	Title of measure	**Belsar-Yungera Floodplain Management Project**
	Proponent undertaking the measure	**Victoria**
	Type of measure	**Supply**
1.	**Confirmation**	
	Date by which the measure entered into or will enter into operation *Must be before 30 June 2024*	This environmental works project will be operational by 30 June 2024.
	Confirmation that the measure is not an 'anticipated measure' *'Anticipated measure' is defined in section 7 02 of the Basin Plan to mean 'a measure that is part of the benchmark conditions of development'*	Yes
	Confirmation that the proponent state(s) undertaking the measure agree(s) with the notification ***Basin Plan 7.12(3)(c)*** *Joint proposals will need the agreement of all proponents*	Yes.
2.	**Details of the measure**	
	Capacity of the measure to operate as a supply measure *'Supply measure' is defined in section 7.03 of the Basin Plan to mean 'a measure that operates to increase the quantity of water available to be taken in a set of surface water SDL resource units compared with the quantity available under the benchmark conditions of development'.*	Yes.
3.	**Description of the works or measure**	
	This supply measure will maintain and improve flora and fauna habitat values and provide periodic breeding opportunities for wetland species, such as fish, frogs and waterbirds. Managed flows will be able to be delivered to 2,370 hectares of highly valued floodplain, representing one third of the total area. The works can be operated flexibly to meet the water requirements of different vegetation communities, mimicking a broad range of River Murray flows up to 170,000 ML/ day. Through the construction of three large regulators, a series of smaller supporting regulators, track raising (levees) and a pipeline (to allow use of temporary pumps), this project will connect extensive areas of floodplain through tiered watering events. These works will make use of natural flow paths to increase the extent, frequency and duration of inundation from either Basin Plan flows or pumping during low flow events. A detailed description of the proposed works package is included in Chapters 3.2 and 12 of the business case **(Attachment B)**.	
4.	**Geographical location of the measure**	
	The Belsar-Yungera Floodplain is located on the River Murray floodplain, approximately 30 km upstream of the Euston weir, near Robinvale in North West Victoria.	
5.	**Representation of the project in the MDBA modelling framework**	
	The MDBA will represent the proposed infrastructure, operating strategies and water use in the MSM-BigMod model. A schematic of the model representation is shown at **Attachment A**. Spatial data provided by the proponent (derived using a hydro-dynamic model) describes the areas inundated through the operating of the works. The areas inundated are combined with the timing of modelled operation by the Environmental Outcomes Scoring Tool to quantify the change in environmental outcomes, relative to the Benchmark environmental outcomes.	

Level-Volume-Area relationship

The flow/inundation parameters were derived from LIDAR and the hydraulic model supplied by the Victorian Government. These parameters are modelled as shown below

Area 1: Upstream of ER1 Regulator			Area 2: Upstream of J1a regulator		
Level (mAHD)	Volume (ML)	Area (ha)	Level (mAHD)	Volume (ML)	Area (ha)
48.0	0.0	0.0	50.0	0.0	0.0
49.8	1.0	0.2	51.5	58.5	6.1
50.8	1220.7	133.6	52.0	144.4	22.7
51.4	3079.0	415.3	52.4	441.9	89.8
51.9	5672.3	732.6	52.7	1344.5	270.3
52.1	8570.0	1028.9	52.9	2553.0	415.0
52.3	15123.0	1444.0			

Area 3: Upstream of J1c regulator			Area 4: Lakes Powell and Carpul		
Level (mAHD)	Volume (ML)	Area (ha)	Level (mAHD)	Volume (ML)	Area (ha)
52.58	0.0	0.0	47.80	0.0	0.0
52.96	0.1	0.0	50.68	686.0	106.5
53.25	32.1	26.6	52.06	2309.2	126.1
53.3	78.3	36.0	52.17	2444.1	126.9
53.47	239.8	68.8	52.29	2610.4	130.6
53.59	354.8	82.0	52.46	3014.9	181.8
53.67	432.5	89.6	52.60	3452.5	198.3
53.81	545.8	100 9	52.61	3482.7	199.4
53.92	633.3	107.6	52.78	4373.5	304.0
54.01	712.0	113.2	52.86	5123.2	382.0
54.08	786.6	117.8	52.94	6141.6	477.4
54.15	863.5	122.7	52.99	6233.8	485.1
54.20	946.1	132.7	53.13	7943.4	615.4
54 25	1030.4	141.0	53.21	8599.5	633.1
54.30	1121.2	152.4			

Interaction between river flows and site inflows

There is no existing representation of this project site in MSM-Bigmod. Two new branch relationships developed to describe natural hydrologic characterises to the site depending on river flows downstream of Boundary Bend were derived from the hydraulic model supplied by the proponent and are modelled as shown below

DS Boundary Bend (ML/d)	Flow to Area 2 (ML/d)	Yungera Creek to Area 1 (ML/d)
10000	0.0	0.0
29000	0.0	10.0
40000	100.0	1850.0
50000	400.0	3940.2
60000	1402.6	5945.3
70000	2611.0	8362.1
80000	4025.2	11190.6
85000	4783.7	12707.7
90000	5593.8	14327.7
100000	7419.6	17979.5
110000	9451.3	22042.9
120000	11688.9	26517.9
130000	14132.2	31404.7
140000	16781.4	36703.0
150000	19636.4	42413.1
160000	22697.3	48534.7
170000	25963.9	55068.1
200000	35963.9	75068 1

Return flow from the site to the river

Once inflows to the site are calculated, the model applies hydrologic routing to calculate level, volume and inundation for key floodplain storage areas within the site There are 4 wetlands included for this site, 2 lakes (Areas 3 and 4) and 2 weir (Areas 1 and 2) storages. For a lake storage, a flow-level relationship at offtake location is required to determine flow direction between the offtake and the lake with amount of water movement controlled by conveyance. For a weir storage, given inflow from a branch or an upstream reach, flow behaviours are calculated by flow-level relationship at downstream of the weir. Using this information, the model calculates storage volume or water level so that downstream level is lower than or equal to the weir pool level.

For storage routing, the following relationships have been used:

The relationship between flow and level at downstream of the weir storages in Belsar-Yungera Forest is below

Area 1		Area 2		Area 3		Area 4	
Flow (ML/d)	Level (mAHD)	Flow (ML/d)	Level (mAHD)	Flow (ML/d)	Level (mAHD)	Flow (ML/d)	Level (mAHD)
0.0	48.00	0.0	50.0	0	48.000	0	47.391
975 0	49.80	100.0	51 5	20000	49.740	20000	50.504
1950.0	50 80	400.0	52.0	40000	50.710	40000	52.061
4340.2	51.40	1402.6	52.4	50000	51.270	50000	52.591
7347.9	51.85	2611.0	52.7	60000	51.655	60000	52.961
10973.1	52.10	4025.2	53.0	70000	51.950	70000	53.251
15215.7	52.35	4783.7	53.1	80000	52.180	80000	53.476
17491.4	52.43	5593.8	53.2	85000	52.300	85000	53.586
19921.5	52 50	7419.6	53.3	90000	52.370	90000	53.666
25399.1	52.65	9451.3	53.4	100000	52.525	100000	53.811
31494.2	52.80	11688.9	53.5	110000	52.680	103000	53.921
38206.8	52.90	14132.2	53.5	120000	52.830	106000	54 011
45536.9	53.00	16781.4	53.6	130000	52.910	115000	54.081
53484.4	53.10	19636.4	53.7	140000	52.990	124000	54.146
62049.5	53.20	22697.3	53.7	150000	53.070	134000	54.201
71232.0	53.26	25963.9	53.8	160000	53.150	144000	54.256
81032 0	53.30	35963.9	53.8	170000	53.230	154000	54.306
111032.0	53.33			200000	53.470	184000	54.426

Channel conveyance for lakes is below

Area 3		Area 4	
Level (mAHD)	Inlet Capacity[1]	Level (mAHD)	Inlet Capacity[1]
52.58	0.0	47.80	0.0
52 96	61.6	50.68	84.9
53.25	81.9	52.06	103.1
53.30	84.8	52.17	104.5
53.47	94.3	52.29	105.9
53.59	100.5	52.46	107.9
53.67	104.4	52 60	110.0
53 81	110.9	52.61	120.0
53.92	115.8	52.78	130.0
54.01	119.6	52 86	140.0
54.08	122.5	52.94	150.0
54.15	125.3	52.99	160.0
54.20	127.3	53 13	170.0
54.25	129.2	53.21	180.0
54.30	131.1		

[1] Inlet Capacity, C is defined using Manning's equation as below

$$Q = \frac{1}{n} A R^{2/3} S^{1/2} = \frac{1}{n} A R^{2/3} \sqrt{\frac{\Delta h}{L}} = C\sqrt{\Delta h}$$

where Q = flow, n= Manning's roughness coefficient, A= area of offtake channel, R= hydraulic radius, S = water surface gradient, Δh = level difference between offtake point and lake and L= length of channel.

Surface water loss relationships

No seepage loss has been applied in the hydraulic model. A standard loss rate for evaporation is applied based on monthly average data from climate station at Hume. A constant seepage loss rate of 2mm/day has been applied for the site.

6. Representation of each operating strategy in the MDBA modelling framework.

Chapter 9 and Chapter 10 of the Business Case (**Attachment B**) outline a series of proposed operating regimes. For modelling, the information outlined in the table below has been used for operating strategies.

Operating Strategy	Flow to start operation (ML/d)	Regulator status	Frequency	Resilience period	Duration	Natural equivalent flow (ML/d)	Through flow/pump rate (ML/d)
Fresh*	10,000	All open	Annually	2	3 months	30,000	-
Intermediate	30,000	Open ER3 , maintain ER1 and S7 at 48.35 mAHD	8 in 10 yrs	3	3 months	50,000	500
Maximum	50,000	Open ER3 , maintain ER1 and S7 at 52.3 mAHD	5 in 10 yrs	S	2 months	90,000	500
Max + Lakes	90,000	52mAHD @ Lake Powell and 53mAHD @ lake Carpul	1 in 4 yrs	6	1 month	170,000	150

* Not modelled as it doesn't provide any additional benefit to the current regime

7. Spatial data describing the inundation extent associated with the operation of the measure

The total area of inundation for each of the operating strategies is given in the table below.

Operation strategy	Inundation area (ha)
Belsar-Yungera Fresh (BYF)	39
Belsar-Yungera Intermediate (BYI)	745
Belsar-Yungera Max (BYM)	2092
Belsar-Yungera Max + Lakes (BYL)	2370

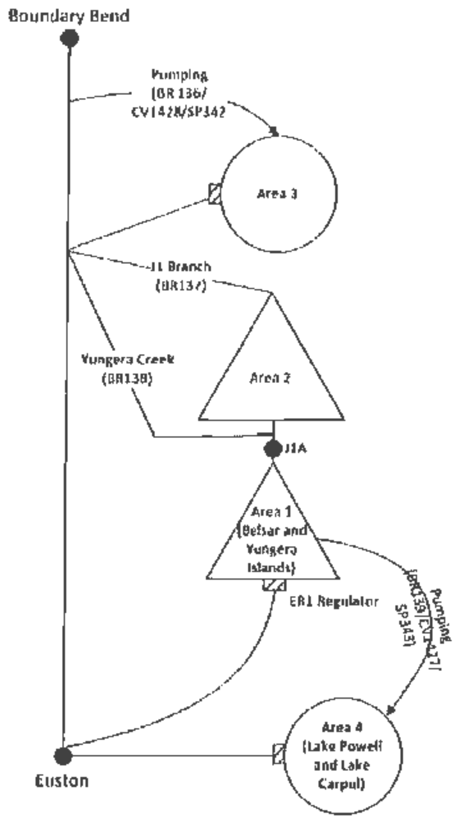
For the purpose of calculating scaling factors for the Ecological Outcomes scoring method, the maps of the inundation areas associated with the works were combined with maps of SFI flow bands and maps representing the ecological elements used in the scoring method. The areas for the resulting hydrological assessment units (HAU) are provided in **Attachment B**. In this case the areas for the works represent the inundation area that is *additional* to the area already inundated by a nested work For example, if BYL is operated, the inundation area associated with the operation of BYM is also inundated, but figures in the table below refer to the additional area the BYL operation would inundate.

8.	**Surface water SDL resource units affected by the measure**
	This measure identifies all surface water resource units in the Southern Basin region as affected units for the purposes of notifying supplying measures. The identification of affected units does not constitute an agreement between juristictions on apportioning the supply contribution, which will be required in coming months.
9.	**Details of relevant constraint measures**
	Not directly linked to any specific constraint measures but implementing a confirmed package of constraint measures may have implications for the proposed operating strategy.

Attachments:

A	MDBA	Belsar Yungera Floodplain Management project representation in Murray model
B	MDBA	Spatial data describing the inundation extent associated with the operation of the measure
C	Mallee CMA, December 2014	Phase 2 Assessment Supply Measure Business Case: Belsar-Yungera Floodplain Management Project

Attachment A - Belsar Yungera Floodplain Management project representation in Murray model (based on Bigmod Rev 255)



Area of inundation for BYF operation

Inundation area (ha) for BYF	SFI Flow Bands						
Ecological Element	**40,000**	**50,000**	**70,000**	**85,000**	**120,000**	**150,000**	**>150,000**
General health and abundance - all Waterbirds	15.0	18.0	4.0	1.0	0.0	0.0	1.0
Bitterns, crakes and rails	14.7	17.3	3.6	0.9	0.3	0.2	1.4
Breeding - Colonial-nesting waterbirds	15.0	18.0	4.0	1.0	0.0	0.0	1.0
Breeding - other waterbirds	14.7	17.3	3.6	0.9	0.3	0.2	1.4
Redgum Forest	2.1	4.4	0.7	0.2	0.1	0.0	0.1
Redgum Woodlands	4.0	2.0	0.5	0.1	0.0	0.0	0.3
Forests and Woodlands: Black Box	6.3	6.3	1.5	0.4	0.1	0.1	0.8
Lignum (Shrublands)	0.2	0.2	0.0	0.0	0.0	0.0	0.0
Tall Grasslands, Sedgelands and Rushlands	14.7	17.3	3.6	0.9	0.3	0.2	1.4
Benthic Herblands	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Short lived fish	14.7	17.3	3.6	0.9	0.3	0.2	1.4
Long lived fish	15.0	18.0	4.0	1.0	0.0	0.0	1.0

Table 8 Additional area of inundation for BYI operation

Inundation area (ha) for BYI	SFI Flow Bands						
Ecological Element	**40,000**	**50,000**	**70,000**	**85,000**	**120,000**	**150,000**	**>150,000**
General health and abundance - all Waterbirds	25.0	34.0	163.0	167.0	48.0	31.0	238.0
Bitterns, crakes and rails	6.1	6.5	6.1	19.2	0.8	0.7	17.0
Breeding - Colonial-nesting waterbirds	25.0	34.0	163.0	167.0	48.0	31.0	238.0
Breeding - other waterbirds	6.1	6.5	6.1	19.2	0.8	0.7	17.0
Redgum Forest	2.3	2.4	1.1	2.3	0.3	0.2	0.8
Redgum Woodlands	7.6	7.8	3.6	3.7	1.1	1.2	7.6
Forests and Woodlands: Black Box	10.1	17.5	90.0	67.1	14.1	9.3	126.3
Lignum (Shrublands)	1.7	1.2	64.7	83.0	29.0	16.7	84.2
Tall Grasslands, Sedgelands and Rushlands	6.1	2.9	5.7	2.6	0.6	0.6	16.8
Benthic Herblands	0.0	3.6	0.4	16.6	0.1	0.1	0.3
Short lived fish	6.1	6.5	6.1	19.2	0.8	0.7	17.0
Long lived fish	25.0	34.0	163.0	167.0	48.0	31.0	238.0

Table 9 Additional area of inundation for BYM operation

Inundation area (ha) for BYM	SFI Flow Bands						
Ecological Element	**40,000**	**50,000**	**70,000**	**85,000**	**120,000**	**150,000**	**>150,000**
General health and abundance - all Waterbirds	3.0	3.0	44.0	203.0	45.0	62.0	987.0
Bitterns, crakes and rails	0.7	0.4	3.6	25.7	2.8	4.2	51.4
Breeding - Colonial-nesting waterbirds	3.0	3.0	44.0	203.0	45.0	62.0	987.0
Breeding - other waterbirds	0.7	0.4	3.6	25.7	2.8	4.2	51.4
Redgum Forest	0.8	0.3	5.2	1.1	0.2	0.1	5.5
Redgum Woodlands	0.9	0.8	10.9	4.5	0.8	0.9	18.3
Forests and Woodlands: Black Box	0.6	1.7	22.7	143.6	30.1	34.3	639.0
Lignum (Shrublands)	0.2	0.2	1.1	62.3	14.6	18.5	238.3
Tall Grasslands, Sedgelands and Rushlands	0.7	0.3	3.2	13.8	2.1	3.7	49.2
Benthic Herblands	0.0	0.0	0.4	11.9	0.7	0.6	2.2
Short lived fish	0.7	0.4	3.6	25.7	2.8	4.2	51.4
Long lived fish	3.0	3.0	44.0	203.0	45.0	62.0	987.0

Table 16 Additional area of inundation for BYL operation

Inundation area (ha) for BYL	SFI Flow Bands						
Ecological Element	**40,000**	**50,000**	**70,000**	**85,000**	**120,000**	**150,000**	**>150,000**
General health and abundance - all Waterbirds	0.0	0.0	0.0	0.0	0.0	0.0	278.0
Bitterns, crakes and rails	0.0	0.0	0.0	0.0	0.0	0.0	185.4
Breeding - Colonial-nesting waterbirds	0.0	0.0	0.0	0.0	0.0	0.0	278.0
Breeding - other waterbirds	0.0	0.0	0.0	0.0	0.0	0.0	185.4
Redgum Forest	0.0	0.0	0.0	0.0	0.0	0.0	5.9
Redgum Woodlands	0.0	0.0	0.0	0.0	0.0	0.0	5.5
Forests and Woodlands: Black Box	0.0	0.0	0.0	0.0	0.0	0.0	80.4
Lignum (Shrublands)	0.0	0.0	0.0	0.0	0.0	0.0	44.3
Tall Grasslands, Sedgelands and Rushlands	0.0	0.0	0.0	0.0	0.0	0.0	185.4
Benthic Herblands	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Short lived fish	0.0	0.0	0.0	0.0	0.0	0.0	185.4
Long lived fish	0.0	0.0	0.0	0.0	0.0	0.0	278.0

Sustainable Diversion Limit Adjustment

Phase 2 Assessment

Supply Measure Business Case:

Belsar-Yungera Floodplain Management Project

mallee

Executive Summary

The *Belsar-Yungera 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 a natural inundation event, 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 Belsar-Yungera Floodplain Complex is located approximately 30 kilometres upstream of Euston Weir, near Robinvale in north-west Victoria. The floodplain complex comprises Belsar and Yungera Islands, which are formed by anabranches of the River Murray, including Narcooyia, Bonyaricall and Yungera Creeks. On the southern limit of the Belsar-Yungera floodplain lie two large ephemeral wetlands, Lakes Powell and Carpul, which currently rely on medium to high flows across the islands to fill (GHD, 2013).

The *Belsar-Yungera Floodplain Management Project* supports an array of flora and fauna as the site has complex and diverse habitat; due to the integration of two environment types, the central river red gum forest and lower Murray floodplain. The floodplain is ecologically significant due to its proportion of high-value forest and wetland habitats, which support a number of nationally threatened species such as the regent parrot (*Polytelis anthopeplus monorchoides*), the white-bellied sea eagle (*Haliaeetus leucogoster*), growling grass frog (*Litoria raniformis*), Murray cod (*Maccullochella peelii*) and other species of conservation significance.

Among the most important values at the site are the intact remnants of river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) communities associated with Lakes Powell and Carpul and the Narcooyia and Bonyaricall creeks.

The frequency and duration of inundation events of the floodplain complex are influenced by regulation of the River Murray. The flow regime of Narcooyia, Bonyaricall and Yungera creeks has also been altered to maintain a supply of irrigation water to landholders south of the complex. The natural flow patterns have been significantly altered and now are not sufficient to meet the needs of the Belsar-Yungera floodplain ecosystem.

The *Belsar-Yungera Floodplain Management Project* lies largely in public land managed by Parks Victoria and includes Murray River Reserve and Lakes Powell and Carpul Nature Conservation Reserve. Some land in the southern part of the project area is private land managed for conservation purposes.

Through the construction of three large regulators, a series of smaller supporting regulators, track raising[1] (levees) and a pipeline (to allow use of temporary pumps), this project will connect extensive areas of floodplain through tiered watering events. These works will make use of natural flow paths to increase the extent, frequency and duration of inundation from either Basin Plan flows or pumping during low flow events.

[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.

Watering will occur at a landscape scale, restoring ecosystem function for more than 2370 hectares (ha) of highly valued floodplain mimicking flows of 110,000 to 170,000 ML/ day across some areas of the floodplain.

These flows are well above the anticipated increase in River Murray flows delivered through the implementation of the Murray-Darling Basin Plan.

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. In-principle support for the progression of the project has been given by materially affected stakeholders, such as Parks Victoria and local irrigators, 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.

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

Project risks have been comprehensively analysed and are well known. They can be mitigated through established management controls that have been successfully applied to previous watering projects by the Mallee CMA and project partners, together with the Murray-Darling Basin Authority (MDBA), the 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 $55,632,428 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
RiMFIM	River Murray Floodplain Inundation Model
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

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
m AHD	Elevation in metres with respect to the Height Datum
m/s	Metres per second
ML	Megalitres
ML/d	Megalitres per day
m	Metres
mm	Millimetres
mS/cm	Millisiemens per centimetre
µS/cm	Microsiemens per centimetre
$M	Million dollars

1. Introduction

1.1 Context

This Business Case for the *Belsar-Yungera 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 including:

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

These measures will work in conjunction with proposed altered river operations and existing environmental infrastructure to deliver the environmental outcomes of the Basin Plan, using much lower volumes of water.

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

1.2 Forest overview

The Belsar-Yungera Floodplain Complex is located within the lower Murray floodplain, approximately 30 kilometres (km) upstream of Euston Weir, near Robinvale in north-west Victoria. The area is ecologically significant as it provides a highly diverse ecotone (a transitional area between two different ecosystems), between the densely forested riverine environment and the more open lower Murray floodplain.

The floodplain complex includes Belsar and Yungera Islands, which are downstream of the Murrumbidgee, Wakool and River Murray junctions. The islands are formed by the Narcooyia, Bonyaricall and Yungera creeks (Figure 1-2). Lakes Powell and Carpul are ephemeral wetlands that lie to the south of the complex. These lakes and their surrounds are protected conservation reserve that are highly dependent on natural inundation from Bonyaricall Creek. Both lakes are recognised for their high ecological value in providing habitat for established stands of black box and river red gum communities.

The project area provides important breeding sites for the *Environmental Protection and Biodiversity Conservation Act* 1999 (EPBC) listed regent parrot (*Polytelis anthopeplus monarchoides*), and high quality fish habitat with deep holes and complex woody debris for the EPBC - listed Murray cod (*Maccullochella peelii*), as well as freshwater hardyhead (*Craterocephalus stercusmescarum fulvus*) and golden perch (*Macquaria ambigua*).

The ecological health of the Belsar-Yungera Floodplain Complex has steadily declined due to the altered flow regimes caused by river regulation and drought. A reduction in inundation frequency, duration and extent has led to adverse impacts on riparian and floodplain vegetation communities, along with fish populations, waterbird communities and other fauna which rely on this area for habitat.

