

Final Report for Riverine Recovery Project

Final



Government
of South Australia

Department for
Environment and Water

Published by the Department for Environment and Water.
Government of South Australia
July 2021

Head Office
81-95 Waymouth St
ADELAIDE SA 5000

Telephone +61 (8) 8204 1910
Internet: www.environment.sa.gov.au

ABN 36702093234
ISBN XXX-XXXX-XXXX-X

Report prepared by:

Water Infrastructure and Operations
Water and River Murray Division
Department for Environment and Water

Copies of the report can be obtained from:

www.environment.sa.gov.au

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1 Executive Summary

The Riverine Recovery Project (RRP) focused on the River Murray in South Australia, between the South Australian-Victorian border and Wellington where the river feeds into Lake Alexandrina, part of the internationally important 'Coorong and Lakes Alexandrina and Albert Wetland' Ramsar site. Within this 440 km stretch of river there are numerous wetlands, floodplains and backwaters of significant environmental value. The project was focused on realising improved environmental outcomes through RRP works.

The RRP was a nine year project delivered across two phases, from 2011 to 2019. The project had a notional budget of \$93 million and a final expenditure of \$83.3 million (90% Australian Government funded and 10% South Australian Government funded). The broad objective was to build resilience and address river health across the River Murray system in South Australia, which has been achieved by enabling a more effective use of environmental water whilst supporting regional communities.

By using infrastructure to manage inflows to wetlands as part of defined management plans, annual evaporative losses are able to be reduced and the savings used for other environmental outcomes. The project initially intended to transfer up to 15 GL of water to the Commonwealth Environmental Water Holder. At project completion 7.245 GL of entitlements had been transferred with the remaining 7.755 GL of benefits delivered via the South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP).

Enabling the return of water savings to the Commonwealth for environmental water purposes within the southern-Murray-Darling Basin allowed the project to form part of the package of 36 supply and constraints projects that were notified under the Basin Plan's Sustainable Diversion Limit Adjustment Mechanism (SDLAM).

Through SDLAM, a suite of projects are implemented that have been assessed to achieve equivalent or improved ecological outcomes throughout the southern Murray-Darling Basin with less environmental water recovery. This allows more water to remain in the system for other users, including households, industry and irrigated agriculture.

The RRP has delivered direct environmental benefits to wetlands and floodplains along the South Australian River Murray. It has boosted the ecological health of wetlands through the re-introduction of more variable wetting and drying cycles, while maximising water available to the environment by reducing evaporative losses. The achievements of the RRP can be best seen in four distinct areas; improved floodplain health, improved wetland health, optimising existing River Weir infrastructure for enhanced environmental benefit and working in partnership with the community to build capacity, resilience and to realise social and environmental benefits.

Floodplains

The RRP delivered a significant suite of works at two geographically expansive and environmentally important Floodplains (Pike Floodplain and the Katarapko/Katfish Floodplain). The two floodplains are sites of significant ecological value and home to range of important native flora and fauna. Both sites had experienced long periods of environmental decline post European settlement as a result of historical management practices.

Due to the significant RRP investment, the on ground works and accompanying revisions to floodplain management are seeing this environmental decline being reversed. The key pieces of work at the floodplains were hydrological investigations and modelling, removing existing impediments to flow and constructing new regulating structures to improve the management of flows and allow future investment to enable inundation to maximise environmental return. Additional works were also undertaken to minimise impacts on the local community, these included protecting cultural heritage during infrastructure design and construction and protecting irrigator infrastructure from inundation during future wetting events.

The result of the RRP work at the Pike and Katarapko floodplains was improved hydrological connectivity and surface water management. This resulted in improved transport of nutrients and fish passage and improved aquatic, riparian and terrestrial fauna habitats.

Wetlands

RRP conducted initial feasibility investigations at more than 100 wetlands along the 400km section of the River Murray between the South Australian-Victorian border and Wellington. From the initial list of more than 100 wetlands, work was undertaken on either revising wetland management regimes or constructing wetland regulating infrastructure at a total of 47 wetlands. Initially the RRP invested at 25 managed wetland sites to improve wetland hydrological management and to deliver environmental water savings. These works included reviewing/modelling the hydrology of sites against stated management objectives and undertaking implementation ready projects that had previously been identified.

Additional on ground works and infrastructure was built at 25 new wetland sites. Most of this infrastructure was designed to enable the introduction of healthier and more productive wetting and drying cycles. This was achieved through the construction of water management infrastructure or habitat restoration works principally designed to facilitate the managed wetting and drying of wetlands to simulate the natural historical wetting and drying cycle that pre-dated the introduction of weirs and static river level regulation.

The wetland works were also able to realise significant improvement in the connectivity/transport processes between wetlands and the main river channel, which in turn was able to improve water dependant ecosystem health, resilience and connectivity of the wetlands. The RRP wetland works also resulted in environmental water savings (through minimising evaporative losses with static wetland water levels).

River Operations and Weir Pool Manipulation

Weir pool manipulation was able to return more natural variations in water River levels using existing weir infrastructure. This has enabled enhancement of environmental benefits from small to medium flows, and provided benefits to in-channel and low-lying wetland and floodplain areas. It addressed the ecological impacts associated with reduced water level variability and connectivity that had arisen due to the construction and operation of the locks and weirs on the River Murray. The Project was implemented using a weir pool manipulation regime primarily at Lock and Weirs 2 and 5 in South Australia.

Water level manipulations can vary in magnitude, rate of change, duration, timing and frequency. Significant ecological benefit was able to be achieved by manipulating these variables in order to more closely mimic pre-regulation conditions to enhance native species health and prevalence, while at the same time operating within and managing the constraints and risks to other river users.

Weir Pool raising was undertaken in 2014, 2015 and 2016 across three different locks. All weir pool raising events were undertaken in spring. In 2014, an additional 365ha was inundated as a result of the weir pool raising activities at locks 1 and 5. In 2015, an additional 960ha was inundated and in 2016 an additional 1264ha was inundated, both by raising Weirs 2 and 5. Weir pool raising in Lock and Weirs 2 and 5 has now become a routine part of river management and has established a process that is being applied successively to other lock reaches in SA.

Community and Indigenous Partnerships

Strong productive partnerships with both the local community and Traditional Owners were critical in successfully delivering the RRP. The most notable examples of active partnerships with the community were the broad ranging Fund My Project initiatives, which were community grants for 12 community led and delivered projects and three RRP led Community Partnership Projects. These partnerships delivered specific environmental restoration work, enhanced nature based tourism amenity and community education initiatives. Community partners included, different Local Action Planning (LAP) groups, Conservation Volunteers Australia, a canoe tour operator, Landcare groups, Nature Foundation, Local Councils and catchment groups.

Critical to the success of the RRP was the partnerships with two Traditional Owner groups. The RRP engaged in partnerships with the First Peoples of the River Murray Mallee and the Mannum Aboriginal Community Association Incorporated. These partnerships enabled the two Traditional Owner groups to be engaged and provide input into project design and delivery. These partnerships were critical in protecting cultural heritage. The partnerships enabled the RRP to undertake appropriate and effective cultural heritage work at all RRP on ground work sites. These partnerships ensured cultural heritage was identified and protected during any ground breaking activity by conducting cultural site surveys and cultural monitoring activities.

2 Riverine Recovery Project Background

The Riverine Recovery Project (RRP, the project) focuses geographically on the section of the River Murray between the South Australian-Victorian border and Wellington where the river feeds into the internationally important 'Coorong and Lakes Alexandrina and Albert Wetland' Ramsar site. Within this 440km stretch of river there are numerous wetlands, floodplains and backwaters of significant environmental value which have been enhanced through RRP works. Some of the significant wetlands and floodplains that were actively managed through the RRP include:

- Pike Floodplain;
- Katfish Reach (also known as Katarapko Floodplain);
- Yatco Lagoon; and
- 50 individual wetland sites.

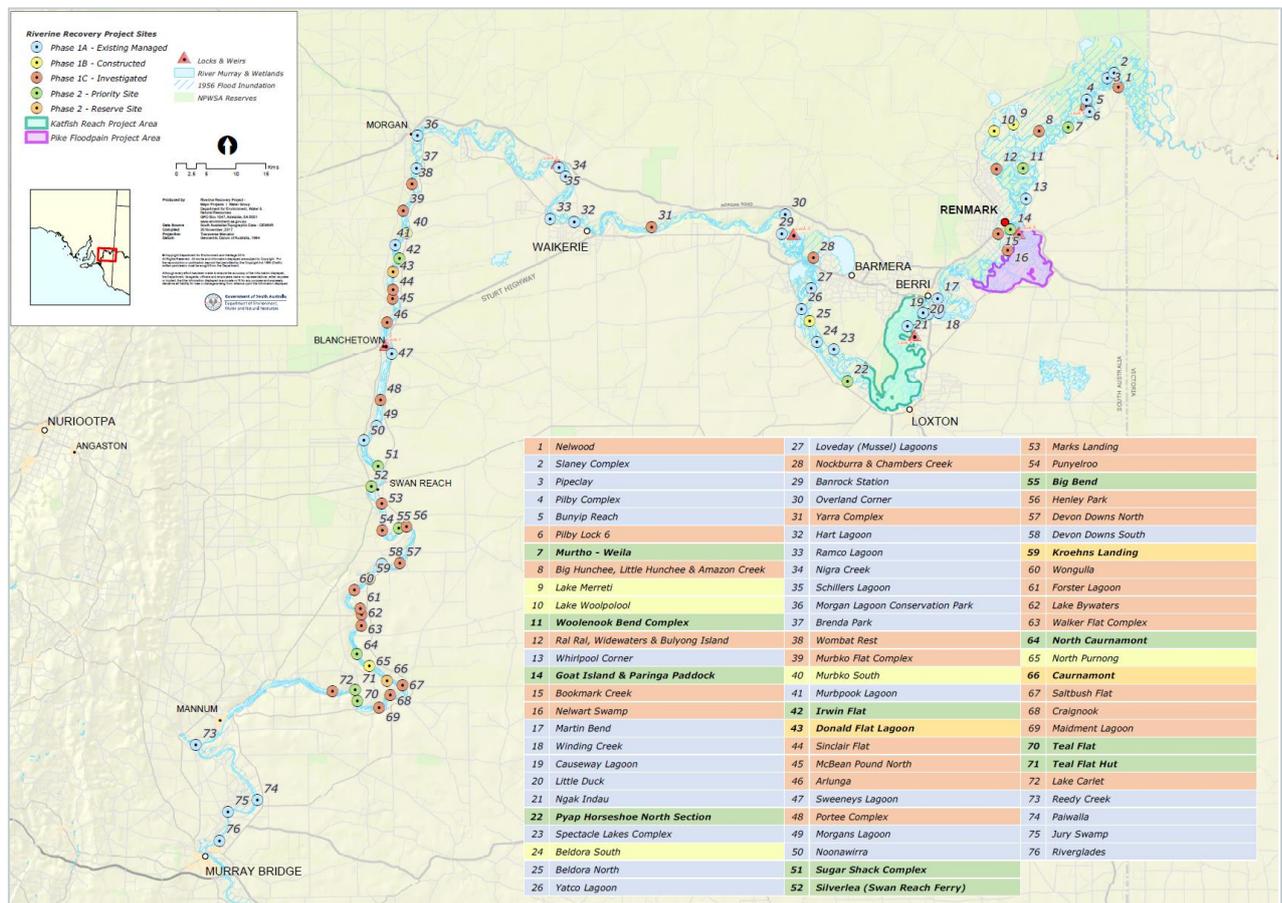


Figure 1: Location of the RRP sites

The RRP, a component of South Australia's Murray Futures Program, has achieved measurable long-term improvements in the health of the riverine environment between Wellington and the South Australian-Victorian border. The project enabled a more effective use of environmental water and supported regional communities through an investment by the Australian and South Australian governments of \$83.3 million. The RRP complements the Murray Futures Coorong, Lower Lakes and Murray Mouth (CLLMM) Recovery Project by extending the efforts to build resilience and address river health across the whole of the River Murray system in South Australia.

The RRP delivered direct environmental benefits to wetlands and floodplains along the South Australian River Murray. The project also enabled the return of valuable water savings to the Commonwealth for environmental purposes within the southern Murray-Darling Basin, thereby allowing the project to form part of the package of projects that were notified under the Basin Plan's Sustainable Diversion Limit Adjustment Mechanism (SDLAM). It boosted the ecological health of the wetlands through the re-introduction of more variable wetting and drying cycles, while improving water available to the environment by reducing evaporative losses.

3 Project Context

On 3 July 2008, the Commonwealth and the Basin States (being the states of New South Wales, Queensland, South Australia, Victoria, and the Australian Capital Territory) signed an Intergovernmental Agreement (IGA) on Murray-Darling Basin Reform. Alongside the *Water Act 2007* (Cth), the IGA progresses the objectives of the National Water Initiative (NWI), which are to increase the productivity and efficiency of Australia's water use, to service rural and urban communities and to ensure the health of river and groundwater systems.

The IGA sets out Commonwealth and State Water Management Partnership Agreement arrangements under which the Commonwealth provided in-principle agreement to make available up to \$3.7 billion in Water for the Future funds for priority projects in Basin States. Priority projects were required to achieve direct outcomes for the Murray-Darling Basin.

The IGA allocated up to \$60 million to South Australia to upgrade irrigation infrastructure and improve river management, including a notional \$10 million for private irrigators to upgrade infrastructure, \$80 million to purchase water from willing sellers and \$200 million to address environmental degradation at the Coorong and Lower Lakes.

The Commonwealth, through its Sustainable Rural Water Use and Infrastructure Program (SRWUIP), a key program of the Water for the Future initiative provided \$75 million to the RRP, one of the five Murray Futures Projects, managed by the Department for Environment and Water (DEW), this was then combined with a further \$7.7 million co-contribution from the Government of South Australia.

Water Savings

The RRP was designed to deliver direct environmental benefits to wetlands and floodplains along the South Australian River Murray whilst generating water savings by reducing evaporative losses. The project was originally intended to provide up to 15 GL of Class 9 water access entitlements to the Commonwealth Environmental Water Holder to help 'bridge the gap' between the existing baseline diversion limit (BDL) and the new sustainable diversion limit (SDL) on consumptive water use under the Murray-Darling Basin Plan.

Class 9 water access entitlements are used for environmental rather than consumptive purposes and use is not accounted under the Cap on Diversions under Schedule E of the MDB Agreement nor the Basin BDL or SDL. Hence, they were ineligible to contribute to bridging the gap. However, the return of water savings to the Commonwealth for environmental water purposes within the southern Murray-Darling Basin allowed the RRP to contribute to Basin Plan outcomes as part of the Sustainable Diversion Limit Adjustment Mechanism (SDLAM).

The RRP forms part of the package of 36 supply and constraints projects that were notified under the Basin Plan's Sustainable Diversion Limit Adjustment Mechanism (SDLAM). Through the SDLAM, the suite of projects implemented have been assessed to achieve equivalent or improved ecological outcomes with less environmental water. A total offset of 605 GL was determined by the MDBA in September 2017. The RRP was one of six notified projects put forward by South Australia (including five projects where South Australia was the sole proponent and one where South Australia was a co-proponent with Victoria and New South Wales).

4 Project Overview

The RRP was delivered through three distinct project components:

- *RRP Start-up Project* – planning and investigations for the RRP Project Proper, which included delivery of an integrated plan and the RRP Project Proper business case;
- *RRP Early works* – on-ground works at three sites which were ready for early commencement. The RRP Early Works commenced in March 2011 and were completed in June 2012; and
- *RRP Project Proper* – improved the efficiency of environmental water use by boosting the ecological health for floodplains and wetlands by reducing evaporative losses and thus providing water savings to be transferred to the Commonwealth.

The RRP Project Proper was by far the largest and most significant of these three project components; accounting for expenditure of \$83.3 million of the total \$93 million budget committed, and is the focus of this Final Report.

The RRP Project Proper aimed to improve the river's health and the resilience of its wetlands, floodplains and backwaters in a future of lower water availability through:

1. implementing an improved riverine management regime for the River Murray from the South Australian-Victorian border to Wellington;
2. utilising a landscape-scale approach to provide for a more effective, efficient and flexible management of environmental water;
3. achieving positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning;
4. supporting regional communities and economies, through the provision of more secure irrigation water sources; and
5. delivering agreed water savings and equivalents of up to 14.3222 GL, with at least 6.567GL for transfer to the Commonwealth for environmental purposes.

The outcomes sought of the RRP Proper were:

1. return 14.3222 GL of Water Entitlements and Equivalents to the Commonwealth;
2. maintain and improve water-dependent ecosystem health, resilience and connectivity;
3. optimise conditions for ecological community recovery, distribution and population viability;
4. increase community knowledge, understanding and involvement in riverine recovery activities; and
5. improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management.

The RRP Proper comprised of nine individual projects (project elements – or PE) which can be seen in Table 1 below. These project components covered floodplain restoration, improved hydrology, wetland management, weir pool manipulation, ecological monitoring, data collection, storage and use and community engagement.

Table 1: Summary of the Individual Riverine Recovery Projects

#	Individual Project	Outcome
1	Pike Floodplain	<p>Implementation of ecologically appropriate hydrological regimes;</p> <p>collection and storage of ecological and surface water monitoring data to inform operational strategy; and</p> <p>Improvement of the environmental health of the Pike anabranch through increased flows, hydrological connectivity and fish passage and improvement of hydraulics for natural flow events.</p>
2	Katfish Floodplain	<p>Implementation of ecologically appropriate hydrological regimes as defined in the hydrological operation plan (with site specific objectives targeting ecological characteristics), to facilitate water level variation of 20 km of waterway and associated wetlands;</p> <p>Improved connectivity/transport processes (water, nutrients, biota in particular fish) between wetlands, water courses and river channel with all in stream fish and flow barriers replaced, increasing flows and fish passage through up to 38km of waterway; and</p> <p>Collection and storage of ecological and surface water monitoring data to inform hydrological operations planning and increased system knowledge.</p>
3.1	Wetlands Project – 1A	<p>Introduction of ecologically appropriate hydrological regimes (as defined in management plans with site specific objectives targeting wetland characteristics) at targeted wetlands;</p> <p>Improvement in connectivity/transport processes between wetland and river channel;</p> <p>Achievement of environmental water savings to deliver of a minimum of 4.2GL and up to 4.547GL of high security water savings to the Commonwealth through wetland management;</p> <p>Community acceptance of the new management plan objectives; and</p> <p>improved knowledge regarding proposed Phase 2 activities.</p>
3.2	Wetlands Project – 1B	
3.3	Wetlands Project – 1C	
4	Phase 1 – Enhanced River Operations and Weir Pool Manipulation	<p>Increased knowledge of means of improving environmental river management through weir pool manipulation and river operation protocols and practices and community acceptance of proposed new protocols.</p>
5	Information Management to Support Decision Making	<p>This project element is made up of three components which, when combined, aim to improve knowledge and understanding about management for water dependent ecosystems.</p> <p><u>Monitoring and Evaluation (M&E)</u></p>

#	Individual Project	Outcome
		<p>Ensure initial and subsequent decisions and actions for floodplain work, changed wetland management regimes and river operation decisions, are examined and reviewed; and</p> <p>Increased knowledge and understanding of water dependant ecosystems.</p> <p><u>Management Action Database (MAD)</u></p> <p>Improved consistency and coordination of data entry and management of current and historical data through creation of a central repository of data about the River Murray in South Australia.</p> <p><u>Ecological Response Models/Integrated Operations Schedules</u></p> <p>Improved ability to model long term ecological outcomes from altered hydrological management and water availability scenarios.</p>
6	Communication, Partnerships and Project Management	<p>Coordinated development and implementation of Priority Project Components;</p> <p>Increased understanding, awareness and engagement of stakeholders;</p> <p>Provide ongoing communication, consultation and engagement with stakeholders; and</p> <p>Establish effective Indigenous, community and South Australian Government partnerships for delivery of the Priority Project.</p>
7	Phase 2 – Enhanced River Operations and Weir Pool Manipulation	<p>Increased knowledge of means of improving environmental river management through weir pool manipulation and community acceptance of manipulations;</p> <p>Improved lateral connectivity/transport process (water, nutrients, biota) between the river and the floodplain fringe; and</p> <p>Collection and storage of ecological monitoring data to inform weir pool manipulations and increased system knowledge.</p>
8	Yatco Lagoon	<p>Protect a high priority wetland at Yatco Lagoon;</p> <p>Improve environmental health and water use efficiency through improved management of the Yatco Lagoon; and</p> <p>Transfer the Agreed Water Savings to the Commonwealth.</p>

#	Individual Project	Outcome
9	Phase 2-Wetlands	<p>Restore hydrological and ecological functions at targeted wetlands and associated water courses (e.g. through re-introduced wetting and drying regimes), contributing to landscape management;</p> <p>Integrate wetland restoration efforts to ensure a representative mosaic of wetland types at an appropriate landscape scale which contribute to the provision of habitat for native species;</p> <p>Provide environmental water through the development and application of ecologically appropriate hydrological management regimes;</p> <p>Improve hydrological connectivity of targeted wetlands and water courses with the River Murray and surrounding habitats, especially where existing infrastructure does not meet current best practice; and</p> <p>Engage community participation in wetland management.</p>

5 Individual Projects

The project delivery approach, with individual projects, allowed the broader RRP to address the many diverse environmental, ecological and social issues related to the River Murray between the South Australian-Victorian border and Wellington. The achievements, benefits and challenges identified by each of these nine individual projects are presented in the following section of the report.

Project 1: Pike Floodplain

The Pike Floodplain Project brought a coordinated approach to improving the environmental health of the Pike Floodplain, reducing salinity impacts and providing a secure and sustainable water supply for domestic and irrigation water use.

The Pike River Floodplain provides a diverse range of aquatic and floodplain habitats and correspondingly diverse flora and fauna. Many of the habitat features of the Pike River Floodplain have been degraded elsewhere along the River Murray and the Pike Floodplain system provides the potential to preserve an important complex of inter-related habitats at one location.

Floods are essential to many important conservation values of the floodplain, but have become less frequent as a result of the storage and diversion of water upstream. Insufficient flooding has led to low productivity on the floodplain, poor vegetation health and low rates of germination and recruitment of floodplain trees.

Prior to RRP, significant areas of the Pike Floodplain were grazed by stock, feral animals and kangaroos. This grazing has exacerbated the negative vegetation impacts associated with salinity and flooding and has completely degraded vegetation in some areas. There were also several blockages to fish passage which further reduced the habitat value of the floodplain.

The Pike Floodplain Project proposed the construction/decommissioning of surface water management infrastructure to preserve this important complex of inter-related habitats. The Pike Floodplain Project focussed on in-stream hydrological responses, and was able to identify and remove flow impediments as well as build new regulating structures to improve the overall hydrological connectivity of the floodplain.

Contribution to the Riverine Recovery Project Aims/Outcomes

As part of the RRP evaluation process for the Evaluation Report it was found that the Pike Floodplain Project component made a direct and meaningful contribution to five RRP aims/outcomes:

- implement an improved riverine management regime for the River Murray from the South Australian / Victorian border to Wellington;
- achieve positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning;
- improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management;
- optimise conditions for ecological community recovery, distribution and population viability; and
- increase community knowledge, understanding and involvement in Riverine Recovery activities.

The evaluation found that the Pike Floodplain Project successfully completed all critical project activities (see figure 2 below), these included:

- developing preliminary and detailed construction plans for all sites that were progressed to on ground works;
- removing key flow impediments, including Snake Creek Crossing, Bank H and Coombs Bridge;
- the replacement of three old and ineffective regulators at Banks B1, B2 and B3;
- the removal and repositioning of Bank C to improve the connectivity and flow regulation between the main channel of the River Murray and the Bank C Mundic Creek entry into the Pike Floodplain;
- pump and sump modifications (including re-location) at 15 irrigation sites to ensure that when the Pike Floodplain is inundated, irrigators still have access to important irrigation equipment, such as their pumps and sumps;
- undertaking all project handover activities including the preparation of documentation and processes for operational use;
- developing a long term surface water and ecological monitoring plan for the site;
- delivering a range of community engagement / communication activities;
- delivering all necessary project planning activities including developing a project implementation plan, undertaking feasibility investigations and land access negotiations;

Some of the Pike Floodplain project activities that were initially identified but were not delivered in full were:

- Replacing banks D, E, F and F1 with a pool rifle fishway; this activity was instead transferred to the South Australian Riverland Floodplain Integrated Infrastructure Program (SARFIIP) and delivered via the construction of the single Tanyaca regulating structure.
- Replacing Bank G with a culvert structure; this activity was also transferred to SARFIIP, the main reason for this was that the Bank G structure was required for site access as part of SARFIIP and will therefore be removed as part of the final stages of SARFIIP.

