VICTORIAN MURRAY FLOODPLAIN RESTORATION PROJECT

HEALTHY LANDSCAPES, STRONG COMMUNITIES

DRAFT Operating Plan

Belsar-Yungera Environmental Works and Measure Program

May 2020

LOWER MURRAY WATER

mallee catchment management authority

Australian Government

Parks VICTORIA Healthy Parks Healthy People

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Author: Tickle, I and Ram, R., Report prepared for Victorian Murray Floodplain Restoration Project by Mallee CMA

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Mallee Catchment Management Authority
www.malleecma.vic.gov.au
PO Box 5017 Mildura 3502
Telephone 03 5051 4377
Facsimile 03 5051 4379

Version	Prepared	Author	Reviewed
1	02.04.2020	Isabel Tickle	MCMA
2	18.05.2020	Rinesh Ram	MCMA
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Contents

Figures

Tables

List of abbreviations	
Abbreviation	**Full description**
AHD	Australian Height Datum
ARI	Arthur Rylah institute
AWOC	After SDL works operation commencement
BSMS	Basin Salinity Management Strategy
BWS	Basin-wide Environmental Watering Strategy
CAMBA	China-Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CMA	Catchment Management Authority
DELWP	Department of Environment, Land, Water and Planning
DEPI	Department of Environment and Primary industry
DTF	Department of Treasury and Finance
EMF	Environmental Management Framework
EPBC	Environmental Protection and Biodiversity Conservation
EWMP	Environmental Water Management Plans
FFG	Flora and Fauna guarantee
GHD	Guttridge Haskins & Davey
GL	Gigalitre
GMW	Goulburn-Murray Water
JAMBA	Japan-Australian Migratory Bird Agreement
LMW	Lower Murray Water
LTWP	Long-Term Watering Plans
MCMA	Mallee Catchment Management Authority
MDBA	Murray-Darling Basin Authority
MDFRC	Murray-Darling Freshwater Research Centre
MER	Monitoring, evaluation, and reporting
ML	Megalitre
PEA	Priority Environmental Assets
PEF	Priority Ecosystem Functions
PWOC	Prior to SDL works operation commencement
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
SCBWEC	Southern Connected Basin Environmental Watering Committee
SDL	Sustainable Diversion Limit
SKM	Sinclair Knight Merz [consultant]
SWP	Seasonal Watering Proposal
TLM	The Living Murray
VEAC	Victorian Environmental Assessment Council
VEWH	Victorian Environmental Water Holder
VMFRP	The Victorian Murray Floodplain Restoration project
WRP	Water Resource Plan

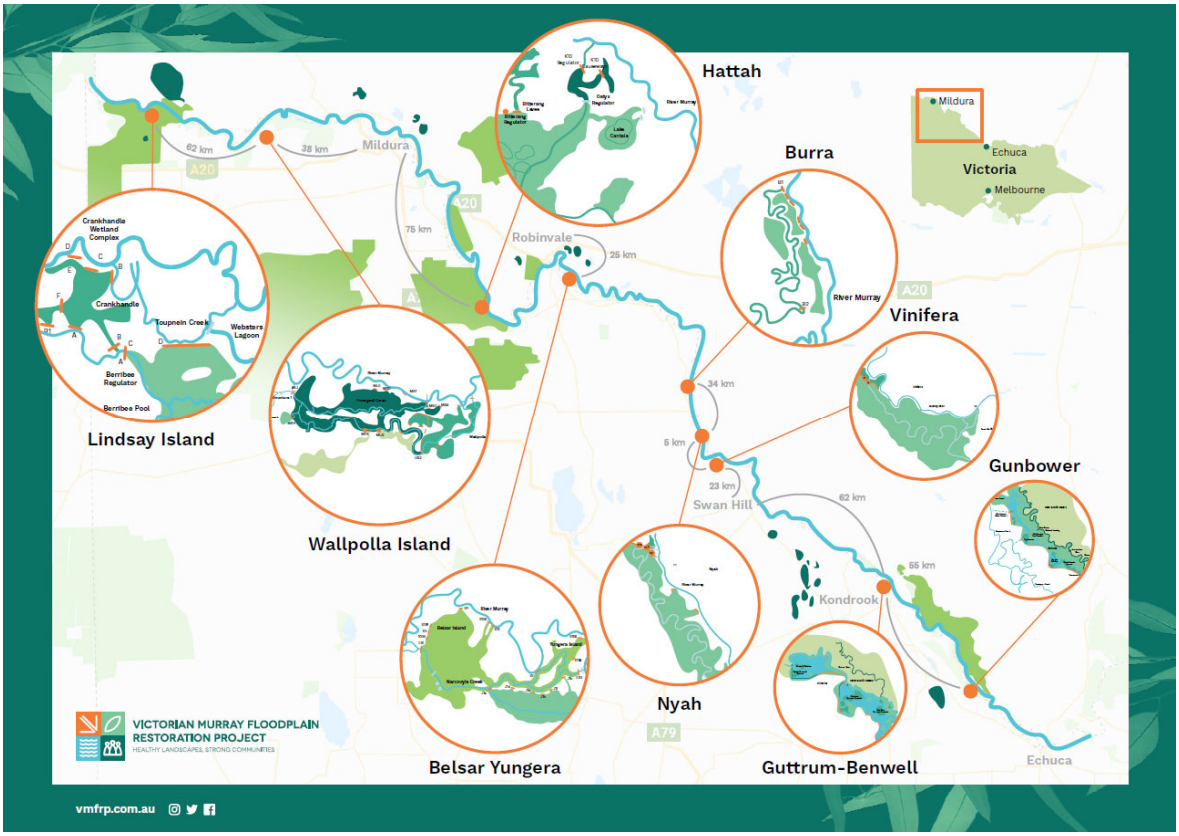
Introduction

The Victorian Murray Floodplain Restoration Project (VMFRP) is being implemented as part of Victoria's obligations under the Murray-Darling Basin Plan in partnership with Lower Murray Water, Goulburn-Murray Water, Mallee CMA, North Central CMA, Parks Victoria and the Department of Environment, Land Water and Planning (DELWP). The VMFRP Project is funded by the Australian Government's Department of Agriculture.

The project consists of nine discrete environmental works projects that aim to return a more natural inundation regime across more than 14,000 ha of high ecological value Murray River floodplain in Victoria through the construction of new infrastructure and in coordination with existing infrastructure operating regimes (refer to Figure 1).

The proposed works will allow environmental water to be diverted from the Murray River to high value wetlands and floodplains. This will mimic the impact of natural flood events and improve the condition of vegetation communities and provide habitat for native fish, birds, frogs, and reptiles.

Figure 1: VMFRP Project Locations



The Belsar-Yungera Floodplain Complex is located in the Lake Powell district approximately 30 km upstream of Euston Weir near Robinvale in north-west Victoria.

The floodplain complex comprises Belsar and Yungera Islands, which are formed on anabranches of the Murray River, 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 (MCMA, 2014).

The Belsar-Yungera project lies within Lakes Powell and Carpul Nature Reserve, Murray River Park, as well as private property managed for conservation purposes. The Belsar-Yungera complex provides significant habitat for a suite of plant and animal species of conservation significance, both at a Victorian and National level (VMFRP Project Team, 2020).

The frequency and duration of inundation events of the floodplain complex has been influenced by the regulation of the Murray River, the flow regime of Narcooyia, Bonyaricall and Yungera creeks has also been altered by the use of these waterways to maintain a supply of irrigation water to landholders south of the complex. Due to these influences, the flow patterns of the three creeks have been significantly altered from the natural regime. The frequency, duration and extent of current inundation patterns have been significantly altered and are not sufficient to meet the needs of the floodplain ecosystem (MCMA, 2014).

