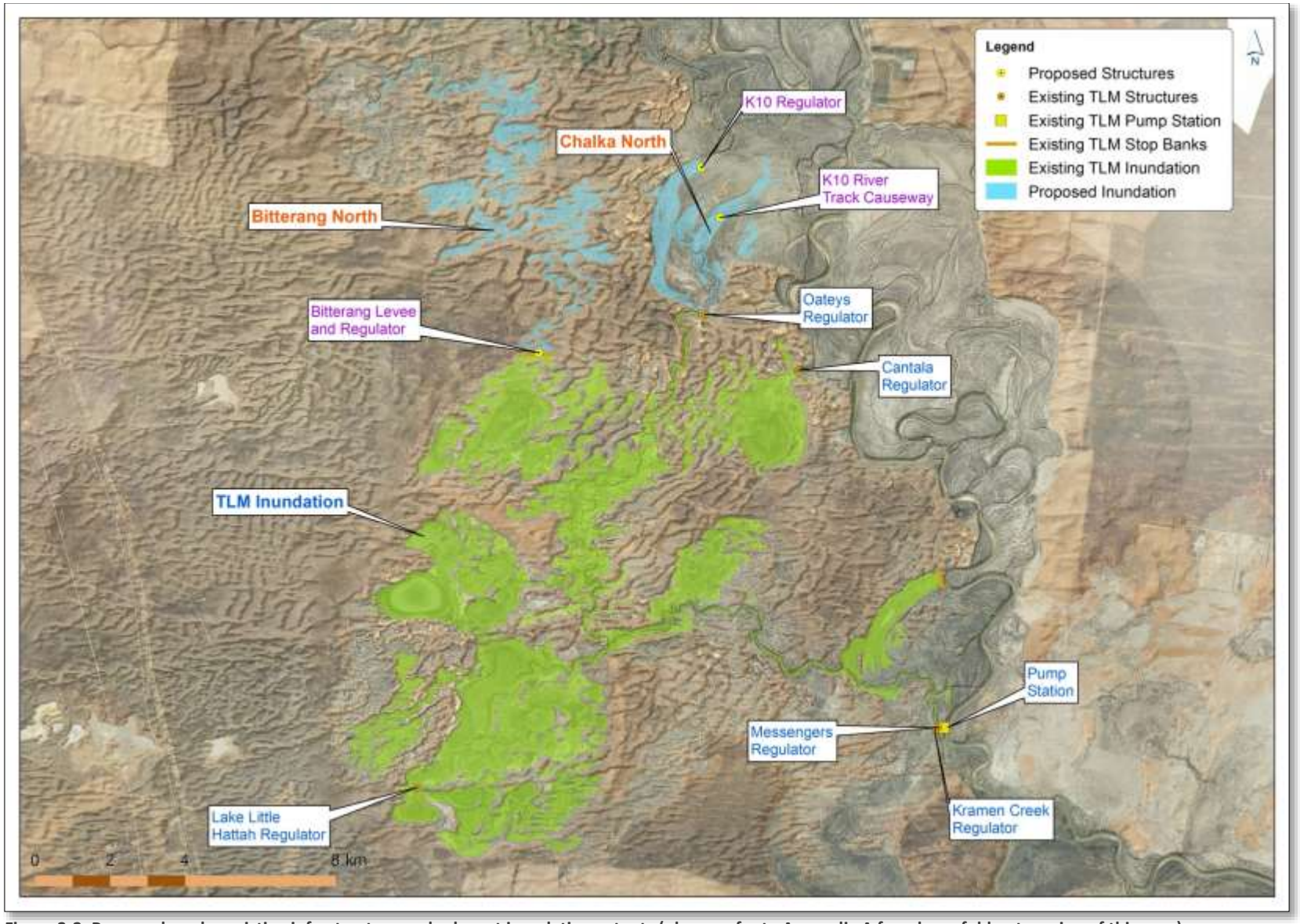


Figure 3-2. Proposed works, existing infrastructure and relevant inundation extents (please refer to Appendix A for a large fold out version of this map)

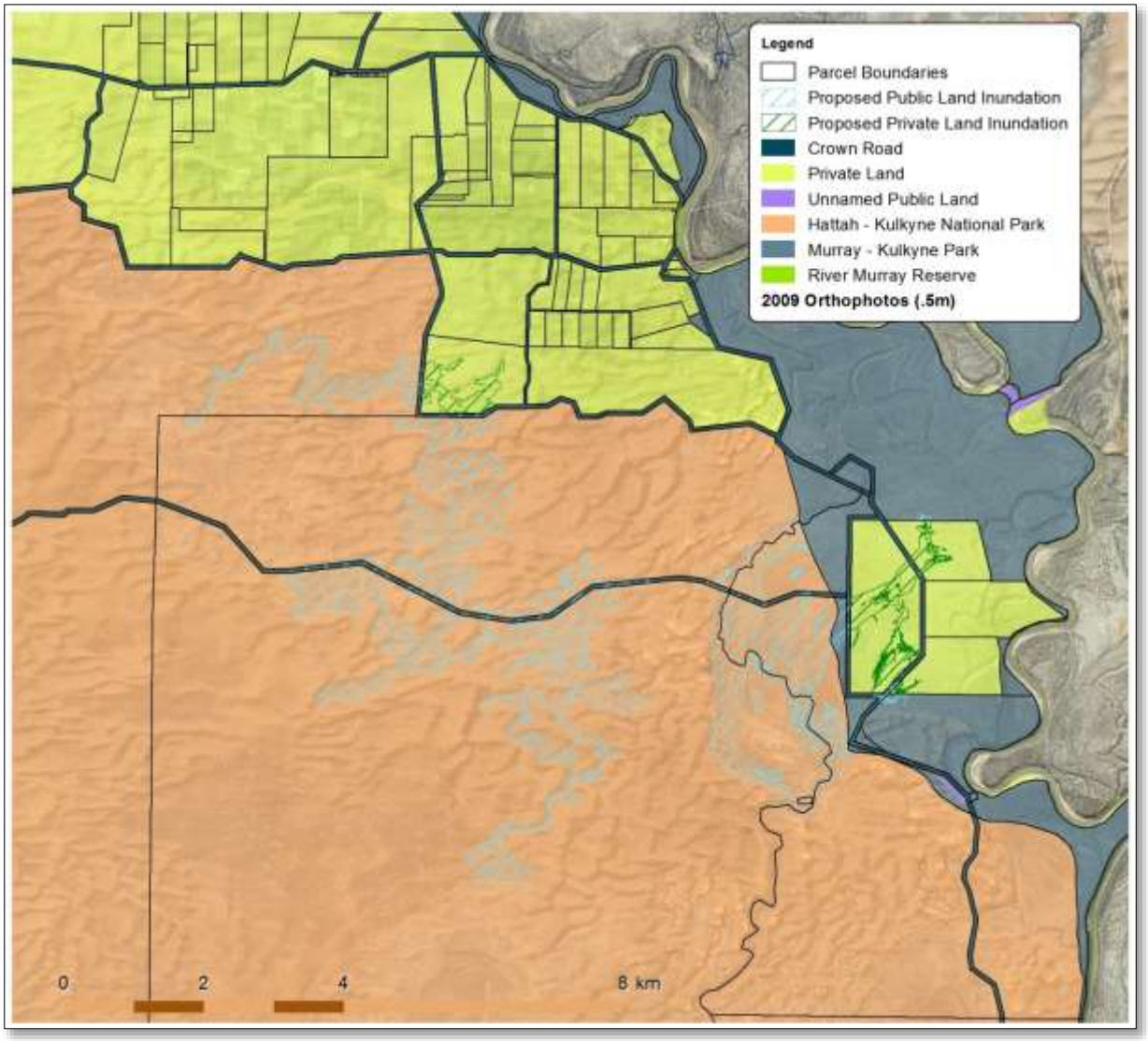


Figure 3-3. Land tenure and extent of inundation

Figure 3-3 shows that the proposed works inundate a small area (112 ha) of private land when operated to achieve the maximum inundation extent. Two landowners are affected however the flooding can be avoided by operating the works at less than maximum design level.

Due to the early stage of project development, it is not yet appropriate to have established flood agreements with the relevant private landholders. This will be resolved in the detailed design stage and provision has been made in the overall project costs to allow this. Preliminary discussions have been held with affected landholders who have generally been supportive of the project. Formalised flooding agreements with the affected landholders however is not a critical factor to the feasibility of the project for the reasons above.

Chalka Creek North

Chalka Creek North (referred to in design reports as Area 1) involves the construction of a primary regulator structure on Chalka Creek North (K10 Regulator) and an ancillary structure (the K10 River Track Causeway), which will facilitate watering of the north-eastern section of the floodplain to a maximum inundation level of 43.5 m AHD. These works will enable inundation of 420 ha of the north-eastern section of the floodplain closest to the River Murray, achieving inundation levels equivalent to greater than 120,000 ML/d River Murray flow. The majority of red gum which can be influenced using the proposed works occurs within the Chalka Creek

North area. Access into and out of the National Park will be maintained by raised tracks and connectivity between adjacent areas will be maintained through culvert works.

The Chalka Creek North structures will be operated in conjunction with TLM works and in response to natural inundation events. As river levels rise and water enters the floodplain, the structures will remain open and then be closed as needed to meet desirable inundation duration when the floodplain begins to drain. The water will be released back to the River Murray via Chalka Creek North once inundation requirements have been met.

Bitterang North

Bitterang North (referred to in design reports as Area 2) works involve construction of a regulator in the existing Bitterang levee to allow natural or managed inundation to pass the levee and inundate the north-western section of the floodplain to a level of 45.0 m AHD, via gravity. This will enable inundation of 300 ha of the floodplain area, as far as Lake Boolca (but will not fill the lake). A further option has also been designed where temporary pumps may be used to pump water over the levee, providing additional head on the northern embankment, resulting in inundation of a further 410 ha (to a level of 45.11 m AHD). This option (described as Option 2b in design reports) enables inundation of extensive stands of black box vegetation to the north-west of Lake Boolca. The works will inundate areas that would be flooded during natural flows of greater than 140,000 ML/d River Murray flow (at Euston).

The Bitterang levee was constructed as part of TLM works to retain environmental water within Lake Bitterang and other lakes downstream. The Bitterang Regulator will enable water to flow into Lake Boolca, as well as retaining water to the north of the Bitterang Levee, when required, to meet the ecological objectives set for the Hattah Lakes North project (see Section 5). During natural floods, the regulator will be open to allow unobstructed flows into Lake Boolca.

The proposed Area 1 and 2 works are listed in Tables 3-1 and 3-2 respectively and areas of inundation are shown in Figure 3-2. The structures will be operated in response to the seasonal flow in the River Murray and ecological cues in order to meet environmental watering targets.

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 Hattah Lakes North Floodplain Management Project is $8,811,408. Further detail on costs is provided in Section 14.

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.

Table 3-3 outlines a high-level program schedule for the project. 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.

Table 3-1. Area 1 Chalka North works (GHD, 2014a)

Works	Description
K10 Regulator	New regulator and track raising[2] on Chalka Creek North (on existing track at Raak crossing) that controls movement of water into the north-eastern section of the Hattah Floodplain. K10 Regulator comprises 3 No. bays with 2000 mm wide x 3400 mm high hydraulically actuated dual leaf combination gates. K10 track raising of 680 m in length across the creek. A small additional section of raised track (350 m) to be positioned upstream of the regulator structure to prevent a breakout occurring to the north.
K10 River Track Causeway	Track raising and culvert works on the existing River Track to maintain access into and out of the Hattah-Kulkyne National Park when the Chalka North pool is in operation (will include regulators to enable free passage of water when not in operation). River Track structure comprises 3 No. 1800 wide x 1200 high box culverts with penstock gates. River Track raising of 710 m in length across the creek.

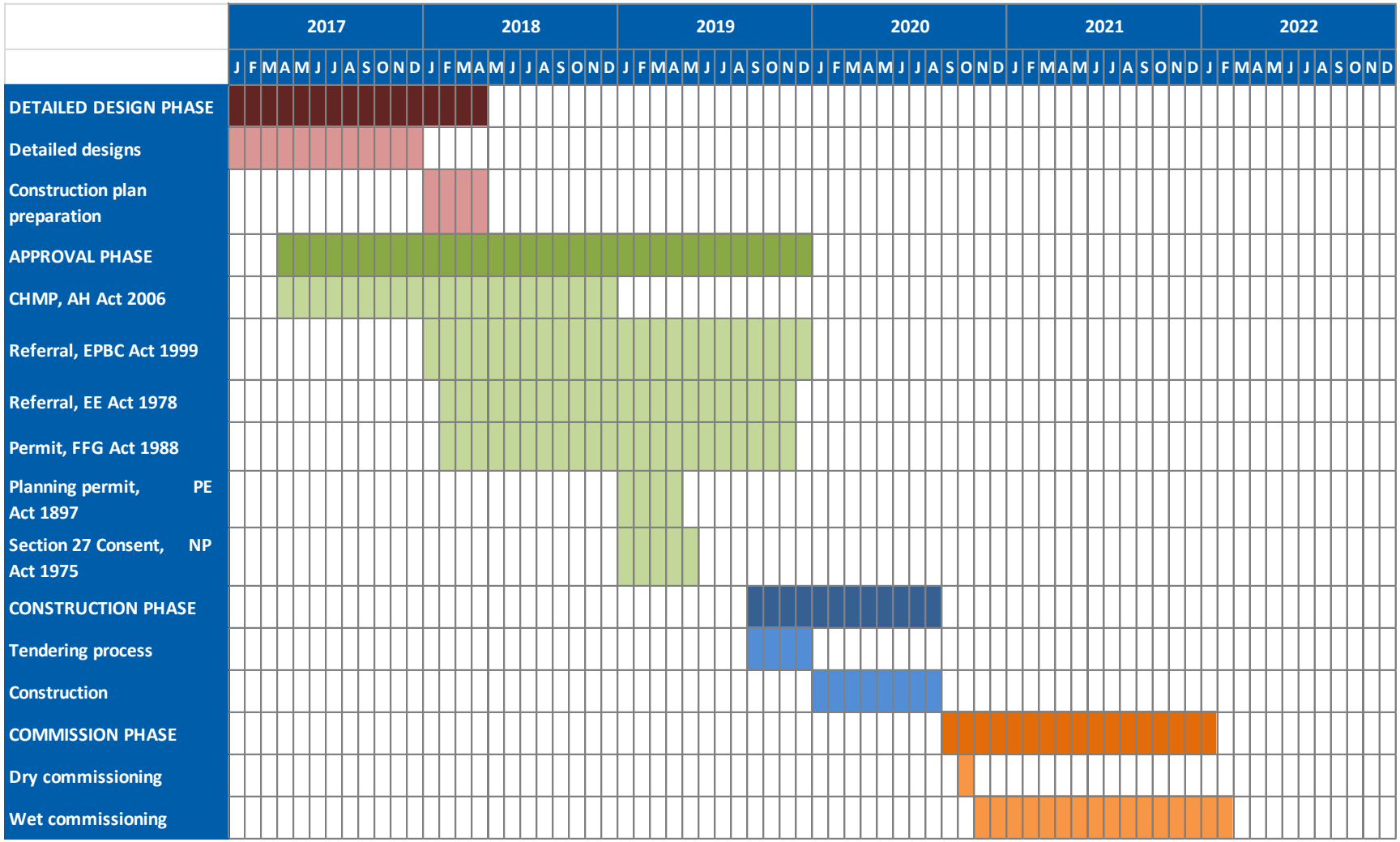
Table 3-2. Area 2 Bitterang North works (GHD, 2014a)

Works	Description
Bitterang Regulator	New regulator installation and widening of the existing (TLM) Bitterang levee to allow delivery of environmental water to the Lake Boolca area. Regulator will comprise 6 No. 1200 mm wide x 900 mm high box culverts with mechanically actuated penstock gates. Existing levee will be widened along a length of 570 m.

[2] '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.

The Messengers environmental regulator, constructed under The Living Murray program during 2012-13

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 Ecological values

The Hattah floodplain lies within the Hattah-Kulkyne National Park and adjoining Murray-Kulkyne Park, designated under the *National Parks Act 1975*, Victoria, and supports several ecological communities and fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) including winged peppercress (*Lepidium monoplocoides*), yellow swainson-pea (*Swainsona pyrophila*), Murray cod (*Maccullochella peelii*), Malleefowl (*Leipoa ocellata*), regent parrot (*Polytelis anthopeplus monarchoides*) and Mallee emu wren (*Stripiturus mallee*). Through TLM, Hattah Lakes was identified as one of six Icon Sites within the Murray-Darling Basin and the site is also listed as a wetland of national significance in the Directory of Important Wetlands in Australia (Environment Australia, 2001).