The cumulative outcome of the implementation of the above activities was the successful achievement of the project's short term goals of:

- improving the connectivity of the Pike Floodplain system;
- improving water level variation within the Pike Floodplain;
- achieving a reduction in the prevalence of pest species at the Pike Floodplain;
- improving the aquatic, riparian and terrestrial fauna habitats of the floodplain;
- enhancing the health and prevalence of key native fauna across the floodplain; and
- increasing community capacity in the management of the Pike Floodplain site.

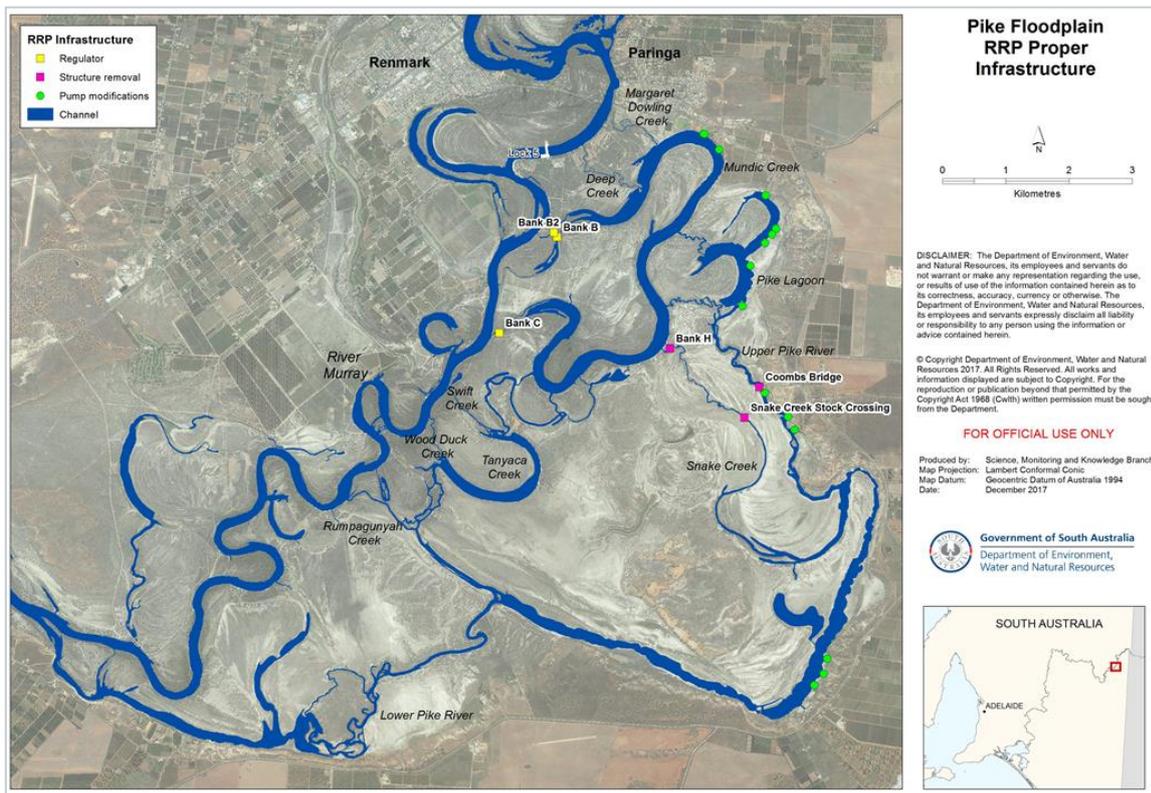


Figure 2, Pike Floodplain

Project Achievements

The Pike Floodplain Project has demonstrated a range of achievements in the three key areas of environmental impact, improved knowledge and community impact and understanding.

Environmental Impact

The most significant environmental achievement of the Pike Floodplain Project was the improved hydrological connectivity at the Pike Floodplain site which is expected to result in a range of positive environmental impacts for many years to come. The work conducted under the RRP Pike Floodplain Project predominantly increased in-stream connectivity, which resulted in improvements to the transport of a range of biota such as fish, turtles, and water rats.

The full range of improved connectivity across the Pike floodplain system as first envisaged in the RRP Pike PE was not realised by June 2016 but, it is expected to be exceeded by the completion of the SARFIIP Pike Project. Connectivity did however directly improve via the installation of a vertical slot fishway at Deep Creek which enabled fish to migrate from downstream of Pike to above lock 5 for the first time in over 80 years.

It is an important distinction that the RRP Pike PE was able to create a hydrological environment which can fully utilise high flow events; however, when SARFIIP is completed it will enable much more regular inundation and environmental water level variation without having to rely on high flow events.

Under natural high flow conditions the RRP Pike Floodplain Project has also greatly improved floodplain inundation which has a range of positive vegetation responses, such as an increase in abundance of key native plant species. The on-ground works directly implemented under the RRP Pike Floodplain Project have enabled a degree of hydrological connectivity on the floodplain, the likes of which has not been experienced for 80 years.

The key project achievements which enabled this significant improvement in hydrological connectivity included the removal of Snake Creek Crossing (see figure 4 below), Coombs Bridge (see figure 5 and 6 below) and Bank H (see figure 7 below). These structures were all significant impediments to vital environmental functions such as flow, fish passage and to the movement of other biota. Through the project planning and design process it was determined that significant environmental gains could be achieved from the removal of these structures without replacing them. This was an environmentally significant undertaking as these structures had been providing a significant impediment to natural flows.

Another key piece of on-ground work undertaken as part of the Pike Floodplain Project was the removal of three old and ineffective regulators from the sites at Bank B1, B2 and B3. The old regulators from these three sites were then replaced with new regulators at Bank B2 and Bank B. Also the regulating structure at Bank C was removed and repositioned with a new regulating structure downstream. The re-positioned Bank C regulating structure regulates flow between the main channel of the River Murray and the Bank C Mundic Creek entry into the Pike Floodplain (see figure 3 below).

Other on-ground works which contributed to the environmental impact of the Pike Floodplain Project were the modification and relocation of pumps and sumps at 15 irrigation sites to ensure that when the Pike Floodplain is inundated, irrigators still have access to important irrigation equipment. Also all willows (environmental pests) that were located on crown land were removed from the Pike anabranch complex. This was a significant undertaking and led to the removal of willows from a 6,700 ha area.



Figure 3, The completed re-located Bank C crossing



Figure 4, The replaced Bank B regulator



Figure 5, Snake Creek Crossing which was removed to improve hydrological connectivity



Figure 6, Coombs Bridge, prior to its removal



Figure 7, The former Coombs Bridge site after the removal of earth bridge



Figure 8, Bank H, which was removed to increase hydrological connectivity

Improved Knowledge

Through the implementation of the Pike Floodplain project a range of important knowledge was acquired relating to improved hydrological connectivity and related ecological outcomes at the Pike Floodplain.

The hydrological operation plan captured a range of knowledge, including the ecological values of the Pike Floodplain and key environmental risks associated with the operation of the Pike. The Environmental Management Plan captured a range of baseline data including bird monitoring, fish monitoring, in-stream habitat monitoring and plant monitoring.

A Monitoring Strategy was developed as part of the project to collect valuable ongoing ecological knowledge. This strategy was a key step in the development of a scientifically robust, financially achievable monitoring program that is directly linked to ecologically sensitive hydrological operating plans.

The hydraulic modelling conducted as part of the Pike Floodplain Project generated some very important knowledge and understanding. The hydraulic modelling was essential in informing the hydrological operational

plan as it was used to predict what scenarios are likely to happen under different inundation approaches and how different management actions will likely influence water behavior changes. The hydraulic modelling was conducted using the MIKE FLOOD model and proved to be a critical tool in designing infrastructure and identifying infrastructure operation.

The Pike Floodplain Project generated additional knowledge relating to the passage of fish through the floodplain. As part of the Pike Floodplain Project a total of 20,704 fish from eight species were sampled from the Deep Creek fishway. Out of the 20,704 fish sampled, 8,965 from seven species were sampled from the entrance and 11,739 fish from eight species were sampled from the exit. The catch was dominated by the small-bodied Australian smelt (*Retropinna semoni*), which comprised ~95% of all fish sampled. Bony herring (*Nematalosa erebi*) was the next most abundant species, comprising ~4% of the catch, whilst the remaining six species collectively comprised of only ~1% of the catch. The fish sampling was conducted over two monitoring seasons in 2015 and 2016.

The First Peoples of the greater Pike Floodplain were able to conduct extensive cultural heritage surveys of the Pike Floodplain as part of the project. The cultural heritage surveys were primarily to ensure no cultural heritage sites were disturbed as part of the on-ground works; however, there was the additional benefit that the local First Peoples were able to greatly increase their records of traditional sites of significance throughout the floodplain.

Community Impact and Understanding

The local community were already engaged and supportive of the efforts to restore the Pike Floodplain for several years prior to the implementation of the RRP Pike Floodplain Project. The community were involved in the creation of the Pike Ecological Restoration Plan on which the Pike Floodplain Project was based.

The Pike Floodplain Project Element had an identified project outcome of increased community capacity for site management. One example of direct community impact via site management was the significant role the local community played in the watering of the priority wetland sites of Duck Hole Wetland, Inner Mundic Flood-runner and Mundic Wetland (see figures 8, 9, 10, 11 below). The local community had a long and close association with the Pike Floodplain Project, this was further reinforced via the site management at the priority watering sites. A total of 40 community volunteers facilitated pumping activities continuously over 26 days to these three key Pike wetlands. Community members volunteered their time, expertise and equipment to provide crucial support, most notably performing critical re-fueling activities for the pumping stations. Through the experience of working directly on this wetland restoration activity community members were able to increase their understanding and awareness of the ecology and management of the Pike site; in particular the value of environmental watering.

The local community had a direct impact on the Pike Floodplain Project and increased their understanding of the Pike Floodplain through the community's representation on the Pike Floodplain Project's Steering Group. Three local community groups were represented on the Steering Group (also known as the Community Reference Group) including the Pike River Land Management Group, Pike-Mundic Irrigators Association and the Renmark Paringa Lyrup Bush Friends. This has demonstrated significant community engagement and passion for the project as well as a forum from which the community has learnt a great deal relating to the management of the site. Each of these three groups had different priorities, however working together as part of the Steering Group enabled each group to gain a greater appreciation of the other's perspective and an opportunity to work together for a common purpose.

The broader community was able to improve their understanding of the Pike Floodplain and the environmental management responses being progressed via the Pike Floodplain Project. The local community were informed about the project via the distribution of information sheets, newsletters and web-site updates. These were largely disseminated via the three community groups and through e-mail mailing lists. Furthermore, significant signage was erected at project sites and time lapse photography was uploaded to the project website.



Figure 9, Aerial image of the three priority community watering wetland sites



Figure 10, Duck Hole community led environmental watering



Figure 11, Duck Hole inundation from the watering event



Figure 12, The Duck Hole wetland

Project Benefits

One of the most significant benefits of the Pike Floodplain Project has been the restoration of connectivity to the Pike anabranch and floodplain complex. Restoring connectivity to the Pike Floodplain has resulted in numerous improvements to the diversity of terrestrial and aquatic habitats, and populations of rare, endangered and nationally threatened species. These benefits are further explored in the below case study:

Pike Floodplain: Restoring Connectivity for a Fish Friendly Pike Floodplain

The Pike floodplain and anabranch, located near the town of Paringa, is the second largest floodplain complex on the lower River Murray in South Australia, spanning ~6700ha. The floodplain comprises a range of vegetation types and habitats including River red gum and black box woodlands, lignum scrublands, chenopod scrublands, herb lands and dunes. The anabranch system bypasses Lock and Weir 5, creating a head difference between inlet and outlet creeks, a unique hydraulic condition within the anabranch. Consequently, the site is characterised by a diverse mosaic of aquatic habitats including permanent fast and slow flowing anabranches, as well as permanent and temporary wetlands.

A total of 16 fish species have been sampled from the Pike anabranch complex as part of the Pike Floodplain Project, comprising 11 native and five non-native species. This assemblage represents a range of life histories, sizes and conservation/economic importance from the small-bodied generalist Carp gudgeon to the large iconic Murray cod. While habitat and hydrological requirements vary, populations within the Pike anabranch have been impacted by habitat fragmentation and flow alteration within the system. Several barriers to fish movement are present, while the original inlet structures were crude, with little capacity to vary flow volumes.

The Pike Floodplain project improved the condition of the anabranch and associated floodplain. Actions involved removing barriers to fish and flow at Banks B1, B3, C, H, Snake Creek Stock Crossing and Coombs Bridge.

In 2014, a new regulator and vertical slot fishway was installed at Deep Creek (one of two primary inlet creeks), making it possible for small-, medium- and large-bodied fish (25 – 800 millimetres) to migrate from the Pike anabranch complex to the river upstream of Lock 5, under non-flood conditions, for the first time since the 1930s. Further, the flow capacity into the anabranch complex has been substantially increased from 150 to 800 megalitres/day as a result of this new structure. This increased capacity to vary flow brings with it the opportunity to not only protect the existing fast flowing habitat within the anabranch complex, but to also extend it.

Fast flowing habitat is under-represented within the Lower Murray, so any action to increase the extent of this is considered to be particularly important for large-bodied native fish, like Murray cod and silver perch, which prefer these hydraulically complex habitats.

In 2015, new fish friendly regulators were also installed on inlet creeks downstream of Lock 5; at Bank B, Bank B2 and Bank C regulators. These inlets activate under higher flows to South Australia (>40 gicalitres/day). Before the upgrade, under a flow to South Australia of 50 gicalitres/day, approximately 100 megalitres/day flowed from the river into the Pike anabranch complex via Banks B, B2 and C. After the upgrade, under the same flow to South Australia scenario, approximately 3000 megalitres/day enters the Pike anabranch complex via these creeks. The substantial flow increase and improved connectivity between the river and anabranch is benefiting a range of instream biota including native fish.

SARDI fish ecologists tested the performance of the Deep Creek fishway using entrance and exit trapping. The trapping confirmed the functionality of the fishway, as well as providing an opportunity to optimise the gate configurations to improve attractant flows. Eight fish species and more than 20,000 individuals were recorded using the fishway over four weeks of sampling. The fishway designers and ecologists were thrilled with the performance of the Deep Creek fishway, with individuals as small as 29 millimetres able to successfully ascend the structure. Other large bodied native fish species detected include the state-listed freshwater catfish, silver perch and golden perch. It is hypothesised that post instream infrastructure upgrades, fish populations within the Pike anabranch will improve. If you're a fish in the Pike anabranch complex your future is certainly looking up!

Challenges and Lessons Learnt

Human Resource Requirements

There was an underestimation of the human resource requirements needed for the implementation of the RRP Pike project. This resulted in some unnecessary project pressure points due to insufficient staffing. These pressure points resulted in periods of extra staff stress, required outputs and hours worked. This did not adversely affect the project, but was not ideal. The most likely reasons for this was the fact that this was the first project of its kind to be directly delivered by DEW and accordingly the extent of the work required was underestimated.

Moving RRP Pike Works to South Australian Riverland Floodplain Integrated Infrastructure Program

A good deal of what was initially in scope for the RRP Pike PE was transferred across to the SARFIIP Pike Project. This was an opportunity to provide a more extensive suite of positive environmental outcomes for the Pike Floodplain. Although not without challenges, by utilising the enhanced opportunities created by the funding available as part of the SARFIIP Pike Project, the RRP Pike Project was able to adaptively manage the project in such a way that will ultimately lead to significantly enhanced outcomes for the whole of the Pike Floodplain.

Access to pumping stations under high flow

There were some oversights in the modifications that were required to irrigation pumps and sumps to accommodate Pike inundation events. Modifications were undertaken to several pumps and sumps to ensure that when the Pike Floodplain was inundated, irrigators still had access to important irrigation equipment. In total 15 irrigation sites were identified, with the relevant pump and sump modifications taking place to ensure access was maintained during Pike inundation events. During the high flow event in October 2016 – January 2017 two additional access tracks, which were missed during the pump and sump modification process, were identified. The result of this was that some irrigation equipment located on these access tracks were not accessible during inundation events. Although the majority of necessary pump and sump modifications were made, the high flow event of late 2016 highlighted this oversight and the challenge of predicting all possible ramifications of high flows prior to the actual high flow events occurring. After the 2016 high flow event the pumping stations that were missed as part of the initial suite of works were subsequently modified.

Project 2: Katfish Reach Floodplain

The Katfish Reach Floodplain Project was developed to build upon the work already undertaken through the Australian Government's investment in the management of the Murray hardyhead habitat, restoration of the Katarapko Island Saline Water Disposal Basin and enhanced floodplain flow and fish passage.

The Katfish Reach Floodplain Project is located on the Katarapko/Eckert Creek anabranch system and its associated floodplain, bypassing Weir and Lock 4. Katfish Reach Floodplain lies opposite the town of Loxton, and is adjacent to the township of Berri. The eastern and southern boundaries of the site are formed by the River Murray, while the northern and western boundaries correspond with the 1956 flood level. The area contains the River Murray National Park, Katarapko, Gerard Aboriginal Reserve, as well as, parcels of Crown and private land. The total area is nearly 9,000ha and traverses over 38km of River Murray frontage.

The Katfish Reach Floodplain is significantly affected by river regulation and the cumulative effects of past local management actions such as the disposal of saline irrigation drainage water onto the floodplain and diverting water around Weir 4. As a result, the conservation values of the Katfish Reach Floodplain were in decline prior to intervention.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the DEW RRP Evaluation process it was found that the Katfish Reach Floodplain project made a direct and meaningful contribution to the below five RRP aims/outcomes:

- implement an improved riverine management regime for the River Murray from the South Australian / Victorian border to Wellington;
- achieve positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning;
- optimise conditions for ecological community recovery, distribution and population viability;
- improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management; and
- increase community knowledge, understanding and involvement in Riverine Recovery activities.

The outcomes were able to be achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that the Katfish Floodplain Project successfully completed all critical project activities, these included:

- project implementation plan completed and approved by the Australian Government;
- successfully completing all hydrological feasibility investigations;
- all detailed designs completed and fully costed;
- all preliminary construction plans successfully completed;
- protecting cultural heritage via cultural heritage surveys and monitoring;
- replacing and constructing new regulators at five key sites (Bank N, Bank K, South Arm Road Crossing, Eckert North Bridge and the Eckert's Main Bridge);

- pump and sump modifications (including re-location) to ensure that when the Floodplain is inundated, irrigators and land holders still have access to important irrigation equipment, such as their pumps and sump;
- hydrological and ecological monitoring;
- community engagement and communication initiatives;
- the handover of all documentation and processes for operational use was completed.

Some of the Katarapko Floodplain project activities that were initially identified but were not delivered in full were:

- the Katarapko Stone Weir and rock ramp fishway were removed from scope due to instability issues with the Stone Weir.

The cumulative outcome of the implementation of the above activities was the successful achievement of the project's short term goals of:

- enhancing health and prevalence of key native fauna within the Katfish Floodplain;
- improving the connectivity / transport process and fish passage of the Katfish Floodplain system;
- improving water level variation within the Katfish Floodplain;
- improving aquatic riparian and terrestrial fauna habitats within the Katfish Floodplain; and
- increasing community capacity in the management of the Katfish Floodplain Site.

KATFISH REACH

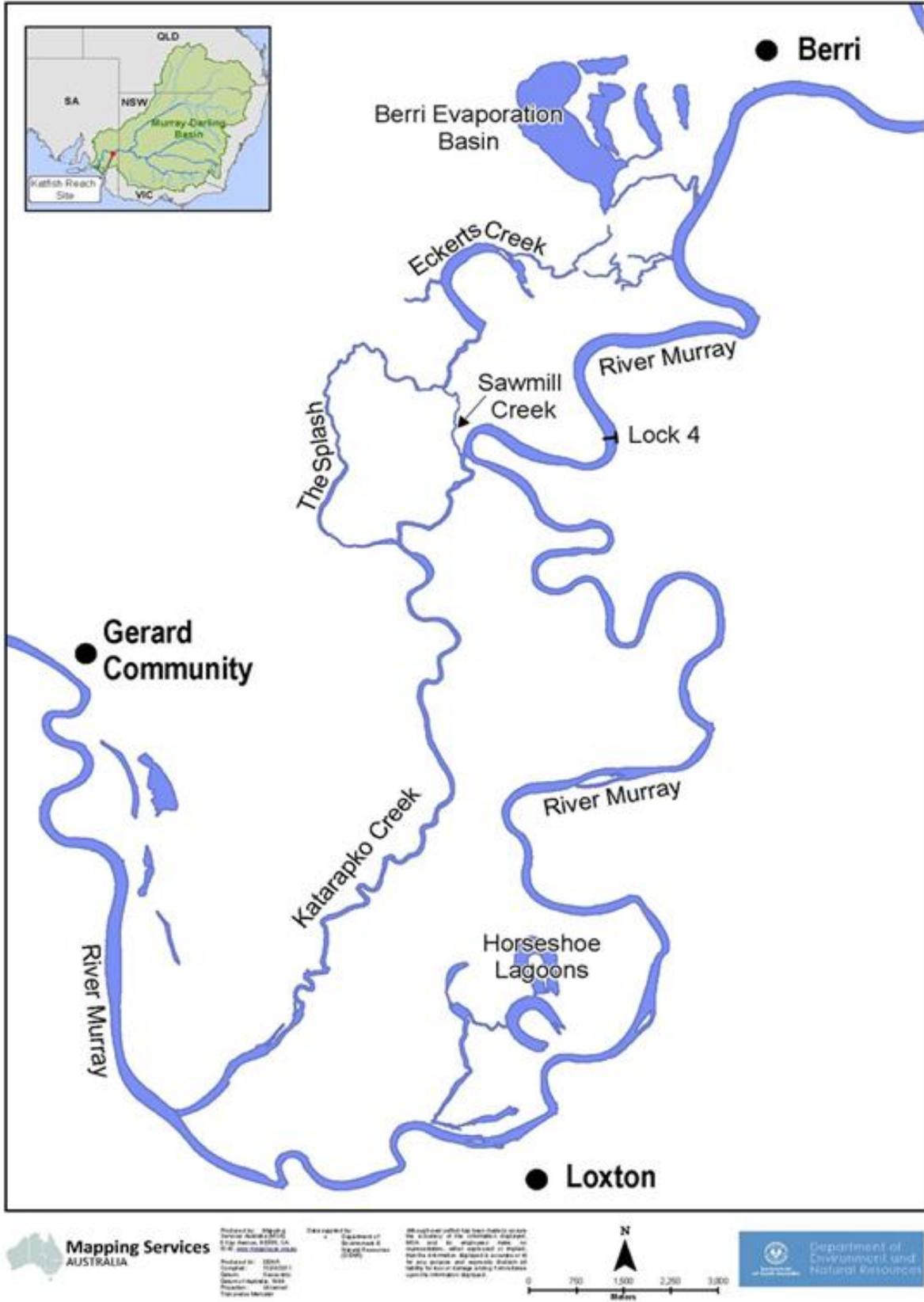


Figure 13, Map of the Katfish Reach Floodplain

Project Achievements

The Katfish Reach Floodplain Project has demonstrated a range of achievements in the three key areas of environmental impact, improved knowledge and community impact and understanding.

Environmental Impact

The most significant environmental impact of the Katfish Reach Floodplain project was improving the connectivity of waterways throughout the Katfish Reach Floodplain. In total 38km of waterway benefited from improved connectivity and transport processes. The removal of five flow barriers (Bank N, Bank K, South Arm Road Crossing, Log Crossing and Eckert Creek Bridge) improved the connectivity and fish passage throughout Eckert Creek. Five barriers were removed and replaced with fish and flow friendly alternatives (including vertical slot fishways) which increased the transport of water, nutrients and biota. This anticipated benefit has been successfully demonstrated via the 2018 spring pulse flow events. A Spring Pulse was undertaken at Eckerts Creek between September and November 2018 that achieved improved flow and velocities down Main Eckerts and South Arm of Eckerts and Sawmill Creeks. An example of the improved flows that the demonstration reach experienced was at Log Crossing where the flows went from 300 ML/day to 490 ML/day during the pulse flows and at Bank J 290 ML/day to 460 ML/day. The velocities were within the preferred envelope for large bodied native fish which is proof that these projects and pulse flows are beneficial to the fish population. Salinity also dropped during the pulse flow event with a reduction from 317 to 245us/cm at Log Crossing and 235 to 195us/cm at Bank J.