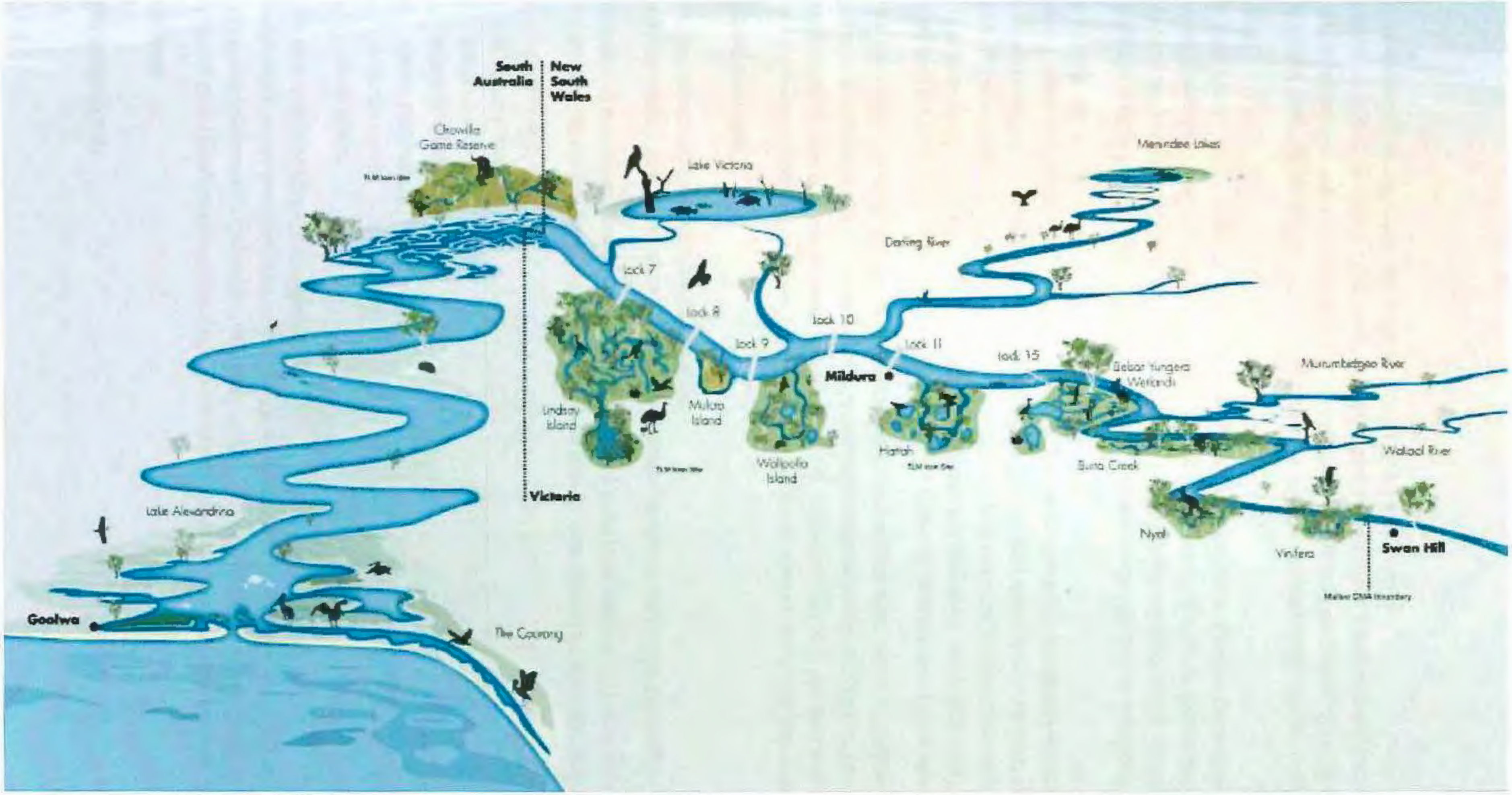


Figure 1-1. Conceptual diagram showing the distribution of sites across the Mallee CMA region and the longitudinal connection to the lower Murray region

Proposed supply measure sites include Vinifera, Nyah, Burra Creek, Belsar-Yungera, Hattah (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.

1.3 Land tenure

The Belsar-Yungera Floodplain Complex is located largely within public land and includes Murray River Reserve and Lakes Powell and Carpul Nature Conservation Reserve (Ecological Associates, 2014). Some land in the southern part of the complex is private land managed for conservation.

The reserve is managed by Parks Victoria and is highly valued for recreation activities such as camping, fishing, canoeing, trail-bike riding and horse riding (DSE, 2004).

Land tenure at Belsar-Yungera is shown in Figure 1-2 below.

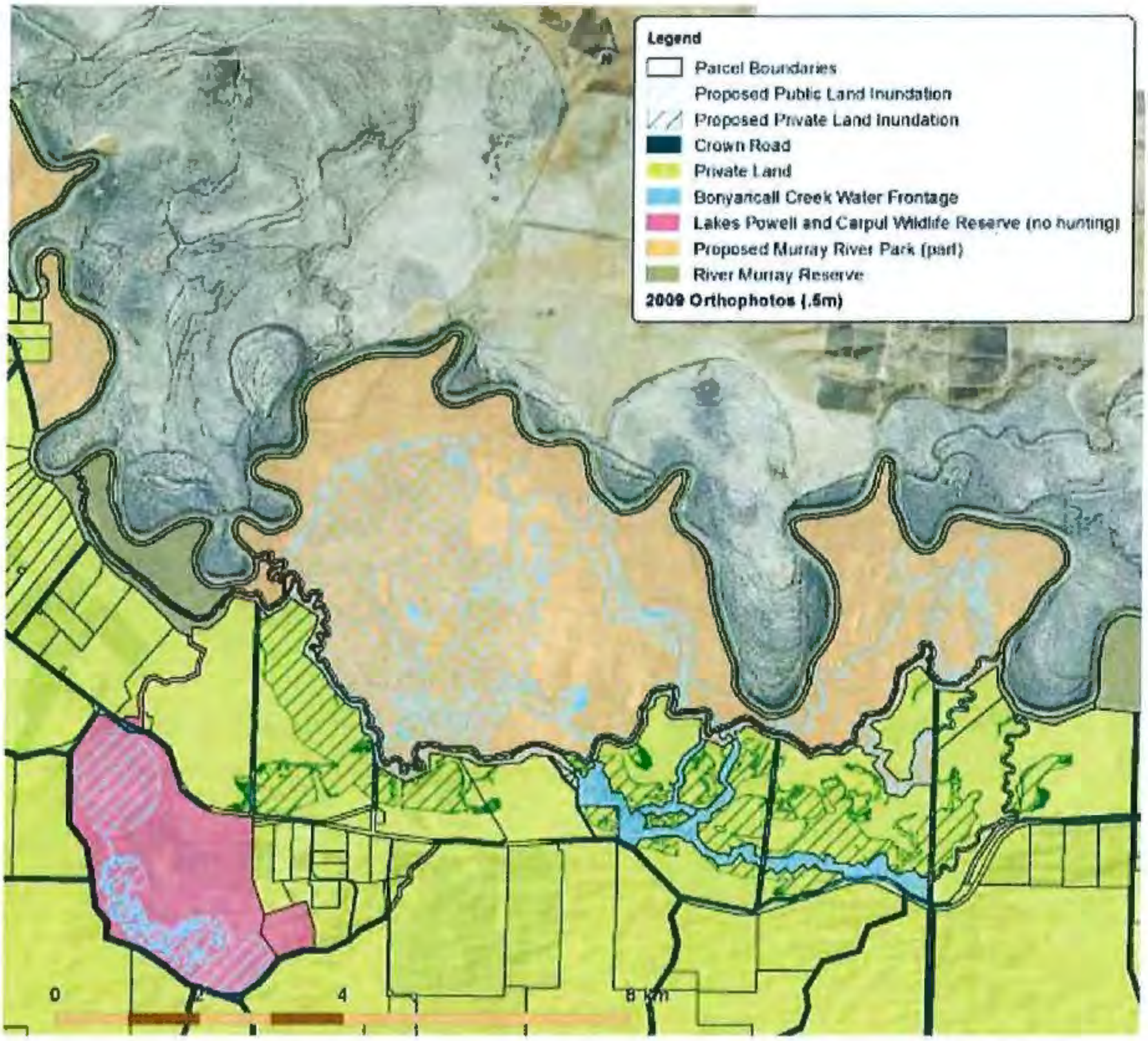


Figure 1-2: Land tenure boundaries in the Belsar-Yungera floodplain complex

1.4 The proposal

In response to the evident decline in the ecological health of the Belsar-Yungera Floodplain Complex, localised environmental watering has already been undertaken using temporary infrastructure, resulting in positive ecological outcomes and strong community support. For these benefits to be replicated and extended into the future, a broader-scale, more cost-effective and targeted solution is required to protect and restore the ecological values of this site.

A range of options were investigated to address the changes to hydrology to achieve defined ecological objectives. Feasibility, cost effectiveness and ability to meet objectives have been considered in the analysis of all options. This has resulted in the development of environmental works and measures that optimises costs, achieves the ecological objectives the Belsar-Yungera Floodplain Complex.

Through the construction of three large regulators, a series of smaller supporting regulators, track raising[2] and a pipeline, this project will connect many parts of the floodplain through tiered watering events (Figure 1-3). These works will use the natural shape of the landscape to increase the frequency, extent and duration of inundation utilising Basin Plan flows, while providing the option to supplement watering events with temporary pumping when required.

This proposed supply measure will maintain and improve flora and fauna habitat values and provide periodic breeding opportunities for wetland species such as fish, frogs and waterbirds. Managed flows will be able to be delivered to 2370 ha of highly valued floodplain, representing one third of the total area. The works can be operated flexibly to meet the water requirements of different vegetation communities, mimicking a broad range of River Murray flows up to 170,000 ML/ day.

The overall objective of water management at Belsar Yungera is:

"to restore the key species, habitat components and functions of the Belsor Yungera ecosystem by providing the hydrological environments required by indigenous plont and animal species and communities".

This will be achieved by:

- restoring habitat linkages between the river and Narcooyia Creek for Murray cod and other native fish
- enhancing native fish habitat by improving the productivity of riparian zones and wetlands
- restoring semi-permanent wetlands capable of supporting growling grass frog
- maintaining lignum shrubland as a frequently flooded and productive habitat for fish and waterbirds
- restoring floodplain productivity to maintain resident populations of vertebrate fauna including carpet python and bats
- intermittently providing productive lake habitat for hundreds of waterbirds
- contributing to the carbon requirements of the River Murray channel ecosystem.

A schematic representation of the landscape features, planned works and inundation at Belsar-Yungera is provided as Figure 1-2.

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

[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.

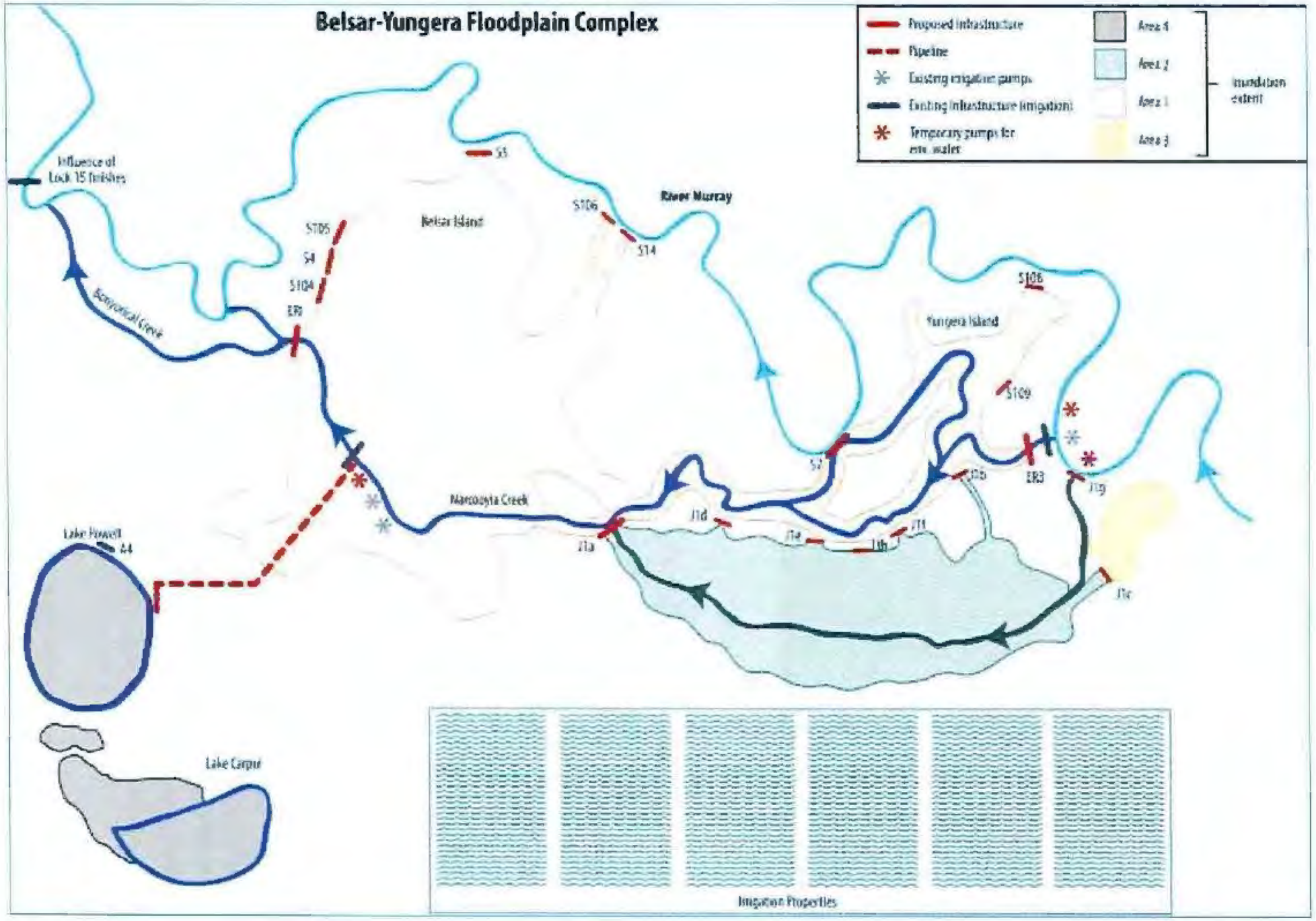


Figure 1-3: Spatial representation of planned works and inundation at the Belsar-Yungera site. Diagram is not to scale

1.5 Project development

The feasibility study and business case for the proposed Belsar-Yungera 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 (DEPI), Parks Victoria and Goulburn-Murray Water, through funding from the Commonwealth Government.

This proposal draws on a decade of collective experience from all project partners in the construction of previous 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 Belsar-Yungera project over the last two years (2012-2014). Consultation has been undertaken with Aboriginal stakeholder groups, land managers, key partner agencies, and targeted community groups. The project has high visibility among materially affected and 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 Belsar-Yungera Floodplain project and ensuring it will continue to be a success.

Lake Powell remained dry in 2011 during high river flows of approximately 70,000 ML/day

2. Eligibility (Section 3.4)

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

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

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

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

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

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

Narcooyia Creek, part of the Belsar-Yungera Floodplain Complex

3. Project Details (Section 4.1)

3.1 Description of proposed measure, including locality map

The *Belsar-Yungera Floodplain Management Project* is a supply measure project located on the River Murray floodplain, approximately 30 km upstream of the Euston weir, near Robinvale in north-west 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.

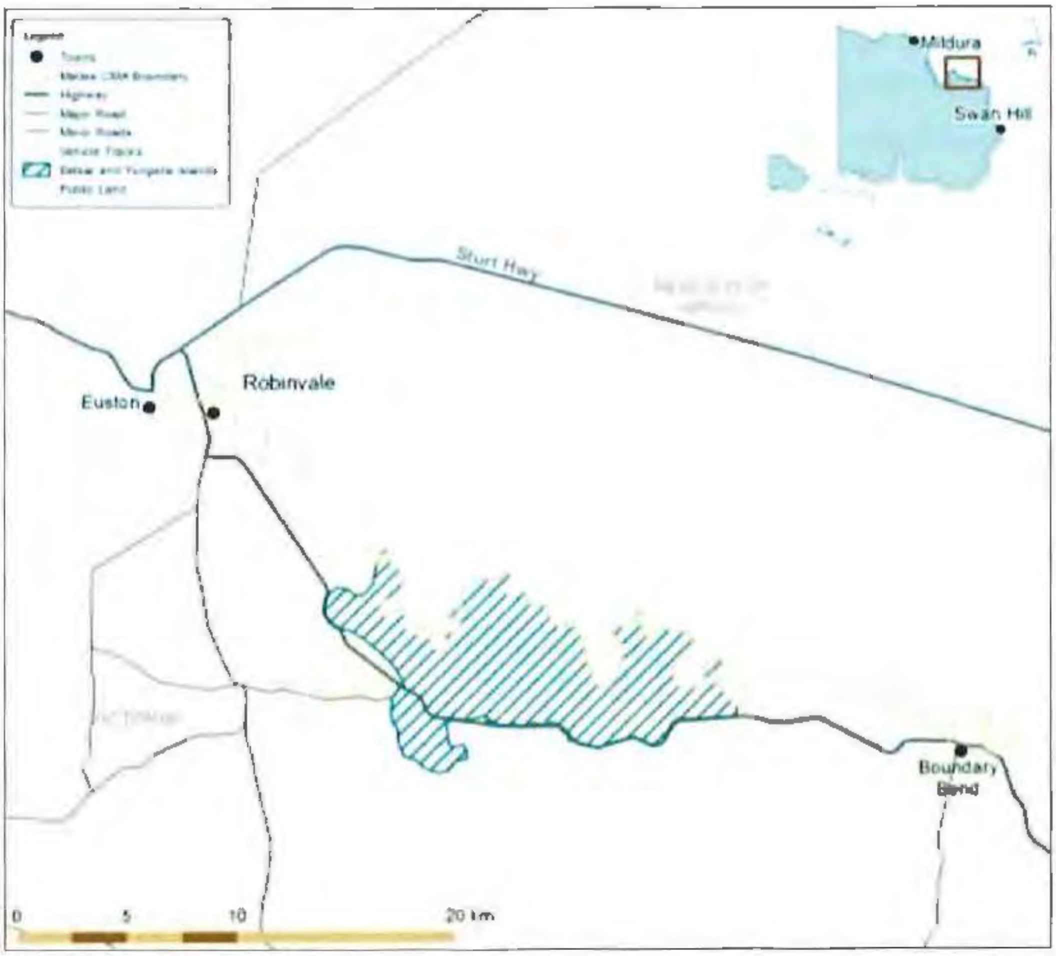


Figure 3-1. Location of the *Belsar-Yungera Floodplain Management Project* (Mallee CMA, 2014)

The project will restore the integrity and productivity of the floodplain ecosystem by reinstating a more natural frequency, duration and extent of inundation.

These works will inundate 2,370 ha of floodplain, wetlands and river benches within Belsar-Yungera (Figure 3-2). Some inundation of private land will occur during operation of the works.

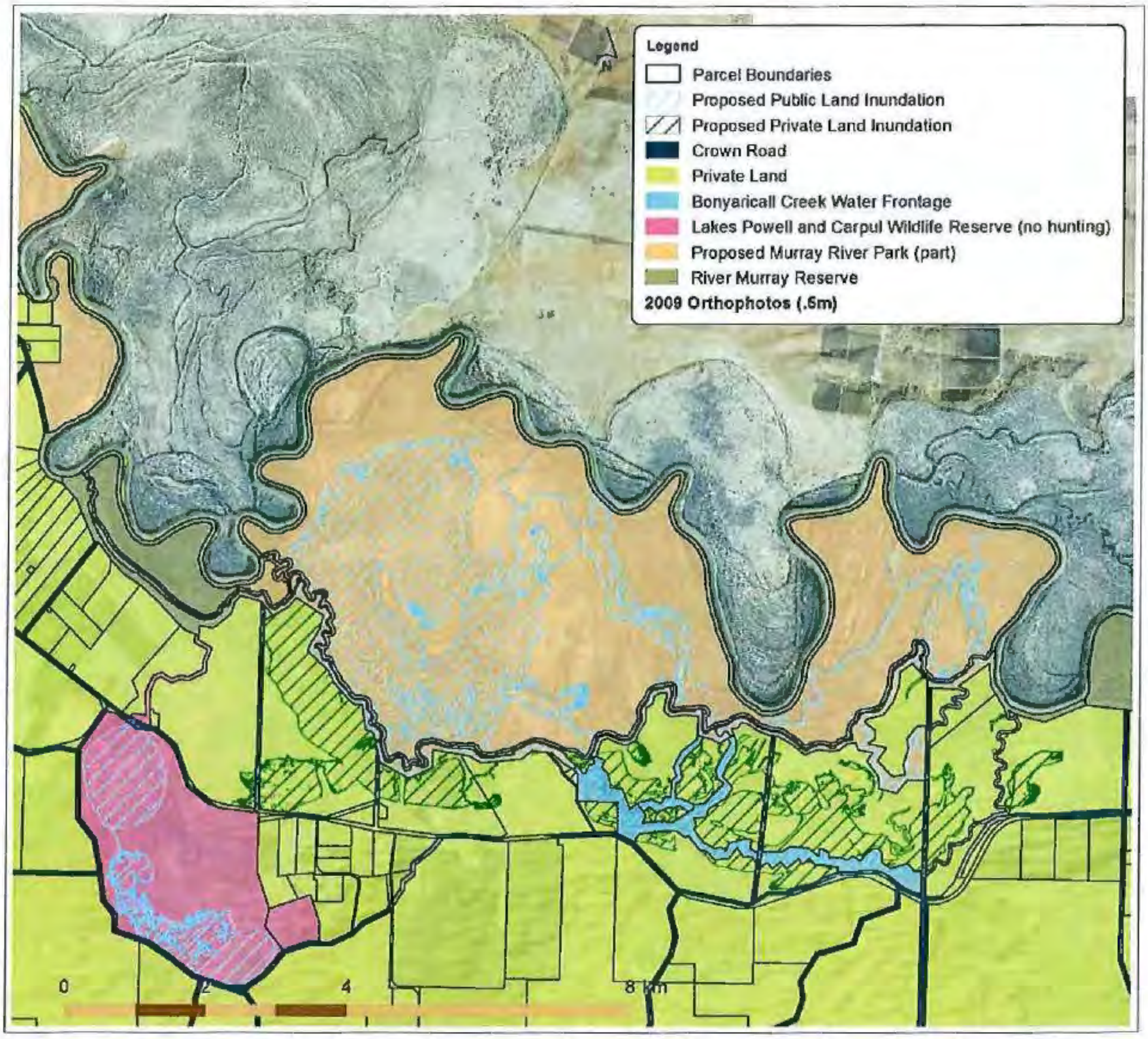


Figure 3-2. Proposed inundation according to land tenure

Figure 3-2 shows that the proposed works inundate a significant area (770 ha) of private land when operated to achieve the maximum inundation extent. Some of this land has been previously flooded during managed environmental watering events with the agreement of the affected landholders.

A significant proportion of the private land to be inundated is protected either under conservation covenants or as an offset for land clearing associated with nearby irrigation developments. In addition to the areas of inundation shown in Figure 3-2 an easement in favour of the asset manager will be along the alignment of the proposed pipeline where it crosses private property.

