Burra Environmental Water Management Plan

mallee catchment management authority

Department of Environment, Land, Water & Planning

State Government Victoria

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EXECUTIVE SUMMARY

Environmental Water Management Plans (EWMPs) have been developed for key sites in the Mallee region. The Mallee Waterway Strategy 2014-22 (Mallee CMA, 2014) covers 216 identified waterways which have been grouped into planning units according to hydrological interconnectedness and commonality of threats impacting on the waterways values; resulting in 23 Waterway Management Units (WMU). This EWMP has been developed for a Sub-unit of Burra WMU, Burra Creek, hereafter referred to as Burra. This Environmental Water Management Plan (EWMP) sets out the long-term objectives for the priority environmental values of Burra. It is an important part of the Victorian Environmental Water Planning Framework and provides the long-term management intentions, based on scientific information and stakeholder consultation that can be used by the respective agencies; Mallee Catchment Management Authority (CMA), Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH); for both short and longer-term environmental water planning.

Burra is located north of Nyah, between Piangil and Kenley. Burra covers an area of 3,642 ha. Burra Creek is a former anabranch of the Murray River that meanders across the floodplain, flowing in a northerly direction. The gradient of the creek bed falls approximately 3 m from Burra Creek South to Burra Creek North. Crossings and block banks have been constructed across the creek channel, significantly altering the creek's hydrology, reducing the frequency, extent and magnitude of flood events.

Burra has been divided into management zones in this EWMP, which consider the ability to deliver water with current and proposed infrastructure, location of impediments to flow and land tenure. The target area for this plan includes the management zones:

- Burra South Proper: Burra Creek South Proper (8 ha)
- Burra South: Burra Creek South (109 ha) and Floodplain (134 ha)
- Burra North: Burra Creek North (50 ha) & Floodplain (357 ha)
- Burra North Wetland (7 ha) & Floodplain (24 ha)

The target area within Burra is the extent to which environmental water is able to be managed with proposed infrastructure in place. With current infrastructure in place, watering of 167 ha is possible in Burra South Proper, Burra South and Burra North. This area can be substantially increased to 647 ha with the proposed infrastructure. Inundation of the entire target area would be possible including Burra North Wetland and the floodplains.

Funding for the infrastructure is currently being sought through the 'Sustainable Diversion Limits (SDL) Works and Measures for Burra Creek' (SDL Business Case). The infrastructure outlined in the document is proposed only and requires further investigation and design.

Burra North has one of the best-preserved floodplain woodland and shrubland communities in the western Murray Fans bioregion. The target area has the capacity to support a diverse range of water dependent flora and fauna species including 25 significant species, including the Broad-shelled turtle (*Chelodina expansa*), White Bellied Sea Eagle (*Haliaeetus leucogaster*), Carpet Python (*Morelia spilota*) and the Regent Parrot (*Polytelis anthopeplus monarchoides*). An excellent diversity of bat and frog species has also been recorded in Burra.

The target area also has significant social values for the local community and the local indigenous community has strong connections to the area.

The long term management goal for Burra is to provide a flow regime that more closely reflects natural events, thus improving the capacity of the target area to provide a productive ecosystem for native flora and fauna.

The values that are central to the management of the site are the seasonal aquatic habitat and the River Red Gum (*Eucalyptus camaldulensis)*, Black Box (*Eucalyptus largiflorens)* and Lignum (*Muehlenbeckia florulenta)* communities which support a diversity of flora and fauna within Burra.

The ecological objectives for Burra are to:

- Improve vegetation health and structure in the fringing Lignum, Black Box and Red Gum;
- Promote growth of seasonal emergent and semi-emergent macrophytes; and
- Reinstate seasonal connectivity along Burra Creek, wetlands and the floodplain in the target area

The watering regimes include three options based upon availability of environmental water, past events, and seasonal requirements:

- Delivering environmental water to Burra Creek and Burra North Wetland nine years in ten to encourage seasonal aquatic macrophytes;
- Delivering environmental water to Burra Creek, and to overtop Burra North Wetland, three years in ten to maintain River Red Gum communities; and
- Delivering environmental water to Burra Creek, overtopping Burra North Wetland, and over topping Burra Creek to inundate Burra North and South Floodplain's once in ten years to maintain Black Box and Lignum communities.

Accurate mapping of impediments to flow and environmental water delivery and detailed design for infrastructure are significant recommendations from this EWMP.

ACKNOWLEDGEMENTS

The Mallee Catchment Management Authority acknowledges the Victorian State Government and the MDBA, Basin Plan Implementation for funding the development of the environmental watering plans. They also acknowledge the contribution to the development of the plans by Parks Victoria, Jane Roberts, Terry Hillman, other agencies and community members. Mallee Catchment Management Authority also acknowledges the contribution of Dr Marcus Cooling for his assistance in setting the objectives for this plan.

1 INTRODUCTION

This Environmental Water Management Plan (EWMP) has been by the Mallee CMA to establish the long-term management goals of Burra.

The key purposes of the EWMP are to:

- identify the long-term objectives and water requirements for Burra Creek, identified as a medium priority reach in the Mallee Waterway Strategy (MWS), and Burra North Wetland;
- provide a vehicle for community consultation, including for the long-term objectives and water requirements of the wetland;
- inform the development of seasonal watering proposals and seasonal watering plans;
- inform Long-term Watering Plans that will be developed under Basin Plan requirements.

A context document has been created to compliment the Mallee CMA EWMPs and should be read in conjunction with this document (Sunraysia Environmental, 2014).

2 SITE OVERVIEW

2.1 Site Location

The Mallee CMA region is located in the north-west of Victoria. The area of responsibility is close to 39,000 km^2 (3.9 million ha), with a regional population estimated to be 65,000. Population centres include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein.

The boundaries of the Mallee CMA region cover almost one fifth of Victoria, making it the largest area managed by a CMA in the state.

Approximately 40% of the land area within the Mallee CMA boundary is public land, consisting mainly of national parks, reserves, wilderness, and large areas of riverine and dryland forests. The other 60% is predominantly dryland crops, but there is also a significant investment in irrigation of grapes, citrus, almonds, olives and vegetables along the Murray River corridor which contributes over 40% of the value of agricultural production for the region.

In 2006, the Mallee CMA engaged consultants (Ecological Associates) to investigate water management options for the Murray River floodplain from Robinvale to Wallpolla Island. One of the major outcomes of these investigations was the development of a system of Floodplain Management Units (FMUs). These divide the floodplain into management units which water regimes can be managed independently of another FMU, but which are relatively consistent in their ecological values and land uses. The Mallee CMA has based its environmental water management plans on these FMUs to achieve more effective management of hydrologically connected systems. In addition to this, the Mallee CMA has also used individual FMUs or groupings of FMUs to form Waterway Management Units (WMUs) for planning within its Mallee Waterway Strategy.

The site for this plan is Burra Creek WMU sub unit, hereafter referred to as Burra, with an area of 3,642.46 ha (Figure 1). Burra is located on the Murray River floodplain, between the rural localities of Kenley and Piangil, 36 river km downstream from Nyah. The WMU sub-unit falls within Burra WMU in the Mallee Waterway Strategy 2014-22 (MCMA 2014). The target area for Burra includes the full inundation extent proposed for Burra Creek, Burra Creek South and North Floodplains and Burra North Wetland and floodplain, as seen in Figure 1. The proposed infrastructure will enable around 799 ha of Burra to be inundated.

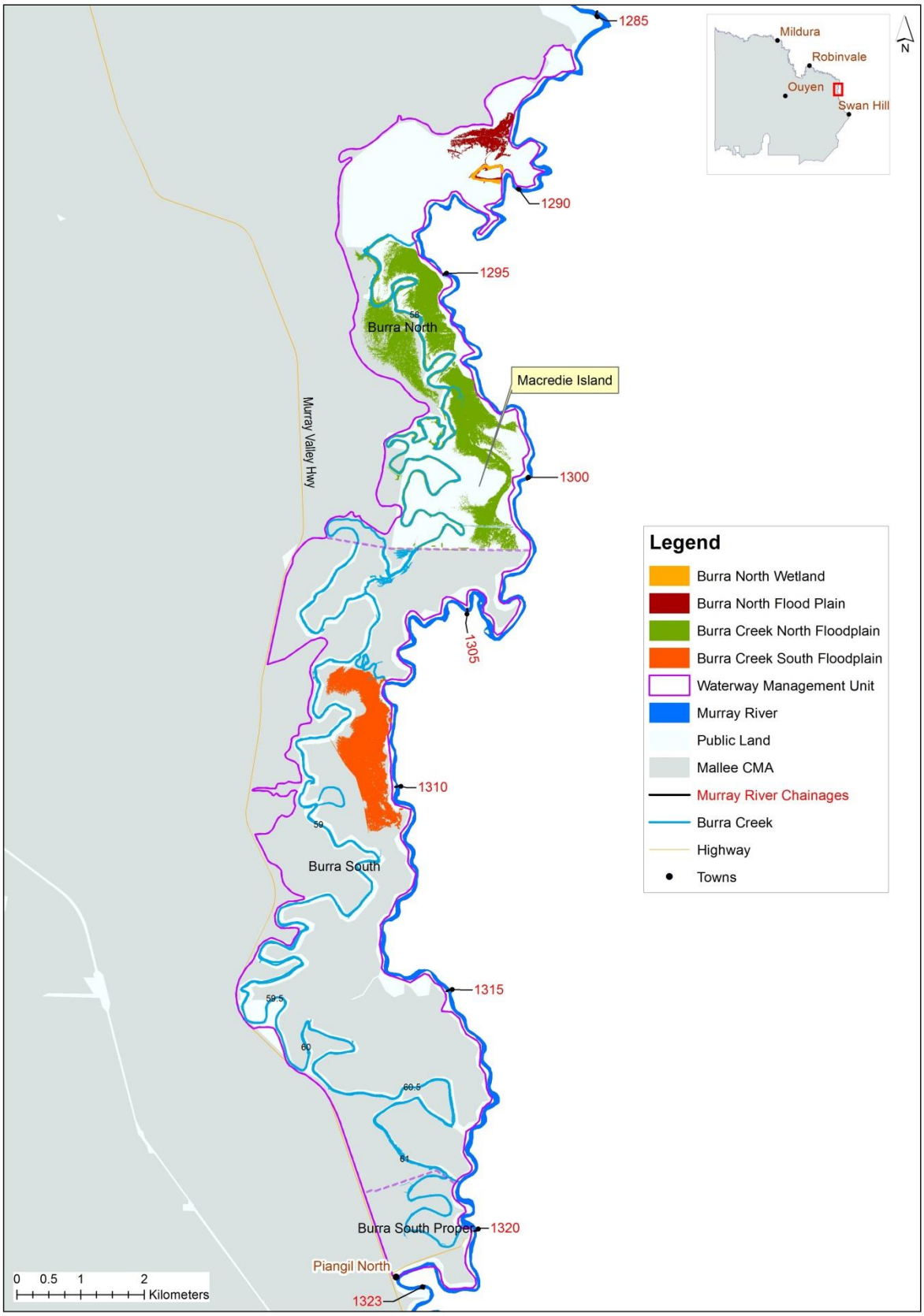

Figure 1 - Burra

2.2 Catchment Setting

Burra is located in the Murray Fans bioregion, which is characterised by a flat to gently undulating landscape on recent unconsolidated sediments with evidence of former stream channels, braided old river meanders and palaeochannels and broad floodplain areas associated with major river systems and prior steams (known as braided/ anastomosing streams). Alluvium deposits from the Cainozoic period gave rise to the red brown earths and texture contrast soils (Chromosols and Sodosols) (DEPI 2014).

The river channel in this section of the Murray River is generally narrow and shallow. During high flood events, larger volumes of water that cannot pass through the Barmah Choke flow via the Edward-Wakool anabranch system in New South Wales, re-entering the main river channel near the downstream extremity of Burra, at Kenley.

The landscape to the west of Burra follows a pattern typical of the Mallee CMA region, with floodplain giving way to grazing land and further afield, elevated terraces of Mallee dunes and mallee vegetation. Private land in the Mallee is used for dryland farming. Closer to the Murray River floodplain, significant investment in irrigation infrastructure has enabled almonds, grapes, olives, vegetables and other crops to be grown. Burra is bounded by the Murray River to the east.

Burra Creek is an anabranch of the Murray River extending approximately 54 km from Piangil to just upstream of Kenley (Figure 1). The land between the creek and the Murray River forms Macredie Island, which consists of floodplain with areas of cropping and grazing land and floodplain vegetation. For approximately 17 km of its northern length, Burra Creek flows through River Murray Reserve. A narrow strip of River Red Gum lines the banks of the Creek forming a striking local landmark. Floodplain vegetation further afield generally consists of Black Box and Lignum communities (Ecological Associates 2006).

2.2.1 Burra

Burra covers 3,642.46 ha and includes Burra Creek and six wetlands, as shown in Figure 2 .

Burra Creek is a highly modified creek line (Figure 3). The creek falls significantly in elevation along Burra Creek South Proper (60.4 m AHD) and Burra Creek South (59.9 m AHD). Burra Creek North (58 m AHD) has a comparatively minimal fall in elevation (Figure 3). Some of the impediments along Burra Creek South help slow environmental water flowing along the creekline providing a water source for longer periods along the creek. However, natural flow events and the movement of water along the creek are impeded by a large number of impediments to water flow.

Recent drought conditions have led to a decline in the health of native vegetation, particularly the River Red Gum lining the creek's banks. Despite the modified hydrology of the creek, a diversity of native flora and fauna has been recorded in Burra, indicating its capacity to support a healthy and productive ecosystem.

Burra has been divided into management zones for the purpose of this EWMP and these are shown in Figure 2. The zones include:

- Burra Creek South Proper;
- Burra Creek South;
- Burra Creek North; and
- Burra North Wetland.

A large irrigation channel traverses the original creek path in three locations. This irrigation channel defines the boundary between Burra North and Burra South zones (Figure 2). Major Mitchell Lagoon and Un-Named Wetland #7428665317 are deep wetlands that are separated from the Murray River by a high narrow sill and fill in high river events, and retain water after the high river flows (Ecological Associates 2006). According to the spells analysis undertaken by Gippel (2014) Major Mitchell

Lagoon and Un-Named Wetland #7428665317 currently receive a near natural flow frequency, interval, commencement date and duration.

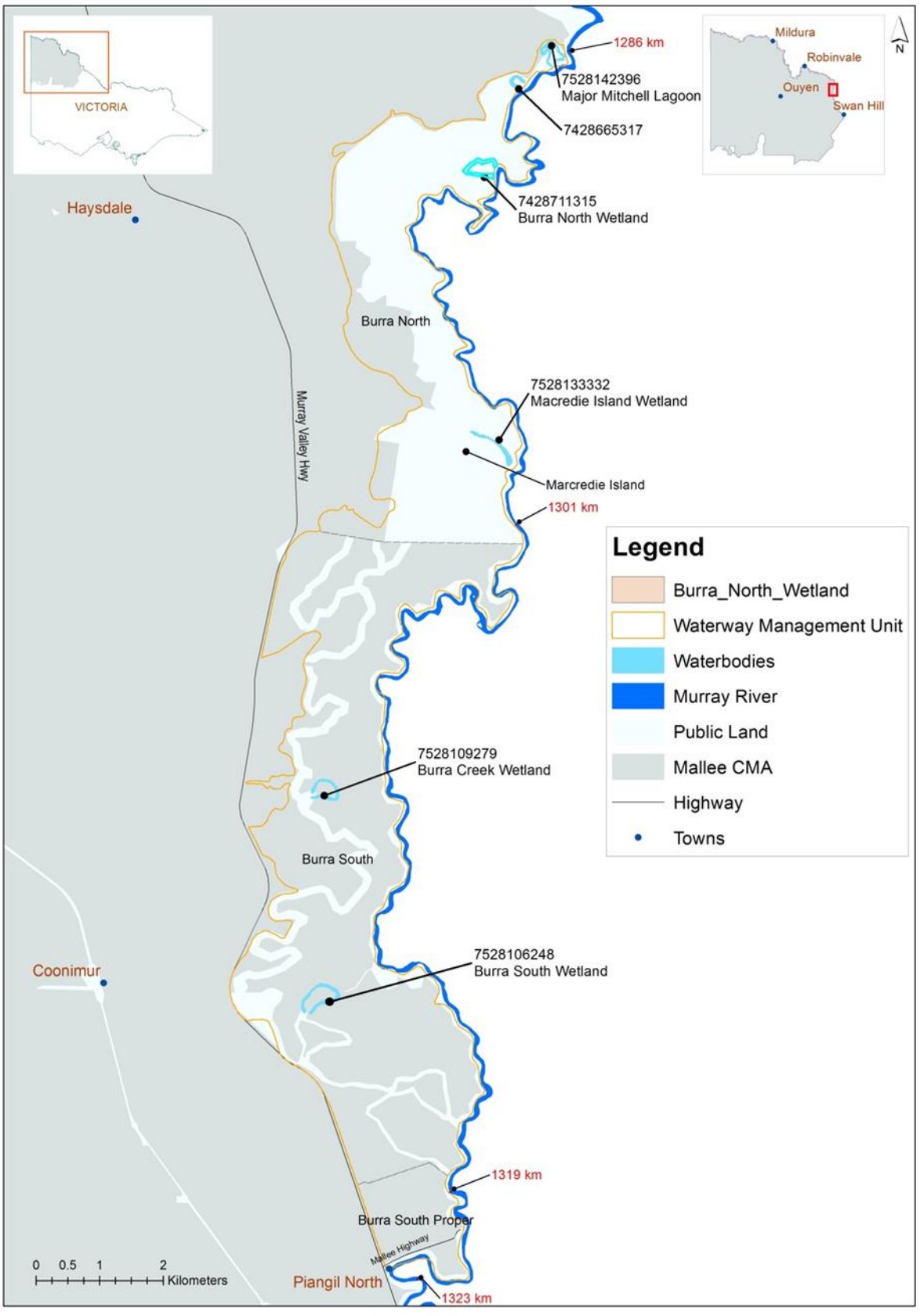

Figure 2 – Wetlands within Burra

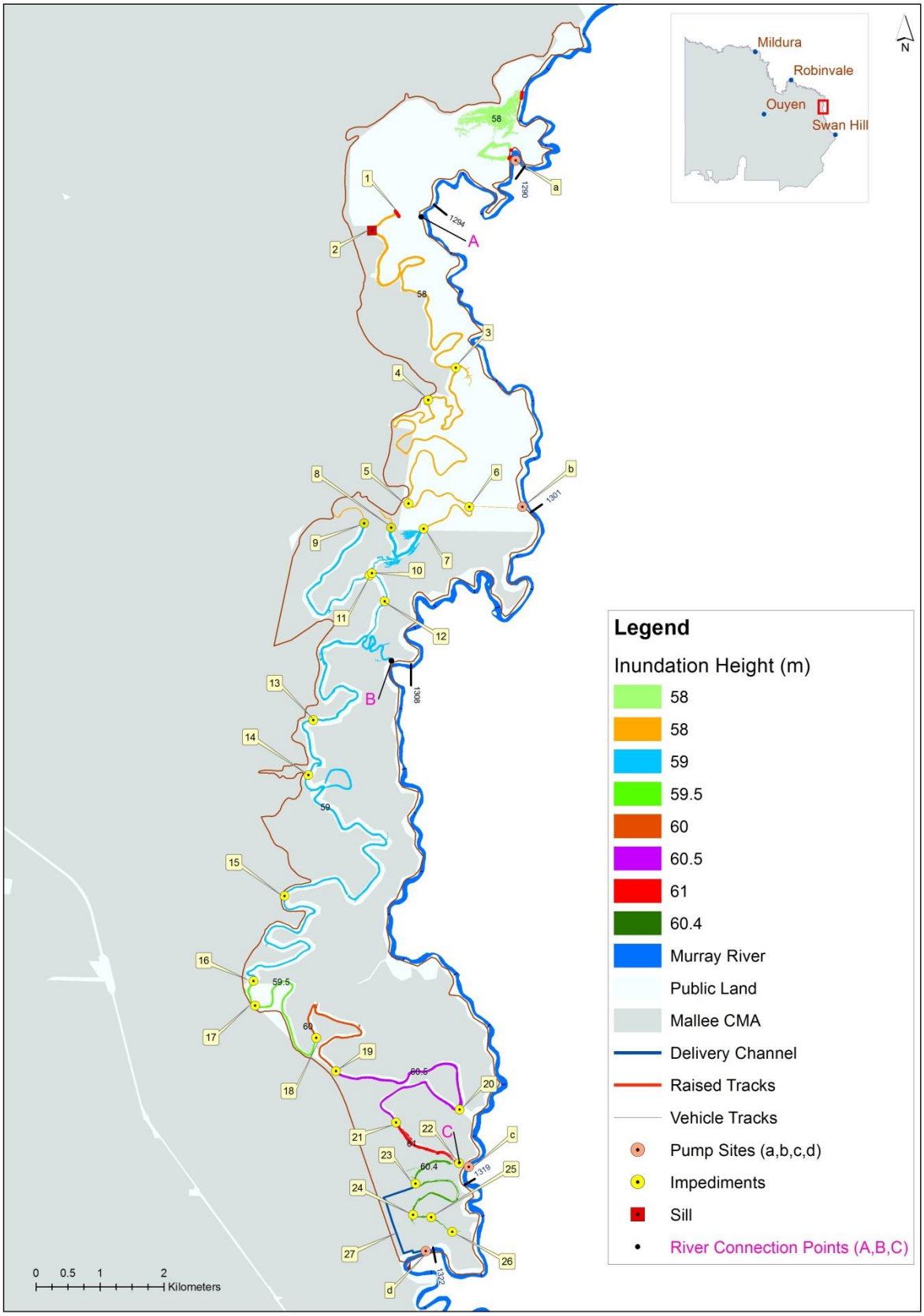

Figure 3 - Hydraulic features of Burra Creek and locations of instream impediments to water movement

2.2.2 Burra Creek South Proper

The southernmost section of Burra Creek, known as Burra Creek South Proper was once connected to the Murray River at two connection points (Figure 4). Since European settlement the original southern connection point of the creek has been 'lost'. The northern connection point has been impeded by a road crossing, Connection Point C (Figure 3).