Improving connectivity, flow and transport processes throughout the floodplain has had the direct environmental benefit of enhancing aquatic and riparian habitats, in terms of reduced salinity levels, sufficient water allocation and improved vegetation health. This was able to be achieved with additional flows and through the removal of flow barriers. The increased flow also had improvements on water quality in terms of salinity, pH and turbidity. A reduction in salinity has been measured as of 2018, however it was still too early to make definitive observations relating to the condition and extent of vegetation health.

As a result of the improved aquatic and riparian habitats there has been a significant increase in the abundance and diversity of key native fish species. Through the securing of Murray hardyhead habitats their population numbers have shown a positive response, so much so that a translocation from the Berri Basin to the Brickworks in Victoria was undertaken to further secure this threatened fish species. The small bodied native fish numbers improved within Eckert Creek, especially upstream of the Log Crossing fishway which may indicate the infrastructure has increased the abundance of native fish. Regular Monitoring has been undertaken at Katfish reach from 2010 to 2018. This monitoring has shown an increase in small bodied native fish in terms of abundance and distribution which correlates with the work done via the RRP Katfish Reach Project. Also increased numbers were recorded for the key small bodied native fish species of unspotted hardyhead, carp gudgeon and Murray River rainbow fish.

Improved Knowledge

Through the implementation of the Katfish Floodplain project a range of knowledge was acquired relating to improved hydrological connectivity and related ecological outcomes at the Katfish Reach Floodplain. This knowledge was captured via the composition of the Katfish Reach Hydrological Operational Plan. The Hydrological Operational Plan outlines management regimes including variable water levels, partial dries, spring pulses and floodplain inundation. The Hydrological Operational Plan defines how infrastructure, such as the Eckert Creek Log Crossing and South Arm Road Crossing regulators should be operated. Knowledge was obtained through ecological monitoring and surface water monitoring and the data was stored to inform and update the Hydrological Operational Plan.

The Ecological Monitoring Plan was used to generate project knowledge in the area of ecological monitoring. Fish, frog, waterbird and littoral vegetation were all monitored according to the specifications in the monitoring plan. Ecological baseline monitoring was undertaken by the RRP employed wetland ecologist and annual monitoring was also conducted against the established ecological baseline for the duration of the project. All of the data collected under the ecological baseline and annual monitoring have been uploaded to the central Biological Databases of South Australia (BDBSA).

Specific project knowledge in the areas of project staffing, structure ownership and Commonwealth-State agreements was articulated in the RRP Katfish Reach Project Implementation Plan. A risk assessment that was conducted as part of an ecological assessment into the benefits and risks associated with the proposed management actions for the Katarapko Creek/Eckert Creek anabranch system also provided valuable new knowledge. The risk assessment identified the benefits and possible risks of different floodplain management scenarios. Increased knowledge was generated in relation to possible risk and benefit associated with different management scenarios, possible risks identified included increases of in stream salinity and dissolved oxygen, benefits identified included increased flow rates and inundation areas.

Community Impact and Understanding

The local community were active participants in the project via their representation on the Katfish Reach Steering Group through local community groups such as the Gerard Aboriginal Community, local Landcare groups, recreational fishers, Friends of the Riverland Parks and adjacent landholders. These local community groups were well supported and informed regarding the RRP and the management of the Katfish Floodplain site (Figure 13). They were active throughout the project, well engaged and very supportive, running community tours and events with support from DEW via the RRP provided funding and support to maintain the project Steering Group as part of the RRP Katfish Floodplain Project.

The community had a positive impact on the project and increased their knowledge of the Katfish Floodplain site via the significant number of community volunteers that were both recruited and supported through the Friends of Riverland Parks. The community volunteers were involved in conducting community tours of the site as well as being involved in carp buster activities. The carp buster activity was run by the RRP communications team and was funded by the RRP.

The project increased the broader community awareness of the Katfish Floodplain site across the Murray-Darling Basin region through TV adverts, a DVD produced for schools, a feature of the site on the South Aussie with Cosi television show, other media, field days, the NR SA MDB website and numerous community tours of the site.

There has been significant and ongoing work with the First Peoples of the River Murray and Mallee to increase the communities' understanding of the link between traditional culture and the ecology of the floodplain. Knowledge and awareness around cultural heritage was increased via the engagement of the First Peoples to undertake the cultural heritage surveying and monitoring work as an opportunity to access and re-connect with sites of cultural heritage. Through the process of cultural heritage monitoring and surveying some of the First Peoples' Elders were able to increase the cultural awareness amongst younger community members. Additionally, all contractors were able to increase their knowledge and understanding of traditional culture via the mandatory cultural awareness inductions that were provided to all contractors that were working on site.

The timing and sequence of the construction at the five sites was adjusted to minimise its negative impact on the local community and site visitors. The National Park generally remained open for the community and visitors, but some sections of the park needed to be closed during construction, so holidays and busy periods were avoided as much as possible and the park only closed when necessary.



Figure 14a, The Katfish Floodplain Bank N site before its removal.



Figure 14b, The Katfish Floodplain Bank N site after the removal of the crossing.



Figure 15, The completed South Arm Road crossing.



Figure 16, The partially completed Eckerts Creek crossing.

Project Benefits

The Katfish Floodplain project removed five flow barriers (Bank N, Bank K, South Arm Road Crossing, Log Crossing and Eckert Creek Bridge) which improved the connectivity and fish passage throughout Eckert Creek. The barriers were replaced with fish and flow friendly alternatives (including vertical slot fishways) which increased the transport of water, nutrients and biota throughout Eckert Creek. One example of how the removal of the flow barriers and construction of fish-friendly alternatives benefited the native fish was the works at the 'Log Crossing' site.

Katfish Floodplain - Log Crossing: A Case Study

Native fish are back with a fighting chance in the Katarapko and Eckert Creek system with the completion of the new Log Crossing Regulator and Fishway. Log Crossing has been a significant barrier to the flow of water and movement of native fish in the upper reaches of the system for many years. The original crossing was constructed in the early 1900s out of large hollow tree logs placed across Eckert Creek, which was then covered with dirt and gravel. This provided vehicle access across the creek to the stone weir and Katarapko Creek, but at the same time blocked the creek from flowing freely.

The Katarapko and Eckert Creek system has some of the most diverse habitat for medium to large bodied native fish, such as Murray cod, golden perch and freshwater catfish however through river regulation (locks and weirs) native fish have been unable to follow their natural cues to move into the upper reaches to breed and spawn. Native fish need the flow of water to cue their natural instinct to breed, but simply if water does not flow, fish do not breed.

The completion of the new Log Crossing regulators and fishway, as well as the removal of associated smaller barriers in the system, allows native fish to move through the anabranch in response to changes in water level and flow for the first time in 80 years. The Log crossing regulator was constructed with a fishway; the fishway provides native fish with the right flow, velocity and light conditions to move up the system. By removing barriers within the creeks, the system has also become re-connected with fresh water, providing many benefits to fish, plants and other animals within the surrounding wetlands and floodplains.

Annual fish surveys have been conducted in the Katarapko and Eckert Creek system, and the results prior to construction of the new Log Crossing was that native fish were present but in low numbers. Fish surveys completed after the completion and operation of the Log Crossing regulator discovered an increase in the numbers of native fish species, such as unspotted hardyhead, carp gudgeon and Murray River rainbowfish compared to previous years. The removal of barriers and providing the fishway on the log crossing facilitated the movement of these species throughout Eckert Creek. This promising outcome demonstrates how barriers in a system such as this can impact on the movement of native fish.



Figure 17: The old RRP Katfish Floodplain log crossing site prior to works commencing.



Figure 18: The new RRP Katfish Floodplain Log Crossing Fishway Regulator.

Challenges and Lessons Learnt

Site investigation

The 'Stone Weir' site (see figure 16 below) proposed works had to be removed from the project. The site was initially identified to be modified by retro-fitting the rock ramp to be more fish friendly. However, at a relatively late stage of project implementation it was deemed that the structure was too unstable to progress the planned works. The learning from this was that there was not enough time and money invested into the investigations phase for the Stone Weir site. Additional consultation with the Loxton Waikerie Council and irrigators near Loxton would have been beneficial. Additional background investigations into the weir stability would have also been beneficial as it would have identified the nature and extent of risks associated with progressing works at the site at an earlier stage in the project.



Figure 19, The Stone Weir Site.

Project 3.1: Wetland Project 1-A (Improved Wetland Management)

The RRP Wetlands 1-A project improved ecological conditions in a suite of already managed wetlands of various types along the River Murray in South Australia. In particular the project invested at 25 managed wetland sites to improve wetland hydrological management and to deliver environmental water savings.

The Wetlands 1-A project focused on existing managed wetland sites that could be supported and improved through RRP investment. Works included reviewing/modelling the hydrology of sites against stated management objectives and undertaking implementation ready projects that had previously been identified through the SA MDB NRM Board's wetland program.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the RRP DEW evaluation process it was found that the Wetlands 1-A project made a direct and meaningful contribution to the below six RRP aims/outcomes:

- utilise a landscape-scale approach to provide for a more effective, efficient and flexible management of environmental water;
- achieve positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning;
- maintain and improve water dependent ecosystem health, resilience and connectivity;
- optimise conditions for ecological community recovery, distribution and population viability;
- improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management; and
- increase community knowledge, understanding and involvement in Riverine Recovery activities.

The outcomes were achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The project evaluation found that the Wetlands 1-A project successfully completed all critical project activities, these included:

- project Implementation Plan completed and endorsed;
- all project feasibility investigations successfully undertaken;
- all necessary pre-construction environmental surveys completed;
- all preliminary construction plans completed and endorsed;
- all necessary pre-construction activities carried out;
- constructing three new regulators at the Bunyip Reach Lagoon;
- constructing one new regulator at the Martins Bend Wetland;
- constructing one new regulator at the Nigra Creek & Schillers Lagoon Complex;
- constructing one new regulator at the Noonawirra Lagoon;
- upgrading one regulator at the Morgan Conservation Park Wetland and installing a carp screen;

- upgrading one regulator at the Morgans Lagoon removing flow impediments (silt and reeds);
- installing carp screens and removing impediments to flow at Murpook Lagoon;
- removing flow impediments at the Jury Swamp Wetland;
- conducting all necessary environmental monitoring at all 1-A wetland sites;
- undertaking hydrological modelling to model wetland management regimes and calculate water savings; and
- reviewing, updating and creating Wetland Management Plans for all 25 1-A wetland sites.

Some of the Pike Floodplain project activities that were initially identified but were not delivered in full were:

- the upgrade to the Jaeschke Lagoon regulating structure was not progressed due to a lack of landholder support;
- the works on the Murtho Park causeway were not progressed due to budget constraints.

The cumulative outcome of the implementation of the above activities was the successful achievement of the projects short term goals of:

- enabling the implementation of wetland management plans;
- ensuring all water users have security of water access and water quality;
- achieving and transferring 3.35GL of water savings;
- improving water dependant ecosystem health, resilience and connectivity of the wetland; and
- optimising conditions for ecological recovery, distribution and population viability;
- handing over all Wetlands 1-A assets.

Table 2, The 25 Wetland 1-A Sites

Wetland	Management action	Size (ha)
Banrock	RRP Wetlands 1-A Hydrological modelling was used to update the Banrock wetland management plan, however this wetland was not managed as part of RRP.	218
Brenda Park Complex	Hydrological modelling, review hydrology against objectives of management plan	70.3
Bunyip Reach	Install new wetland regulating structures, develop wetland management plan. Provision of a through flow system around Lock 6 reinstating a natural fish passage between Lock 5 and Lock 6 weir pools	42
Causeway Complex	Hydrological modelling, review hydrology against objectives of management plan	28.2
Devon Downs (South)	Hydrological modelling, review hydrology against objectives of management plan	52.3

Wetland	Management action	Size (ha)
Hart Lagoon	Hydrological modelling, review hydrology against objectives of management plan	72.5
Lake Merreti	Hydrological modelling, update management plan and review hydrological regime	381
Lake Woolpolool	Hydrological modelling, update management plan and review hydrological regime	295
Loveday (Mussel) Lagoons	Hydrological modelling, review hydrology against objectives of management plan	131
Martins Bend	Hydrological modelling, review hydrology against objectives of management plan, install new wetland regulator	12.7
Morgan Lagoon Conservation Park	Hydrological modelling, review hydrology against objectives of management plan, upgrade existing infrastructure	56.8
Morgan Lagoon (LM)	Hydrological modelling, review hydrology against objectives of management plan, repairs to existing wetland regulating structures	35
Murbpook Lagoon	Hydrological modelling, review hydrology against objectives of management plan, upgrade existing infrastructure and remove obstructions to flow	102.6
Murtho Park	Hydrological modelling, review hydrology against objectives of management plan, upgrade existing infrastructure	59
Ngak Indau	Hydrological modelling, review hydrology against objectives of management plan	21
Nigra Creek Complex (incl. Schillers Lagoon)	Hydrological modelling, review hydrology against objectives of management plan, upgrade existing infrastructure, install new wetland regulator, assess feasibility for improving connectivity of through-flow system around Lock 2 reinstating a natural fish passage between Lock 1 / Wellington and Lock 2 weir pools	78.2
Noonawirra	Hydrological modelling, review hydrology against objectives of management plan, install new wetland regulator	10
Pilby Complex	Hydrological modelling, review hydrology against objectives of management plan	21.4
Pipeclay Billabong	Hydrological modelling, review hydrology against objectives of management plan	8.6

Wetland	Management action	Size (ha)
Ramco Lagoon	Hydrological modelling review hydrology against objectives of management plan	93
Reedy Creek (Mannum)	Hydrological modelling, review hydrology against objectives of management plan	15
Riverglades	Hydrological modelling, review hydrology against objectives of management plan	40
Slaney Complex	Hydrological modelling, review hydrology against objectives of management plan	17
Sugar Shack	Hydrological modelling, review hydrology against objectives of management plan	30
Sweeney's Lagoon	Hydrological modelling, review hydrology against objectives of management plan	8

Project Achievements

The Wetland 1-A Project (Improved Wetland Management) has demonstrated a range of achievements. These achievements have been listed below, in the three key areas of Environmental Impact, Improved Knowledge and Community Impact and Understanding.

Environmental Impact

The RRP Wetland 1-A Project (Improved Wetland Management) had a significant positive environmental impact at 25 individual wetlands along the River Murray in South Australia. A range of work was done at 25 wetland sites to improve the ecological condition of the sites. All of the 1-A wetlands were already being managed in some capacity, so the majority of the improvements to environmental condition at the sites were achieved through updating and improving how the wetlands were being managed. This took the form of reviewing, updating and improving 23 existing Wetland Management Plans as well as producing 2 new Wetland Management Plans for Jaeschke Lagoon and Bunyip Reach.

Through the process of reviewing and updating management plans some critical on ground works were identified in order to enable the implementation of the newly revised management plans. All wetland Management Plans have been made available to interested community groups and project stakeholders. The project can also provide any interested individual with the Wetland Management Plans upon request; however, they are not currently on a publicly accessible information platform.

The process of reviewing, updating and improving Wetland Management Plans comprised of reviewing the ecological objectives, monitoring data, integrated operational schedule and water needs for these wetlands and incorporating the outcomes of this review into the management plans. The new and updated wetland management plans included a summary of the collated ecological and physical data, developed refined objectives and rationale, proposed operational hydrographs and conceptual understanding of expected outcomes of the new wetland management. Extensive consultation was undertaken with technical experts, community (including Traditional Owners) and key stakeholders during the development of the Wetland Management Plans.

The work that was done on reviewing, updating and improving the Wetland Management Plans had a significant positive environmental impact. The revised and updated management plans have enabled the restoration of preferred hydrological and ecological functions at targeted wetlands and associated water courses (e.g. through re-introducing wetting and drying regimes and increasing hydrological connectivity between wetlands and the main river channel.) The re-introduction of wetting and drying regimes and increasing hydrological connectivity between wetlands and the main river channel has been able to build more robust threatened ecological communities and reduce impacts of pest plant and animal species at the targeted wetlands. Period monitoring and observation by the SA MDB Floodplain and Wetland Team as part of their ongoing management of the 1-A sites has verified the effectiveness of the updated management plans.

As a result of the 23 reviewed and updated Wetland Management Plans and 2 new Wetland Management Plans several sites were identified as requiring new or upgraded infrastructure in order to fully implement the new management plans. The specific on ground works which were delivered under the Wetlands 1-A project which enabled the successful implementation of all new and revised wetland management plans were:

Bunyip Reach

The construction of three new flow control structures at Bunyip Reach, allows the wetland complex to be managed as a temporarily inundated wetland. Two new inlet flow control structures were built at Lock 6 pool level which allows water to flow into a number of wetland basins across the site, with one outlet flow control structure also built at the Lock 5 pool level.



Figure 21, The completed Bunyip Reach Gillies Outlet flow control structure.



Figure 22, The completed Bunyip Reach Arcadia Outlet structure.



Figure 23, The completed Bunyip Reach 40 Acre flow control structure.

Martins Bend

A new wetland regulator at Martins Bend (Figure 17) was constructed in order to re-inundate the wetland and then enable future management of the wetland to replicate a more natural wetting and drying cycle. Unprecedented low flows were experienced between 2001 and 2010, which resulted in Martins Bend being disconnected from the River Murray in October 2006. Due to the flow-control structure at the time being set above pool level, the permanent lagoon at Martins Bend was disconnected and the wetland dry for approximately 55 months between March 2006 until September 2010. The new regulator (located below pool level) will enable the wetland to be fully managed, allowing for managed wetting and drying events, replicating a more natural wetting and drying cycle and enabling a range of environmental benefits.



Figure 24, The new wetland regulator at Martins Bend.

Nigra Creek and Schillers Lagoon

Existing infrastructure at Nigra Creek and Schillers Lagoon (Figure 18) was upgraded. The upgrade included the installation of a new wetland regulator as well as assessing the feasibility for improving connectivity of the through-flow system around Lock 2. Improved connectivity of the through-flow system around Lock 2 reinstated a natural fish passage between Lock 1 / Wellington and Lock 2 weir pools.



Figure 25, Upgraded Nigra Creek / Schillers Lagoon infrastructure.

Noonawirra Lagoon

A new structure regulating the flow of water into the Noonawirra Lagoon was installed (Figure 20). The new regulating structure, in combination with the revised Management Plan, had the aims of re-establishing submerged vegetation to pre-drought levels, restoring and expanding a diverse littoral zone rush and sedge vegetation community and reducing the impact of the common carp. The operation of the new regulating structure resulted in a more natural hydrological regime being reintroduced and specific actions targeting the control of pest species in order to achieve the above aims.



Figure 26, Noonawirra Lagoon prior to RRP works at the Southern Causeway East (looking from wetland).

Morgan Conservation Park

The on ground work at Morgan Conservation Park included the upgrading of an existing regulator to provide improved control and flow of water into the Morgan Conservation Park Wetland as well as the installation of a carp screen. The upgraded regulator, carp screen and associated Management Plan supported the site's recovery and established a healthy and resilient wetland supporting a range of native biota. The specific ecological aims of the work at Morgan Conservation Park were:

- the restoration of the semi-permanent nature of Morgan Conservation Park Lagoon;
- improving the diversity and area of vegetation including littoral and fringing zones and submerged and emergent aquatic vegetation. Improving the condition of river red gums across a range of age-classes, particularly regenerating stands and mature, hollow bearing trees;
- improving the abundance and diversity of water bird species foraging and breeding;
- maintaining or improving the diversity and abundance of frog species; and
- maintaining or improving the diversity and abundance of native fish and reducing the abundance of introduced fish species.

Morgan's Lagoon – Lower Murray Wetlands

A range of repairs were made to the Morgan's Lagoon – Lower Murray wetlands regulating structures. Specifically, the Morgan's Lagoon - Lower Murray structure was upgraded by replacing the old and ineffective stop logs thereby improving wetland regulation (Figure 27). Also the impediments to flow (silt and reeds) were removed to improve flow through the connecting creek from the wetland to Portee Creek.



Figure 27, Morgans Lagoon – Lower Murray regulating structure with new stop logs installed.

Murbpook Lagoon

At Murbpook Lagoon (Figure 28), the barriers to flow identified as significant impediments to management were removed. The main high points and blockages along the inlet creek were caused by the dense stands of common bulrush, resulting in siltation. The common bulrush was cut and removed to enable flow and connectivity between the main River channel and the lagoon.



Figure 28, Murbpook Lagoon.

Jury Swamp

The circulation of water through the Jury Swamp wetland was impeded by the extensive coverage of Phragmites which spread when the wetland was dry during the Millennium Drought. The reeds were removed (figure 30) to reinstate the natural flow path, improve water quality and promotion of submerged and emergent plant species favored by the native fish.

Improved Knowledge

Through the implementation of the Wetland 1-A project (Improved Wetland Management) a range of important knowledge was acquired relating to improved hydrological connectivity and related ecological outcomes across the various Wetland-1A sites.

Knowledge which went into the review of the Wetland Management Plans

A significant amount of knowledge was generated via the process of reviewing and updating the 24 Wetland Management Plans. This included reviewing and updating the ecological objectives, identifying and collecting monitoring data, creating integrated operational schedules and identifying wetland water needs. The new and updated wetland plans included a summary of the collated ecological and physical data, developed refined objectives and rationale, proposed operational hydrographs and conceptual understanding of expected outcomes of the proposed management. Extensive consultation was undertaken to generate the best and most relevant knowledge, this was undertaken with technical experts, community (including Traditional Owners) and key stakeholders during the development of the Wetland Management Plans. Specific areas of knowledge generation were:

Hydrological modelling

Hydrological modelling was undertaken for 29 initial sites and was utilised in 25 Wetland Management Plans. The hydrological modelling produced key knowledge of when structures should be opened and closed in order to wet or dry wetlands to a certain point by a certain time, improving management effectiveness.

SWET Modelling (water saving modelling)

Savings by Wetland Evaporation Time Series (SWET) modelling was conducted in order to estimate and quantify the water savings. The SWET modelling was conducted by the Science branch of DEW. The SWET models looked at local climatic conditions and morphology to determine an average water savings estimate for each wetland based on average climatic conditions and the time at which regulating structures were opened and closed. The SWET model was also used concurrently with hydrograph modelling to inform the Wetland Management Plans in terms of the timing of structure operations. Through the use of both the SWET model and the hydrographs the maximum water savings were achieved while not compromising any of the ecological outcomes. All water savings (3.35GL) generated via the improved management of wetlands were then transferred to the Commonwealth as per the terms of the project funding agreement.

Ecological Objectives (and Monitoring)

For each of the Wetland Management Plans, knowledge was generated relating the most appropriate ecological objectives for each of the 24 wetlands. Included in each of the 24 Wetland Management Plans was a suite of ecological objectives and indicators and a monitoring strategy for each of the 24 sites. The monitoring of the wetlands and collection of data for each of the 1-A Wetlands was also a key knowledge generation achievement for the project. This data is publicly available and can be found on the Biological Database of SA (BDBSA). This data has been used to demonstrate if the watering objectives were being met and to inform adaptive management decision making.

Ecological Baseline Condition

For the Wetlands 1-A project most of the ecological baseline condition for the 24 Wetland Management Plans was generated from compiling already available monitoring data from existing SA MDB site monitoring. As a result of this process some baseline ecological gaps were identified at some sites. When gaps were identified measures were taken to then conduct separate specialist baseline ecological surveys.

Community Impact and Understanding

Stakeholders were identified for each of the wetland sites, and were consulted through the development of the Wetland Management Plans. Stakeholders provided input in the identification of objectives and hydrographs, and had opportunity to review the plans. Stakeholders included wetland community groups, private landholders and Traditional Owners. All stakeholders involved at each of the wetlands were supportive of the recommendations made within the Wetland Management Plans. By ensuring that extensive landholder and community consultation took place it ensured that access to sites was secured to both conduct baseline ecological surveys, as well as any additional surveying requirements and any required on ground works.

Project Benefits

The Wetlands 1-A (Improved Wetland Management) Project Element was able to improve the ecological health of 24 wetlands through being able to reinstate preferred hydrological regimes, restore ecological functions, improve hydrological connectivity, build more robust threatened ecological communities and reduce the impacts of pest plant and animal species at targeted wetlands. A specific example of the benefits realised through the enhanced wetland habitat that has been realised through the Wetlands 1-A Project has been in relation to the purple-spotted gudgeon small bodied native fish.

Wetlands 1-A (Improved Wetland Management): A Case Study

The Southern purple-spotted gudgeon (SPSG), species name *Mogurnda adspersa*, is a small bodied native species (Figure 29) that had not been recorded in South Australia for 30 years, before being re-discovered in 2002 living in a single Lower Murray wetland: Jury Swamp.

Genetic testing confirmed that the population was genetically distinct from other populations further upstream in the Murray-Darling Basin, making these little fish critically endangered regionally, and this population and wetland very important for the species as a whole.