Through the proposed works, 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 flood events. Watering will occur at a landscape scale, restoring ecosystem function for more than 2374 ha of highly valued floodplain, mimicking flows of 70,000 to 170,000 ML/d.

Environmental watering goals, ecological objectives and watering regimes are detailed in the Belsar-Yungera Environmental Water Management Plan Addendum (VMFRP Project Team, 2020).

1. Purpose of the Operating Plan

This Operating Plan provides the framework for the operation of the Belsar-Yungera water management structures to meet key ecological objectives within the broader context of VMFRP legislative requirements and governance. The purpose of this Operating Plan is to:

- Summarise the governance arrangements for managed inundation activities at the site;
- Summarise the roles and responsibilities of partner agencies;
- Aid in decision making and planning prior to, during, and after watering events;
- Summarise operational risks and mitigations strategies;
- Outline water measurement arrangements;
- Outline communication and consultation requirements; and
- Provide links to document containing further detail.

The Operating Plan also defines the obligation of the various parties to manage and operate the structure as required under the Murray-Darling Basin Agreement (S 52-54; *Water Act* (Commonwealth of Australia, 2007)).

The Operating Plan is not intended to prescribe particular watering events. The audience for the Operating Plan is summarised in Table 1.

This document is a 'living document' that will be further refined and updated over time by the Mallee CMA and relevant project partners if legislation changes, or changes in operations in the major river systems require it. It is expected that knowledge and information in relation to adjusting and optimising structure operations will improve with each event.

Table 1: Intended Audience for the Operating Plan

Audience	Key Requirements	Primary Interest		
		Ecological	Operation	Risk
Event Managers (Lower Murray Water, Goulburn-Murray Water)	Adaptive Management	✓	✓	✓
Land Manager (Parks Vic)	Adaptive Management	✓	✓	✓
Other Environmental Managers (DELWP)	Adaptive Management	✓		✓
Operators (Lower Murray Water, Goulburn-Murray Water,)	Operation of structures Accounting		✓	✓
Water holder/funder (TLM-MDBA, CEWH, VEWH)	Accountability	✓	✓	✓
MDBA (BSMS) MDBA River Murray Operations	Meet legal requirements			✓
Asset Manager (Lower Murray Water, Goulburn-Murray Water)	Meet legal requirements		✓	✓

Additional Documents

This addendum is one of six supporting documents to the Belsar and Yungera Floodplain Management Unit Environmental Water Management Plan (EWMP) (Stacey, 2010). Each schedule focuses on a specific area of operations for Belsar-Yungera (Table 2).

Table 2: Additional documents supporting water management at the Belsar-Yungera Project Area.

Document	Purpose
Belsar and Yungera Floodplain Management Unit Environmental Water Management Plan (Stacey, 2010)	Environmental Water Management Plan
Belsar-Yungera Environmental Water Management Plan Addendum (VMFRP Project Team, 2020)	Update to the Belsar and Yungera Floodplain Management Unit Environmental Water Management Plan 2010 to include information relevant to the VMFRP project
Hydrodynamic modelling report (Jacobs, 2017)	Report on the Hydrodynamic modelling of the Belsar-Yungera project
Belsar-Yungera Detailed Design Report (R8, In prep)	Report on the detailed design for Belsar-Yungera including detailed design drawings
Groundwater salinity monitoring bore specifications for SDL projects (Jacobs, 2019)	Report on groundwater salinity monitoring of the proposed inundated areas
Monitoring and Evaluation Reporting Plan (MER plan) (Arthur Rylah Institute, 2020)	Framework for reporting on monitoring and evaluations, in preparation by the Arthur Rylah institute. Anticipated completion by June 2020.

2. Proposed VMFRP Structures and Inundation Extent

The Belsar-Yungera Floodplain Complex is situated 30 km upstream of the Euston Weir and the eastern part of the system is influenced by the weir pool. The weir maintains a normal operating level of 47.6 m AHD which pools water in Bonyaricall Creek and reduces the variation in creek water level as river discharge rises and falls.

The infrastructure works to be delivered for the Belsar-Yungera project include:

- Three main environmental regulators (with one incorporating a vertical slot fishway),
- 12 containment regulators,
- Two culverts
- 3.6 km of raised track, and
- A two km low pressure pipeline

The project will provide inundation of up to 2,374 ha of inundation dependent habitat within four individual tier levels:

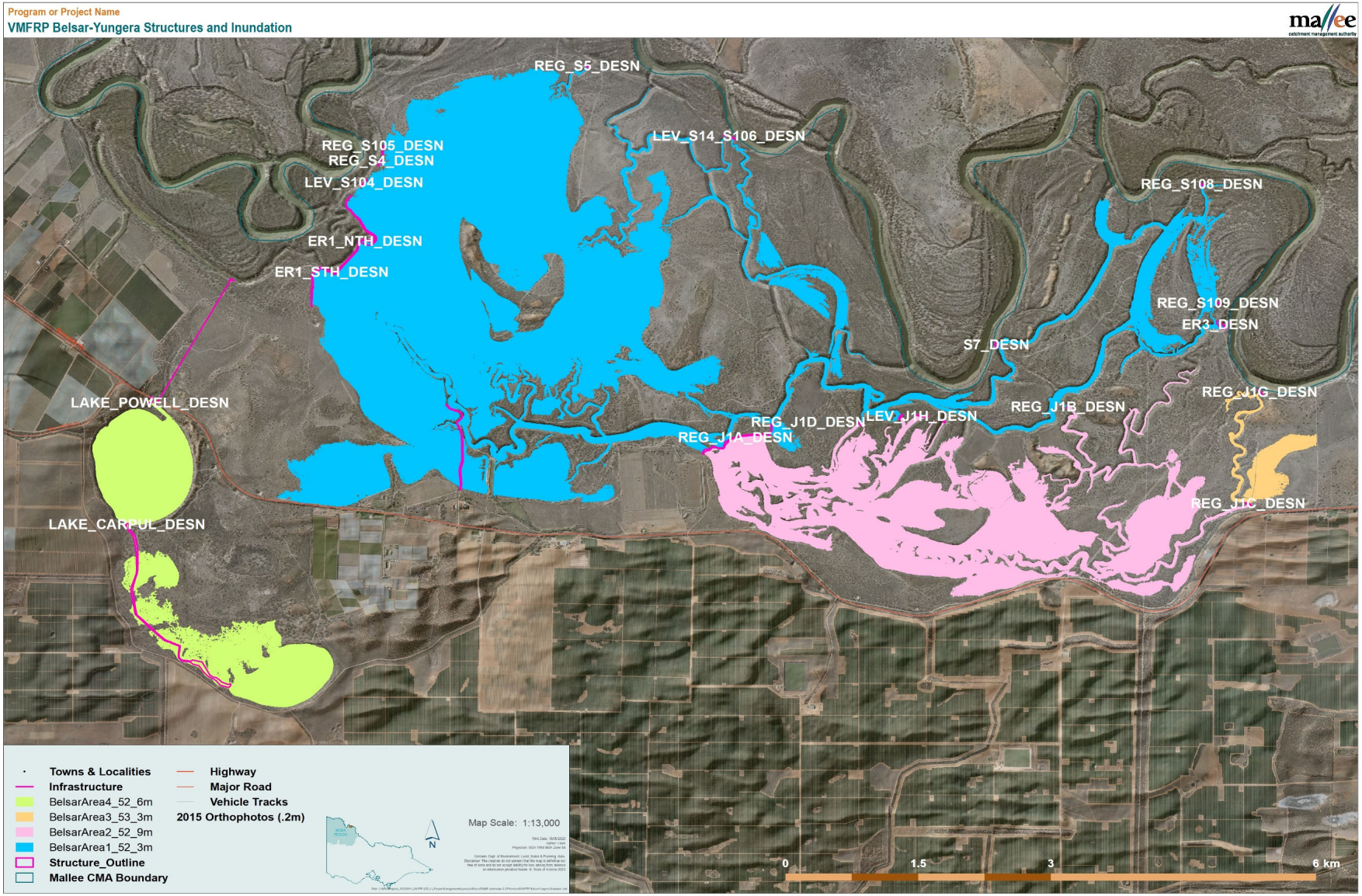
- Area 1 at 52.3 m AHD; 13.33 GL
- Area 2 at 52.9 m AHD; 3.30 GL
- Area 3 at 53.3 m AHD; 0.07 GL
- Area 4 at 52.6 m AHD; 4.7 GL

The inundation will require a total of 21.4 GL (MCMA, 2014).