Burra Creek South Proper is a shallow and wide creek bed (Figure 5) approximately 3 km in length. Burra Creek South Proper is dominated by Lignum Swamp and Lignum Swampy Woodland vegetation communities. Tangled Lignum, provides valuable habitat for waterbirds, fish and macro-invertebrates, and can be an important feeding area for raptors, owls and predatory reptiles (Ecological Associates, 2007).

In the past, Burra Creek South Proper has been used for grazing, and beyond the creek line, cropping. Past grazing of the creek bed and cropping up to the creek bank is also likely to have altered the creek form since European settlement.

Figure 4 - Southern and northern connection points for Burra Creek South Proper

Figure 5 - Burra Creek through Burra Creek South Proper

2.2.3 Burra Creek South

Burra Creek South is a stretch of creek line measuring approximately 27 km in length. It commences as a narrow (5 m) and relatively deep (3 m) channel, and changes into a wider (17 m) and flatter (2 m deep) channel by the time it reaches an impediment upstream of the irrigation channel (Figure 6). Burra Creek South is connected to the Murray River at the southern end of Burra Creek South (~1319), Connection point C and at another site around river km 1307.5, Connection Point B (Figure 3). Burra Creek South and Burra Creek North are physically separated by a large irrigation channel (Figure 6 and Figure 7).

Figure 6 - Irrigation channel crossing Burra Creek

Figure 7 - The irrigation channel (foreground) that separates Burra Creek North and South, crossing Burra Creek (background).

Burra Creek south supports stands of River Red Gum and Black Box, surrounded by agricultural land. The creek has experienced significant alterations and threats include unrestricted livestock grazing. Fences and roads have been constructed across the creek bed in several locations, with aged pipe culverts under roads that impede flow and movement of aquatic fauna. Stop banks or levees have been constructed across the creek bed to form dams allowing pumping of water for irrigation and stock and domestic use; man-made cuttings have been constructed to allow high flow events to bypass rather than overtop some levees.

Two meander loops are mapped as Burra Creek Wetland and Burra South Wetland (Figure 2). Burra Creek Wetland is dammed and used as an irrigation storage; Burra South Wetland has been cut off from the creek channel, possibly as a consequence of land use practices. Both wetlands are adjacent to the creek reserve, on private land.

2.2.4 Burra Creek North

The northern section of Burra Creek meanders for approximately 16 km, it is generally wide (50 – 70 m) and relatively shallow. Burra Creek North is almost entirely within the River Murray Reserve, and is surrounded by relatively dense floodplain vegetation. The floodplain of the western bank of the creek is generally narrow, and in some places is adjacent to cropping and grazing land. Burra Creek connects with the Murray River at the northern end (Figure 3), Connection Point A.

The land to the east of Burra Creek North is known as Macredie Island, part of the River Murray Reserve. This floodplain includes Macredie Island Wetland.

2.2.5 Burra North Wetland

Burra North Wetland (Figure 2) is a former meander loop of the Murray River and is the first wetland to fill as the river rises. It has been reported that this wetland can hold water for more than a year following a flood recession (Ecological Associates 2006). The Burra North Wetland and an area of floodplain are located on public land (as shown in Figure 1 and Figure 2) and are within the Murray River Reserve.

2.3 Conceptualisation of the Site

Burra has been represented in a conceptual model. The model provides a visual representation of the site's processes and components that are discussed throughout this EWMP.

The vegetation structure of Burra typically comprises aquatic macrophytes and/or herbs and forbs at creek bed level, River Red Gum fringe the Burra North Wetland and Burra Creek, and on higher elevations of the floodplain, Black Box and Lignum are found.

Rainfall is unreliable and intermittent, natural flood events entering the creek have been reduced by river regulation, and agriculture and levee construction can impact runoff patterns, altering hydrology. Many impediments (structures) restrict flow of water and movement of aquatic fauna within the creek. In some locations the creek has been dammed to enable storage and pumping of irrigation water. River Red Gums have suffered considerably from restricted flows, altered hydrology and prolonged drought conditions.

Freshwater inflows to the system will be delivered as environmental water to provide a range of feeding, breeding, watering points and habitats for native fauna. This inundation leads to the rapid release of nutrients from the soils, and the seed and egg banks of plants and aquatic invertebrates emerge. This pulse in aquatic macrophytes and invertebrates provides food for turtles and frogs, which in turn provides food for waterbirds. The system becomes more productive and surrounding vegetation such as Lignum, understorey and Eucalypt species benefit from periodic inundation as water levels rise and fall. Healthy vegetation promotes visitation by woodland birds and terrestrial fauna for roosting and nesting sites, and provides fallen timber and hollows for nesting and shelter.

Processes

- Levee
- Altered Hydrology
- Private Road
- Agriculture
- Vehicular Access
- Soil disturbance - Agriculture
- Irrigation Pump Connection
- Irrigation Activities
- Fallen Timber
- Dead Trees

Terrestrial Fauna

- Woodland Birds
- Reptiles

Wetland Fauna

- Large Waders
- Small Waders
- Dabbling & Diving Ducks
- Grazing Waterfowl
- Turtle species
- Frog species
- Channel-specialist fish

Water Dependent Flora

- River Red Gum
- Black Box
- Understorey
- Lignum

2.4 Land Status and Management

Within Burra, an 80 m wide Crown Land water frontage reserve applies to almost the entire length of Burra Creek (Figure 8). Burra Creek South Proper is private land. In Burra South, the proposed Murray River Park reserve crosses freehold land. Much of the land to the west of the creek in Burra Creek North is also freehold land; however, Macredie Island is managed as a part of the proposed River Murray Park (VEAC 2008) in conjunction with the River Red Gum Forests Investigation (VEAC 2008). Relevant stakeholders are listed in Table 1.

Macredie Island has historically been managed by Parks Victoria as Piambie State Forest under the River Murray Reserve since the 1989 Land Conservation Council Final Recommendations (Land Conservation Council, 1989). Prior to these recommendations, the land had been managed as State Forest, dating back to 1929.

Table 1 - Stakeholders for Burra

Group	Role
Parks Victoria	Land Manager
Mallee CMA	Regional environmental management
Department of Environment and Primary Industries	State level environmental management
Goulburn Murray Water	Murray River operations
Swan Hill Rural City Council	Local Government
Robinvale Aboriginal Community	Indigenous Representation
The Wadi Wadi people	Native Title Claimant
Landholders with land adjacent creek reserve	Consultation regarding timing of deliveries, access points, improvements to flow impediments
Kooloonong - Natya Landcare Group	Assistance in planning and implementation of programs
Victorian Environmental Water Holder	Determines locations and volumes for environmental water delivery
Irrigators	Utilise Burra for access to pumping infrastructure on the Murray River.

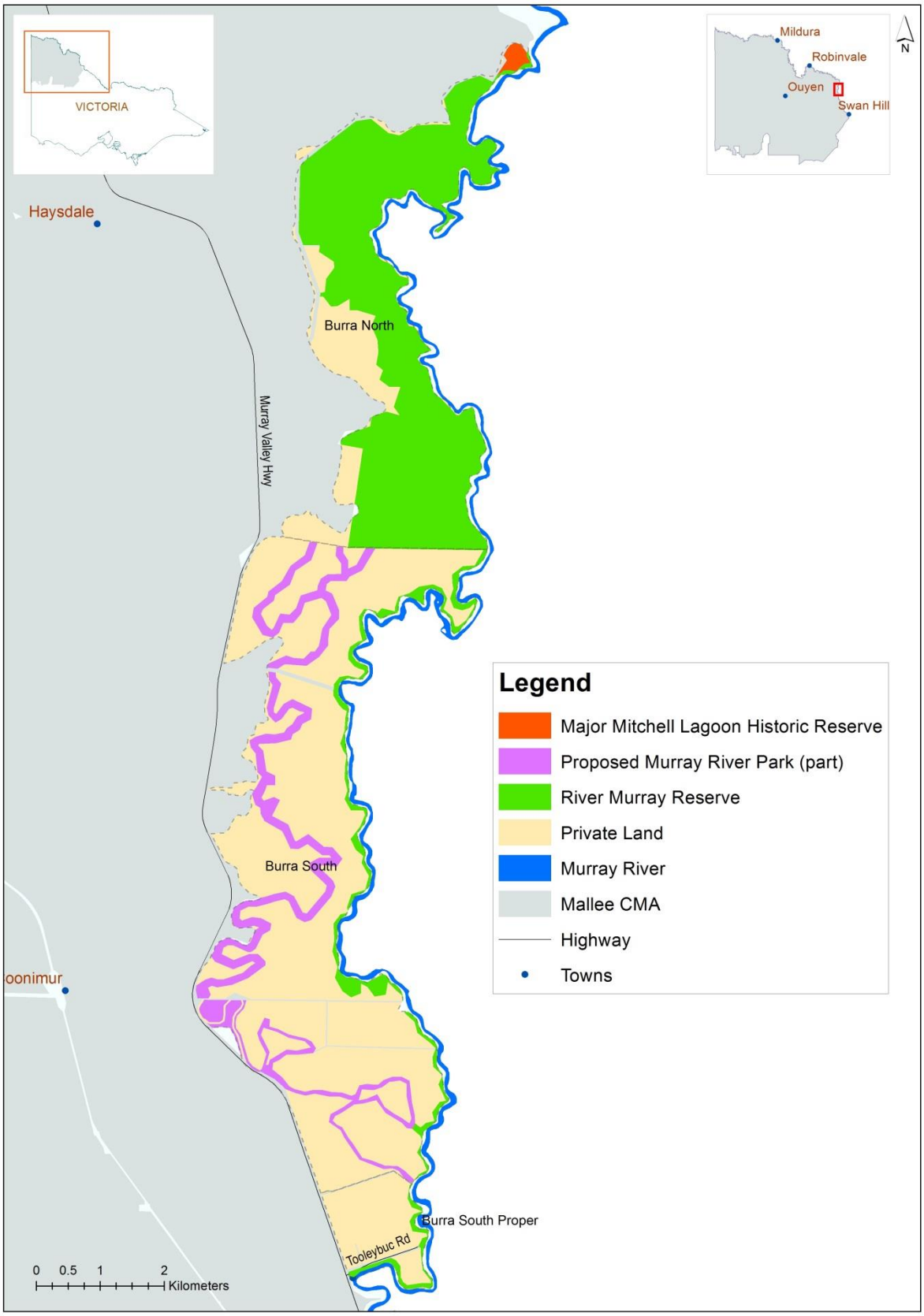

Figure 8 - Land management boundaries for Burra

2.5 Creek and Wetland Characteristics

As discussed, Burra has been divided into four management zones: Burra Creek South Proper, Burra Creek South, Burra Creek North, and Burra North Wetland. Table 2 provides details of the characteristics of the management zones described in this plan.

Table 2 - Summary of creek and wetland characteristics

Characteristics	Burra South Proper Management Zone	Burra South Management Zone	Burra North Management Zone		Burra North Wetland Management Zone
Name	Burra Creek South Proper	Burra Creek South	Burra Creek North	Macredie Island	Burra North Wetland and Floodplain
Mapping ID within area	N/A	7528109279 7528106248	N/A	7528 133332	7428 711315
1788 wetland category	N/A	Both Deep Freshwater Marsh	N/A	Shallow Freshwater Marsh	Deep Freshwater Marsh
1994 wetland category and sub-category	N/A	Both Deep Marsh	N/A	Shallow Freshwater Marsh	Deep Freshwater Marsh
Management Zone Area (ha)	8.05	242.92	407		31.72
Creek Line Length	~4 km	~32 km	~18 km	N/A	N/A
River Connection Point (s)	1319.7 river km 1318.7 river km	1318.7 river km 1308 river km	1294.3 river km	N/A	1290.4
Conservation status	Bioregional Conservation Status: EVCs listed as Vulnerable	Bioregional Conservation Status: areas of EVC listed as Endangered, Vulnerable, and Depleted	Bioregional Conservation Status: EVC listed as Vulnerable	Bioregional Conservation Status: areas of EVC listed as Endangered, Vulnerable, and Depleted	Bioregional Conservation Status: areas of EVC listed as Vulnerable, and Depleted
Land status	Private Land	Crown Land: 80 m wide water frontage reserve, surrounded by Private Land	River Murray Reserve	River Murray Reserve	River Murray Reserve

Characteristics	Burra South Proper Management Zone	Burra South Management Zone	Burra North Management Zone		Burra North Wetland Management Zone
Land manager	Private landholders	Private landholders	Parks Victoria	Parks Victoria, private landholders	Parks Victoria
Surrounding land use	Cropping & grazing	Cropping & grazing	River Murray Reserve, cropping, grazing and irrigated horticulture to the west	River Murray Reserve	River Murray Reserve
Commence to Flow Rates	CTF ~28,000 ML/d, flowing southerly from Burra Creek South	20,000 ML/d, at Connection Point C; and 22,500 ML/d at Connection Point B	17,000 ML/d (Connection Point A)	27,500 ML/d	Not Known
Full Connected Flow (Creek)	27,500 ML/d, 60.5 m AHD	27,500 ML/d, 60.5 m AHD	27,500 ML/d, 60.5 m AHD	N/A	N/A
Wetland depth at capacity/Creek depth at deepest point	~0.5 m	~3 m	~2 m	Not Known	Not Known
Water supply	Regulated natural connection. Option to fill from irrigation channel on private land.	Regulated natural connection. Option to fill from disused irrigation channel on Public Land	Regulated natural connection. Option to fill from downstream river connection point.	Regulated natural connection in high flows only. Option to fill Burra Creek to height to inundate floodplain.	Regulated natural connection. Option to fill from temporary pump site

2.6 Management Scale

2.6.1 Burra EWMP Target Area

Burra covers 3,642.46 ha, which includes Burra Creek and six wetlands. The target area (Figure 1) for the Burra EWMP includes:

- Burra South Proper: Burra Creek South Proper (8 ha)
- Burra South: Burra Creek South (109 ha) and Floodplain (134 ha)
- Burra North: Burra Creek North (50 ha) & Floodplain (357 ha)
- Burra North Wetland (7 ha) & Floodplain (24 ha)

The target area within Burra is the extent to which environmental water is able to be managed with proposed infrastructure in place. Constraints and proposed infrastructure are discussed fully in the Environmental Water Delivery Infrastructure Section. The target area is shown in Figure 9.

The Nationally Important Major Mitchell Lagoon (7528 142396), Un-Named Wetland (7428 665317) and Macredie Island Wetland (7528133332) are not considered for environmental watering in this EWMP (Figure 3). These wetlands are located on the Murray River Floodplain, and are not hydrologically connected to Burra Creek. They also currently receive a near natural flow frequency, interval, commencement date and duration and do not require specific environmental watering intervention.

Burra Creek Wetland is dammed and used as irrigation storage and Burra South Wetland has been cut off from the creek channel, possibly as a consequence of land use practices. Both wetlands are adjacent to the creek reserve, on private land, and are not targeted for delivery of environmental water.

2.6.2 Overview of the Watering Regime

As mentioned above, Burra Creek has been divided into management zones. With current infrastructure in place, watering of 167 ha is possible in Burra South Proper, Burra South and Burra North. This area can be substantially increased to 647 ha with the proposed infrastructure. Inundation of the entire target area would be possible including Burra North Wetland and the floodplains.

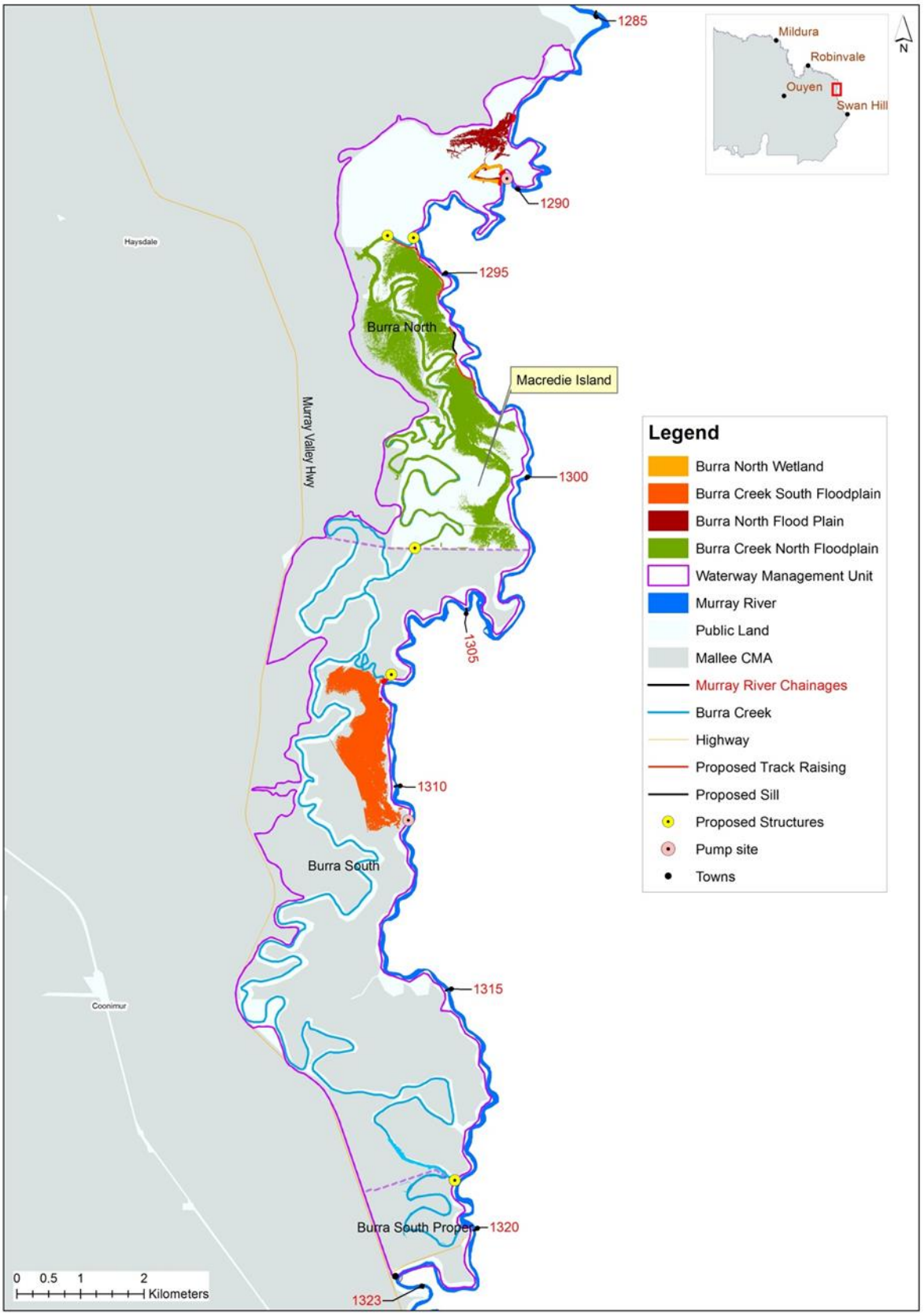

Figure 9 - The target area for the Burra EWMP

2.7 Environmental water Sources

Environmental Water for the study site may be sourced from the water entitlements and their agencies listed in Table 3. Sources of environmental water are further explained in the Mallee CMA Region Context Document (Sunraysia Environmental 2014).