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 all affected landholders who have generally been supportive of the project.

3.2 Environmental works and measures at point locations

The supply measure works for the *Belsar-Yungera Floodplain Management Project* comprise three large environmental regulators (with one incorporating a vertical slot fishway), 12 containment regulators, 2 culverts, 3.6 km of raised track (levees) and a 4 km low pressure pipeline. The proposed supply measure at Belsar-Yungera involves environmental works across four distinct areas:

- Area 1 includes the ER1, ER3 and S7 regulators, their supporting levees and minor regulators, which will enable inundation of Belsar-Yungera utilising Basin Plan flows, supplemented by temporary pumping when required.
- Areas 2 and 3 include the J1 and J1C structures, which will be used to inundate the floodplain south of Belsar and Yungera Islands, via temporary pumping when required.
- Area 4 includes Lakes Powell and Carpul, which can be inundated by delivering water from Area 1 via temporary pumping and a pipeline.

Figure 3-2 illustrates the extent of inundation that will be achieved in each of the four areas.

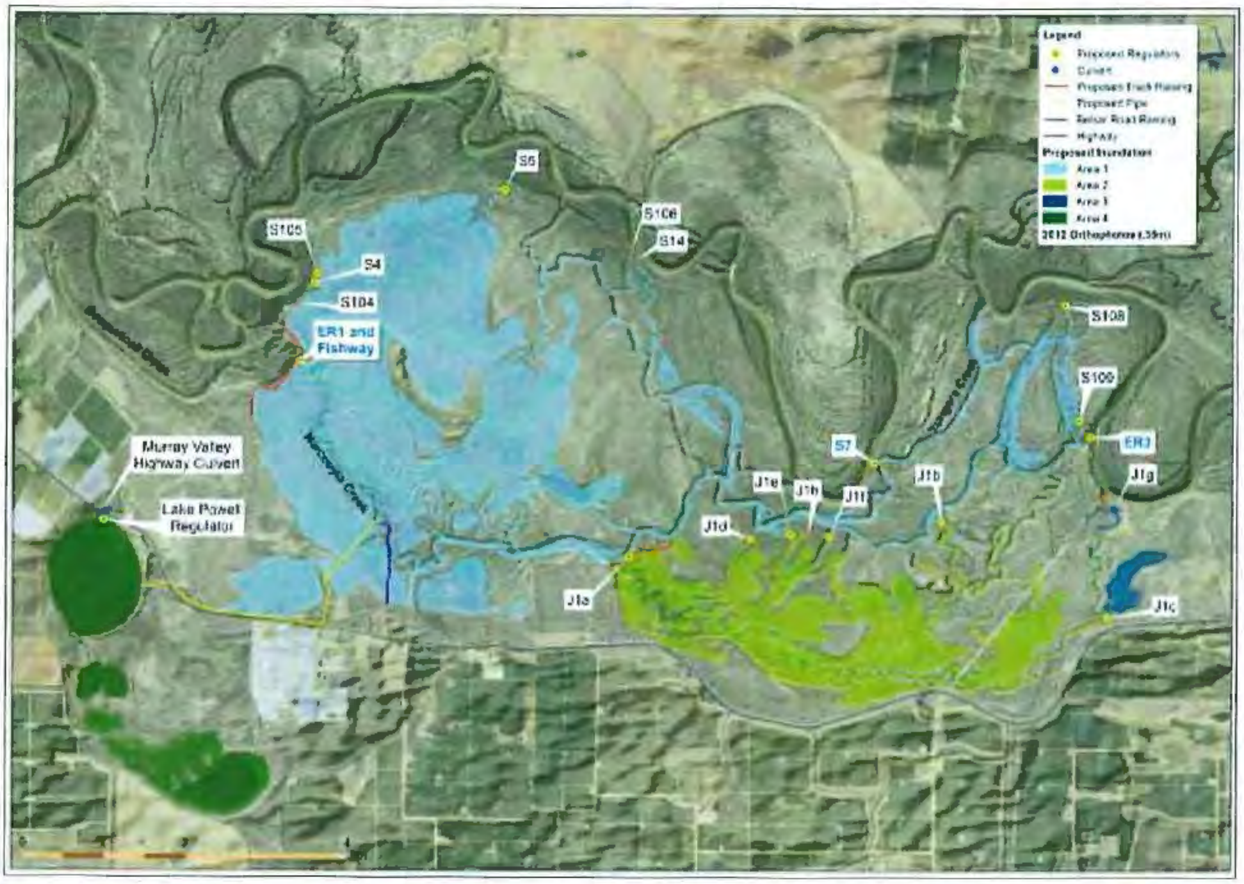


Figure 3-2. Overview of proposed works and inundation extent of the *Belsar-Yungera Floodplain Management Project*

Impediments to natural flow created by existing irrigation and road infrastructure will also be reduced to improve natural connectivity and maximise opportunities to benefit from increased Basin Plan flows.

A Fish Passage Workshop was held on 16 July 2014, which included key fish ecologists. Based on recommendations from this workshop, a fishway will be provided as part of the ER1 regulator to manage fish passage during operation of the works through Narcooyia Creek providing connection back to the River Murray. Smaller regulators have been designed to provide passive fish passage.

The operation of works alters the hydraulic gradient of these sites and as such, a range of flow equivalents is specified for each inundation area.

Area 1 works

The proposed works in Area 1 include three main regulators: ER1 incorporating a fishway, ER3 and S7, along with eight supporting structures comprising minor regulators and track raising sections. Two long sections of track raising are required either side of ER1 to enable water to be held at 52.3 m AHD.

Area 1 works will enable inundation of 1,535 ha of Belsar-Yungera. This will achieve inundation levels equivalent to a River Murray flow of up to 85,000 ML/d, utilising Basin Plan flows, supplemented with temporary pumping when required (Jacobs, 2014; Ecological Associates, 2014).

Additional works include:

- Two hard stands for a temporary pump, located in close proximity to ER3, providing the primary location for delivering water to all four sections in the absence of high River Murray flows
- Belsar Road will be raised to provide access to private pump infrastructure owned by Narcooyia Creek irrigators that would otherwise be limited by Area 1 inundation.

Area 2 works

The proposed works in Area 2 (Lower J1 Creek) include two main regulators at the downstream end of the creek (J1a structure) and five supporting structures to manage breakout areas. Two levees are required either side of the J1a structure to enable water to be held at 52.9 m AHD.

Area 2 works will enable inundation of 524 ha of floodplain south of Belsar-Yungera. This will achieve inundation levels equivalent to 85,000 ML/d River Murray flows, utilising Basin Plan flows, supplemented with temporary pumping when required (Jacobs, 2014; Ecological Associates, 2014).

Area 3 works

The proposed works in Area 3 (Upper J1 Creek) include one main regulator at the downstream end of the J1 Creek (J1c regulator) and a single regulator/crossing provided at the upstream end of the creek, adjacent to the River Murray confluence (J1 g culvert). In addition, a hard stand for a temporary pump is located in close proximity to the upper regulator structure (J1 g regulator). This site provides a secondary location for delivering water to all four areas.

Area 3 works enable water retention to a level of 53.3 m AHD, inundating 36 ha of floodplain. This will achieve inundation levels equivalent to 80,000 ML/d River Murray flow (Jacobs, 2014; Ecological Associates, 2014). In the absence of high River Murray flows, temporary pumps would deliver water to Area 3.

Area 4 works

A pipeline of four kilometres will be constructed between Narcooyia Creek and Lake Powell. The pipeline, together with a temporary pump, will facilitate inundation of Lake Powell and Lake Carpul to 52.6 m AHD. A regulator and levee structure will be located on the southern side of the Murray Valley Highway to retain water and inundate 278 ha. The regulator will also be used for releasing impounded water. A new culvert will be installed across the Murray Valley Highway to increase the flow capacity for natural high flows to enter and exit the lakes.

Minor earthworks will also be undertaken within the existing flowpath between the lakes to improve connectivity, reducing the time required to fill Lake Carpul. These works will achieve inundation levels equivalent to a range of 110,000–170,000 ML/d River Murray flow (Jacobs, 2014; Ecological Associates, 2014).

The proposed work in each of the four areas are detailed in Tables 3-1 to 3-4.

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

Temporary pipes used to delivery environmental water to Lakes Powell and Carpul (2011)

Table 3-1. Area 1 works components (GHD 2014)

AREA ONE WORKS – MAJOR STRUCTURES	
Name	**Description - Size of structure, function**
ER1 Regulator and fishway	This regulator is similar to the regulators recently commissioned at Hattah Lakes and includes: a new regulator and associated bridge deck access and abutment works; cast in situ base, walls and piers, founding on sheet pile cut offs and concrete piles. 9 No. 2,000 wide x 7,000 high bays, with hydraulically actuated Dual Leaf Combination gates on 7 bays, a concrete sill and gate on one bay to maintain the minimum water level of 48.35 m AHD for irrigation requirements and a vertical slot fishway integrated into the remaining bay. The structure also incorporates two widened hardstand areas, one at each side of the structure, to the south of the track.
ER1 South track raising	Raising of existing tracks by up to 2 m, for a distance of approx. 1,160 m. The levee incorporates vehicle access. This section also includes a minor regulator of 2 No. 1,800 wide x 1,800 high box culverts with penstock gates.
ER1 North track raising	Raising of existing tracks by up to 2 m, for a distance of approx. 690 m. The levee incorporates vehicle access. This section also includes a minor regulator of 2 No. 1,800 wide x 1,800 high box culverts with penstock gates.
ER3 Regulator	Similar to ER1, this structure includes: a new regulator and associated bridge deck access and abutment works; cast in situ base, walls and piers, founding on sheet pile cut offs and concrete piles. 7 No. 2,000 wide x 4,800 high bays with hydraulically actuated Dual Leaf Combination gates on 5 bays, a concrete sill and gate on one bay and amenity to house irrigation pipe outlets on the remaining bay.
S7 Regulator	Similar to ER1 and ER3, this structure includes: a new regulator and associated bridge deck access and abutment works; cast in situ base, walls and piers, founding on sheet pile cut offs and concrete piles. 7 No 2,000 wide x 3,500 high bays with Dual Leaf Combination gates on all bays. The structure also incorporates to widened hardstand areas.
AREA ONE WORKS – SUPPORT STRUCTURES	
Name	**Description - Size of structure, function**
S104 track raising	75 m long x up to 0.4 m high, over an existing track. Includes access provision.
S4 Regulator	Structure includes: 3 No. 1,800 wide x 1,500 high concrete box culverts with penstock gates 80m long track raising with access provision.
S105 Regulator	Structure includes: 4 No. 1,200 wide x 900 high concrete box culverts with penstock gates 75 m long track raising with access provision.

AREA ONE WORKS – SUPPORT STRUCTURES	
Name	**Description - Size of structure, function**
S5 Regulator	Structure includes: 2 No. 1,800 wide x 1,200 high concrete box culverts with penstock gates 30 m long track raising with access provision.
Belsar Road raising	Earthworks to raise unsealed road. Includes 3 culvert crossings.
S106 track raising	60 m long x up to 0.2 m high, over an existing track. Includes access provision.
S14 track raising	25 m long x up to 0.16 m high, over an existing track. Includes access provision.
S108 Regulator	Structure includes: 2 No. 1,200 wide x 1,500 high concrete box culverts with penstock gates 30 m long levee with access provision.
S109 Regulator	Structure includes: 2 No. 1,200 wide x 1,200 high concrete box culverts with penstock gates 10 m long levee with access provision.

Table 3-2. Area 2 works components

AREA TWO WORKS COMPONENTS	
Name	**Description - Size of structure, function**
J1a Regulator	J1a is the main structure for Area 2 and includes 2 regulators and a section of track raising: 2 regulators, each consisting of 4 No. 1,800 wide x 1,800 high concrete box culverts with penstock gates
J1a track raising	950 m long x up to 2 m high, over an existing track. Includes access provision.
J1b Regulator	Structure includes: 2 No. 1,200 wide x 900 high concrete box culverts with penstock gates 45 m long track raising with access provision.
J1d Regulator	Structure includes: 2 No. 1,800 wide x 1,800 high concrete box culverts with penstock gates 30 m long track raising with access provision.
J1e Regulator	Structure includes: 2 No. 1,800 wide x 1,200 high concrete box culverts with penstock gates 45 m long track raising with access provision.
J1f Regulator	Structure includes: 2 No. 1,200 wide x 600 high concrete box culverts with penstock gates 25 m long track raising with access provision.
J1h track raising	110 m long x up to 0.8 m high, over an existing track. Includes access provision.

Table 3-3. Area 3 works components

AREA THREE WORKS COMPONENTS	
Name	**Description - Size of structure, function**
J1c Regulator	Structure includes: 3 No. 1,200 wide x 750 high concrete box culverts with penstock gates. 60 m long levee with access provision. Hardstand area
J1g Culvert	Structure includes: 2 No. 1,200 wide x 1,200 high concrete box culverts. 85 m long track raising with access provision.

Table 3-4. Area 4 works components

AREA FOUR WORKS COMPONENTS	
Name	**Description - Size of structure, function**
Lake Powell pipeline and hard stand	A four km low pressure pipeline with inlet and outlet pits. Includes a hard stand for temporary pump
Highway Regulator	Structure includes: 5 No. 1,800 wide x 1,200 high concrete box culverts with Dual Leaf Combination gates. 50 m long levee.
Murray Valley Highway Culvert	1 No. 600 mm diameter x 25.42 m long pipe
Lake Powell Outlet Modifications	Earthworks to lower sill between Lakes Powell and Carpul.

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 sections 14 and 17.

3.4 Summary of estimated costs and proposed schedule

The total cost of the *Belsar-Yungera Floodplain Management Project* is $55,632,428. Further details are 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 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.

Table 3-5 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 3-5. Proposed project delivery schedule

Note: 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 Belsar-Yungera Floodplain Complex is recognised as being ecologically significant as it provides a highly diverse ecotone where the riverine and lower Murray floodplain environments integrate. This transition area is a mosaic of aquatic and terrestrial vegetation communities and habitat types which support a wide variety of flora and fauna species. The complex also provides important longitudinal connection to the River Murray and its floodplains, creating essential biodiversity corridors to allow species dispersal between environments vital to their life cycles.

Belsar-Yungera has a high number of fish species, with eight native species reported from Narcooyia Creek and Bonyaricall Creek (Ecological Associates, 2014). Bonyaricall Creek provides slow-flowing, shallow water with fringing reed beds that supports a number of small-bodied fish species (Ho, et al. 2004), while Narcooyia Creek is permanently inundated and provides complex habitat including deep holes and woody debris over 17 km. It features habitat for the EPBC listed Murray cod (*Maccullochella peelii*) as well as the freshwater hardyhead (*Craterocephalus stercusmescarum fulvus*) and golden perch (*Macquaria ambigua*) (SKM, 2006, GHD, 2009).

The combined floodplain and terrestrial flora of Belsar-Yungera is diverse with over 630 flora species known to occur at or near the site, of which 124 are of conservation significance (Ecological Associates, 2014). A recent survey recorded 207 species, of which 57 are floodplain species listed as rare or threatened under the Advisory List of Rare or Threatened Plants in Victoria (Australian Ecosystems, 2014). The high diversity of plants is related to the close proximity of the contrasting mallee and floodplain vegetation communities (Ecological Associates, 2014). Vegetation at Lakes Powell and Carpul and the surrounding woodland is diverse and includes endangered and threatened vegetation communities. At least 35 plant species found in this area are of conservation significance, such as the endangered hoary scurf pea (*Cullen cinereum*) and woolly scurf pea (*Cullen pallidum*) (VEAC, 2008).

Lying near the western limit of the Murray Fans bioregion, the floodplain complex is ecologically significant due to its proportion of high-value forest, woodland and wetland habitats, which provide important resources for a number of nationally-threatened species such as the regent parrot (*Polytelis anthopeplus monarchoides*), the white-bellied sea eagle (*Haliaeetus leucogaster*), growling grass frog (*Litoria raniformis*) and Murray cod (*Maccullachella peelii*). Among the most important values at the complex are the intact remnants of river red gum (*Eucalyptus camaldulensis*), black box (*Eucalyptus largiflarens*) and lignum (*Duma florulenta*) communities associated with Lakes Powell and Carpul and the Narcooyia and Bonyaricall Creeks.

Fifteen reptile species have been recorded at the complex, including three species of conservation significance. The tessellated gecko (*Diplodactylus tessellatus*) has not been recorded but would be expected to occur in Lakes Powell and Carpul and other wetland beds where cracking clays provide shelter. The *Flora and Fauna Guarantee Act* (FFG) listed species, the carpet python (*Morelia spilota metcalfei*) also uses these cracking clays.

The complex also supports a number of woodland mammal species including the western grey kangaroo (*Macropus fuliginasus*), shortbeaked echidna (*Tachyglossus aculeatus*), sugar glider (*Petaurus breviceps*) and common brushtail possum (*Trichasurus vulpecula*) (Ecological Associates, 2014). The recent observation of sugar gliders in November 2013 is a range extension that represents the most-downstream population of this species (GHD, 2014b).

The bat fauna is diverse with eight taxa having been observed at the complex. Bats are almost entirely insectivorous and inundation maintains high levels of canopy and understory productivity that will attract insect prey, while trees provide bat roosting habitat in bark, crevices and hollows (Ecological Associates, 2014).

The central areas of Belsar-Yungera feature extensive lignum shrubland and shrubby black box woodland. Inundated lignum shrublands provide nesting platforms for waterbirds including ibis (*Threskiornis molucca*), cormorants (multiple spp.), pelicans (*Pelecanus conspicillatus*) and freckled duck (*Stictonetta naevosa*). Inundated lignum is a highly productive aquatic habitat, providing abundant food and physical habitat for small native fish species and frogs.

Yungera Island is one of the largest breeding colonies for the EPBC listed regent parrot. The birds utilise areas of river red gum forest and woodland that are close to waterways and contain large numbers of healthy, large, old, hollow-bearing trees. Nesting and foraging habitat is also used by the EPBC listed migratory/marine white-bellied sea-eagle (Ecological Associates, 2014).

Deepwater habitat, occurring in combination with lignum and woodland vegetation, is important for the breeding of a number of birds of conservation significance including blue-billed duck (*Oxyura australis*), musk duck (*Biziura lobata*) and hardhead (*Aythya australis*) (Ecological Associates, 2014). Lake Powell is one of only seven recorded breeding sites in Victoria for FFG listed freckled duck (*Stictonetta naevosa*) (Ecological Associates, 2014).

Semi-permanent wetland habitat within the complex includes a number of deep, frequently inundated wetlands including Yungera Creek and the Carp Hole. These wetlands received inflows almost annually under natural (unregulated) conditions and remained inundated most of the time (Gippel, 2014), 2014). A variety of wetland plants depend on sustained seasonal inundation, including spiny mudgrass (*Pseudoraphis spinescens*). Reliably inundated habitat provides a refuge from which species such as growling grass frog can disperse to other floodplain habitat during inundation, and provide reliable breeding sites for waterfowl and other wetland birds.

Turtle at Belsar Island (2014)

4.2 Vegetation classes

Ecological vegetation classes

The vegetation communities of the Belsar-Yungera Floodplain Complex are distributed across the floodplain according to hydrological conditions, soils type and groundwater quality. In Victoria vegetation mapping units known as Ecological Vegetation Classes (EVCs) are used to classify vegetation types. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and preferred environmental attributes (DSE, 2014). The EVC classifications provide a suitable basis to inform water management planning at the site.

A total of 22 EVCs have been mapped at the Belsar-Yungera site (Figure 4-1). Of these EVCS 21 are inundation dependent, being:

- 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
- Spike-sedge Wetland
- Water Body – Fresh.

EVCs that are not inundation dependent include:

- Chenopod Mallee
- Loamy Sands Mallee
- Woorinen Mallee
- Woorinen Sands Mallee
- Semi-arid Chenopod Woodland
- Semi-arid Parilla Woodland
- Semi-arid Woodland.

One EVC, Bare Rock/Ground, is neither inundation or non-inundation dependent.

A number of the EVCs present at Belsar-Yungera are of conservation significance:

- Riverine Chenopod Woodland is endangered, and
- six EVCs are vulnerable in the Murray Fans Bioregion: Lake Bed Herbland, Lignum Swamp, Lignum Swampy Woodland, Riverine Grassy Woodland and Shallow Freshwater Marsh (Ecological Associates, 2014).

Lignum Swampy Woodland is the most widespread EVC.

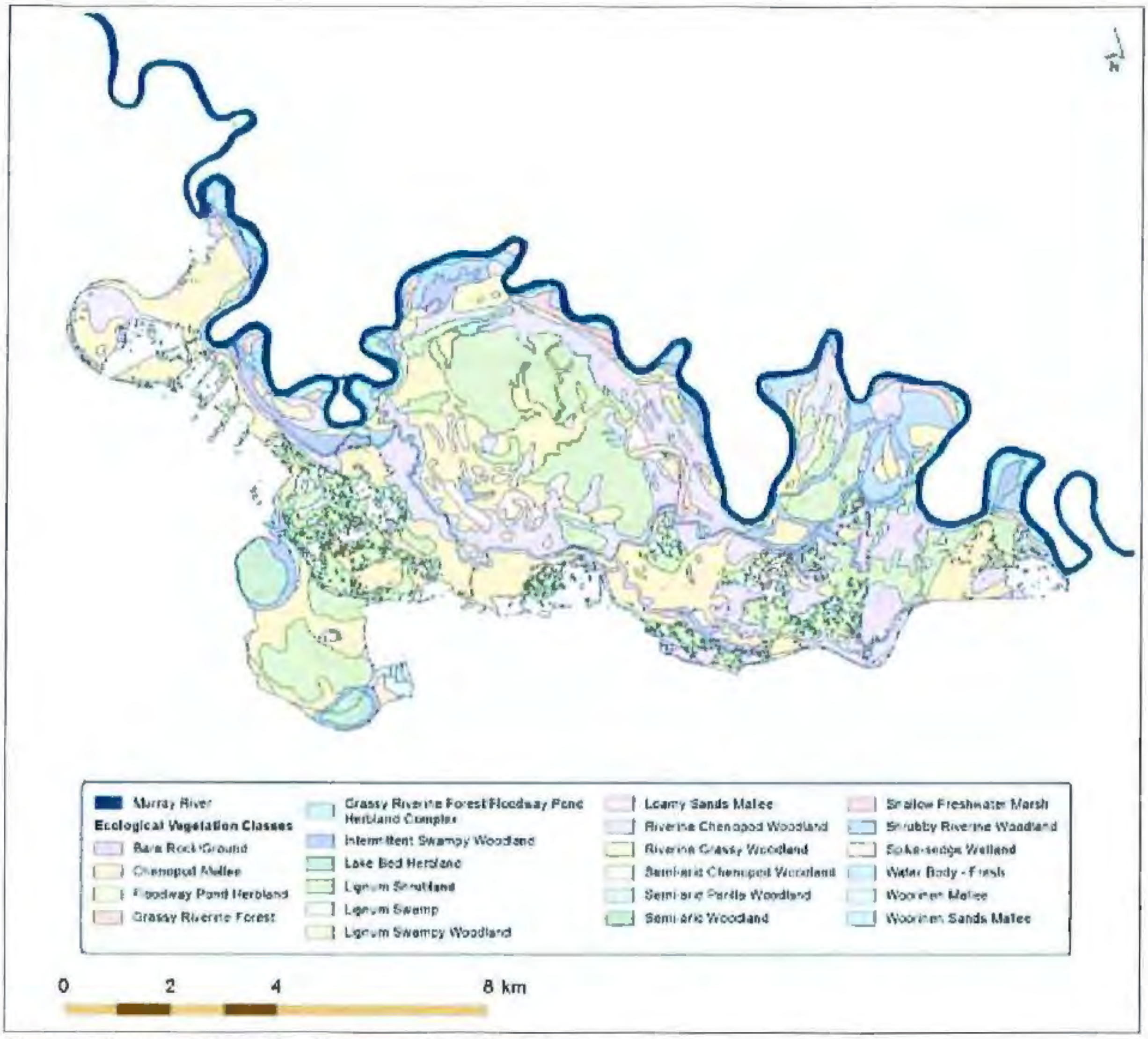


Figure 4-1. Ecological Vegetation Classes present at the Belsar-Yungera site

Water regime classes

Floodplain ecology is influenced by the duration, depth, frequency and timing of inundation events. Therefore, it is useful to define water regime classes (WRCs) to establish objectives for the location, extent and condition of components of the floodplain ecosystem. They can also be used to set hydrologic objectives, as described in Ecological Associates (2007)

Plant communities at Belsar-Yungera have been described and mapped in detail as EVCs (Figure 4-1). 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, the frequency and relative durations of flooding. This environmental gradient was refined by reviewing the EVC descriptions, which set out the species present during flooded and dry phases, their relative abundance and their habitat. Species with known relationships to flooding could be used to rank EVCs from most likely to least likely to be flooded (Ecological Associates 2007).