Unfortunately for the SPSG in Jury Swamp, the Millennium Drought hit and water levels in the southern part of the River in South Australia where Jury Swamp is located, began to fall away and dry out the wetland. A rescue mission took place to translocate to aquariums all of the individual fish that the team was able to capture. This way, a captive breeding program could be established to help build up the SPSG numbers, with the aim of releasing stock back into the wild post-drought.

The efforts to save the South Australian population of SPSG was a partnership effort between DEW, SA MDB NRM Board, Aquasave-Nature Glenelg Trust, SARDI, Eastern Hills and Murray Plains Catchment Group and local landholders.

The Millennium Drought broke in late 2010, with continued high flows seen in the South Australian River Murray in 2011, which lead to the rewetting of Jury Swamp. Although rewetting and reconnection of the wetland was a welcome relief, the circulation of water through the wetland had been impeded by the extensive growth of the common reed, *Phragmites australis*, which spread when the wetland was dry during the drought. As well as this, the high flows had resulted in cooler water temperatures and this restricted the growth of submerged aquatic plants, favouring floating aquatic plants that are not ideal habitat for SPSG.

The SPSG group identified potential works that would improve Jury Swamp and enhance its habitat for this endangered species. This included the control of *Phragmites australis* and willows to reinstate old flow paths through the wetland. After trialling a number of techniques, it was decided that the most effective method of removal was to hand cut the reed root mass under the surface of the water. The hard work of reed removal across large areas of the wetland was completed in 2013 by the Monarto Zoo Aboriginal Learning on Country (ALoC) team (Figure 22). The ALoC team spent eight days completing this process which resulted in a cleared section 10m wide by 190mlong. On completion of these works, there was a marked visual improvement in water movement and clarity.

In conjunction with the works undertaken under the RRP, there have been a number of reintroductions of the offspring of the rescued broodstock into Jury Swamp. Recent monitoring has found that the SPSGs are still surviving at this site.

While there have been positive signs of the SPSG continuing to make Jury Swamp their home, the current status of the species is still tenuous, with further work needed in the future to secure captive and surrogate dam stocks. The habitat within the wetland is still recovering from the effects of the drought, however the flow path through the wetland is still clear of *Phragmites* following reed control.



Figure 29, The Southern Purple-Spotted Gudgeon.



Figure 30, Reeds being removed from the Jury Swamp.

Challenges and Lessons Learnt

The Wetlands 1-A Project encountered several challenges over the course of project implementation and learnt several important lessons.

Choice of Contractors

The Wetlands 1-A Project attempted to achieve the twin objectives of both supporting the local community and local economy while also getting the best contractors available for the given job at hand. This was a balancing exercise which did not always go according to plan. The Wetlands 1-A Project endeavored to work with and support local contractors as much as possible. Unfortunately, some smaller value contracts using local suppliers ran into problems with work not being undertaken within the expected timeframes. This is not to say that there is

not merit in actively supporting the local economy and local suppliers, but project procurement must also be careful to ensure standards and value for money is not compromised.

Opportunities for improved co-ordination between DEW and SA Water

At Bunyip Reach there were structures that were designed and built by DEW through RRP and complementary structures that SA Water was responsible for overseeing the design and undertaking the construction of. This meant that numerous personnel, consultants and contractors were on site at the same time but looking at a different suite of infrastructure. This created confusion for the lessee about who was responsible for which structures. In this instance it may have been more appropriate to have one contact person and project manager to represent both organisations and oversee the suite of Bunyip Reach structures. Also as different contractors were awarded the construction work by DEW and SA Water there was also some on site duplication in relation to site visits and the resources used. The lesson learnt was that it may have been more efficient if one contractor was awarded the contract to build all of the Bunyip Reach infrastructure.

Project 3.2: Wetland Project 1-B (New Wetland Management)

The Wetlands 1-B project took advantage of opportunities within the highly regulated RRP area between Wellington and the South Australian/Victorian border to utilise available environmental water to restore function to wetlands and their hydrological regimes. The Wetlands 1-B project managed wetlands via the introduction of a healthier and more productive wetting and drying cycle. This was achieved through the construction of water management infrastructure or habitat restoration works designed to facilitate the managed wetting and drying of wetlands.

The Wetlands 1-B project improved the ecological conditions in a suite of 'implementation-ready' wetlands of various types along the River Murray in South Australia. Wetlands 1-B focused on unmanaged wetland sites identified for investment during an RRP wetland selection process. Some sites were previously unmanaged but had baseline survey information, while others had wetland management infrastructure that required upgrading. The Wetlands 1-B project provided the opportunity to capitalise on the consultation that had already commenced and the baseline survey information that had already been collected at the identified sites prior to RRP. The Wetlands 1-B project invested at eight unmanaged wetland sites to improve hydrological management and deliver environmental water savings. Eight Wetland Management Plans were prepared under the Project with three plans not progressed to the site management stage. The three sites that were not progressed to the on ground works phase were Lake Carlet, Wongulla Wetland and Kroehns Landing. These sites were not progressed due to a range of reasons including a lack of environmental benefit from site intervention, potential negative environmental impacts of intervention, landholder difficulties and prohibitive costs.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the RRP Evaluation process it was found that the Wetlands 1-B project made a direct and meaningful contribution to the below six RRP aims/outcomes:

- utilise a landscape-scale approach to provide for a more effective, efficient and flexible management of environmental water;
- achieve positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning;
- maintain and improve water dependent ecosystem health, resilience and connectivity;
- optimise conditions for ecological community recovery, distribution and population viability;
- improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management; and
- increase community knowledge, understanding and involvement in riverine recovery activities.

The outcomes were able to be achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that the Wetlands 1-B project successfully completed all critical project activities, these included:

- completing the project implementation plan for endorsement;
- completing all preliminary construction plans for endorsement;
- completing all project feasibility investigations;

- completing all ecological baseline monitoring surveys;
- completing all necessary pre-construction activities;
- constructing one new regulator at the Lake Merreti site;
- constructing two new regulators at the Lake Woolpolool site;
- constructing one new regulator at the Beldora-Spectacle Lakes site;
- constructing two new regulators at the Murkbo South wetland site;
- constructing one new regulator at the North Purnong wetland site;
- undertaking hydrological modelling to model wetland management regimes and calculate water savings; and
- creating Wetland Management Plans for eight potential 1-B wetland sites, with five being used for ongoing site management.

The cumulative outcome of the implementation of the above activities was the successful achievement of the projects short term goals of:

- implementing five Wetland Management Plans;
- achieving 2.56GL of water savings;
- Ensuring water users have water security and water access;
- Handing over all documentation and processes for the operational use of infrastructure;
- improving water dependant ecosystem health, resilience and connectivity of the wetland; and
- optimising conditions for ecological recovery, distribution and population viability.

Project Achievements

The Wetland Project 1-B (New Wetland Management) has demonstrated a range of achievements. These achievements have been listed below, in the three key areas of Environmental Impact, Improved Knowledge and Community Impact and Understanding.

Environmental Impact

The Wetland 1-B project (New Wetland Management) had a significant positive environmental impact at five individual wetlands along the River Murray in South Australia. A range of work was done at the five wetland sites to improve the ecological condition of the sites. The majority of the Wetland 1-B sites were regarded as 'brown field' sites meaning the wetland sites had experienced some form of previous intervention but were not currently operated as managed sites. The works undertaken at each of these five wetland sites can be seen in two parts: firstly creating detailed Wetland Management Plans for each of the five wetlands; and secondly implementing the on ground works as identified by the plans. Creating Wetland Management Plans for the sites involved identifying ecological objectives, identifying the monitoring data to be collected, developing management objectives and rationale, proposed operational hydrographs and a conceptual understanding of the expected outcomes of proposed wetland management. Extensive consultation was undertaken with technical experts, community (including Traditional Owners) and key stakeholders during the development of the Wetland Management Plans.

The new Wetland Management Plans, when combined with the relevant on ground works, had a significant positive environmental impact; they enabled the restoration of preferred hydrological and ecological functions at

the five wetlands and associated water courses (e.g. through re-introducing wetting and drying regimes and increasing hydrological connectivity [between wetlands and the main river channel]). The re-introduction of wetting and drying regimes and increased hydrological connectivity between the wetlands and the main river channel has built more robust threatened ecological communities and reduced the impacts of pest plant and animal species.

Through the extensive work that was undertaken in composing the Wetland Management Plans, specific on ground works were identified for each of the five wetland sites. By conducting the on ground works the new Wetland Management Plans were able to be fully implemented. At each site, old and ineffective structures were removed and replaced with newer, more effective regulators, some of which also incorporated modern fishways. Each new structure provided better regulation of wetting and drying as well as, increased flows and fish passage.

Specific on ground works were delivered at the following Wetlands 1-B sites:

Lake Merreti

One regulating structure was constructed and commissioned at Lake Merreti (Figure 31). Before the new structure could be built a failed flow control structure was first removed from the site. The failed structure was an embankment with a pipe culvert that had malfunctioned to be permanently opened and thus no drying was able to be conducted. The structure size also restricted flow and therefore prevented water level fluctuation through flows and future weir pool manipulation.



Figure 31, The newly constructed Lake Merreti regulating structure.

Lake Woolpolool

Two regulating structures were constructed and commissioned at the Lake Woolpolool site (Figures 32 and 33). One failed structure was removed; this structure was a levy bank and culvert pipe that was previously constructed for agricultural purposes. The structure had failed to shut and therefore conducting wetting activities was very difficult. The structure size also restricted flow and therefore prevented water level fluctuations through high flows and future weir pool manipulation. In response to this, the culvert pipe and part of the levy bank was removed to increase flow into Lake Woolpolool. When the new flow control mechanism (culvert pipe) was constructed it was moved from a single creek crossing location to two road crossings as the creek splits into two. The new locations served the dual purpose of increasing flow control and improving fish passage. The timing of these works was critical as Lake Woolpolool had been dry or near dry for several years and the wetland was starting to turn terrestrial as a result.



Figure 32, The removed culvert pipe at Lake Woolpolool.



Figure 33, The newly constructed Lake Woolpolool regulating structure.

Beldora-Spectacle Lakes Wetland Complex

Beldora and Spectacle Lakes Wetland Complex (Figures 34 and 35) was made up of two separate wetlands (Lake Beldora and Lake Spectacle) where some environmental management had previously occurred. The Beldora and Spectacle Lakes Wetland Complex had two separate (and somewhat ineffective) embankments with in-built flow control mechanisms. The embankments were retained as they facilitated vehicle access but the flow control mechanisms were removed. These were then replaced by one single large structure; a 150m embankment (including flow control regulator) at the entry to both lakes. This new embankment was able to extend the wetland area under environmental management as well as coordinate the management of both lakes.



Figure 34, An aerial image of the completed embankment and flow control regulator.



Figure 35, The Beldora-Spectacle embankment and flow control regulator.

Murbko South

Two regulating structures were successfully constructed and commissioned at the Murbko South site (Figure 36). Structures had previously been constructed at Murbko South site at the height of the drought in 2008/2009. These structures were put in place to keep water out of the wetland and to increase flows moving down the River. In this sense the site was disconnected for the broader health of the River and Lower Lakes. The works conducted in 2008/2009 were done very hastily and as a consequence the structures constructed were not safe to operate, nor were they overly effective in what they were trying to achieve. The ownership and ongoing operation of the structures was also unclear. As part of the Wetlands 1-B project these structures were replaced with more effective and contemporary structures. The new regulating structures were effective in their purpose of regulating flow into the wetland to simulate natural wetting and drying cycles.



Figure 36, New crossing and regulating structure at the Murbko South Lagoon.

North Purnong

One regulator was successfully constructed at the North Purnong site (Figures 37 and 38). North Purnong was the only greenfield site (meaning there had been no previous works at the site) which was improved under the Wetlands 1-B project, therefore no structures or regulators were removed. North Purnong was a regular pool connected wetland with a narrow wetland inlet, therefore the structure built at the inlet was of a modest size, however significant work was required to construct a track to access the inlet. These works were the opposite of those conducted at the Beldora-Spectacle site in that the embankment constructed at Beldora-Spectacle was approximately 150m long but site access was straightforward, whereby at North Purnong the embankment constructed was approximately ten metres long but the work needed to get to the inlet were extensive. The embankment and regulator were able to successfully facilitate wetting and drying whereas previously the wetland had been almost always fully inundated.



Figure 37, The completed North Purnong regulating structure.



Figure 38, The North Purnong during construction.

Improved Knowledge

Through the implementation of the Wetland 1-B project (New Wetland Management) a range of important knowledge was acquired relating to improved hydrological connectivity and the associated ecological outcomes across the five Wetland 1-B sites.

Knowledge which went into the creation of the Wetland Management Plans

A significant amount of knowledge was generated through the creation of the eight Management Plans (five of which were implemented). The three sites that were not progressed to the on ground works phase were Lake Carlet, Wongulla Wetland and Kroehns Landing. Lake Carlet was not progressed as environmental investigations found that the best environmental benefits would be realised from leaving the wetland as is with no additional interventions or management. The Wongulla Wetland was not progressed as works were deemed to be both too expensive as well as having the potential to create unwanted ecological outcomes. The third wetland (Kroehns Landing) was not progressed due to the difficulty associated with obtaining full landholder support to proceed with the works. This included reviewing and updating the ecological objectives, identifying and collecting monitoring data, creating integrated operational schedules and identifying wetland water needs. The new wetland plans included a summary of the collated ecological and physical data, refined objectives and rationale, proposed operational hydrographs and conceptual understanding of expected outcomes of the proposed management. Extensive consultation was undertaken with technical experts, community (including Traditional Owners) and key stakeholders to generate the best and most relevant knowledge during the development of the plans, specifically the areas of knowledge generated were:

Ecological Objectives and Monitoring

Detailed ecological objectives and indicators were used to inform a post construction monitoring strategy at each of the five wetlands, these were documented as part of the monitoring strategy in each of the five Wetland Management Plans. The objectives and targets included in the monitoring strategy were derived from the rapid baseline survey, expert ecological advice as well as consultation with landholders and the local community. The rapid baseline survey collected baseline data in the areas of fish health and abundance, bird health and abundance, tree condition, groundwater and surface water quality. The Wetlands 1-B project rapid baseline surveys were conducted by Adelaide University with the exception of the bird surveys which were conducted by a local Riverland based contractor. Ongoing monitoring is being conducted by the SA MDB Floodplain and Wetland Team, with the relevant results being uploaded to the BDBSA, Hydstra and South Australia Geodata databases.

Site Hydrographs

The Wetland Management Plans also contained hydrographs for each site, the hydrographs acted as a tool to balance out the best way to achieve the differing ecological objectives. Some ecological objectives were complementary, for example carp eradication and improving wetland bed vegetation both relied on drying the wetland to achieve their objectives, but others such as improving small bodied fish habitat relied on high water levels. Consequently, the hydrograph mapped out the best way to manage the wetland and the water levels in such a way that a balance was achieved between the needs of the different ecological objectives. The hydrograph would specify when regulators should be opened to achieve set water levels by certain dates.

SWET Modelling

Savings by Wetland Evaporation Time Series (SWET) modelling was conducted in order to estimate and quantify the water savings. The SWET models looked at local climatic conditions and the depth and surface area of a wetland to determine an average water savings estimate for each wetland based on average climatic conditions and the time at which regulating structures were closed. The SWET model was also used concurrently with

hydrograph modelling to inform the Wetland Management Plans in terms of the timing of structure operations. Through the use of both the SWET model and the hydrographs the maximum water savings were generated in addition to generating ecological outcomes. All water savings achieved were transferred to the Commonwealth Government (2.56GL) as per the terms of the projects funding agreement.

Pump Survey

Knowledge was also generated via the Wetlands 1-B project in relation to the location of irrigation pumps at and around all potential RRP wetland sites. The pump surveys were conducted through a combination of aerial imagery observations, water meter locations and finally through on ground visual identification. Once the pumps were identified, the details of the pumps and their specifications were recorded. The information gained through the pump surveys was valuable in the planning of RRP Wetlands 1-B as well as other RRP projects such as the *Enhanced River Operations and Weir Pool Manipulation* project. The survey data provided the details of where pumps were located and the associated pumping capacity, enabling project staff to determine whether the pumps could play a role in RRP activities or if any pumps required replacing or relocating. Specifically, the pump surveys played a role in helping to inform the Wetlands 1-B site selections and in undertaking the options assessment for pump relocation.

Community Impact and Understanding

The Wetlands 1-B project was designed and implemented in such a way that minimised any potential negative impacts on the local community, in particular on site landholders. No landholders were negatively affected by the on ground works at any of the five wetland sites. The project ensured that the water quality or water security was not compromised for landholders at any of the five sites. If any water quality or water security issues were identified the project had budgets and plans in place to re-locate water access points and pumps from the relevant wetland to the River channel, however these measures were not required for the Wetland 1-B project. The reason for this was that none of the five wetland sites were used by landholders. All landholders of the wetland sites already had water access and pumps located directly to the main river channel and there was no need for any pump relocation.

Building good landholder relationships was one of the most important parts of the project. By working closely with the landholders and informing them about the intended Wetlands 1-B project, what works were required and why the project was important, relationships were built and local community understanding was enhanced. Ensuring that good relationships were established and landholders and the community more broadly were well informed were crucial in successfully negotiating land management / access arrangements. Establishing initial land access arrangements and obtaining consent was often challenging. A key obstacle to getting landholders on board often had an impact on the timing of the project. At the commencement of RRP, the River was just coming out of a severe and prolonged drought, many wetlands had been dry for long periods during the drought and had only just filled post drought. A central component of what RRP was proposing was the drying of wetlands as part of reinstating natural wetting and drying cycles. Thus, it could be said that this was at times a difficult message to sell to the community. Within this context it should be seen as a significant achievement that the project was able to have as much success as it did with negotiating land management/access arrangements and getting landholders to agree to the project.

Project Benefits

RRP was able to partner with existing wetland site managers to work together to further enhance existing environmental watering and wetland management. The RRP Lake Merretti and Lake Woolpolool sites were located on Calperum Station which is managed by the Australian Landscape Trust.

Wetlands 1-B (Improved Wetland Management): A Case Study

The Lake Merretti and Lake Woolpolool wetlands are both located on the Calperum station site. Calperum Station lies along the Old Wentworth Road and covers the western half of the Chowilla Floodplain on the River Murray, approximately 25km north of Renmark and downstream of Weir & Lock No 6. It is adjacent to the Murray River National Park (Chowilla Regional Reserve and Bulyong Island). It is included in the Riverland Ramsar Site, a wetland complex of international importance stretching from Renmark to the SA border. This community of red gum forest, black box woodland and lignum shrubland has suffered serious decline due to reduced frequency of flooding, drought and saline groundwater intrusion. Improved environmental watering with the help of RRP can help to repair the ecosystems.

Calperum is well recognised as an internationally significant wetland system, making up approximately one third of the Riverland Ramsar site. The property provides habitat to several rare and threatened species of wildlife and plays an important part in preserving many significant Aboriginal cultural sites.

The Australian Landscape Trust owns and manages Calperum Station. The Australian Landscape Trust (ALT) was established in the Riverland by Patricia Feilman, AM executive secretary of The Ian Potter Foundation in 1996. It has its origin in the Potter Farmland Plan, a plan that engaged families in rethinking the use and management of their farms for long-term prosperity. The philosophy of the ALT is that through building collaborative partnerships between land managers, ecologists and the wider community they can support and improve the management of regional landscapes and important ecological environments.

One such collaborative partnership has been the one between the RRP and the ALT in managing the Lake Merretti and Lake Woolpolool wetlands for maximum environmental benefit. In its role owning and managing Calperum Station the ALT have been managing Lake Merretti and Lake Woolpolool since the late 1990's. The work which has been done via the RRP has enabled improved environmental management of the two sites, significantly enhancing the ability to control water flows and wet and dry the sites for maximum environmental benefit.

Specifically, the work undertaken as part of RRP at Lake Merretti removed a failed flow control structure from the site. The structure was an embankment with a pipe culvert that had malfunctioned to be permanently opened and thus no drying was able to be conducted at the site. The structure size also restricted flow and therefore prevented water level fluctuation through flows and future weir pool manipulation.

Two regulating structures were constructed and commissioned at the Lake Woolpolool site. One failed structure (culvert pipe) was removed; this structure was a levy bank and culvert pipe that was previously constructed for agricultural purposes. This structure had failed to shut and therefore conducting wetting activities was very difficult at this site. The structure size also restricted flow and therefore prevented water level fluctuations through high flows and future weir pool manipulation. In response to this, the culvert pipe and part of the levy bank was removed to increase flow into Lake Woolpolool.

Challenges and Lessons Learnt

The Wetlands 1-B Project team encountered several challenges over the course of project implementation and learnt several important lessons.

A notable challenge and lesson learnt related to the amount of time allocated for implementation of the Wetland 1-B project. As often occurs during a project design phase, particularly for projects delivered over many years such as the RRP Wetlands 1-B project, the full extent of the projects complexity was not realised. As implementation occurred, tasks were often found to be larger and more time consuming than originally anticipated. The net result of this was that the three distinct RRP Wetland Projects (A, B & C) were compressed into each other with the learnings from one unable to be fully applied to the others in the manner in which they were designed. There were many reasons as to why the initial time allocations were not entirely sufficient, the most notable of which was the 2011 and 2012 flooding event. Even though this event was not entirely predictable, the lesson learnt was that more time and resourcing should have been allocated to ensure that external influences were able to be better managed by the South Australian government.

Project 3.3: Wetland Project 1-C

(Investigations for New Wetland Management)

The Wetlands 1-C Project Element was an investment to undertake feasibility assessments, stakeholder engagement, wetland management planning, water use modelling and detailed designs for up to an additional 20 Riverine wetlands. The Wetlands 1-C Project focused on unmanaged wetland sites identified for investment during the RRP wetland selection process as sites that required a full suite of investigations (including landholder consultation, baseline surveys, development of management plans, detailed hydrological modelling and infrastructure design).

The aim of Wetlands Phase 1-C Project was to acquire sufficient knowledge to determine if the identified wetlands could proceed to the next stage - the Wetlands Phase 2 Project. To achieve this, an initial list of 31 potential wetland sites were identified for ecological baseline surveys. From this initial list, survey work reduced the list to 24 sites, at which concept/preliminary designs were undertaken in conjunction with initial wetland management plans. This dual process of developing concept designs and wetland management plans was able to generate a final shortlist of the 15 most appropriate Wetlands 1-C sites. Detailed designs were then commissioned for each of the 15 sites. After detailed designs were completed a final decision was made to progress 11 sites (plus three reserve sites) to the RRP Wetlands Phase 2 Project. A full list and description of the 11 sites (plus three reserve sites) can be found on page 67.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the RRP Evaluation process it was found that the Wetlands 1-C project made a direct and meaningful contribution to the below six RRP aims/outcomes:

- utilise a landscape-scale approach to provide for a more effective, efficient and flexible management of water for the environment;
- achieve positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning;
- maintain and improve water dependent ecosystem health, resilience and connectivity;
- optimise conditions for ecological community recovery, distribution and population viability;
- improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management; and
- increase community knowledge, understanding and involvement in Riverine Recovery activities.

The outcomes were able to be achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that the Wetlands 1-C project successfully completed all critical project activities, these included:

- identify an initial list of 31 potential wetland sites to investigate further in order to identify the most suitable Wetlands Phase 2 project sites;
- short list 24 potential Phase 2 Wetland sites based on initial ecological investigations and surveys;
- develop up to 24 concept designs (preliminary designs) and draft wetland management plans in order to further refine this list down to the most appropriate 15 Phase 2 Wetland sites;

- detailed site designs were undertaken at all proposed 15 Phase 2 Wetland sites, resulting in a final list of 11 sites at which on ground works will occur and which will be managed in accordance with the site management plans (see page 67 for a list of the final 11 sites and 3 reserve sites);
- conducted a range of hydrological modelling to input into the Wetland Management Plans and to calculate anticipated water savings;
- developed 24 draft Wetland Management Plans and 15 Detailed Management Plans;
- the creation and submission of the Wetlands Phase 2 Project Plan and Communications, Partnerships and Project Management Proposal to the Australian Government for consideration and RRP Wetlands Phase 2 Project approval; and
- undertook a comprehensive suite of communication activities across the potential 24 short-listed Phase 2 wetland sites.

The cumulative outcome of the implementation of the above activities was the successful achievement of the projects short term goals of:

- successfully quantifying all Phase 2 Wetland project water saving estimations;
- ensuring water users have security to water access and water quality;
- ensuring the Phase 2 Wetland project successfully improved the hydrological management of all 11 Phase 2 Wetlands; and
- ensuring that all 11 Phase 2 Wetlands will be successfully managed in accordance with their wetland management plans, including the monitoring of the identified ecological objectives.