Table 3 - Summary of environmental water sources available to Burra

Water Entitlement	Responsible Agency
Murray River Unregulated Flows	Murray Darling Basin Authority
Murray River Surplus Flows	
Victorian River Murray Flora and Fauna Bulk Entitlement	Victorian Environmental Water Holder
Commonwealth water	Commonwealth Environmental water Holder
Donated Water	VEWH

* Other sources of water may become available through water trading or changes in water entitlements.

2.8 Related Agreements, Policy, Plans and Activities

Burra is situated on the Victorian floodplain of the Murray River which is the subject of investigation in many guises. These include Salinity Management Plans, Flow studies and Land Conservation Council Reviews. An investigation into River Red Gum Health by the Victorian Environmental assessment Council (VEAC) in 2008 resulted in the Burra Creek North area being changed from State Forest status to a Murray River Public Purposes Reserve in 2010.

The Mallee Waterway Strategy (MCMA 2014b) identifies Burra Creek as a medium priority waterway, and Burra South Wetland as a high priority wetland. Further information on management activities can be found in the Mallee Waterway Strategy (MCMA 2014).

Additional information on regional agreements, policies, plans and activities can be found in the Mallee CMA Regional Context Document (Sunraysia Environmental 2014).

There have also been local investigations. In 2006, Mallee CMA engaged consultants Ecological Associates to investigate water management options for the floodplain of the Murray River from Nyah to Robinvale. In 2007, Ecological Associates described the hydrology of Burra Creek and provided a detailed investigation of impediments within the creek. This investigation proposed infrastructure to enable greater inundation of the target area in Burra which is outlined as part of this plan.

Burra is one of the seven business cases prepared in 2014, for consideration as 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 ground. The Business Case for Burra identifies engineering works including flow control regulators, pipes and pumps to achieve similar environmental benefits to natural inundation, using a smaller volume of water. In preparing the business case, several in-depth studies were undertaken for the Burra North management zone, including stakeholder consultation, flora and fauna surveys, hydrologic modelling, preliminary salinity investigation, and European and Aboriginal cultural heritage assessment.

3 HYDROLOGY AND SYSTEM OPERATIONS

Wetland hydrology is the most important determinant in the establishment and maintenance of wetland types and processes. It affects the chemical and physical aspects of the wetland which in turn affects the type of flora and fauna that the wetland supports (DEPI 2005). A wetland's hydrology is determined by surface and groundwater inflows and outflows in addition to precipitation and evapotranspiration (Mitsch and Gosselink, 2000 in DEPI 2005). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands, creeks and rivers.

The target area within Burra Creek is located on the Victorian floodplain of the Murray River (chainage 1294 km to 1322 km) between river gauges Swan Hill (# 409204) and downstream of Wakool Junction (# 414200). Since there are no major tributaries that enter the Murray River between Swan Hill and Burra, the hydrology of Burra Creek can be best described in terms of flow events at Swan Hill.

3.1 Water Management and Delivery

3.1.1 Pre-regulation

Due to natural diversion of high volume flood flows from the Murray River to the Edward-Wakool system, this stretch of the Murray River does not exceed maximum flows of approximately 35,000 ML/d (Ecological Associates 2006). Floods in the order of 30,000 ML/day are often dependent on the occurrence of a series of flood events on the Murray and its tributaries which result in a very large volume of unregulated flow over an extended period that builds to a peak flow after filling the floodplain.

Under un-modified, pre-regulation conditions, Burra Creek would have been completely connected by flows of 20,000 ML/day (Alluvium, Jacobs cited in Ecological Associates 2014). The floodplain of Burra North would have been connected by flows of 27,500 ML/day and completely inundated by flows of 30,000 ML/day.

Prior to river regulation in this reach of the Murray River, the floodplain experienced inundation more frequently and lasted 2-3 times longer (Figure 10):

- Flow events of 20,000ML/d occurred on average 9 years in 10
- The median duration was 143 days
- High flow events of 30,000 ML/d occurred on average 2 years in 10 (Gippel 2014)).

Flows of 20,000 ML/d would have connected Burra Creek 9 out of 10 years and the creek would have stayed inundated longer. The floodplain would have been inundated 2 years in 10.

3.1.2 Post-regulation

In this part of the Murray River, the frequency, duration and magnitude of all but the largest floods have been reduced due to effects of major storages in the Murray River and tributaries (Thoms et al, 2000, p 106). Low flow events of less than 10,000 ML/d now occur for long periods (Ecological Associates 2014).

In comparison to pre-regulation (Figure 10):

- Flow events of 20,000ML/d now occur on average 6 years in 10
- The median duration is 72 days
- High flow events of 30,000 ML/d occur on average 1 year in 10 (Gippel 2014)).

Full connection of the creek under current conditions requires flows similar to the floodplain inundation threshold (27,500 ML/d), therefore both the creek and the floodplain receive natural flows on average

only 1 year in 10. This is due to a combination of river regulation and construction of impediments within the creek.

The seasonal distribution of flows in this section of the Murray River shows that, despite a reduction in discharge, the river retains the same annual pattern of higher flows in winter and spring with lower flows in summer and autumn (Figure 11).

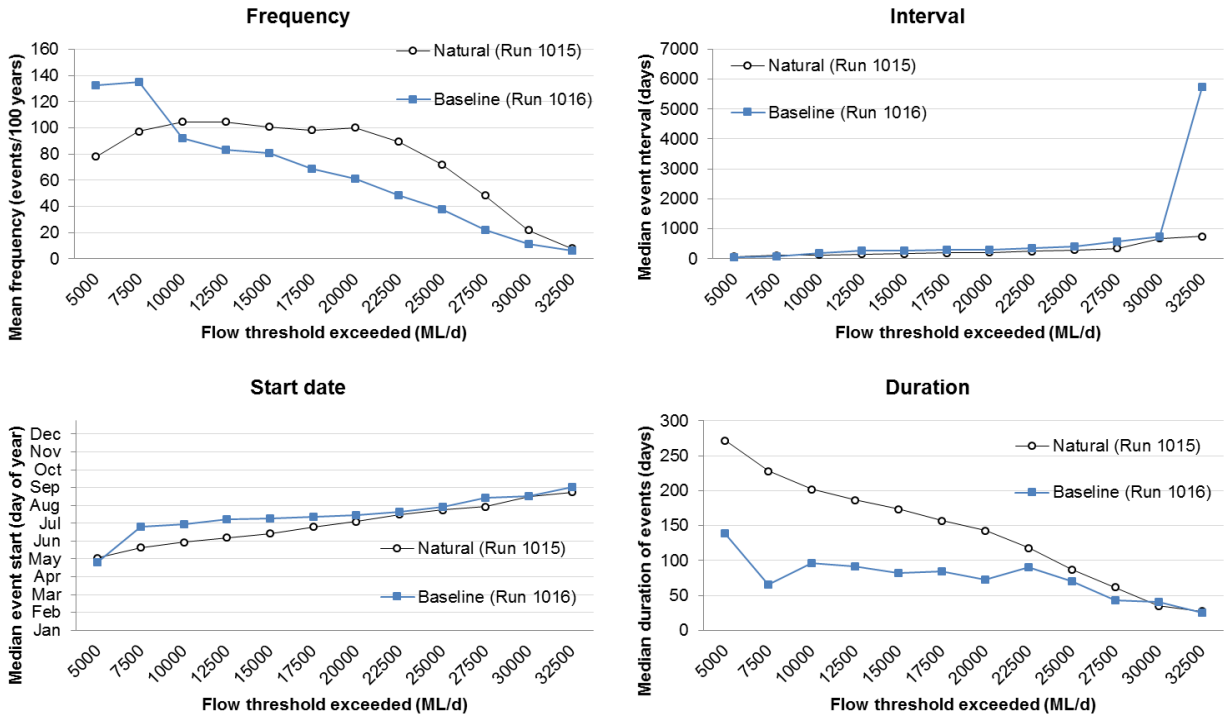

Figure 10 - Comparison of natural (pre-regulation) and Baseline Modelled Flow(Post-regulation) scenarios for Swan Hill (Gippel 2014).

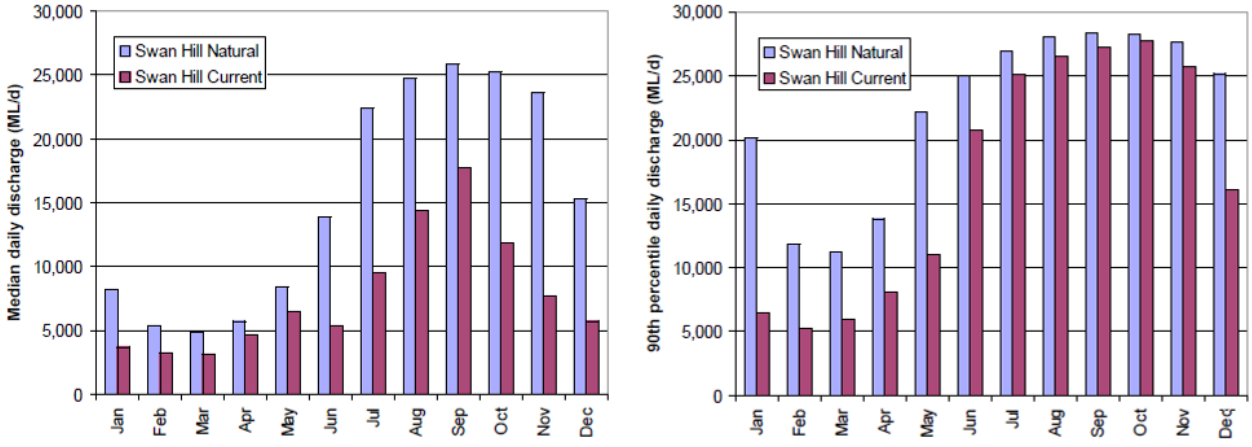

Figure 11 - Distribution of median flows and 90th percentile flows for each month in the Murray River through Burra section for natural and current (benchmark) conditions. Source: derived from MDBC MSM-Bigmod 109-year data (Ecological Associates 2006).

3.1.3 Current Creek and Floodplain Hydrology

Burra Creek South Proper is not hydrologically connected to the Murray River and only receives water when water levels in Burra Creek South are greater than 60 m AHD. Lidar suggests creek bed elevation for Burra Creek South Proper is 60.4 m AHD.

Burra Creek currently has three connection points to the Murray River (EA 2014) with the following commence to flow (CTF rates) (Figure 12):

- Connection Point A: 1294 river km, CTF 17,000 ML/d, 58 m AHD;
- Connection Point B: 1308 river km, CTF 20,000 ML/d, 59 m AHD; and
- Connection Point C: 1319 river km, CTF 22,500 ML/d, 59.9 m AHD.

There is a natural fall in the bed elevation of Burra Creek from approximately 60 m at the southern end to 58 m at the northern end (Figure 11). In several locations impediments are positioned higher than the invert of the creek increasing the threshold for flow-through to 27,500 ML/d (60.5m AHD).

Inundation of Burra North Floodplain commences at flows of 27,500 ML/d (Ecological Associates 2014), with complete inundation occurring at 30,000 ML/d.

The CTF threshold for Burra North Wetland is not known, however it is the first wetland to fill in Burra (Ecological Associates 2006). The wetland and floodplain are mapped at 58m AHD (Figure 12), suggesting the flow threshold for inundation of the floodplain at this location may be in the region of 17,000 ML/d.

3.1.4 Movement of water within Burra Creek

During a natural inundation event, the upstream Connection Point C (Burra Creek South) (Figure 12) is the last to connect at 59.9 m AHD. Part way along the creek from this connection point however, the invert of the creek is closer to 61 m AHD.

The mid-section of the creek receives floodwaters from Connection Point B (Burra Creek South) (Figure 12) via a meandering natural channel connection. Water flows from this location in both directions within the creek.

The lowest point, Connection Point A (Burra Creek North) (Figure 12) receives water first from a natural inundation as water backs up in Burra Creek towards the first impediment.

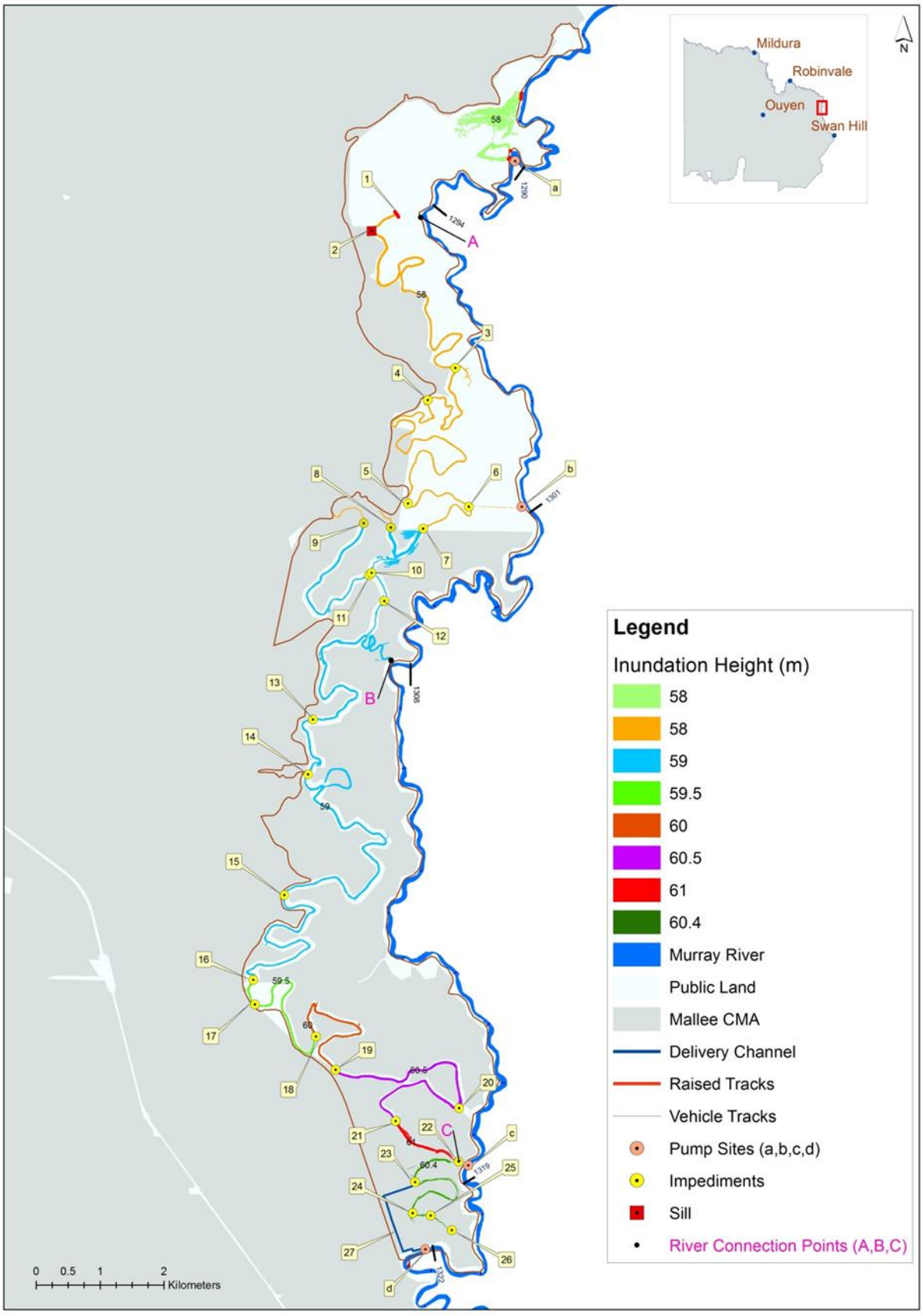

Figure 12 - Burra Creek river connection points and inundation heights, and impediments to flow at Burra.

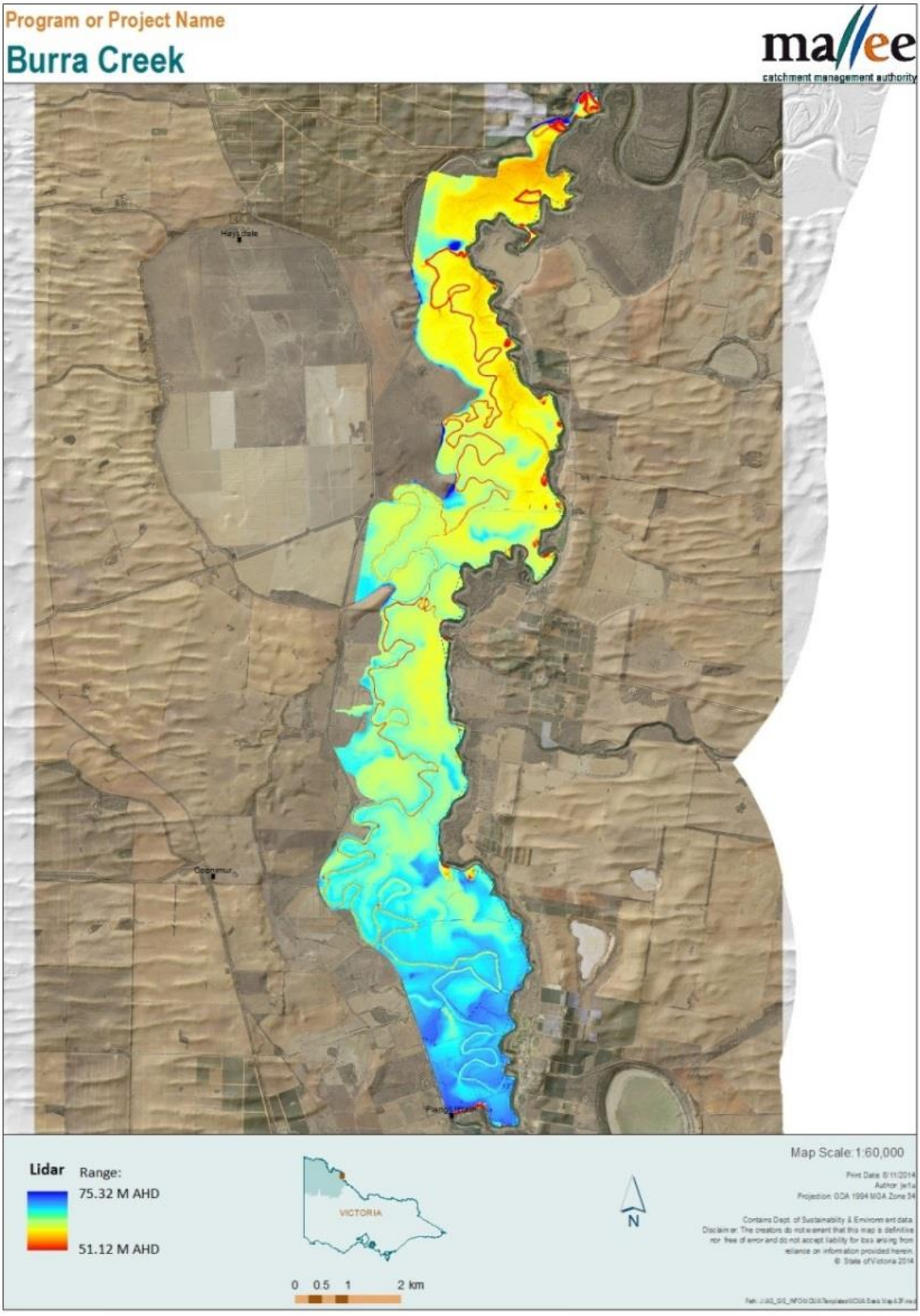

Figure 13 - LiDAR map of Burra

3.1.5 Previous Environmental Watering

Environmental watering at Burra commenced in 2004 as emergency River Red Gum watering. The water for these events was from various sources as outlined in

Table **4**. All management zones have previously received environmental water, except the Burra North Wetland.