EVCs were amalgamated into eight water regime classes (Figure 4-2). Table 4-1 shows EVCs that make up each WRC, the area of each WRC at Belsar-Yungera and the potential area to be watered through this project. Detailed descriptions of the characteristics are provided in Appendix B.

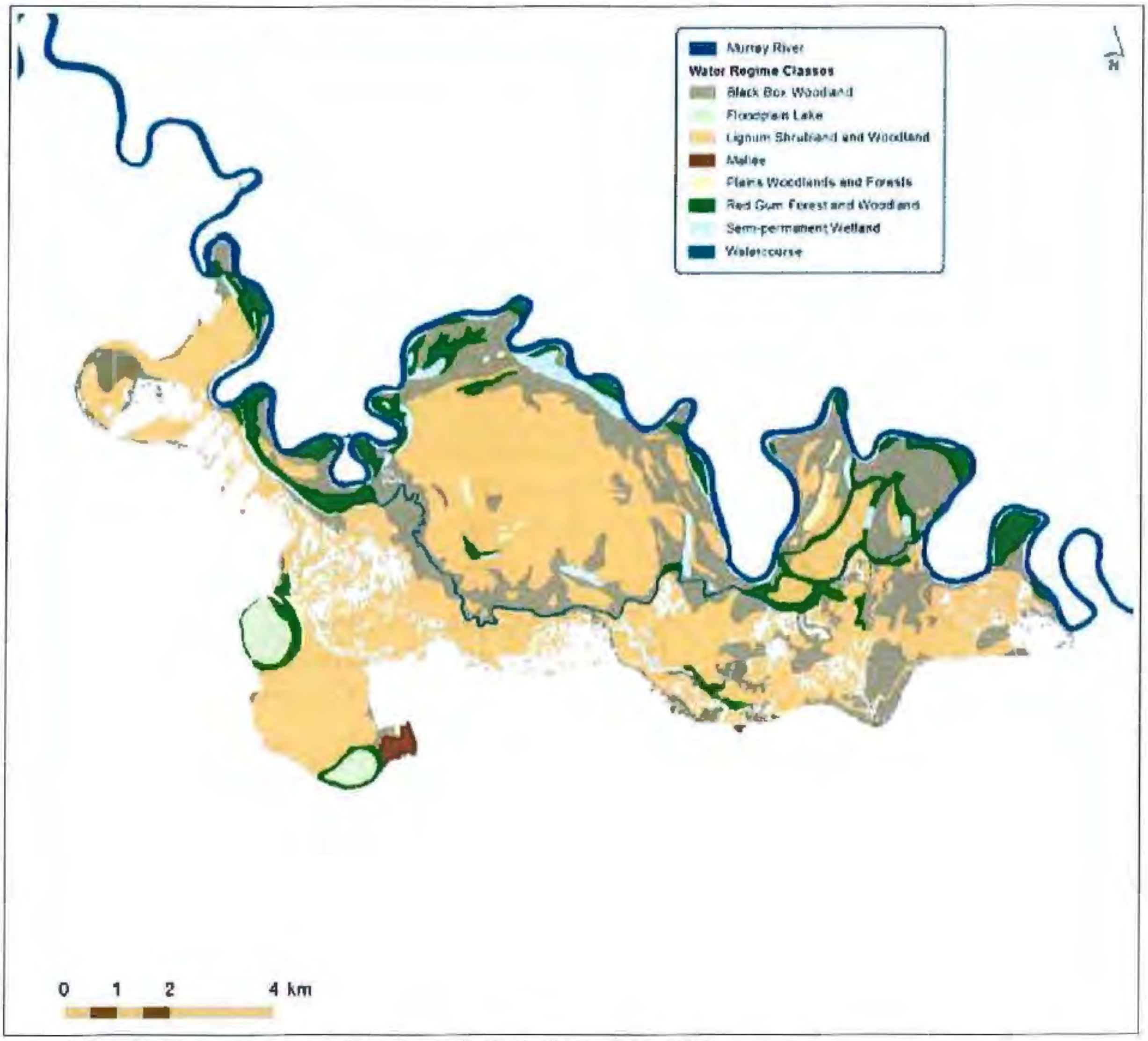


Figure 4-2. Belsar-Yungera water regime classes (Ecological Associates 2014)

Table 4-1. Belsar-Yungera Water Regime Classes (Ecological Associates, 2014)

Water Regime Class	Area (ha)	Area to be watered within this project	Ecological Vegetation Class
Watercourses	72	56	Waterbody - Fresh
Semi-permanent Wetlands	172	54	Bare Rock/Ground Floodway Pond Herbland Shallow Freshwater Marsh Spike Sedge Wetland
Red Gum Forest and Woodland	613	126	Grassy Riverine Forest / Floodway Pond Herbland Complex Intermittent Swampy Woodland Grassy Riverine Forest
Lignum Shrubland and Woodland	4085	1537	Lignum Swamp Lignum Shrubland Lignum Swampy Woodland
Black Box Woodland	2056	392	Riverine Grassy Woodland Riverine Chenopod Woodland Shrubby Riverine Woodland
Floodplain Lake	130	130	Lake Bed Herbland
Mallee[1]	45	<1	Chenopod Mallee Loamy Sands Mallee Woorinen Mallee Woorinen Sands Mallee
Plains Forest and Woodland*	85	<1	Semi-arid Chenopod Woodland Semi-arid Parilla Woodland Semi-arid Woodland
Unmapped EVCs[2]		78	
Total	7,088	2,370	

[1] Not inundation dependent

[2] There is a small area on Belsar-Yungera where EVCs have not been mapped which is due to gaps in spatial data

4.3 Current condition

The ecological condition of the Belsar-Yungera Floodplain Complex has declined due to altered flow regimes, altered inundation patterns and extended drought conditions of the early 2000s.

The alteration in water regimes is adversely affecting riparian and floodplain vegetation as well as impacting native fish populations, water birds and other fauna. Index of Wetland Condition (IWC) assessments conducted in 2010 demonstrate that Lake Carpul would have received an excellent condition score if the hydrological regime of the lake was addressed. Instead, the lake was determined to be of good condition. The condition of

Lake Powell was moderate as there was less than 50 percent of critical life form groups present, in addition to the shared hydrological issues with Lake Carpul (http://ics.water.vic.gov.au/ics/, accessed 13 November 2014).

Lakes Powell and Carpul are known to have previously recorded a high number of inundation-dependent threatened species. Flora surveys conducted in 2009 indicate that up to 26 inundation-dependent threatened species expected to occur were missing from the beds of Lakes Powell and Carpul and the complex's other wetlands. While this is not uncommon in the drought conditions experienced at this time, encroachment of a drought-tolerant community could threaten the diversity of these lakes if long periods occur between inundation. If the lakes and wetlands receive more frequent inundation this would significantly enhance species diversity (Australian Ecosystems, 2009).

The flora surveys outlined that the health, extent and species diversity of inundation-dependent EVCs was low in areas that had not experienced recent inundation and wetland contained stressed canopy and the risk of encroachment of a drought tolerant community (Australian Ecosystems, 2009).

The current inundation patterns across the Belsar-Yungera Floodplain Complex are not sufficient to meet the ecological requirements of the complex's flora and fauna. This is evident from the poor tree condition in the mid to lower Narcooyia Creek valley and the IWC assessments (Ecological Associates, 2014).

A 2009 fish survey (referenced in GHD, 2009) identified numerous impediments in the complex's waterways that inhibit fish movement between the River Murray and the complex. This restriction of movement of the Narcooyia Creek native fish population (consisting of eight species) with the River Murray, prevents the completion of vital life cycles. It also inhibits fish access to the complex's resources as emigration into the complex's waterways is impeded

Environmental condition of Lakes Powell and Carpul has improved since the delivery of environmental water in 2011-12. Photopoint monitoring demonstrates an improvement in river red gum and black box condition through increased foliage vigour. The presence of water in the lakes enabled waterbird activity to be supported for the first time since 1993.

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

Environmental water in Lake Powell (2011)

4.4 Past management activities and actions

Belsar and Yungera Islands and Lakes Powell and Carpul have historically been managed by the (then) Department of Sustainability and Environment as State Forest and Wildlife Reserve. Under recommendations from the Victorian Environmental Assessment Council River Red Gum Forests Investigation (VEAC 2008) they are now managed as River Murray Reserve and Nature Conservation Reserve.

Management activities for regional parks and nature conservation reserves include but are not limited to management of pest species, managing fire, preserving natural values and providing recreational opportunities.

Approximately 42 percent of the inundated freehold land within the complex (known as the Nenandie floodplain) is a designated vegetation offset. The area was created to compensate for native vegetation clearance associated with irrigation development to the south of the complex. It is managed for the protection and enhancement of its conservation values in accordance with the memorandum of understanding 2006.

To prevent catastrophic ecosystem collapse at the complex, an emergency environmental watering program was initiated in 2005-06 as an immediate response to the complex's poor condition. Over three years, environmental water was delivered to low lying wetlands and creeklines on crown and freehold land via portable pumps and contained with temporary earthen levees.

Environmental watering of Lakes Powell and Carpul in 2011-12, broke an 18 year absence of inundation in the lakes. The ecological response of the watering was immense; waterbird activity at the lakes was supported for the first time since 1993 and the vegetation surrounding the lakes improved in condition as evident by the following photographs.

Lake Carpul before (above, 2011) and after (below, 2012) environmental watering

4.5 Other values

In addition to its ecological importance, Belsar-Yungera has important social and cultural values.

Cultural and historical values

Prior to European settlement, Aboriginal people occupied all aspects of the Victorian landscape, governed by a distinct system of land ownership. The Belsar and Yungera Islands and their associated floodplain have been shown to form part of a highly sensitive region for Aboriginal cultural heritage values, including evidence of past Aboriginal occupation. Archaeological occurrences commonly include stone artifact scatters, hearths and earth ovens, shell middens, scarred trees, and burial sites, some of which regularly occur in association with each other (e.g. hearths and artifact scatters). Approximately 50 percent of sites consist of scarred trees (GHD, 2012).

Sites found within the Belsar-Yungera conform with what is known of regional human occupational patterns. Approximately 80 percent of all previous recorded sites are within one kilometre of the River Murray, with most of the balance associated with other wetland environments.

Following initial European settlement, land in the Belsar-Yungera area was taken up by squatters and later by pastoralists. By 1848, a number of grazing runs were being operated in the Mallee, including the Yungera run (LCC, 1987). The Belsar and Yungera islands were grazed by sheep and cattle, with the western end of the proposed project site used to farm wheat from the early 1920s (Bell et al, 2013a).

Currently there are no known recorded historic or European cultural heritage values within the proposed Belsar-Yungera Islands works or inundation area. This was confirmed via searches of the following (GHD, 2012):

- Heritage Victoria Register and Inventory
- Swan Hill Rural City Council planning schemes and heritage overlays
- GeoVic planning schemes heritage overlays
- Rural City of Swan Hill Heritage Study Stage II: heritage place datasheets (Lovell et al, 2001)
- Register of the National Estate: Australian Heritage Places Inventory.

Social and economic values

The Belsar-Yungera project site forms part of the River Murray Reserve, which is highly valued for recreation. Major forest-based activities include camping, fishing, canoeing, trail-bike riding and horse riding (DSE, 2004). The area is a popular camping destination, attracting visitors from within and outside the district who contribute to the local economy by purchasing supplies during their stay.

The Belsar-Yungera site is also important for economic reasons as the creeks are used to convey irrigation water to large-scale almond plantations to the south of the project site. The works have been carefully designed to ensure that both the ecological and economic use of the creeks can co-exist.

The surrounding agricultural land is a major economic resource for the region.

Aboriginal artefact at Belsar Island (2014)

5. Ecological objectives and targets (Section 4.3)

Ecological objectives have been developed for the Belsar-Yungera Floodplain Complex, 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 2009; Australian Ecosystems 2013, 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 (Ecological Associates, 2014).

The ecological objectives for Belsar-Yungera 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

The overall objective of water management at Belsar-Yungera is:

*"to **protect and restore** the key species, habitat components and functions of the Belsar-Yungera ecosystem by providing the hydrological environments required by indigenous plant and animal species and communities".*

This will be achieved by using infrastructure to better meet the water requirements of the floodplain ecosystem. The proposed works will enable widespread inundation of the Belsar-Yungera Floodplain Complex, as well as Lakes Powell and Carpul. The works have been designed to operate in conjunction with Basin Plan flows; temporary pumps can also be used under low River Murray flows to protect this wetland system through droughts.

5.2 Specific objectives and targets

Specific ecological objectives have been developed for the proposed supply measure based on key water-dependent values of the Belsar-Yungera Floodplain Complex. The objectives 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 project's interim specific objectives to the Basin Plan objectives is demonstrated in Table 5-1.

Table 5-1: Relationship between the site based objectives and targets and the Basin Plan objectives

Specific objective	Ecological Targets	Water regime class	Associated Basin Plan Objective
Restore and enhance habitat linkages between the river and Narcooyia Creek for Murray cod and other native fish	More than ten adult Murray cod in Narcooyia Creek migrate to and from the River Murray channel at least once per year.	Water Courses	1,2,4,5,6,7,8,9,101 1, 14
Restore and enhance native fish habitat by improving the productivity of riparian zones and wetlands	The average lateral extent of aquatic macrophyte vegetation on the banks of Narcooyia Creek will increase by 100% from 2015 to 2030 The December projected plant cover exceeds 50% in at least 30 ha of wetland habitat connected to Narcooyia Creek by 2030	Water Courses Semi-permanent Wetlands	1,2,4,5,6,7,8,9,101 1,13, 14
Restore and enhance semi-permanent wetlands capable of supporting growling grass frog	More than one ha of dense sedgeland is present in at least two wetland sites by 2030. These sedgelands are completely dry no more than six months in the period from 2020 to 2030.	Semi-permanent Wetlands	1,2,4,5,6,7,8,9,101 1,13, 14
Maintain lignum shrubland as a frequently flooded and productive habitat for fish and waterbirds	Platform-building waterbirds to breed in lignum shrublands on at least four occasions between 2025 and 2035.	Lignum Shrubland and Woodland	1,2,4,5,6,7,8,9,101 1,13, 14
Restore and enhance floodplain productivity to maintain resident populations of vertebrate fauna including carpet python and bats	Total bat abundance to increase by 25% from 2015 levels by 2030.	Red Gum Forest and Woodland Lignum Shrubland and Woodland Black Box Woodland	1,2,4,5,6,7,8,9,101 1,13, 14
Intermittently provide productive lake habitat for hundreds of waterbirds	Total summer waterbird abundance at Lake Powell Island to exceed 500 on at least two occasions between 2025 and 2035 Total summer waterbird abundance at Lake Carpul to exceed 500 on at least one occasion between 2025 and 2035	Floodplain Lakes	1,2,4,5,6,7,8,9,101 1,13, 14

Specific objective	Ecological Targets	Water regime class	Associated Basin Plan Objective
Contribute to the carbon requirements of the River Murray channel ecosystem	The average annual carbon load (dissolved and particulate) to the River Murray from Belsar and Yungera for the period 2025 to 2035 is double 2015 to 2020 levels.	Red Gum Forest and Woodland Lignum Shrubland and Woodland Black Box Woodland	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14

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
- 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.

Narcooyia Creek during a period of high River Murray flows (2011)

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 hydrology experienced by each WRC has varied from natural (unregulated conditions) due to river regulation and diversions. The environmental water requirements for each WRC are described in detail in Section 9. Detailed ecological justification and the water requirements of each WRC is provided in Appendix B.

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), and
- Basin Plan (2750) without the measure.

Basin Plan flows will contribute toward achieving the environmental water requirement of Belsar-Yungera Floodplain complex compared to baseline conditions. The proposed measure is required to bridge the gap between Basin Plan flows and the environmental water requirements of the complex.

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.

Table 5-2. Comparsion of water regimes provided by natural, baseline, Basin Plan (2750) and the Belsar-Yungera Floodplain Complex measure (Gippel, 2014)

Threshold (ML/d)	WRC	Scenario	Frequency Mean (/100 yrs)	Interval Median (days)	Duration Median (days)	Event start date Median (day of year, 1 Jan = 1)	Prevalence years with event %
10,000	Watercourses[2]	With Measure[1]	120.2	78	164	146	100
		Natural	93	96	243	144	100
		Baseline	135.1	91	93	180	99
		Basin Plan without measure*	120.2	78	164	146	100
30,000	Semi-permanent Wetlands	With Measure[1]	80	220	120	152	80
		Natural	95.6	208	162	195	93
		Baseline	60.5	303	97	204	59
		Basin Plan without measure	82.5	267	109	195	77
40,000	Red Gum Forest	With Measure[1]	80	275	120	152	80

	and Woodland	Natural	87.7	253	122	215	87
		Baseline	47.4	341	81	223	46
		Basin Plan without measure	59.6	308	104	214	60
50,000	Lignum Shrubland and Woodland	With Measure[1]	70	300	100	152	70
		Natural	72.8	283	103	225	75
		Baseline	38.6	612	62	239	37
		Basin Plan without measure	45.6	401	75	227	45
90,000	Black Box Woodland	With Measure[1]	60	560	44	152	60
		Natural	50.9	351	55	252	46
		Baseline	17.5	1049	40	258	15
		Basin Plan without measure	21.9	720	37	259	19
170,0000	Floodplain Lake	With Measure[1]	5	6000	50	250	25
		Natural	6.1	4976	34	246	5
		Baseline	2.6	8136	51	243	2
		Basin Plan without measure	3.5	7372	57	274	3

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

2 Note that delivery of flows through Narcooyla Creek cannot occur at this flow without implementation of the measure.

6. Anticipated ecological benefits (Section 4.4.1)

6.1 Current condition and management

The creeks, wetland and floodplain systems of the Belsar-Yungera Floodplain Complex support a variety of aquatic and terrestrial ecological communities (see Section 4). The condition of ecological values of the complex 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 tree communities 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. As floodwaters recede, this material enters the River Murray contributing to the energy requirements of the broader river system. Flowering plants attracts nectar-eating insects and birds and provides abundant insect prey for the eight species of bats and the insectivorous birds found at Belsar-Yungera (Ecological Associates, 2014).

Delivery of environmental water to Lakes Powell and Carpul in 2011-12 enabled the ecological functionality of the lakes to be protected until permanent works can reliably deliver water. \resources to support waterbird activity were provided in abundance for the first time in 18 years and the condition of fringing river red gum and black box improved. Aquatic vegetation establishment was extensive which assisted in rejuvenating the lake bed seed bank.

Drawing upon the ecological response monitoring outcomes associated with large scale watering of the Hattah Lakes through TLM, it is expected the observed trend of improved ecological condition (Henderson, 2014) would also occur at the Belsar-Yungera complex once permanent works can reliably deliver water. This assumption is made due to similar nature of the EVCs, WRCs, conditions and water requirements of both Belsar-Yungera and Hattah Lakes.

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 Belsar-Yungera Floodplain Complex.

Photo point monitoring at Lake Powell, within the Belsar-Yungera Floodplain Complex, shows the ecological response to environmental watering (Left: 2011; Right: 2012)

6.3 Proposed ecological benefits

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

Ten ecological targets have been developed to measure progress towards the ecological objectives (Table 5-1).

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

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

Water regime	Strategy	Ecological benefits
Watercourse	Provide a fishway in the downstream regulating structure on Narcooyia Creek Open Narcooyia Creek to through-flow whenever river discharge provides levels in Narcooyia Creek that exceed pump requirements Pump water into Narcooyia Creek system to provide seasonal connections to adjacent wetlands	In-channel macrophytes; flows convey seeds and propagules resulting in an increase in diversity and abundance of aquatic species. Water quality may also improve; Enhanced 'flowing habitat' within both the Narcooyia and Bonyaricall Creeks is particularly suited to species such as Murray cod.
Semi-permanent Wetlands	Capture peaks in river flow in Yungera Creek wetlands and wetlands associated with Narcooyia Creek by closing regulators on the inundation recession. Pump water into wetlands if peaks in river flow are not available.	Stimulation of seed bank upon inundation leads to greater diversity and abundance of wetland flora during inundation and on recession of floodwaters. This will provide foraging and breeding habitats for wetland birds and frogs. Riparian shrubs; increased vigour in species such as lignum, and possibly also exhibit an increase in abundance and diversity; Adjacent trees; increased vigour, recruitment, overall improvement in wetland health, maintenance of wetland buffers and maintenance of fauna habitats. Stimulate the growth of aquatic and emergent wetland vegetation, in turn providing habitat for frogs, waterbirds and fish. Maintenance and enhancement of fauna habitat values and periodic breeding opportunities for wetland species (e.g. frogs and waterbirds).
Red Gum Forest and Woodland	Protect and restore the inundation of red gum forest and woodland	Maintenance and enhancement in condition of river red gum communities. Regular inundation events promote aquatic and grassy woodland vegetation, woody debris, submerged aquatic vegetation and other prey habitats (EA 2007). Improved quality and extent of habitat for a wide range of native species, including threatened species, e.g. regent parrot and other species such as carpet python and lace monitor

Water regime	Strategy	Ecological benefits
Lignum shrubland and woodland	Protect and restore inundation to lignum shrublands	Inundation of lignum shrubland extends habitat for aquatic floodplain fauna, e.g. fish, reptiles and frogs. Inundated lignum is used as a platform by nesting waterbirds including ibis and spoonbill. Floodwater draining from lignum will carry dissolved and particulate carbon as well as algae and invertebrates will contribute to the food web of the river channel.
Black Box Woodland	Protect and restore inundation to black box woodland	Maintenance and enhancement in condition of floodplain black box woodland communities. Recruitment, maintaining a diverse age structure, including maturation and development of hollows, maintaining habitat in the long-term for native fauna species. Diverse tree age structure and a complex understorey plant community are required by carpet python and other vertebrate fauna.
Floodplain Lakes - Lake Powell and Lake Carpul	Protect and restore inundation to floodplain lakes	Stimulate the growth of aquatic and emergent wetland vegetation, providing habitat for frogs, waterbirds and fish; Maintenance and enhancement of fauna habitat and periodic breeding for wetland species (e.g. frogs and waterbirds); Inundated wetlands provide productive food for small fish, waterbirds, frogs and turtles. Lakes Powell and Carpul are important habitat and support breeding by blue-billed duck, musk duck, hard head and freckled duck. Drying wetland beds support a range of wetland herbs. Sustained dry periods expose a muddy herbland on the lake bed. Small wading birds such as ruddy turnstone and red-necked stint will feed on macro-invertebrates in shallow water and mud. Fish-eating birds and carrion feeders, including white-bellied sea-eagle feed on stranded fish.