The Hattah site is an important biodiversity corridor allowing movement of biota to the broader Murray-Sunset National Park. This linkage enables movement and dispersal of biota between floodplain and terrestrial bioregions. Fauna that regularly use the corridor include regent parrot and Major Mitchell's Cockatoo (*Lopocroa leadbeateri*). These birds feed in mallee vegetation and nest in hollow-bearing trees on the floodplain.

Fauna surveys conducted at eight locations within the Hattah Lakes North site in November 2013 identified 129 native fauna species (GHD 2014b). Observations included 107 native bird species, three native amphibian species, five native and five exotic terrestrial mammal species, four bat species and ten native reptile species. Significant and listed species recorded during these surveys included a total of 50 records of the EPBC Act-listed regent parrot, a total of seven bird species listed as threatened under the *Flora and Fauna Guarantee Act 1988* (FFG) and nine species of bird and one reptile listed under the DEPI Advisory List of Threatened Vertebrate Fauna in Victoria 2013. Significant and listed species recorded during the Hattah Lakes North surveys are provided in Appendix B.

Many mammals, reptiles and birds, including fat-tailed dunnart, bats, carpet python and bush birds, live in both the floodplain and terrestrial landscapes. The hollow bearing trees and open grassland within Hattah Lakes North provide valuable complementary habitat components to several vertebrate species living within the surrounding mallee (Ecological Associates, 2014).

The bird fauna of Hattah North comprises 15 waterbirds species associated with the floodplain and 92 bush birds species associated with the wetlands and adjacent mallee habitat (GHD 2014b).

The interface of Mallee and floodplain habitat also supports a range of other verbertate fauna including reptiles, frogs and bats. Five frog species and seven bat species have been reported at Hattah Lakes, as well as 23 reptile species including four species of conservation significance (Ecological Associates, 2014).

The bats roost in black box trees where they find shelter in hollows and crevices. Their diet is comprised almost entirely of insects derived from the nearby mallee vegetation. When flooded, the wetlands provide an abundant source of prey.

Nine native fish species are expected to regularly occur in Hattah Lakes and to colonise the Hattah North area when it floods. Small fish species that inhabit localised riparian and wetland habitats include the FFG-listed Murray-Darling rainbowfish (*Melanotaenia fluviatilis*), flathead gudgeon (*Philypnodon grandiceps*) and Australian smelt (*Retropinna semoni*)

Sand goanna (*Varanus gouldii*), Hattah Lakes (2012)

4.2 Vegetation classes

Of the 169 indigenous flora species recorded during a survey of Hattah Lakes North in November 2013 (Australian Ecosystems, 2013), 20 rare or threatened flora were detected, including two species listed under the *Flora and Fauna Guarantee Act 1988* – the endangered woolly scurf-pea (*Cullen pallidum*) and buloke (*Allocasuarina luehmannii*). Other rare or threatened indigenous flora species were recorded as scattered or isolated individuals. The most frequently observed included the rare Wimmera woodruff (*Asperula wimmerana*), spreading nut-heads (*Sphaeromorphaea australis*) and branching groundsel (*Senecio cunninghamii var. cunninghamii*) which was common adjacent to the creek lines and waterways. Several poorly known species were also recorded across the study area. These included plains joyweed (*Alternanthera* sp.), goat head (*Malacocera tricormis*), tangled copperburr (*Sclerolaena divaricate*) and desert spinach (*Tetragonia eremaea s.s*).

Ecological vegetation classes

The vegetation communities of Hattah Lakes North are distributed across the floodplain according to hydrological conditions, soils type 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 (DSE, 2014).

A total of 19 EVCs are present at the Hattah Lakes North site (Figure 4-1). Of the 19 EVCs, 12 are inundation dependent, of which seven are considered depleted in the Robinvale Plains bioregion. The EVCs are:

Inundation dependent EVCs

- 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
- Riverine Chenopod Woodland
- Riverine Grassy Woodland
- Shallow Freshwater Marsh
- Shrubby Riverine Woodland

Not Inundation dependent EVCs

- Semi-arid Chenopod Woodland
- Semi-arid Woodland
- Woorinen Mallee
- Woorinen Sands Mallee
- Loamy Sands Mallee
- Chenopod Mallee
- Bare Rock/Ground

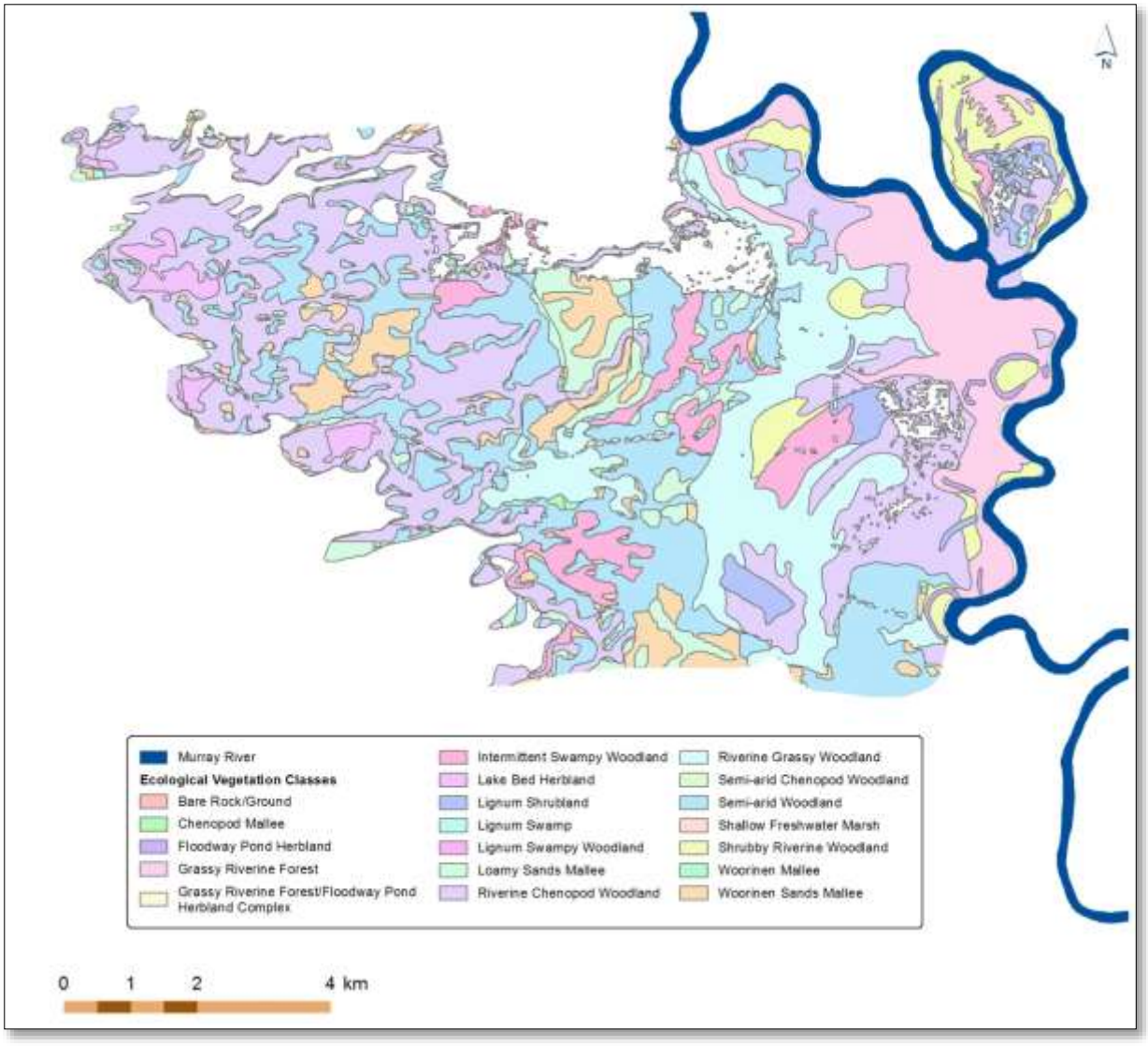


Figure 4-1. Ecological Vegetation Classes present at the Hattah Lakes North site.

Water regime classes

Water regime classes are a spatial classification of the floodplain into areas with common water regimes and ecological characteristics. Water regime classes provide the basis to establish objectives for the location, extent and condition of the floodplain ecosystem, and therefore to set hydrological objectives.

Plant communities present at Hattah North 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 six water regime classes, (Figure 4-2), of which four are inundation dependant. Table 4-1 provides a brief description of the seven water regime classes at Hattah Lakes. A more detailed description of the characteristics of these water regime classes is provided in Appendix C.

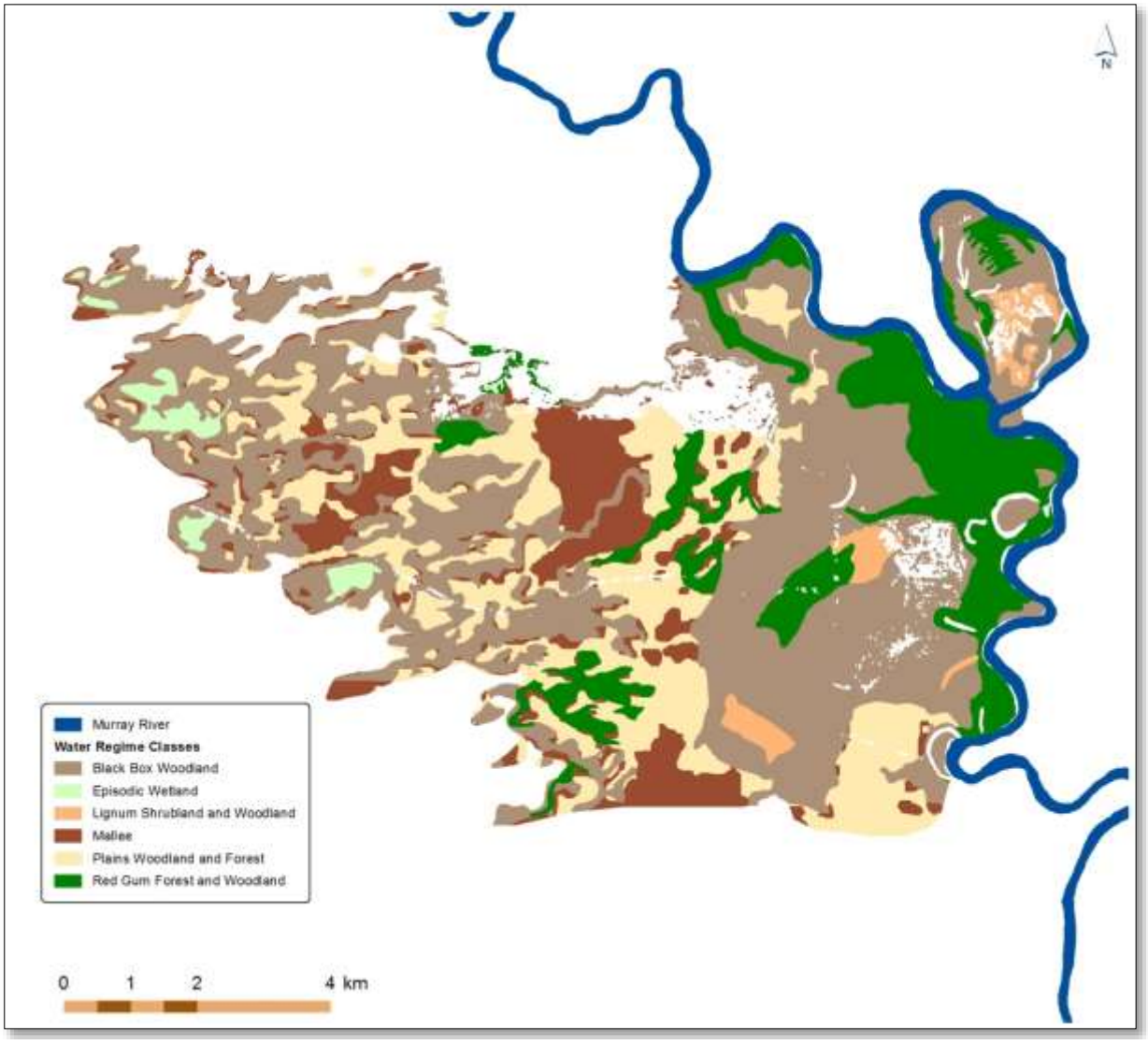


Figure 4-2. Hattah Lakes North Water Regime Classes

Table 4-1. Hattah Lakes North Water Regime Classes (Ecological Associates, 2014)

Water Regime Class	Area at Hattah North (ha)	Area to be watered within this project (ha)	Component Ecological Vegetation Classes
Red Gum Forest and Woodland	1,376	125	Intermittent Swampy Woodland Grassy Riverine Forest/Floodway Pond Herbland Complex Grassy Riverine Forest.
Black Box Woodland	4,113	883	Riverine Chenopod Woodland Riverine Grassy Woodland Shrubby Riverine Woodland.
Episodic Wetlands	125	33	Lake Bed Herbland.
Lignum Shrubland and Woodland	235	3	Lignum Shrubland Lignum Swamp Lignum Swampy Woodland.
Mallee[1]	1,271	30	Loamy Sands Mallee Chenopod Mallee Woorinen Mallee Woorinen Sands Mallee.
Plains Woodland and Forest[1]	1,908	31	Semi-arid Chenopod Woodland Semi-arid Woodland.
Unmapped EVCs[2]	NA	25	
Total	**9,028**	**1130**	

[1] Not inundation dependent

[2] There is a small area at Hattah Lakes where EVCs have not been mapped 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 die back is associated with increasing regulation of the River Murray and extended periods of drought. (Cunningham et al, 2011).

Water-dependent vegetation within the higher-level floodplain of Hattah Lakes North was in poor or declining condition prior to the extended drought period. Surveys conducted during the drought reported a further decline in tree health with more than half surveyed either dead or in very poor condition (Sluiter, 2007).

The Hattah Lakes North floodplain areas are more extensively water-deprived than the central Hattah lakes area. The woodlands around Lake Boolca are at a relatively high elevation and remote part of the floodplain that are seriously degraded.

In 2010, Cunningham et al (2011) found that 79% of the area covered by river red gum and black box communities in The Living Murray Icon Sites were 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).

TLM condition monitoring found the stressed condition of black box during this time corresponds with the extreme drought conditions between 1997 and 2009 (BOM 2014). Under these conditions lower than average rainfall leading up to and during tree surveys in 2008 (230 mm) and 2009 (279 mm) was recorded at the Nulkwyne-Kiamal weather station 20km south west of the Hattah Lakes (BOM 2014).

Exceptionally high rainfall in 2010 (506 mm) and 2011 (465 mm) (BOM, 2014, in Henderson et al, 2014) and associated flooding provided some relief to drought stressed plant communities.

TLM condition monitoring in 2012-13 found that river red gum condition has improved following higher than average rainfall and natural flooding in 2010–11 and 2011-12. Since then, low mortality rates and an increase in crown condition have been recorded, coupled with a substantial increase in germination. Crown condition scores from 2010–11 onwards exhibited a positive response to the floods, the number of trees in good condition increased from 27% in 2008–09 to 72% in 2011–12. At the same time, the number of trees in poor and moderate condition respectively decreased from 21% and 46% in 2008–09 to 1% and 10% in 2011–12 and 2% and 7% in 2012–13.

Black box condition improved in 2010–11 following above average rainfall and flooding evidenced by an increase in crown condition and zero mortality amongst sample trees between 2011–12 and 2012–13. Size-class distributions show there has been some recent establishment of black box seedlings. Where seedlings have established within black box woodland, this has been predominately at lower elevations that received flooding in 2010–11.

While the presence of seedlings and saplings may indicate a successful establishment 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. It is anticipated that follow up watering events will support successful recruitment.

Based on the response to environmental watering observed at Hattah Lakes, it is expected that the ecological condition of this site will improve when the water regime better matches its ecological requirements. Benefits of environmental watering are further detailed in Section 6.1

Red gums prior to environmental watering (above left; 2005) and after watering (above right, 2007). Photos Parks Victoria

4.4 Past management activities and actions

In 1960, the Hattah Lakes was reserved as Hattah Lakes National Park with the adjacent State forest added in 1980 to form Hattah-Kulkyne National Park. In line with the Mallee Parks Management Plan, the park is managed according to conservation and recreational values. Management activities include, but are not limited to, management of pest species, managing fire, preserving natural values and providing recreational opportunities.