Table 4 - A summary of recent environmental watering events in Burra

Water year	Time of inflow	Inflow source	Inundation Zone	Source volume (ML)	Total volume (ML)
2003-04	07 May – 30 Jun	EWA	North	223	223
			South	609	609
2004-05	01 Feb – 30 Jun	Donation	North	228	228
2005-06	Mar – 30 Jun	Donation	North	200	200
			South	600	800
2013-15	28 May- 30 Sept	VEWH CEWH	South	1150	1034.895
2013-15	28 May- 24 Aug	VEWH CEWH	South Proper	50	50
2014-15	7 Apr – 30 May	VEWH	North	400	317
2015-16	6 May – 17 June	VEWH	North	350	277
2016-17	30 July – 4 Dec	Natural inundation	North South	N/A	N/A

The initial purpose of the emergency watering program was to alleviate the impact of prolonged dry conditions that had resulted in a drastic decline in River Red Gum health, among the trees lining the creek. Anecdotal evidence indicated a positive response by the River Red Gums to the watering through increased foliage vigour.

Once the trees began to respond positively to the environmental watering and dry conditions abated, the purpose of the environmental watering changed from emergency response to long term sustainability of the system. Objectives included providing habitat, feeding and breeding opportunities to increase the abundance, distribution and diversity of native wetland species at Burra.

The extent of inundation achieved through the delivery of environmental water at Burra Creek North and South can be increased if further infrastructure were to be put in place. These opportunities for future works are discussed in the Environmental Water Delivery Infrastructure Section.

4 WATER DEPENDENT VALUES

4.1 Environmental Values

Wetlands and waterways on the floodplain support a vast array of flora and fauna. The habitat provided by vegetation communities around wetlands is essential for maintaining populations of water dependent fauna species. Other ecological functions provided by floodplain complexes include water filtration, slowing surface water flow to reduce soil erosion, flood mitigation and reducing nutrient input into waterways. Protecting the ecological functioning of wetlands ensures these vital services are maintained.

4.1.1 Listings and Significance

Fauna

Native species recorded in Burra are listed in Appendix 3. Of special interest and responsibility are the species listed in legislation, agreements or conventions that would benefit from the creek experiencing more frequent inundation (Table 5).

Table 5 – Listed fauna recorded at the site

Scientific name	Common name	Type	International agreements	EPBC status	FFG Status	DEPI status	Hollow Dependent
Ardea modesta	Eastern Great Egret	B	NL	NL	L	V	
*Burhinus grallarius**	Bush Stone-curlew	B	NL	NL	L	EN	
Chelodina expansa	Broad-shelled Turtle	R	NL	NL	L	EN	
Chelodina longicollis	Common Long-necked Turtle	R	NL	NL	NL	DD	
Circus assimilis	Spotted Harrier	B	NL	NL	NL	NT	
Climacteris picumnus	Brown Treecreeper	B	NL	NL	NL	NT	
Diplodactylus tessellatus	Tessellated Gecko	R	NL	NL	NL	NT	
Dromaius novaehollandiae	Emu	B	NL	NL	NL	NT	
Egretta garzetta	Little Egret	B	NL	NL	L	EN	
Geopelia cuneata	Diamond Dove	B	NL	NL	L	NT	
Haliaeetus leucogaster	White-bellied Sea-Eagle	B	CAMBA	L	L	V	

Scientific name	Common name	Type	International agreements	EPBC status	FFG Status	DEPI status	Hollow Dependent
Hieraaetus morphnoides	Little Eagle	B	NL	NL	NL	NT	
*Lophochroa leadbeateri leadbeateri**	Major Mitchell's Cockatoo	B	NL	NL	L	EN	□
Lophoictinia isura	Square-tailed Kite	B	NL	NL	L	V	
*Melanodryas cucullata**	Hooded Robin	B	NL	NL	L	NT	
Merops ornatus	Rainbow Bee-eater	B	JAMBA	Ma, Mi	NL	NL	
Morelia spilota metcalfei	Carpet Python	R	NL	NL	L	EN	□
Nycticorax caledonicus	Nankeen Night Heron	B	NL	NL	NL	NT	
Pogona barbata	Eastern Bearded Dragon	R	NL	NL	NL	V	
Polytelis anthopeplus	Regent Parrot	B	NL	VU	L	V	□
Pomatostomus temporalis	Grey-crowned Babbler	B	NL	NL	L	EN	
Stagonopleura guttata	Diamond Firetail	B	NL	NL	L	V	
Sterna nilotica	Gull-billed Tern	B	NL	NL	L	EN	
Suta suta	Curl Snake	R	NL	NL	NL	V	
Varanus varius	Lace Monitor	R	NL	NL	NL	V	

Legend
Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal
EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed
FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing
DEPI status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

*Species are included as water dependent due to habitat requirements.

The species listed in Table 5 include species that forage or nest in or on water or require flooding to trigger breeding and fledging. The list also includes species that are indirectly dependent on water, i.e. they require riparian trees, vigorous ground cover and fallen timber. In order to provide breeding opportunities, habitat elements in Burra such as temporary wetlands and River Red Gum and Black Box communities must be maintained in good condition.

The diverse freshwater habitats at Burra provide opportunities for foraging birds such as the Little Egret, Eastern Great Egret and Nankeen Night Heron. Environmental watering that promotes aquatic vegetation and a productive ecosystem will support these water dependant species. The Long-necked Turtle and Broad-shelled Turtle should also benefit from a regular watering regime.

The River Red Gum, Black Box and Lignum communities found at Burra also provide a range of habitats for water dependant species. A watering regime that supports the longevity and recruitment of these communities will support many of the listed species in Table 5. Some of these species include the Regent Parrot and Major Mitchell Cockatoo that require large hollow bearing trees and the White-bellied Sea-eagle, Spotted Harrier and Little Eagle that require large healthy trees for nesting.

Species such as Carpet Python and Lace Monitor require dense understorey, ground cover, fallen timber and a readily available source of food, which are all supported by River Red Gum woodlands. Ground foraging species such as the Brown Tree-creeper and Hooded Robin and insectivorous species such as the Grey-crowned Babbler, Tessellated Gecko and Rainbow Bee-eater should also be supported by a productive floodplain.

The protection of Burra North within state forest could have also provided refuge for species such as the Bush Stone Curlew and Brown Tree-creeper that have been affected by habitat clearance and fragmentation.

Burra is a unique and valuable site, as it is partially protected within state forest, is longitudinally connected along the Burra Creek and it also contains a mosaic of wetland and floodplain habitats.

Frogs

Burra supports six species of native frog and although none of these species are listed, this diversity is of significance. Like most flood dependent species, frogs respond to the timing, duration and frequency of flooding, with the timing of inundation being the most significant factor. Aquatic vegetation complexity is important for many frog species, particularly at tadpole stage, and can drive occupancy patterns and recruitment success (Tarr & Babbitt 2002, cited in Rogers & Ralph 2011).

Seasonal inundation of the target area may help to reinstate seasonal emergent and semi-emergent macrophytes. This in turn will improve habitat values within the target area for frogs and other aquatic fauna.

Bats

Various species of insectivorous bats, or microbats, are found in the Mallee region. Eleven species of microbat have been recorded at Burra North (Table 6). Microbats are important in ecological processes such as seed dispersal and pollination (Medellin et al. 2000). In fact, Medellin and Gaona (1999, cited in Medellin et al. 2000) found that bats disperse more seeds than birds in every step of the disturbance gradient. Bats can also be useful as indicators of environmental change as they are diverse and abundant, occupy many trophic levels and have specialised diets and specific roosting and foraging habitats. Medellin (2000) suggests they can be a better indicator of ecological integrity than a group that occupies a single trophic level, such as vegetation or top order predators. Medellin (2000) also found that increased species diversity and abundance are indicators of undisturbed, or healthy habitats.

Table 6 - List of bat species recorded at Burra North

Species	Scientific Name	Roost in Hollows?	Foraging Zones
Chalinolobus gouldii	Gould's Wattled Bat	✓	Below canopy, along edges of forests
Chalinolobus morio	Chocolate Wattled Bat	✓	Mostly between top of understorey and canopy
Mormopterus sp. (sp. 2)	Eastern Freetail Bat	✓	Above canopy
Mormopterus sp. (sp. 4)	Southern Freetail Bat	✓	Ground, between trees and above canopy.
Nyctophilus geoffroyi	Lesser Long-Eared Bat	✓ or under peeling bark	Ground, foliage and mid-air
Nyctophilus gouldi	Gould's Long-Eared Bat	✓ or under bark (DECC 2007)	Not known
Scotorepens balstoni	Inland Broad-Nosed Bat	✓	Up to 15 m above ground, but not above tree canopy
Tadarida australis	White-Striped Freetail Bat	In trees	Ground and above canopy.
Vespadelus darlingtoni	Large Forest Bat	✓	Between tree canopy and understorey
Vespadelus regulus	Southern Forest Bat	✓	Close to vegetation and understorey
Vespadelus vulturnus	Little Forest Bat	✓	Close to vegetation, upper levels, 3-8 m above ground, always below the canopy

(Ecological Associates 2014 (Species Records); Mid Murray LAP [n.d.] (Roosting & foraging data))

All the species of microbats recorded in the study area are insectivorous and roost in tree hollows, under peeling bark, or in the tree canopy. Such species diversity is a good indicator of a productive environment, particularly given the broad range of foraging preferences. Microbats commonly use Red Gum and Black Box Woodlands and roost in these hollow-bearing trees. It is expected that the health of the extensive River Red Gum and Black Box communities inundated through delivery of environmental water would improve, and microbat presence and diversity may be used as an indicator to measure this.

Vegetation communities

Within the target area, the most extensive Ecological Vegetation Community (EVC) is Lignum Swampy Woodland, the creek itself is identified as having a riparian zone of Lignum Swamp. Eleven water dependent EVCs are identified within the target area, these are listed in Table 7.

For a full list of EVCs within Burra and details on each see Appendix 4. The EVCs within the target area and their conservation status can be seen in Figure 14.

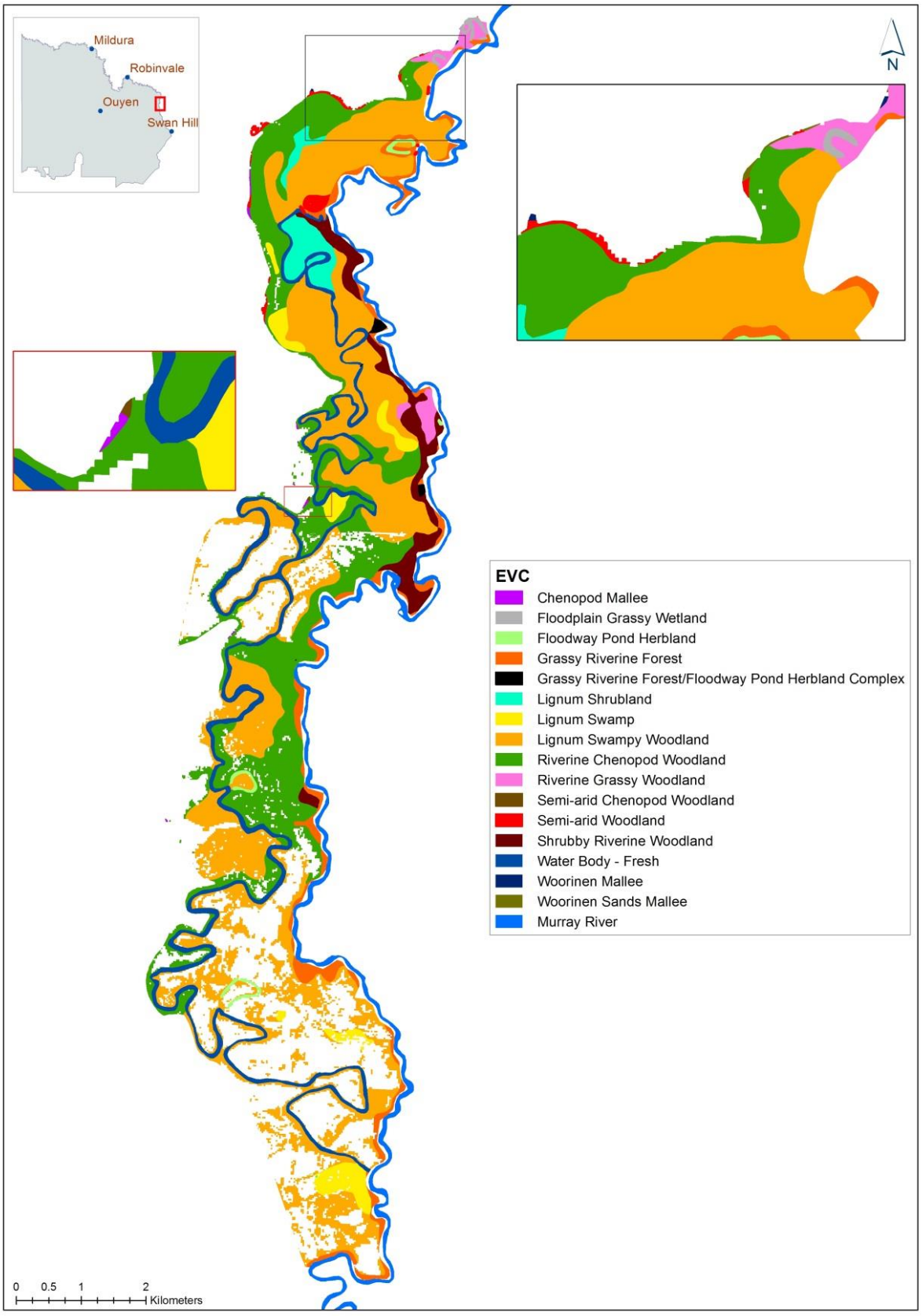

Figure 14 - EVCs within the target area of Burra

Table 7 - Bioregional conservation status of water dependent EVCs in the target area

EVC no.	EVC name	Bioregional Conservation Status Murray Fans Bioregion	Structurally dominant species
103	Riverine Chenopod Woodland	Endangered	Black Box
104	Lignum Swamp	Vulnerable	Lignum
106	Grassy Riverine Forest	Depleted	River Red Gum
295	Riverine Grassy Woodland	Vulnerable (Terrestrial BCS)	Either or both River Red Gum and Black Box (but dominated by River Red Gum at this site)
808	Lignum Shrubland	Vulnerable	Lignum
810	Floodway Pond Herbland	Depleted	Sedges, rushes, grasses and low herbs
811	Grassy Riverine Forest/Floodway Pond Herbland Complex	Vulnerable	River Red Gum
818	Shrubby Riverine Woodland	Least Concern (Terrestrial BCS)	Either or both River Red Gum and Black Box (but dominated by River Red Gum at this site)
823	Lignum Swampy Woodland	Vulnerable	Co-dominate species Lignum, River Red Gum and Black Box.
97	Semi-arid Woodland	Vulnerable (Terrestrial)	Belah (Casuarina pauper)
98	Semi-arid Chenopod Woodland	Endangered (Terrestrial)	Belah (Casuarina pauper)

Note: The bioregional conservation status (BCS) of the wetland EVCs in this plan are based on expert advice but have not yet been formally approved by DEPI. In the case of Riverine Grassy Woodland and Shrubby Riverine Woodland, no preliminary wetland BCS has been advised, consequently the terrestrial BCS has been applied.

Burra North Wetland consists of Floodway Pond Herbland and its surrounding floodplain is Grassy Riverine Forest and Lignum Swampy Woodland.

All of the EVCs listed in Table 7 are mapped in Burra North, which has one of the best-preserved floodplain woodland and shrubland communities in the western Murray Fans bioregion (Ecological Associates 2014).

Two EVCs present that are not water dependent are relevant to this plan:

- Semi-arid Chenopod Woodland occurs alongside Burra Creek, near Impediment Site 5. At this location, the eastern bank of the creek is formed by a sand dune, which is likely to be of very high Aboriginal Cultural Heritage significance. It is subject to disturbance by recreational motorbikes (Figure 15), with several tracks crossing both the dune and the creek bed.
- Semi-arid Woodland occurs adjacent to Burra Creek at Impediment Site 1 (where road raising has been conducted to retain water within the creek).

Figure 15 - An area of semi-arid woodland on a sand dune adjacent to the creek (Deadmans Hill). The creek bed is shown in the foreground. Erosion and loss of native vegetation on Deadmans Hill from motorbike activity is notable.

These EVCs are positioned high in the landscape, but may encroach onto the creek line over time. As such, these locations should be monitored during delivery of environmental water to ensure significant terrestrial flora is not inundated for prolonged periods.

The most commonly occurring EVCs adjacent to the creek are:

- Lignum Swampy Woodland;
- Riverine Chenopod Woodland;
- Lignum Swamp; and

- Lignum Shrubland.

Black Box is the dominant tree species in the Riverine Chenopod Woodland EVC that is found on the higher elevations of Burra North and Burra South.

Black Box is co-dominant with River Red Gum in the Riverine Grassy Woodland and Shrubby Riverine Woodland EVCs found adjacent to the Murray River in Burra North and Burra South, and surrounding Major Mitchell Lagoon and wetland 7428 665317.

Tangled Lignum is the dominant species in the Lignum Swamp EVC, mapped in small areas across Burra, and the Lignum Shrubland EVC on the floodplain within Burra North.

Lignum is also co-dominant with Black Box and River Red Gum in the Lignum Swampy Woodland EVC recorded throughout Burra. Illustrating the commonality of overstorey comprised of Red Gum and Black Box and/or mid storey of Lignum, with a diversity of other flora species occurring across the target area.

Tangled Lignum is considered to be the most significant floodplain shrub in mainland Australia due to its extensive distribution, local dominance and value as habitat (Roberts & Marston 2011). Lignum occurs in many EVCs across Burra and, combined with other understorey species offers shelter for a range of birdlife, nesting sites for smaller birds, and cover for frogs, mammals and reptiles.

River Red Gums are the most widespread eucalypt tree in Australia, occupying riparian habitats along water courses and wetlands (Roberts & Marston 2011). They provide extensive habitat for a range of waterbirds and other fauna such as the listed Regent Parrot, which use these trees for nesting. However, trees in poor condition have little contribution to the function and productivity of the ecosystem and the quality of woodland habitat is greatly reduced (Roberts & Marston 2011). Healthy River Red Gums contribute to the wetland ecosystem by depositing organic material, and submerged fallen trees provide structural habitat features (Roberts & Marston 2011) for wetland fauna such as perching sites for waterbirds, basking sites for turtles and snags for fish (Ecological Associates 2007b).

Black Box provides essential habitat and foraging opportunities for a range of species including mammals and reptiles and supports a high proportion of ground foraging and hollow-nesting species, such as Carpet Python, microbats, and the Regent Parrot. Healthy Black Box helps provide important vegetative corridors to other areas above the floodplain for a range of transient native fauna. Black Box can tolerate a range of conditions from wet to dry (Roberts & Marston 2011), however, under extended periods of dry conditions trees will suffer a decline in health and eventually death (Ecological Associates 2007a).

Flora

A full list of flora recorded at the Burra Creek site can be found in Appendix 3. Water dependent flora species listed in the various acts and agreements which have been recorded in Burra are listed in Table 8.

Dwarf Flat-sedge (*Cyperus pygmaeus*) and Yelka (*Cyperus victoriensis*) are two listed water dependent sedges recorded at Burra Creek. *Cyperus* spp. have differing water regimes, however generally prefer fluctuating water levels, from drying to seasonally inundated during spring and summer (Rogers & Ralph 2011).

Table 8 - Listed flora species recorded at the site

Scientific name	Common name	EPBC status	FFG status	DEPI status	Water Dependent
Acacia Oswaldii	Umbrella Wattle	NL	NL	VU	
Amaranthus macrocarpus var. macrocarpus	Dwarf Amaranth	NL	NL	VU	✓
Asperula gemella	Twin-leaf Bedstraw	NL	NL	R	
Atriplex pseudocampanulata	Mealy Saltbush	NL	NL	R	
Atriplex rhagodioides	Silver Saltbush	NL	L	VU	
Centipeda nidiformis	Cotton Sneezeweed	NL	NL	R	
Chenopodium desertorum subsp. desertorum	Frosted Goosefoot	NL	NL	R	
Cullen pallidum	Wooly Scurf-pea	NL	L	EN	
Cynodon dactylon var. pulchellus	Native Couch	NL	NL	K	
Cyperus pygmaeus	Dwarf Flat-sedge	NL	NL	VU	✓
Cyperus victoriensis	Yelka	NL	NL	K	✓
Eremophila divaricata subsp. divaricata	Spreading Emu-bush	NL	NL	R	
Geijera parviflora	Wilga	NL	L	EN	
Pimelea flava subsp. dictoma	Diosma Rice-flower	NL	NL	R	
Sida intricata	Twiggy Sida	NL	NL	VU	
Senecio cunninghamii subsp. cunninghamii	Branching Groundsel	NL	NL	R	
Swainsona swainsonioides	Downy Swainson-pea	NL	L	EN	
Triglochin dubium	Slender Water-ribbons	NL	NL	R	✓
Vittadinia cuneata var. morrisii	Fuzzy New Holland Daisy	NL	NL	R	

EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed
FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing
DEPI status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

Acacia stenophylla (A.Cunn. ex Benth) or commonly known as River Coomba or Eumong is commonly found at Burra. It is often found in amongst River Red Gum and Black Box communities, along watercourses and floodplains. This species provides valuable habitat for bird and insect species. It provides pollen, nectar and seed. It also has a symbiotic relationship with a nitrogen fixing rhizobia improving surrounding soil fertility by fixing nitrogen. A water regime that supports River Red Gum and Black Box Communities should also support this valuable species, as its tolerant of waterlogged and period flooding.