6.4 Monitoring and evaluation plans (Section 4.4.1)

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

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

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

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

A detailed monitoring and evaluation plan has been prepared for the Belsar-Yungera Floodplain Complex by Ecological Associates (2014b). Monitoring and evaluation will focus on the effects of local watering actions and include:

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

The Belsar-Yungera Floodplain Complex's monitoring and evaluation plan identifies the agencies responsible for commissioning, reviewing and acting on monitoring data. The linkages back to decision-making are described in the detailed plan.

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

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

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

The final MER approach for this supply measure will be informed by broader intergovernmental arrangements for Basin-wide monitoring and evaluation under the Basin Plan. This measure is expected to contribute to the achievement of outcomes under two key Chapters of the Plan, namely: Chapter 8: the delivery of ecological outcomes; and 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 MDBA's 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.

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

7. Potential adverse ecological impacts (Section 4.4.2)

This business case has taken into consideration potential adverse ecological impacts of this proposal. It is acknowledged that works that alter floodplain hydraulics and hydrology may threaten the ecological values of the Belsar-Yungera Floodplain, 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 Belsar-Yungera project ensures risk management strategies can be implemented to ensure management and mitigation of:

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

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

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

7.1 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.

7.2 Risk assessment outcomes

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

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

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

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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Development of saline mounds under wetlands and displacement of saline groundwater	An increase in groundwater levels may occur in response to project inundation events. Shallow saline groundwater can impact on the health of floodplain vegetation and wetland communities, both at Belsar-Yungera 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

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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Permanent habitat removal or disturbance during construction	Construction of the proposed works will cause disturbance to the floodplain and require the permanent removal of some vegetation/habitat.	Certain	Moderate to Severe	High to Very High	Utilise existing access tracks wherever possible. Design and locate infrastructure/works to avoid and minimise the extent of clearing and disturbance. Ensure clear on-site delineation of construction zones and adequate supervision during works to avoid unauthorized clearance/disturbance.	Moderate
Temporary habitat removal or disturbance during construction	Construction of the proposed works will cause disturbance to the floodplain and require the temporary removal of some vegetation/habitat.	Certain	Moderate	Moderate to Very High	As above. Remediate/revegetate the site once construction activities are complete.	Moderate
Invasion of river red gum in watercourses and open wetlands	Germination of dense thickets of river red gum within watercourses and wetlands 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						

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Increase in fire frequency, extent and intensity	The reinstatement of more frequent flooding regimes threat will increase the biomass of floodplain vegetation, increasing the fuel load for bushfires. An increase in the frequency, extent and duration of bushfire could have impacts on ecosystem form and function.	Possible	Moderate	Moderate	No specific mitigating actions have been identified. If a bushfire occurs on Lindsay Island, Parks Victoria and DEPI will respond as usual in such situations.	Moderate
Managed inundation regimes do not match flow requirements for key species	The delivery of an inappropriate water regime may occur through inadequate knowledge of biotic requirements or conflicting requirements of particular species with broader ecological communities. This may lead to adverse ecological outcomes, e.g. failure of waterbird breeding events, lack of spawning response in fish, spawning response but no recruitment.	Possible	Moderate	Moderate	Consider the various requirements of key species/communities when developing operating strategies and planning for watering events. Assess the response of species of concern during and after managed watering events and adjust operational arrangements if required. Update operating strategies to capture new information on the water requirements/ response of key species/communities. Target different taxa at different times (e.g. target vegetation one year and fish the next).	Low
Prolonged inundation of vegetation	Vegetation in the deepest parts of the regulator pool may receive excessive inundation (duration and depth) if the water requirements of vegetation at the perimeter of the pool are met. This is likely to cause localized impacts on vegetation health, possibly death of some less tolerant species.	Possible	Moderate	Moderate	Ensure through-flow when operating structures to more closely replicate a more natural hydraulic gradient. Incorporate information on operations, potential impacts and tolerance of inundation regimes and the role of natural floods in ecosystem function into operational plans to minimise the impact.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
Inadequate water regime delivered	An inadequate water regime could be delivered through: • Design and construction issues; • Invalid modelling assumptions and/or flow measurement; • Inadequate or incorrect information regarding water requirements and/or system condition; • Errors in planning and calculation of the volumes required; or • An inadequate volume allocated to the event. This could result in adverse ecological impacts such as drought-stress of vegetation, loss of habitat and limited breeding opportunities for fauna.	Unlikely	Severe	Moderate	Confirm the validity of modelling assumptions during operations to inform future planning and refine the operating arrangements. Design structures for maximum operational flexibility. Ensure adequate measures are in place to measure inflows/outflows. Assess ecosystem response during and after managed watering events and adjust operational arrangements if required. Maintain strong working relationships with river operators, partner agencies and water holders to facilitate timely issue resolution (e.g. allocation of additional water if required).	Low
Stranding and isolation of fish on floodplains	Stranding can occur through sudden changes in water levels and/or new barriers preventing native fish from escaping drying areas during flood recessions. This may result in the death of a portion of the native fish population.	Possible	Moderate	Moderate	Develop a 'Fish Exit Strategy' to inform regulator operation during the drawdown phase to maintain fish passage for as long as possible and to provide cues for fish to move off the floodplain. Monitor fish movement and adapt operations as required. Continue to build on knowledge and understanding through current studies relating to fish movement in response to environmental watering and cues.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual risk
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

7.3 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 Belsar-Yungera Floodplain (see Section 4). Overall, the project is expected to benefit these species by increasing the frequency, duration and extent of floods of various sizes (see Section 6). However, construction activities will involve physical disturbance to the floodplain and some vegetation clearance is unavoidable. This will result in temporary and permanent vegetation removal and habitat disturbance (see Table 7-5).

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

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

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

Operation of the proposed supply measure could also have adverse impacts on threatened species. The Belsar-Yungera Floodplain has potential to support significant native fish populations. The protection and, where possible, the enhancement of these populations has been a primary consideration during the development of designs and operational scenarios for the proposed works.

The project will remove existing embankments within Narcooyia Creek which currently hinder inflows from the Murray River and restrict fish movement into the creek. Regulator designs allow passive fish passage through minor regulators and a dedicated fishway is proposed on the ER1 Regulator. These design considerations will allow passage for both small and large bodied fish over a range of operational scenarios. All structures have been designed to minimise impediments to fish passage when not in use.

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

Monitoring 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.

7.4 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.

7.5 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.

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

Threat	Risk without mitigation	Residual Risk Rating	Additional considerations (Lloyd Environmental, 2014)	Guiding documents[3]
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.	Belsar-Yungera Floodplain Management Project Operating Plan (Preliminary) *Fish exit strategy*
Permanent habitat removal or disturbance during construction	High to Very High	Moderate	The risk assessment for these threats will be revised once construction footprints are finalised and detailed vegetation assessments are carried out. If significant species or EVCs are found to be at or close to the site and could be impacted, further actions to reduce the residual risk would include targeted management actions and/or vegetation offsets for the relevant biota.	Basin Plan Environmental Works Program: Regulatory Approvals Strategy (GHD, 2014a) Statutory Approval Requirements (Golsworthy, 2014). *Environmental Management Framework* *Construction Environmental Management Plan* *Offset Strategy* *Threatened Species Management Plan*
Temporary habitat removal or disturbance during construction	Moderate to Very High	Moderate		
Hypoxic blackwater events resulting from watering actions	High	Moderate	The risk assessment has assumed that more frequent inundation will result in more frequent blackwater events than occur currently, and that these events will be of similar magnitude. It is, however, possible that more frequent events may be less intense as tannins and organic material are thought to reduce in subsequent watering events. This is a knowledge gap that could be	Assessing the Risk of Hypoxic Blackwater Generation at Proposed SDL Offset Project Sites on the Lower River Murray Floodplain (Ning et al, 2014) Belsar-Yungera Floodplain Management Project Operating Plan (Preliminary)

[3] Documents in italics are yet to be developed

Threat	Risk without mitigation	Residual Risk Rating	Additional considerations (Lloyd Environmental, 2014)	Guiding documents[3]
			addressed through ongoing studies.	
Increase in pest animals	High	Moderate	More intensive culling programs may be needed. Further research into alternative control measures may provide additional control options.	Belsar-Yungera 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)

8. Current hydrology and proposed changes (Section 4.5.1)

8.1 River hydrology

The Belsar-Yungera Floodplain Complex is located approximately 30 kilometres upstream of the Euston Weir near Robinvale. The River Murray flows are influenced by the Murray, Murrumbidgee, Edward-Wakool system and Goulburn River and other upstream tributaries and are typically highest from late winter to spring. The complex experiences its largest inundation events when both the Murrumbidgee River and River Murray systems are in flood (Ecological Associates, 2014).

The network of waterways, wetlands and floodplain at the complex supports a hydraulically diverse landscape that would have experienced inundation to varying degrees in almost every year.

Prior to regulation River Murray flow events of 50,000 ML/d were a regular occurrence at the complex, with a mean frequency of 7.3 events in 10 years. The period between successive 50,000 ML/d flow events was also frequent, with a median interval of 283 days. These flow events had a median duration of 3 months (Gippel, 2014).

8.2 Current floodplain hydrology

The majority of the floodplain complex lies outside the influence of the Euston weir pool; however, the upstream end of the weir pool has a minor influence on Bonyaicall Creek.

Narcooyia Creek defines the southern edge of the Belsar and Yungera site. Flowing over 17 km, it diverges from the river at 1195 river kilometres (km), upstream of Yungera Island, and returns to the river at 1168 river km downstream of Belsar Island (Ecological Associates, 2014). Narcooyia Creek has been modified to allow its use as a delivery channel for irrigation water, with limited ecological connectivity to the River Murray. The channel is impounded between a bank at the upstream end and a fixed-crest weir in the mid-section of the creek. The impounded area is permanently inundated to meet irrigation requirements.

The Murray Valley Highway crosses the natural connection between Lakes Powell and Carpul and Bonyaricall Creek. While culverts have been installed to allow flow into the lakes, the sill of these culverts is approximately one metre above the natural sill.

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

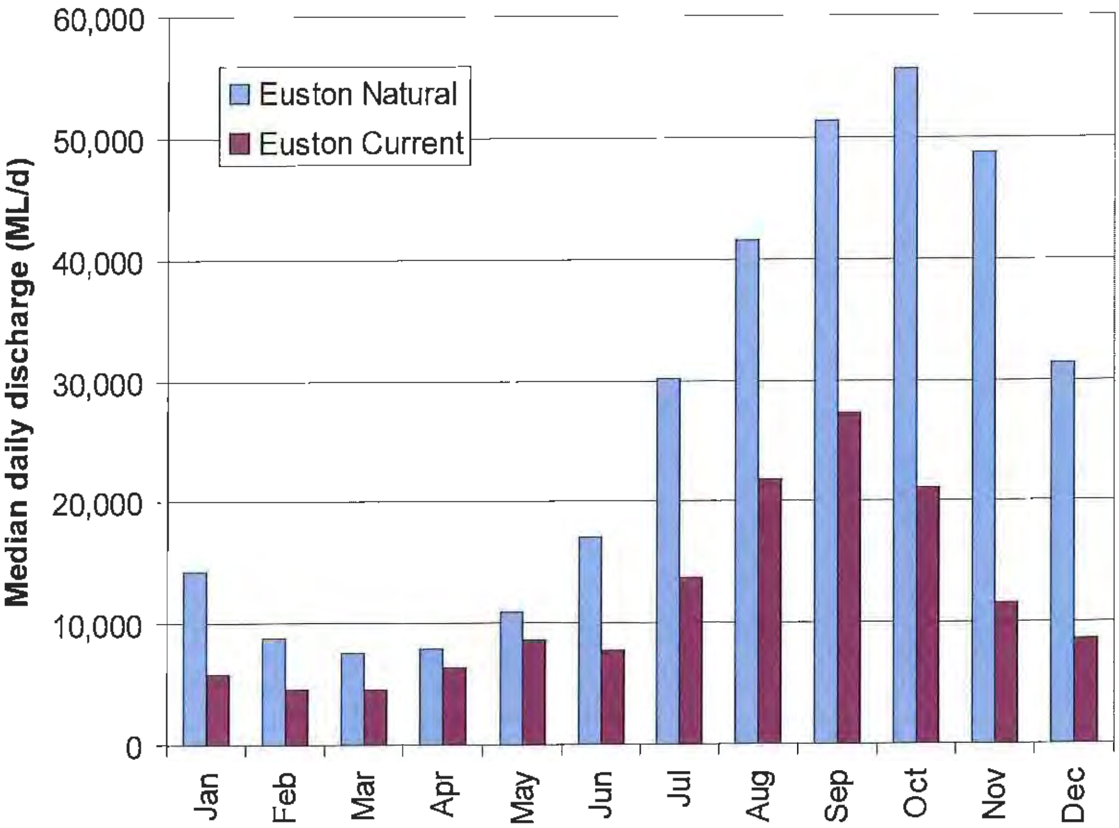


Figure 8-1. Distribution of median flows for each month in the River Murray for natural and current (benchmark) conditions over a 114 year modelled period (Ecological Associates, 2006)

Regulation has significantly altered the frequency, recurrence interval and duration of 50,000 ML/d flow events at the complex. The mean frequency of these flows has declined to as much as 53 percent of natural, (to 3.8 events in 10 years). This has caused a 116 percent increase in the interval between these flow events, resulting in a median recurrence interval of 1.6 years. The duration of these flows has declined to as much as 60 percent of natural, resulting in a median duration of 2 months (Gippel, 2014).

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

- For flows greater than 20,000 ML/d, event frequency has reduced significantly under regulated conditions. Current event frequency is in the order of 50% to 70% less than pre-regulation frequency, even for flows exceeding 140,000 ML/d
- The duration of spells is lower for intermediate events: spells are 50% shorter for events 20,000 to 60,000 ML/d; however, for high flows, greater than 90,000 ML/d, the duration of spells under natural and benchmark scenarios is similar
- The river is in a low-flow state for a greater proportion of time under current conditions as it is managed to deliver water to downstream consumers efficiently. Events of 5,000 ML/d occur 1.6 times per year with a median duration of 130 days. Under natural conditions river discharge exceeded 5,000 ML/d for most of the year.

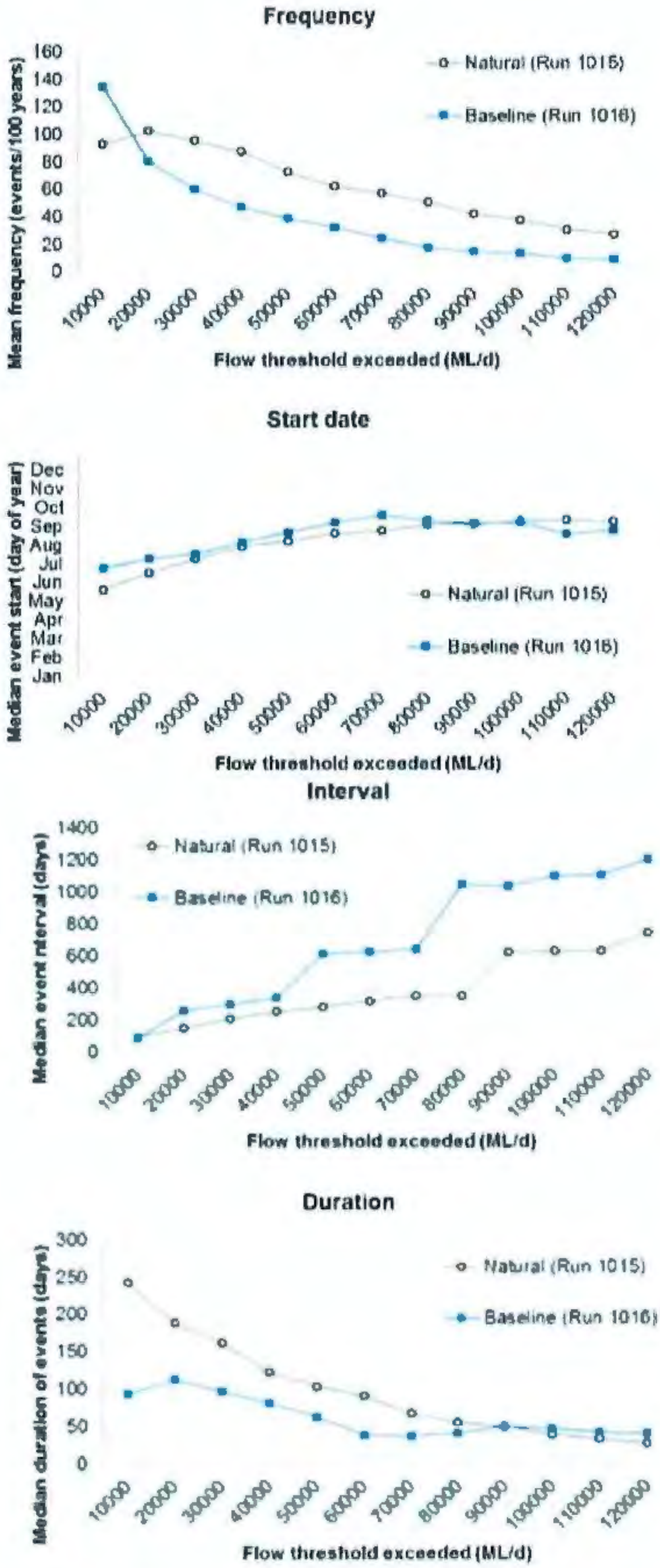


Figure 8-2. Comparison of statistical properties of events at Euston under Natural and Baseline modelled flow scenarios, over a 114 year modelled period (Gippel, 2014)

The Belsar-Yungera Floodplain Complex consists of waterway, wetland and floodplain environments that connect to the River Murray at a variety of river flows. Hydraulic modelling of the complex under current condition shows that at approximately 10,000 ML/d, the upstream inlet to Narcooyia Creek commences to flow and the existing irrigation embankment in the mid-section of Narcooyia Creek is overtopped (Figure 8-3). At 16,000 ML/d additional waterways commence to flow. Inundation of the surrounding, low-lying floodplain areas occurs at flows exceeding 20,000 ML/d. More widespread floodplain inundation occurs at flows exceeding 27,000 ML/d (Jacobs, 2014).

Lignum shrubland occupies a broad, shallow basin in central Belsar Island and is significantly inundated by flows exceeding 70,000 ML/d. Inundation of the islands is largely complete at flows of 120,000 ML/d. Black box woodland has a similar inundation pattern, with inundation initiated at flows over 70,000 ML/d and mostly complete at flows of 120,000 ML/d (Jacobs, 2014).

The flow threshold for significant inundation in Lake Powell is in the order of 140,000 ML/d and 170,000 ML/d for Lake Carpul (Jacobs, 2014).

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. For example the modelled extent of inundation shown in figure 8-3 represents the absolute maximum extent achieved after steady state flows have been maintained over a period of months.

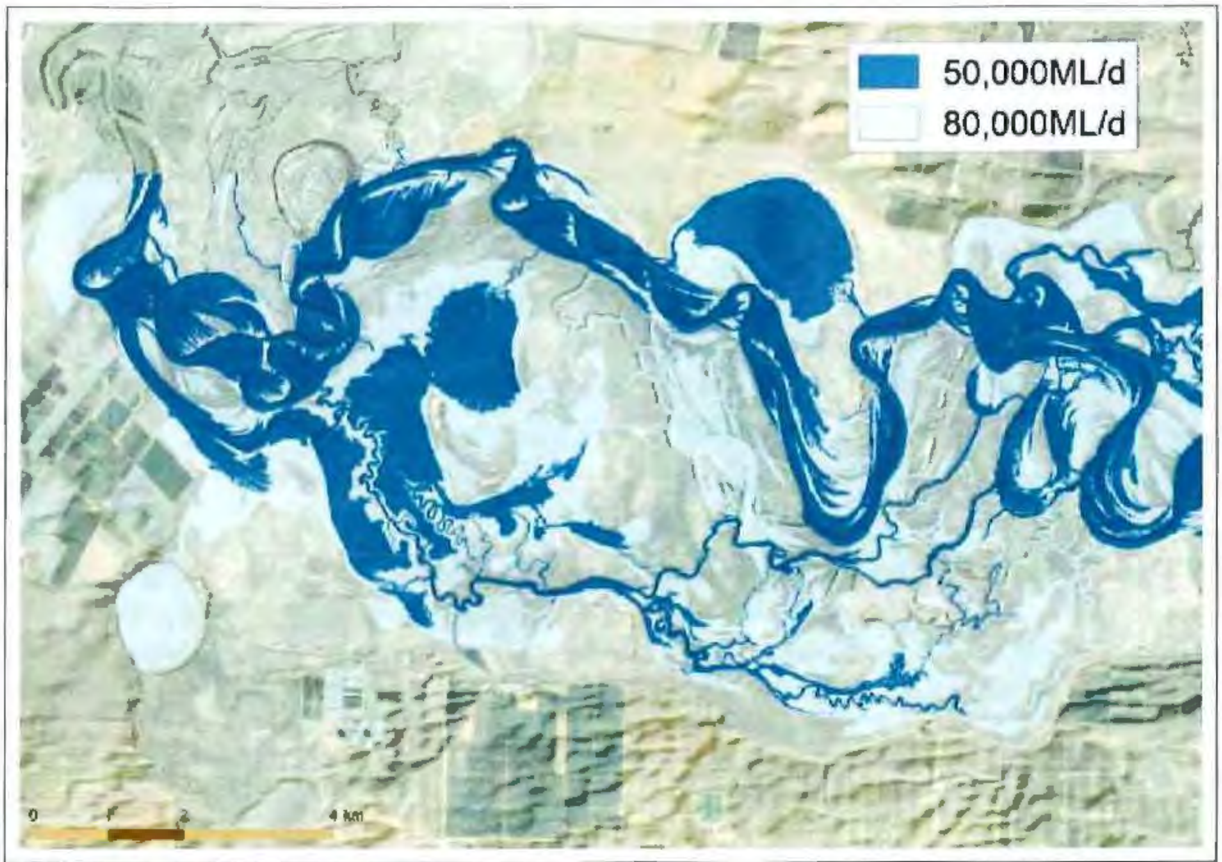


Figure 8-3. Belsar-Yungera floodplain inundation at flows of 50,000 and 80,000ML/d (data supplied Jacobs, 2014)

8.3 Proposed Changes

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

The Basin Plan will primarily affect flows less than that required for floodplain watering at the complex (Table 8-1). For example flows of 30 000 ML/day will occur 6 times in 10 years under baseline, 8 times under Basin Plan and 9.5 naturally. By comparison flows of 80 000 ML/day will occur 1.7 times in 10 years under baseline, 2 times under Basin Plan and 5 naturally.