The project works will rely on natural high Murray River flow events and temporary pumps to deliver water to the Belsar-Yungera project (Ecological Associates, 2015). These works and the existing infrastructure are described in Table 4.

Table 4 describes the infrastructure that will be used. Section 6 details the infrastructure that will be used in different operating scenarios.

Figure 2: VMFRP Structures and inundation extent



3. Governance

3.1 Governance Arrangement for Operating the Belsar-Yungera Structures

Structures will be owned and operated under an agreement between Lower Murray Water and Goulburn-Murray Water. The Mallee CMA and environmental water holders will plan and select the areas of inundation as per their published Seasonal Watering Proposals.

Arrangements will be put in place to ensure appropriate senior oversight of project operations to allow for the successful operation of the works.

These arrangements will be predominantly based around those that were used to deliver the four Living Murray Environmental Works and Measures Program projects within Victoria, complemented by existing state government frameworks, which together will underpin a set of robust and thorough processes for project management.

The project management structure and team will be overseen by the project owner. In line with the governance arrangements that have underpinned the Business Case preparation for this proposed supply measure, the project owner will be supported by a Project Control Board (PCB), comprised of senior executives representing the project owner, the relevant Victorian CMAs, the relevant water authorities (e.g. GMW; LMW), Parks Victoria and the Commonwealth.

3.2 Belsar-Yungera Operations Group

An Operations Group will be established to assist and advise on the commissioning and operation of the Belsar-Yungera works. This Group will provide a forum to involve project partners in the decision-making process, to consider broader system operations (e.g. of the Murray River 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 Murray-Darling Basin Authority, Department of Environment, Land, Water and Planning, , Goulburn-Murray Water, Lower Murray Water, Parks Victoria, the Commonwealth Environmental Water Holder and the Victorian Environmental Water Holder.

Other agencies and organisations may be invited to participate as guests or observers.

The key responsibilities of the Operations Group will be to ensure the necessary planning, monitoring, communication, and reporting arrangements are established prior to and during events and to identify and monitor any event risks or issues. This allows for safe and effective operation of the works, real time response and adaptive management when necessary. See Table 3 for Organisational roles and responsibilities supporting Belsar-Yungera environmental watering.

Table 3: Organisational roles and responsibilities supporting Belsar-Yungera environmental watering

Organisation	Main Roles	Tasks/Responsibilities		
		Event Planning	**Event Management**	**Event Reporting**
Planning & monitoring- Mallee CMA	Communications Monitoring	▪ Ensure planning process is to annual schedule ▪ Review and Revise Operating Plan and Risk Management Plan with other Belsar-Yungera Operations Group (BYOG) input ▪ Prepare Annual Watering Plan with BYOG input	▪ Coordinate event monitoring (ecology/environment/water use) ▪ Coordinate Community Communications and Consultation	▪ Prepare Annual Watering Report with other stakeholder input ▪ Compile/Collate Monitoring Results ▪ Update event record and incorporate lessons learnt into operating plan
Site Manager - LMW	Event Coordination Communications Monitoring	▪ Convene BYOG	▪ Convene BYOG and coordinate weekly (or as required) meetings/teleconferences. ▪ Coordinate Community Communications and Consultation ▪ Coordinate event monitoring (water use)	
MDBA - River Operations and Modellers	Delivery operation Modelling	▪ Provide advice on basin wide river operations and any implications for Belsar-Yungera ▪ Provide advice to assist in planning	▪ Provide advice on basin wide river operations and any implications ▪ Re-calibrate the water use model during the event	▪ Assist LMW/GMW with water measuring ▪ Provide advice on any water delivery implications encountered and future considerations ▪ Model calibration confidence
LMW GMW	Structure Operation & Maintenance, Water Accounting	▪ Provide advice on structural or maintenance issues and any implications ▪ Conduct maintenance ▪ Provide advice on water accounting planning and preparedness and any implications for an event	▪ Operate Structures to meet requests ▪ Provide advice on structural or maintenance issues and any implications ▪ Data collection and provision of data to MDBA during events including flow, level, and water quality monitoring ▪ Watering accounting – calculate weekly diversion volumes	▪ Provide details on performance of structures and any issues or future considerations ▪ Provide details of issues associated with operational costs ▪ Watering accounting against Victorian entitlements – provide the VEWH with volumes used and inform BYOG ▪ Report on water use.

Parks Victoria	Land Manager	▪ Provide advice on expected ecological response to proposed watering ▪ Advise the group regarding site ecological values or threats and any implications ▪ Approve watering on public land	▪ Manage public access during and after event ▪ Advise of any threats to site ecological values	▪ Provide details of site ecological responses and any future implications
VEWH	Water Availability (If VEWH water used) Approvals	▪ Approve Victorian statewide watering priorities ▪ Approve Annual Watering Plan – Victorian priorities ▪ Co-ordinates water use with other environmental water holders, including advising on water availability for the site from all environmental water holders.	▪ Authorises all watering activities through Seasonal Watering Statements ▪ Provides indication on water availability for watering activities ▪ Seek further water if required ▪ Water accounting verification of volumes, use and coordinate return flows	▪ Assist with report compilation and review ▪ Review volumes of environmental water used
MDBA Environmental Water Coordination	Water Availability (If TLM water used)	▪ Advise on TLM watering objectives ▪ Advise on TLM water availability ▪ Coordinating activities across TLM Icon Sites	OBSERVER ROLE ONLY if contributing environmental water	Assist with report compilation and review
CEWH	Water Availability (If Commonwealth water used)	▪ Advise on Commonwealth watering objectives ▪ Advise on Commonwealth water availability ▪ Coordinating other CEWH activities	Decision making role in planning, delivery, monitoring and reporting in collaboration with CMA's and Water Authorities.	Assist with report compilation and review
DELWP	Environmental Water Policy	▪ Provide advice on statewide environmental water policy ▪ Ensure integration of activities with the Basin Plan and related state initiatives	OBSERVER ROLE ONLY	OBSERVER ROLE ONLY

Scientific consultants	Event Monitoring	▪ Provide advice on achieving ecological objectives	Undertake monitoring activities as directed by the Mallee CMA or other contracting agency	Report monitoring results
Scientific Advisors	Specialist Advice	Assist setting ecological objectives	Provide specialist advice when required	NO ROLE EXPECTED
SCBEWC (includes TLM partner governments)	Allocation of TLM water (if TLM water used) Coordination of the delivery environmental water in the Southern Connected Murray-Darling Basin	- Decision making on the use of TLM portfolio, Murray River unregulated flows and Murray River increased flows - Input into the development of large-scale multi-site environmental watering events	NO ROLE –unless site or in river conditions lead to substantial change from planned event	Reporting included in annual SCBEWC report to the Basin Officials Committee and reporting on annual TLM watering activities

3.3 Stakeholder Roles and Responsibilities

Mallee Catchment Management Authority (CMA) – Site Manager

Catchment Management Authorities are the caretakers of river health and responsible for the management of environmental water in Victoria, as specified in the Water Act 1989. The Mallee CMA works closely with its partner agencies, Lower Murray Water, Goulburn-Murray Water, Parks Victoria and DELWP and is supported by several site-specific committees.