Several emergent and semi-emergent macrophytes are also recorded at Burra Creek, including:

- Marsh Club-rush (*Bolboschoenus medianus*)
- Nardoo (*Marsilea drummondii*)
- Gold Rush (*Juncus flavidus*)
- Spiny Mud-grass (*Pseudoraphis spinescens*)

Aquatic and emergent macrophytes are particularly important as they support frog, fish and turtle species by providing food, shelter and spawning habitat.

Aquatic macrophytes are rooted to the wetland floor with their canopies floating near the water surface. They rise and fall with water levels and provide a physical structure to the aquatic environment as well as providing a food source for waterbirds and habitat for fish and macro invertebrates (Ecological Associates 2007). Aquatic macrophytes are highly productive wetland habitats providing shelter for macro-invertebrates, and frogs, turtles and small-bodied fish that graze on this vegetation and the macro-invertebrates within it (Ecological Associates 2007). Aquatic macrophytes are dependent on water for growth and reproduction. Promotion of semi-emergent macrophytes can be managed with inundation at a depth up to a metre, with duration of one to twelve months. Events should occur with a minimum frequency of every two years (Ecological Associates, 2007) and an ideal frequency of every 9-12 months. They may persist in wetlands that are frequently flooded but if summer drying occurs they will die off and be replaced by lake bed herbs (Ecological Associates 2007).

Emergent macrophytes are often found on the perimeter of ephemeral or seasonally inundated waterways and can provide essential habitat for frogs and foraging opportunities for waterbirds. During flooding, native fish will also utilise reed beds and semi-emergent vegetation where they feed on macro-invertebrates and shelter from predators (Ecological Associates 2007b). Emergent macrophytes require annual flooding of approximately 6-12 months depending on species. The return of an inundation cycle more closely mimicking natural conditions may encourage a diversity of species requiring differing water regimes.

4.1.2 Wetland Depletion and Rarity

Victoria's wetlands are currently mapped and are contained within a state wetland database, using an accepted statewide wetland classification system, developed by Andrew Corrick from the Arthur Rylah Institute. Mapping was undertaken from 1981 using 1:25,000 colour aerial photographs, along with field checking. This database is commonly known as the 1994 wetland layer and contains the following information:

- categories (primary) based on water regime and
- subcategories based on dominant vegetation

None of the post-1994 wetland mapping is contained within this State wetland database.

At the same time, an attempt was made to categorise and map wetland areas occupied prior to European settlement. This was largely interpretive work and uses only the primary category, based on water regime. This is known as the 1788 layer.

It has been possible to determine the depletion of wetland types across the state using the primary category only, based on a comparison of wetland extent between the 1788 and 1994 wetland layers.

Comparison between the wetland layers has demonstrated the impact of European settlement and development on Victorian wetlands. This has been severe, with approximately one-third of the state's wetlands being lost since European settlement; many of those remaining are threatened by continuing degradation from salinity, drainage and agricultural practices (ANCA, 1996).

Burra contains six wetlands, which have been classified using the Corrick-Norman wetland classification system, as Deep Freshwater Marsh and Shallow Freshwater Marsh (Table 9). Burra North Wetland is the only wetland proposed to be inundated in this EWMP.

Based on a comparison of the geospatial wetland layers (1788 and 1994), Deep Freshwater Marshes are the most depleted (-70% change) type of wetland in Victoria, second most (-45% change) in the Mallee CMA region and second most (-37% change) in the Robinvale Plains Bioregion. This makes Burra North Wetland, which is a Deep Freshwater Marsh, significant in the Mallee region.

Table 9 - Changes in area of the wetlands in the target area by Corrick classification

Category	No of Wetlands in target area	Total area (ha)	Decrease in wetland area from 1788 to 1994		
			% Change in area in Victoria	% Change in area in Mallee CMA	% Change in Murray Fans
Deep freshwater marsh	5	17.99	-70	-45	-6
Shallow freshwater marsh	1	5.19	-60	-6	-10

Source: DEPI Biodiversity interactive maps, Mallee Wetland Strategy

4.1.3 Ecosystem Functions

A healthy ecosystem at Burra has the potential to support distinctive communities of plants and animals and provide numerous ecosystem services. These ecosystems can perform important functions necessary to maintain the hydrological, physical and ecological health of the river systems and floodplain. Connectivity with the Murray River enables these ecosystem functions to include:

- providing a conduit for the movement of native fish from the main river channel to the floodplain;
- providing extended foraging, breeding and basking opportunities for native frogs and turtles;
- absorbing and releasing floodwaters;
- in-stream primary production;
- providing organic material to rivers to maintain riverine food chains; and
- providing feeding, breeding and drought refuge sites for flora and fauna, especially waterbirds, frogs and fish.

Altered water regimes in the target area due to river regulation, construction of at least 26 impediments to flow, and extended dry conditions have seen a decrease in the frequency and extent of inundation in these floodplain wetlands and creek and therefore a decrease in the ability for the creek and wetlands to perform these valuable ecosystem functions.

4.2 Social

4.2.1 Cultural Value

The Mallee has been occupied for thousands of generations by Indigenous people with human activity dated as far back as 23,400 years ago. The region's rich and diverse Indigenous heritage has been formed through the historical and spiritual significance of sites associated with this habitation; together with the strong connection Traditional Owners continue to have with the Mallee's natural landscapes.

Given the semi-arid climate of the region, ready access to more permanent water has been a major determinant of human habitation, and as such the highest density of identified Indigenous Cultural Heritage sites are located around or close to areas of freshwater sources.

Within the Mallee CMA region, the Murray River and its associated waterways were important habitation areas for multiple Aboriginal groups, containing many places of spiritual significance. The high number of Indigenous Cultural Heritage sites throughout the Murray floodplain is unique in Victoria, for both concentration and diversity. They include large numbers of burial, middens and hunting sites.

In the south of the region, waterways were focal points for the region's Traditional Owners, with many lakes being the site for large gatherings of several social clan groups that afforded trade and cultural exchanges.

Waterways also play a large role in the region's more recent non-Indigenous heritage due to the historical infrastructure (e.g. buildings, irrigation and river navigation structures) they often contain. These places provide links to early industries and settlements and play a key part in the region's identity.

4.2.2 Cultural Heritage

Burra Creek is of significant cultural value to Indigenous and non-Indigenous people, with the area popular for fishing, camping, hunting, and as a meeting place.

In regard to Indigenous cultural values, some cultural sites have been documented through various archaeological investigations, but the true extent of the number and types of sites present is still unknown.

One survey notes at least one scarred tree, but the potential for other sites is high and may include hearths, middens and artefact scatters. The close proximity of two dunes suggests a high likelihood of additional Aboriginal artefacts being present.

The area is documented by Tindale (cited in Bell 2013, p.14) as being occupied by the Wadi Wadi language group. The dialect of the Wadi Wadi was referred to by the Wemba Wemba language group as 'Burrea' (Tindale, cited in Bell 2013, p.14), which is possibly where the name Burra Creek originated (Bell 2013, p.14). Several early European records exist of different language groups within the area (Clark, cited in Bell 2013, p.14). Aboriginal people had a strong connection to the area and made use of the natural resources within the forest for bush medicine, basket weaving and other cultural activities.

Aboriginal people continue to have a connection to this country. The Wadi Wadi people are part of the Native Title Claim over the area. The Robinvale Aboriginal community continue to value this country through traditional laws and customs.

European heritage reflects the pioneering history of the area. Burra was part of the Burra Burra pastoral lease between circa 1848 and 1880. A parish plan dating to 1929 identified the state forest within Burra North. This early designation as state forest has retained much of the natural landscape within Burra North, and makes the area popular for bird watching and water related activities such as camping, fishing, barbequing and picnics.

4.2.3 Recreation

The region is popular for swimming, camping, fishing, boating, four wheel driving, picnics, barbeques and walking and these uses will continue in the River Murray Reserve.

4.3 Economic

Burra has been used for grazing, irrigation and stock and domestic water supply in the past. Burra North has been gazetted as River Murray Reserve and Burra South remains as private land used for grazing and a number of residential sites. Sections of the creek are used for storage of irrigation water.

One of the landholders in Burra Creek South Proper has expressed a desire to place a covenant on the property title to conserve the environmental values in perpetuity.

4.4 Significance

Burra is able to support a rich diversity of flora and fauna. Native vegetation is present along the entire length of Burra Creek. The iconic River Red Gum and Black Box provide essential habitat to a range of species, including the Major Mitchell Cockatoo, Regent Parrot and microbat species.

Burra Creek provides potential for refuge and/or extended breeding and foraging areas for native fauna species including fish, waterbirds, frogs and turtles. The large number of high sills and small culverts may assist in providing refuge, with pools acting like scour holes if water can be maintained within some sections.

Macredie Island in Burra North contains diverse and well preserved floodplain vegetation, offering habitat, feeding and foraging opportunities for terrestrial fauna including the Carpet Python, Lace Monitor, and many species of ground-foraging woodland birds, such as the Grey-crowned Babbler. Burra North is believed to have one of the best-preserved floodplain woodland and shrubland communities in the western Murray Fans bioregion, making it particularly significant. The large number of bat species recorded is a good indication of floodplain productivity.

The cultural importance of this site is considered very significant as one scarred tree is recorded, and the likelihood of additional cultural heritage sites is high. European history dates back to the mid-nineteenth century, which also documents Aboriginal cultural ties to the area. The declaration of the Piambie State Forest early last century and its long history of human visitation make Burra North significant to the local communities. The interaction between agriculture, residential zones and the natural environment of the creek create a striking landscape.

The values contained within Burra and specifically the target area for this plan makes this area a priority for protection and enhancement through environmental water management. Of particular significance is the potential to encourage seasonal aquatic vegetation as habitat and for frogs, fish and turtles. Equally significant are the River Red Gum, Black Box and Lignum communities. These vegetation groups form the basis for the functioning ecological system and are the primary focus of this plan.

5 ECOLOGICAL CONDITION AND THREATS

5.1 Current Condition

5.1.1 Burra Creek

In 2010, Burra Creek North and Burra Creek South were assessed using the Index of Stream Condition (ISC) assessment methodology. Burra Creek South Proper was not assessed. The score for both North and South was 22, which is considered poor (Table 10).

Further information on the ISC scoring is provided in the Mallee CMA Regional Context Document (Sunraysia Environmental 2013).

Table 10 - ISC sub index and overall score for Burra Creek North and Burra Creek South

ISC sub index	Reach #19 (Burra Creek North)		Reach #18 (Burra Creek South)	
	Score /20	Category	Score /20	Category
Streamside Zone	7		7	
Physical form	7		7	
Hydrology	2		2	
Water quality	Not assessed		Not assessed	
Aquatic Life	Not assessed		Not assessed	
Overall ISC score	22	Poor	22	Poor

There are 26 impediments to water flow and movement of fauna within Burra Creek. Some of these impediments may be redundant. Images of several impediments are provided Appendix 1. The impediments within Burra Creek include:

- private and public roads and stock crossings constructed across the creek bed, with ~600-1500 mm pipe culverts allowing some passage of water;
- crossings for irrigation pipes and channels;
- levees constructed across the creek bed to dam natural water flow, enabling pumping of irrigation water;
- levees constructed across the creek to form a dam for water to be pumped into and held for irrigation;
- levees constructed across the creek to contain irrigation drainage water; and
- levees constructed across the creek and narrow cuttings constructed around the blockage.

In several locations within Burra Creek South, levees have been constructed on the floodplain, presumably to protect private land from inundation when the creek is flooded. This, however, limits rainfall runoff to the creek, reducing the volume of water that would naturally enter the creek system.

The altered water regime and large number of flow impediments are the two major threats for the target area of Burra. This plan aims to address these threats.

5.1.2 Wetlands

The condition of two of the six wetlands at Burra was assessed in 2010 using the Index of Wetland Condition (IWC) method. Further information on the IWC scoring is provided in the Mallee CMA Regional Context Document (2014).

Wetlands in the target area have not been assessed using the IWC method, however the overall IWC score for the two assessed wetlands was considered to be moderate and it is worth noting given the proximity of these wetlands to the target area (Table 11).

Table 11 - IWC sub index and overall score for two wetlands in Burra

IWC sub index	Macredie Island Wetland		Major Mitchell Lagoon	
	Score /20	Category	Score /20	Category
Wetland catchment	20	Excellent	16	Good
Physical form	20	Excellent	20	Excellent
Hydrology	0	Very Poor	0	Very Poor
Water properties	17	Good	17	Good
Soils	17	Good	20	Excellent
Biota	10	Poor	8	Very Poor
Overall IWC score	6	Moderate	5	Moderate

Although IWC assessments have not been conducted for the remaining four wetlands in Burra, Burra South Wetland and Burra Creek Wetland are hydrologically connected to Burra Creek and are likely to be in a similar condition to that of the creek itself.

It is suggested that Burra North Wetland may be in reasonable health due to its more frequent inundation.

5.2 Condition Trajectory

A natural flood event through the entire length of the creek is difficult to achieve. This reduces the volume and frequency of water available to the vegetation along the creek banks in all but the highest flood events.

Burra Creek could provide refuge, habitat, and breeding and foraging sites for native aquatic fauna, however due to the current threats these ecosystem functions are unlikely to be met. Movement of fish and turtles into the system is limited due to the impediments meaning that recruitment will be limited and the long term populations likely to decline. Without improvements to flow frequency and extent, the health of the ecosystem of Burra Creek is likely to suffer.

5.3 Water Related Threats

The values for the target area of Burra are described in section 4. Threats to these values are the result of such factors as human intervention and climate variability. Some of the threats which may have an impact on Burra include:

- Changed water regime and reduced flow capacity
- Degraded buffers
- Livestock access
- Reduced vegetation width
- Loss or reduction of wetland and creek connectivity
- Loss of instream habitat
- Water quality
- Introduction/increase of exotic aquatic and terrestrial flora and fauna (Mallee CMA 2014)

The regulation of the Murray River and man-made impediments along the creek has seen the water regime through Burra Creek significantly altered. Flow events of the magnitude required to reach the creek, wetlands and floodplain are less frequent and of shorter duration (Gippel 2014). This combined with dry conditions over the last decade has affected vegetation health, productivity and functioning of the floodplain ecosystem, and the capacity of water rich in organic matter to be returned to the river.

Agricultural and associated weeds are an ongoing threat and management issue along the Murray River floodplain. These may pose a threat when water is applied.

Stock access to watering points through the riparian zone of the Burra Creek may impact water quality, via erosion and sedimentation. Stock also convey weeds and limit native vegetation regeneration.

6 MANAGEMENT OBJECTIVE

6.1 Management Goal

The overall goal proposed for the target area at Burra is:

To provide a flow regime that more closely reflects natural events, thus improving the capacity of the target area to provide a productive ecosystem for native flora and fauna.

6.2 Ecological Objectives

Ecological objectives represent the desired ecological outcomes of the site based on the management goal and the key environmental values identified for the site. The ecological objectives are expressed as the target condition or functionality for each key value.

As with any healthy wetland ecosystem, ecological outcomes are interrelated. The objectives outlined in Table 12 will contribute to ecosystem productivity and improve the overall health of the system. The ecological objectives at this site are centred on improving the health of Lignum, Black Box and River Red Gum communities fringing the waterways, on improving aquatic macrophyte diversity and abundance and reinstating seasonal connectivity.

Lignum, Black Box and River Red Gum are keystone species and their health is essential to maintaining a functioning floodplain and river system. They provide breeding and feeding habitat for floodplain fauna, particularly waterbirds and hollow-dependent species such as the Regent Parrot.

Table 12 - Ecological objectives for Burra Creek

Ecological objective	Justification (value based)
Improve vegetation health and structure in the fringing Lignum, Black Box and Red Gum	A healthy vegetation structure includes diversity of species and age classes. The vegetation lining the creek is in poor condition structurally, with old trees in varying degrees of health lining much of the creek. It is important to continue to improve this condition and to assist recruitment of the keystone species: River Red Gum; Black Box; and Lignum. In turn, a healthy vegetation structure may provide important habitat and refuge for terrestrial and aerial fauna such as the hollow dependent Regent Parrot and microbat populations. Wetland productivity may be improved through deposition of organic matter from all vegetation life forms present, enhancing carbon cycling and promoting frog activity.
Promotion of seasonal emergent and semi-emergent macrophytes	Burra has a rich native frog diversity and suitable frog habitat should be encouraged to help preserve this diversity. Seasonal aquatic habitat can be promoted through delivery of environmental water timed to promote growth of instream, semi-emergent and emergent macrophytes. This may also improve habitat values for aquatic macro invertebrates, native fish, turtles and waterbirds. Connectivity between the creek and the river may provide a greater range of feeding, breeding and spawning and nursery habitat thus encouraging native aquatic fauna from the main river channel.
Reinstate seasonal connectivity along Burra Creek, wetlands and the floodplain in the target area	Connectivity between wetlands and to rivers is important for flow, water quality and energy and nutrient dynamics. Connectivity also facilitates breeding, maintenance, diversity and movement of aquatic plant and animal populations. This connectivity will also be important for movement of native fish, frogs and turtles between wetlands and the river (Amezaga, Santamaria and Green, 2001; MDBC, 2001)

The ecological objectives focus on wetland health and ecological vegetation communities with the dominant species of Lignum, Black Box and River Red Gum, representing the ecological communities that meet habitat and feeding requirements of many of the fauna species present in the target area. Many of the listed flora species found in the target area occur in EVC's dominated by these species. Attainment of the ecological objectives is anticipated to have wider benefits for the target area and is expected to result in:

- Improving understorey productivity;
- Improving floodplain productivity;
- Reinstating seasonal aquatic habitat to Burra Creek including submerged and semi emergent aquatic macrophytes;
- Improving nesting opportunities for waterbirds and the Regent Parrot in flooded trees lining Burra Creek and the wetlands;
- Providing structural habitat for native fish, frogs and turtles; and
- Providing a refuge for turtles, frogs and large fish species.

In addition to the opportunity to maintain vegetation health and diversity, inundation of Burra North Wetland offers additional foraging sites for waterbirds and additional feeding and breeding sites for native aquatic fauna.

As more is learnt about the area and the response to the watering events are monitored the principles of adaptive management along with availability of environmental water sources will guide future requirements and management actions at this and other environmental watering sites.

6.3 Hydrological Objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives at this site. Hydrological objectives are described under two scenarios (Table 13), these are:

- without proposed infrastructure; and
- with proposed infrastructure. (Table 13).

Details of the proposed infrastructure are provided in the Environmental Water Delivery Infrastructure section.

Seasonal emergent and semi-emergent macrophytes occur within the creek line and Burra North Wetland. The watering regime can vary depending on species; however annual inundation may encourage germination, vegetative growth and/or reproduction (Rogers & Ralph 2011). Durations of six to twelve months are required to sustain vigorous growth. Following natural seasonality is encouraged.

River Red Gum is the dominant species in four of the ten water dependent EVCs within the target area. River Red Gum fringe Burra Creek and Burra North Wetland. River Red Gum Woodlands require flooding every two to four years with durations of two to four months. Flood events may differ and a variance in ponding duration around the mean requirement for this species is encouraged. Although the timing of flooding is not vital for River Red Gum, spring-summer flooding encourages greater growth. Timing is important for understorey plant communities. The critical interval for Red Gum Woodlands is five to seven years to prevent deterioration of tree condition (Roberts & Marston 2011).