The anticipated amount of Phase 2 Wetland project water saving calculated as part of the Wetlands 1-C project was 0.65GL p/year of water savings.

Table 3: Wetland 1-C / Phase 2 Sites

Wetland	Description of activities	Location	Expected ecological outcomes	Estimated Water Savings (GL/year)
Murtho-Weila	Increase fish passage and hydraulic connectivity of main anabranch by decommissioning existing structures and installing box culverts at two causeways, and decommissioning existing culvert crossing and constructing a new ford crossing across the connection between main anabranch and River Murray main channel; replace box culvert crossing structure with regulating gates to facilitate pumping to temporary wetland through removal of existing causeway structure.	Eastern side (left bank) of the River Murray, 7km north-west of Paringa (River kms 603-613)	<p>Improve hydraulic connectivity by removing barriers to flow and fish passage by reinstating more natural flow-through and water level fluctuations in the main anabranch</p> <p>Upgrade infrastructure to facilitate MWWG management of water levels in floodplain wetlands for the following outcomes:</p> <p>Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants aquatic plant community at and below pool level</p> <p>Improve the community viability of river red gum communities by pumping onto the floodplain</p> <p>Maintain diverse frog communities, including Southern bell frog</p> <p>Control Common carp (<i>Cyprinus carpio</i>) to ensure optimal plant growth in the southern lagoon</p> <p>Maintain diverse native fish and waterbird communities</p> <p>Control willow and other pest plant species</p>	nil
Woolenook Bend	Increase regional availability of permanently flowing water by removing Jermacans Causeway, reinstating the natural bank at Fisherman’s Cutting and possibly dredging Plummers/Squiggly Creek where deemed necessary.	The Woolenook Bend site is located north of Renmark and just downstream from Murtha - Weila	Improve hydraulic connectivity in Plummers/Squiggly Creek to restore habitat for large-bodied native fish by providing favoured permanent flow-through creek habitat (currently regionally scarce), decreasing sedimentation and facilitating scour to restore deep hole habitat, and increasing passage between wetland, creek and river habitats	nil

Wetland	Description of activities	Location	Expected ecological outcomes	Estimated Water Savings (GL/year)
Goat Island and Paringa Paddock	<p>Increase frequency of inundation of the Paringa Paddock floodplain River Red Gum and Lignum vegetation community by installing a culvert with the ability to control water flows under the 'Old Paringa Road' track; increase flow through the floodplain to the terminal end of 'Old River' by replacing the 'Old Culvert'; increase capacity of whole system to pass through more water, and ensure that when inundating the floodplain there is still sufficient flow through 'The Billabong' by replacing the upstream inlet culvert; investigate need for small scale dredging or embankments to enable flooding of the Paringa Paddock floodplain and enable flows through the temporary basins into the 'Old River' wetland.</p>	<p>Connected to the River Murray, just downstream of Lock 5, located on the west side of the River between Renmark and Paringa (River km 560-566)</p>	<p>Maintain or improve River Red Gum (<i>Eucalyptus camaldulensis</i>) condition within the lower lying areas of the Paringa Paddock floodplain section</p> <p>Maintain or improve Tangled Lignum (<i>D. florulenta</i>) condition and extent within the lower lying areas of the Paringa Paddock floodplain section</p> <p>Maintain or improve diverse frog communities, including Southern bell frog (<i>L. raniformis</i>)</p> <p>Improve surface water salinity in the Old River permanent channel</p> <p>Improve the condition of the lower lying salinised temporary basins between the 'Old River' and the River channels</p>	<p>nil</p>
Pyap Horseshoe	<p>Dredging of main eastern creek connection to increase permanent flowing water; replace current dilapidated pipes with box culverts to increase fish passage and hydraulic connectivity on the eastern creek; replace current flow restricting wetland crossings with a fish friendly regulator; remove shallow levee on northern section of wetland (constructed during the</p>	<p>Located within a large bend of the River Murray (left bank); 10km from Loxton (River Km 466)</p>	<p>Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level</p> <p>Control common carp (<i>Cyprinus carpio</i>) to ensure optimal plant growth</p> <p>Create permanently flowing habitat (currently regionally scarce) through the floodplain</p> <p>Establish diverse frog communities, including Southern bell frog (<i>Litoria raniformis</i>)</p> <p>Maintain diverse native fish communities and increase passage between wetland, creek and river habitats (adjacent to known deep water fish habitats in river)</p> <p>Improve the community viability of river red gum and black box</p>	<p>0.049</p>

Wetland	Description of activities	Location	Expected ecological outcomes	Estimated Water Savings (GL/year)
	drought); excavate silted north-western connection.		communities by temporarily holding water to optimise short peaks in river levels Optimise use of high river levels to inundate temporary shallow lagoons.	
Irwin Flat	Increase hydraulic connectivity by remediating the causeway across Carinya Creek to improve flow and fish passage, and excavating the channel between Carinya Creek and Irwin Flat Lagoon; facilitate restoration of a more variable littoral zone by constructing a regulator to control water levels in Irwin Flat Lagoon and constructing an embankment to dissect the impounded area from Carinya Creek (may contain regulators).	On the eastern bank of the river; 13km upstream of Blanchetown; River kms 290-294.	Improve hydraulic connectivity in Carinya Creek to improve fish habitat Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level Improve the community viability of River red gum (<i>Eucalyptus camaldulensis</i>), Lignum (<i>Duma florentula</i>) and River cooba (<i>Acacia stenophylla</i>) by facilitating recruitment below pool level Maintain threatened fish communities, including Eel-tailed catfish (<i>Tandanus tandanus</i>) and Silver perch (<i>Bidyanus bidyanus</i>). Control common carp (<i>Cyprinus carpio</i>) in Irwin Flat Lagoon to optimise plant growth Increase diversity of frogs and waterbirds	0.008
Sugar Shack	Construct four new regulators on three permanent wetlands to introduce intermittent regime; pump to two temporary wetlands to generate an intermittent regime; improve hydraulic connectivity and fish passage by dredging creeks, upgrade crossings with culverts and removing rock banks across the creeks.	Eastern side (right bank) of the River Murray, 4km north of Swan Reach (River Kms 251 to 261)	Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level Enable young Wuri/Karrarru (River red gums) to establish and improve community viability of river red gum communities by optimising the water regime Increased abundance and breeding success of culturally significant fauna Increase abundance of Menperi (frogs) communities	0.291
Silver Lea	Improve hydraulic connectivity and enable water level management with the construction of two regulators through the embankments.	Western bank of the River Murray; opposite Swan Reach, (River km 244)	Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level Promote breeding by Black swan and other water birds Provide resources for at least 27 waterbirds including seasonal exposure of mud flats for migratory waders Control common carp (<i>Cyprinus carpio</i>) to ensure optimal plant growth	0.089

Wetland	Description of activities	Location	Expected ecological outcomes	Estimated Water Savings (GL/year)
			<p>Establish diverse frog communities, including Southern bell frog (<i>Litoria raniformis</i>)</p> <p>Maintain diverse native fish communities and increase passage between wetland, creek and river habitats (adjacent to known deep water fish habitats in river)</p> <p>Enable young River red gums to establish and improve community viability of river red gum communities by optimising the water regime</p>	
Big Bend	<p>Improve hydraulic connectivity and fish passage with the construction of regulators through the two embankments currently crossing the two constructed channels connecting the wetland to the main channel – replacing current small pipes. Some vegetation clearance in one of the channels to improve hydraulic connectivity.</p>	<p>North-west side (left bank) of the River Murray 7km south-east of Swan Reach (River kms 232)</p>	<p>Control Common carp (<i>Cyprinus carpio</i>) to ensure optimal plant growth</p> <p>Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level</p> <p>Maintain diverse native fish communities</p> <p>Establish diverse frog communities, including Southern bell frog (<i>Litoria raniformis</i>)</p> <p>Maintain diverse bird community</p> <p>Through monitoring and adaptive management, test our understanding of drier water regimes, and the benefits and risks to native flora and fauna.</p>	0.095
North Caurnamont	<p>Increase the hydraulic connectivity and fish passage between the south and middle lagoon and middle and northern lagoons, with the construction of fish-friendly culverts on the embankments between the lagoons. Construct a regulator on the embankment between the southern and middle lagoons. Some vegetation clearance in northern lagoon to increase hydraulic connectivity.</p>	<p>Following the western side (right bank) of the River Murray, River km 197.</p>	<p>The unique nature of the three connected lagoons presents the opportunity to have three different water regimes – permanent (southern lagoon), partial dries only (middle lagoon) and a mixture of partial and complete dries (northern lagoon) – to create a mosaic of aquatic habitats within one wetland complex.</p> <p>Protect and increase three threatened aquatic plant populations</p> <p>Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants</p> <p>Establish diverse frog communities, including Southern bell frog (<i>Litoria raniformis</i>)</p> <p>Control common carp (<i>Cyprinus carpio</i>) in the northern lagoon to ensure optimal plant growth</p>	0.057

Wetland	Description of activities	Location	Expected ecological outcomes	Estimated Water Savings (GL/year)
Teal Flat	Improve hydraulic connectivity and fish passage through the installation of new fish- friendly regulators through the northern and southern embankments. Improve hydraulic connectivity with some targeted vegetation clearance in the connection channels.	Located on the northern side (right bank) of the River Murray near Purnong (River km 176)	Protect endangered aquatic plant populations Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants Maintain diverse native fish communities Establish diverse frog communities, including Southern bell frog (<i>Litoria raniformis</i>) Maintain waterbird communities	0.034
Teal Flat Hut	Improve hydraulic connectivity by clearing vegetation and constructing regulators on the two connections. Improving hydraulic connectivity of the two basins by dredging the narrow gap between them.	Northern side (right bank) of the River Murray near Purnong (River km 175)	Establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants aquatic plant community Maintain diverse native fish communities Improve conditions for water fowl, waders and shorebirds. Establish diverse frog communities, including Southern bell frog (<i>Litoria raniformis</i>) Control Common carp (<i>Cyprinus carpio</i>) to ensure optimal plant growth	0.027
Donald Flat (reserve site)	Construct an embankment containing regulators across the northern end of the main basin, thereby creating a managed wetland of diverse littoral vegetation and saving water to be partially used for establishing Black box. Dredge channels to temporary lagoons and install regulators to enable optimal watering of Black box communities.	Donald Flat is located approximately half way between Morgan and Blanchtown and is situated immediately downstream of the Murbko South RRP site.	Establish an open Black Box woodland at pool level that can supply fresh seed, as needed (mitigating climate impact by establishing Black box at lower elevation) Prevent loss of Hornwort and establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level Create interconnected mallee, samphire, Black box, littoral, open water, riparian and riverine habitats, ideal for EPBC-listed Regent parrot Establish diverse frog communities, including Southern bell frog (<i>Litoria raniformis</i>) Maintain diverse native fish communities Control pests, including Common carp (<i>Cyprinus carpio</i>) to ensure optimal plant growth in the managed sections	0.037

Wetland	Description of activities	Location	Expected ecological outcomes	Estimated Water Savings (GL/year)
Kroehns Landing (reserve site)	Improve hydraulic connectivity and enable water level management with the construction of one regulator on the downstream river connection and remediation of one regulator of the upstream river connection.	Kroehns landing is one of the more southern (downstream) of the RRP sites and is downstream of Swan Reach and just downstream of the Big Bend site.	<p>Support the voluntary establishment of Lignum shrubland at pool level (mitigating climate impact by promoting floodplain species at lower elevation)</p> <p>Prevent loss and enhance a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level</p> <p>Create interconnected mallee, samphire, Black box, Lignum, littoral, riparian and riverine habitats, ideal for EPBC-listed Regent parrot</p> <p>Establish diverse frog communities, including Southern bell frog (<i>Litoria raniformis</i>)</p> <p>Increase the diversity and abundance of waterbirds, including cryptic bird species</p> <p>Control pests, including Common carp (<i>Cyprinus carpio</i>), by completely drying the wetland twice in two years to ensure optimal plant growth</p>	0.068
Caurnamont (reserve site)	Construct an embankment with fish-friendly culverts and regulators near the southern connection. Upgrade the (current) northern embankment with fish-friendly culverts and regulators. Increase hydraulic connectivity with selective vegetation clearance in both the northern and southern connection channels.	The Caurnamont site is the southern most of the RRP Phase 2 reserve sites and is just upstream of the Teal Flat and teal Flat Hut sites.	<p>Re-establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants</p> <p>Improve condition and structure of surrounding woody riparian vegetation including River red gums</p> <p>Promote successful breeding of and recruitment of waterbirds, especially Black swan (<i>Cygnus atratus</i>)</p> <p>Maintain diversity of native fish, especially use of the wetland by large-bodied native fish</p>	0.041

Project Achievements

The Wetland Project 1-C (Investigations for New Wetland Management) has demonstrated a range of achievements. These achievements have been listed below, in the three key areas of Environmental Impact, Improved Knowledge and Community Impact and Understanding.

Environmental Impact

Minimal direct on ground environmental impacts were generated via the Wetlands 1-C (Investigations for New Wetland Management) project. The Wetlands 1-C Project was all about investigations, planning and preparation for future wetland environmental works and wetland management. To this end the Wetlands 1-C project was very successful in identifying and investigating potential RRP Phase 2 Wetland sites and ultimately undertaking all required planning and preparation for the final list of 11 wetland sites to the point of being shovel ready. Consequently, no on ground works were undertaken, nor were any wetlands actively managed under the Wetlands 1-C project. It was envisaged that the significant work undertaken by the Wetlands 1-C project will result in a significant positive environmental impact through the RRP Phase 2 Wetlands Project.

Improved Knowledge

The key output of the Wetlands 1-C project was the investigation, planning and preparation for future wetland environmental works and wetland management. This required a large amount of knowledge to be generated relating to a host of potential future wetlands sites for environmental management.

Ecological Objectives and Monitoring

Important knowledge was generated to identify ecological objectives and targets to include in the ecological monitoring plan for each of the final 11 1-C wetlands sites. This knowledge was generated by conducting baseline surveys (and other relevant surveys where available), seeking expert ecological advice as well as consultation with landholders and the local community. The baseline surveys collected data on each wetlands fish, bird and frog communities; understory vegetation; tree condition; and groundwater and surface water quality. Where appropriate the data from the monitoring that was undertaken at the 1-C sites was uploaded to the BDBSA, Hydstra and SA Geodata databases.

Hydrological Modelling & Water Saving Estimations

Hydrological modelling was undertaken and contributed to two key areas of project knowledge; firstly, the hydrological modelling provided an input into the wetland management plans regarding when structures should be opened and closed in order to wet or dry wetlands to a certain point by a certain time. The second key output from the hydrological modelling was the quantification of anticipated water savings.

The Wetlands 1-C project was able to calculate the annual water savings which are due to be achieved when all of the 1-C wetland sites are being actively managed in accordance with the wetland management plans and after all on ground works have been completed. These calculations indicated that when managed the final 11 1-C wetland sites will generate 0.65GL of water savings per year. This valuable knowledge was generated by using the SWET hydrological modelling approach. The SWET model looked at local climatic conditions and wetland morphology (depth and surface area of a wetland) to determine an average water savings estimate based on average climatic conditions and the time at which regulating structures were closed.

Hydrograph Modelling

Another valuable piece of knowledge which was generated by the Wetlands 1-C Project was the results from the hydrograph modelling. The hydrograph modelling generated hydrographs for each 1-C wetland site, which were incorporated into the Wetland Management Plans. The hydrographs acted as a tool to balance out the best way to achieve the differing ecological objectives. Some ecological objectives were complementary, for example carp eradication and improving wetland bed vegetation both relied on drying the wetland to achieve their objectives, but others such as improving small bodied fish habitat relied on high water levels and therefore the hydrograph mapped out the best way to manage the wetland and the water levels in such a way that a balance was achieved between the needs of the different ecological objectives. The hydrograph would specify when regulators should be opened to achieve set water levels by certain dates.

Undertake Pre-construction activities

The Wetlands 1-C project did a lot of work to ensure that all identified on ground work would be shovel ready for implementation under the RRP Wetlands Phase 2 Project. Knowledge which was ascertained to ensure this happened included; preparing all necessary legal approvals and land access agreements, undertaking necessary geotechnical investigations, site surveys and ensuring all necessary design criteria were established and finally ensuring these all inputted into the final detailed designs.

Community Impact and Understanding

Communications and Community Engagement

Of the 24 potential long list Wetlands 1-C project sites, 22 were located on private property. Most of these 22 sites that were privately owned were also located across numerous landholders. It is estimated that approximately 70 landholders were consulted as part of the Wetland Management Plan composition process. All Wetland Management Plans incorporated landholder consultation and most management plans contained some peripheral landholder and community consultation.

The initial contact with landholders consisted of phone calls and e-mails to explain the project and the intended process for works at the site. Further consultation and community information activities were only then progressed at sites with landholders that had expressed an initial agreeance with the proposed wetland activities. The project delivered an open communication process which fully disclosed all potential works and related processes and activities with all landholders.

A number of broader community consultation events were also conducted which targeted the local community beyond the immediate site landholders. These events mainly took the form of 'open house' style information events or town hall style meetings. Some notable community consultation events took place at Walker Flat in relation to the Lake Bywater site (not one of the final 11 sites).

Landholder engagement and communications was a very important aspect of the project. This was especially the case given the challenges in keeping landholders engaged and supportive given the long passage of time between the initial landholder discussions in 2013/14 and the commencement of on ground works in 2017/2018.

Project Benefits

The Wetlands 1-C (Investigations for New Wetland Management) Project targeted up to 11 priority wetland sites, one of which was the Sugar Shack Wetland complex. The Sugar Shack site is a culturally important site and one at which the Traditional Owners were able to play a prominent role in the delivery of RRP works and in the ongoing management of the Sugar Shack site.

Wetlands 1-C (Improved Wetland Management): A Case Study

The Sugar Shack Complex, is a system of complex wetlands and anabranch creeks located on lower Murrundi (the River Murray) immediately upstream of Swan Reach, South Australia. The property, known as Sugar Shack, is owned and managed by the Sugar Shack Aboriginal Corporation.

Cultural significance

The Sugar Shack site is and has always been a site of major cultural significance for the Traditional Owners (Nganguraku and Ngaiawang). The Traditional Owners highly value the Sugar Shack site for both its plentiful supply of fish and yabbies' as well as it being a site of great cultural significance. The Sugar Shack site's cultural significance owes largely to it being home to numerous valuable cultural materials such as reeds for weaving baskets, specific trees for spears and building materials as well as the site being used for a range of cultural ceremonies and as an important meeting place. Today the site remains an important meeting spot for intergenerational family gatherings, connecting to country with shared time spent camping and fishing.

The works which were undertaken as part of RRP were able to do two key things which meant a great deal to the Traditional Owners of the site. These were to improve the environmental condition of the site and to improve site access to and around the site.

Improving environmental condition

The RRP works were able to re-connect and improve flows at key parts of the Sugar Shack site and better regulate environmental flows. When a site visit was undertaken in September 2019, after works were completed, the Traditional Owners were already able to report improved flows, an increase in bird and fish numbers and improved water quality. This meant a great deal to the Traditional Owners as they were watching the site return to a similar environmental character to that which originally made it so plentiful and culturally important many years before.

Improving access

Almost as important to the Traditional Owners as the environmental restoration of the site was the significantly improved site access that was made possible through the RRP works. A key part of ensuring the continued and renewed connection to site and getting younger generations onto the site to share stories and build understanding and connection is site access. Due to the many access tracks that were built as part of RRP the Traditional Owners now have greatly improved access, which means the site is visited more often and that community elders are able to more easily visit the Sugar Shack site.

Maintaining and restoring cultural connection

The combined RRP benefit of environmental restoration and improved site access is helping to maintain and restore cultural connection to the site and once more make it a central focus for the next generation of Nganguruku and Ngaiawang people. The improved access and environmental condition of the site has seen it become a central meeting point for family camping and fishing trips. The restoration of the Sugar Shack site has provided an invaluable opportunity for the Nganguruku and Ngaiawang elders to introduce a new generation to the Sugar Shack site and to show them why the Sugar Shack site has been such a culturally significant place for such a long time.



Figure 39: Sisters Issy and Ivy Campbell and their mother Anita Hunter, Traditional Owners and proud custodians of the Sugar Shack site.



Figure 40: A new crossing and regulator at the Sugar Shack site.

Challenges and Lessons Learnt

The Wetlands 1-C Project encountered several challenges over the course of project implementation and learnt several important lessons.

Underestimation of project time contingencies

There was an overall project tendency to underestimate timeframes. For example, landholder consultation and reaching agreements took a lot longer than the time allocated. Landholders needed sufficient time to be engaged and have time to reflect and seek legal advice; however, this was not adequately reflected in the project schedules. Another event which caused project delays was the significant floods which occurred in 2011/2012, although unexpected, additional project time contingencies would have made this situation less critical.

Time between detailed design completion and on ground works commencing

The detailed designs created under Wetlands 1-C were generally completed around 2013/14; however, the construction of these detailed designs did not occur until 2017/2018 after Wetlands Phase 2 was formally approved in 2016. This significant gap between the detailed designs and construction caused some issues. For example within that time, land ownership may have changed, access tracks may have changed or landholders may have changed their mind about the intended works on their land. Approximately half of all detailed designs created under Wetlands 1-C needed to be re-visited and modified due to the significant passage of time prior to construction taking place. Although the RRP project team were not able to do much to negate this situation, if a comparable project was to occur again a greater emphasis must be placed on more quickly progressing on-ground works once initial landholder approval was obtained and detailed designs created.

Project 4: Phase 1 – Enhanced River Operations and Weir Pool Manipulation

The Phase 1 – Enhanced River Operations and Weir Pool Manipulation Project undertook investigations, planning and preparation for future weir pool manipulation events and modified river operations. Weir pool manipulations seek to return more natural variations in water level following River regulation. This aims to enhance the environmental benefits from small to medium flows, and provide benefits to in-channel and low-lying wetland and floodplain areas. The Project addressed the ecological impacts associated with reduced water level variability and connectivity that had arisen due to the construction and operation of the locks and weirs on the River Murray. The Project was implemented using a weir pool manipulation regime across Lock and Weirs 1 to 6 in South Australia.

Water level manipulations can vary in magnitude, rate of change, duration, timing and frequency. The Enhanced River Operations and Weir Pool Manipulation Project achieved significant ecological benefit by manipulating these variables in order to more closely mimic pre-regulation conditions to enhance native species health and prevalence, while at the same time operating within and managing the constraints and risks to other river users.

The Project considered ways to optimise environmental responses to various flow regimes given the constraints of limited volume, delivery infrastructure and the needs of other users. The Project explored these issues and delivered an increased understanding of, and capacity to, undertake weir pool manipulations as well as the capacity to operate the River to deliver the optimal outcomes from all potential management methods available.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the RRP Evaluation process it was found that the Phase 1 – Enhanced River Operations and Weir Pool Manipulation project made a direct and meaningful contribution to the below RRP aim/outcome.

Improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management.

The outcomes were able to be achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that Phase 1 – Enhanced River Operations and Weir Pool Manipulation project successfully completed all critical project activities, these included:

- conducting baseline monitoring for weir pool manipulation sites;
- identifying inundation modelling scenarios;
- developing the environmental flow and conceptual models;
- identifying the secondary structure sites;
- identifying all necessary State and Australian Government Approvals; and
- developing a communication plan and community engagement strategy.

The cumulative outcome of the implementation of the above activities was the successful achievement of the projects short term goals of:

- the successful quantification of salinity impacts;
- the generation of a pump off-takes database;
- an inundation model to guide weir pool manipulation events;
- assessing key risks of manipulation events and calculating water use estimations;
- completing an environmental flow delivery and options assessment identifying opportunities for optimising environmental flows;
- Undertaking detailed designs and costings for secondary structures.

Project Achievements

The Phase 1 – River Operations and Weir Pool Manipulation Project has demonstrated a range of achievements. These achievements have been listed below, in the three key areas of Environmental Impact, Improved Knowledge and Community Impact and Understanding.

Environmental Impact

Minimal direct on ground environmental impacts were generated via the Phase 1 – Enhanced River Operations and Weir Pool Manipulation Project. The Project conducted investigations, planning and preparation for future weir pool manipulation events and modified river operations. To this end the Phase 1 – Enhanced River Operations and Weir Pool Manipulation project was very successful in planning for future weir pool manipulation events and modified river operations; however, during the course of project implementation no actual weir pool raising or lowering events took place (nor were they planned) and therefore there can be no direct on ground environmental impact attributed to this project. The project did enable significant positive environmental impacts to be realised as part of the Phase 2 - Enhanced River Operations and Weir Pool Manipulation Project, through the extensive weir pool raising events which took place.