To prevent catastrophic ecosystem collapse at Hattah, an emergency environmental watering program was initiated in 2004-05 as an immediate response to the site's poor condition. Over six years, environmental water was delivered to low lying wetlands and creeklines via portable pumps and contained with temporary earthen levees.

Cook et al (2010) concluded that without the allocation of environmental water many of the Hattah wetlands would have dried out completely or remained dry until a suitably large flooding event. The main benefits of watering these wetlands has been to create a drought refuge for the regions wetland birds, enabling them to survive in the area until the next natural flood and to increase the resilience of the wetland plant communities upon which they depend for food, shelter and breeding areas.

A peak in wetland bird diversity and abundance is often evident after a delivery of environmental water. Dry wetlands provide little attraction for waterbirds, and the addition of environmental water to a dry wetland will almost instantly attract waterbirds. As food resources such as water plants and aquatic invertebrates build up and habitat complexity increases the diversity and abundance of waterbirds can increase in parallel.

Between November 2005 and January 2010, during environmental watering events, a total of 51 wetland bird species were recorded at Hattah Lakes, including 12 rare and threatened wetland bird species; australasian shoveler (*Anas rhynchotis*), freckled duck (*Stictonetta naevosa*), blue-billed duck (*Oxyura australis*), musk duck (*Biziura lobata*), hardhead (*Aythya australis*), azure kingfisher (*Alcedo azurea*), common sandpiper (*Actitis hypoleucus*), glossy ibis (*Plegadis falcinellus*), royal spoonbill (*Platalea regia*), intermediate egret (*Ardea intermedia*), white-bellied sea-eagle (*Haliaeetus leucogaster*) and whiskered tern (Chlidonias hybridus) (Cook et al, 2010).

Environmental watering has also been shown to have a positive effect on frog populations at Hattah. Surveys showed watering in 2010 provided aquatic habitat and resources to support the presence of five frog species and breeding of three species (Robertson, 2011).

Provision of a long-term approach to water management at Hattah Lakes was investigated as a TLM initiative. Permanent infrastructure was developed to reinstate an appropriate water regime throughout the central lakes and Chalka Creek. However, due to funding constraints the full suite of works was not able to be implemented. Using the available funding the TLM initiative has installed five environmental regulators, three stop banks and a permanent pump station in 2013.

The installation of these works allows for the inundation in excess of 6000 ha of watercourse, wetland and floodplain habitat. The large inundation events can be achieved by retaining natural River Murray inflows or using the permanent pump station, when conditions permit.

The proposed works build upon early investigations and construction to provide infrastructure capable of increasing the area of inundation to include more valuable inundation dependent floodplain.

Black cormorant nesting at Lake Bitterang, following environmental watering (2014)

4.5 Other values

The Hattah Lakes Floodplain Complex is also recognised for its many social and cultural values, residing within the Hattah–Kulkyne National Park and bordering the Murray-Kulkyne Park area. These parks are managed primarily for ecosystem conservation and appropriate recreation.

Cultural and historical values

The Hattah Lakes system has been shown to form part of a highly sensitive region for Aboriginal cultural heritage values and contains considerable evidence for past Aboriginal occupation (Bell, 2013). There are a large number of Aboriginal cultural heritage sites and places in the Hattah-Kulkyne National Park, including many scarred trees and burial sites near the central and into the northern lakes system. Shell middens also occur around geomorphologically diverse palaeo lakes as well as around the margins of current lakes and streams throughout the park (VEAC, 2008). The freshwater lakes and wetlands were focal points for trade and cultural exchanges amongst the region's traditional owners (Mallee CMA, 2013).

The Hattah Lakes area is also known to have significant historical values. The northern end of the Hattah Lakes system, which includes the Hattah Lakes North project site, is understood to have originally formed part of the Gayfield/Kulkyne pastoral run, which was gazetted in 1849 with an estimated area of 64,000 acres (Bell, 2013a). This area was leased by a number of people until the lease was forfeited in 1883 (Ibid); however, during the 1860s new legislation (Land Acts) resulted in some of the original pastoral lease grants in the region becoming freehold blocks, which led to the establishment of Kulkyne Station. This area of freehold land remains today and lies adjacent to the Hattah-Kulkyne National Park and the Hattah Lakes North project site.

Social and recreational values

The Hattah–Kulkyne National Park and the Murray-Kulkyne Park support a range of recreational activities, receiving more than 70,000 visitors per year. Campgrounds at the central lakes, including Lake Mournpall and Lake Hattah, provide basic facilities such as toilets and picnic tables. Visitors to the campgrounds are in the order of 30,000 annually (DSE, 2003). Lake Lockie, in particular, is highly valued for walking, hiking, cycling, sightseeing and picnicking. Some recreational fishing also occurs at Lake Mournpall. The park offers beautiful natural settings and remoteness, and is very popular with birdwatchers as the diverse range of habitats and

access to water host many bird species (VEAC, 2008). Canoeing, bike riding and walking are also popular activities within the park. Canoeing is particularly good when the park is inundated, providing recreational access to the northern parts of the floodplain (Parks Victoria, 2014).

Living culturally scarred tree at Hattah Lakes (2009)

5. Ecological objectives and targets (Section 4.3)

Ecological objectives have been developed for the Hattah Lakes North site, drawing on a range of approaches and recommended lines of enquiry including:

- 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 and GHD, 2014b)
- site visits
- 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.

The ecological objectives for Hattah Lakes North 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 objectives

There are two distinct water-dependent habitat areas that will be targeted by works at Hattah Lakes North: Chalka Creek North and Bitterang North.

The overarching objective of water management at Chalka Creek North is:

"*to **protect and restore** the productivity and integrity of floodplain vegetation and its capacity to support floodplain fauna*" (Ecological Associates, 2014).

The overarching objective of water management in the Bitterang North area is:

"*to provide important flood-dependent habitat components for terrestrial vertebrate fauna when the lakes are dry and to retain the capacity to provide a **productive** and **diverse** wetland habitat when the lakes are inundated*" (Ecological Associates, 2014).

These objectives are also supported by recommendations arising from the *Investigation into Red Gum Forests* conducted by the Victorian Environmental Assessment Council (VEAC, 2008). The review recommended that an appropriate environmental water regime be established for the Hattah-Kulkyne National Park and that small additions to the Murray-Kulkyne Park be made.

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 Hattah Lakes North. The objectives are consistent with those of the Hattah Lakes Icon Site Environmental Water Management Plan (MDBA, 2012b) and will contribute to achieving the environmental objectives set by the Basin Plan. The Basin Plan objectives have been summarised as follows:

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.

The contribution of the proposed project's specific objectives to Basin Plan objectives is demonstrated in Table 5-1

Table 5-1. Specific objectives and targets established for Hattah Lakes North (Ecological Associates 2014) and the relevant water regime classes (this table also shows the contribution of each specific objective to the Basin Plan objectives)

Specific objective	Ecological Targets	Water regime class	Associated Basin Plan Objective
Protect and restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, lace monitor and bats	Total bat abundance to increase by 25% from 2015 levels by 2030.	Red Gum Woodland, Black Box Woodland,	1, 2, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14.
Provide occasional breeding habitat for waterbirds	Any species of waterfowl, crake, rail, waterhen or coot to breed in at least six seasons between 2025 and 2035.	Red Gum Woodland, Episodic Wetlands	1, 2, 4, 6, 7, 8, 9, 10, 11, 12.
Maintain the health and age structure of red gum and black box trees	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.	Red Gum Woodland, Black Box Woodland	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14.
Maintain a plant community of drought-tolerant wetland species in infrequently inundated areas	The drought-tolerant wetland species *Cyperus gymnocaulos* and *Eleocharis acuta* are to be present in vegetative form in 75% of wetlands following any filling event.	Episodic Wetlands	1, 2, 3, 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 Hattah Lakes North for the period 2025 to 2035 is double 2015 to 2020 levels.	Red Gum Woodland, Black Box Woodland	2,7.

Ecological targets have also been developed to measure progress towards the specific ecological objectives. 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.

5.3 Environmental water requirements

The proposed works will provide flexibility to deliver a wide range of environmental watering events to meet the ecological objectives described in Section 5.2.

The hydrological regime experienced by each water regime class has varied from natural due to river regulation and diversions. The environmental water requirements for each water regime class are described in detail in Section 9. Detailed ecological justification and the water requirements of each water regime class is provided in Appendix C.

Table 5-2 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)
- Basin Plan (2750) without the measure.

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

A detailed analysis of the frequency, extent and duration provided by the proposed measures, in comparison to the natural flow regime and under the Basin Plan without the measure, are provided in Section 8.

Pied cormorants nesting following environmental watering at Lake Bitterang (2014)

Table 5-2. Comparison of water regimes provided by natural, baseline, Basin Plan and the Hattah Lakes North measure. Natural, baseline, Basin Plan (Gippel, 2014)

Threshold (ML/d)	WRC	Scenario	Frequency Mean (/100 yrs)	Duration Median (days)	Event start date Median (day of year, 1 Jan = 1)	Prevalence yrs with event %
80,000	Red Gum Forest and Woodland	With Measure[1]	60	50	244	60
		Natural	50.9	55	252	46
		Baseline	17.5	40	258	15
		Basin Plan 2750 without measure	21.9	37	259	19
120,000	Black Box Woodland	With Measure[1]	25	30	244	25
		Natural	27.2	27	256	24
		Baseline	8.8	40	242	8
		Basin Plan 2750 without measure	9.6	41	237	8
140,000	Episodic Wetlands	With Measure[1]	15	30	244	15
		Natural	17.5	29	257	16
		Baseline	6.1	62	237	5
		Basin Plan 2750 without measure	7	37	236	6

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

6. Anticipated ecological benefits (Section 4.4.1)

6.1 Current condition and management

The creeks, wetland and floodplain systems of Hattah Lakes North support a variety of aquatic and terrestrial ecological communities (see Section 4). The condition of ecological values of Hattah Lakes North 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 integrity and productivity of floodplain habitats. Inundation promotes the germination of aquatic plants, which provide understorey habitat for a range of aquatic fauna species including fish, invertebrates and frogs (Ecological Associates, 2014; GHD 2013; Mallee CMA, 2013). Inundation also helps to maintain the health of woodlands that provide important habitat like nesting sites and hollows for regent parrot and carpet python (*Morelia spilota metcalfei*) (Mallee CMA, 2013; GHD 2013) and promotes the growth of trees and triggers flowering.

Increased rates of tree growth provide organic matter to the floodplain system, which promotes productivity and as floodwaters recede this material also enters the River Murray contributing to the energy requirements of the broader river system. Flowering attracts nectar-eating insects and birds and provides abundant insect prey for the nine species of bats and the insectivorous birds found at Hattah Lakes (Ecological Associates, 2014).

Delivery of environmental water to Hattah Lakes between 2005 - 2010 provided a drought refuge for the regions wetland birds, enabling them to survive in the area until the next natural flood. A total of 51 wetland bird species were recorded at Hattah Lakes during this time, including 12 rare and threatened wetland bird species. In the absence of environmental water delivery to Hattah Lakes the lake system would have dried out completely and dry wetlands provides little attraction for waterbirds (Cook et al, 2010).

The environmental watering was of considerable benefit to local frog populations. Surveys showed watering in 2010 provided aquatic habitat and resources to support the presence of five frog species and breeding of three species (Robertson, 2011).

Large scale inundation has occurred at Hattah Lakes since construction of the TLM works in 2013, contributing to the trend of increasing ecological condition since the end of the millennium drought (Henderson, 2014). The TLM works have been successful in delivering native fish outcomes, with recorded movement of larval fish into the lakes and the return of mature fish to the River Murray (I Ellis, 2014, pers comm).

These results provide a high level of confidence that the implementation of the proposed supply measure and its associated watering regime will provide the expected benefits.

This project provides a significant opportunity to improve and enhance the important ecological values of the northern and most water-deprived part of the Hattah floodplain system. The expected environmental outcomes at Hattah Lakes North will complement environmental improvement already being experienced in the central Hattah lakes areas following environmental watering under TLM.

Photo point monitoring at Chalka Creek, Hattah Lakes shows the ecological response to environmental watering (left: 2005; right: 2007 - Photos: Parks Victoria)

6.3 Proposed ecological benefits

The proposed supply measure will restore flooding and productivity to extensive areas of red gum woodland and black box woodland. It will improve quality and extent of habitat for a wide range of native species, including threatened species. In particular, colonial nesting waterbirds that rely on productive inundated red gum woodland and shallow wetlands to forage during breeding would be expected to benefit. The inundation will cause stimulation of seed bank leading to germination of aquatic and emergent plant species, resulting in greater diversity and abundance of wetland flora. This will in turn provide foraging and breeding habitats for wetland birds, fish and frogs.

Five ecological targets have been developed to provide some 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.

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

Water Regime Class	Strategy	Ecological benefit
Red Gum Woodland	Restore the inundation of red gum woodland	A long-term net benefit through the maintenance and enhancement in condition of river red gum communities Quality and extent of habitat for a wide range of native species, including threatened species, would be expected to result from improved flow regimes. In particular, colonial nesting waterbirds that rely on productive inundated Red Gum Woodland and shallow wetlands to forage during breeding would be expected to benefit.
Black box Woodland	Restore intermittent inundation events	A long-term net benefit through the maintenance and enhancement in condition of floodplain Black Box Woodland communities. The increased inundation regime would provide the appropriate conditions for black box recruitment within the area, maintaining a diverse age structure, including maturation and development of hollows, maintaining habitat in the long-term for native fauna species.
Episodic Wetland	Restore intermittent inundation events	Stimulation of seed bank upon inundation leads to germination of aquatic and emergent plant species, resulting in greater diversity and abundance of wetland flora during inundation and on recession of floodwaters. 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. Bank and channel edge macrophytes; flows convey seeds and propagules from water source into the wetland resulting in an increase in diversity and abundance of emergent species. Water quality may improve, wetland banks will be stabilised and habitats for fauna will be provided. In-channel macrophytes; flows convey seeds and propagules from water source into the wetland resulting in an increase in diversity and abundance of aquatic species. Water quality may also improve.

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 the Mallee CMA's 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.

These 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
- 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 for Hattah Lakes North has been prepared for the 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
- refining conceptual models and improving knowledge
- managing risk.

The Hattah Lakes North 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. Measures for each ecological objective of the supply measure for Hattah Lakes North are detailed in the accompanying technical report, (Ecological Associates 2014b - Appendix D – full report).

The environmental risks from implementing the proposed water regime are detailed in section 10 - Operational Risks. Monitoring data will identify emerging hazards and enable operational decisions to minimise risk.

This MER approach will be formalised once funding for this 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.

Regent parrots at Hattah Lakes (2012)

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 Hattah Lakes, 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 Hattah Lakes 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
- 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
- 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” (including TLM works) or “Basin Plan without works” scenario, but are included because the proposed works provide mitigation opportunities.

Table 7-5. Risk assessment - potential adverse ecological impacts without mitigation and residual risk rating with mitigation, adapted from Lloyd Environmental (2014)

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Adverse salinity impacts or water quality outcomes						
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 and optimize timing of releases via Chalka Creek. 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 (e.g. pump to Bitterang North). 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
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 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
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 Hattah Lakes 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	Moderate	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.	Low
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
Proliferation of pest plants	Pest plants may be promoted under certain water regimes, potentially impacting the health of all wetland and floodplain vegetation communities.	Certain	Severe	Very High	Time water manipulations to drown seedlings, minimise growth, germination and seed set. Time water manipulations to promote native	Low

	This, in turn, will impact on dependent fauna, including threatened species.				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.	
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						
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
Adverse impacts on ecological function and connectivity						
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
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 at Hattah Lakes, Parks Victoria and DEPI will respond as usual in such situations.	Moderate
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	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	Low

	flood recessions. This may result in the death of a portion of the native fish population.				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.	
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). 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 Hattah Lakes (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).

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
- 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.

Six 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.

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

Threat	Risk without mitigation	Residual Risk Rating	Additional considerations (Lloyd Environmental, 2014)	Guiding documents
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.	Hattah North Floodplain Management Project Operating Plan (Preliminary) Fish exit strategy.
Permanent removal or disturbance of flora and fauna habitat 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 removal or disturbance of flora and fauna habitat during construction	Moderate to Very High	Moderate		
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) Hattah North 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.	Hattah North Floodplain Management Project Operating Plan (Preliminary).
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).