Black Box occurs in four of the ten water dependent EVCs within the target area. They occur on higher levels of the floodplain and require flooding to occur every three to seven years with durations of two to six months. This species can tolerate shorter flood durations but plant vigour will suffer. Although timing of flood events is not crucial for Black Box it will affect understorey and other woodland biota. Black Box trees may survive prolonged periods of 12 to 16 years with no flooding but

tree health will suffer and woodlands will become dysfunctional (Roberts & Marston 2011). Lignum is a dominant species in three of the ten water dependent EVCs within the target area, often on higher elevations of the floodplain and above the creek line. Lignum can tolerate a wide range of wet and dry conditions as well as moderate salinity levels. Flood requirements vary with frequencies of one to three years needed to maintain large shrubs with vigorous canopy, and flooding every three to five years for maintenance of healthy shrubs. Intervals of seven to ten years can be tolerated by small shrubs but growth will decline and these plants may not accommodate nesting by birds compared with shrubs that receive a more regular watering cycle. Durations of three to seven months is required to sustain vigorous canopy, but continuous flooding is detrimental. Although timing of flooding is not crucial for Lignum, following natural seasonality is encouraged to provide for understorey and wetland plants (Roberts & Marston 2011).

These water requirements have been used as a guide to develop the hydrological objectives for the target area.

Table 13 - Hydrological objectives for Burra target area

Ecological Objective		Water Management Area	Hydrological Objectives										
			Mean frequency of events (number per 10 years)			Tolerable interval between events (years)		Duration of ponding (months)			Preferred timing of inflows	Target Supply level (m)	Average Total Volume[1] per Event (ML)
			Min	Opt	Max	Min	Max	Min	Opt	Max			
Without proposed infrastructure	Promote seasonal emergent and semi-emergent macrophytes	Burra Creek – South Proper, South and North	6	9	10	1	3	1	3	3	Spring/Summer	~1.5 m	600
	Improve fringing terrestrial vegetation health and structure (River Red Gum)		2	3	5	2	7	2	3	4	Spring/Summer	~1.5 m	700
With proposed infrastructure	Improve terrestrial vegetation health and structure (Box/Lignum)	Burra Creek North and South Floodplain	1	1	3	3	10	1	1	3	Spring/Summer	~0.5 m	474
	Promote seasonal emergent and semi-emergent macrophytes	Burra North Wetland & Floodplain	6	9	10	1	3	1	3	3	Spring/Summer	~2 m	150
	Improve fringing terrestrial vegetation health and structure (River Red Gum)		2	3	5	2	7	2	3	4	Spring/Summer	~2.5 m (wetland)	175
	Improve terrestrial vegetation health and structure (Box/Lignum)		1	1	3	3	10	1	1	3	Spring/Summer	~0.5 m (Floodplain)	200

Ecological Objective		Water Management Area	Hydrological Objectives										
			Mean frequency of events (number per 10 years)			Tolerable interval between events (years)		Duration of ponding (months)			Preferred timing of inflows	Target Supply level (m)	Average Total Volume[1] per Event (ML)
			Min	Opt	Max	Min	Max	Min	Opt	Max			
	Reinstate seasonal connectivity along Burra Creek, wetlands and the floodplain in the target area	Objective met by other hydrological objectives											

1 Estimate based on filling from empty to the target supply level (TSL), assuming no inflows. Due to the inter-annual variability of these estimates (particularly climatic conditions), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned.

6.3.1 Watering Regime

The optimal wetland watering regime has been derived from the ecological and hydrological objectives. It is important to note that environmental water can be delivered to Burra Creek in isolation to the Burra North Wetland, and that water can be delivered to Burra Creek North or Burra Creek South independently.

Seasonal Aquatic Habitat Regime

To promote seasonal aquatic habitat including emergent and semi-emergent macrophytes, deliver water to fill Burra Creek and Burra North Wetland nine years in 10, for a duration of one to three months between July and November. Deliver water to the creek progressively by pulse-pumping. A slow drawdown of water level is required to prevent collapse of plants (Roberts & Marston 2011).

River Red Gum Regime

For long term maintenance of River Red Gum, deliver water to fill Burra Creek and overtop the Burra North Wetland three years in ten. Deliver water to the creek progressively by pulse-pumping. Allow water to pond for up to three months.

Black Box and Lignum Regime

For long term maintenance of Black Box and Lignum communities, deliver water to the creek, Burra Creek Floodplain North and South, and Burra North Wetland Floodplain one year in ten. Deliver water to the creek progressively by pulse-pumping allowing water in Burra Creek to inundate the floodplain and pond for up to three months. Note that inundation of Burra Creek South and North Floodplain requires infrastructure.

7 MANAGING RISKS TO ACHIEVE OBJECTIVES

Delivery Plans will be developed for all wetland sites allocated environmental water. A broad risk assessment has been undertaken for the system to identify any major risks which would require mitigation measures; these are outlined in Table 15. The Risk Rating matrix in Table 14 has been used to evaluate the risks. A more detailed risk assessment will be undertaken by the Mallee CMA in the development of the delivery plan taking into consideration the broad risk assessment. These plans are signed-off by the Victorian Environmental Water Holder before delivery commences.

Table 14 - Risk Rating

		Consequence				
Likelihood		Negligible 1	Minor 2	Moderate 3	Major 4	Extreme 5
	Almost Certain 5	Medium 5	Medium 10	High 15	High 20	High 25
	Likely 4	Low 4	Medium 8	Medium 12	High 16	High 20
	Possible 3	Low 3	Medium 6	Medium 9	Medium 12	High 15
	Unlikely 2	Low 2	Low 4	Medium 6	Medium 8	Medium 10
	Rare 1	Low 1	Low 2	Low 3	Low 4	Medium 5

Table 15 - Environmental Water Delivery Risk Assessment

Risk Category	Risk #	Risk Type	Without Mitigation			Mitigation	After Mitigation		
			Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Quality Assurance issues lead to no achievement of objectives	1.0	Current recommendations on environmental flow inaccurate	Possible	Moderate	Medium	• Base decisions on referenced literature and CMA knowledge	Rare	Moderate	Low
	1.1	Storage Operator maintenance works affect ability to deliver water	Possible	Moderate	Medium	• Keep in contact with G-MW to identify delays to allow for adaptive management	Rare	Moderate	Low
Time	2.0	Limited CMA resource to deliver environmental release	Possible	Minor	Medium	• Ensure that environmental water management within the CMA is adequately resourced to undertake required delivery tasks	Rare	Moderate	Low
Cost	3.0	Cost of delivery exceeds available funding	Unlikely	Moderate	Low	• CMA to manage delivery and regularly monitor costs	Rare	Moderate	Low
Human	4.0	Environmental releases cause personal injury to river user	Unlikely	Major	High	• Ensure land manager/land holder is informed of delivery actions • Erect signage where risk is significant	Rare	Moderate	Medium

Risk Category	Risk #	Risk Type	Without Mitigation			Mitigation	After Mitigation		
			Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Environmental	5.0	Releases cause water quality issues (e.g. blackwater, low DO, mobilisation of saline pools, acid-sulphate soils, etc.)	Possible	minor	Medium	• Observe the quality of the water throughout the watering season and manage accordingly	Rare	Moderate	Low
	5.2	Releases followed by heavy rainfall and/or natural high flow events cause flooding of non-target areas	Possible	Minor	Medium	• Observe long range weather forecasts, monitor Murray River flows and forecasts, manage delivery to allow additional capacity	Rare	Moderate	Low
	5.3	Improved conditions for non-native species (e.g. carp)	Possible	Moderate	Medium	• Adaptive management. Review current research findings and manage water delivery and recession according to current best practice.	Rare	Moderate	Low
	5.4	Releases cause over-watering of terrestrial flora species	Unlikely	Moderate	Medium	• Monitor terrestrial sites within close proximity of inundation zone if they are at risk	Rare	Moderate	Low
	5.5	Releases cause erosion bank instability	Possible	Moderate	Medium	• Monitor delivery at high risk sites, slow delivery or re-engineer impediment sites	Rare	Moderate	Low

Risk Category	Risk #	Risk Type	Without Mitigation			Mitigation	After Mitigation		
			Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
	5.6	Sudden reduction in water levels strands native fish	Possible	Moderate	Medium	• Monitor recession rates, install structures to better manage retention/release of water. Consider replacement of those impediments that most severely restrict fish passage.	Rare	Moderate	Low
	5.7	Releases promote weed spread	Possible	Moderate	Medium	• Liaise with land managers to control invasive weeds in vicinity of creek • Monitor weed emergence after event	Rare	Moderate	Low
Compliance	6.0	Environmental water account is overdrawn	Possible	Major	Medium	• Ensure delivery contractor is aware of deliver volumes and adheres to delivery plan	Rare	Major	Medium
	6.1	Environmental releases causes flooding of private land	Possible	Minor	Medium	• Monitor delivery, progress of water through creek, pulse pump as required to ensure sufficient capacity within creek banks • Landholder agreements undertaken for flooding on private land. Delivery plans will be developed and approved by VEWH.	Rare	Moderate	Low

Risk Category	Risk #	Risk Type	Without Mitigation			Mitigation	After Mitigation		
			Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
	6.2	Environmental release causes flooding to public infrastructure	Possible	minor	Medium	• Monitor delivery, progress of water through creek, pulse pump as required to ensure sufficient capacity within creek banks	Rare	Moderate	Low
	6.3	Environmental releases causes flooding of Crown land	Possible	minor	Medium	• Land managers are signatories to the proposal	Rare	Moderate	Low
	6.4	Environmental releases causes flooding of access tracks	Possible	Minor	Medium	• Provide temporary signage where applicable	Rare	Moderate	Low
Reputation	7.0	Unable to provide evidence in meeting ecological objective	Possible	Major	Medium	• Need to communicate ecological objectives • Ensure monitoring activities are undertaken • Establish monitoring framework	Rare	Moderate	Low
	7.1	Key stakeholders not supportive of environmental water release	possible	minor	Medium	• Continue to engage with stakeholders and undertake communications	Rare	Moderate	Low

8 ENVIRONMENTAL WATER DELIVERY INFRASTRUCTURE

8.1 Current environmental watering arrangements

Burra Creek currently receives environmental water using diesel pumps, pumping from the Murray River. The creek bed generally has a falling gradient, allowing water flow to gravity feed from the pump site towards the northernmost point. Due to flow impediments within the creek, several 'pulses' of water are necessary. As each section is filled and water is backed up at each impediment, pumping may need to be halted whilst water slowly transfers through narrow pipe culverts to the next section. Additionally these impediments can and do block with debris, sticks and leaves, reducing flow. As the water level subsides at the pump site after each pulse, pumping can recommence.

Burra Creek is currently receiving environmental water in all three management zones. Current inundation extents for Burra Creek total and in each management zone are shown in Table 16.

Table 16 - Current achievable inundation extents for Burra Creek.

Site	Current (ha)
Burra Creek North	50
Burra Creek South	109
Burra Creek South Proper	8
Total	**167**

8.1.1 Burra Creek South Proper

Environmental water can be delivered to Burra Creek South Proper in isolation to the rest of the creek. A private pump site located on the Murray River and an existing shallow irrigation channel can be used for delivery (Figure 16). This occurred previously in 2014.

Water can be retained in this section of the creek by an existing low stop bank that restricts flow to (and from) Burra Creek South. The inundation of the floodplain of Burra Creek South Proper is not recommended as a private residence is located on this section of the floodplain.

8.1.2 Burra Creek South

Environmental water can be delivered to Burra Creek South to a height of approximately 61m AHD at the southern end, and can inundate approximately 32km of creek bed to a maximum depth of approximately 2 m.

Pulse pumping is necessary. Water will be pumped from Connection Point C (Figure 18) until the creek fills at the first impediment (Figure 18) and stopped to allow water to flow though downstream culverts.

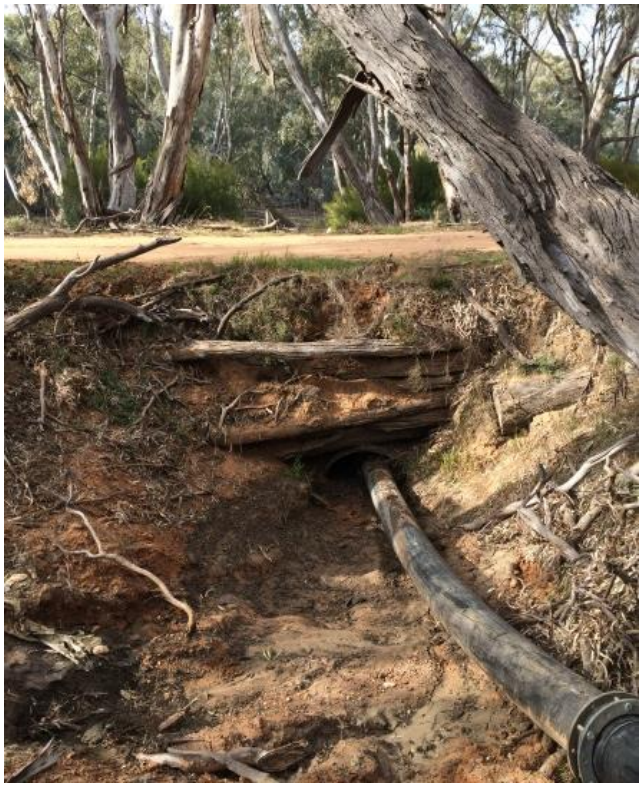

Figure 16 - Pump Site C and Impediment Site 22. Pipe shown is for delivery of environmental water, delivered through the existing culvert.

8.1.3 Burra Creek North

Burra Creek North can receive environmental water in isolation to Burra Creek South by delivery initiated at Pump Site B (Figure 18). This utilises a privately operated irrigation channel that runs through the River Murray Reserve to Burra Creek, where a levee has been constructed to hold water for irrigation purposes (Impediment Site 5, Figure 17). A culvert 600 mm in diameter, positioned in a man-made cutting, allows water to pass around this levee and provide flows to the creek.

Pulsed pumping is required in Burra Creek North so as to allow time for water to pass each impediment in turn. Water flows northerly towards Connection Point A. Road raising has occurred at the downstream end of Burra Creek (Impediment Site 1, Figure 18), which enables water to be held within the creek rather than flowing to the Murray River.

Figure 17 - Levee across Burra Creek at Impediment Site 5

8.2 Constraints

The existing arrangements limit the extent of area that can be efficiently inundated by environmental watering in Burra. Delivery of environmental water to Burra Creek South and North Floodplain, and Burra North Wetland and floodplain is not possible without new infrastructure, as water begins to break out through low points and return to the Murray River rather than being held on the floodplain. Some of the impediments within Burra Creek also constrain inundation of the creek line.

8.2.1 Impediments within Burra Creek

Currently it is possible to deliver environmental water to the creek itself via pulse-pumping. Minor works could improve the flow efficiency including cleaning of blocked culverts and replacement of some with larger pipes. Some of the impediments could be removed as they are redundant. Table 17 provides descriptions of the impediments surveyed along the creek. Four impediment sites identified and mapped by Mallee CMA lack data and have not been described

There are 26 impediments currently mapped within Burra Creek (Figure 18). Five additional impediments were mapped during field work for the Ecological Associates 2007 report, which suggests there may be as many as 34 separate impediments to flow within the creek.

The large number of impediments in Burra Creek reduces the ability for water to flow down the creek line. Under flood conditions the number of impediments within the creek reduces the benefits of flows by limiting the inundation extent, duration and frequency of all but the largest flows. The impediments cause a higher flow requirement in the Murray River to achieve flow through of flood waters. The culverts also trap woody debris, further restricting water flow and causing sediment build up. It is likely that the culverts would provide a barrier to fish movement, due to the darkness within the culverts. This situation is in contrast to the unimpeded, slowly advancing flood events that would have occurred pre-regulation, and it restricts natural delivery of floodwater to the floodplain of Burra North (Ecological Associates 2007).

The impediments also provide some environmental benefit. Burra Creek South has a steeper gradient than Burra North. The impediments slow the flow of water down Burra Creek South, prolonging the period of inundation as the water travels along the creek.

Burra Creek South Proper

There are four impediments to flow that have been mapped in this section of the creek (Figure 18).

Burra Creek South

Burra Creek South has a total of sixteen mapped impediments to flow between River Connection Point C and the irrigation channel, which itself provides a further three locations where flow is impeded (Figure 18).

Burra Creek North

The downstream (northernmost) connection point occurs at 1294.3 river km (Connection Point A). Natural flows are restricted in the creek by an elevated track crossing that was constructed in 2005 to retain pumped environmental water within the creek upstream. Approximately 600 m upstream of this crossing is a second impediment with similar inflow limitations, thus the additional impact of the track crossing on current overall creek hydrology is minimal, yet the benefit of retaining pumped water in the creek can be significant.

Burra Creek North has six mapped flow impediments (Figure 18) in addition to the three located at the irrigation channel crossing.

Table 17 - Description of impediments mapped in Burra Creek

Ecological Associates 2007 Reference	Study Area	Impediment No (Figure 16)	Description	Purpose	Land Tenure	Culvert diameter	Height above bed level
2	BN	1	Elevated track crossing, constructed 2005	Retains pumped environmental water within creek; provides creek crossing point	Parks Vic	None	1.5 m
3	BN	2	Earthen stop bank	Assumed historical dam, no current purpose	Parks Vic	None	1.5 - 3 m
4	BN	N/M	Earthen stop bank	Unknown, no current purpose	Parks Vic	None	2-3 m
N/M	BN	3	?	?	Parks Vic	?	?
5	BN	4	Earthen stop bank	Unknown, no current purpose	Parks Vic	None	1-4 m
6	BN	5	Earthen stop bank	Contain irrigation water pumped from Murray River via channel (not currently in use)	Parks Vic	600 mm, valved (artificially diverted cutting)	1.5 m
7	BN	6	Vehicle access track	Provides creek crossing point for public and irrigator at Impediment 5	Parks Vic	900 mm, decaying	1.5 m
8	Border of BN & BS	7	Elevated access track	Access track (to River Murray Reserve and irrigation infrastructure); 1.2 m above floodplain. Channel is siphoned below creek	Private	1.5 m, elevated 0.5 m	2 m
8	BS	N/M	Earthen stop bank	Unknown, no current purpose	Private	None	1 m
9	Border of BN & BS	8	Elevated access track and 4 m wide irrigation channel	Access track (to River Murray Reserve and irrigation infrastructure); 1.2 m above floodplain. Irrigation channel also crosses creek bed	Private	~600 mm	2.5 m
10	BN	N/M	Earthen stop bank	Historical irrigation dam, no apparent current purpose	Private	None	1-2 m

Ecological Associates 2007 Reference	Study Area	Impediment No (Figure 16)	Description	Purpose	Land Tenure	Culvert diameter	Height above bed level
11	Border of BN & BS	9	Elevated access track and 4 m wide irrigation channel	Access track (to River Murray Reserve and irrigation infrastructure); 1.2 m above floodplain. Irrigation channel also crosses creek bed	Private	~600 mm (blocked with debris)	2.5 - 3.5 m
12	BS	N/M	Elevated access track	Private access	Private	None	1 m
13	BS	11	Floodplain levee	Also provides vehicle access	Private	None	4 m
14	BS	10	Elevated access track	Provides vehicle access	Private	600 mm, elevated 0.3 m	1.5 m (blocks natural cutting)
15	BS	12(a)	Earthen bank	Provides vehicle access	Private	500 mm, elevated 0.3 m	1 m
15	BS	12(b)	Irrigation pipe	Also provides vehicle access; may also comprise flood levee	Private	None	3.5 m
15	BS	12(c)	Earthen bank	No apparent current purpose	Private	None	1 m
18	BS	13	Earthen bank	Private road crossing	Private	600 mm	3 m
N/M	BS	14	?	?	Private	?	?
20	BS	N/M	Earthen bank	Dam to hold water in creek, also private access track		800 mm	4 m
N/M	BS	15	?	?	Private	?	?
21	BS	16	Earthen bank	Provides vehicle access	Private	600 mm (elevated 1 m)	3.5 m
22	BS	17	Earthen bank	No apparent current purpose, although connects with levee on eastern bank	Private	None	2.5 m
23	BS	N/M	Earthen bank	Old road crossing, almost completely eroded to natural creek bed	Private	None	0.5 m

Ecological Associates 2007 Reference	Study Area	Impediment No (Figure 16)	Description	Purpose	Land Tenure	Culvert diameter	Height above bed level
24	BS	18	Earthen bank	Provides vehicle access; part of levee	Private	800 mm (elevated 1 m)	1 m
25	BS	19	Earthen bank	Provides vehicle access	Private	1.2 m (elevated 0.5 m)	2 m
27	BS	20	Irrigation pipe	Also provides vehicle access	Private	1 m (elevated 0.5 m)	2.5 m
28	BS	21	Irrigation pipe	Also provides vehicle access	Private	600 mm	2 m
30	BS	22	Earthen bank with horizontal timber supports (in decay)	Vehicle access	Private	800 mm	3 m
31	BSP	23	Earthen bank	Irrigation channel?	Private	None	0.5 m
33	BSP	24	Earthen bank	Part of past channel infrastructure	Private	None	2.5 m
34	BSP	25	Earthen bank	Irrigation or drainage dam	Private	None	1.5 m
N/M	BSP	26	?	?	Private	?	?