Lower Murray Water (LMW) – Site Manager

The site manager for the Belsar-Yungera project is LMW, working closely with its partner agencies, Mallee CMA, Goulburn-Murray Water, Parks Victoria and DELWP and is supported by several site-specific committees.

Murray-Darling Basin Authority – River Management (Operations, Modelling and Data Management)

MDBA River Murray Operations attends and contributes to the Belsar-Yungera Operations Group meetings.

Operational data is collected at structures throughout watering events. The data is stored on the MDBA data system and is available for all to use upon request. Modellers provide advice to Mallee CMA during events – from the water bid proposal to the end of the event. The modellers also re-calibrate the model as the event takes place.

Lower-Murray Water (LMW) – Asset operations and maintenance

LMW is also responsible for the operation and maintenance of all water delivery structures within Belsar-Yungera, as well as the weir operations that support environmental watering.

LMW is also responsible for collecting data during the event and providing it to MDBA River Management to assist with real-time management and modelling.

Goulburn-Murray Water (GMW) – Water accounting

GMW is the appointed Resource Manager for the Victorian Murray River system under the Water Act 1989 (Victoria) and coordinates the accounting of resources associated with operations in this reach. In this role, GMW liaises closely with the Murray River Operations team of the MDBA to ensure bulk and retail water accounts are correctly credited and debited.

Parks Victoria – Public Land Manager

Parks Victoria is the public land manager responsible for management of the Belsar-Yungera Park. Under the Parks Victoria Act 2018, Parks Victoria is responsible for providing services to the state and its agencies for the management of parks, reserves and other public land and is responsible for all areas reserved under the National Parks Act 1975.

Victorian Environmental Water Holder (VEWH)

The VEWH is responsible for holding and managing Victoria's environmental water entitlements and allocations and coordinating the delivery of Victorian environmental water allocations with other environmental entitlement holders to maximise benefits to the environment.

The VEWH works closely with catchment management authorities and Melbourne Water to ensure that environmental water entitlements are used to maximise ecological outcomes for the water available. In terms of Belsar-Yungera, the VEWH will consider environmental watering proposals along with all others in the state to determine environmental watering priorities from a state perspective.

If Belsar-Yungera is determined to be an environmental priority for the year and water is made available to the site, the VEWH then authorises the use of water by the Mallee CMA through a Seasonal Watering Statement.

Murray-Darling Basin Authority – Environmental Water Coordination

The MDBA – Environmental Water Coordination team coordinates the planning and delivery of TLM environmental water to TLM Icon Sites. This undertaken as part of Southern Connected Basin Environmental Watering Committee (SCBEWC) environmental delivery coordination. SCBEWC is chaired by the MDBA and includes representative from the TLM government partners and the Commonwealth Environmental Water Office.

Commonwealth Environmental Water Office (CEWH)

As a component of Murray-Darling Basin reforms, the Australian Government has acquired several water entitlements with the objective to return more water to the environment. These entitlements have become a part of the Commonwealth environmental water holdings and are managed by CEWO. The volume of environmental water held by CEWO is significant and may constitute an important source of environmental water for the Belsar-Yungera Floodplain Management Unit.

Victorian Department of Environment, Land, Water and Planning (DELWP)

In Victoria, the overall Environmental program is delivered by DELWP, which provides high level policy input and coordinates the delivery across all Victorian Sites. One of the key roles for DELWP is to provide statutory and strategic guidance to the planning of Victoria. DELWP is also the site owner for most Crown land in Victoria and may delegate the management of Crown land to others on its behalf, as is the case with Parks Victoria.

Southern Connected Basin Environmental Watering Committee (SCBEWC)

The Southern Connected Basin Environmental Watering Committee (SCBEWC) coordinates the delivery of environmental water to maximise environmental outcomes in the Southern Connected Murray-Darling Basin. Members include Basin state and Australian Government environmental water holders, water managers and key river operators. In addition to the coordination function, SCBEWC also makes decisions on the use of jointly held environmental water portfolios -The Living Murray portfolio, Murray River Unregulated Flows and Murray River Increased Flows. The MDBA chairs the Committee and provides secretariat support for SCBEWC activities.

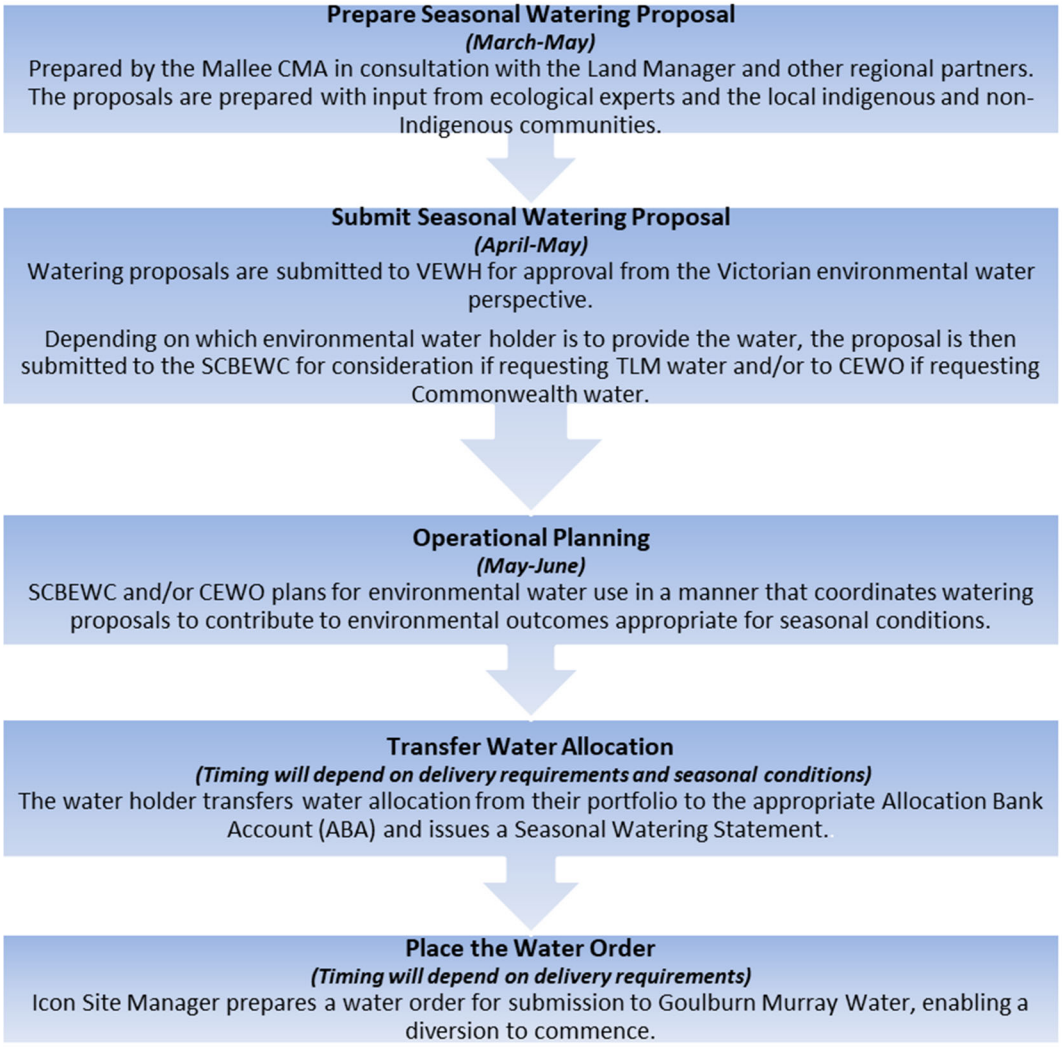
3.4 Sourcing Water for Managed Inundation Events

Environmental watering at the site will be undertaken in accordance with the VEWH's annual seasonal watering plan and in partnership between Lower Murray Water, Goulburn-Murray Water, the Mallee CMA and Parks Victoria.