Improved Knowledge

The key output of the Phase 1 – Enhanced River Operations and Weir Pool Manipulation project was the investigation, planning and preparation for future weir pool manipulation events. The project was designed to generate sufficient knowledge to proceed with weir pool manipulations and modified river operations. To this end, significant knowledge was generated, including:

Quantification of salinity impacts

The Phase 1 – Enhanced River Operations and Weir Pool Manipulation project was able to conduct salinity investigations and quantify the risks associated with weir pool manipulation events. The Project undertook salinity modelling, the result of which was a scoring system that was used to rank the locks in increasing order of salinity risk. The ranking scores varied from 100 to 184. The lowest score (being the lowest salinity risk) was for raising weir pool 1 by 0.25m during a 20GL/d flow. The highest score (greatest salinity risk) was for raising weir pool 4 by 1.14m during a 20GL/d flow. Overall Lock 4 and Lock 3 were ranked the highest risk sites for salinity impacts, followed by Lock 5, Lock 6, and Lock 2 and Wellington which has the lowest risk. It was also found that the groundwater salinity potential risk increases as the weir pool level increases. The quantification of salinity impacts allowed the project to adequately monitor and mitigate risk when raising weir pools at different sites.

Pump off-takes data base

Pump surveys were conducted at Lock 3 - 4 and Lock 4 - 5 reaches. A total of 516 pumps were examined and 469 pumps tagged. The extensive pump survey identified those pumps along the River Murray between Lock 3 and 5 that could potentially be affected by the manipulation of weir pools and resulting river height. For those irrigation and recreation pumps that draw water from the River Murray, the surveys determined the impact on pumps of lowering the water level by minus 0.3 metres to minus one metre below the normal operating pool height.

Spatial information was also developed for pump locations and is contained in a GIS layer owned by DEW. This is the first time a complete data set of all irrigation pumps and the majority of stock and domestic pumps between the border and Lock 1 / Wellington has been available in the one place. This data greatly assisted in the planning and undertaking of weir pool manipulations and also assisted in the delivery of the RRP Wetlands Projects.

Inundation model

Potential weir pool raising scenarios were modelled to identify wetland connection issues and to show which areas would be flooded under different weir pool manipulation scenarios at different flow rates. The results were considered to be sufficiently accurate for identifying those scenarios that offered significant ecological benefits. The model of the River Murray between Lock 1 / Wellington and Lock 2 was adapted to model a small number of weir pool raising scenarios for Lock 1 / Wellington. The model was calibrated to these "lower" flows, which primarily consisted of determining appropriate variables for the flow ranges to be modelled and identifying wetland connection issues.

Environmental flow delivery and options assessment

Hydrological test models were performed to generate important knowledge in relation to the needs of certain structures, what the project risks were and how to manipulate weir pool levels. The information gathered through the hydrological test models helped to identify that raising weir pools 0.2m to 0.5m provided the desired environmental outcomes that were sought. It was also identified that small elevations in weir pool resulted in the same environmental response as a large scale flooding scenario.

Detailed designs and costings of secondary structures

A range of investigations were conducted around possible secondary structure work which needed to be undertaken relating to the weir pool raising events. A secondary structure is a structure which may be impacted by weir pool raising, at which additional works may be required to mitigate any potential negative effect from the increased water level; an example could be raising an access track which becomes inundated during a weir pool raising event. Secondary structure site investigations covered landholder's properties, access roads, pumps, and pump locations. The investigations entailed surveys, onsite investigations, monitoring of weir pool raising, and responses to calls from the public.

The end result of these investigations was that several secondary regulating structures within the riverine environment were identified as requiring upgrades or alterations to prevent overtopping, erosion, failure or other damage associated with weir pool raising and to contribute to improved outcomes from weir pool raising. Designs and costing were developed for these initial secondary structures. These sites were further refined during the actual weir pool raising events which took place as part of the Phase 2 – River Operations and Weir Pool Manipulation Project as well as additional secondary structures being identified.

Community Impact and Understanding

Prior to the commencement of the Phase 1 – River Operations and Weir Pool Manipulation Project, there had already been a significant amount of community consultation undertaken in the area of Weir Pool Manipulation through other projects. Due to the fact that a significant amount of community consultation had been undertaken but no weir pool manipulation had actually taken place, the community were suffering from consultation fatigue, and had already clearly indicated their support for weir pool manipulation. However, a Communication and Community Engagement Strategy was still created for this project, but on the whole, the focus of the strategy was on internal government to government communication, with some external non-government communication. Engagement with the community was much more relevant and prevalent during the Phase 2 - River Operations and Weir Pool Manipulation Project, when weir pool raising activities were actually taking place.

Project Benefits

The Phase 1 – River Operations and Weir Pool Manipulation project was critical in laying the foundations for successful long term weir pool manipulation for environmental benefit. A key part of these foundations was developing the Digital Elevation Model.

Phase 1 – River Operations and Weir Pool Manipulation Case Study

In 2011, the Science Group of DEW undertook a large and critical piece of work which would significantly improve the effectiveness of the Phase 1 & 2 River Operations and Weir Pool Manipulation Project Elements.

This piece of work was known as the Digital Elevation Model (DEM). Prior to the creation of the DEM there was no single adequate resource relating to the topography and bathymetry of the River Murray and surrounds (banks, wetlands, channels and floodplains). In creating the DEM several existing resources were identified and 'stitched together' to form a single detailed point of truth for exploring the topography and bathymetry of the river and surrounds and to subsequently model inundation effects and required water volumes for wetland, bank and floodplain inundation. This information was critical in successfully modelling and implementing the inundation extent to be delivered through Weir Pool raising events and the amount of flows / water required to do so.

In building the DEM model a range of existing information sources were used and 'stitched together'. This primarily comprised of starting with the existing satellite imagery (which was the default information source prior to the DEM) and adding the more detailed Lidar detailed imagery, adding structural locations from LGA databases and adding river channel bathymetry. The DEM was then further refined through a series of ground truthing exercises, such as surveying of sill heights for structures and river flow connections and collecting detailed bathymetry for wetlands.

Prior to the DEM, equivalent modelling tended to rely solely on satellite imagery which did not provide the level of detail necessary to accurately model inundation effects and water requirements.

The DEM was a key input to the surface water model which made it possible for the first time to accurately model likely inundation outcomes from weir pool raises by predicting the water levels and which flow connections are active along the entire SA River Murray in relation to the level of weir raising and flow in the river. This in turn made it possible to model the amount of environmental water required to undertake set weir pool raising events to achieve a pre-defined inundation. Critically, the DEM was able to model the main channel bathymetry and commence-to-flow thresholds, and therefore the extent of weir pool raise required to realise certain flow connections to floodplains and wetlands. The DEM tool was critical in accurately and effectively undertaking weir pool raising as it improved the accuracy of the hydraulic model predictions and also provided direction where investment in relatively expensive on-ground surveys should be prioritised.

The DEM also made it possible to model with a high degree of accuracy the need and location of secondary infrastructure work (to minimise third party impacts of weir pool raising and to enhance the environmental benefit of weir pool raising).

The DEM was created in 2011 and is now a corporate spatial data layer which is maintained as per the corporate standard for knowledge management. It remains a critical tool today for numerous inundation modelling work, including the ongoing raising and lowering of weir pools for environmental benefit.

Challenges and Lessons Learnt

The Phase 1 – River Operations and Weir Pool Manipulation Project encountered challenges over the course of project implementation and learnt an important lesson.

Landholder Communication

Often obtaining landholder contact details was difficult due to the diverse databases used and the fact that they were not aligned. As a result, considerable cross referencing was required. Contacting landholders during both the holiday and dryland cropping periods was more difficult than envisaged and therefore should be avoided for future weir pool manipulation communication. An improved approach to this for future weir pool manipulation events would be to establish a corporate Customer Relationship Management system (CRM). The CRM can assist not only in the delivery of Weir Pool Manipulation but also other parts of the DEW that engage with the community. The CRM would also assist in coordinating engagement with individuals and avoiding duplication of effort and sending out uncoordinated and inconsistent messages.

Project 5: Information Management to Support Decision-Making

The Information Management to Support Decision-Making Project was designed to assist with the adaptive management of aquatic ecosystems where RRP investments were made. The project aimed to provide the monitoring and management capability required to implement an adaptive management system for the River Murray in South Australia.

In an environment where there are multiple managers of wetlands associated with the River Murray, the information collected can be inconsistent and un-coordinated. Information, including data collection and analysis, is the primary driver for adaptive management. The information gained from monitoring the responses to specific management actions, or by utilising research outputs, underpins sound adaptive management and policy decisions.

The Information Management to Support Decision Making Project is made up of three components (Monitoring Plan, Management Action Database and Ecological Response Models) which, when combined, improved knowledge and understanding about management for water dependent ecosystems.

Monitoring and Evaluation (Monitoring Plan)

A first step in the implementation of this project was the development of a monitoring plan. Specifically, the monitoring plan progressed biological conceptual models that followed on from work developed under the RRP start-up funding, including wetland geomorphic conceptual models. Ecosystem response research needs were identified, related policy questions were developed and research was encouraged through research agencies such as South Australia's Goyder Institute and universities.

The Monitoring and Evaluation component of the project had the following initial outcomes:

- ensuring decisions and actions for floodplain work, changed wetland management regimes and river operation decisions, were examined and reviewed; and
- increasing knowledge and understanding of water-dependent ecosystems.

Management Action Database (MAD)

With the increasing number of wetlands being managed the data related to ecological response as well as the actual operations of the sites that drive the response has grown. There were already concerns with the secure storage of ecological response data at operational sites and no centralised capture of management actions. The concept behind MAD was therefore to develop a platform to simplify the capture of that data and its accessibility. The MAD triggers management action through email notifications based on planned management actions as defined in the wetlands management plans, and captures data on operations and ecological response as well as site specific background data. This has enabled transparent, robust decision-making through data. The data is stored in a centralised location, ensuring data integrity, effective retrieval and ease of analysis into the future. The MAD project addressed the need for quality data management that supports adaptive management, environmental water monitoring and other management activities.

The MAD project analysed business requirements and investigated options to build on past efforts. The outcome was an improvement of the consistency and coordination of the management information. The data provided inputs into the decision-making capabilities ensuring best management practices in the wetlands and the best use of resources to maximise ecological results.

The MAD component of the project had the following initial outcome:

- improving consistency and coordination of data entry and management of current and historical data through the creation of a central repository of data about the River Murray in South Australia.

Ecological Response Models/Integrated Operations Schedules

The ERM's were investigated as a potential tool to help identify RRP wetlands based on their expected ecological response to different management actions. These investigations ultimately led to the decision (as outlined in the lessons learnt section below) to use an alternative method to identify which wetlands to include within RRP.

The Ecological Response Models (ERM) / Integrated Operations Schedules component of the project had the following initial outcome:

- an improved ability to model long term ecological outcomes from altered hydrological management and water availability scenarios.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the RRP evaluation process it was found that the Information Management to Support Decision-Making project made a direct and meaningful contribution to the below RRP aims/outcomes:

- improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management;
- achieve positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning; and
- implement an improved riverine management regime for the River Murray from the South Australian-Victorian border to Wellington.

The outcomes were able to be achieved as a result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that the project successfully completed all critical project activities, which included:

- establish an ongoing adaptive monitoring and evaluation system to enable the assessment of the RRP project outcomes for water dependent ecosystems;
- define required monitoring at each site and establish the monitoring, reviewing and reporting requirements and processes to inform future management;
- develop modules of the MAD to provide a repository for current and historical monitoring and management data collected through existing wetland programs as well as those developed under RRP;
- scripting database on to new hosting environment and development of database queries; and host upgrade / maintain the MAD as required; and
- refine the Ecological Response Models to inform long term ecological outcomes from altered hydrological management and water availability scenarios.

The cumulative outcome of the implementation of the above activities was the successful achievement of the project's short-term goals:

- applying the Monitoring and Evaluation Plan to inform decisions and actions;
- achieving increased knowledge and understanding of water dependent ecosystems;

- an improved data entry and data management system; and
- an improved ability to model long term ecological outcomes from altered hydrological management and water availability scenarios.

Project Achievements

The Information Management to Support Decision Making Project has demonstrated a range of achievements in the three key areas of environmental impact, improved knowledge and community Impact and understanding.

Environmental Impact

No on-ground works were conducted as part of the Information Management to Support Decision Making Project. The project focused on generating knowledge which would improve how other RRP projects were delivered as well as improving the broader understanding of the riverine environment. The project will also influence the long term future operation and management of on-ground works by helping to predict broader on ground impact of site and infrastructure operation and management.

Improved Knowledge

Monitoring and Evaluation Plan

The whole of RRP Monitoring and Evaluation Plan was used to guide the Weir Pool Manipulation events for the duration of RRP. The plan operated as a guiding framework for implementation and monitoring. For example, all weir pool monitoring activities (water quality assessment, bio-film measurement, soil sampling and groundwater monitoring) were informed by the Monitoring and Evaluation Plan. Additionally, new learnings from these monitoring activities fed back into updating and improving the plan.

Management Action Database

The MAD component of the project was not directly related to gaining new or additional knowledge, but instead improving how existing knowledge was collected, stored and utilised. The MAD facilitated improved data entry, analysis and reporting on the River Murray in South Australia. The database allows for improved extraction of information and has also improved DEW's processes for entering data into a single database. By implementing the MAD, protocols for updating data and for entering data into appropriate databases (e.g. biological database versus surface water monitoring database) have been documented and established. The database provides secure data access and storage via the web. Databases are available through the MAD user interfaces. Users can search for data via the spatial interface or via text. Relevant reporting requirements have also been established on an ongoing basis in collaboration with DEW River Murray Operations and NR SAMDB Floodplain and Wetlands Team as they use the MAD.

Ecological Response Models

Improved knowledge of the suitability of the ERM's for identifying wetlands for RRP was generated. After significant investigations, it was decided that the ERM was not the most suitable tool to determine which wetlands to progress. The tool was cumbersome to run and did not provide optimal results to prioritise the close to 100 wetlands. The other factor in not progressing the ERM was that determining ecological responses was only one determinant of many in deciding which wetlands would be progressed. Other key determinants included social value, landholder engagement and cost. A key finding was the importance of having landholder support and how this was often more important than focussing purely on ecological outcomes.

The project changed its focus from using the ERM to utilising the Conceptual Models and Integrated Operating Schedule (IOS) to inform long-term ecological outcomes and to select wetlands which would be progressed as part of RRP (further elaborated below in 'Challenges and Lessons Learnt'). The IOS was developed internally within DEW by its Science Branch. The IOS formally replaced the ERM's around mid-2012. The IOS was designed to best coordinate the management of the many wetlands which were identified to be managed under RRP. For example, when should the many different wetlands commence their respective drying cycles? The IOS runs many different scenarios relating to the wetting and drying of the different wetlands and determines the optimal path of wetland management to replicate what would happen following a natural flooding event. It is anticipated the SA MDB region will use the IOS to determine which wetlands to manage and when.

Community Impact and Understanding

No community engagement or consultation activities were conducted through the project due to its research and information management focus. The local community will experience long-term environmental and ecological benefits as part of the broader RRP of which the Information Management to Support Decision Making Project has played a key enabling part.

Challenges and Lessons Learnt

The Information Management to Support Decision Making Project encountered several challenges over the course of project implementation and learnt an important lesson; some notable challenges included:

Not being able to utilise the Ecological Response Models as anticipated

It was initially envisaged that the ERM would be used to model the long term outcomes from altered hydrological management and water availability scenarios and therefore guide the process of selecting wetlands for inclusion in RRP. However, through exploring and interrogating the tool it was ascertained that this would not be the most appropriate course of action. The initial intent was that an ERM would be a tool that would assist RRP to determine which wetlands to include in RRP solely on likely ecological responses.

The CSIRO were commissioned to create the ERM. There were close to 100 wetlands which needed to be prioritised at the commencement of RRP. The ERM did provide some information on likely ecological responses at each wetland but, overall, the tool was cumbersome to run and didn't provide optimal results. The other factor in not progressing the ERM was that ecological response was only one determinant of many in deciding which wetlands would be progressed. Other key determinants included social value, landholder engagement and cost. A key finding was the importance of having landholder support and how often this was more important than focusing only on ecological outcomes. Instead of progressing the ERM's, the project instead focused on more suitable tools for the task at hand, such as Conceptual Models and Integrated Operating Schedules.

Unforeseen changes in scope and cost

Most cost estimates developed during planning were correct but one exception was the re-scoping of the MAD activity. Initially MAD was set up by the SA MDB region and the proposed design was deemed likely to be quickly superseded and not up to the demands which would be placed on it (setting up web pages with a database behind them). RRP assumed management of the MAD project component, which was subsequently delivered through the Business Technology Information (BTI) branch of DEW. BTI made a strong recommendation for a re-design of this project component which was endorsed by the project manager. This did not impact the overall project budget but did lead to a significant re-working of project budget lines. The final deliverable resulting from this re-design saw a much improved IT solution, with increased usability, adaptability and longevity.

Building relationships between Major Projects and the SA MDB Region

The original project design for RRP was one that was based on projects being owned and run internally by the then SA Department for Water (DfW). When DfW merged with the SA Department of Environment (DEW), additional stakeholders took on a greater role in the project. For example, the SA MDB region took on the role of wetland monitoring, so there was an increased importance of actively engaging the SA MDB to ensure successful uptake of the work that RRP was delivering. Initially, the Monitoring and Evaluation Plan was not being used as anticipated in wetland monitoring. The SA MDB had its own wetland monitoring practices in place, had limited capacity and a degree of skepticism when it came to fully embracing the Wetland Management Plans. This resulted in minimal wetland monitoring occurring during RRP Phase 1.

Over time the relationship between the RRP and the SA MDB wetland monitoring team was strengthened and improved arrangements made to best support resourcing the SA MDB Wetland team. The result of this was that wetland monitoring was able to be undertaken in accordance with the Wetland Management Plan during RRP Phase 2.

Project 6: Communication, Partnerships and Project Management

The RRP Communication Partnerships and Project Management (CP&PM) PE provided ongoing communications, consultation and engagement throughout the life of the project. The Project Element was developed to establish and maintain effective Indigenous, community and government partnerships for project delivery.

As a multi-faceted project, RRP required a coordinated approach to effectively deliver project management and governance activities. The Project Management component of the CP&PM covered internal program management, human resources management, governance, reporting and evaluation, corporate requirements and broader operation and administration.

The Communication and Partnerships component of the CP&PM covered a broad range of partnership and communication activities. Successful implementation of RRP was dependent on the level of engagement and support of a diverse range of key stakeholders including irrigators, community, wetland management groups, researchers and scientists, industries associated with tourism and recreation, landowners and river communities, including Local Government and Aboriginal Traditional Owners.

The CP&PM Project Element had four overarching outcomes, which were to:

- coordinate the development and implementation across all RRP Project Elements;
- increase understanding, awareness and engagement of stakeholders;
- provide ongoing communications, consultation and engagement services; and
- maintain effective Indigenous, community and Government partnerships for delivery of the whole RRP.

Some of the specific activities that were delivered as part of the CP&PM Project Element included:

- developing and utilising promotional materials and maintaining a Riverine Recovery website presence;
- scoping requirements and strategies for negotiating Indigenous partnership arrangements;
- engaging Indigenous communities in the delivery of RRP;
- undertaking consultation with stakeholders;
- developing communications products to showcase how the management of the river is contributing to desired environmental and river outcomes;
- delivering on all financial and project reporting requirements, including Annual Work Plans, Progress Reports, Evaluation and Final Reports.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the RRP Evaluation process it was found that the Community Partnership and Project Management Project made a direct and meaningful contribution to the below RRP aim/outcome.

Increase community knowledge, understanding and involvement in the Riverine Recovery activities

The outcomes were able to be achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that the Communication Partnerships and Project Management project successfully completed all critical project activities, these included:

- developing and implementing an integrated communications plan;
- developing and utilising promotional materials and maintaining a Riverine Recovery website presence;
- negotiating Indigenous partnership arrangements;
- engaging Indigenous communities in the delivery of the Project; and
- consulting and partnering with a range of community partners.

The cumulative outcome of the above activities was the successful achievement of the projects short term goals of:

- developing and delivering the RRP in a coordinated manner;
- increasing the understanding, awareness and engagement of RRP stakeholders;
- providing ongoing communications, consultation and engagement with stakeholders; and
- establishing and maintaining effective Indigenous, community and Government partnerships for delivery of the RRP.

Project Achievements

The Communications Partnerships and Project Management (CP&PM) Project has demonstrated a range of achievements. These achievements have been listed below, in the three key areas of Environmental Impact, Improved Knowledge and Community Impact and Understanding.

Environmental Impact

The CP&PM Project was primarily an enabling and support project for the RRP as a whole, which had a limited on ground works focus. That being said there were some small on ground works that were undertaken as part of the CP&PM that will contribute towards the direct environmental impact of the RRP.

Indigenous Specific RRP Projects

The Indigenous Partnerships component of the CP&PM enabled the RRP to work closely with Traditional Owner partners to identify an additional project. The Putjeda Creek project was a small scale wetland works project, which was designed to improve wetland health and to provide environmental and cultural benefits. The project was implemented as a partnership between the RRP project team and the local Gerard Aboriginal community.

Fund My Project

The Fund My Project initiative provided the community an opportunity to design and pitch ideas for funding, which related to the health and awareness of the River and surrounding communities and environment. In total 12 initiatives were funded with 12 separate community groups or individuals. These projects provided a diverse range of benefit, much of which will make a contribution to the long term environmental legacy of RRP, some of which are described below:

Project Description (legacy)	Community Partner
The restoration of the Paiwalla and Sunnyside wetlands (weeding, track restoration, native planting and installation of interpretive signs)	Conservation Volunteers Australia
Restoration of the Murrundi Reserve Wetland, including weed and reed control, improved visitor access and the installation of interpretive signage)	Goolwa to Wellington Local Action Planning Group
The installation of a bird hide and interpretive signs at frequently visited wetlands to enhance nature based Canoe tourism experiences.	Canoe the River
A walking trail at Maize Island including interpretive signage talking about the importance of environmental watering.	Riverland West Landcare
Creating an interactive boating trail between Taillem Bend and Wellington featuring interpretive signs and geocaches. The trail will increase awareness around native and introduced species as well as the importance of managing wetlands.	Coorong Tatiara Local Action Planning Group
The construction and installation of a viewing platform along with interpretive signage at the Bookmark Creek site.	Renmark Paringa Council
Contributing towards the long term reduction in waste along the River through the installation of 12 bins for fishing tackle waste along River throughout Murray Bridge	Eastern Hills and Murray Plains Catchment Group
A part contribution towards the installation of a board walk at Mypolonga which will allow easier and safer access for recreational fishers and local primary school students to undertake water sampling.	Eastern Hills and Murray Plains Catchment Group
The removal of reeds from the Bookmark Creek site to improve canoe and fish passage.	Renmark Paringa Council

Community Partnership Projects

The Community Partnerships Projects were projects which were not specifically wetland or environmentally focused but did provide opportunities to increase awareness and understanding around the RRP work and River health amongst the local community. These projects provided opportunities for the community be involved and engaged in the delivery of the RRP and included:

An interpretive child's learning space

An interpretive child's learning space at the Murtho Weila site located at the Woolshed Brewery complex. The space uses natural materials to simulate a range of waterways and water-management structures and helps children learn about how water moves down a slope and what can stop or start it flowing. The interactive learning space uses simplified versions of weirs and regulators that children can lift to show how rivers can be managed by stopping water flow, building up water levels behind a 'blockage' etc. The play space also contains a fish maze, which illustrates how structures can allow fish to move from one part of the river to another past a lock.

A cultural re-burial activity

The RRP was undertaken on the land of the First Peoples of the River Murray and Mallee Region, the Ngaiaawang, Ngawait, Nganguruku, Erawirung, Ngintait, Ngaralte & Ngarkat people, the Traditional Owners of that land. The support and engagement of the Traditional Owners working in partnership on this project was critical to the successful delivery of RRP. For example Traditional Owner groups were integral to providing cultural heritage surveys and monitoring work for RRP on ground works. In the spirit of further strengthening and developing the relationship between the project and Traditional Owner groups the RRP was also able to facilitate a cultural re-burial activity at Calperum Station in collaboration with the River Murray and Mallee Aboriginal Corporation (RMMAC).

Improved Knowledge and Community Impact and Understanding

The CP&PM Project provided critical communications support for other RRP Projects. CP&PM also undertook a range of direct activities which enhanced the local communities understanding and appreciation of the unique and important Riverine environment.