The proposed measure may be used to provide equivalent inundation on the complex to that of a 50,000 ML/d flow event. Targeted operation of the works in junction with Basin Plan flows will enable mean frequency of inundation equivalent to a 50,000 ML/d flow event to be restored. The mean frequency of inundation will increase from 3.8 to 7.2 events in 10 years. This will improve the duration of the event, by increasing the median duration from 62 to 2.3 years (Table 8-1).

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

Table 8-1. Proposed operating plan to meet the gap in the shortfall in flood frequency and duration for Belsar-Yungera under the Basin Plan (2750) without measures scenario (source: Gippel, 2014)

Threshold (ML/d)	WRC	Conditions	Prevalence yrs with event %	Duration Median (days)	Timing	Proposed operations to meet gap: Frequency (years in 10)	Proposed operations to meet gap: Duration
10,000	Watercourses[2]	With Measure	100	164	Late autumn	No additional operations above Basin Plan flows required[2]	
		Basin Plan without measure	100	164	Late autumn		
30,000	Semi-permanent Wetlands	With Measure	80	120	Late autumn – early winter	No additional operations above Basin Plan flows required	
		Basin Plan without measure	77	109	Late autumn – mid winter		
40,000	Red Gum Forest and Woodland	With Measure[1]	80	120	Late autumn – early winter	2	4 months
		Basin Plan without measure	60	104	Mid-late winter		
50,000	Lignum Shrubland and Woodland	With Measure[1]	70	100	Late autumn – early winter	2.5	3 - 4 months
		Basin Plan without measure	45	75	Mid-late winter	4.5	3 - 4 weeks
90,000	Black Box Woodland	With Measure[1]	60	44	Late autumn – early winter	4	6 - 7 weeks
		Basin Plan without measure	19	37	Late winter – early spring		
170,0000	Floodplain Lake	With Measure[1]	25	50	Late winter – early spring	2	7 – 8 weeks
		Basin Plan without measure	3	57	Early spring		

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

[2] Note that delivery of flows through Narcooyia Creek cannot occur at this flow without implementation of the measure.

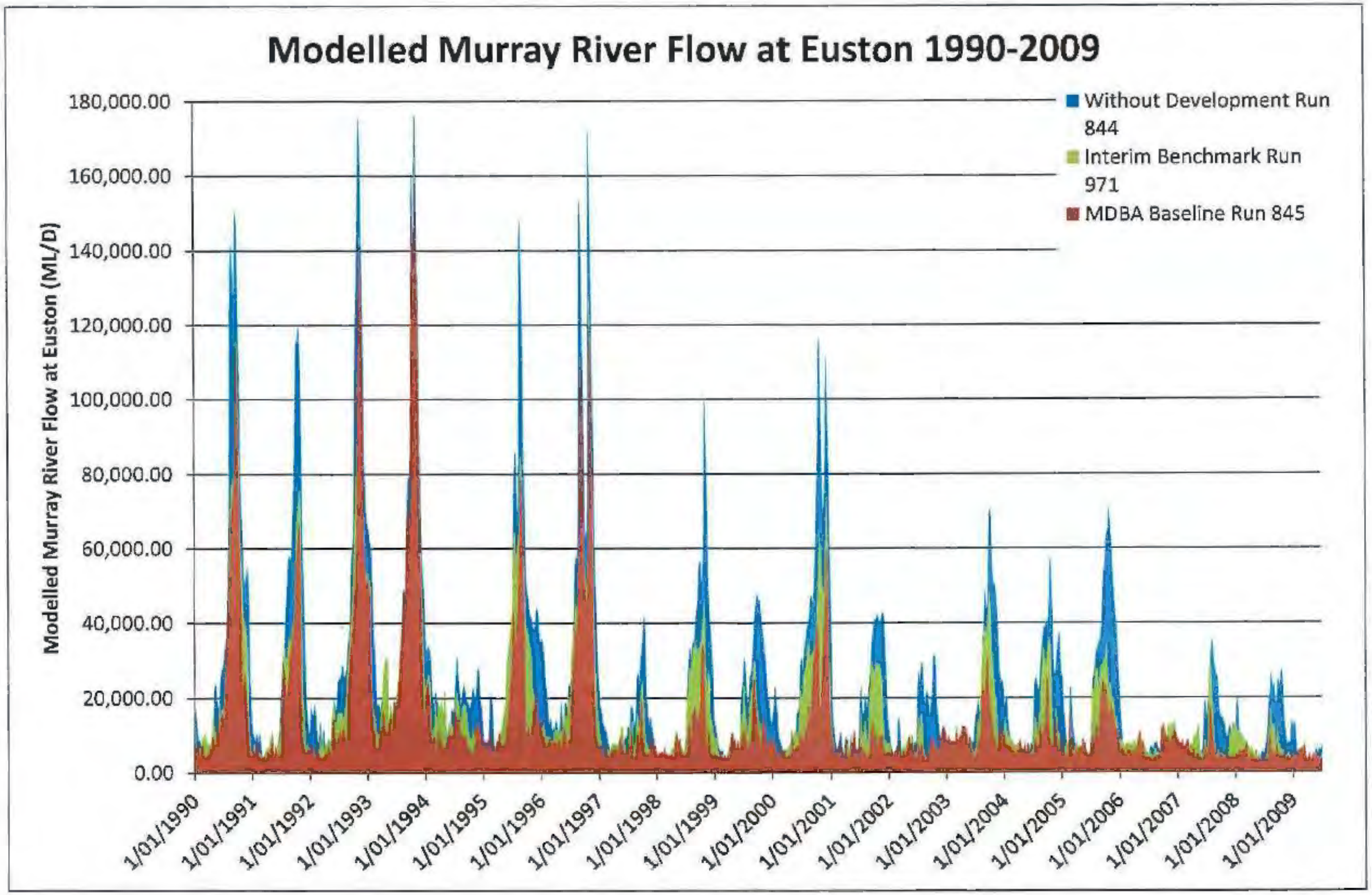


Figure 8-4. Daily Peak Flow by year for different flow regimes at Euston (Data supplied Mallee CMA, 2014)

9. Environmental water requirements (Section 4.5.2)

The environmental water requirements of the *Belsar-Yungera Floodplain Management Project* have been identified and contribute to the achievement of ecological objectives and targets for this site (Ecological Associates, 2014).

The process for identifying the environmental water requirements for this site 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 was then combined to generate site-specific environmental water requirements (Ecological Associates, 2014).

This project considers the environmental water requirements across the following water regime classes:

- Watercourse
- Semi-permanent wetlands
- Red gum forest and woodland
- Lignum shrubland and woodland
- Black box woodland
- Floodplain lakes (Lakes Powell and Carpul).

A key environmental outcome of this project is to maintain the productivity and structure of Black Box Woodland. Black Box Woodland requires inundation on average 5-6 years in 10 for 4-8 weeks (Ecological Associates, 2014). Inundation of this extent requires passing flows of approximately 100,000 ML/d for an extended period. Under the current hydrologic regime, this inundation requirement is not met.

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.

The environmental water requirements for the target water regime classes and their corresponding flows thresholds are outlined in Table 9-1. . Importantly this table illustrates the flexibility that will be incorporated into the future operation of the proposed works to mimic the variability that would have occurred under natural flow patterns.

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

reshold	Strategy	Frequency	Duration	Timi
ML/d	Open Narcooyia Creek to through-flow whenever river discharge provides levels in Narcooyia Creek that exceed pump requirements Pump water into Narcooyia Creek system to provide seasonal connections to adjacent wetlands	Provide open, through-flowing habitat in Narcooyia Creek annually	Two to three months	Sprin
		Water levels in the creek raised by 0.5 to 1.5 m for eight years in ten.	Three to six months	Betw
ML/d	Capture peaks in river flow in Yungera Creek wetlands and wetlands associated with Narcooyia Creek by closing regulators on the inundation recession. Pump water into wetlands if peaks in river flow are not available.	Water depth to exceed retention level (1 m) of wetland in eight years in ten. Wetlands completely dry one year in ten	Four of these events to last more than three months Four of these events to last more than six months	Late
ML/d	Protect and restore the inundation of red gum forest and woodland	Provide inundation events eight years in ten to a level equivalent to flows of 40,000 ML/d	Four events to be three months long Four events to be four months long	Late
ML/d	Protect and restore inundation to lignum shrublands	For areas above an inundation threshold equivalent to 50,000 ML/d, provide inundation eight times in ten years:	Four events to be two months long Four events to be four months long	Late
		For areas above an inundation threshold equivalent to 70,000 ML/d, provide inundation seven times in ten years	Four events to be three weeks long Three events to be nine weeks long	
ML/d	Protect and restore inundation to black box woodland	Provide inundation events equivalent to flows of 60,000 ML/d six years in ten	Two months	Late
		Provide inundation events equivalent to flows of 100,000 ML/d five years in ten	One month	
ML/d	Protect and restore inundation to floodplain lakes	Fill Lake Powell and inundate surrounding woodland vegetation up to a level of 52 m AHD in 25% of years	40 to 60 days	Late
		Fill Lake Carpul and inundate surrounding vegetation up to a level of 53 m AHD in 10% of years	30 days	

10. Operating regime (Section 4.6)

10.1 Role of structures and operating scenarios

The Belsar-Yungera Floodplain Complex works consist of three main regulators, a range of supporting structures and a permanent pipeline (GHD, 2014). These structures will be operated either in conjunction with Basin Plan flow or temporary pumping will deliver water to the complex.

These works and the existing infrastructure are described in Table 10-1. The volumes in Table 10-1 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.

Table 10-1. Summary of existing and proposed environmental watering infrastructure for Belsar-Yungera and its role in the project (GHD, 2014)

Infrastructure	Role	Inundation Area (ha)	Volume (GL)
Irrigator: Syndicate pumps[1]	Lifting irrigation water from River Murray to Narcooyia Creek (these pumps will be retained post works)	N/A	N/A
Irrigator pumps[1]	Lifting irrigation water from Narcooyia Creek to irrigation properties south of the complex (these pumps will be retained post works)	N/A	N/A
Embankments[1]	Contains water in Narcooyia Creek (these will be replaced by ER1 and ER3)	N/A	N/A
Area 1: ER1 and fishway, ER3, S7 and support structures	Enables inundation of Narcooyia and associated floodplain on a large scale Contain flows on floodplain.	1,535	13.283
Area 2: J1a and associated support structures	Enables inundation of Area 2 J1 Creek and associated floodplain	524	3.297
Area 3: J1C and associated support structures	Enables inundation of Area 3 J1 Creek and associated floodplain	36	0.07
Area 4: Lakes Powell and Carpul works	Delivers water from Narcooyia Creek to inundate Lake Powell and Carpul and associated floodplain	278	4.777

[1] existing infrastructure

10.2 Operating Scenarios

The *Belsar-Yungera Floodplain Management Project* works have been designed to provide maximum operational flexibility and be used to complement Basin Plan flows to deliver the environmental benefits. Six scenarios have been developed in order to summarise the range of scenarios possible. These include:

- Default
- Seasonal Fresh

- Belsar Intermediate
- Belsar Island Maximum
- Belsar Island Maximum and Lakes Powell and Carpul, and
- Natural Inundation.

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

Table 10-1: Links between the operating scenarios and water regime classes at Belsar Island

<table>
<tr><th>Corresponding river flow:</th><th>> 10,0000 ML/d</th><th>30,000 – 50,000 ML/d</th><th>50,000 – 90,000 ML/d</th><th>170,000 ML/day[1]</th></tr>
<tr><td>Watercourse</td><td>Seasonal Fresh</td><td rowspan="4">Belsar Intermediate</td><td rowspan="5">Belsar Maximum</td><td rowspan="6">Belsar Maximum with Lakes Powell and Carpul</td></tr>
<tr><td>Semi-permanent Wetlands</td><td></td></tr>
<tr><td>Red Gum Forest and Woodland</td><td></td></tr>
<tr><td>Lignum Shrubland and Woodland</td><td></td></tr>
<tr><td>Black Box Woodland</td><td></td><td></td></tr>
<tr><td>Floodplain Lakes - Lake Powell and Lake Carpul</td><td></td><td></td><td></td></tr>
</table>

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

Default

This scenario is the default configuration for Belsar-Yungera water management structures, in normal regulated flows when environmental watering is not required.

In this scenario the water level in Narcooyia Creek will be managed by fixed crest in one bay of ER1 and ER3, to maintain a minimum level of 48.35 m AHD – the same levels maintained by existing infrastructure to provide irrigation access. Pumping of water from the River Murray will be the responsibility of the irrigators using their existing fixed pumping system.

Seasonal Fresh

The seasonal fresh scenario is achieved via opening ER1 and ER3 to allow water to flow through Narcooyia Creek during Basin Plan flows. This will enable watering of riparian vegetation and provide varied flow conditions and additional access to resources for fish.

Belsar Intermediate

This scenario requires the operation of ER1, S7, ER3 and support structures to intermediate levels (between 48.35 m AHD and the maximum operational height) to take advantage of high river flows. High river flows may also be augmented through use of temporary pumps. This will enable watering of Red Gum Forest and Woodland and Lignum Shrubland and Woodland on the lower floodplain of Belsar-Yungera. Where appropriate passing flow downstream of ER1 would be provided, in additional to flows passing through the fishway.

Belsar Maximum

The ER1, ER3 and S7 regulators and associated support structures will be operated to their maximum operational height to enable broad scale inundation of Red Gum Forest and Woodland, Lignum Shrubland and Woodland and Black Box Woodland on Belsar-Yungera. Where appropriate, passing flow downstream of ER1 would be provided, in addition to flows passing through the fishway.

The J1 and J1c and their supporting structures will also be operated to maximum operational level.

Delivery to these sites will take advantage of high river flows or could be augmented with use of temporary pumps if necessary.

Belsar Maximum and Lakes Powell and Carpul

This scenario is a variation of the Belsar Island Maximum operation. In addition, the Lake Powell Regulator will be closed and water delivered through the pipeline to inundate Lakes Powell and Carpul with temporary pumps.

Natural Inundation

In order to minimise the impact of the infrastructure on natural inundation patterns it is proposed that all regulating structures will be open during times of natural floods, allowing full connectivity between the River Murray, Narcooyia Creek 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 Belsar intermediate, ER3 would be opened to allow river flows to enter Narcooyia Creek, S7 would be fully closed and ER1 would be progressively closed until the desired target level is reached. Appropriate passing flows over ER1 and its associated fishway would be maintained during this operation.

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

During transition to all structure open under flood conditions, ER1 and ER3 and other 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.

Fresh				
ing sed fixed in | tures	ER3 open	ER1 and associated supporting structures set to height required to achieve operational objectives, (between open (48.35 m AHD) and 52.3 m AHD), with through flow maintained. S7 closed. ER3 opened to allow river flows to enter Narcooyia Creek and closed to augment flow with temporary pumps.	ER1, S7 and associated supporting structures set to maintain 52.3 m AHD and through flow. ER3 opened to allow river flows to enter Narcooyia Creek and closed to augment flow with temporary pumps. J1 set to maintain 52.9 m AHD and through flow, augmented by temporary pumps if required. J1c set to maintain 53.3 m AHD and through flow, augmented by temporary pumps if required.	ER1, S7 and associated supporting structures set to maintain 52.3 n through flow. ER3 opened to allow river flows to enter Narcooyia Creek and close flow with temporary pumps. J1 set to maintain 52.9 m AHD and through flow, augmented by ten pumps if required. J1C set to maintain 53.3 m AHD and through flow, augmented by te pumps if required. Lake Powell regulator set to closed and pipeline and temporary pur operation to fill Lake Powell and Carpul to 52.6 m AHD.
	Condition During Scenario ER1 set to maintain irrigation weir pool height, while passing flow and fishway in operation All other structures open, including ER1	ER1 and associated supporting structures set to height required to achieve operational objectives, (between spring fresh level and 52.3 m AHD), with through flow maintained. S7 closed. ER3 opened to allow river flows to enter Narcooyia Creek and closed to augment flow with temporary pumps	ER1, S7 and associated supporting structures set to maintain 52.3 m AHD and through flow. ER3 opened to allow river flows to enter Narcooyia Creek and closed to augment flow with temporary pumps J1 set to maintain 52.9 m AHD and through flow, augmented by temporary pumps if required. J1c set to maintain 53.3 m AHD and through flow, augmented by temporary pumps if required.	ER1, S7 and associated supporting structures set to maintain 52.3 n through flow. ER3 opened to allow river flows to enter Narcooyia Creek and close flow with temporary pumps J1 set to maintain 52.9 m AHD and through flow, augmented by ten pumps if required. J1c set to maintain 53.3 m AHD and through flow, augmented by te pumps if required. Lake Powell regulator set to closed and pipeline and temporary pur operation to fill Lakes Powell and Carpul to 52.6 m AHD
sed fixed in | tures	ER1 set to maintain irrigation weir pool height, while passing flow and fishway in operation	Condition During Scenario ER1 and associated supporting structures set to height required to achieve operational objectives, (between open (48.35 m AHD) and 52.3 m AHD), with through flow maintained. S7 closed. ER3 opened to allow river flows to enter Narcooyia Creek and closed to augment flow with temporary pumps J1, J1c and Lake Powell regulator set to open	ER1, S7 and associated supporting structures set to maintain 52.3 m AHD and through flow. J1 set to maintain 52.9 m AHD and through flow, augmented by temporary pumps if required. J1c set to maintain 53.3 m AHD and through flow, augmented by temporary pumps if required.	ER1, S7 and associated supporting structures set to maintain 52.3 n through flow. ER3 opened to allow river flows to enter Narcooyia Creek and close flow with temporary pumps J1 set to maintain 52.9 m AHD and through flow, augmented by ten pumps if required. J1c set to maintain 53.3 m AHD and through flow, augmented by te pumps if required. Lake Powell regulator set to closed and pipeline and temporary pur operation to fill Lake Powell and Carpul to 52.6 m AHD
sed fixed in	ER1 set to maintain irrigation weir pool height, while passing	ER1 and associated supporting structures set to height required to achieve operational objectives, (between open (48.35 m AHD) and 52.3 m AHD),	Condition During Scenario ER1, S7 and associated supporting structures set to maintain 52.3 m AHD and through flow. ER3 opened to allow river flows to enter Narcooyia Creek and closed to augment flow with temporary	Lake Powell regulator set to closed and pipeline and temporary pur operation to fill Lakes Powell and Carpul

			augmented by temporary pumps if required. Lake Powell Regulator set to open	
sed fixed in | tures	ER1 set to maintain irrigation weir pool height, while passing flow and fishway in operation All other structures open	ER1 and associated supporting structures set to height required to achieve operational objectives, (between open (48.35 m AHD) and 52.3 m AHD), with through flow maintained. S7 closed. J1, J1c and Lake Powell regulator set to open	Lake Powell Regulator set to open Cease temporary pumping	Condition During Scenario ER1, S7 and associated supporting structures set to maintain 52.3 n through flow. ER3 opened to allow river flows to enter Narcooyia Creek and close flow with temporary pumps J1 set to maintain 52.9 m AHD and through flow, augmented by ter pumps if required. J1c set to maintain 53.3 m AHD and through flow, augmented by te pumps if required. Lake Powell regulator set to closed and pipeline and temporary pur operation to fill Lakes Powell and Carpul to 52.6 m AHD
losed fixed in |	ER1 set to maintain irrigation weir pool height, while passing flow and fishway in operation All other structures open	ER1 and associated supporting structures set to height required to achieve operational objectives, (between open (48.35 m AHD) and 52.3 m AHD), with through flow maintained. S7 closed. J1, J1c and Lake Powell regulator set to open	ER1, S7 and associated supporting structures set to maintain 52.3 m AHD and through flow. ER3 opened to allow river flows to enter Narcooyia Creek and closed to augment flow with temporary pumps J1 set to maintain 52.9 m AHD and through flow, augmented by temporary pumps if required. J1C set to maintain 53.3 m AHD and through flow, augmented by temporary pumps if required. Lake Powell Regulator set to open	ER1, S7 and associated supporting structures set to maintain 52.3 n through flow. ER3 opened to allow river flows to enter Narcooyia Creek and close flow with temporary pumps J1 set to maintain 52.9 m AHD and through flow, augmented by ter pumps if required. J1c set to maintain 53.3 m AHD and through flow, augmented by te pumps if required. Lake Powell regulator set to closed and pipeline and temporary pur operation to fill Lakes Powell and Carpul to 52.6 m AHD

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

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

The proposed works are adjacent to irrigation properties, which use Narcooyia Creek as a key component of their irrigation supply system. Operation of the environmental works has been planned to ensure irrigation supply is maintained, along with access to irrigation infrastructure during environmental watering events.

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

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

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

11.1 Risk assessment methodology

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

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

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

11.2 Risk assessment outcomes

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

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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Adverse impacts on cultural heritage						
Loss of artefacts via erosion; loss of artefacts via inundation	Lindsay Island is considered an area of high cultural heritage sensitivity. Fluvial processes during watering events could damage cultural sites and places, resulting in the loss of artefacts in-situ on the floodplain. This may damage relationships with Indigenous stakeholders and subsequently affect future operation of the works.	Possible	Moderate	Moderate	A preliminary cultural heritage assessment has been undertaken through the Belsar-Yungera Island Floodplain Due Diligence Assessment (Bell, 2013). A Cultural Heritage Management Plan will be required prior to construction activities and will be developed in partnership with Indigenous stakeholders. This will provide for any further remedial works during/after operations. Implement measures during operations to minimise damage to cultural sites. Proactive engagement with Indigenous stakeholders during operation, which may involve inspection of cultural sites pre and post watering events to monitor and undertake protection works, relocation of artefacts as required, and rehabilitation works.	Low
Damage to relationships with Indigenous stakeholders	This threat could occur through unforeseen impacts on cultural sites during operation, which may damage relationships with Indigenous stakeholders. This could affect the future operation of works and subsequently impact on the site's water-dependent ecological values.	Possible	Moderate	Moderate	As above.	Low
Adverse impacts on socio-economic values						
Restricted access to public land during watering events	Watering events may inundate roads and bridges, limiting or prohibiting public access. This may reduce opportunities for active and passive recreation, and possibly tourism.	Certain	Minor	Moderate	Improved planning and modelling to predict access limitations during operation. Issue public notifications of access changes/limitations prior to watering events. Close consultation with tourism industry to ensure timely communication around planned events. Upgrade roads to improve access where practical. Provide boat access as an alternative, where relevant.	Moderate

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
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 Lindsay River is discharge of saline groundwater along gaining reaches during a flow recession. Increases in salinity (measured as EC units at Morgan) may breach Basin Salinity Management Strategy requirements and also exceed Basin Plan salinity targets. This may result in poor water quality for downstream users.	Likely	Moderate	Moderate	Provision of 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 rate of recession to manage the volume of saline water 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
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	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.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
	including strip boards and handrails.				Flood preparation actions written into O&M documents including removing structural parts likely to be barriers to flow or large debris.	
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 operation	Lack of clear understanding of roles and responsibilities of ownership and operation could prevent the effective operation of the infrastructure.	Possible	Moderate	Moderate	Establish a MoU between all relevant agencies outlining roles and responsibilities during operation. Facilitate shared knowledge of project objectives among asset owners and operators. Develop all documentation with relevant agencies prior to construction, including production of Operation and Maintenance manuals. Ensure emergency response arrangements are in place. Ensure ongoing maintenance of structures and insurance arrangements.	Low

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
					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 the capacity to operate the site as required.	Possible	Moderate	Moderate	Ongoing stakeholder liaison (early and often) guided by a stakeholder engagement plan. Targeted engagement to address identified concerns of key stakeholders.	Low
Inundation of private land without prior agreement	The only private land to be inundated by this project is currently owned by Trust For Nature and managed for conservation. It is possible that ownership could change and the new owner may not permit inundating.	Possible	Moderate	Moderate	Ongoing engagement with landholders regarding planned watering events and outcomes. Negotiate conservation covenants and/or flood/access easements to be registered on title if ownership changes.	Low

11.4 Risk mitigation and controls

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

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

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

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

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

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

Threat	Risk without mitigation	Residual risk rating	Additional considerations (Lloyd Environmental, 2014)
Restricted access to public land during watering events	Moderate	Moderate	Alternative recreational sites could be promoted as a form of 'offset' during watering events. New infrastructure could be provided to enhance the most common recreational pursuits (e.g. walking tracks and bird hides, campgrounds for campers)
Rise in river salinity from salt wash off from floodplain soils, mobilisation in stream salt store or via mobilisation of saline groundwater to watercourses	High	Moderate	Implementation of comprehensive monitoring including the installation of additional groundwater monitoring bores during early operations and the use of information obtained will inform a more detailed analysis of local and downstream salinity impacts and adaptive management of the site. This local scale investigation should form part of a larger scale investigation covering river operations and environmental watering activities taking in the Lower Murray.
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 *Belsar-Yungera Floodplain 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 *Belsar-Yungera Floodplain Project* and considered the findings of the expert peer review (see Appendix L). The Group endorses the assessment methodology as consistent with the BSMS and fit for purpose to support this business case.