Legend: BN: Burra Creek North; BS: Burra Creek South; BSP: Burra Creek South Proper; N/M: Not Mapped.

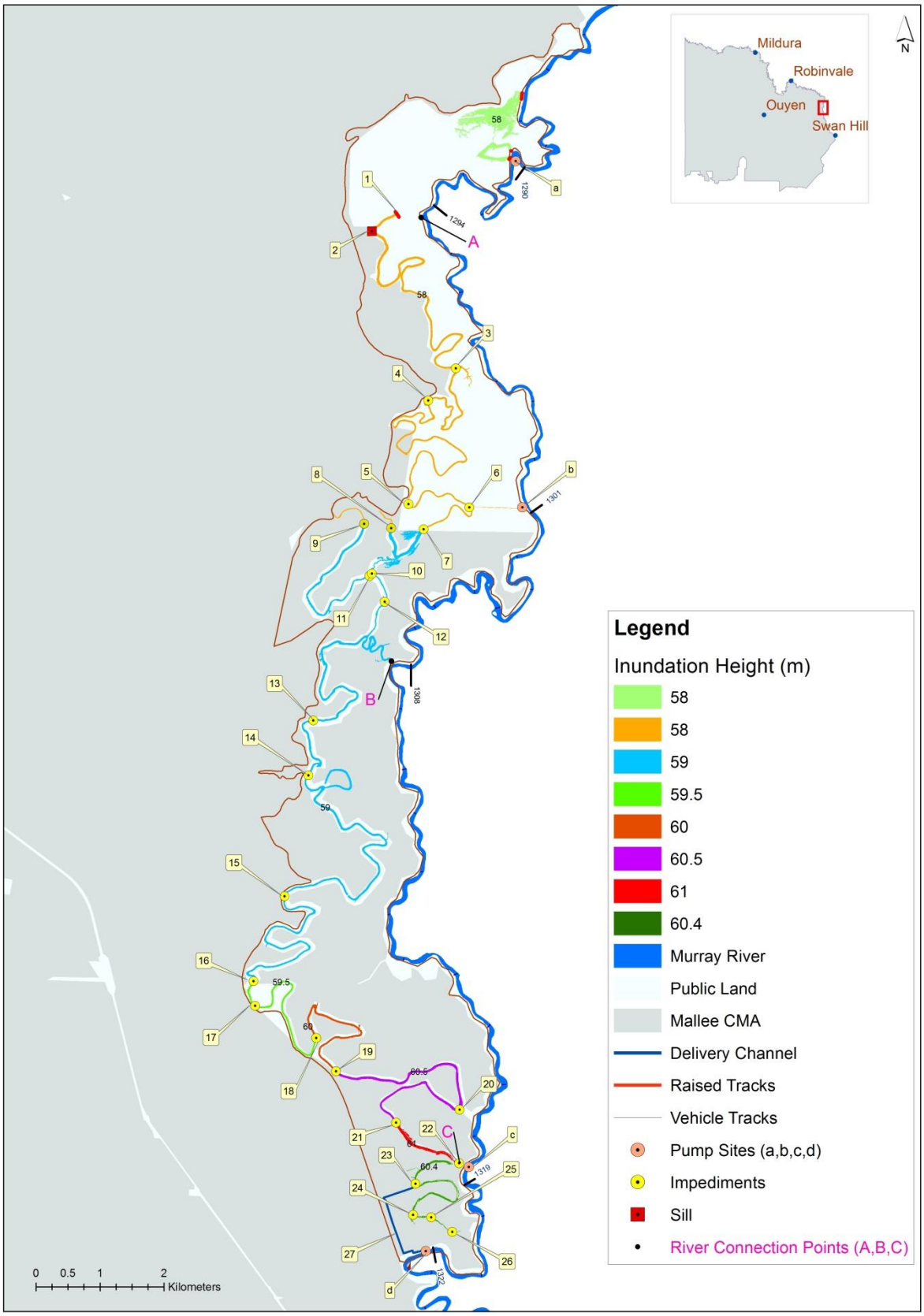

Figure 18 - Current Impediments Mapped in Burra Creek, Proposed Infrastructure

8.3 Infrastructure and Complementary Works Recommendations

As described above, significant improvements in efficiency and area of inundation for the delivery of environmental water could be achieved through the construction of additional infrastructure, upgrading of existing infrastructure and removal of redundant infrastructure. The works are identified in Table 18 and described below for each management zone.

8.3.1 Burra North Wetland and Floodplain

Recommended works for Burra North Wetland include the installation of two levees at the Murray River connection to retain water in the wetland and an additional levee to facilitate inundation of Burra north floodplain (Figure 19). This will enable 32 ha to be inundated (Table 19).

8.3.2 Burra Creek and Floodplain Recommendations

Small scale infrastructure options to improve flow through Burra Creek could involve the modification or removal of flow impediments as deemed appropriate with stakeholders and landholders. Refer to Section 8.2 Constraints for further information.

8.3.3 Burra Creek and Burra North Floodplain

The combination of three regulating structures and raised tracks and overflow sills would enable return of a more natural inundation regime to Burra Creek and Burra North Floodplain. The proposed infrastructure would give greater control of the water levels in the creek and would provide opportunity to return flows to the river after a satisfactory duration (Jacobs 2014).

Concept designs of the infrastructure were prepared under the Sustainable Diversion Limit project in 2014. Further refinement of the infrastructure is required and funding is currently being sought. The proposed infrastructure would enable 407 ha of Burra North to be inundated (Table 19).

8.3.4 Burra Creek South Floodplain

Burra Creek South floodplain could be inundated to 59.2 m AHD, with an extent of 91 ha (Table 19). A series of small levees would enable containment of water pumped onto the floodplain from the Murray River (Figure 19).

Table 18 - Proposed works for Burra North and Burra South Floodplain

Works	Description
B1	A six bay regulator located on the downstream end of Burra Creek will retain water during a managed event and control flows between Burra Creek and the River Murray.
B2	A twin pipe culvert regulator structure located at the upstream end of Burra Creek that will contain flow during a managed inundation event in Burra Creek North.
B4	A pipe culvert regulator structure located at the upstream end of Burra Creek that will allow flow into Burra Creek and forest area during a natural event.
Raised Track and Overflow Sill	Minor works including block banks and overflow sills to secure local low points in the natural levee system and contain water within the flood plain.

Table 19 - Burra inundation extents with and without the proposed infrastructure

Burra Areas	Current extent (ha)	Proposed Infrastructure inundation extent (ha)	Combined total (ha)
Burra North Wetland		7	32
Burra North Floodplain		24	
Burra North	50	357	407
Burra South	109	91	200
Burra South Proper	8		8
Total (ha)	167		647

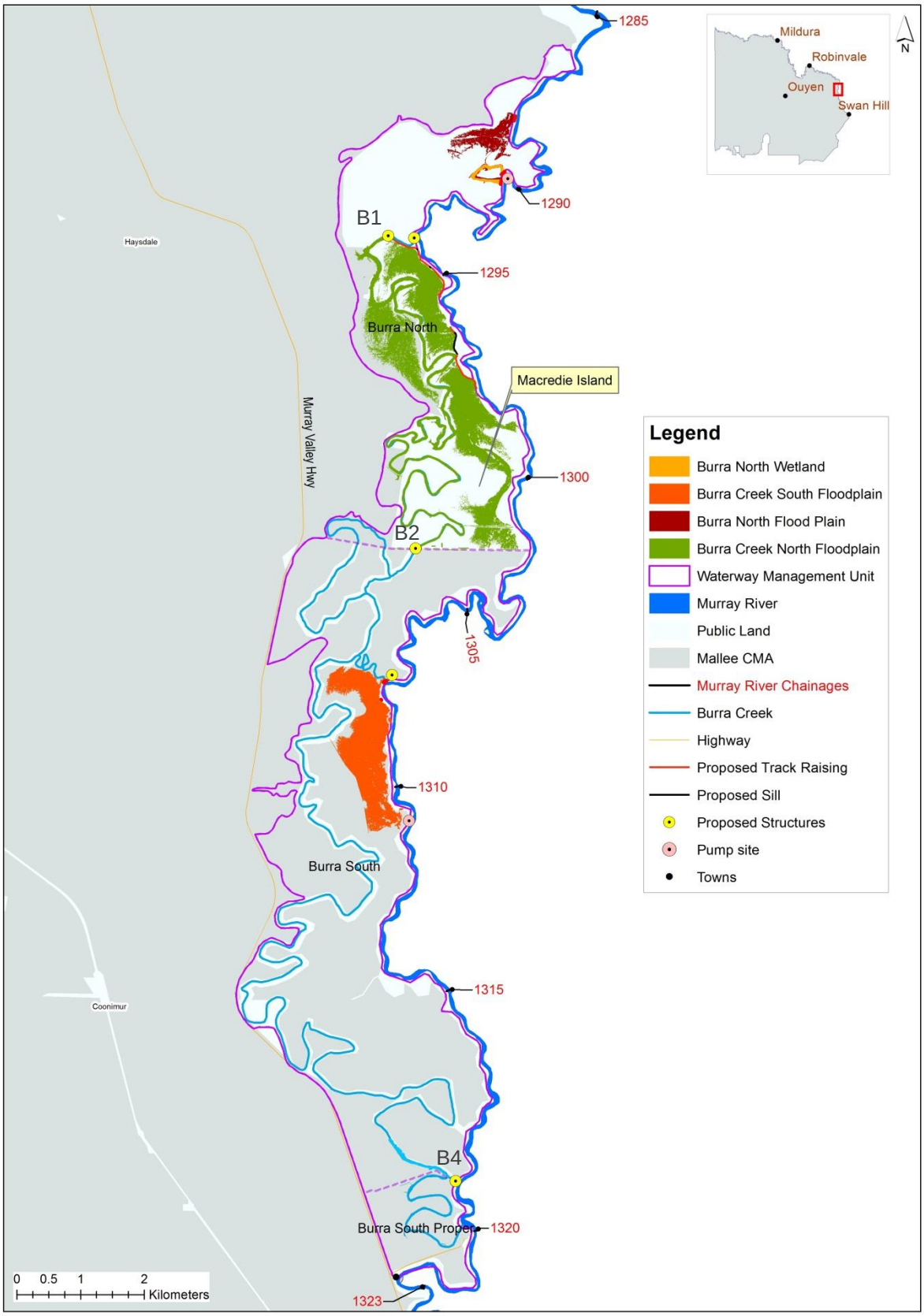

Figure 19 - Inundation extents achievable with proposed infrastructure.

9 DEMONSTRATING OUTCOMES

9.1 Monitoring Priorities at the Site

Monitoring of the impact of environmental watering events is proposed as outlined in Table 20.

Table 20 - Proposed monitoring for Burra

Management Zone	Objective	Hypotheses	Indicator(s)	Frequency
All Zones	Improve/ Wetland Vegetation Condition	Delivery of environmental water as per plan will improve vegetation structure and condition	Photopoints IWC/ISC assessments	Annual Every 5 years
All Zones	Fauna diversity and abundance	Improving the vegetation structure and condition leads to improved conditions for fauna species present	Fauna Survey	Every 5 years
All Zones	Assess bat numbers & nesting habits	Improving the vegetation structure and condition maintains or improves bat diversity	Bat Surveys	Every 5 years

Photo point monitoring will be conducted before and after watering events at Burra to measure the success of environmental water in improving wetland and riparian vegetation communities.

Event based monitoring may be used to measure water quality, particularly in areas where irrigators are drawing water, or may be concerned about water quality, and to gauge the viability of discharging water back to the Murray River.

Other incidental observations that may occur in the course of the monitoring methods above, such as visitation by waterbirds and other species to the wetlands during and after watering events, may be utilised.

Detailed monitoring of environmental water delivery to Burra would be dependent on funding from the State or Commonwealth governments.

10 CONSULTATION

This Plan was developed in collaboration with key stakeholders namely Parks Victoria, landholders, the Department of Environment and Primary Industries and local interest groups. Several meetings were held during the development phase to seek input and gather information from experts and stakeholders as well as meetings with the DELWP and other CMAs involved in the development of the guidelines for the plans. Table 21outlines consultation undertaken in the development of this plan.

Table 21 - Consultation Process for development of Burra Environmental Water Management Plan

Meeting date	Stakeholders	Details
19th of June 2014	Landholders/Irrigators	Determine current usage, access requirements, views on delivery of environmental water, risk of private property inundation, potential for blackwater events
2014	Agencies (DELWP; PV; MDBA; G-MW)	Various meeting to discuss project planning, development, on ground site visits.
2014	Indigenous Community	Various tailored events (site tours, funding announcements etc.) teleconferences and presentations.
2014	Local Landholders	
2014	Local Community (Piangil)	
9th of February 2015	Parks Victoria	Discussion to introduce concept of plan
12th of February 2015	Land and Water Advisory Committee	Presentation of Plan
2nd of March 2015	Aboriginal Reference Group	

11 KNOWLEDGE GAPS AND RECOMMENDATIONS

This plan is based on best information at the time of writing. In some cases this information is scarce or outdated. Further investigation and information collection will continue and the results of this further work will continue to build a better picture of the site and add rigor to future planning. Some areas where further knowledge would be beneficial are outlined in Table 22. A cultural heritage management plan would be essential before any on ground works could be undertaken.

Table 22 - Knowledge gaps for the target area

Knowledge and data gaps	Action recommended	Priority level	Responsibility
Accurate description and mapping of impediments within the creek, including current status of use	Comparison of Ecological Associates 2006 and Mallee CMA mapping data and site assessment for inconsistencies; update of GIS and amendment to this plan; assessment of suitable sites for large culverts to help restore flow	1	Implementation of any of these recommendations would be dependent on investment from Victorian and Australian Government funding sources as projects managed through the Mallee CMA
Impact of environmental watering on riparian vegetation condition and diversity	Annual vegetation assessments (including understorey diversity and condition)	2	
Full extent of cultural Heritage values	Cultural heritage assessment and mapping of values within target area	3	
Impact of watering program on littoral vegetation	Assessment of littoral vegetation extent and diversity before and after watering events	4	
Understanding of fish population and potential within Burra	Baseline survey of fish population	5	

In addition to the knowledge gaps provided above the following recommendations are made for Burra:

- Follow up with landholder at Burra South regarding a covenant to protect significant values.
- Consider the impact of climate variability on Burra, as part of region wide planning.

Access to deadmans hill by motorbikes needs to be restricted. The erosion

Motorbike activity and the associated erosion of Deadmans Hill needs to stop. The hill may contain aboriginal artefacts, so a cultural heritage assessment needs to be conducted at the site. Regardless of the sites potential value as a site of cultural significance Deadmans Hill needs to be fenced and revegetated.

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13 ABBREVIATIONS AND ACRONYMS

CAMBA	China-Australia Migratory Bird Agreement
CMA	Catchment Management Authority
DELWP	Department of Environment, Land, Water and Planning
DEDJTR	Department of Economic Development Jobs Transport and Resources
PV	Parks Victoria
G-MW	Goulburn-Murray Water
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
G-MW	Goulburn-Murray Water
JAMBA	Japan-Australia Migratory Bird Agreement
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
TSL	Targeted Supply Level
VEWH	Victorian Environmental Water Holder

APPENDIX 1: SELECTED IMAGES OF BURRA CREEK IMPEDIMENTS

Burra Creek South Proper, the creek bed in the middle distance. This view looking northwest.

Burra Creek South Proper, looking south.

Pump Site C, showing temporary pump in foreground and pipe through Impediment 22. This is also River Connection Point C, looking away from river.

The downstream side of Impediment 22, looking back towards river, (visible in the background).

The outlet to the pump at Pump Site C, (downstream of Impediment 22) showing recession of water; pumping can soon recommence.

Impediment 19 (left of image) is an access track used by a private landholder. Pipe culvert and altered creek course is shown in the foreground.

The culvert at Impediment 19, looking downstream.

The private access track that forms Impediment 19).

Impediment 18. Fallen timber often accumulates at the upstream entrance to culverts. In this image, on the left bank of the creek, intensive disturbance is evident from agricultural uses.

A levee has been constructed in places along the creek line, presumably to prevent inundation of private land, but also reducing rainfall runoff to the creek. Tree canopy health is noticeably poor, but regenerating.

This image captured from an access track that crosses the creek at Impediment 18, vegetation growing on the edges of this track can be seen in the foreground.

The culvert at Impediment 18, again diverting the creek flow to just outside the natural bank. Fast-flowing water can be seen entering the pipe, and evidence of logs removed from the entrance on right of picture.

Upstream of Impediment 16.

The private access track at Impediment 16. Note the difference in water levels from upstream (right) to downstream via the culvert (left).

Downstream of Impediment 16.

A narrow cutting has been excavated around Impediment 17. The impediment at this location is no longer serves any obvious purpose.

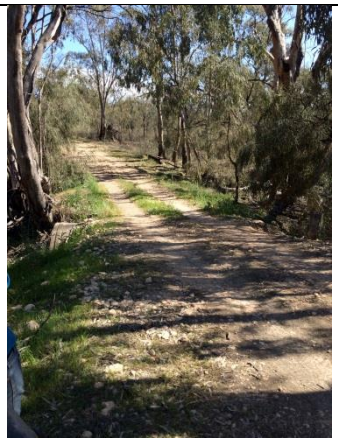
The downstream cutting exit to the creek at Impediment 17. Note the fallen timber at this point, which, if allowed to accumulate would further impede flow.

A large irrigation channel (foreground) crosses the creek (dry, in the background) at three locations. This site is Impediment 9.

The downstream side of the pipe culvert at Impediment 9 under the channel. The culvert is of comparatively good size (~900 mm diameter), however a large volume of debris almost completely blocks flow.

The downstream side of the pipe culvert at Impediment 8 under the channel. Again, a large volume of debris severely restricts flow.

At Impediment 7, the irrigation channel enters a pipe and flows under the creek bed, remerging once more into open channel. There is evidence of a leak in this wetland shown.



The roadway at Impediment 7 crossing the creek line. The pipe culvert is visible left of picture.

At Impediment 7, the road parallel to the channel and pipeline crosses the creek, with a large culvert enabling passage of creek water.

The downstream end of the culvert at Impediment 7, however, is partially blocked by soil and rubble.

The aged pipe culvert at Impediment 6 is in worrying need of attention.

An internal view of the pipe culvert at Impediment 6.

Impediment 5 is a long levee completely crossing the creek bed. A narrow cutting and culvert has been constructed to the east of this levee.

The ~600 mm diameter pipe culvert at the cutting at Impediment 5. This view is the downstream end.

Impediment 5. Several large old River Red Gums have suffered dramatically in the past, however regeneration of saplings has occurred in recent years.

The upstream end of the pipe culvert at the cutting at Impediment 5. Evidence exists of past ability to close off the culvert.

The sand dune immediately downstream of Impediment 5. Note significant disturbance by motorbike access.

Upstream of Impediment 1, showing dead trees and healthy regeneration.

The low bank constructed at Impediment 1 traverses the creek bed and enables water to be held in the creek rather than returning to the Murray River.

Downstream of Impediment 1, with sand dune in background, and several dead River Red Gums in middle distance.

A scarred tree on the floodplain near Impediment 1 that may be of cultural significance.

A suspected hearth located on the floodplain near Impediment 1.

The downstream Connection Point A for Burra Creek and the Murray River (shown in background).