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
- 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.

8. Current hydrology and proposed changes (Section 4.5.1)

8.1 River hydrology

The Hattah Lakes are located on the River Murray 69 km downstream from the Euston weir (Lock 15). The River Murray flows in this reach are influenced by the Murray, Edward-Wakool, Murrumbidgee and Goulburn tributaries and are typically highest from late winter to early summer.

The Hattah Lakes wetlands system comprises waterways, approximately 20 lakes and a large area of floodplain, which receive water from the River Murray via Chalka Creek (Ecological Associates, 2014).

Chalka Creek is a tributary of the River Murray, diverging at the southern end of the Hattah-Kulkyne National Park and re-joining in the north of the Park. The creek is ephemeral and comprises two main reaches, Chalka Creek South which traverses an east-west direction, flowing into the central and southern lakes area, and Chalka Creek north, a branch which is progressively engaged as the flow in Chalka Creek South increases, filling the northern lakes.

The creek and wetlands of the Chalka Creek north area would have experienced flow and inundation events to varying degrees in almost every year under natural conditions.

Naturally, River Murray flow events of 140,000 ML/d inundated the area north of Bitterang levee including Lake Boolca at a mean frequency of 1.7 events in 10 years. The period between successive 140,000 ML/d flow events had a median interval of 2.5 years (Gippel, 2014).

For comparative purposes throughout Section 8 the mean frequency and median interval of a 140,000 ML/d flow event will be discussed for a range of scenarios.

8.2 Current floodplain hydrology

The Hattah Lakes are located on a section of the Murray not influenced by the backwater effects of weir pools; however, upstream regulation of the River Murray and its tributaries has caused a reduction in peak flows and changes in seasonality (Figure 8-1).

In order to address the changes in the central and southern lakes area, works were developed under TLM. The TLM works at Hattah Lakes have been designed to operate to extend the benefit of natural flows or in their absence provide inundation through use of a permanent pumping station located at the southern end of Chalka Creek. These works are able to replicate inundation extents of floods up to 90,000 ML/d in the central lakes area and in excess of 150,000 ML/d at Lake Kramen.

The influence of these works stops at the Bitterang Levee and at Oatey's regulator. The hydrology of the floodplain to the north of these points is still subject to the full impact of river regulation.

Since TLM works, water enters the southern branch of Chalka Creek when flow in the River Murray exceeds 20,000 ML/d at Euston or with the operation of Messengers pump station. From Chalka Creek this flow moves to the central low-lying lakes in the following order (Ecological Associates, 2014):

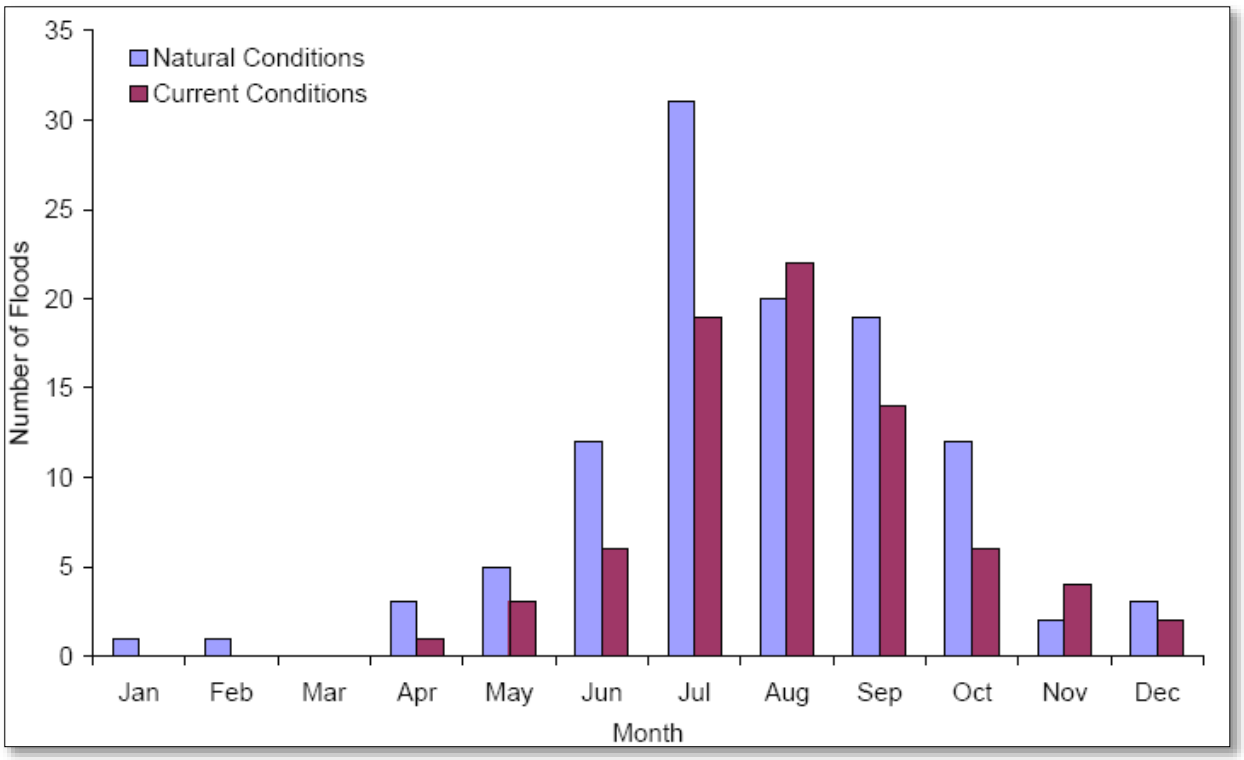
- Lake Lockie
- Lake Little Hattah, Lake Hattah, Lake Yerang, Lake Mournpall and others.

Finally, as River Murray levels rise, water also enters the floodplain via the northern branch of Chalka Creek and through Cantala Creek. These higher river levels introduce water to additional lakes and inundate surrounding floodplain.

The Chalka Creek north area is also the principal route for water returning to the River Murray on flood recession or on the conclusion of TLM works. Water backs up into Chalka Creek north at flows exceeding approximately 33,000 ML/d at Euston and reaches the bank-full level of the creek near the River Track of 42.5

m AHD when flow at Euston exceeds 75,000 ML/d (Gippel, 2008). The wetlands in the Chalka Creek north area are ephemeral and fill after Chalka Creek north is engaged, equivalent to passing River Murray flows of greater than 120,000 ML/d (Gippel, 2008, Jacobs, 2014). Figure 8-2 (GHD, 2012a) provides a summary of information used to estimate the levels expected in Chalka Creek for different flows at Euston.

Figure 8-1. Commencement month for floods in the River Murray at Euston (Ecological Associates, 2007a)



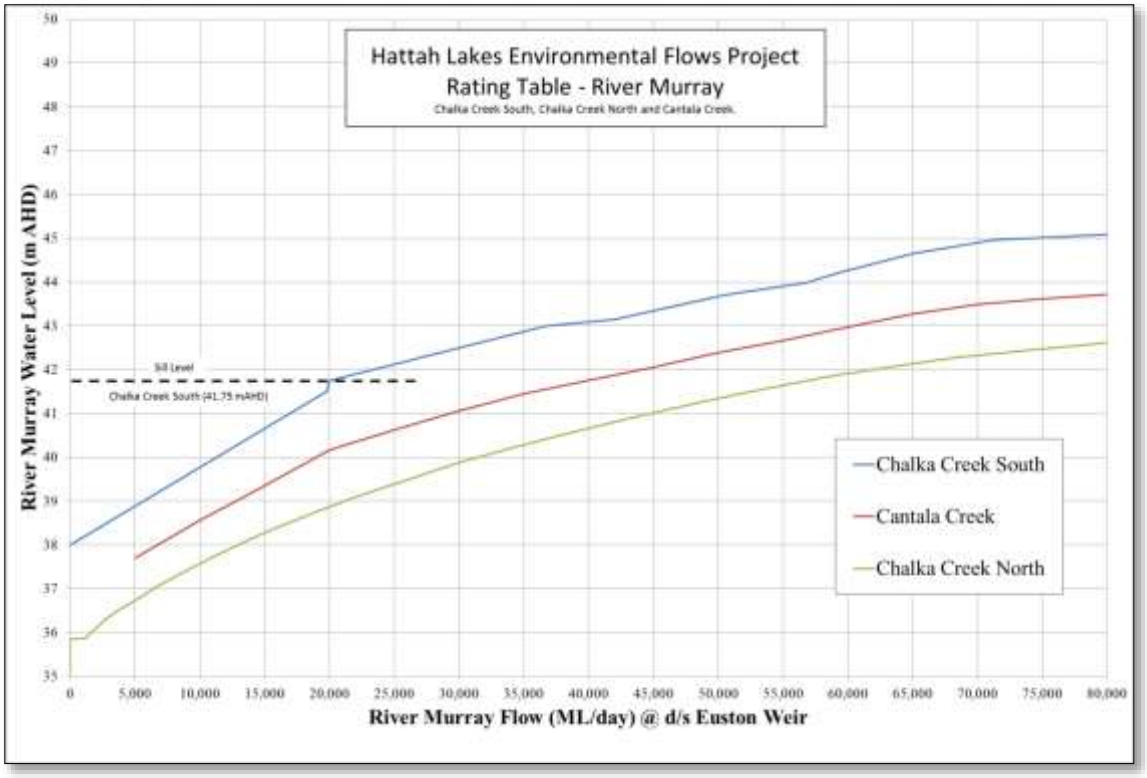


Figure 8-2. Flows at Euston on the River Murray as a comparison with levels in Chalka Creek (MDBA, 2010)

The Bitterang north area is a relatively high and remote part of the floodplain and among the last areas to be inundated. The area comprises wetlands and floodways confined between sand dunes. Two floodways connect the area to the broader floodplain. These are:

- Bitterang floodway, which extends north from Lake Bitterang and distributes water to a number of wetlands, including Lake Boolca, when floodplain levels exceed 44.5 m AHD (GHD 2012b) and passing River Murray flows exceed 160,000 ML/d (Ecological Associates, 2014) [actual flows not modelled]
- Raakjlim Creek is an episodic waterway that passes water west from Chalka Creek north to the Bitterang north Area. The natural sill level for Raakjlim Creek is 43.8 m AHD but two stop banks constructed across the channel have raised the level to 44.11 m AHD. It is estimated that the stop banks have raised the threshold for inflows from 100,000-120,000 ML/d to greater than 160,000 ML/d (Ecological Associates 2014).

Regulation has significantly altered the frequency and recurrence interval of 140,000 ML/d flow events at Hattah North. The mean frequency of these flows has declined to as much as 35% of natural, (to 6.1 events in 100 years). This has caused a 624 percent increase in the median interval between these flow events, resulting in a median recurrence interval of 15.6 years (Gippel, 2014).

Spells analysis of the hydrology of the River Murray at Euston weir under natural and baseline conditions (Figure 8-3) shows that:

- the River Murray now experiences more time at very low flows, less than 10,000 ML/d
- events that create flow in Chalka Creek, 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 percent
- the frequency of events that inundate the area north of Bitterang including Lake Boolca has declined to 32 percent of natural. It is important to note however, in addition to river hydrology impacts

impediments on the floodplain have increased the commence to flow threshold to greater than 160,000 ML/d.

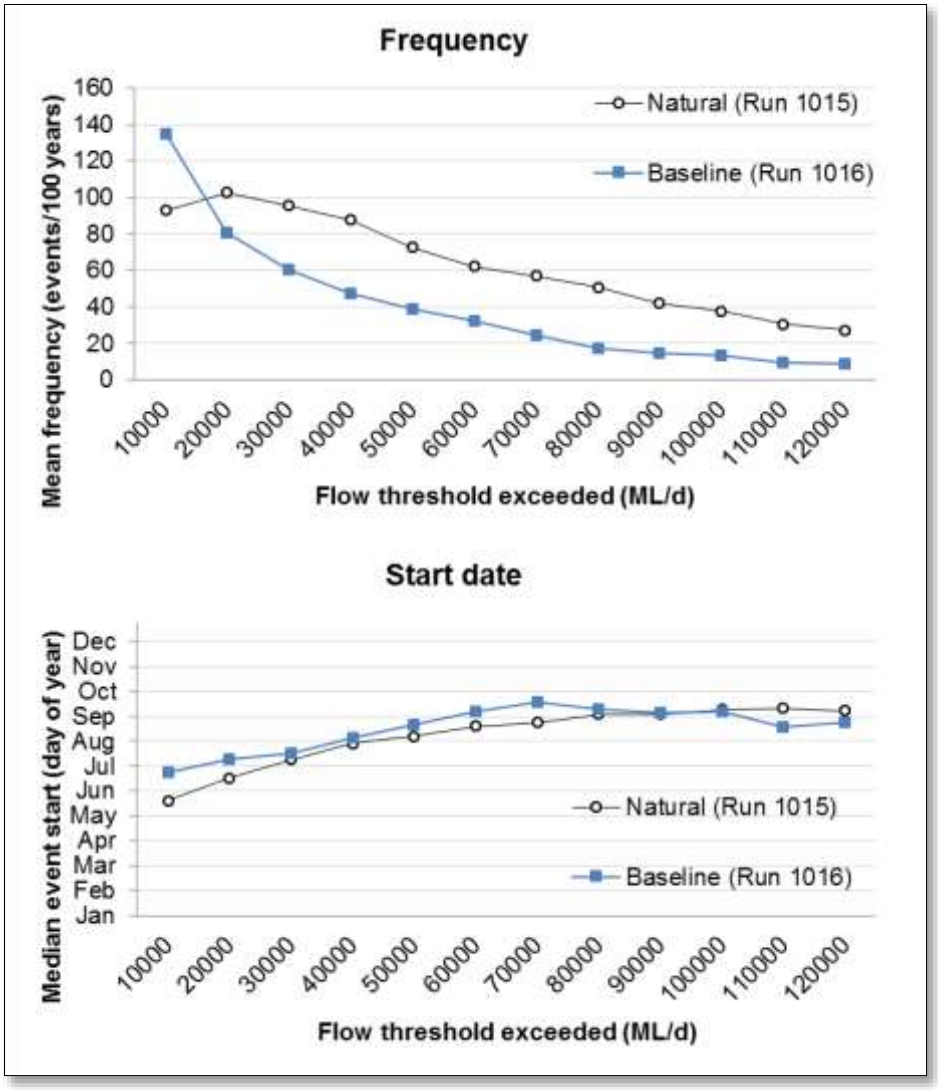


Figure 8-3. Comparison of statistical properties of River Murray flow events at Euston downstream under the Natural and Baseline modelled flow scenarios, over a 114 year modelled period (Gippel, 2014) (continued overleaf)

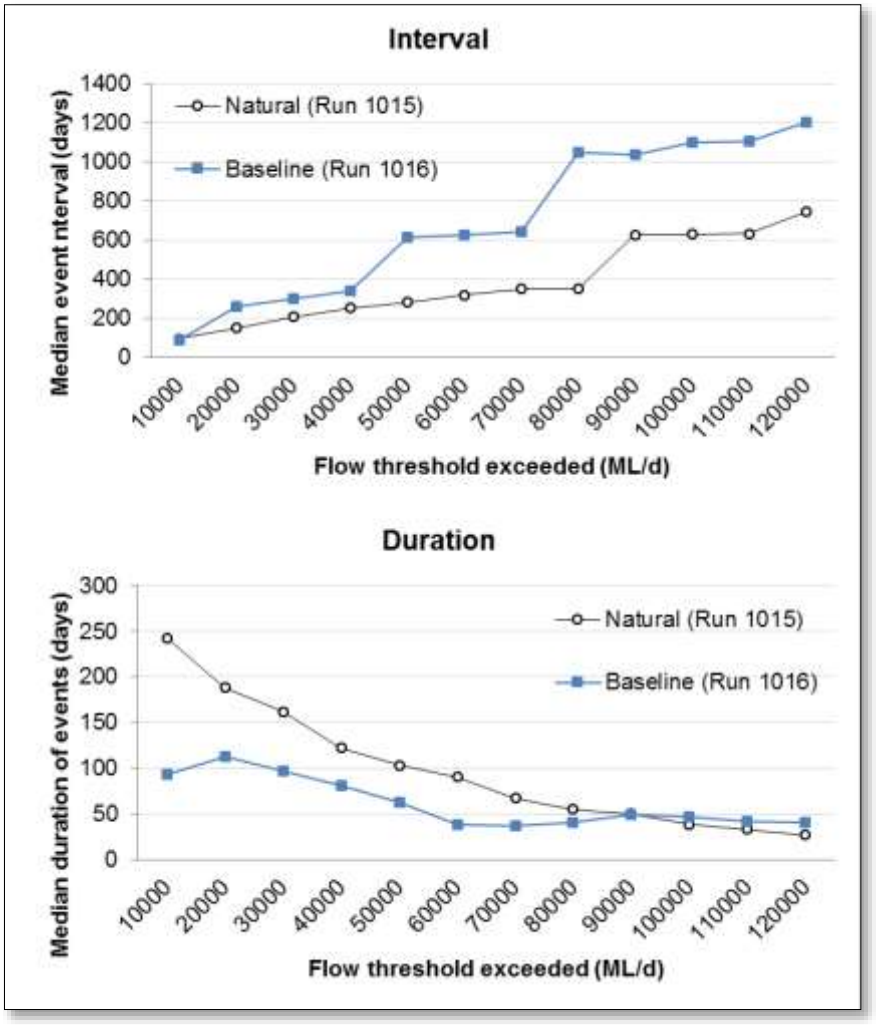


Figure 8-3. Comparison of statistical properties of River Murray flow events at Euston downstream under the Natural and Baseline modelled flow scenarios, over a 114 year modelled period (Gippel, 2014)

Hydraulic modelling of natural and current conditions of Hattah Lakes North show that the commence to flow threshold to inundate north of the Bitterang levee including Lake Boolca has increased from 140,000 ML/d to greater than 160,000 ML/d (Figure 8-4). These hydraulic modelling outputs were derived from steady state conditions, which may not reflect operational River Murray hydrographs and, as such, may result in lower inundation areas in practice than expressed in the modelling outputs. For example, the modelled extent shown of 140,000 ML/d in Figure 8-4, represents the absolute maximum extent achieved after a steady state flow of 140,000 ML/d over a period of many months.