Before a watering action can commence, a Seasonal Watering Proposal must be prepared by the Mallee CMA and approved by the VEWH; see Figure 3 . Submissions for environmental water allocations are presented by the VEWH to the relevant water holders who subsequently prioritise the watering proposals against all other watering proposals.

Once a watering action is approved, the VEWH ensures sufficient water is in the appropriate allocation account. This may require a transfer of water from one ABA to another. The VEWH will then issue a Seasonal Watering Statement to the Mallee CMA allowing access to an allocation of water in the ABA. Once the Seasonal Watering Statement is approved, a water order can be placed by MCMA with GMW, enabling a diversion to commence.

Figure 3: Sourcing Environmental Water for a watering event at Belsar-Yungera



The VMFRP works will leverage natural high Murray River flow events to deliver water to the Belsar-Yungera site.

4. Site Characteristics Guiding Managed Inundation

The proposed Belsar-Yungera project addresses deficiencies in the water regime of the floodplain and unnatural flow regimes. The proposed works will maintain and improve flora and fauna habitat values and provide periodic breeding opportunities for wetland species such as fish, frogs and waterbirds (MCMA, 2014).

4.1 Waterflow

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 Bonyaricall 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 km, upstream of Yungera Island, and returns to the river at 1168 river km downstream of Belsar Island. Narcooyia Creek has been modified to allow its use as a delivery channel for irrigation water, with limited ecological connectivity to the Murray River. 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 at a water level of 48.51 m AHD (MCMA, 2014; Ecological Associates, 2015). These operations maintain constant flooding in the creek and near constant flow.

Bonyaricall Creek branches from Narcooyia Creek near its downstream end. It is 6 km in length and joins the Murray River at 1163 river km to create Tonsing Island (Ecological Associates, 2015). The Euston weir, when at its normal operating level of 47.6 m AHD, pools water in Bonyaricall Creek and reduces the variation in water level that would naturally occur (Ecological Associates, 2015).

Excess water in Narcooyia Creek flows over the weir into Bonyaricall Creek rather than the final reach of Narcooyia Creek. Both creeks are subject to siltation and encroachment of *Typha* sp. (Ecological Associates, 2014). Intensive irrigation diversions from Bonyaricall Creek may draw water into the creek from downstream, reversing the flow (Ecological Associates, 2015).

Lakes Powell and Carpul are large floodplain lakes located south of Bonyaricall Creek. Lake Powell natural fills at its northern end when high flows spill from Bonyaricall Creek into a long narrow floodway. The channel passes under the Murray Valley Highway. 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 invert of the pipe culverts matches the maximum thalweg of the channel; that is 51.2 m AHD. The bed of Lake Powell is generally flat and has an invert of 49.75 m AHD, so that the lake stores water at a depth of 1.45 m after the flood water receded. Lake Powell has an approximate area of 115 ha and a volume of 1.5 GL (Ecological Associates, 2015).

Lake Carpul fills primarily from overflows from Lake Powell when water levels exceed 52.3 m AHD. The lake has an approximate invert of 49.3 m AHD and retains water to a depth of up to 3 m.

Generalised thresholds for floodplain inundation have been determined for the Belsar-Yungera project using descriptions of floodplain hydraulics and published thresholds (Ecological Associates, 2006; GHD, 2011; GHD, 2012); with reference to the Predictor hydrologic/hydraulic model (Gippel, 2008) and lidar data (Ecological Associates, 2015).

Due to the effect of the Euston Weir, rising river flows inundates upstream areas of the Belsar-Yungera floodplain before the downstream areas. Water first enters the floodplain at the downstream end of the Yungera Creek when river discharge exceeds 16,000 ML/d at Euston. Pools and wetlands near the creek are more than two metres deep. They are readily filled by small peaks in river flows and can retain water for up to a year. Significant inundation of the surrounding floodplain occurs at flows exceeding 20,000 ML/d. Higher flows activate upstream connections and create through-flow (Ecological Associates, 2015).

While low floodplain terraces on meander loops on the Murray River occur when river flows at Euston exceed 20,000 ML/d, significant inundation occurs at flows of over 27,000 ML/d. The Carp Hole is the largest wetland of the meander loops.

Lignum shrubland and Black Box Woodland are significantly inundated by flows exceeding 70,000 ML/d. Inundation is largely complete at flows of 120,000 ML/d.

The flow threshold for significant flooding in Lake Powell is in the order of 140,000 ML/d and 170,000 for Lake Carpul.

5. Operating Thresholds

This section provides guidance on the operational thresholds that inform the Belsar-Yungera Operational Group during planning and adaptive management of events.

5.1 Natural Inundation Events

- Under normal flow conditions (when no environmental watering is occurring) ER3 will be closed to regulate water levels in Narcooyia Creek according to existing arrangements, maintaining a level that supports irrigation diversions from the channel (48.51 m AHD) (Ecological Associates, 2015). All other regulators will be open.
- Under conditions of a minor peak in river flow, the Narcooyia / Bonyaricall Creek system will be operated as a through-flow system. When river levels exceed 48.51 m AHD (approximately 7,000 ML/d) the Narcooyia Creek inlet and outlet regulators will be opened. This will meet the water level requirements of the Narcooyia Creek diverters while increasing channel velocity and providing free movement of aquatic fauna between the creek and the river.

The arrangement of structures, containment banks and overflow sills are designed to minimise the potential for erosion over the whole range of flow conditions.

- Pass low and medium flows through hard structures (regulators)
- Pass higher flows through purpose designed overflow sills, with rock protection, located on natural flow paths.
- Overtop the earthen banks only after the water levels are near equalised on either side

Outflows from Narcooyia Creek to the Murray River occurs via the Bonyaricall Creek end.

5.2 Managed Events

- When a moderate to large flood occurs, the system will be operated to increase the duration of wetland floodplain inundation. Regulators at the perimeter of the ponded areas, including ER1, S1, S7 and ER3, will remain open on the rising hydrograph to allow the system to fill. The regulators will be closed when river levels start to fall to store water at the target level, up to limits of the regulators: 52.3 m AHD at ER1 and 52.9 and 53.3 m AHD in the J1 Creek system. Water will be detained to meet the duration requirements of environmental targets, then returned to the Murray River by opening regulators. ER3 will be close to restore the regulated pool in Narcooyia Creek.

The direction of inflow during a flood capture event could be either backflow through regulator ER1 or through flow.

Managed events will also utilise minor works in the form of sills and containment banks required at drainages along the riverbank to prevent the escape of water. In total the works will inundate up to 2374 ha of the floodplain.

5.3 Managed Events – Managed Drawdown

The infrastructure will have the capacity to control the drawdown following a managed event. The drawdown criteria are as follows:

- Drawdown the water level in the floodplain in a period of 7 to 10 days (maximum 20 days) for the purpose of drying the access tracks and reopening the park to the public; and limiting the period of operation.
- Managed drawdown to be coincident with a low water level in the Murray River, typically one month after a flood capture event.
- Limiting the frequency of operator visits during the drawdown period. This would be no more than once per day, and preferably less frequent depending on the duration of the drawdown period.
- Minimise the potential for erosion at the regulator and the confluence of the Murray River.
- Provide downstream fish passage for fish to exit the forest.
- Prevent stranding of fish due to excessive rate of drawdown.

6. Details of Structures

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

These works and the existing infrastructure are described in Table 4.