APPENDIX 2: FLORA AND FAUNA SPECIES LIST

Flora – Native

Scientific Name	Common Name	DELWP Advisory List
Acacia oswaldii	Umbrella Wattle	
Acacia stenophylla	Eumong	
Acaulon chrysacanthum	Pygmy Moss	
Acaulon leucochaete	Pygmy Moss	
Alternanthera denticulata s.s.	Lesser Joyweed	
Amaranthus macrocarpus var. macrocarpus	Dwarf Amaranth	Vulnerable
Amyema miraculosa subsp. boormanii	Fleshy Mistletoe	
Amyema preissii	Wire-leaf Mistletoe	
Asperula gemella	Twin-leaf Bedstraw	Rare
Atriplex pseudocampanulata	Mealy Saltbush	Rare
Atriplex rhagodioides	Silver Saltbush	Vulnerable
Atriplex spp.	Saltbush	
Austrostipa scabra subsp. falcata	Rough Spear-grass	
Bolboschoenus medianus	Marsh Club-sedge	
Brachyscome basaltica var. gracilis	Woodland Swamp-daisy	
Brachyscome ciliaris	Variable Daisy	
Callitris columellaris	Murray Pine	
Callitriche sonderi	Matted Water-starwort	
Calotis hispidula	Hairy Burr-daisy	
Centipeda cunninghamii	Common Sneezeweed	
Centipeda minima subsp. minima s.s.	Spreading Sneezeweed	
Centipeda nidiformis	Cotton Sneezeweed	Rare

Scientific Name	Common Name	DELWP Advisory List
Centipeda spp.	Sneezeweed	
Chenopodium curvispicatum	Cottony Saltbush	
Chenopodium desertorum	Frosted Goosefoot	Rare
Chenopodium nitrariaceum	Nitre Goosefoot	
Crassula sieberiana s.l.	Sieber Crassula	
Cynodon dactylon var. pulchellus	Native Couch	Poorly known
Dianella revoluta s.l.	Black-anther Flax-lily	
Duma florulenta	Tangled Lignum	
Eclipta platyglossa subsp. platyglossa	Yellow Twin-heads	
Einadia nutans	Nodding Saltbush	
Elatine gratioloides	Waterwort	
Enchylaena tomentosa var. tomentosa	Ruby Saltbush	
Enteropogon acicularis	Spider Grass	
Epilobium billardierianum subsp. billardierianum	Smooth Willow-herb	
Eragrostis dielsii	Mallee Love-grass	
Eremophila divaricata subsp. divaricata	Emu Bush	Rare
Eucalyptus camaldulensis	River Red-gum	
Eucalyptus largiflorens	Black Box	
Euphorbia drummondii	Flat Spurge	
Exocarpos strictus	Pale-fruit Ballart	
Geijera parviflora	Wilga	Endangered
Glinus lotoides	Hairy Carpet-weed	
Gnaphalium polycaulon	Indian Cudweed	
Goodenia fascicularis	Silky Goodenia	

Scientific Name	Common Name	DELWP Advisory List
Goodenia heteromera	Spreading Goodenia	
Goodenia pinnatifida	Cut-leaf Goodenia	
Hakea leucoptera subsp. leucoptera	Silver Needlewood	
Hakea tephrosperma	Hooked Needlewood	
Helichrysum luteoalbum	Jersey Cudweed	
Juncus flavidus	Gold Rush	
Lachnagrostis filiformis s.l.	Common Blown-grass	
Lachnagrostis filiformis s.s.	Common Blown-grass	
Lythrum hyssopifolia	Small Loosestrife	
Maireana excavata	Bottle Bluebush	
Maireana rohrlachii	Rohrlach's Bluebush	
Marsilea drummondii	Common Nardoo	
Oxalis perennans	Grassland Wood-sorrel	
Paspalidium jubiflorum	Warrego Summer-grass	
Persicaria decipiens	Slender Knotweed	
Persicaria lapathifolia	Pale Knotweed	
Persicaria prostrata	Creeping Knotweed	
Phascum robustum var. crassinervium	Ball Moss	
Pimelea flava subsp. dichotoma	Diosma Rice-flower	Rare
Pimelea trichostachya	Annual Rice-flower	
Pittosporum angustifolium	Weeping Pittosporum	
Poa labillardierei var. labillardierei	Common Tussock-grass	
Polygonum plebeium	Small Knotweed	
Pseudoraphis spinescens	Spiny Mud-grass	

Scientific Name	Common Name	DELWP Advisory List
Rhodanthe corymbiflora	Paper Sunray	
Rumex brownii	Slender Dock	
Rumex spp.	Dock	
Rumex tenax	Narrow-leaf Dock	
Rytidosperma caespitosum	Common Wallaby-grass	
Rytidosperma setaceum	Bristly Wallaby-grass	
Sclerolaena muricata	Black Roly-poly	
Senecio cunninghamii var. cunninghamii		Rare
Senecio glossanthus s.l.	Slender Groundsel	
Senecio quadridentatus	Cotton Fireweed	
Senecio runcinifolius	Tall Fireweed	
Sida corrugata	Variable Sida	
Sida intricata	Twiggy Sida	Vulnerable
Sida spp.	Sida	
Spergularia brevifolia	Salt Sea-spurrey	
Sporobolus mitchellii	Rat-tail Couch	
Stelligera endecaspinis	Star Bluebush	
Swainsona swainsonioides	Downy Swainson-pea	Rare
Teucrium racemosum s.l.	Grey Germander	
Teucrium racemosum s.s.	Grey Germander	
Vittadinia cuneata var. morrisii	Fuzzy New Holland Daisy	Rare
Vittadinia gracilis	Woolly New Holland Daisy	
Wahlenbergia fluminalis	River Bluebell	
Wahlenbergia gracilenta s.l.	Annual Bluebell	

Flora – Exotic

Scientific Name	Common Name
Asphodelus fistulosus	Onion Weed
Aster subulatus	Aster-weed
Avena fatua	Wild Oat
Brassica tournefortii	Mediterranean Turnip
Bromus diandrus	Great Brome
Bromus rubens	Red Brome
Capsella bursa-pastoris	Shepherd's Purse
Centaurea melitensis	Malta Thistle
Cerastium glomeratum s.l.	Common Mouse-ear Chickweed
Cirsium vulgare	Spear Thistle
Conyza bonariensis	Flaxleaf Fleabane
Conyza spp.	Fleabane
Cynodon dactylon var. dactylon	Couch
Fumaria bastardii	Bastard's Fumitory
Hordeum glaucum	Northern Barley-grass
Hypochaeris glabra	Smooth Cat's-ear
Juncus acutus subsp. acutus	Spiny Rush
Lactuca serriola	Prickly Lettuce
Lolium rigidum	Wimmera Rye-grass
Lycium ferocissimum	Boxthorn
Marrubium vulgare	Horehound
Medicago truncatula	Barrel Medic

Scientific Name	Common Name
Opuntia Species	Cacti Species
Phyla canescens	Fog-fruit
Psilocaulon granulicaule	Wiry Noon-flower
Reichardia tingitana	False Sow-thistle
Reseda luteola	Weld
Rorippa palustris	Marsh Yellow-cress
Rostraria cristata	Annual Cat's-tail
Salvia verbenaca	Wild Sage
Schinus molle	Pepper Tree
Silene apetala var. apetala	Mallee Catchfly
Sisymbrium erysimoides	Smooth Mustard
Solanum nigrum s.l.	Black Nightshade
Sonchus asper s.l.	Rough Sow-thistle
Sonchus oleraceus	Common Sow-thistle
Spergularia rubra s.l.	Red Sand-spurrey
Trifolium glomeratum	Cluster Clover
Vulpia bromoides	Squirrel-tail Fescue
Vulpia myuros f. myuros	Rat's-tail Fescue
Xanthium strumarium spp. agg.	Noogoora Burr species aggregate

Fauna – Native

Scientific Name	Common Name	Type	DELWP Advisory List
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	B	
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	B	
Acanthiza nana	Yellow Thornbill	B	
Acanthiza reguloides	Buff-rumped Thornbill	B	
Acanthiza uropygialis	Chestnut-rumped Thornbill	B	
Accipiter fasciatus	Brown Goshawk	B	
Anas gracilis	Grey Teal	B	
Anas superciliosa	Pacific Black Duck	B	
Anhinga novaehollandiae	Darter	B	
Aphelocephala leucopsis	Southern Whiteface	B	
Aquila audax	Wedge-tailed Eagle	B	
Ardea modesta	Eastern Great Egret	B	Vulnerable
Artamus cyanopterus	Dusky Woodswallow	B	
Artamus superciliosus	White-browed Woodswallow	B	
Cacatua galerita	Sulphur-crested Cockatoo	B	
Chalinolobus gouldii	Gould's Wattled Bat	M	
Chalinolobus morio	Chocolate Wattled Bat	M	

Scientific Name	Common Name	Type	DELWP Advisory List
Chelodina expansa	Broad-shelled Turtle	R	Endangered
Chenonetta jubata	Australian Wood Duck	B	
Chelodina longicollis	Common-Long-necked Turtle	R	Data Deficient
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo	B	
Cincloramphus cruralis	Brown Songlark	B	
Cincloramphus mathewsi	Rufous Songlark	B	
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern ssp.)	B	Near threatened
Colluricincla harmonica	Grey Shrike-thrush	B	
Coracina novaehollandiae	Black-faced Cuckoo-shrike	B	
Coracina papuensis	White-bellied Cuckoo-shrike	B	
Corcorax melanorhamphos	White-winged Chough	B	
Corvus coronoides	Australian Raven	B	
Corvus mellori	Little Raven	B	
Cracticus nigrogularis	Pied Butcherbird	B	
Crinia parinsignifera	Eastern Sign-bearing Froglet	A	
Cryptoblepharus carnabyi	Carnaby's Wall Skink	R	
Cuculus pallidus	Pallid Cuckoo	B	
Dacelo novaeguineae	Laughing Kookaburra	B	
Dicaeum hirundinaceum	Mistletoebird	B	
Diplodactylus tessellatus	Tessellated Gecko	R	Near threatened
Dromaius novaehollandiae	Emu	B	Near threatened

Scientific Name	Common Name	Type	DELWP Advisory List
Egretta novaehollandiae	White-faced Heron	B	
Elseyornis melanops	Black-fronted Dotterel	B	
Entomyzon cyanotis	Blue-faced Honeyeater	B	
Eolophus roseicapilla	Galah	B	
Eurystomus orientalis	Dollarbird	B	
Geopelia cuneata	Diamond Dove	B	
Geopelia striata	Peaceful Dove	B	
Gerygone fusca	Western Gerygone	B	
Grallina cyanoleuca	Magpie-lark	B	
Gymnorhina tibicen	Australian Magpie	B	
Haliastur sphenurus	Whistling Kite	B	
Hieraaetus morphnoides	Little Eagle	B	Near threatened
Lalage sueurii	White-winged Triller	B	
Lerista punctatovittata	Spotted Burrowing Skink	R	
Lichenostomus penicillatus	White-plumed Honeyeater	B	
Limnodynastes dumerilii	Pobblebonk	A	
Limnodynastes fletcheri	Barking Marsh Frog	A	
Limnodynastes tasmaniensis	Spotted Marsh Frog	A	
Litoria peronii	Peron's Tree Frog	A	
Lophocroa leadbeateri	Major Mitchell's Cockatoo	B	Vulnerable
Lophoictinia isura	Square-tailed Kite	B	Vulnerable

Scientific Name	Common Name	Type	DELWP Advisory List
Macropus giganteus	Eastern Grey Kangaroo	M	
Malurus cyaneus	Superb Fairy-wren	B	
Malurus lamberti	Variegated Fairy-wren	B	
Manorina melanocephala	Noisy Miner	B	
Melanodryas cucullata	Hooded Robin	B	
Melopsittacus undulatus	Budgerigar	B	
Merops ornatus	Rainbow Bee-eater	B	
Microcarbo melanoleucos	Little Pied Cormorant	B	
Microeca fascinans	Jacky Winter	B	
Morelia spilota metcalfei	Carpet Python	R	Endangered
Morethia boulengeri	Boulenger's Skink	R	
Mormopterus sp. 2	Eastern Freetail Bat	M	
Mormopterus sp. 4	Southern Freetail Bat	M	
Myiagra inquieta	Restless Flycatcher	B	
Ninox novaeseelandiae	Southern Boobook	B	
Nycticorax caledonicus hillii	Nankeen Night Heron	B	Near threatened
Nyctophilus geoffroyi	Lesser Long-eared Bat	M	
Nyctophilus gouldi	Gould's Long-eared Bat	M	
Nymphicus hollandicus	Cockatiel	B	
Ocyphaps lophotes	Crested Pigeon	B	
Pachycephala rufiventris	Rufous Whistler	B	

Scientific Name	Common Name	Type	DELWP Advisory List
Pardalotus striatus	Striated Pardalote	B	
Petrochelidon ariel	Fairy Martin	B	
Petrochelidon neoxena	Welcome Swallow	B	
Petrochelidon nigricans	Tree Martin	B	
Petroica goodenovii	Red-capped Robin	B	
Phalacrocorax carbo	Great Cormorant	B	
Phalacrocorax sulcirostris	Little Black Cormorant	B	
Phaps chalcoptera	Common Bronzewing	B	
Philemon citreogularis	Little Friarbird	B	
Phylidonyris albifrons	White-fronted Honeyeater	B	
Platycercus elegans	Crimson Rosella	B	
Platycercus elegans flaveolus	Yellow Rosella	B	
Platycercus eximius	Eastern Rosella	B	
Polytelis anthopeplus monarchoides	Regent Parrot	B	Vulnerable
Pomatostomus ruficeps	Chestnut-crowned Babbler	B	
Pomatostomus superciliosus	White-browed Babbler	B	
Pomatostomus temporalis temporalis	Grey-crowned Babbler	B	Endangered
Psephotus haematonotus	Red-rumped Parrot	B	
Pseudonaja textilis	Eastern Brown Snake	R	
Rhipidura albiscarpa	Grey Fantail	B	

Scientific Name	Common Name	Type	DELWP Advisory List
Rhipidura leucophrys	Willie Wagtail	B	
Scotorepens balstoni	Inland Broad-nosed Bat	M	
Smicrornis brevirostris	Weebill	B	
Stagonopleura guttata	Diamond Firetail	B	Near threatened
Sterna nilotica	Gull-billed Tern	B	Endangered
Suta suta	Curl Snake	R	Vulnerable
Tadarida australis	White-striped Freetail Bat	M	
Taeniopygia guttata	Zebra Finch	B	
Threskiornis spinicollis	Straw-necked Ibis	B	
Todiramphus sanctus	Sacred Kingfisher	B	
Trichosurus vulpecula	Common Brushtail Possum	M	
Tyto javanica	Pacific Barn Owl	B	
Varanus varius	Lace Monitor	R	Vulnerable
Vespadelus darlingtoni	Large Forest Bat	M	
Vespadelus regulus	Southern Forest Bat	M	
Vespadelus vulturnus	Little Forest Bat	M	
Zosterops lateralis	Silvereye	B	

Legend
Type: Amphibian, Reptile, Bird, Mammal

Fauna – Exotic

Scientific Name	Common Name	Type
Columba livia	Rock Dove	B
Lepus europaeus	European hare	M
Oryctolagus cuniculus	European Rabbit	M
Passer domesticus	House Sparrow	B
Sturnus vulgaris	Common Starling	B
Sus scrofa	Wild Pig	M
Turdus merula	Common Blackbird	B
Vulpes vulpes	Red Fox	M

Legend
Type: Bird, Mammal

APPENDIX 3: ECOLOGICAL VEGETATION CLASSES

Description of each EVC in Burra

EVC no.	EVC name	Bioregional Conservation Status Murray Fans	Description
97	Semi-arid Woodland	Vulnerable	Non-eucalypt woodland or open forest to 12 m tall, of low rainfall areas. Occurs in a range of somewhat elevated positions not subject to flooding or inundation. The surface soils are typically light textured loamy sands or sandy loams.
98	Semi-arid Chenopod Woodland	Endangered	Sparse, low non-eucalypt woodland to 12 m tall of the arid zone with a tall open chenopod shrub-dominated understorey to a treeless, tall chenopod shrubland to 3 m tall. This EVC may occur as either a woodland (typically with a very open structure but tree cover >10%) or a shrubland (tree cover <10%) with trees as an occasional emergent.
103	Riverine Chenopod Woodland	Endangered	Eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded.
104	Lignum Swamp	Vulnerable	Typically treeless shrubland to 4 m tall, with robust (but sometimes patchy) growth of lignum. Widespread wetland vegetation type in low rainfall areas on heavy soils, subject to infrequent inundation resulting from overbank flows from rivers or local runoff.
106	Grassy Riverine Forest	Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum forest to 25 m tall with a groundlayer dominated by graminoids. Occasional tall shrubs present.
295	Riverine Grassy Woodland	Vunerable	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are rare, on deposited silts and sands, forming fertile alluvial soils. River Red Gum woodland to 20 m tall with a groundlayer dominated by graminoids and sometimes lightly shrubby or with chenopod shrubs.

EVC no.	EVC name	Bioregional Conservation Status Murray Fans	Description
808	Lignum Shrubland	Vulnerable	Relatively open shrubland of species of divaricate growth form. The ground-layer is typically herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods. Characterised the open and even distribution of relatively small Lignum shrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces.
809	MML only		
810	Floodway Pond Herbland	Depleted	Low herbland to < 0.3 m tall with occasional emergent life forms, usually with a high content of ephemeral species. Floors of ponds associated with floodway systems. Typically heavy deeply cracking clay soils. Characteristically smaller wetlands with a more regular flooding and drying cycle in comparison to sites supporting Lake Bed Herbland.
811	Grassy Riverine Forest/Floodway Pond Herbland Complex	Depleted (both EVCs)	EVC complex
818	Shrubby Riverine Woodland	Least Concern (Terrestrial BCS)	Eucalypt woodland to open forest to 15 m tall of less flood-prone (riverine) watercourse fringes, principally on levees and higher sections of point-bar deposits. The understorey includes a range of species shared with drier floodplain habitats with a sparse shrub component, ground-layer patchily dominated by various life-forms. A range of large dicot herbs (mostly herbaceous perennial, several with a growth-form approaching that of small shrub) are often conspicuous. Dominant tree species; Eucalyptus largiflorens Eucalyptus camaldulensis
823	Lignum Swampy Woodland	Vulnerable	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.

APPENDIX 4: CULTURAL HERITAGE CONTINGENCY PLAN

CONTINGENCY PLANS

In the event that Aboriginal cultural heritage is found during the conduct of the activity, contingency measures are set out below. The contingency measures set out the sponsor's requirements in the event that Aboriginal cultural heritage is identified during the conduct of the activity.

1 Management of Aboriginal Cultural Heritage found during the activity

In the event that new Aboriginal cultural heritage is found during the conduct of the activity, then the following must occur:

- The person who discovers Aboriginal cultural heritage during the activity will immediately notify the person in charge of the activity;
- The person in charge of the activity must then suspend any relevant works at the location of the discovery and within 5m of the relevant place extent;
- In order to prevent any further disturbance, the location will be isolated by safety webbing or an equivalent barrier and works may recommence outside the area of exclusion;
- The person in charge of the activity must contact the and the Mallee CMA Indigenous Facilitator
- Within a period not exceeding 1 working days a decision/ recommendation will be made by the Mallee CMA Indigenous Facilitator and the Aboriginal stakeholder;
- As to the process to be followed to manage the Aboriginal cultural heritage in a culturally appropriate manner, and how to proceed with the works;

Separate contingency plan has been developed in the event that suspected human remains are discovered during the conduct of the activity.

2 Notification of the Discovery of Skeletal Remains during the carrying out of the Activity

1. Discovery:

- If suspected human remains are discovered, all activity in the vicinity must stop to ensure minimal damage is caused to the remains, and,
- The remains must be left in place, and protected from harm or damage.

2. Notification:

- Once suspected human skeletal remains have been found, Victoria Police (use the local number) and the Coroner's Office (1300 309 519) must be notified immediately;
- If there is reasonable grounds to believe that the remains could be Aboriginal, the DSE Emergency Co-ordination Centre must be immediately notified on 1300 888 544; and
- All details of the location and nature of the human remains must be provided to the relevant authorities.
- If it is confirmed by these authorities that the discovered remains are Aboriginal skeletal remains, the person responsible for the activity must report the existence of the human remains to the Secretary, DPCD in accordance with s.17 of the Act.

3. Impact Mitigation or Salvage:

- The Secretary, after taking reasonable steps to consult with any Aboriginal person or body with an interest in the Aboriginal human remains, will determine the appropriate course of action as required by s.18(2)(b) of the Act.
- An appropriate impact mitigation or salvage strategy as determined by the Secretary must be implemented.

4. Curation and Further Analysis:

- The treatment of salvaged Aboriginal human remains must be in accordance with the direction of the Secretary.

5. Reburial:

- Any reburial site(s) must be fully documented by an experienced and qualified archaeologist, clearly marked and all details provide to AAV;

Appropriate management measures must be implemented to ensure that the remains are not disturbed in the future.