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 salt load magnitude.

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

Preliminary salt estimate

The preliminary salinity impact estimate for the *Belsar-Yungera Floodplain Management Project* is 0.05 EC at Morgan for the nominated frequencies of inundation. This is not deemed significant under BSMS. 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 Belsar-Yungera was modelled (over the 25 year benchmark period) and neither the primary or secondary options caused an exceedance of salinity targets at Lock 6 or Morgan.

Mitigating measures and their feasibility

While the estimated salinity impact is deemed 'not significant' under BSMS, mitigating strategies can be used to minimise any impacts that may occur in practice. Mitigation strategies are therefore described below in general terms. A more detailed analysis of the potential salinity impacts and risk mitigation strategies is recommended upon approval of this business case. This will be 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 the 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 available for Belsar-Yungera 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:

- Six new bore sites drilled close to the inundation areas
- Four data logger sites to capture continuous salinity and water level data – additional sites may be required where inundation presents access issues
- Ten bores monitored for water level and salinity before, during and immediately after watering events, and every three months between events, and
- Additional surface water data (flow, level and salinity collected at a series of locations along Narcooyia, Yungera and Bonyaricall Creeks (close to the proposed regulator sites).

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

12.1 Development of designs

The *Belsar-Yungera Floodplain Management Project* has 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:

A. **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.

B. **Maximising cost effectiveness, environmental benefits and water efficiency returns for investors through**
   - Analysis of existing 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.

C. **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.

D. **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.

E. **Minimising negative impacts on the environment, cultural heritage 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 avoiding extensive networks of tall levees

12.2 Design criteria used

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

Capacity and Flow Conveyance

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

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

Fish Passage

A fish passage workshop was held on the 16th of 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 considered.

Specific outcomes for the proposed works across Belsar and Yungera islands, included:

- Freshwater catfish will be a predominant species at this site, due to the proximity to the Euston Weir
- Connectivity to the river is very important
- Catfish are not tolerant of significant water level changes during nesting (summer)
- When the wetlands are connected it could be very productive, if it can connect for a river flow of 7000 – 10,000 ML
- Will require fish passage (vertical slot) back to the river at downstream regulator (ER1)
- There is a need mindful of high velocities at the ER3 regulator on the river
- Murray cod have been found in this area; there is some good habitat (if supported could provide net gain for fish)

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.

Explicit fish passage has been provided at the ER3 regulator. Passive fish passage is to be provided on all minor structures to limit the placement of barriers or encumbrances to fish such as overshot gates, ensuring optimal natural lighting conditions.

Gate Design

A gate assessment workshop was held at Tatura on 31 July 2014 and included representatives from G-MW Operations and Major Projects, GHD and the Mallee CMA. The object of this workshop was to determine appropriate design criteria for each of the regulator.

Specific outcomes for the proposed works, included:

For large regulators:

- dual leaf penstock gates are preferred by G-MW where fish passage is a primary design requirement
- slots be incorporated on either end of the gates (upstream and downstream) to enable isolation of the gates if required
- hard stand areas need to be incorporated on the access track either side of the regulator to enable the operation of a crane to remove gates for maintenance or replacement

For small regulators:

- mechanically-assisted/actuated gates
- gate widths of 1,200 mm or 1,800 mm

Other design considerations

- remote real-time monitoring of the upstream water levels at ER1 regulator is required.

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 of up to 0.5m.

The freeboard adopted for design of the Large regulators 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

A description of the proposed works package has been provided in section 3.2.

Advanced concept designs have been prepared for areas 1, 2, 3 and 4 as described in Tables 12-1 to 12-4.

Concept design drawings for each structure are provided within Appendix E. Figure 12-1 shows the section view of the proposed K10 Regulator.

Table 12-1. Area 1 works components

AREA ONE WORKS – MAJOR STRUCTURES	
Name	**Description - Size of structure, function**
ER1 Regulator	This regulator is similar to the regulators recently commissioned at Hattah Lakes and includes: a new regulator and associated bridge deck access and abutment works. 9 bays, with hydraulically actuated Dual Leaf Combination gates on 7 bays, a concrete sill on one bay to maintain the minimum water level of 48.35 m AHD for irrigation requirements and a vertical slot fishway integrated into the remaining bay.
ER1 South track raising	Raising of existing tracks by up to 2 m, for a distance of approx. 1,160 m. The levee incorporates vehicle access and includes a minor regulator of 2 box culverts with penstock gates.
ER1 North track raising	Raising of existing tracks by up to 2 m, for a distance of approx. 690 m. The levee incorporates vehicle access and includes a minor regulator of box culverts with penstock gates.
ER3 Regulator	Similar to ER1, this structure includes: a new regulator and associated bridge deck access and abutment works. 7 bays with hydraulically actuated Dual Leaf Combination gates on 5 bays, a concrete sill on one bay and amenity to house irrigation pipe outlets on the remaining bay.
S7 Regulator	Similar to ER1 and ER3, this structure includes: a new regulator and associated bridge deck access and abutment works; cast in situ base, walls and piers, founding on sheet pile cut offs and concrete piles. 7 bays with Dual Leaf Combination gates on all bays. The structure also incorporates to widened hardstand areas.
AREA ONE WORKS – SUPPORT STRUCTURES	
Name	**Description - Size of structure, function**
S104 track raising	75 m long x up to 0.4 m high, over an existing track. Includes access provision.
S4 Regulator	3 box culverts with penstock gates and an 80m long track raising with access provision.
S105 Regulator	4 box culverts with penstock gates and a 75 m long track raising with access provision.
S5 Regulator	2 box culverts with penstock gates and a 30 m long track raising with access provision.
S106 track raising	60 m long x up to 0.2 m high, over an existing track. Includes access provision.
S14 track raising	25 m long x up to 0.16 m high, over an existing track. Includes access provision.
S108 Regulator	2 box culverts with penstock gates and a 30 m long levee with access provision.
S109 Regulator	2 box culverts with penstock gates and a10 m long levee with access provision.

Table 12-2. Area 2 works components

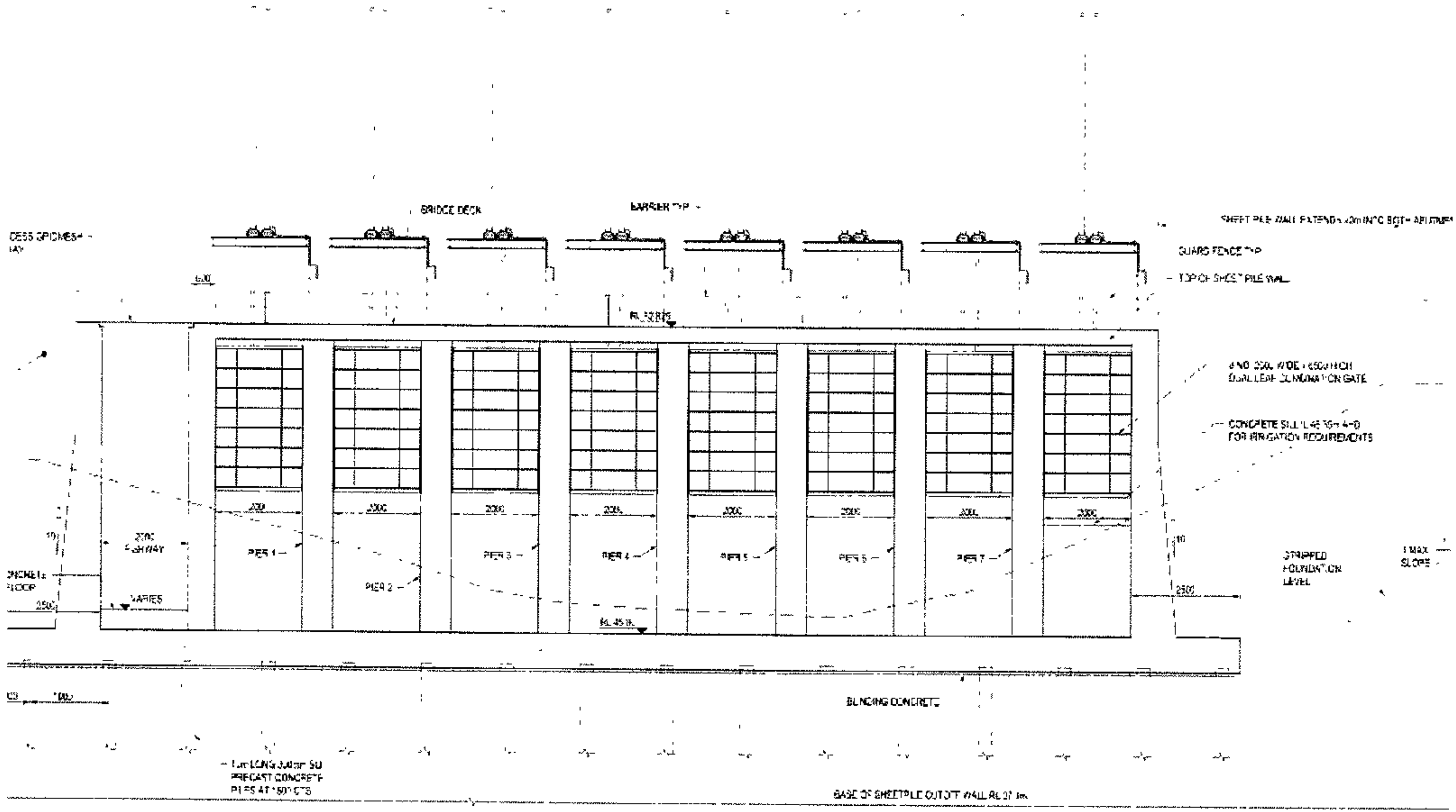
AREA TWO WORKS COMPONENTS	
Name	**Description - Size of structure, function**
J1a Structure	J1a is the main structure for Area 2 and includes 2 regulators and a section of track raising: 2 regulators, each consisting of 4 box culverts with penstock gates 950 m long x up to 2 m high, over an existing track. Includes access provision.
J1b Regulator	2 box culverts with penstock gates 45 m long track raising with access provision.
J1d Regulator	2 box culverts with penstock gates 30 m long track raising with access provision.
J1e Regulator	2 box culverts with penstock gates 45 m long track raising with access provision.
J1f Regulator	2 box culverts with penstock gates 25 m long track raising with access provision.
J1h track raising	110 m long x up to 0.8 m high, over an existing track. Includes access provision.

Table 12-3. Area 3 works components

AREA THREE WORKS COMPONENTS	
Name	**Description - Size of structure, function**
J1C Regulator	3 box culverts with penstock gates. 60 m long levee with access provision. Hardstand area
J1g Culvert	2 box culverts. 85 m long track raising with access provision.

Table 12-4. Area 4 works components

AREA FOUR WORKS COMPONENTS	
Name	**Description - Size of structure, function**
Lake Powell pipeline and hard stand	A four km low pressure pipeline with inlet and outlet pits. Includes a hard stand for temporary pump
Highway Regulator	Structure includes: 5 box culverts with Dual Leaf Combination gates. 50 m long levee.
Murray Valley Highway Culvert	1 No. 600 mm diameter x 25.42 m long pipe
Belsar Road raising	Earthworks to raise unsealed road
Lake Powell Outlet Modifications	Earthworks to lower sill between Lakes Powell and Carpul. Includes 3 culvert crossings.



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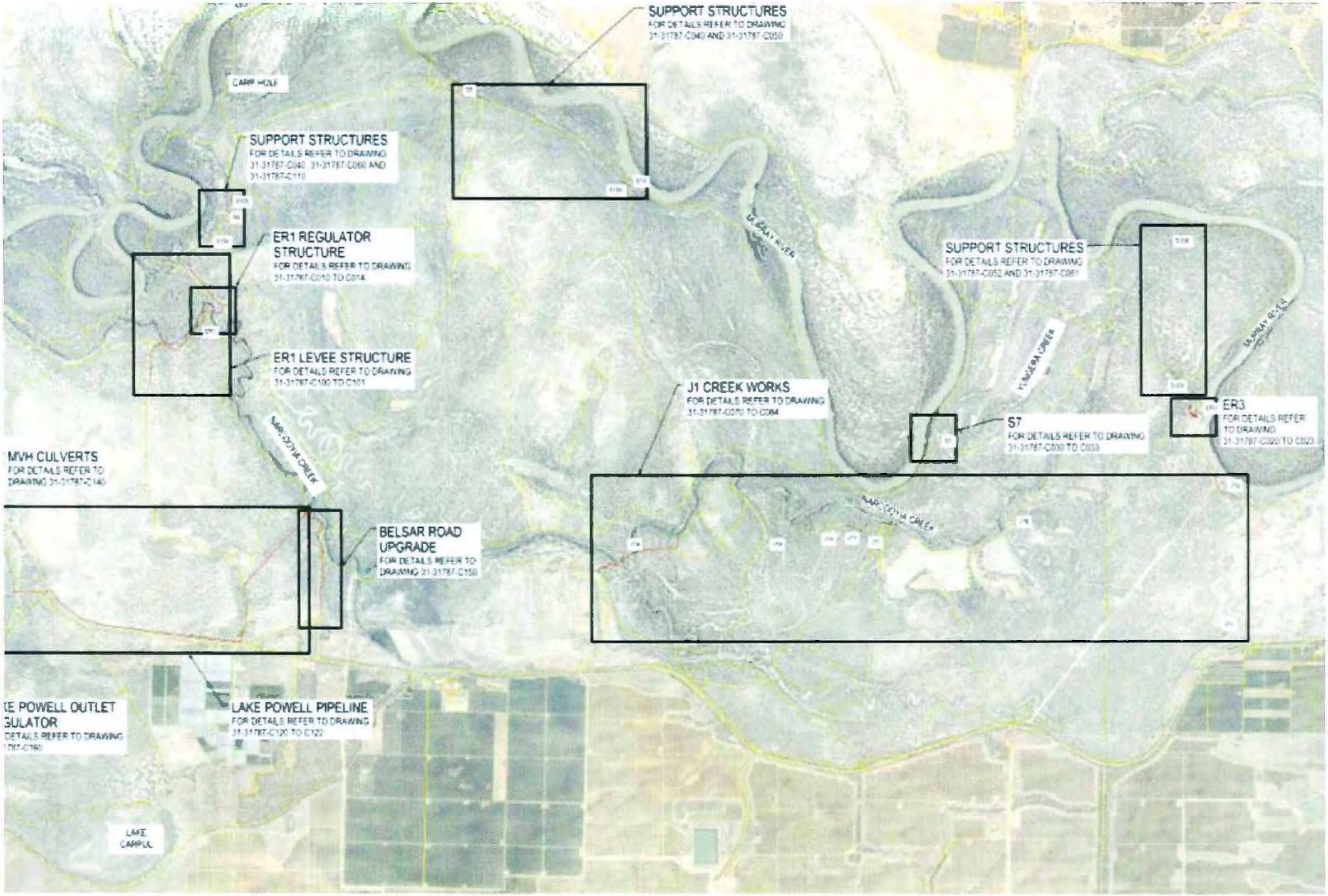
12.4 Location of activities to be undertaken, access routes, footprint area

The location of each structure has been selected to maximize the efficiency of the works whilst minimizing impacts on cultural heritage, native vegetation and the visual or recreational amenity of the park and adjacent landholders. Figure 12.2 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 to the works and to private infrastructure during operation. Comprehensive mapping of these access arrangements is provided in GHD 2014.

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.



PLAN

NOTES

1 FOR TYPICAL REGULATOR DETAILS REFER TO DRAWINGS 31-31787-C200

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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 cutoff

Bores identified that subsurface conditions generally consist of:

- Aeolian and fluvial sand and silt; overlying
- Quaternary clay deposits and minor sandy silt; overlying
- Dense to very dense sand and fine gravel
- There was significant variability in the depths at which the different units were encountered across the four test borehole sites
- 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).

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

- Drilling of 27 solid flight auger to depths of between 2.0 and 4.0 m. Dynamic cone penetrometer tests (DCP) were carried out to 2.0 m at all auger sites. SPT testing was carried out at selected location between 2 and 4 m.
- Drilling of 6 boreholes to a depths of 14.45 and 19.45 m. These boreholes were drilled at the three major regulator structures. SPT tests were undertaken at 1.5 m intervals in all boreholes and undisturbed samples were collected at selected locations.
- 18 Cone Penetrometer Tests to depths of up to 20 m. These boreholes were drilled at the three major regulator structures.

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

ER1 Regulator

At the ER1 Regulator site boreholes were extended to a depth of 19.45 m on each of the abutments along the proposed alignment. CPTs were carried out within the river bed and also on both abutments. In general the soil profile from the surface at the ER1 site is as follows:

- Stiff to very stiff, intermediate plasticity clay with trace sand to a depths of between 4 and 6m approximately, overlying
- Medium dense fine to medium sand to a depth of between 11.5 and 12.8 m below the surface, overlies
- Medium dense sandy silt to a depth of between 14.5 and 16.0 m from the surface, overlies
- Very stiff, intermediate to high plasticity clay with trace sand.

In two of the borehole locations a 2 to 2.8 m thick layer of gravelly sand was encountered between 8.5 m and 12.8 m below the ground surface. This layer was above the sandy silt and was not persistent across the entire site.

The layering was seen to be fairly consistent across site and generally horizontal with only minor variations in the levels between the soil interfaces. The clay capping was seen to be thicker on the west abutment as this abutment was at a higher RL. In the base of the river the clay cap has been eroded and the medium dense sands are exposed at the surface.

ER 3 Regulator

At the ER3 Regulator site only one borehole was drilled on the north abutment as part of the current investigations however as part of the previous investigation a borehole were extended along the alignment on the southern abutment. CPTs were carried out on both the northern and southern abutments. In general the soil profile from the surface at the ER3 site is as follows:

- Firm to stiff, intermediate to high plasticity clay with sand to a depths of between 4 and 9.5m approximately, overlying
- Medium dense fine to medium sand to a depth of between 10 and 14 m below the surface, overlies
- Very stiff, intermediate to high plasticity clay with trace sand interbedded with sandy clay.

In the bore extended on the north abutment a 1.5 m thick layer of gravelly sand was encountered at a depth of 10.5 m. It is unknown if this layer extends across the site as the borehole on the southern abutment stopped short of this depth.

The layering was seen to be fairly consistent across site. The clay capping was seen to be thicker on the south abutment as this abutment was approximately 2 to 4 m higher than the northern side at a higher RL. It is possible that the sand unit is exposed in the base of the river.

S7 Regulator

At the S7 Regulator site two boreholes were drilled, one on each of the abutments as part of the current investigations. In addition one borehole was drilled on the southern side of the creek bed, as part of the previous investigations. CPTs were carried out on both abutments and within the base of the creek bed. In general the soil profile from the surface at the site is as follows:

- Stiff to very stiff, intermediate plasticity clay to sandy clay to a depths 2.0 and 5.8 m. This unit is not present in the base of the creek bed as it has been eroded away; overlying
- Medium dense fine to medium sand to a depth of between 11 and 14.5 m below the surface, overlies
- Very stiff, intermediate to high plasticity clay to sandy clay to depths of between 12.5 m and 19.5m, overlies
- Medium dense sand and sandy gravel

The interface between the upper clay and the medium dense sand is generally consistent with the clay capping being thicker at higher RLs. The base of the upper unit of medium dense sand was variable and the thickness of the clay to sandy clay under this material was also variable however the minimum thickness of this lower clay unit was at least 1.5 m.

Minor Structure and levees
The soils encountered across site were generally consistent and included

- Stiff to very stiff intermediate to high plasticity clay with trace sand to sandy clay
- Medium dense sand with silt
- In some locations along the existing tracks, shallow depths of fill were encountered up to approximately 1 m deep.

At least 1 m and often greater of clay was found at the surface with the exception of the culvert crossing under highway where 1.6 m of sand and silty sand was encountered at the surface.

12.6 Alternative designs and specifications

During 2012 an options assessment was undertaken; this work was summarised in the Functional design - preferred options paper (GHD, 2013a).

This work is summarised in GHD (2014) as follows:

- Two groups of options were identified as part of this study, these being Primary Options and Secondary Options.
- Primary Options comprise works which have a widespread impact in terms of the flooding extent achieved, generally requiring at least one main structure of larger size/higher cost. These options aim to achieve large scale inundation, maximising outcomes in terms of enhanced connectivity between floodplain elements, the floodplain and the river. Hydraulic modelling was undertaken on key primary options to determine general system capabilities and characteristics, and to confirm the relationships of floodplain interconnections.
- Secondary Options comprise a range of works which would generally operate in conjunction with the Primary Option to target specific additional areas or enhance the transfer of flow around the system.

Supporting investigations which were completed in conjunction with this project included:

- Cultural heritage due diligence assessment (GHD, 2013b)
- Preliminary geotechnical investigations (GHD, 2013c)
- Specialist investigations summary report (GHD, 2013a)

Following an evaluation process (section 12.1) which considered ecological benefit and cost effectiveness, the recommended options included those listed below:

Primary options

Six primary options were proposed in this wide scale overview of the floodplain, with two main variables: the first being the top water levels considered (51.8 and 52.3 mAHD) and the second being the location of the main downstream environmental regulator, ER1 (three locations considered). Locations proposed for ER1 included a site mid-way along Bonyaricall Creek and two sites on Narcooyia Creek, upstream of the confluence with Bonyaricall Creek.

A preferred top water level was not identified as part of this study and therefore the scope of the associated support structures was not well defined.

The proposed works from this study included three major regulating structures: two environmental regulators on Narcooyia Creek and/or Bonyaricall Creek (ER1 and ER3) and regulator on Yungera Creek (S7). Initially, the two environmental regulators on the primary waterway/s both included vertical slot fishways.

The range of associated works to manage breakouts and improve flow efficiency included:

- 4 No. regulator/crossing combination structures
- Channel works to interconnect Narcooyia Creek overflow into the Lake Powell inflow channel and potentially also Lake Powell to Lake Carpul, and
- Associated levee and track raising works.