Table 4: Existing and proposed Belsar-Yungera VMFRP structures (MCMA, 2014)

Infrastructure	Description	Role
Irrigator Syndicate pumps (existing)	Existing irrigation syndicate pump on Murray River	Lifting irrigation water from Murray River to Narcooyia Creek (these pumps will be retained post works)
Irrigator pumps (existing)	Individual irrigator pumps on Narcooyia Creek	Lifting irrigation water from Narcooyia Creek to irrigation properties south of the complex (these pumps will be retained post works)
Embankments (existing)	Embankment to impound irrigation supply within Narcooyia Creek	Contains water in Narcooyia Creek (these will be replaced by ER1 And ER3)
Area 1: Er1 and fishway, ER3, S7 and support structures	Large environmental regulators including one vertical slot fishway. Support structures include track raising and minor regulators fitted with dual leaf gates	Enables inundation of Narcooyia Creek and associated floodplain on a large scale
Area 2: J1a and associated support structures	Eight environmental regulators on J1 Creek fitted with dual leaf gates	Enables inundation of Area 2 J1 Creek and associated floodplain
Area 3: J1C and associated support structures	An environmental regulator on J1c fitted with a single penstock gate	Enables inundation of Area 3 J1 Creek and associated floodplain
Area 4: Lakes Powell and Carpul Pipeline	A pipeline and regulator and additional culvert on Murray Valley Highway	Delivers water from Narcooyia Creek to inundate Lake Powell and Carpul and associated floodplain

Examples of the proposed types of works to be delivered to the Belsar-Yungera project are shown in Figure 4 and Figure 5

Figure 4: A regulating structure at Mullaroo inlet (Lindsay Island) similar to proposed Belsar-Yungera regulators

Figure 5: A containment bank constructed under The Living Murray at the Hattah Lakes, similar to those proposed for Belsar-Yungera

7. Operations

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 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.

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 Murray River 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 potentially 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.

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 J1a 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 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

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 Murray River, Narcooyia Creek and the floodplain.

Transition between operating scenarios

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

Factors that may influence a decision to transition between scenarios may include;

- Catchment inflows causing increase in environmental water allocations
- Catchment 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 7, 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.

7.1 Watering Regimes

The watering regime has been derived from the ecological and hydrological objectives. To allow for adaptive and integrated management, the watering regime is framed using the seasonally adaptive approach. This means that a watering regime is identified for optimal conditions, as well as the maximum and minimum tolerable watering scenarios.

The minimum watering regime is likely to be provided in drought or dry years, the optimum watering regime in average conditions and the maximum watering regime in wet or flooded years.

The optimum, minimum and maximum watering regimes are described in Table 5

Table 5: Target water regime in response to climatic condition

	Dry/Drought	Median	Wet
Belsar-Yungera	Seasonal Anabranch	Seasonal Anabranch Lignum Shrubland and Woodland Black Box and Red Gum Woodland	Seasonal Anabranch Lignum Shrubland and Woodland Black Box and Red Gum Woodland

7.2 Operational Scenarios

The Belsar works have been deigned to replicate key components of the natural hydrology of the system. The infrastructure has been designed to be operated in several possible flow regimes consistent with the requirements set out in the Business Case (MCMA, 2014). Transitioning between scenarios is possible and provides a high level of operational flexibility when delivering planned watering events or responding to natural inflows.

Water will be delivered to the Belsar floodplain area using gravity and occasional temporary pumping when required (Scenario 4), this is further described in Table 6. The works will provide for the inundation of up to 2374 ha of floodplain.

Table 6: Belsar-Yungera operating scenarios (Ecological Associates, 2015) (Jacobs, 2017)

Scenario	Pre-conditions	Structure Operation	Maximum design inundation level (m AHD) (Jacobs, 2017)	Preferred Frequency	Threshold (depth, level or discharge)	Holding Duration	Preferred Timing	Maximum Interval Between Events	Water Regime Class Targeted
Narcooyia Through flow (seasonal Fresh) (Scenario 1)	River levels exceed 48.51 m AHD at Narcooyia Creek inlet (approx. 7,000 ML/d at Euston)	Narcooyia Creek inlet and outlet regulators are opened as long as threshold exceeded.	48.41	Any opportunity	River levels exceed 48.51 m AHD at Narcooyia Creek inlet	As long as possible	At all times	N/A	Watercourse
Capture Low Flood Peak (Scenario 2)	Capture can occur when discharge at Euston exceeds 20,000 ML/d. Peaks up to 40,000 ML/d represent a	Regulators ER1, S7 and ER3 are closed when the flood peak starts to recede. Regulators are opened to release water when flood duration target is met.	50.84	8 years in 10	Levels equivalent to 40,000 ML/d	4 of these events to last more than 3 months 4 of these events to last more	June to November with longer events continuing up to February	2.5 years	Semi-permanent Wetlands

	low flood peak					than 4 months			
Pump to Low Floodplain Area (Scenario 4)	None	Regulators ER1, S7 and ER3 are closed. Water is pumped into containment area. Regulators are opened to release water when flood duration target is met.	As above	As above	As above	As above	As above	As above	As above
Capture Moderate Flood Peak (Scenario 3)	Peaks between 40,000 and 70,000 ML/d at Euston represent a moderate flood peak	Regulators ER1, S7 and ER3 are closed when the flood peak starts to recede. Regulators are opened to release water when flood duration target is met.	52.3 m AHD at Regulator ER1	6 years in 10	70,000 ML/d	4 of these events to last 6 weeks 2 of these events to last 12 weeks	June to November, with longer events continuing up to February	7.5 years	Semi-permanent wetlands Red Gum Forest and Woodland Lignum Shrubland and Woodland Black Box Woodland
Pump to Intermediate Floodplain Areas (Scenario 4)	None	Regulators ER1, S7 and ER3 are closed. Water is pumped into containment area. Regulators are opened to release water when flood duration target is met.	As above	As above	As above	As above	As above	As above	As above
Capture High Flood Peak (Scenario 3)	River discharge exceeds approximately 100,000 ML/d	Regulators J1a and J1c are closed when the flood peak starts to recede. Regulators are opened to release water when	52.9 m AHD at regulator J1a and 53.3m AHD at	4 years in 10	Approximately 100,000 ML/d	1 month	September to February	10 years	Semi-permanent wetlands Red Gum Forest and Woodland Lignum Shrubland and Woodland

		flood duration target is met	regulator J1c						Black Box Woodland
Pump to High Floodplain Areas (Scenario 4)	None	Regulators J1a and J1c are closed. Water is pumped into containment area. Regulators are opened to release water when flood duration target is met	As above	As above	As above	As above	As above	As above	As above
Capture Lake Flood Water (Scenario 2)	Discharge at Euston exceeds 170,000 ML/d	Powel and Carpul Lake regulators are open on rising hydrograph. Regulators are closed when flood peak starts to recede. Water is released from lake regulator when flood duration target is met	52.6m AHD	1 year in 20	Flood to 52.6m AHD	20 to 60 days at a maximum threshold. Detain water at natural still level after that	Any time	20 years	Lignum Shrubland and Woodland Black Box Woodland Floodplain Lake
Pump to Floodplain Lakes (Scenario 4)	None	Lake regulator is closed. Water is pumped to the lakes. Regulator is opened when flood duration target is met.	As above	As above	As above	As above	As above	As above	As above