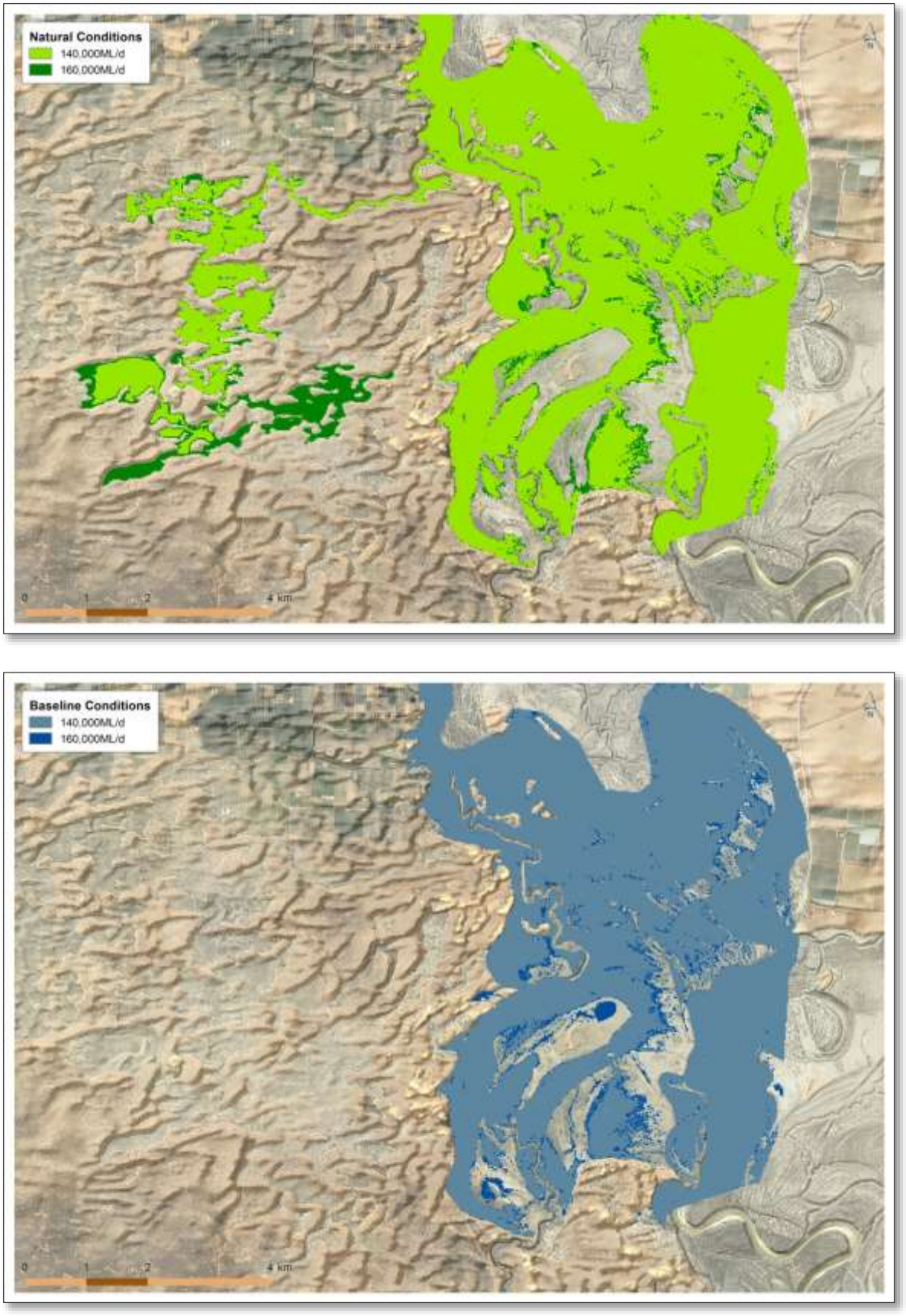


Figure 8-4. Modelled inundation extent of natural (top) and baseline (bottom) conditions at Hattah North at flows of 140,000 ML/d

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 8-5) 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 Hattah Lakes North (Table 8-1). For example flows of 40 000 ML/day will occur 4.7 times in 10 years under baseline, 5.9 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 2.2 compared to 5.9 naturally.

The proposed Bitterang regulator and temporary pumps may be used to provide equivalent inundation to the north of Bitterang including Lake Boolca, to that of a 140,000 ML/d flow event under natural conditions. Targeted operation of the works in conjunction with Basin Plan flows will enable mean frequency of inundation equivalent to a 140,000 ML/d flow event to be restored. This event occurs on average 5.3 times in 100 years under baseline conditions, as flows greater than 160,000 ML/d are required to over top man made impediments in Raakjlim Creek. The measure will increase the frequency to 15 times in 100 years.

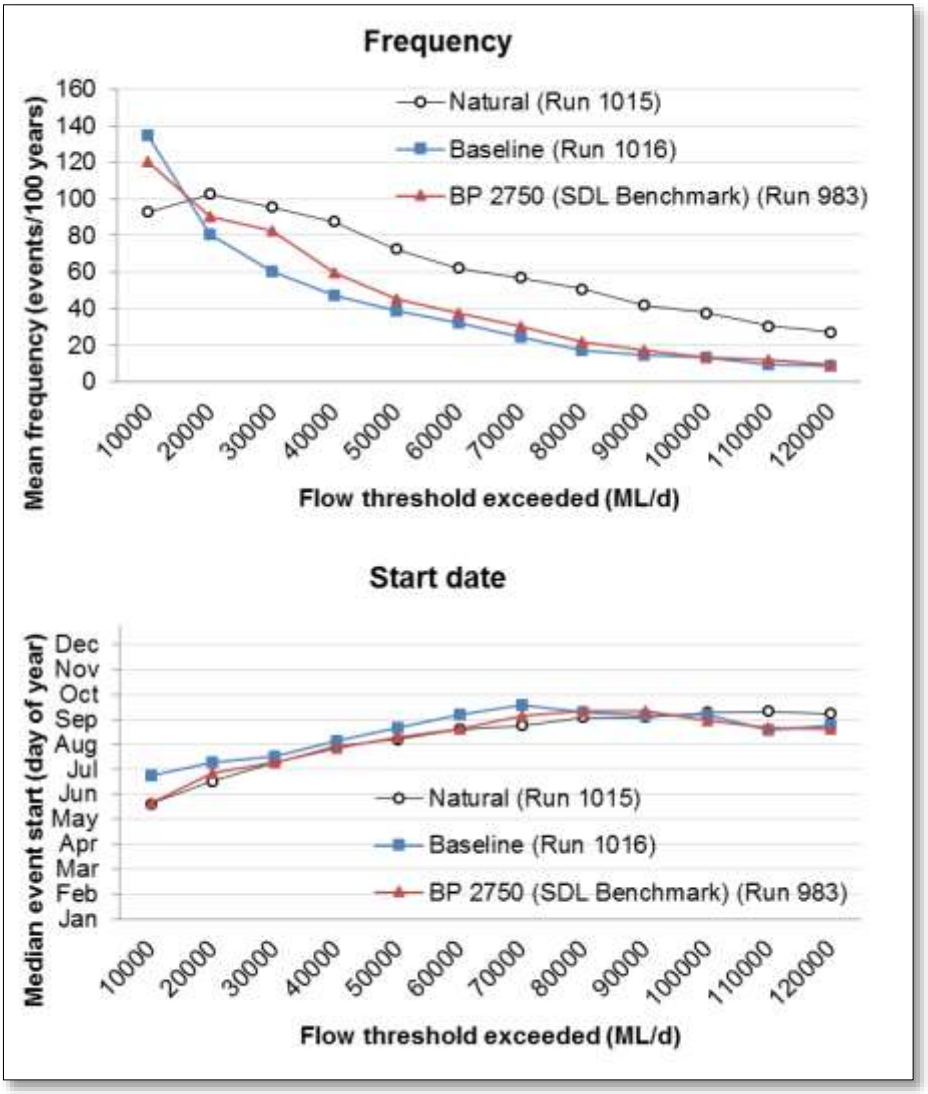


Figure 8-5. Comparison of statistical properties of events at Euston under the Natural, Baseline and BP 2750 modelled flow scenarios, over a 114 year modelled period (continued overleaf)

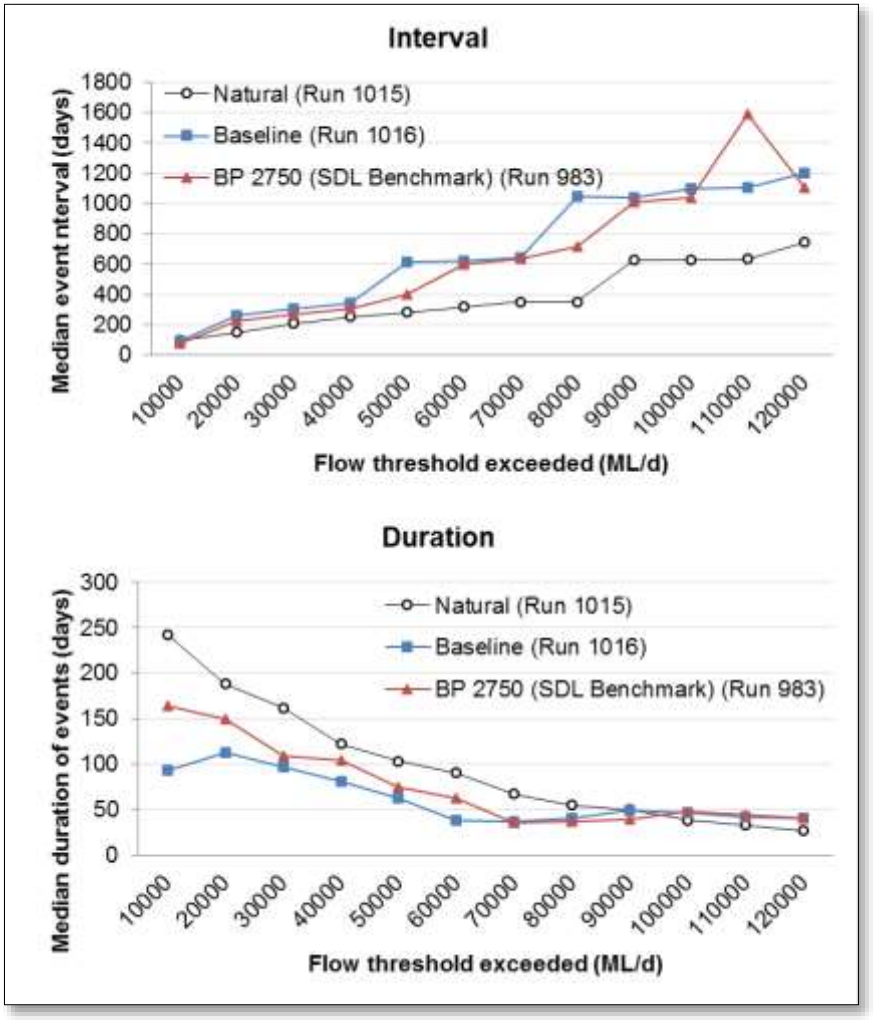


Figure 8-5. Comparison of statistical properties of events at Euston under the Natural, Baseline and BP 2750 modelled flow scenarios, over a 114 year modelled period

In order to further demonstrate the differences in the scenarios described in Table 8-1, hydrographs of the flow regimes are illustrated in Figure 8-6. The flow regimes represent a wetter than average sequence of years (1990s) and an extremely dry sequence of years (2000s).

Table 8-1. Comparison of water regimes provided by natural, baseline, Basin Plan and the Hattah Lakes North measure. Natural, baseline, Basin Plan (adapted from Gippel, 2014).

Threshold (ML/d)	WRC	Scenario	Prevalence yrs with event %	Duration Median (days)	Timing	Proposed operations to meet gap	
						Frequency	Duration
80,000	Red Gum Forest and Woodland	With Measure[1]	60	50	Early spring	4 in 10 years	6 to 7 weeks
		Basin Plan 2750 without measure	19	37	Early spring	Additional operations expected to provide variability in duration requirements	
120,000	Black Box Woodland	With Measure[1]	25	30	Early spring	1.7 in 10 years	1 month
		Basin Plan 2750 without measure	8	41	Late winter		
140,000	Episodic Wetlands	With Measure[1]	15	30	Early spring	1 in 10 years	1 month
		Basin Plan 2750 without measure	6	37	Late winter		

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

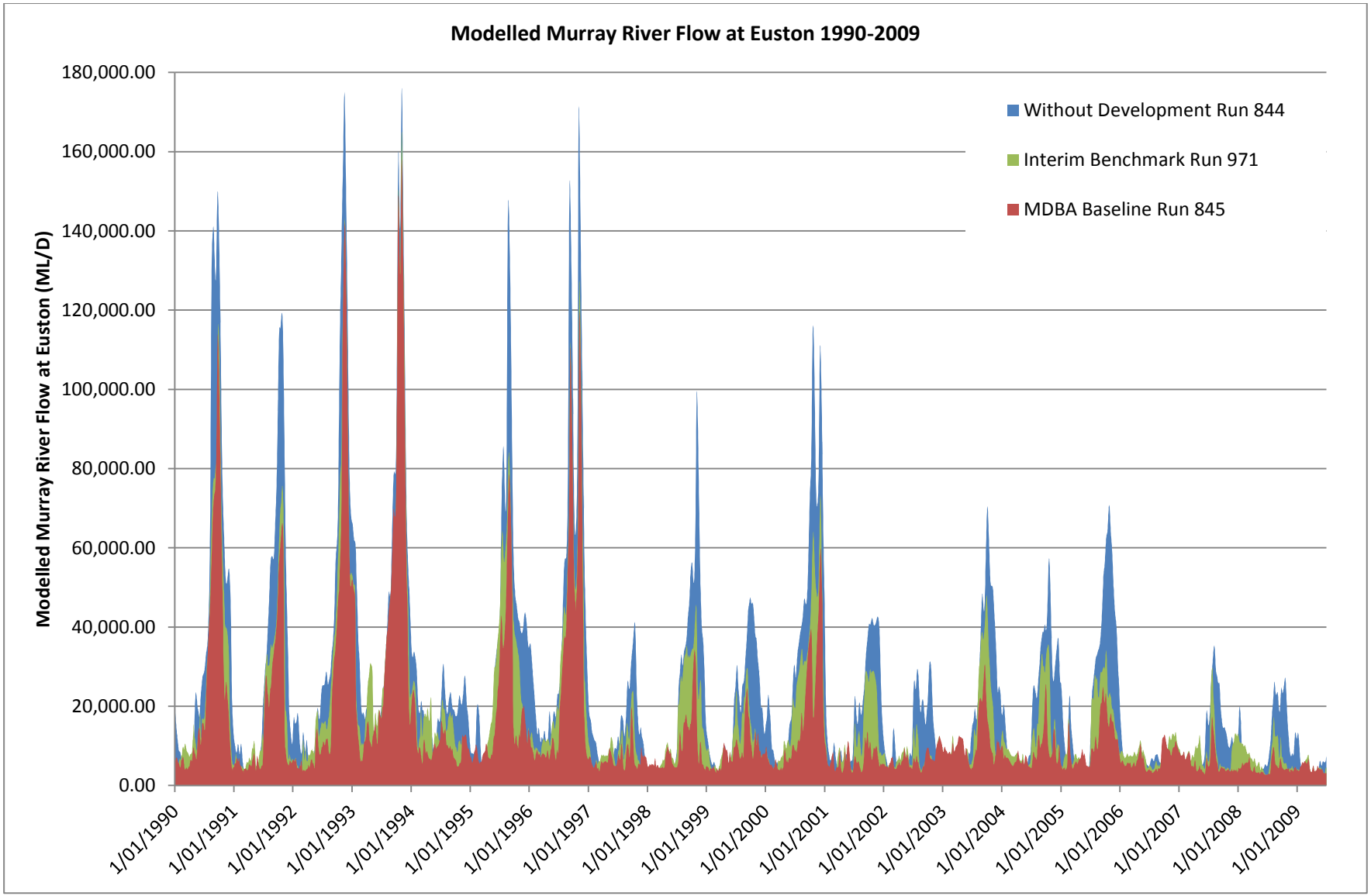


Figure 8-6. Daily Peak Flow by year for different flow regimes at Euston (Data supplied MCMA, 2014)

9. Environmental water requirements (Section 4.5.2)

The environmental water requirements of the Hattah Lakes North Floodplain Management Project have been identified and contribute to the achievement of ecological objectives and targets for this site (Ecological Associates, 2014, Appendix C).