Secondary options

A number of secondary options were considered to maximise the inundation extent and/or operational flexibility of the structures.

The following options were considered for secondary works:

- Lake Carphole – additional flooding, separate minor system. Lake Carphole wetland also watered by Basin Flows (MDBA 2010) or pumping with regulator to retain for extended duration.
- Lake Carpul – additional filling option (improvements to inflows)
- Lake Powell – water management enhancements (gating the inflows)
- J1 Creek Works – enhancing flooding extents
- J1 Creek Outlet Works – securing control of connectivity of the J1 Creek with Narcooyia Creek (fully gated to ensure J1 Creek can be separated from Narcooyia Creek under normal, non-operating conditions)
- S5 Secondary Release – option to enhance flooding by planned release
- S4 Secondary Release – option to enhance flooding by planned release
- S14 Pump in Location - option to use pumped inflows to enhance flooding extent.

Table 12-1. Final options selected (Mallee CMA, 2013a) areas and volumes have changed in subsqeuent design work (2014)

Option	Total Area of Inundation (ha)	Volume (GL)
Area 1, Primary Inundation Area	2,147	18.83
Area 2, Lower J1 Creek Area	313	2.26
Area3, Upper J1 Creek Area	38	0.07
Area 4, Lake Powelland Lake Carpul Area	280	Included in area 1
Upgrade access	-	
Total	**2,778**	**21.16**

12.7 Ongoing operational monitoring and record keeping arrangements

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 have systems in place to manage data generated by operations including water accounting and water quality monitoring data. Operating and maintenance considerations will be documented in an operations manual.

Maintenance and operating costs will be similar to other environmental works projects delivered through TLM. The designs incorporate simple, easy to operate structures without automation, specialist equipment or telemetry.

Pumping will be needed approximately 2.5 years in 10 years for Areas 2, 3 and 4 using portable pumps. This will require approximately 17.12 GL to be pumped per event.

The concept design report (GHD, 2014) details considerations given to construction and operation of each of the proposed structures. This will be further refined during the detailed design stage, with additional Workplace Health and Safety considerations prepared.

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 recorded and 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 Belsar-Yungera works and their interactions with River Murray Operations and the existing irrigation works.

12.8 Peer review of concept designs

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

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

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

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

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

The operation of the proposed works is not dependent on the operation of any existing works.

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

13.1 Cumulative impacts of operation of existing and proposed works

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

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

On a local scale, the cumulative impacts of the proposed Belsar- Yungera Floodplain Management Project and the existing and proposed Hattah works on downstream water quality will need to be monitored. It is expected that Basin plan flows will more than meet any dilution flow requirements of proposed and existing works as well as delivering environmental and water quality benefits along the full length of the river. The operation of the proposed Belsar works in conjunction with the Hattah infrastructure, 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 Belsar -Yungera Floodplain Management Project to the outcomes of the Basin Plan.

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

14.1 Introduction

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

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

These include:

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

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

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

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

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

This chapter provides this information on the following:

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

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

14.2 Capital cost estimates

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 $47,177,817. The 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 and Gunbower Forest), in conjunction with agencies involved in these and other projects. These cost estimates have been peer reviewed by a review panel, comprised of recognised experts (as described in Section 17).

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

Total project implementation costs, through to commissioning of the structures, in Present Value 2014 dollars are $55,632,428.

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.

It is important to note:

- Costs incurred for monitoring related to verifying the performance and integrity of newly constructed infrastructure have been included as commissioning costs.
- Costs expressed in this document are present day values and investors will need to consider indexation and cost variations as appropriate.
- The costs presented here relate to the implementation of this project in isolation.

[redacted]

[redacted]

[redacted]

14.3 Operating and maintenance costs

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

Operating and maintenance costs for the project are summarised in Table 14-3. As the precise operating procedures of the project will be detailed subsequent to this business case, Table 14-3 outlines the operating costs for an 'operating year' and a 'non-operating year', along with an estimate of a total present value operating and maintenance costs over the analysis timeframe (30 years), discounted to 2014 dollars using a 7% real discount rate.

[redacted]

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

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

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
- Goulburn-Murray Water.

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

- Access to capability to perform the required functions, either directly or under contract
- Access to suitable resources which can be deployed in a timely, efficient manner
- Sufficient powers conferred under legislation to enable services to be provided

- Demonstrable benefit or linkage to primary business mission or activities
- Ability to collaborate and co-ordinate effectively with multiple parties
- Risks are allocated to those best placed to manage them.

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

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

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

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

14.6 Project benefits

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

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

- Improved healthy native vegetation: studies have shown that the Victorian community values improvements to the health of native vegetation, specifically River Murray red gum forests4. Values were applied to 128 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 2.5% increase in native fish populations in the river produced by the project5

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[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.

- 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 3.5% 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 Belsar-Yungera project was estimated to increase the net annual tourist visitor days to the site by 1,000 days7. Using previous studies that estimated the economic value of a visitor day ($134 per visitor day8), the economic value of an increase of 1,000 visitor days was estimated.

The economic value of these four[9] quantified economic benefits associated with the Belsar-Yungera project are presented in Table 14-4. 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 14-4. Economic benefits produced by the project ($2014) (Aither, 2014)[10]

	Annual value ($M)	Present value ($M)[11]
Healthy native vegetation	$0.25	$2.3
Native fish population	$3	$28
Frequency of colonial water-bird breeding	$1.3	$11.7
Recreation	$0.16	$1.5
Total	**$4.7 million**	**$43.3 million**

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

- Cultural heritage: There are 13 known archaeological sites in the Belsar-Yungera project which may be impacted by the project, including scar trees that depend on seasonal high river flows and natural inundation regimes, and are currently stressed. However, increased visitation may have negative impacts on some sites, and as such no estimation of cultural heritage values has been undertaken.

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[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.
[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.

- Apiarists: the beehives that currently exist at Belsar-Yungera 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 Belsar-Yungera can be estimated in terms of employment, output, wages and salary, and industry value added.

During the two year construction phase of the proposed works, the additional expenditure will result in $35.6 million per year of gross output and 85 jobs. After this construction phase, annual operations and maintenance expenditure will result in output of $3.1 million per annum and 7 additional jobs.

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 from 2012 to 2014 to develop the concept for the Belsar-Yungera project. Engagement via formal and informal methods has directly informed this project and helped contribute to its development. Communication and engagement activities conducted throughout the Business Case phase have included:

- More than 125 face-to-face briefing sessions, meetings, presentations and on-site visits, engaging more than 542 people, which is reflective of the wide range of project stakeholders and population density surrounding the project site;
- 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 Belsar-Yungera, as evidenced by the receipt of letters of support from:

- Materially-affected land managers such as Parks Victoria
- Materially-affected private landholders and irrigators
- Aboriginal stakeholders
- Adjacent private landholders
- Regional Development Australia and Regional Development Victoria – Loddon Mallee
- Local government (Swan Hill Rural City Council), and
- Community groups and organisations.

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

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

15.1 Communication and Engagement Strategy

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

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

The Communication and Engagement Strategy includes:

- Identification of key stakeholders of the Belsar-Yungera 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 Belsar-Yungera Communications and Engagement Strategy and the outcomes from the Business Case phase are provided in the following sections. The full strategy is provided in Appendix H.

15.2 Identification of key stakeholders and engagement approaches

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

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

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

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

The engagement approach for Stakeholder Group 3 is of lower intensity, publicly accessible and generic in nature. On the iap2 public participation spectrum, the aim of the engagement approach for Stakeholder Group 3 is to INFORM stakeholders on the planning, construction and operation phases of the Belsar-Yungera 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 *Belsar-Yungera 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:** Latji Latji Mumthelang Aboriginal Corporation, Tati Tati, Pearce Mob **Narcooyia Creek Irrigators** Adjacent freehold landholders **Local community:** townships of Robinvale **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:** Swan Hill 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 Continuity of irrigation water supply Access to pumps during flooding 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

Stakeholder group	Stakeholder	Summary of issues and sensitivities
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:** Robinvale Indigenous Landcare Group, Birdlife Australia (Mildura Branch), River Watch, Sunraysia Field Naturalists Club, Sporting Shooters Association of Australia (Nhill), Murray-Darling Wetlands Working Group, Victorian National Parks Association **Indigenous organisations/groups:** North West Native Title Claimants, Murray Lower Darling Rivers Indigenous Nations (MLDRIN), Mildura and District Aboriginal Services, Robinvale Aboriginal Cooperative **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:** River Murray Reserve/State Forest	Impact to local amenity, recreation, economy and environment Ensuring projects are delivered in a way that both benefits the environment and respects Indigenous culture
Group 3	**Wider community:** Mallee region, Victoria, Murray Darling Basin	As above

15.3 Communication and engagement approaches and outcomes from 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
- 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 Belsar-Yungera Communication and Engagement Strategy (Appendix H).

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 Monitoring and management of salinity and turbidity during operation of proposed infrastructure	Adjusted structure location to reflect stakeholder advice Designs developed in accordance with stakeholder preferences/requirements Operational scenarios for proposed infrastructure investigated to minimise water quality impacts Business case adjusted in accordance with feedback received Salinity investigations undertaken, monitoring and management strategies considered Planned ongoing engagement with project partners	Letters of support for the project from partner agencies such as Parks Victoria and Goulburn-Murray Water Sustained, consistent high-level involvement in project development throughout business case phase

Group 1: Project stakeholders	Small group (face-to-face) briefing sessions with Mallee CMA, including on-site visits Face-to-face engagement and on-site visits with Aboriginal stakeholders Presentations conducted by Mallee CMA	Inundation of private land Minimisation of harm to sites of cultural heritage, in line with legislative requirements Monitoring and management of salinity and turbidity during operation of proposed infrastructure	Specific control mechanisms included in project proposal to include/exclude private land inundation in line with stakeholder preference Works proposed for existing tracks/disturbed areas where possible to minimise harm to sites of cultural heritage Preliminary cultural heritage assessment completed to inform project development Salinity investigations undertaken, monitoring and management strategies considered Planned ongoing engagement with project stakeholders	Letters of support from Aboriginal stakeholders, Narcooyia Creek irrigators, adjacent freehold landholders, Mallee CMA community committees and local government (Swan Hill Rural City Council) On-going discussions/preliminary approval processes completed with Swan Hill 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 and 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 Belsar-Yungera 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 Belsar-Yungera Communication and Engagement Strategy (Appendix H).

A large effort has been invested in the communication and engagement activities in order to develop broad community support for the Belsar-Yungera 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 Belsar-Yungera 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 *Belsar-Yungera 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 to guide the approvals process (GHD, 2014a, Golsworthy 2014). The strategies provide a clear understanding of the current relevant legislation as well as the approvals required, based on the type and location of planned works, the cultural heritage, flora and fauna values present within the works footprint, and the past experience of the Mallee CMA and partner agencies in completing approvals for large, infrastructure-based projects within National Parks.

16.1 Regulatory approvals

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

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

The approvals required for Belsar-Yungera are listed in Table 16-1.

Table 16-1. Regulatory approvals anticipated for Belsar-Yungera (GHD, 2014a)

<table>
<tr><th>Approvals required</th><th>Description</th></tr>
<tr><td colspan="2">Commonwealth legislation</td></tr>
<tr><td>Environmental Protection & Biodiversity Conservation Act 1999
Referral</td><td>A number of "matters of national environmental significance" (MNES) are potentially present at Belsar-Yungera:
• Upstream of Banrock, Coorong and Riverland Ramsar sites
• Nine migratory waterbird species
• 20 nationally threatened species
• 1 threatened ecological community</td></tr>
<tr><td colspan="2">Victorian legislation</td></tr>
<tr><td>Environmental Effects Act 1978
Referral</td><td>Relevant to three of the six referral criteria for individual potential effects i.e.
• Potential clearing of 10 ha or more of native vegetation from an area that:
- Is of an is of an Ecological Vegetation Class identified as endangered by DEPI (in accordance with Appendix 2 of Victoria's Native Vegetation Management Framework), or
- Is, or is likely to be, of very high conservation significance (as defined in accordance with Appendix 3 of Victoria's Native Vegetation Management Framework), and
- Is not authorised under an approved Forest Management Plan or Fire Protection Plan
• Potential long-term change to the ecological character of a wetland listed under the Ramsar Convention or in 'A Directory of Important Wetlands in Australia'
• Potential extensive or major effects on the health or biodiversity of aquatic, estuarine or marine ecosystems, over the long term.</td></tr>
<tr><td>Planning & Environment Act 1987
Planning permit
Public Land Managers Consent</td><td>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: likely to include an offset strategy and threatened species management plan
Local Council refers applications and plans to appropriate authorities for advice</td></tr>
<tr><td>Aboriginal Heritage Act 2006
Cultural Heritage Management Plan</td><td>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 relates to:
(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</td></tr>
<tr><td>Water Act 1989
Works on waterways permit</td><td>Application for a licence to construct and operate works on a waterway.</td></tr>
<tr><td>Flora & Fauna Guarantee Act 1988
Protected flora licence or permit</td><td>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</td></tr>
</table>

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

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

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

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

16.2 Legislative and policy amendments and inter-jurisdictional agreements

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

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

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

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

16.3 Cultural heritage assessment

An Archaeological Due Diligence Report has been prepared for this project (Bell et al, 2013, Appendix K). A desktop analysis indicated that there were no sites of Aboriginal significance within 100m of proposed structures and field inspections identified eight previously unrecorded sites at Belsar-Yungera. Under the *Aboriginal Heritage Act 2006* the Belsar-Yungera 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 *Belsar-Yungera 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, and the descriptions of anticipated ecological outcomes and environmental water requirements.

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

Regulatory Governance Group

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

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

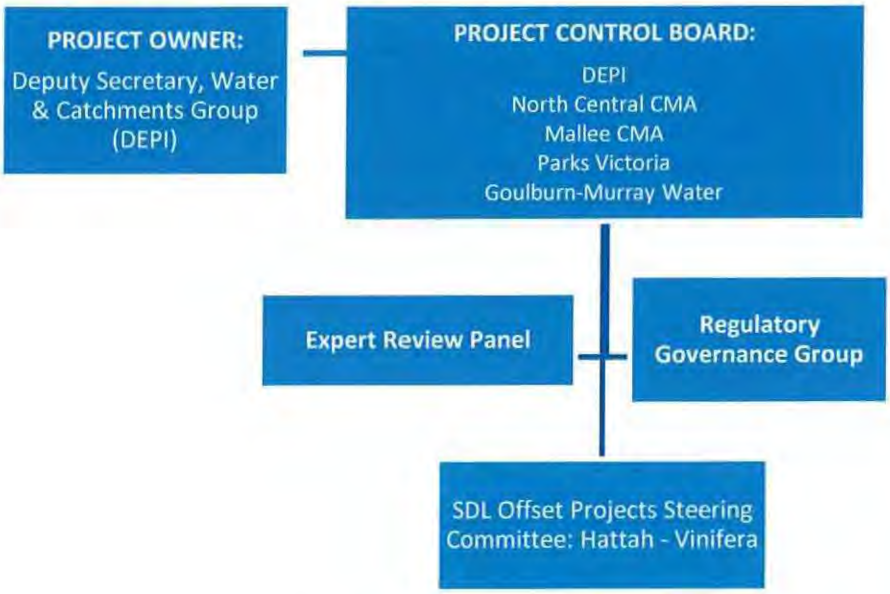

Figure 17-1. Governance arrangements during business case development.

SDL Offset Projects Steering Committee: Hattah - Vinifera

At the project level, development of the business case for the *Belsar-Yungera 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)
- Department of Environment and Primary Industries (DEPI) representative/s (land manager representative and coordinator of regional environmental advice and approvals)
- Goulburn-Murray Water (G-MW) representative/s
- SA Water representative/s
- Murray-Darling Basin Authority representative/s.

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

17.2 Governance arrangements during project implementation

To ensure that this proposed supply measure is delivered on time, arrangements will be put in place that ensures 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 the Living Murray, it is expected that the PCB would meet regularly throughout the construction of this proposed supply measure to ensure that milestones and timelines are met, and to resolve any potential arising issues.

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

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

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 Belsar-Yungera 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 Belsar-Yungera will be a partnership between four agencies: Mallee CMA, DEPI, Parks Victoria and Goulburn Murray Water.

Mallee CMA

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

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

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

DEPI

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

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

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

Parks Victoria

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

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

Parks Victoria works in partnership with other government and non-government organisations and community groups such as the Department of Environment and Primary Industries, catchment management authorities, private land owners, friends groups, volunteers, licensed tour operators, lessees, research institutes and the broader community.

Healthy 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.

Goulburn-Murray Water

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 G-MW's activities for the delivery of each of the SDL Offset projects.

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

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

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

18.2 Risk assessment outcomes

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

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

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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
Poor contractual arrangements	Ambiguous contractual arrangements may lead to confusion regarding the scope of work to be delivered and/or multiple contract variation requests. This can delay construction and have significant financial impacts.	Possible	Moderate	Moderate	Seek expert/legal advice on contractual arrangements. Ongoing supervision of contractors.	Very Low
Poor engineering design	Poor engineering design can create a number of issues, including: • Design not fit for purpose • Difficulties in operation • Increased maintenance costs • Reduced design life	Possible	Moderate	Moderate	Detailed designs and construction drawings peer reviewed before they are finalised. Early engagement of contractors and operators to provide feedback on design practicalities/constructability.	Very Low
Inadequate geotechnical information	Unforeseen geotechnical conditions encountered during construction may require significant alteration to existing designs or relocation of infrastructure causing project delays and additional expense.	Possible	Severe	High	Appropriate geotechnical investigations conducted carried out during the design phase to reduce uncertainty. Conservative design of structures to allow for variations to geotechnical conditions.	Moderate
Unclear roles and responsibilities	Unclear roles and responsibilities could hinder effective project development and 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

Threat	Description	Likelihood	Consequence	Risk without mitigation	Mitigation	Residual Risk
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.

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:

Belsar-Yungera proposed works and inundation extents.

Appendix B:

Ecological Associates, 2014. SDL Rationale and Outcomes. Ecological Associates report AL040-1-D prepared for Mallee Catchment Management Authority, Irymple.

Appendix C:

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

Appendix D:

SKM 2014. Preliminary Salinity Impact Assessment for Mallee Environmental Watering Projects – other sites. Report for the Mallee CMA.

Appendix E:

GHD 2014. Belsar-Yungera SDL Adjustment Supply Measures Advanced Concept Design Report. Report for the Mallee CMA.

Appendix F:

Aither 2014. Social and economic assessment- Belsar-Yungera Water Management Works, Benefits for the Basin Plan Sustainable Diversion Limits offset program business case. Report for the Mallee CMA.

Appendix G:

Belsar-Yungera letters of support.

Appendix H:

RMCG 2014. Belsar-Yungera Sustainable Diversion Limits Offset Project, Final Communication and Engagement Strategy. Report for the Mallee CMA.

Appendix I:

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

Appendix J:

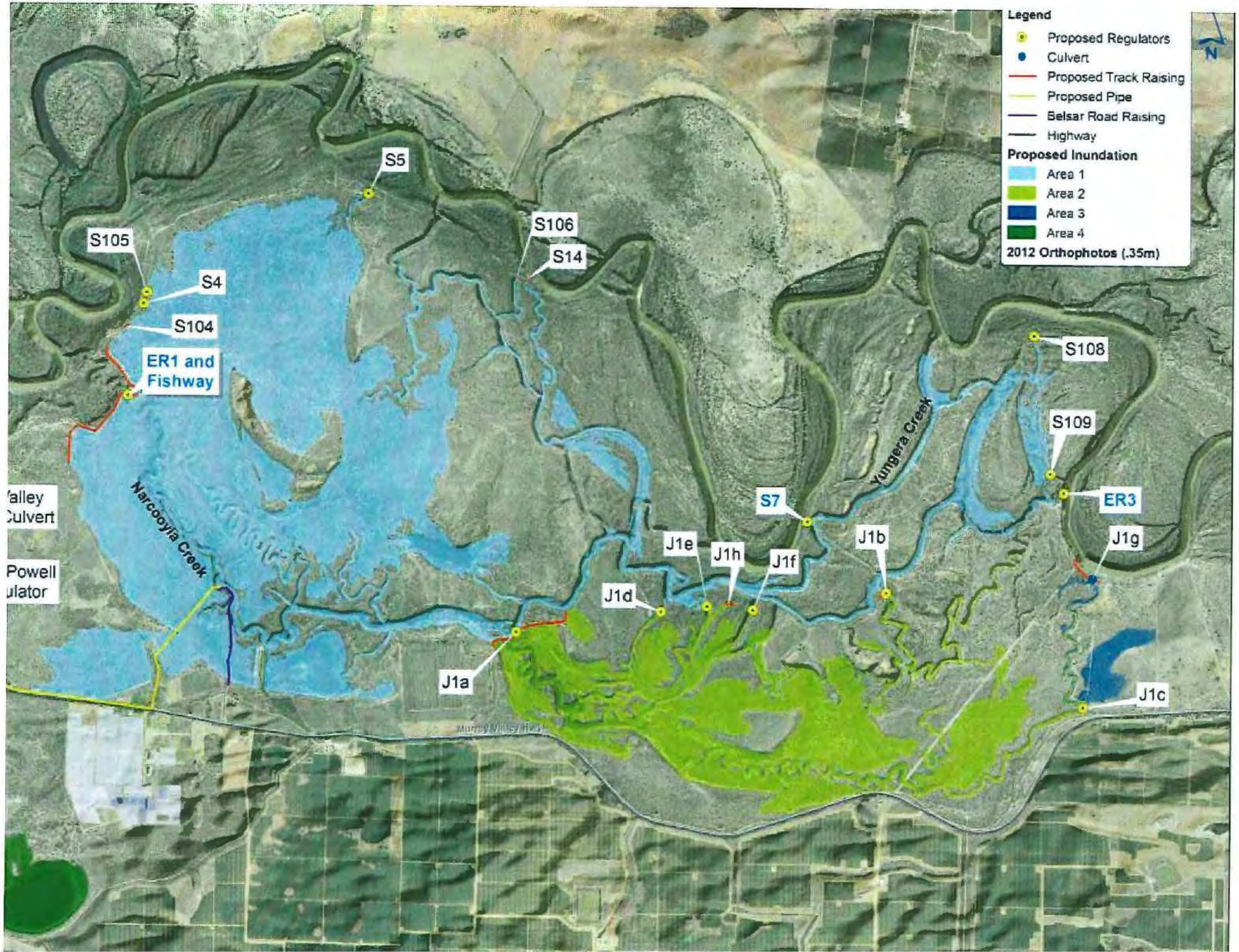
James Golsworthy Consulting 2014. SDL Offsets Projects, Statutory Approval Requirements, Belsar, Burra, Hattah, Lindsay, Nyah, Vinifera and Wallpolla. Report for the Mallee CMA.

Appendix K:

Bell, J and Edwards, A., 2013. Belsar-Yungera Floodplain Northwest Victoria Due Diligence Assessment. Report for Mallee Catchment Management Authority.

Appendix L:

Expert Review Panel Reports.



Legend
Proposed Regulators
Culvert
Proposed Track Raising
Proposed Pipe
Belsar Road Raising
Highway
Proposed Inundation
Area 1
Area 2
Area 3
Area 4
2012 Orthophotos (.35m)
N
S5
S105
S106
S14
S4
S104
ER1 and Fishway
S108
S109
Yungera Creek
Narcooyla Creek
S7
ER3
J1g
J1b
J1e
J1h
J1f
J1d
J1a
J1c
Powell