Table 7:Operational Matrix

	Scenario	To Default	To Seasonal Fresh	To Belsar Intermediate	To Belsar Maximum	To Belsar Maximum and Lakes Powell and Carpul	To Natural
From	Default	Condition During Scenario ER1 & ER3 closed except for the fixed bay to maintain irrigation pool All other structures set to open	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 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 closed and pipeline and temporary pumps in operation to fill Lake Powell and Carpul to 52.6 m AHD.	All structures
From	Seasonal Fresh	ER3 closed	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 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 closed and pipeline and temporary pumps in operation to fill Lakes Powell and Carpul to 52.6 m AHD	All structures
From	Belsar Intermediate	ER1 & ER3 closed except for the fixed bay to maintain irrigation pool All other structures set to open	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 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 closed and pipeline and temporary pumps in operation to fill Lake Powell and Carpul to 52.6 m AHD	All structures
From	Belsar Maximum	ER1 & ER3 closed except for the fixed bay to maintain irrigation pool All other structures set to open	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	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 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	Lake Powell regulator set to closed and pipeline and temporary pumps in operation to fill Lakes Powell and Carpul	All structures
From	Belsar Maximum and Lakes Powell and Carpul	ER1 & ER3 closed except for the fixed bay to maintain irrigation pool All other structures set to open	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 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 closed and pipeline and temporary pumps in operation to fill Lakes Powell and Carpul to 52.6 m AHD	All structures
From	Natural flows	ER1 and ER3 closed except for the fixed bay to maintain irrigation pool	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 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 closed and pipeline and temporary pumps in operation to fill Lakes Powell and Carpul to 52.6 m AHD	Condition Scenario All structures

8. External Considerations for Operations

8.1 Upstream and Downstream Considerations

- Minimum river height to restore seasonal flow to Narcooyia Creek with proposed works is 48.51m AHD, Murray River flows at approximately 7,000 ML/d measured at Euston (Ecological Associates, 2015).
- Working through SCBEWC during strategic annual planning and the MDBA Murray River operation team during operation to facilitate the coordination and re-use of net flows from upstream and downstream to optimise timing of e-water delivery across the Southern connected Murray-Darling Basin; time environmental water events at Belsar-Yungera .
- Water quality of inflows into Narcooyia Creek
- Water quality of return flows to the Murray River particularly regarding water quality targets outlined in the Basin Plan, including targets for salinity, blackwater and cyanobacteria
- Dilution flows required in the advent of the release of water from the lakes impacted by a blackwater event.

8.2 Temporary Pumps

A pump hard stand will be located on the Murray River to enable the setup of temporary infrastructure to deliver environmental water into Narcooyia Creek. A permanent pipeline will be installed between the hardstand and the ER3 Regulator. The permanent pipeline will be located immediately adjacent to the realigned irrigation pipeline. Like the irrigation pipeline, the proposed environmental pipeline has been designed for a peak flow of 200ML/d and max velocity of 2 m/s, comprising a single 1,200 mm diameter pipe.

A 2 km long 900 mm diameter pipeline will be constructed between Bonyaricall Creek and Lake Powell, including a hardstand for a temporary pump installation adjacent to Bonyaricall Creek, to permit pumping of water into Lake Powell and release into Lake Carpul.

9. Water Use

9.1 Flow types

There are four general operating scenarios (plus maintenance):

- Natural inflows/outflows – Scenario 1
- Enhance natural (extend duration) – Scenario 2
- Enhance natural (extend duration and extent) – Scenario 3
- Managed event (pumped event) – Scenario 4
- Maintenance (in years with and without a watering operation to prepare for an event, or post event)

These scenarios are described in detail in Section 7.2 Operational Scenarios, Table 6.

Based on inflow types, the scenarios fit into three groups for water measurement purposes: natural inflows (includes Scenarios 1 and 2), a hybrid event (a combination of natural and pumped flows (scenario 3)), or pumped only flows (Scenario 4).

9.2 Water Requirements

Inundation provided by the VMFRP structures will extend up to 2374 ha when water is stored at the maximum level of 53.3 m AHD, inundating Area 1 to 3, and 52.6 m AHD in Area 4, using a total water volume of approximately 21.4 GL (MCMA, 2014). Environmental water reserves are potentially available for this purpose and will best meet the requirements of Belsar-Yungera floodplain if they are provided over the preferred frequency and timing for the various scenarios (Ecological Associates, 2015).

9.3 Measuring Water Used in Managed Inundation Events

While the details of the measurements arrangements are under development, it is anticipated that pumped environmental water will be measured using an electromagnetic or ultrasonic flow meter or similar equipment/procedure to account for river extractions while return flows are measured via gauging station at the project regulators. The key aspect to consider with water delivery for the Belsar-Yungera floodplain is that it is a storage system with controlled inflows and outflows at Bonyaricall and Narcooyia Creek.

While significant volumes of water can be stored on the floodplain during pumping and natural large events, up to 50% of flows entering the Belsar-Yungera floodplain could potentially return to the Murray River.

The key conditions for water delivery purposes are:

- Commencement of Murray River natural inflows requires 7000 ML/d or greater.
- Water can be contained in the Belsar-Yungera floodplain and may be released to the river.
- Not all inflows can be measured i.e. overbank flows.
- Being possible to calculate the initial volume held in the floodplain by gauge boards/stations and capacity tables. This approach will be consistent with volumes held in large storages (such as Hume Dam, Dartmouth Dam, Lake Victoria, and Menindee).
- Water may switch from regulated flow to unregulated flow and vice versa during an event.

9.4 Measurement Types

The measurement types and location of the Belsar-Yungera works are outlined in Table 8.

Table 7 provides a matrix for the operating scenarios as well as the transitional periods between operating scenarios.

Table 8: Summary of flow measurement types and location at Belsar-Yungera

Site	Flow Measurement	Purpose
ER1 Regulator	Height and Flow	For use during managed and hybrid events
ER 3 Regulator	Height and Flow	For use during managed and hybrid events
S7 Regulator	Height and Flow	For use during managed events
Lake Powel Regulator	Height and Flow	For use during managed events
Lake Carpul Regulator	Height and Flow	For use during managed events

10. Operational Risks and Mitigation Measures

10.1 Ecological, Cultural Heritage and Socio-Economic Threats

Ecological assessments and a Cultural Heritage Management Plan are being undertaken as part of the project.

Shared operational risks associated with environmental watering are managed through an annual workshop with DELWP that Mallee CMA participates in. This process includes discussion of risk learnings of from the previous year, risk assessment for the coming year, and improving risk management processes.

In addition to the above measures, a monitoring, evaluation, and reporting (MER) framework is being put together for the VMFRP project that includes ecological, cultural, and socio-economic outcomes of managed inundation events at the VMFRP sites.

10.2 Impact on Salinity, Water Environments, and Fish Passage

The in-river salinity impacts (at Morgan, South Australia) potentially caused by the proposed actions at Belsar-Yungera were assessed relative to a base case scenario by SKM (2014).

The assessment concluded that the magnitude of the salinity impacts of the proposed watering scenarios was negligible or insignificant. The largest component of the salinity impact is associated with the displacement of groundwater due to diffuse recharge following inundation, but the impact is insignificant. This calculation is considered conservative as it assumes uniform salinity and assumes a significant percentage of the recharged water is returned the Murray River (SKM, 2014).

SKM expects that multiple managed inundation events will raise groundwater levels which may increase the salt load impact on the floodplain and river system.

Based on the uncertainty of the inundation events on salinity over time, SKM recommended a monitoring program. This would comprise groundwater and surface water monitoring. The MCMA monitors an existing network of bores within the Belsar-Yungera vicinity and undertakes a long-term salinity monitoring program to assess the impact of inundation events on groundwater levels and groundwater quality.

To assist in the monitoring of salinity impacts of Belsar-Yungera inundation the VMFRP, with assessment and recommendations from SKM (SKM, 2014) and Jacobs (Jacobs, 2019), has proposed new bores within the proposed project inundation area.

These will be integrated into the existing MCMA monitoring network and monitoring program. Monitoring and ongoing assessment of risks will occur consistent with the Basin Salinity Management Strategy (MDBA, 2015).

In addition to the regular groundwater monitoring, Mallee CMA will manage the monitoring of surface water quality within the Belsar-Yungera project area, during operations. These monitoring activities are critical to verify modelled salinity impacts and to provide timely advice for management of any water quality issues arising during operation of the works.