The process for identifying the environmental water requirements built on the work undertaken in establishing ecological objectives. Detailed hydrographic information, spatial data and scientific literature relating to the site was analysed and compared against ecological objectives, which were then combined to generate site-specific environmental water requirements (Ecological Associates, 2014).

One of the key environmental outcomes of the Hattah Lakes North project is to maintain the health and age structure of black box woodland, which requires inundation 1.5 years in 10 for at least 4 weeks, with a maximum period between events of 20 years. Inundation of this extent requires passing flows of approximately 140,000 ML/d, for an extended period, to reach black box areas, which occurs less-often under the current hydrologic regime.

Environmental benefits for black box can be achieved using the proposed environmental works, as they are able to deliver water to these areas, at times when high river flows are not available.

Ecological objectives and targets, and their corresponding environmental water requirements, are outlined in Table 9-1.

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

Table 9-1. Proposed operations to meet the gap in the environmental water requirements for the water regime classes at Hattah Lakes North (adapted from Ecological Associates, 2014)

Water Regime Class	Flow threshold	Strategy	Frequency	Duration	Timing
Red gum forest and woodland	80,000 ML/d	Restore the inundation of red gum woodland	Provide inundation events 6 years in 10.	Four of these events to be one month long. Two of these events to be three months long.	Early spring
Black box woodland	120,000 ML/d	Restore intermittent inundation events	One year in 10 Maximum interval between events of 20 years.	At least four weeks.	Early spring
Episodic wetlands	140,000 ML/d	Restore intermittent inundation events	One year in 10 Maximum interval between events of 20 years	Fill to retention level and allow to dry through evaporation and seepage	Early spring

10. Operating regime (Section 4.6)

10.1 Role of structures and operating scenarios

The Hattah Lakes North Floodplain Management Project will make use of natural high River Murray flow events as well as managed TLM flow events to build upon the ability to deliver water to Hattah Lakes by including the Chalka Creek north and Bitterang north areas.

The primary mechanism for delivering water to the Chalka North area will be via releases of water from the central lakes area from behind the existing Oateys Regulator, constructed as a TLM initiative. This water will then be held within Chalka Creek North and its associated floodplain by the K10 regulator on Chalka Creek at Raak Crossing. Inundation of areas of the privately owned Kulkyne station will be managed via regulators on the River Track causeway.

Water will be delivered to the Bitterang North area by opening the proposed Bitterang North Regulator and allowing water contained south of the existing Bitterang Levee to flow through via gravity. When flows through the regulator equalise the regulator will be shut and temporary pumps will be able to be used to deliver additional water to the Bitterang North area. The use of these temporary pumps both reduces the time taken for water to spread through the Bitterang North area and increases the extent of watering possible.

The proposed works and existing infrastructure are described in Table 10-1.

Environmental water being held against the existing Bitterang levee (2014)

Table 10-1: Summary of environmental watering infrastructure and its role at Hattah Lakes

Infrastructure	Existing or proposed	Description	Role	Associated area	Inundation area (ha)	Volume (GL)[3]
The Living Murray						
Messengers Pump Station	Existing	7 variable speed axial flow pumps and ancillary works.	Pump water from River Murray to Chalka Creek and Lake Kramen.	Central lakes, Lake Kramen and associated riparian and floodplain areas	>6000	Can provide flows of up to 1000 ML/d
Regulators	Existing	Messengers and Oateys Regulators are dual leaf overshot/undershot gate Cantala and Kramen regulators are box culverts with aluminium stop logs.	Messengers and Oateys, pond water on the floodplain during operations and provide capacity for controlled releases to the River Murray. Cantala to pond water within Cantala creek and lake. Kramen to allow through flows to Kramen creek and lake. All regulators have also been designed to allow unimpeded through flow during natural high flows events.	Central lakes, Lake Kramen and associated riparian and floodplain areas		
Levees	Existing	Breakout, Cantala and Bitterang track raising.	Used to pond water on the floodplain by preventing water flowing back to the River Murray during operations.	Floodplain areas		
Chalka Creek North						
K10 regulator	Proposed	A concrete box culvert regulator with dual leaf combination gates.	Pond water in Chalka Creek North, wetlands and associated riparian and floodplain area. Also used to release flows to the River Murray and the end of	Chalka Creek north channel and associate riparian, wetland and	420	6.8 (Assuming floodplain losses

[3] Volumes were derived from scenario modelling to determine the extent of flooding, and depth/area relationships with stage height for each of the regulators. The volumes therefore refer to void space and assumes no losses or return flows. This information, together with the proposed operating regime, will enable the MDBA to model return flows for the full range of operational scenarios during the assessment process.

Infrastructure	Existing or proposed	Description	Role	Associated area	Inundation area (ha)	Volume (GL)[3]
		1030 m levee/track raising.	operations. All regulators have also been designed to allow unimpeded through flow during natural high flows events.	floodplain areas.		of 25%).
River Track causeway	Proposed	710 m levee, incorporating concrete box culverts with penstock gates.		Chalka Creek north channel and associate riparian, wetland and floodplain areas.		
Bitterang north						
Bitterang levee regulator	Proposed regulator in an existing levee	Cast in-situ concrete structure incorporating penstock gates.	Allows through flow of water from south of the levee to the north. Also necessary to retain pumped flows.	Flowpath, wetland and floodplain north of the Bitterang Levee. Includes Lake Boolca.	Up to 710 (dependant on operation type).	9
Hardstand	Proposed	Clear flat area on top of Bitterang levee.	Used to accommodate set-up of temporary pumps.	Flowpath, wetland and floodplain north of the Bitterang Levee. Includes Lake Boolca.		

10.2 Operating Scenarios

The Hattah Lakes North water management works have been designed to provide maximum operational flexibility and can be used in conjunction with the existing TLM Works to complement Basin Plan flows environmental benefits. Four scenarios have been developed in order to summarise the range of operations possible. These include:

- default
- river red gum
- black box
- natural flood.

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

Table 10-2. Links between the operating scenarios and water regime classes at Nyah Park

Water regime class	Corresponding river flow (ML/d)			
	80,000	120,000	> 120,000	Default
Red gum forest and woodland	River red gum	Black box	Black box	Natural flows All structures open
Black box woodland				
Episodic wetlands				

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

Default

This scenario is the default configuration for the proposed works, during normal operations when environmental water is not being delivered.

In this scenario, neither the TLM works nor the proposed works will be in use. All regulators will be open, allowing natural flows, if they occur, to inundate the areas as per usual.

River Red Gum

The majority of red gum which can be influenced using the proposed works occurs within the Chalka Creek north area.

Using the existing TLM Works, water will be ponded within Chalka Creek and the central lakes area using Oateys, Messengers and Cantala regulators and their associated support structures to a target level of 43.5 m. The pool may be filled by gravity, using pumped water or by capturing natural flood peaks. During this operation, water will be released from Oateys regulator.

Using the proposed works, water released through Oateys Regulator may be detained using K10 regulator and the K10 River Track Causeway. Once environmental water requirements of the Chalka Creek north wetlands and floodplain have been met, water can be released via K10 regulator and Chalka Creek north, to the River Murray.

Black Box

The majority of black box which can be influenced using the proposed works occurs within the Bitterang north area.

During TLM operations (floodplain inundation scenario to 45 m AHD) water can be allowed to flow into the Bitterang floodway by gravity via the Bitterang Regulator. Under this scenario the pool will generate a gravity flow of approximately 100 ML/d at the regulator and over 30 days will distribute water over approximately 300 ha, including Lake Boolca (GHD, 2012). Under the TLM program it is planned to operate the floodplain inundation scenario to 45 m AHD approximately one year in eight years (Greenfield, 2013).

Temporary pumps may also be used to supplement floods or managed flows, to speed up delivery and achieve a greater area of inundation. In this scenario, the regulator would be closed to retain either natural or TLM operations water. A temporary pump can be used to re-lift water over the levee from Lake Bitterang to the Bitterang floodway. At a flow of 300 ML/d, a level of 45.11 m AHD can be achieved against the northern side of the levee which distributes water to over 710 ha.

It is proposed to operate the levee and regulator to augment flooding to meet environmental water requirements. The decision to inundate the Bitterang North area will be based on the duration since the last event. It will be important to limit the interval between floods so that the health and age structure of Black Box Woodland is maintained and the value of these trees as habitat for terrestrial fauna and as a component of the wetland ecosystem during floods is preserved.

Natural Flood

In order to minimise the impact of the infrastructure on natural flooding patterns all existing TLM and proposed regulating structures will be open during natural flooding events allowing full connectivity between the River Murray, Chalka Creek, the central lakes, the Chalka Creek north, Bitterang north areas and the floodplain.

Transition between operating scenarios

For a range of reasons it may be necessary to change between operation scenarios during the course of a watering event.

Factors that may influence a decision to transition between scenarios may 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
- response to water quality risk mitigation requirements.

An operation matrix (Table 10.3) has been developed which summarises how each structure would be operated to change from one scenario to another.

For example, to move from default conditions to a black box scenario, TLM works will be operated, with the pump station delivering water to a level of 45 m AHD in the central lakes area. The Bitterang levee regulator will be open to allow gravity flows until water levels across the levee equalise, at which point the regulator will be closed and temporary pumps can be used to supplement the water delivery. During the black box scenario, water will also be delivered to the Chalka North Area with water passed into the Chalka Creek north area via the Oateys regulator, where it will be retained by the K10 regulator.

The 'Condition during scenario' sections of the matrix show 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 all structure open under flood conditions, regulators are progressively opened until tailwater and headwater levels are matched. The structure may then be completely opened to allow unimpeded passage of natural flows.

Table 10-3: Operational Matrix

Scenario	Default	Red gum	Black box	Natural flood
Default	Condition during scenario All regulators open TLM pump station shut down.	Oatey's Regulator set to maintain between 43.5 -45 m AHD to central lakes area and to pass flow as required to Chalka North area. Cantala, Messengers and K10 Regulator set to closed. Bitterang Regulator closed TLM pump station operating.	Oatey's Regulator set to 45m AHD and to pass flow as required to Chalka North Area. Cantala, Messengers and K10 Regulator set to closed. Bitterang Regulator open until levels equalise and then closed to allow temporary pumping. Temporary pumps in operation to deliver water to 45.11m AHD at Bitterang North TLM pump station operating.	All structures open. Pumps shut down.
Red gum	Oatey's Messenger's, Cantala and K10 Regulator set to open.	Condition during scenario Oatey's Regulator set to maintain between 43.5 - 45 m AHD to central lakes area and to pass flow as required to Chalka North area. Cantala, Messengers and K10 Regulator set to closed. Bitterang Regulator open TLM pump station operating.	Oatey's Regulator set to 45m AHD and to pass flow as required to Chalka North area. Bitterang Regulator open until levels equalise at 45 m AHD and then closed to allow temporary pumping. Temporary pumps in operation to deliver water to 45.11m AHD at Bitterang North.	All structures open. Pumps shut down.
Black box	All regulators open. TLM pump station shut down.	Oatey's Regulator set to maintain between 43.5 - 45 m AHD as required to central lakes area and to pass flow as required to Chalka North area. Bitterang Regulator open. TLM pump station operating.	Condition during scenario: Oatey's Regulator set to 45m AHD and to pass flow as required to Chalka North Area. Cantala, Messengers and K10 Regulator set to closed. Bitterang Regulator open until levels equalise at 45 m AHD and then closed to allow temporary pumping. Temporary pumps in operation to deliver water to 45.11m AHD at Bitterang North. TLM pump station operating.	All structures open. Pumps shut down.
Natural flood	All structures open. Pumps shut down.	All structures open. Pumps shut down.	All structures open. Pumps shut down.	Condition during scenario: All structures open Pumps shut down.

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 i.e. consistent with ecological objectives, ecological targets, environmental water requirements and watering regime
- operational risks
- regional context (i.e. survival watering, recruitment watering, maintenance watering).

Timing will be in response to late winter/spring flow cues and inundation will be managed according to the flow rate in the River Murray and the TLM works operating levels.

The structures will be operated to manage potential adverse impacts as per the risk mitigation covered in Section 11.

Environmental watering reaching fringing vegetation at Hattah Lakes (2014)

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. The proposed works operate in conjunction with that of the TLM infrastructure. It is recognized that the threats identified are existing and the operation of the proposed works incrementally build on this risk.

11.1 Risk assessment methodology

The risk assessment for the Hattah Lakes 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	Hattah Lakes 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 Hattah Lakes North 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						
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.	Moderate

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
					Upgrade roads to improve access where practical. Provide boat access as an alternative, where relevant.	
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
Rise in river salinity	A key driver to salinity in the Murray 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	Moderate	Provide dilution flows in the Murray River during and following drawdown. Not operating during high-risk periods. Use regulators to: • 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. Ongoing monitoring of groundwater and surface water levels and salinity to inform adaptive management and update of Operational Plans.	Low
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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
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 O&M documents including removing structural parts likely to be barriers to flow or large debris.	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
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	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	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
operation					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).	
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
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	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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
	the capacity to operate the site as required.					
Inundation of private land without prior agreement	The proposed works enable 112 ha of private land to be inundated, once landholder agreements are in place. If ownership changes and flooding agreements aren't registered on title, it is possible that the new owners will not permit flooding.	Possible	Moderate	Moderate	Ongoing engagement with landholders regarding planned watering events and outcomes. Negotiate relevant agreements to be registered on title to enable watering of private land. Build in design-based mechanisms to avoid/prevent private land flooding.	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).
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.

11.5 Salinity Impact Assessment and Mitigation Strategies

A preliminary salinity impact assessment of the *Hattah North Floodplain Management Project* has been completed which includes analysis of both Basin Salinity Management Strategy (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 *Hattah North Floodplain Management 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.

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).

There 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 magnitude of the salt load.

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

Preliminary salt estimate

The preliminary salinity impact estimate for the *Hattah North Floodplain Management Project* is 0.10 EC at Morgan for the nominated frequencies of inundation. This would be an accountable action under BSMS however the preliminary analysis does not account for implementation of mitigation strategies.

Groundwater monitoring records suggest that, for several sites, current groundwater levels are higher than historic levels. This suggests that successive watering events coupled with natural floods would not significantly increase salt loads, compared to the 1990s. As such, the cumulative impacts are likely to be negligible at this site (SKM 2014).

The real-time salinity impact immediately downstream of Hattah Lakes North was modelled (over the 25 year benchmark period) and salinity targets at Lock 6 or Morgan were not exceeded. The rise in river salinity was minor and estimated to last for less than a week. It should be noted that the background River Murray salinities also exceeded the salinity operation target at Morgan and Lock 6 for many days during the benchmark period.