The CP&PM Communications team delivered a range of events and communication initiatives that were able to inform the local Riverine community about what RRP was doing and why this was important, these included:

An **end of project event** held at the Paringa Paddock RRP site which celebrated the many RRP achievements and was accompanied by a media release.

A **program legacy education package** was developed. The education package was comprised of an end of project film, a model which simulated floodplain inundation and river level variability, a large interpretive map and a set of revised project fact sheets.

A **revised communications strategy and materials**. In 2017, a revised set of fact sheets were produced which focused more on project outcomes, explaining projects in a connected, holistic way and in a way which could be more easily understood and engaged with by the general public. A key part of this revised approach was a large pictorial map to contextualise all of the projects for both RRP and SARFIIP and how they relate to each other.

The program legacy education package and revised communication materials were shared through **numerous events**, including at, Riverland Field days, Water Allocation Plan Road Show, Karoonda Farm Fair, Riverland bio-blitz and internally with DEW staff.

Participating in delivery

Another method which enhanced the local communities understanding and appreciation of the unique and fragile Riverine environment was via the actual involvement of the community in delivering parts of the RRP. The Communications and Partnerships component of the CP&PM Project prioritised not only sharing information with the community, but also actively engaging the community in RRP delivery. This was done via the innovative "Fund My Project" initiative where the public were encouraged to design and pitch ideas for funding, which related to the health and awareness of the River and surrounding communities and environment. The CP&PM also oversaw

the delivery of a further three RRP driven community partnership projects. In total 15 community partnership projects were delivered, directly engaging numerous different community groups including, different LAP groups, Conservation Volunteers Australia, a canoe tour operator, Landcare groups, Nature Foundation, Local Councils and catchment groups, Indigenous communities and local businesses.

There was one area in which the knowledge and understanding of the Riverine environment was directly improved via the implementation of the CP&PM Project and this was in relation to enhanced cultural heritage knowledge and understanding. The CP&PM Project oversaw extensive cultural heritage surveys and cultural heritage monitoring at each RRP site where on ground works were undertaken. Due to the numerous number of sites at which works were undertaken and the extensive geographic spread along the river of these sites, this was a significant opportunity to survey and formally document a range of culturally significant sites along the River. The two main Traditional Owner groups that oversaw and directed this process were the First Peoples of the Murray and Mallee and the Mannum Aboriginal Community Association Incorporated, and they hold the survey information that was produced.

Project Benefits

The Communications, Partnerships and Project Management project was designed to engage the local community in the Riverine Recovery Project and to raise awareness about the issues faced by the river. The Fund My Project initiative was able to do both by funding the local community to deliver awareness raising projects.

Fund My Project: A Case Study

The Fund My Project Initiative was a unique experimental approach to community led project design and delivery.

The Fund My Project initiative was rolled out to increase public awareness of the issues surrounding river health. This involved the community coming up with ideas, developing project scope and voting on their favourite projects. Using the YourSay website, over 200 people voted and 12 local projects, worth a total of \$200,000, were successful in securing project grants. The successful projects included interpretive signage designed by a Youth Council, canoe trails, a healthy river toolkit and viewing platforms and boardwalks.

The Fund My Project initiative was a response to a lack of community buy in as part of the RRP Phase 1. After speaking with a range of community members and groups it was identified that the community wanted to have more input into what works were undertaken along the river.

All aspects of Fund My Project were community led, the community were involved in submitting applications, considering the merits of the ideas submitted, and subsequently choosing which projects would receive grant funding. The Fund My project initiative was successful in achieving much broader levels of engagement and awareness raising than what were achieved under the traditional RRP Phase 1 delivery model.

We achieved lasting outcomes in the implementation of the projects and opened lines of communication between DEW and community members which may not have been possible through other more traditional channels.

– Emma Pink, RRP Coordinator of Community Engagement

The project has seen community members volunteering to take part in working bees, tours of new walking and canoe trails and people from all facets of the community volunteering to take part in the filming of Riverland, the creative film project. The materials produced are a long lasting legacy and will be used to educate people in the future. The Fund My Project initiative gave the community ownership over the works being carried out on the river. It allowed individuals as well as organisations to propose projects with the only criteria being to raise awareness of the issues faced by the river. The community proposed projects and then the community had the final decision on which projects would be funded.

Additionally the RRP project team gained an increased understanding of what the community values about the river and surrounding region, which also helped to inform the RRP's communication and engagement plans going forward.

These Fund My Projects have left a lasting legacy for RRP which is improving the health of the riverine environment along the South Australian length of the River Murray. The Fund My Project initiative has empowered the community to implement their ideas and assist with increasing awareness.

Challenges and Lessons Learnt

The CP&PM project encountered some challenges over the course of project implementation and learnt some valuable lessons.

The RRP was a complicated project, involving detailed engineering solutions to complicated environmental issues, large construction projects and a complex mix of stakeholders (including landholders). In hindsight a greater margin for slippage in project implementation timelines should have been worked into project plans and budgets. As the CP&PM Project was an enabling project, supporting the implementation of the other nine RRP PEs, when a PE was delayed and extended the CP&PM also required an extension, this ultimately led to a significant increase in budget and timeframe for the CP&PM.

It was found to be very effective embedding the CP&PM Communications team within the regional SA MDB offices (Murray Bridge and Berri). Multiple factors including the geographic location of offices has meant that the local communities situated on or near the River Murray feel a closer connection with the SA MDB as opposed to the centrally CBD located Department for Environment and Water. In an effort to more effectively integrate the work of the RRP Communications and Partnerships Team into the regions where RRP was being implemented, the RRP Communications and Partnerships Team formally moved from being located within Major Projects at the CBD DEW Office to the SAMDB. This was seen as a positive and effective change which resulted in improved insights into the communities the project worked with, improved opportunities for community partnerships, improved networks with local media, better collaboration and learning opportunities between the SA MDB and Major Projects as well as an improved community perception of the RRP project being part of the local community.

Another lesson learnt was in relation to the monitoring and evaluation process that was undertaken. The monitoring and evaluation process was introduced in the second half of the RRP in order to produce the Final and Evaluation Reports. The process was fit for purpose, to produce a single final evaluation report. However, this was a missed opportunity to add a mechanism to inform ongoing adaptive project improvements informed by an ongoing monitoring and evaluation system. This would have required monitoring and evaluation to be integrated within project planning and reporting from project commencement to project conclusion.

Project 7: Phase 2 – Enhanced River Operations and Weir Pool Manipulation

The Phase 2 – Enhanced River Operations and Weir Pool Manipulation Project was designed to return some of the natural variations in water level; enhance the environmental benefits from small to medium flows; and provide benefits to in-channel and low-lying wetland and floodplain areas. The Project addressed the ecological impacts associated with reduced water level variability and connectivity that had arisen due to the construction and operation of the locks and weirs on the River Murray.

Water level manipulations can vary in magnitude, rate of change, duration, timing and frequency. The aim of weir pool manipulation is to achieve the greatest ecological benefits by manipulating these variables in order to more closely mimic pre-regulation conditions to which native species are adapted. At the same time a range of operational constraints and risks to other river users needed to be overcome or effectively managed.

Weir Pool raising was undertaken in 2014, 2015 and 2016 across three different locks. All weir pool raising events were undertaken in spring. In 2014, an additional 365ha was inundated as a result of the weir pool raising activities at locks 1 and 5. In 2015, an additional 960ha was inundated and in 2016 an additional 1264ha was inundated. The key benefits of the inundation was the creation of habitat and biodiversity corridors for biota.

No Weir Pool lowering was undertaken as part of the Project Element; however, a comprehensive weir pool lowering feasibility assessment was undertaken in 2016. Additionally, Weir Pools 3 and 4 were not raised during the PE because of backwater issues. Both of these weir pools, if raised would connect with backwaters with very high salt content.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the RRP Evaluation process it was found that the Phase 2 – Enhanced River Operations and Weir Pool Manipulation project made a direct and meaningful contribution to the below RRP aim/outcomes:

- implement an improved riverine management regime for the River Murray from the South Australian / Victorian border to Wellington;
- maintain and improve water dependent ecosystem health, resilience and connectivity; and
- increase community knowledge, understanding and involvement in Riverine Recovery activities.

The outcomes were able to be achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that the Phase 2 – Enhanced River Operations and Weir Pool Manipulation project successfully completed all critical project activities, these included:

- undertaking investigations to assess inundation extent to be derived from improved river flow management (including weir pool raising and lowering);
- construct required infrastructure to facilitate weir pool manipulations;
- complete the baseline monitoring and ongoing monitoring of weir pool manipulations for each year for the project;
- consult with the Murray-Darling Basin Authority and the Commonwealth Environmental Water Office in relation to the Commonwealth Environmental Water allocations;

- ensure linkage with proposed monitoring and evaluation activities undertaken by other Commonwealth initiatives;
- complete a risk assessment at the beginning of the project and at the end of each year's weir pool manipulation; and
- obtain necessary State and Australian Government approvals as required.

The cumulative outcome of the implementation of the above activities was the successful achievement of the project's short-term goals of:

- increased knowledge of means of improving environmental river management through weir pool manipulation and community acceptance of manipulations;
- improved lateral connectivity/transport process (water, nutrients, biota) between the river and the floodplain fringe; and
- collection and storage of ecological monitoring data to inform weir pool manipulations and increase system knowledge.

Additional Secondary Infrastructure Project Component

The original 2013 project design included four secondary infrastructure sites (Nikalapko Flat, Paisley Island, Causeway Rd, and Schillers Lagoon). These four sites focused on minimising third party impact. Of these four sites Paisley Island was the only one which was completed on time as part of the original 2014/2015 scope of works. Nikalapko Flat was postponed due to higher than anticipated costs, Causeway Road was postponed due to unanticipated landholder issues and Schillers Lagoon was delayed and subsequently removed from scope due to difficulties in securing a suitable contractor to undertake the work. The two delayed project sites were completed as part of the Phase 2 – Enhanced River Operations and Weir Pool Manipulation across the 2018/19 revised scope of works.

In 2017, an opportunity was identified to maximise the environmental impact of the ongoing annual Weir Pool events manipulation via adding an additional four secondary infrastructure sites. The new sites tended to focus on maximising the ecological outcome from existing weir pool raising events as opposed to minimising third party impact.

All secondary infrastructure sites

#	Site	Original (2013) / New (2017)	Description
1.	Nikalapko Flat	Original (2013)	Re-profiling inlet channel to allow for wetland inundation under lower flows/lower weir pool raise.
2.	Paisley Island	Original (2013)	Removing flow obstructions and securing the operations of the regulator at Paisley inlet to minimise third party impact (Blanchetown caravan park) during weir pool raising events at lock 1 and increasing environmental flows into the wetland.
3.	Causeway Rd	Original (2013)	Raise road height to 17.3m AHD in order to maintain landholder access and prevent road closures during weir pool raising events at lock 5. Thereby minimising third party impact (inundation of Causeway Road) during weir pool raising events at lock 5.
4.	Gurra Gurra – Bollenhagen Rd	New (2017)	Minimising third party impact (inundation of Bollenhagen Road) during weir pool raising at lock 4 by maintaining access along Bollenhagen Road during the lock 4 weir pool raising. This was achieved by constructing two new box culvert crossing structures to replace the existing ford crossings and raising the height of the section of the road between the two ford crossings to the same height as the new structures.
5.	Morgan East	New (2017)	Re-profiling inlet channel to allow for wetland inundation under lower flows/lower weir pool raise.
6.	Little Toolunka Flat	New (2017)	Removal of dysfunctional carp screens from existing structures.
7.	Sheepyard Creek/Mussel Lagoon	New (2017)	Removal of silt and reeds, re-profiling the permanent connection at Sheepyard Creek to enable improved connectivity.



Figure 41, Nikalpko Channel prior to works.



Figure 42, Nikalpko after re-channeling works.



Figure 43, Sheepridge Creek / Loveday, prior to the removal of silt, reeds and channel re-profiling.



Figure 44, Sheepridge Creek / Loveday, after the removal of silt, reeds and channel re-profiling.



Figure 45, Aerial image of Paisley Island – Existing regulating structure (588).



Figure 46, Aerial image of Causeway Road
(Areas A and B require build up to avoid inundation during weir pool raise events)



Figure 47, Bollenhagen Road during the 2016 high flow event, before RRP works.



Figure 48, Southern Creek Crossing structure at the Bollenhagen Road site (after RRP works).



Figure 49, Northern Creek crossing structure at the Bollenhagen Road site (after RRP works).



Figure 50, Site location for the Morgan East re-channeling works.



Figure 51, The Morgan East re-channelling works.

Project Achievements

The Phase 2 – River Operations and Weir Pool Manipulation Project has demonstrated a range of achievements. These achievements have been listed below, in the three key areas of Environmental Impact, Improved Knowledge and Community Impact and Understanding.

Environmental Impact

There were several on ground environmental benefits that were realised during project implementation. These benefits will continue for the foreseeable future as long as weir pool raising is maintained as part of future weir pool operations. These benefits included increased in-channel water level variability, enabling wetting and drying at low level wetlands, improving the hydrological connectivity of anabranch channels, enabling small scale flooding events and the cycling of carbon and nutrients.

A total of 3 in-channel variations were undertaken as part of the project. In 2014 Weir Pools 1 and 2 were raised to 50 cm above the normal operating level. In 2015 Weir Pools 2 and 5 were raised to 50cm above normal pool level and in 2016 Weir Pools 2 and 5 were raised to 75cm and 45cm above normal pool level respectively. All three raising events were undertaken in spring. Field surveys were undertaken to assess the response of littoral and floodplain vegetation to Weir Pool Raising and revealed clear patterns of change in community composition.

The project also enabled wetting and drying of low level wetlands and floodplains. Numerous wetlands and low lying floodplains connected to Weir Pools 1, 2 and 5 have all received numerous wetting and drying regimes from 2014-16 (the exception being Weir Pool 1 that was only wet/raised once in 2014). The wetting and drying of low level wetlands contributed towards enhanced productivity, health, diversity and distribution of floodplain and riparian vegetation as well as enhanced connections between wetland and riverine aquatic habitats.

The project was able to increase the hydrological connectivity of anabranch channels. A total of ten anabranches were created as a result of the weir pool raising events. All ten anabranches sites experienced an increase in the flowing water habitat as well as improved hydrological connectivity in the affected anabranch channels. Approximately 6 anabranch sites were created as a result of the Weir Pool raising events at weir pool 2 and approximately 4 anabranch sites were created as a result of the Weir Pool raising events at weir pool 5.

The project delivered small scale flooding events in low lying floodplains and wetland habitats. There were a total of three small scale flooding events in low lying floodplain and wetland habitats, one each in 2014, 2015 and 2016. In 2014 an additional 365ha of wetlands and low lying floodplain was inundated with the Weir Pool 1 and 2 raise. In 2015 an additional 960ha was inundation with the Weir Pool 2 and 5 raise. In 2016 an additional 1264ha was inundation with the Weir Pool 2 and 5 raise. Environmental responses to these flooding events included improved feeding, breeding and recruitment opportunities for flood dependent biota.

Finally the project delivered improved cycling of carbon and nutrients. When the water level was raised it inundated banks and floodplains that had been dry for some time and when the water receded it brought back with it a range of carbon and nutrients back into the main channel. This process therefore promoted the cycling of carbon and nutrients between the river, anabranches, floodplain and wetlands.

Improved Knowledge

A significant amount of ecological response knowledge was generated by undertaking weir pool manipulation activities, this knowledge will has been used to inform long term weir pool manipulation beyond project closure.

The project was able to enhance the Department for Environment and Water's understanding of weir pool manipulation events. This knowledge was captured via the Event Plans and the Business Process Diagram and

Actions Log. The Event Plans are a form of an operational guideline and describe the objectives of the event including ecological objectives and operational considerations. A Business Process Diagram and an Actions Log was also developed which articulated a clear step-by-step process for undertaking a Weir Pool Raising, including all related requirements (monitoring, approvals and community engagement).

The ecological response monitoring that was undertaken as part of the weir pool raising activities generated a range of valuable knowledge and improved understanding of the Riverine environment. The ecological monitoring improved knowledge and understanding relating to the specific detailed scientific findings of the different monitoring activities. Additionally, all monitoring findings were synthesised in order to inform future management decisions and to identify implications for long term ecologically driven weir pool operations.

Another critical piece of knowledge which was improved over the course of the project related to the complex approvals process which is required for weir pool manipulation events. The initial small scale raising events in 2014 identified valuable learnings relating to the approvals process. Through the 2014 raising events it was identified that the approval process was more lengthy and involved than first anticipated. The approval requirements included activities such as, conducting risk assessments, event plans, and communication activities with community, salinity modelling and water use modelling. Some of these processes were understood prior to project commencement in 2014, while others were identified as the project was implemented. The project was able to understand and clearly document this complex approvals process, which has led to a much smoother management of weir pool manipulation events.

Finally, the knowledge and understanding which was gained as part of the project was all captured in a handover package which was given to DEW River Murray Operations to facilitate future weir pool raising activities by River Murray Operations. The handover package contained all relevant information required to successfully run a weir pool raising event, including Event Plans.

Community Impact and Understanding

Weir Pool manipulation does affect the local community. The South Australian section of the River Murray has a relatively high density population living on and near the banks of the river, the local community uses the river for a diverse range of purposes, including varied recreational activities, as a water supply and for irrigation purposes. With so many people using this section of the river for such a diverse range of uses it has proved to be very challenging ensuring that all stakeholders are on board and supportive of the weir pool manipulation events. In the first year of the project (2014) it was not uncommon for the local community to raise concerns about the weir pool raising activities. As a result the project team set about improving how they engaged the local community, providing them with more relevant project information via more effective communication channels, with increased warning time in the lead up to weir pool raising events. The project team was largely effective in better informing the community about its weir pool manipulation activities and saw a noticeable change in the effected local community's attitudes towards weir pool raising. This was most notable at the lock 5 weir pool raising. Over the course of project implementation the local community (Renmark and surrounds) grew to embrace the weir pool raising events, with local organisation and landholders often acting as project champions.

Project Benefits

The RRP Phase 2 River Operations and Weir Pool Manipulation Weir Pool raising events at Lock 5 were a success, they were well received by the community and provided significant environmental benefit and led to ongoing Weir Pool raising at Lock 5. An example of the Weir Pool raising being embraced by the local community and providing an ongoing environmental benefit is the relationship between the Lock 5 Weir Pool raising and the Renmark Irrigation Trust environmental watering.

Renmark Irrigation Trust: A Case Study

The Renmark Irrigation Trust (RIT) is an integral part of the Renmark community, with more than 600 irrigators as members and responsibility for irrigating more than 4,900 hectares. The RIT recognise the scarcity and value of water as a resource and strive to be as efficient as possible in how they extract and distribute this resource to their members.

From as early as the 1960's, the RIT saw the need to be as efficient as possible with how water is used and extracted from the Murray. To achieve this a single main pumping station was installed which is capable of pumping up to 5,000 litres a second. All RIT water is pumped from the main pumping station and transferred via underground piping to its members. The Renmark Irrigation District has been fully piped since 1975 with over 140km of irrigation pipelines. Water diverted at the main pump station is metered and again measured at the point of supply, including for the delivery of Commonwealth environmental water. Each irrigation supply connection includes a magnetic flow meter with LCD display that records flow rate and kilolitres used.

On 20 April 2016, the RIT became the first irrigation body in Australia to enter a partnership with the Commonwealth Environmental Water Holder (CEWH) to return water to parts of the environment that have suffered long term degradation due to past irrigation practices.

Both the RIT and the Weir Pool raising at Lock 5 are able to use major existing infrastructure (Lock 5 and the RIT Pumps and Pipes) in a non-traditional way for environmental benefit. From 2015 onwards, the annual raising of Lock 5 has been able to inundate between 500 – 1300ha of wetland and floodplain. From 2016 onwards, the RIT has been able to deliver water to key wetland and floodplain sites using the existing RIT pumping and piping infrastructure (with some small modifications).

Not only have both initiatives been able to use existing water infrastructure for innovative environmental benefit, but they have also been able to co-ordinate their efforts to maximise the environmental return. One example, is the Ral Ral Floodplain site (approximately 5km North West of the Renmark township). The Ral Ral floodplain becomes inundated at the southern end via the increased water levels of the Ral Ral creek as a result of the Lock 5 weir pool raise. The RIT also has pipe outlets onto the Ral Ral floodplain at several different locations. The RIT pumping of environmental water onto the floodplain is able to target specific locations which the average weir pool raise inundation does not reach. The combined efforts of the Lock 5 weir pool raise and the targeted RIT environmental watering has seen the health of the Ral Ral floodplain start to return, with significantly more environmental benefit expected at the site over the coming years.

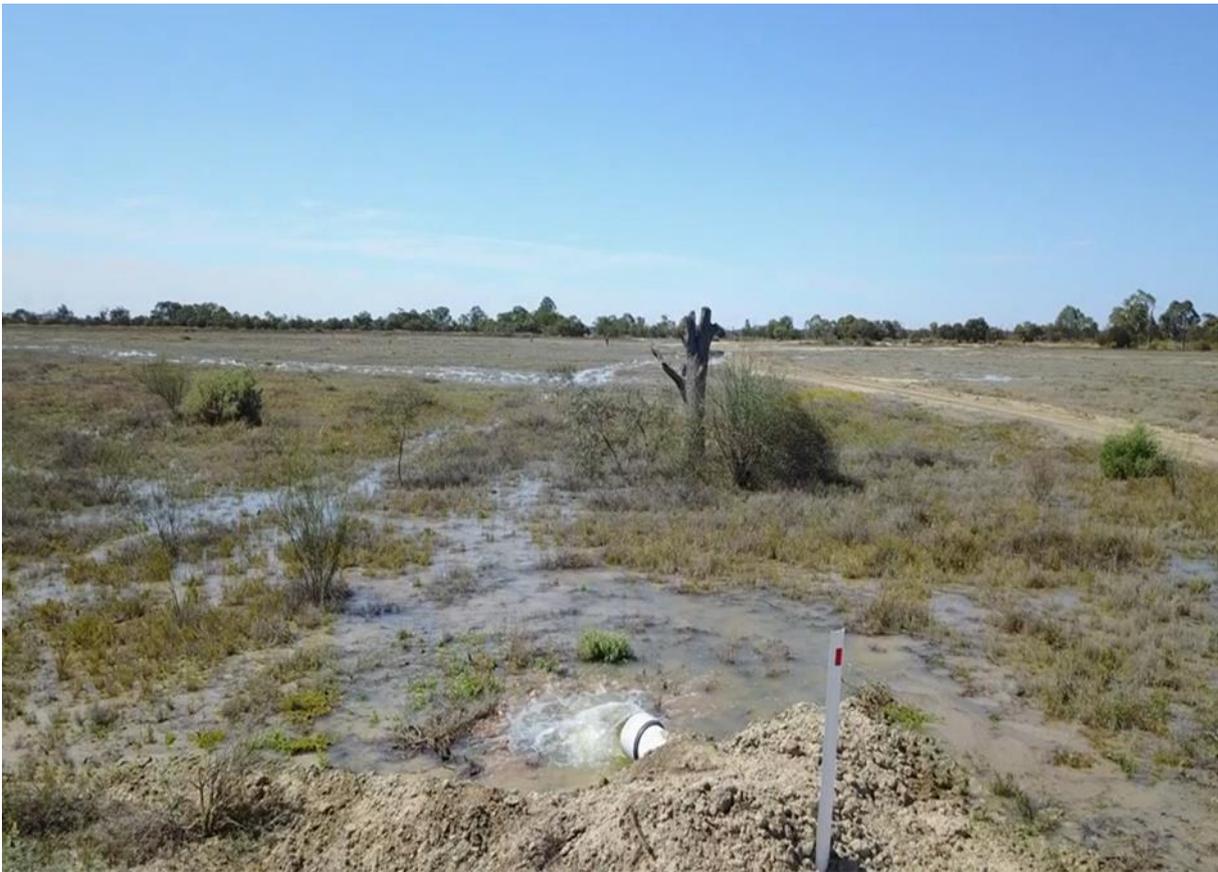


Figure 52, The Namoi St, RIT Watering point onto the Ral Ral Floodplain, which complemented the RRP Weir Pool raising at Lock 5.



Figure 53, The David St, RIT watering point onto the southern end of the Ral Ral Floodplain, which



complemented the RRP Weir Pool raising events at Lock 5.



Figure 54, RIT network of irrigation piping, used to inundate the David St and Namoi St sites above.



Environmental Watering Sites Renmark South Australia



Figure 55, Ral Ral Floodplain and RIT Watering points #5 and #8 above were used for environmental watering which complemented the RRP lock 5 weir pool raising inundation.