The following mitigation measures are proposed to minimise and avoid impacts on water environments, salinity, and fish passage during operation of the project:

- Continue to undertake water quality monitoring before, during and after watering events to inform adaptive management strategies and real-time operational decision making.
- Commence watering as early as possible to move organic matter off the floodplain while temperatures are low. Maintain a through-flow where possible in other areas to maximise exchange rates and

movement of organic material. Monitor dissolved oxygen and water temperature to identify hypoxic areas to inform consequence management.

- Schedule watering events to make use of dilution flows where possible and optimise timing of releases of Bonyaricall Creek. Ensure dilution of low dissolved oxygen 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.
- Integrate water management with other sites in seasonal water planning process. Maintain good relationships with other water managers.
- Tailor watering regimes to provide competitive advantage for native fish over carp. Dry wetlands that contain carp. Manage drawdown following managed events to provide triggers for native fish to move off the floodplain, and where possible, strand carp.
- Mitigation measures would be implemented to minimise risks associated with barriers to fish passage, including:
    - Design of regulating structures to satisfy fish passage requirements including those described in the Belsar-Yungera Fish Management Plan (Arthur Rylah Institute, 2018).
    - Continuing to build on knowledge and understanding through current studies relating to fish movement in response to environmental watering and cues to further develop and refine a fish exit strategy.
- 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:
    - Developing an understanding of potential river flow requirements to dilute higher than expected salinity impacts and provision of contingency estimates in environmental water bidding process for initial operation events.
    - 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.

10.3 Risks Associated with Pest Plants and Animals

Mitigation measures would be implemented to minimise risks associated with pest plants and animals, including:

- Timing water manipulations to drown seedlings, minimise growth, germination, and seed set. Time water manipulations to promote native species.
- Controlling 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.

10.4 Risks Associated with Structures

The owner and operators have responsibility for management of risks to the integrity of the structures themselves.

These risks are managed through operation of the structures within their design capabilities, monitoring of structural integrity and through maintenance.

Risk frameworks are being put together for the management and operation of the structures and will be confirmed during Stage 2 works.

11. Operational Costs

The operations and maintenance (O&M) arrangements considers all activities to operate, maintain, monitor and report on the Belsar-Yungera works.

The funding arrangements for ongoing management costs (Table 9) have not formally been established at this time. Funding arrangements could involve cost sharing with the Commonwealth, or partially or in whole funding by Victoria.

There are multiple funding options currently being considered and will require further deliberation by DELWP, DTF, and the Commonwealth.

The estimated operations and maintenance costs for the project are provided in the Business Case, summarised in Table 9.

The precise operating procedures of the project will be detailed in the operations planning to be finalised as part of Stage 2 which includes the scope of works, schedule, and cost estimate for the project.

Stage 2 addresses the matters listed in the most recent guidance on the content of proposals for Supply and Constraint Measures.

The operating costs in **Error! Reference source not found.** are provided as an average annual cost and maximum annual cost to reflect the environmental water delivery via temporary pumping and will be updated as part of Stage 2 works for the Belsar-Yungera project.

Environmental water entitlement storage and works licencing costs are not included in this cost estimate.

Operation and maintenance are based on a 30-year timeframe and excludes asset refurbishment and replacement expenses.

Major refurbishment and replacement costs for VMFRP assets would need to be funded by government and be subject to normal funding practices.

Table 9: Belsar-Yungera Project Average and Annual Costs (MCMA, 2014)

Item	Average cost ($/year)	Maximum cost ($/year)	Responsible party	Notes
Capital maintenance cost and operating cost	[redacted]			
Pumping cost				
Ecological monitoring costs (condition and intervention)				
Salinity monitoring costs				
Compliance				
Project management costs				
Total estimated				

12. Communications

12.1 Community Communication and Engagement Strategy

The Belsar-Yungera Site has a Community Communication and Engagement Strategy. A Stakeholder Engagement and Communication Plan was developed to ensure awareness amongst all stakeholders and the wider community of the Belsar-Yungera environmental watering operations.

The VMFRP Stakeholder Engagement & Communication Plan is attached as Appendix 1 and will be updated as appropriate as part of the Stage 2 works for the Belsar-Yungera project.

The Site Manager, LMW, and the Mallee CMA are committed to establishing and maintaining strong relationships within the local community during watering operations. A vital tool in the consultation process is structured engagement with the community through engagement with key stakeholders and advisory groups.

12.2 Indigenous Engagement

Indigenous stakeholders are consulted to ensure the Indigenous community has an opportunity to provide input into water management and a chance to raise and identify their cultural and spiritual links to the Belsar-Yungera area.

These stakeholders are representatives of each of the Aboriginal parties who have a vested interest in the Belsar-Yungera area.

Indigenous consultation is managed via the Mallee CMA Indigenous Facilitator and through the Mallee CMA Aboriginal Reference Group. This group provides a valuable single source for Indigenous engagement, advice, input, and recommendation.

The reference group has Indigenous representatives who ensure that cultural heritage and values are considered and incorporated by the Site Manager and Mallee CMA.

The representatives also distribute information about Site management into the Aboriginal communities.

The development of an Indigenous engagement framework will be developed during Stage 2 works.

12.3 Communication during managed events

Mallee CMA and Lower Murray Water will coordinate communication activities for upcoming and ongoing watering events via the Belsar-Yungera Operations Group.

The Mallee CMA prepares a Communications Plan each year that covers environmental watering events for the entire Mallee CMA region, including the Belsar-Yungera area.

The plan is a high-level framework for communication and engagement activities, relating to that years' environmental watering. It addresses all wetlands listed in the Mallee CMA Seasonal Watering Proposals and will incorporate watering proposals for Belsar-Yungera under the VMFRP.

The plan does not cover government agencies as a stakeholder as the Communication Plan and Engagement occurs at an operational level, predominantly via the Belsar-Yungera Operations Group for the Belsar-Yungera site.

Parks Victoria will be responsible for communicating with its stakeholders and visitors regarding any impacts on visitor experience such as road closures, access restrictions to areas of the park and water quality issues.

During routine river operations or in the event of a broad, basin scale event such as blackwater, the MDBA, Water Authorities, and CMAs will work together to communicate with local agencies.

12.4 Complaints and Enquiries

Complaints and enquiries relating to the environmental watering process shall be directed to MCMA.

Parks Victoria will be responsible for dealing with complaints and enquiries regarding visitor access to the park and water quality concerns within the park.

13. Water Management Operations Record

A record of water management operations is maintained as part of this Operations Plan.

The purpose of the record is to document how well the infrastructure and management arrangements at Belsar-Yungera meet environmental watering needs and manage risk.

The record documents watering plans, actions, and outcomes. An entry is made at the conclusion of each watering event and includes analysis of the strengths and weaknesses of operating arrangements.

The record is used to revise and refine the Belsar-Yungera Operations Plan as well as to inform annual watering actions, to ensure that water delivery is as efficient and effective as possible and that risks are managed appropriately.

The Water Management Operations Record comprises the following information:

- Event Water Year
- Watering Objective – This identifies the primary objective(s) of the watering event. Detailed rationales are provided in the Annual Watering Proposal.
- Operational Targets – The key thresholds that were set for operations, such as wetland water levels, watercourse discharge or structure settings and the dates on which they were to be achieved. This can be presented as a target hydrograph or a table. Operational targets will be required for each watercourse and wetland.
- External Factors – External factors that influenced operations are presented. These could include river flows, rain events, risk management or structure malfunction. Their influence on operations is described.
- Operational Outcomes – The actual water levels / flow rates / total water volume used/structure settings achieved and dates. This can be presented as an annotated hydrograph or table. Operational outcomes will be required for each watercourse and wetland.
- Performance – How well were the watering objectives met?
- Risk Management – How well were known risks monitored? How well were they managed?
- Considerations for future operations

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Appendix 1: VMFRP Stakeholder Engagement and Communication Plan