Key salt mobilisation processes

The key driver of the salinity response across Hattah Lakes North is the increase in groundwater levels above the height of the water level in Chalka Creek. The AEM data indicates that there are large areas of highly saline

groundwater in the floodplain and that the salinity of groundwater aquifers are highly variable. The available groundwater data in this area is sparse, which creates some uncertainty regarding the salinity impact.

It is expected that multiple watering events will occur at this site over time. These successive watering events coupled with natural flood events could return groundwater conditions to that seen in the 1990s. The ability to accurately quantify the cumulative impact using the analytical approaches is limited and requires more detailed data in order to refine the salinity impact estimates (SKM 2014).

Mitigating measures and their feasibility

The estimated salinity impact highlights the need to develop and test suitable mitigation strategies. A balanced approach is required to maximise environmental benefits while minimising salinity impacts. The level of impact is highly dependent on river flows and baseline salt load, 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:

- Creation of an operations protocol that explicitly connects projected salinity impacts, salinity thresholds for operation and contingency planning; and
- 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.

Should larger impacts occur with time, these will be offset by the less frequent operation and shorter duration of watering events as required.

Significant opportunities exist to manage the way that salt is generated and to mitigate the overall impacts including:

- Optimising the timing of diversion to bring fresher water into wetlands and minimising the salt impact on the release.
- Optimising the timing of releases so that water is released into a higher river.
- Optimising the rate of release so that, if high salinity water must be released, localised impacts can be minimised.

Monitoring requirements and further analysis

The limited surface water and groundwater data limits the ability to refine the quantum of salinity impact. SKM (2014) recommended the implementation of comprehensive monitoring during early operations and the use of information obtained to inform a more detailed analysis of local and downstream salinity impacts and inform adaptive management. This local scale investigation should form part of a larger scale investigation covering river operations and environmental watering activities taking place along the River Murray System.

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

- Five new bore sites to be drilled close to the inundation areas
- Five data logger sites to capture continuous salinity and water level data - additional sites may be required where inundation activities present access issues
- Thirty-one bores to be monitored for water level and salinity before, during and immediately after watering events, and every three months between events, and
- required additional surface water data (flow, level and salinity) to be collected at a series of locations along Chalka Creek (close to proposed regulator sites).

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
- 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
- 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 Hattah North 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 G-MW 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 F - 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, 2014a):

- conveyance of a volume of flow into a given area downstream, over a defined period of time;
- velocity of flows through the structure and at entry and exit points
- minimising allowances for freeboard to reduce the (inundation) height range over which the structure may potential obstruct natural flows
- operability - to provide controlled release of flows and drawdown rates to ensure fish passage and erosion control criteria are optimised.

Fish Passage

A fish passage workshop was held on 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.

Outcomes from the workshop relevant to design of the Hattah North works included the following:

- facilitating fish passage via use of dual leaf gates
- new works to be consistent with existing fish passage (at Oateys regulator)
- works to incorporate deep plunge pools at regulators during over shot flow
- works to consider fish passage for all scenarios of watering events
- the velocity through the open regulators should be minimised 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.

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, 2014a).

Gate Design

A gate assessment workshop was held in Tatura on 31 July 2014 and included representatives from G-MW 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 dual leaf gate system in use on the existing TLM Hattah Lakes Environmental Regulators and on weirs managed by SA water in the region was confirmed for the K10 Regulator.

Design of smaller regulators at the site was standardized to use mechanically actuated penstock gates 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 K10 regulator was 500mm above the maximum operating level.

In setting the levee crest level a minimum freeboard of 300mm above design water level has been adopted for small structures and levees:

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 Chalka North works (Area 1) described in Table 12-1 and the Bitterang North works (Area 2) 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 F. Figure 12-1 shows the section view of the proposed K10 Regulator.

Table 12-1. Chalka North (Area 1) works (GHD, 2014a)

Works	Description
K10 Regulator	New regulator and track raising on Chalka Creek North (on existing track at Raak crossing) that controls movement of water into the north-eastern section of the Hattah Floodplain. K10 Regulator comprises 3 No. bays with hydraulically actuated dual leaf combination gates. K10 track raising of 680 m in length across the creek. A small additional section of raised track (350 m) to be positioned upstream of the regulator structure to prevent a breakout occurring to the north.
K10 River Track Causeway	Track raising and culvert works on the existing River Track to maintain access into and out of the Hattah-Kulkyne National Park when the Chalka North pool is in operation (will include regulators to enable free passage of water when not in operation). River Track structure comprises 3 box culverts with penstock gates. River Track raising of 710 m in length across the creek.

Table 12-2. Bitterang North (Area 2) works (GHD, 2014a)

Works	Description

Bitterang Regulator	New regulator installation and widening of the existing (TLM) Bitterang levee to allow delivery of environmental water to the Lake Boolca area. Regulator will comprise 6 box culverts with mechanically actuated penstock gates. Existing levee will be widened along a length of 570m

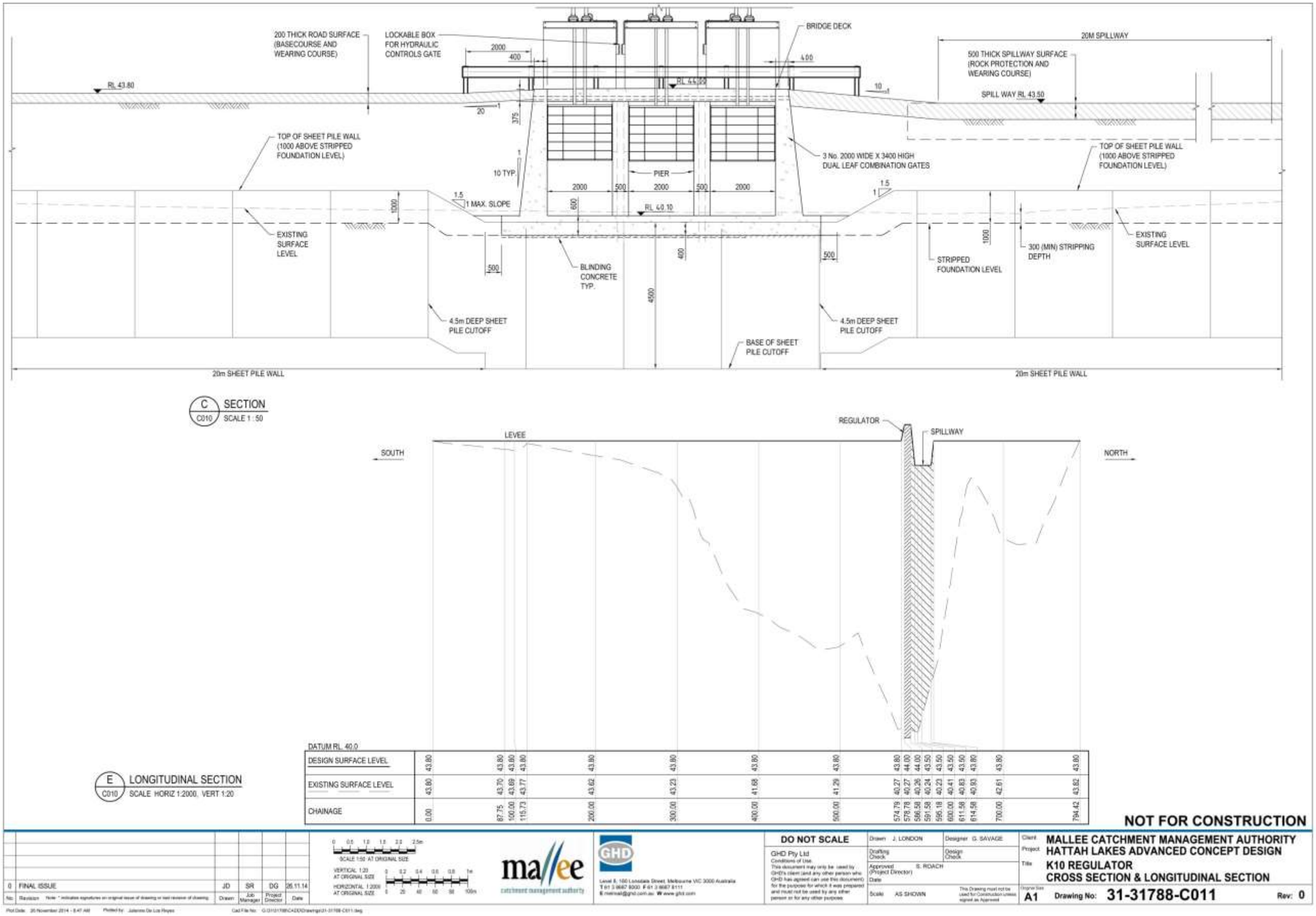


Figure 12-1. K10 Chalka North regulator design (GHD, 2014a)

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

The location of each structure has been selected to maximise the efficiency of the works whilst minimising impacts on cultural heritage, native vegetation and the visual or recreational amenity of the park and adjacent landholders. Figure 12.2 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 2014a.

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.

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.

For the purposes of preparing an estimate of vegetation impacts a nominal footprint at each of the proposed regulator sites was used along with nominal widths for access tracks and levees. These estimates were conservative and provide a correspondingly conservative (high) estimate of vegetation impacts.

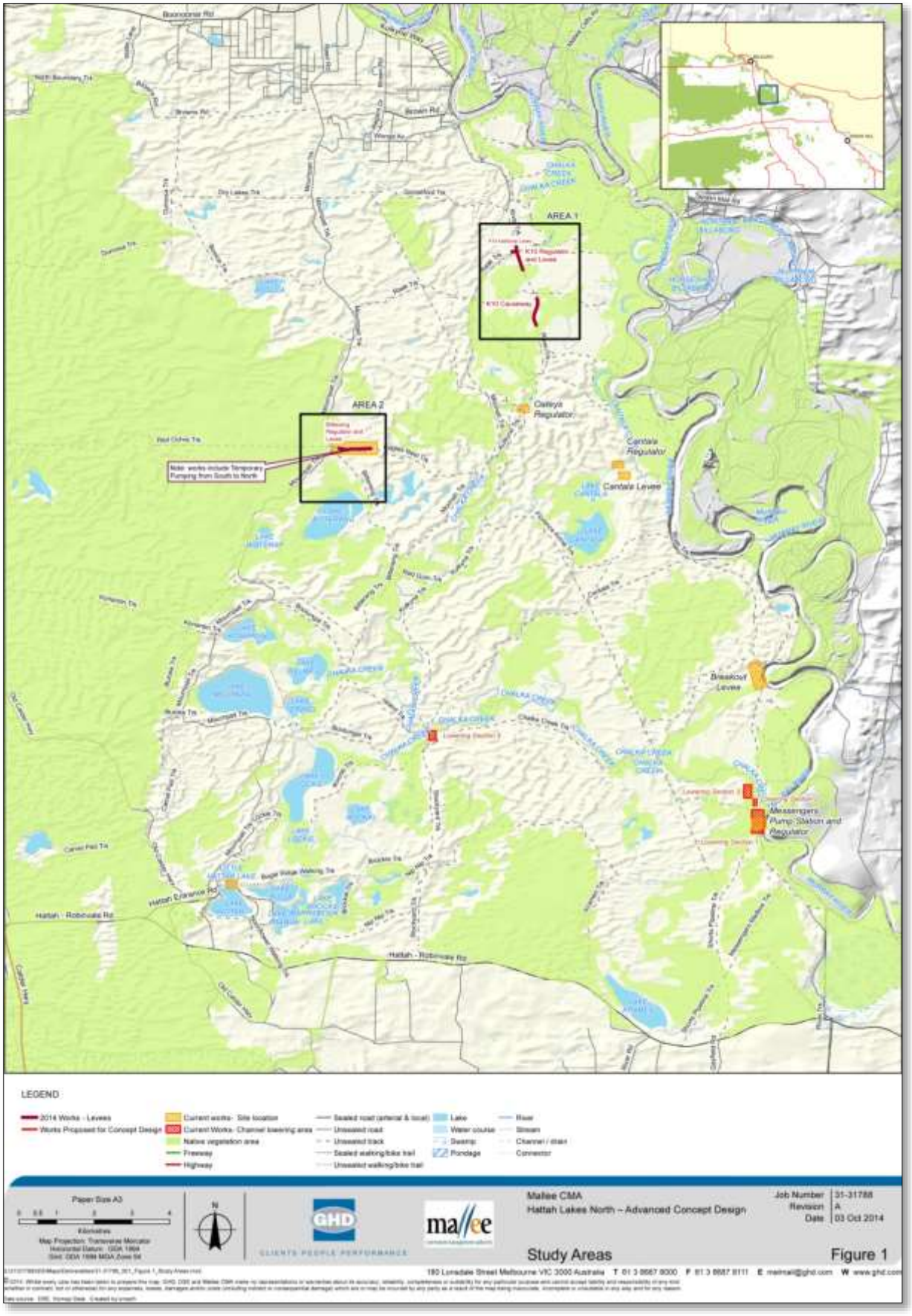


Figure 12-2. Overall map of proposed works for Hattah Lakes North

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.

Other findings included:

- significant variability in the depths at which the different units were encountered across the four test borehole sites
- the depth to groundwater intersected during drilling was determined to be approximately 4.5 – 5.0 m below existing ground surface level.

During the development of advanced concept designs, further geotechnical investigation was undertaken. At the time of writing of this business case laboratory analysis had not been completed; however the following is a preliminary summary of the investigations completed during the development of advanced concept designs (GHD 2014).

A site walkover was completed by a GHD senior engineering geologist and geotechnical engineer. 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, 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:

- The surface condition and expected underlying geology are as expected for the area (clays, silts and sands of the Coonambidgal Formation). Highly reactive clays forming “gilgai” features are present at the K10 Causeway site. These form characteristic hummocky terrain and abundant desiccation cracking and fissuring. Dispersion of this surface clay layer appears to be severe with numerous vertical dispersion features present immediately to the west of the site. These features are thought to originate by vertical migration of fines into a possible sandy unit below. These conditions should be investigated during the geotechnical investigations to assist in understanding the impact these features may have on the proposed structure.

- At the K10 Regulator site, a dune deposit was noted towards the north of the structure. This dune formation of the Woorinen of Lowan Formation is likely comprised of fine to medium sand and should be assessed as a possible seepage path around the proposed structure [MM2]. The sand dune material may be underlain by Blanchetown clay at uncertain depth. Some vertical dispersion features were located in the clay soils approximately 40 m south of the creek.
- K10 Levee site was within a steeply incised creek and assumed to be in the clays of the Coonambidgal Formation. The clays at this site are dispersive with moderate erosion gullies forming along the roadside drain.

Site investigations were carried out in November 2014. The investigation works consisted of the following:

- drilling of 9 solid flight auger to depths of between 2.0 and 3 m
- dynamic cone penetrometer tests (DCP) were carried out to 2.0 m at all auger sites
- drilling of 2 boreholes to a maximum depth of 16 m at the K10 Regulator site - SPT tests were carried out within these boreholes at selected locations
- 4 Cone Penetrometer Tests to depths of up to 20 m.

The following presents a summary of the geotechnical conditions encountered across the site based on preliminary review of the information available to date.

The subsurface profile was generally consistent across the site, with the general stratigraphic profile (consistent with boreholes BH02, BH03, BH04, BH05, BH06, BH07, BH08, BH11) as follows:

- Fill: Generally consisting of gravelly material likely to be associated with track construction. Maximum thickness encountered was 0.3 metres. Overlying clay.
- Clay: (CI-CH) frequently with minor fine grained sand component, Stiff to hard consistency, dry to moist moisture condition. Encountered to depths of between 1.45 and 3.3 metres. Overlying (where penetrated).
- Sand: (SM-SP) frequently with minor silt component. Medium dense. BH11 loose to medium dense from 3.3 to 5.5 metres. Dry moisture condition. Grain size varies from fine to coarse. Borehole BH04 encountered a layer of stiff to very stiff sandy silt (ML) from 2.0 to 2.4 metres, overlying sand (SP).
- Borehole: (BH11) extended to a greater depth, encountering medium dense sandy gravel (GP) from 7.0 to 8.5 metres, medium dense sand (SP from 8.5 to 11.5 metres, an organic layer from 11.5 to 11.6 metre overlying stiff clay and clay with sand (CL-CH) to the base of the borehole at 14.95 metres.

Within the vicinity of the proposed structures an exception to the profile described above was encountered in borehole BH10: as follows

- Underlying the fill at this location, interbedded layers of loose to medium dense silty sand (SM)
- Very stiff sandy clay/clay with sand (CI) and very stiff sandy silt (MH) were encountered to a depth of 4.1 metres
- Underlying these layers, loose to medium dense sand (SP) was encountered to a depth of 13.0 metres, with an organic layer from 11.6 to 11.8 metres
- From 13.0 to 13.3 metres, loose to medium dense silty sand/ sandy silt (SM/MH) was encountered, overlying stiff clay with sand (CI) to the base of the borehole at 14.95 metres.

12.6 Alternative designs and specifications

Numerous studies have been undertaken over the last decade to investigate the most effective designs for watering the Hattah Lakes North site. Each study builds on previous work and has resulted in refinement of the preferred options that are reflected in 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 (Ecological Associates, 2007a):

- removal of levees in Raakjlim Creek – relies on inundation flows in the River Murray of at least 120,000 ML/d to provide water and reduces the retention of water from events exceeding 44.1 m AHD or 180,000 ML/d
- pump water directly into Dry Lakes through existing irrigation mains – is dependent on spare capacity in the irrigation pipe and requires clearance of vegetation for pipe works and channels
- installation of regulating structures on Raakjlim Creek, Chalka Creek and two locations in proximity to Lake Boolca and pumping water from the River Murray through these locations to the Dry Lakes area – high cost, large amounts of water required for limited additional inundation and therefore resulted in limited anticipated ecological benefits to the Dry Lakes area.

As the preferred options became clearer more detailed analysis (GHD, 2012b) was carried out on the options outlined in Table 12-3. While costs were analysed as a part of the assessment they have been omitted from this table to avoid confusion with current cost estimates provided elsewhere throughout the remainder of this document.

Table 12-3: Options that were subject to detailed analysis (GHD, 2012b)

Options	Details	Area Inundated	Cost ($/ha)[1]
Option 1: Chalka Creek North regulator	Targets an inundation level of 43.5 m AHD Comprises a main regulating structure (K10 regulator) located on Chalka Creek North. Includes other works to manage access and retain inundation flows: • K10 River Track causeway – levee with box culverts and stop logs • K10 levee with box culverts and stop logs • Area of inundation: 420 ha.	420 ha	$12,000
Option 2: Bitterang levee regulator	Targets an inundation level of 45.11 m AHD Comprises a main regulating structure within the Bitterang levee on the north of Lake Bitterang along Eagles Next Track.	300 ha (710 ha with pumping)	$1,300
Option 3: Lake Bitterang regulator	Maximum operating level of 44.0 m AHD Comprises a main regulating structure on the branch of Chalka creek to Lake Bitterang to allow flows to be excluded from lake bitterang during watering events targeting the central lakes area. Includes minor track works to provide access to the regulator.	393 ha	$1,000 (one off)

It was concluded during the 2012 options assessment (GHD, 2012b) that options 1 and 2 would offer the greatest ecological benefits for the following reasons

- Option 1 inundates the greatest area, maximising inundation of the lower floodplain area while minimising flow back to the River Murray during inundation events to retain water. Additional benefits include maintaining access to the National Park, avoiding disturbance of culturally sensitive areas and minimising disturbance to vegetation.
- Option 2 ranks second on area to be inundated, provides the most operational flexibility and extends the area of inundation to the most northern and water depleted part of the floodplain.

Based on this prioritisation the following works (outlined in Table 11-4) were identified as the optimum mix. Forecast costs were updated during the advanced concept design phase (GHD, 2014a).

Table 11-4: Final option selected (GHD, 2014a)

Works	Total area of inundation (ha)	Volume (GL)
Area 1 – Chalka Creek North regulator	420	0
Area 2 – a) Bitterang levee regulator	300	9
b) Temporary pumping at Bitterang North	410	-
Total	**1130**	**9**

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 will be assigned to the constructing authority.

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 TLM Works at Hattah Lakes and Gunbower Island. Along with this experience comes the necessary organisational capacity including data management and asset management systems required to maintain and operate large works. 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 the Chalka North and Bitterang North works and interactions with the existing TLM Works 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.

Jacobs have undertaken their own 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 and Shane McGrath.

13. Complementary actions and interdependencies (Section 4.9)

The proposed Hattah Lakes North Floodplain Management Project supply measure will affect the Victorian Murray (SS2) 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 interdependencies 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 operation of the existing TLM works and the design process has ensured compatibility with existing infrastructure. Under current arrangements, the operation of TLM infrastructure is undertaken by G-MW at the request of MDBA river operators, following advice from Hattah Operating Group (chaired by the Mallee CMA). This arrangement ensures operations 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.

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 Hattah North project and the existing Hattah TLM project on downstream water quality will need to be monitored. The operation of the proposed North Hattah in conjunction with the Hattah TLM infrastructure, natural and Basin Plan flows and other nearby environmental watering events will dramatically increase available floodplain habitat for valued flood-dependent fauna beyond that provided by the operation of either 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 Hattah North 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
- 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
- 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

Total project implementation costs, in Present Value 2014 dollars are $8,811,408.

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 $5,586,623. This cost of individual structures is outlined in Table 14-1. Capital cost estimates for this project have been developed by engineering consultancies responsible for project designs, 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 and see Appendix M).

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.

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). 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.

Table 14-1 Breakdown of capital costs, design costs and contingencies per structure (GHD, 2014a)

Table 14-2. Project implementation costs (GST exclusive)

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 operating strategy is yet to be finalised, Table 14-3 provides average and maximum annual costs to reflect the likely range of temporary pumping costs. Operation and maintenance are based on a 30 year timeframe and does not include asset renewal.

Table 14-3. Operating and maintenance costs

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.

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 DEPI 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
- G-MW.

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
- 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. his 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 G), 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 those discussed below (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 applied to 125 hectares of the project area.
- Improved native fish populations: the same studies reveal a community WTP for improvement in native fish populations, calculated at an estimated 0.2% 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 site represents 0.5% of this River Murray value, a value for increased water bird breeding to the Victorian community was developed.
- Increased recreation: Mallee CMA staff estimated that the Hattah Lakes North project was estimated to increase the net annual tourist visitor days to the site by 5,000 days[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 5,000 visitor days was estimated.

[4] Bennett et al (2007) found that annual household willingness to pay for improvement to the health of 1000 hectares of river red gum forests was $3.90 for Bairnsdale households and $1.20 for Melbourne residents (local residents identified no willingness to pay for this improvement. We adjust these values with CPI from 2007 to 2014

[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 this source value 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.

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

The economic value of these four[9] quantified economic benefits associated with the Hattah Lakes North project are presented in Table 14-1. 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	$0.24	$2.2
Native fish population	$0.24	$2.2
Frequency of colonial water-bird breeding	$0.18	$1.6
Recreation	$0.8	$7.4
Total	$1.48 million	$13.5 million

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

- Cultural heritage: There are more than 50 known archaeological sites in the Hattah Lakes North which may be impacted by the project, including scarred trees that depend on seasonal high river flows and natural inundation regimes, and are currently stressed. 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. However, increased visitation may have negative impacts on some sites, and as such no estimation of cultural heritage values has been undertaken.
- Apiarists: the large number of beehives that currently exist at Hattah Lakes North 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 Wallpolla Island can be estimated in terms of employment, output, wages and salary, and industry value added.

During the one year construction phase of the proposed works, the additional expenditure will result in $15.2 million of gross output and 36 jobs. After this construction phase, tourism expenditure and annual operations and maintenance expenditure will result in output of $0.9 million per annum and two additional jobs.

[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). 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.

These numbers illustrate the regional benefits of the project but are not proposed to be included in the cost-benefit analysis.

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 Hattah Lakes North Floodplain Management Project from 2012 to 2014. Communication and engagement activities conducted throughout the Business Case phase have included:

More than 115 face-to-face briefing sessions, meetings, presentations and on-site visits, engaging more than 325 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 Hattah Lakes North, as evidenced by the receipt of letters of support from:

- materially-affected land managers such as Parks Victoria
- partner agencies such as Goulburn-Murray Water
- adjacent private landholders
- Aboriginal stakeholders
- Regional Development Australia and Regional Development Victoria – Loddon Mallee
- local government (Mildura Rural City Council)
- industry groups
- tourism operators, and
- community groups such as Sunraysia Riverwatch.

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

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).

The strategy reflects the intent of the principles to be applied in environmental watering outlined in the Basin Plan (MDBA, 2012a). In addition, the strategy aligns with the directions of the Victorian Government's Environmental Partnerships policy (Victorian Government, 2012) and is also 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 strategy is informed by the IAP2's Public Participation Spectrum, which is designed to assist with the selection of the level of participation that defines the public's role in any community engagement program.

The Communication and Engagement Strategy includes:

- identification of key stakeholders of the Hattah North 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 Hattah Lakes North Communications and Engagement Strategy and the outcomes from the Business Case phase is provided in the following sections. The full Strategy is provided in Appendix I.

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; that is, 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 Hattah Lakes North project. For project stakeholders, the aim is to involve stakeholders in all phases of the Hattah Lakes North project (RMCG, 2014).

The engagement approach for Stakeholder Group 2 is one 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 Hattah Lakes North project (RMCG, 2014).

The engagement approach for Stakeholder Group 3 is one 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 Hattah Lakes North 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 Hattah Lakes North 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 MDBA G-MW	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:** Latje Latje, Tati Tati, Pearce Mob, Nyeri-Nyeri Weregaia Adjacent freehold landholders **Local community**: townships of Hattah, Nangiloc/Colignan, Wemen, Robinvale and Ouyen **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:** Kulkyne Way Landcare Group, Red Cliffs Community Landcare Group, Millewa Carwarp Landcare Group, Mallee Parks Consultative Group, Birdlife Australia (Mildura Branch), River Watch, Sunraysia Field Naturalists Club, Murray Darling Wetlands Working Group, Victorian National Parks Association **Indigenous organisations/groups:** North West Native Title Claimants,	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
	Murray Lower Darling Rivers Indigenous Nations (MLDRIN) **Other community groups/businesses:** Regional Development Australia and 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-Kulkyne Park and the Hattah-Kulkyne 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 Hattah Lakes North Communication and Engagement Strategy (Appendix I: 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: Hattah - Vinifera 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.	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. Planned ongoing engagement with project partners.	Letters of support for the project from partner agencies such as Goulburn-Murray Water and Parks Victoria. 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 project stakeholders.	Letters of support from Aboriginal stakeholders, adjacent freehold 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.

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, Sunraysia Branch Victorian Apiarists Association, Mildura West Inc, Sunraysia Riverwatch. 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 Hattah Lakes North 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 Hattah Lakes North Communication and Engagement Strategy [Appendix I: 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 Hattah Lakes North project. The project has high visibility among materially affected and adjacent landholders/managers, along with Aboriginal stakeholders and other interested parties. It is critical to the project that 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 Hattah Lakes North 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.	Inform	Accessible throughout implementation phase.
	Information package accessed on the Mallee CMA website (fact sheets, case studies, photos, contact information).		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 Hattah North 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 (2014c, Appendix J) and Golsworthy (2014, Appendix K) 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 Hattah North 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, 2014c).

The approvals required for Hattah North Floodplain Management Project are listed in Table 16-1.

Table 16-1. Regulatory approvals anticipated for Hattah Lakes North (GHD, 2014c)

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 Hattah Lakes North: Upstream from Banrock, Coorong and Riverland Ramsar sites Nine migratory waterbird species 18 nationally threatened species 1 community ecological community
Victorian legislation	
Environmental Effects Act 1978 **Referral**	Relevant to two of the six referral criteria for individual potential effects i.e. 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 which is likely to include an: offset strategy and 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 **Protected flora licence or permit**	Application for approval to remove protected flora within public land for non-commercial purposes. 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, 2014c):

- an offset strategy for native vegetation losses
- an environmental management framework
- a threatened species management plan
- 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, 2014c). 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 (that is, 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 Report has been prepared for this project (Bell, 2013, Appendix L). A desktop analysis indicated that there are six sites of Aboriginal significance within 100 m of proposed structures and field inspections identified one previously unrecorded site at Hattah Lakes North. Under the *Aboriginal Heritage Act 2006* the Hattah Lakes floodplain is specified as an area of cultural heritage sensitivity in accordance with several categories, and the preparation and approval of a Cultural Heritage Management Plan (CHMP) will be required prior to commencement of works.

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
- 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 Hattah North 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)
- 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
- ecology: review of the descriptions of ecological values, the ecological objectives and targets, and environmental water requirements.

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

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 J).

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.

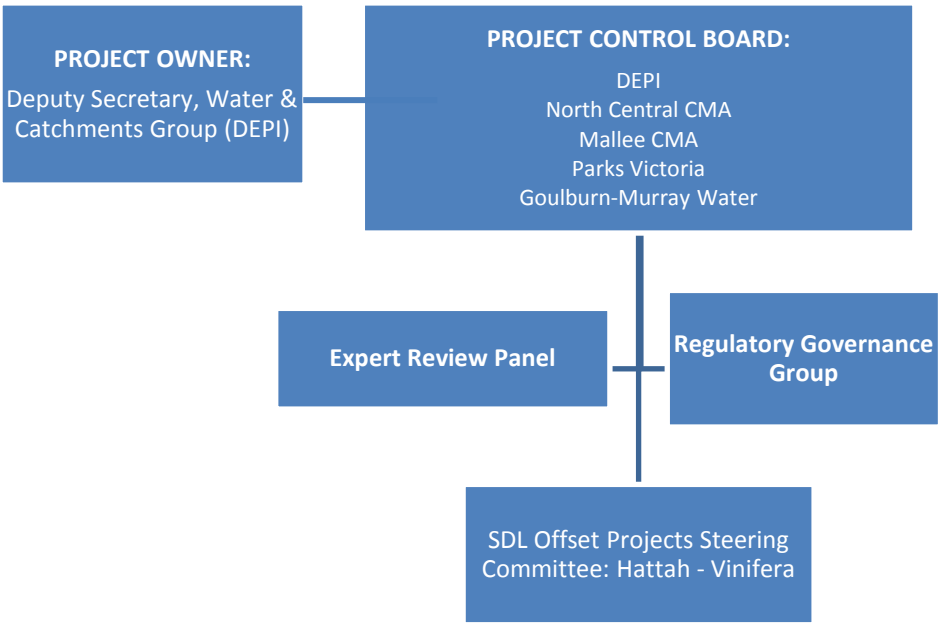


Figure 17-1. Governance arrangements during business case development.

SDL Offset Projects Steering Committee: Hattah - Vinifera

At the project level, development of the business case for the Hattah North Floodplain Management Project was overseen by the SDL Offset Projects (Hattah- Vinifera) 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
- 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)
- DEPI representative/s (land manager representative and coordinator of regional environmental advice and approvals)
- G-MW representative/s
- SA Water representative/s
- MDBA 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 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 TLM, 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
- 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
- consideration of any milestone or payment reporting that is likely to be required under all contractual funding arrangements associated with this supply measure
- a 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.

For the Hattah North site, the Operations Group membership will consist of partners and stakeholders, including the MDBA, DEPI, G-MW, 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 Hattah North will be a partnership between four agencies: Mallee CMA, DEPI, Parks Victoria and G-MW.

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.

G-MW

G-MW provides rural water and drainage services in northern Victoria. G-MW is the Victorian State Constructing Authority (SCA) for the MDBA. G-MW manages $4 billion of its own assets and a further $2 billion of MDBA assets to fulfil its functions. As SCA, G-MW was the delivery authority for the Hattah and Gunbower Living Murray Projects in Victoria. G-MW has the asset management and design and construction policies and controls in place to delivery against a large capital works program. These policies and controls will direct GG-MWMW's activities for the delivery of each of the SDL Offset projects.

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 Hattah Lakes 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 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 Hattah Lakes 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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
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 ensure the principal and client are not put at undue risk for natural events.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
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 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.	Low
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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Unclear roles and responsibilities	Unclear roles and responsibilities could hinder effective project development and construction.	Possible	Moderate	Moderate	Establish a MoU between all relevant agencies outlining roles and 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.	Low
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
- 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:

Hattah North proposed works and inundation extents.

Appendix B:

GHD 2014b. SDL Offsets - Fauna Survey Hattah North and Belsar Yungera. Irymple, Victoria. Report for the Mallee CMA.

Appendix C:

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Appendix D:

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Appendix E:

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Appendix F:

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Appendix G:

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Appendix H:

Hattah North letters of support.

Appendix I:

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Appendix J:

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Appendix K:

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

Appendix L:

Bell, 2013. Hattah Lakes Wetland System, Due Diligence Assessment. Report for the Mallee CMA.

Appendix M:

Expert Review Panel Reports.

Appendix A: Proposed works