Challenges and Lessons Learnt

The Phase 2 – River Operations and Weir Pool Manipulation Project encountered challenges over the course of project implementation and learnt several important lessons.

An overarching lesson learnt was in relation to the extent of the complexities of operating weir pool manipulation events within the South Australian section of the river (between locks 1 and 5). The South Australian section of the River Murray has a relatively high density population living on and near the banks of the river. There is a diverse range of river users, with the river being used for recreational activities and irrigation activities. A constant balance needs to be struck between the community interests, environmental interests and economic interests of the River. With so many people using this section of the river for such a diverse range of uses it has proved to be very challenging ensuring that all stakeholders are on board and supportive of the weir pool manipulation events.

Many of the river users referred to above are on river users, partaking in a variety of recreational activities such as house boating, water skiing, speed boating and jet skiing. Some of these activities have a degree of inherent risk attached to them, when the usually stable and predictable river level changes this has the potential to increase this degree of risk. Users which are very familiar with the usual pool level river become uncomfortable when this familiar environment is changed due to weir pool raising or lowering.

Post project completion the Department for Environment and Water's River Murray Operations (RMO) Branch inherited full carriage of ongoing Weir Pool raising events. RMO's key priority is the safe operation of the River Murray for all water users, as a consequence there was a perception that they may have been more risk adverse than the project team when it comes to achieving environmental benefit via significant scale weir pool

manipulation activities. This challenge was mitigated by the integration of all weir pool manipulation activities that were proven to be safe and effective via the Phase 2 – River Operations and Weir Pool Manipulation RRP trials into standard weir pool operations (weir pool raising at locks 2 & 5). Any further weir pool raising or lowering activities that had not yet been trialled or proven to be safe and effective were instead further investigated and trialled as part of the SARFIIP (raising at lock 3, lowering at locks 1, 2 and 6), provided these trials and investigations also prove to be safe and effective they too will be included in the standard weir pool operations.

Another project lesson learnt was the extent and complexity of the approvals process required for weir pool manipulation activities. The complexity and scale of this process has made undertaking weir pool manipulation activities challenging. If this approvals process was able to be simplified this would increase the likely success of long term and sustainable weir pool manipulation being incorporated into the standard operation of River Murray locks on the South Australian section of the River.

Project 8: Yatco Lagoon

Yatco Lagoon is a permanent shallow wetland situated on the western bank of the River Murray immediately upstream of the irrigation township of Moorook. Since 2005, the local Yatco Wetland Landcare Group has been working towards implementing a wetland management plan for the lagoon, which also functioned as a supply for local irrigation water.

Yatco Lagoon, comprises two lagoons (Figure 56) with a total surface area of 346ha and approximately 150ha of floodplain vegetation. Prior to the Yatco Lagoon Project there was a causeway that separated the two lagoons, with two sets of concrete pipe culverts to enable the connections between the lagoons that were in need of refurbishment.

The main connection to the River Murray occurs at the northern end of the wetland system. The southern lagoon is connected to the River through a smaller 3.9km long, part natural, part man-made channel that prior to the RRP Yatco Lagoon project supplied river water to eleven irrigators. A small runner (Middle Creek) also connected the River Murray to the wetland near the junction of the northern and southern lagoons. There was no direct connection between Middle Creek and the southern lagoon.

The Yatco Lagoon project aimed to facilitate the long term management of the Yatco Lagoon (wetlands) in a manner which would balance the ecological objectives of the lagoon along with its recreational, community and economic objectives. The key management approach which the Yatco Lagoon project aimed to facilitate was the re-introduction of a more natural wetting and drying regime. In order to allow this to occur the project needed to ensure that there was no disruption to the water supply for irrigators, stock and domestic water users.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the RRP Evaluation process it was found that the Yatco Lagoon project made a direct and meaningful contribution to the below RRP aims/outcomes:

- achieve positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning;
- support regional communities and economies, including through the provision of more secure irrigation water sources; and
- deliver Agreed Water Savings and Equivalents of 14.3222 GL, with at least 6.567 GL for transfer to the Commonwealth for environmental purposes.

The outcomes were able to be achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that the Yatco Lagoon project successfully completed all critical project activities, these included:

- creating a Yatco Lagoon Project plan for endorsement (undertaken as part of RRP early works);
- undertaking all preliminary design work and landholder negotiations (undertaken as part of RRP early works);
- undertaking all detailed design work and ensuring approvals have been obtained;
- constructing two additional regulators in the existing earthen blocking bank and three additional regulators in the causeway to achieve the recommended fish passage within the lagoon;

- providing direct flow connection from Middle Creek to the southern lagoon and increasing the flow capacity of Middle Creek; and
- relocating 14 existing pumps (irrigation, and stock and domestic) from the lagoon to the River Murray to allow proper wetting and drying regimes for the wetland without impacting on irrigators or domestic water users.

The cumulative outcome of the implementation of the above activities was the successful achievement of the projects short term goals of:

- improving the environmental health and water use efficiency through improved management of the Yatco Lagoon (wetting and drying regime);
- improved fish passage within the lagoon;
- ensuring a reliable water supply; and
- the creation and transfer of 677.8ML of water savings from the State to the Commonwealth.

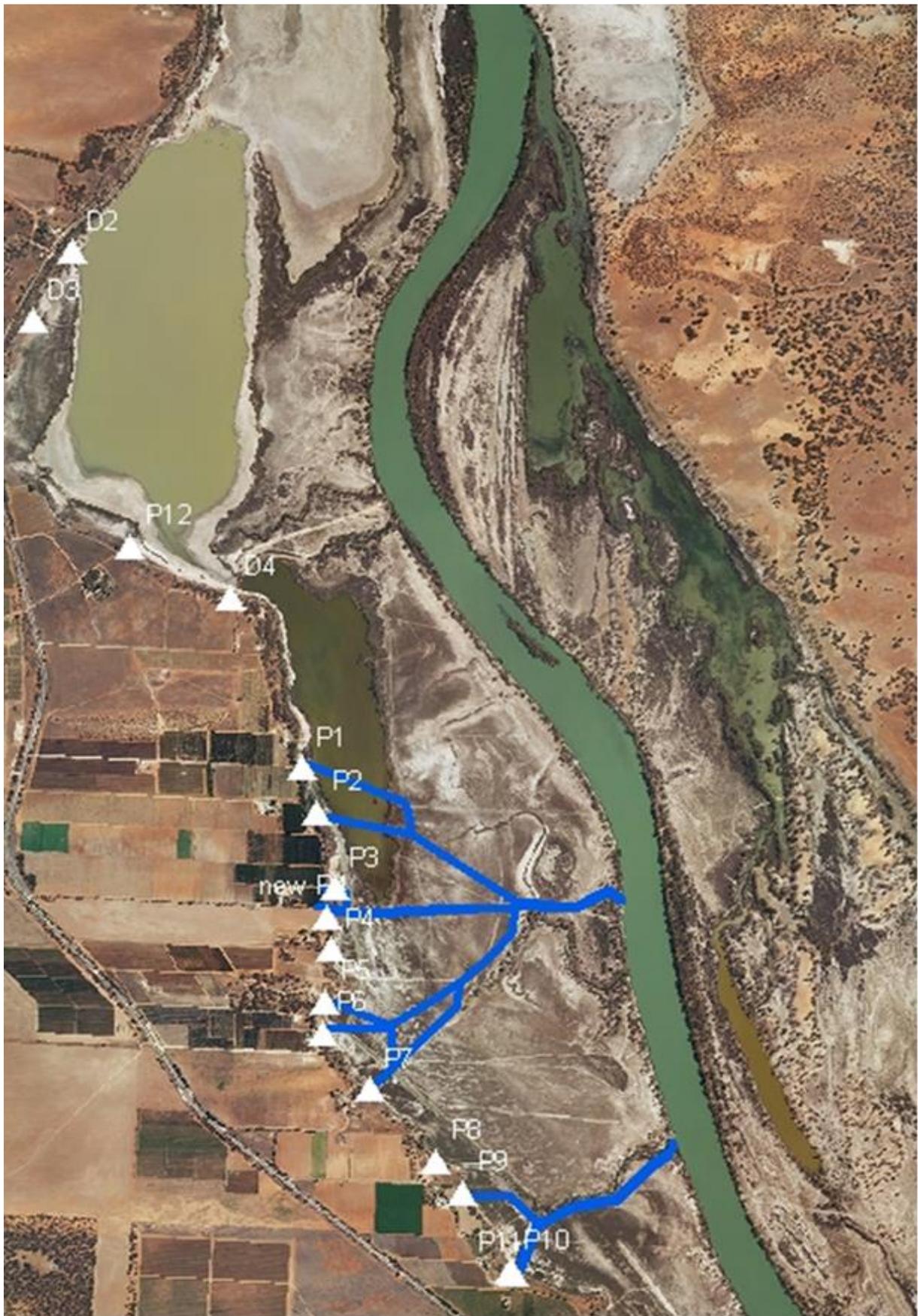


Figure 57, Aerial map of Yatco Lagoon (including re-located water supply pumps).

Project Achievements

The Yatco Lagoon Project has demonstrated a range of achievements. These achievements have been listed below, in the three key areas of Environmental Impact, Improved Knowledge and Community Impact and Understanding.

Environmental Impact

The central long term environmental impact of the works conducted at the Yatco Lagoon was the enabling of a management approach which facilitated the re-introduction of a more natural wetting and drying regime. To enable this, the project needed to ensure that there was no disruption to the water supply for irrigators and stock and domestic water users. A total of 14 properties had their water access points re-located from the Yatco Lagoon to the main River Murray channel. Reliability of access and quality of water has not been negatively affected via the re-location; in fact due to the relocation, all properties now experience a more reliable and better quality water supply. Another benefit of the pump re-locations in addition to enabling wetting and drying without affecting landholders was an estimated 12.8% reduction in water use, when using the new relocated pumping system.

The pump relocations allowed for the re-introduction of a more natural wetting and drying regime, however it was the installation and upgrading of regulators, as well as modifications to the causeway and Middle Creek which greatly improved the flow and ability to conduct effective wetting and drying of the Yatco Lagoon. In total five new regulators were constructed at the Yatco Lagoon site (two in the existing earthen blocking bank and three in the causeway). The new regulators increased hydrological connectivity as well as fish passage for small bodied native fish while limiting fish passage for carp via the incorporation of carp screens within the regulators.

The sum total of the environmental works conducted under the Yatco Lagoon project will be a long term environmental legacy which will see a more natural wetting and drying regime, improved fish passage, improved vegetation health, a trigger for breeding cycles for native species, carp eradication as well as water savings.

Improved Knowledge

A comprehensive Yatco Lagoon Wetland Management Plan was developed in 2009 by the Yatco Wetland Landcare Group. This Wetland Management Plan was initiated by the local Wetland Landcare Group and was largely driven by the local community and landholders who had witnessed a discernible decline in the health of the site. The Wetland Management Plan intended to improve the overall health of the Lagoon by reinstating a semi-natural watering regime while also protecting the environmental, social, economic and cultural values of the site. The Wetland Management Plan is a repository for a wide range of valuable information to guide the future management of the Yatco Lagoon in the most environmentally effective and appropriate manner. Although the Wetland Management Plan was not composed as a direct result of the RRP Yatco Lagoon project it was a key input and driver for the design and implementation of the Yatco Lagoon project.

The RRP Early Works Implementation Plan (Pike, Katarapko, Yatco) captured a large amount of knowledge and understanding about the riverine environment, including specific knowledge about the Yatco Lagoon site and project implementation. Examples of the extensive knowledge and understanding that was identified and captured via the Implementation Plan process included; stakeholder identification and engagement, environmental management measures, possible project risks, communication protocols and strategies and land access arrangements as well as more general project management inputs such as governance arrangements, schedules, and financial management.

Community Impact and Understanding

The local Yatco Lagoon community were already very active in the pursuit of long term environmentally beneficial management of the Yatco Lagoon wetlands prior to the delivery of the RRP Yatco Lagoon project. The Yatco Wetland Landcare Group were instrumental in the creation of the Yatco Lagoon Wetland Management Plan which outlined the key objectives to which the design of the RRP Yatco Lagoon project had to align. The Loxton to Bookpurnong Local Action Planning Association were instrumental in facilitating complex and difficult landholder negotiations about pump relocations. The local Yatco Lagoon community did, however, experience a significant direct change as a result of the RRP Yatco Lagoon Project. A total of 14 landholders had their water supply re-located from the wetland to the main River Murray channel; this resulted in both improved water quality and security as well as enabling the effective long term environmental management of the Yatco Lagoon wetland.

Project Benefits

A flow on benefit from the RRP work at the Yatco lagoon site is the community stewardship for the site. The Moorook Primary School have developed a close connection with the health of the Yatco lagoon and consequently incorporated the caretaking of Yatco Lagoon into their education program.

Yatco Lagoon: A Case Study

The 346ha Yatco Lagoon has for the previous 100 or so years been maintained at a constant water level, unable to follow a natural cycle of wetting and drying and consequently discouraging the growth of native flora and fauna.

Once effective regulators had been installed, the lagoon was drained and dried. From this point the Moorook Primary School (MPS) students were able to see the lagoon come back to life.

An education program was developed around the Lagoon, led by NRM Education, in partnership with Loxton District Landcare, Yatco Wetland Group and staff at MPS.

The reinvigoration of the Yatco Lagoon has enabled a comprehensive education program. A competition was run within the school – to design a logo for the Moorook Primary School Yatco Project. A winner was chosen and the logo was applied to school jumpers and sportswear, giving the students a sense of ownership and connection.

Students have participated in fish and vegetation monitoring, water quality testing, journaling discoveries, drawing and photographing of what they have seen. Students were able to get into the dried lagoon and see and feel what had happened to the land. They learnt about the importance of having a wetting and drying cycle and the impacts this has on water quality, vegetation and wildlife.

With a passion to share their new knowledge MPS exhibited their findings, drawings and photos at the Riverland Field day in the NRM Education tent. Their works included answering questions such as – How do plants survive when the Lagoon is dried? How do Yabbies survive when the Lagoon is dried?

Once the Lagoon was dry, the water was let back in and the students attended to watch. They were thrilled to be able to see how the regulator worked and the water running through the dry earth.

Through the process of taking on the stewardship role for the lagoon the students have been able to develop a closer connection with nature and have developed a passion for environmental causes and strengthened their ties with the community.



Figure 58, Moorook Primary School, Yatco Lagoon display.



Figure 59, The Yatco Lagoon.

Challenges and Lessons Learnt

The Yatco Lagoon project encountered challenges over the course of project implementation and learnt some valuable lessons as a result. Some notable challenges included:

Delays to project delivery

The single most significant issue encountered over the life of the project was delays to project delivery. There were several reasons for this and several lessons were learnt as a result. The main cause of the project delays was underestimating the difficulties of working in a low lying, inundation prone environment. Delays and unexpected challenges were experienced through both specific high flow events, as well as, general problems associated with working at a low lying site near the main river channel. At the commencement of the Yatco Lagoon project the River Murray had been experiencing prolonged low flows and drought conditions, this may have led to a degree of complacency and an underestimation of the likelihood of high flow conditions occurring. Additionally, the project overestimated its ability to conduct on ground works at the Yatco Lagoon site during high flow conditions. Even outside of specific high flow events unexpected difficulties in construction still occurred due to the low lying nature of the site and its susceptibility to groundwater inundation and soil instability. The combination of these two factors led to several project modifications which increased costs and delivery times. In 2013, construction was stopped and work commenced on a range of flood mitigation measures for the site to better allow construction in a high flow environment. Flood mitigation measures included, building earthen blocking banks across several flood runners as well as raising the height of a causeway and an embankment. This led to extensive additional work being undertaken, such as establishing a dewatering system and the establishment of additional risk mitigation measures to deal with the groundwater at the site.

Securing Land Management Agreements with Landholders

The issue of securing land management agreements with landholders in a timely manner proved challenging. Prior to works commencing on re-locating irrigation and domestic water supply pumps from the Yatco Wetland to the main river channel, a deed of agreement was negotiated with the 14 affected landholders. The deed of agreement enabled the works to take place in re-locating the pumps. The Loxton to Bookpurnong Local Action Planning Association were instrumental to ensuring this complex and difficult negotiation to secure the deed of agreement was achieved.

The second component of this process was securing land management agreements with each of the 14 affected landholders. The deed of agreement enabled the pumps to be relocated whereby the land management agreement stipulated what the landholder was and was not able to do on their land in pursuit of protecting the substantial environmental investment that had been made at the site. In practice this often meant limiting the ability of the landholder to graze stock within the wetland area. Ultimately 3 of the 14 land management agreements were unable to be secured with landholders for various reasons.

The land management agreements, due to procedural and legal constraints, were not able to be formally signed and lodged until after the physical relocation of the pumps had been completed and commissioned. It was at this point that the project experienced difficulties with getting land management agreements signed and formally lodged with the Crown Solicitor in a timely manner with some landholders. Although this task will always have the possibility of encountering problems given its reliance on landholders signing up to land management agreements, specific lessons were learnt relating to the Yatco experience. The lessons learnt were that finalising land management agreements with landholders should occur as soon as possible after the completion of the works and that they should then be subsequently lodged with the Crown Solicitor as soon as they have been signed.

Project 9: Phase 2 Wetlands

River regulation and water extraction have dramatically altered the ecology of the Murray-Darling Basin (MDB), transforming the SA River Murray from a dynamic river into a series of stable pools. The wetlands that fringe the river are either too wet or too dry. These changes to river flow, together with a reduction in overbank flooding have reduced the river's resilience and increased its vulnerability to a range of stressors, evident in the death and dieback of riparian and floodplain forests during the Millennium Drought (2006-2010).

Within the Wetlands component of RRP, a phased approach was used. Wetlands Phase 1 included immediate works at small 'shovel ready' sites as well as revisions and updates to Wetland Management Plans at existing managed wetlands (1A). Phase 1 also included larger construction works at existing managed wetland sites, including design, survey, community engagement and construction (1B). Finally, Wetlands Phase 1 also included a process to identify a suite of additional sites (1C) for investment to complement the 1A and 1B sites. In total 11 additional priority sites, plus three reserve sites were identified for investment via the Phase 2 Wetlands Project Element with 10 of the total 14 sites then progressed to completion through the Phase 2 Wetlands Project Element. The only priority site not progressed was the Irwin Flat site. The decision to move Irwin Flat to the reserve site list was made predominantly due to difficulties reaching agreement with landholders as well as a lesser level of environmental benefit and some other site specific difficulties.

The 10 priority wetlands progressed to construction in the Phase 2 Wetlands Project Element covered 7301ha of floodplain spanning 440km of the river. Importantly these floodplains included 374ha of wetlands that were ready for hydrological management, including more than 50km of wetland fringe where the condition of the riparian zone was directly improved by reinstating a variable hydrograph. The works also facilitated pumping at 23ha of wetlands which enabled the re-introduction of more natural wetting and drying regimes and improved flow and fish passage through 47km of anabranches and creeks.

All of the works which were undertaken at the 10 Phase 2 Wetlands sites were designed to improved connectivity between the wetland, anabranches and main channel as well as increase the management potential to wet and dry the wetlands through improved regulation. The 10 wetland sites progressed were: Murtho-Weila, Woolenook Bend, Goat Island and Paringa Paddock, Pyap Horseshoe, Sugar Shack, Silver Lea, Big Bend, North Curnamont, Teal Flat and Teal Flat Hut. A description of each of the above ten sites is outlined in the Wetlands 1C section of this report.

The Phase 2 Wetlands Project Element included a significant monitoring and investigations component. The monitoring and investigations project component included seven distinct areas of monitoring and investigation which will enable better informed and improved management of all RRP wetland sites.

Contribution to the Riverine Recovery Project Aims/Outcomes

The RRP was designed to contribute to ten overarching aims/outcomes. As part of the DEW RRP Evaluation process it was found that the Phase 2 – Wetlands project made a direct and meaningful contribution to the below five RRP aims/outcomes:

- utilise a landscape-scale approach to provide for a more effective, efficient and flexible management of environmental water;
- achieve positive environmental outcomes and improved ecosystem health through improved management of wetland and floodplain health and ecosystem functioning;
- improve the scientific knowledge and understanding for the management of floodplains, wetlands and environmental river management; and
- deliver water savings for transfer to the Commonwealth for environmental purposes.

The outcomes were able to be achieved as a direct result of successfully implementing a range of project activities and achieving the necessary short term results. The evaluation found that the Phase 2 Wetlands project successfully completed all critical project activities, these included:

- undertaking on ground works at 10 wetland sites (Murtho-Weila, Woolenook Bend, Goat Island & Paringa Paddock, Pyap Horseshoe, Sugar Shack, Silver Lea, Big Bend, North Caurnamont, Teal Flat and Teal Flat Hut);
- undertaking baseline ecological monitoring at all Phase 2 Wetland Sites.
- Undertaking seven research investigations projects:
 - assessing the impacts & management of ASS and soil microbial communities in managed wetlands;
 - evaluation of Carp Screen Efficiency;
 - improving the knowledge base for prioritising environmental watering of wetland and floodplain trees;
 - historic tree condition data evaluation;
 - securing the long-term future of threatened small-bodied wetland specialist fish across the SA Murray-Darling Basin;
 - SAMDB wetland and floodplain seedbank status and response capability assessment;
 - undertaking stakeholder engagement activities and securing all legislative approvals;
 - undertaking a research investigations scoping and prioritisation process.

The cumulative outcome of the implementation of the above activities was the successful achievement of the project's short term goals of:

- Completing work on all Phase 2 Wetland infrastructure and handing over assets for ongoing operation;
- Ensuring water users are not impacted negatively by works, either in regards water access or water quality; and
- Completing all research investigations and handing over findings to the relevant business owners.

Project Achievements

The Phase 2 Wetlands Project has demonstrated a range of achievements. These achievements have been listed below, in the three key areas of Environmental Impact, Improved Knowledge and Community Impact and Understanding.

Environmental Impact

The RRP Phase 2 Wetlands PE was designed to provide a long term on ground environmental legacy. The PE undertook significant works at ten wetland sites with the intent of improving the ability to manage and the long term management of these sites to maximise efficient environmental water use, resulting in a positive legacy of environmental improvement and water savings. Some of the specific on ground environmental works and intended impact are:

The long term environmental legacy of work at the **Murtho-Weila** site will be improved connectivity of the anabranch and improved management of the lagoon. The works will improve fish passage, establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants, improve the community viability of river red gum communities, maintain diverse frog communities, including Southern bell frog and maintain diverse native fish and waterbird communities.



Figure 60, The completed Murtho-Weila regulating structure.

The long term environmental legacy works at the **Woolenook Bend** site will be improved hydraulic connectivity in Plummers creek to restore habitat for large-bodied native fish by providing favoured permanent flow-through creek habitat (currently regionally scarce), decreasing sedimentation and facilitating scour to restore deep hole habitat, and increasing passage between wetland, creek and river habitats at Squiggly Creek.

The long term environmental legacy of works at the **Goat Island and Paringa Paddock** sites will be to provide periodic freshening flows through the saline temporary basins into the terminal end of the 'Old River'. The ecological benefits of this will be to maintain or improve River red gum (*Eucalyptus camaldulensis*) condition, maintain or improve Tangled Lignum (*Duma. florulenta*) condition and extent. As well as maintaining or improving diverse frog communities, including Southern bell frog (*L. raniformis*), improving surface water salinity in the 'Old River' permanent channel and to improve the condition of the lower lying salinised temporary basins between the 'Old River' and the River channels.



Figure 61, Paringa Paddock Regulating Structure

The long term environmental benefit of the interventions at the **Pyap Horseshoe** site will be the establishment of a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level. It will control common carp (*Cyprinus carpio*) to ensure optimal plant growth and create permanently flowing habitat (currently regionally scarce) through the floodplain. As well as establishing diverse frog communities, including Southern bell frog (*Litoria raniformis*) and maintaining diverse native fish communities and increase passage between wetland, creek and river habitats (adjacent to known deep water fish habitats in river), improving the community viability of river red gum and black box communities as well as inundating temporary shallow lagoons.



Figure 62, Pyap Horseshoe crossing and regulating structure.

The long term environmental legacy of the works at the **Sugar Shack** site will be the establishment of a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level. To enable young Wuri/Karrarru (River red gums) to establish and improve community viability of river red gum communities by optimising the water regime. Increasing the abundance and breeding success of culturally significant fauna, increasing the abundance of Menperi (frogs) communities and increasing the abundance of Mrayi (birds), large waders and shorebirds. Maintaining the diverse Mami (native fish) communities and observe Bony herring (*Nematalosa erebi*) recruitment as well as controlling the common carp (*Cyprinus carpio*) to ensure optimal plant growth.



Figure 63, Sugar Shack regulating structure.

The long term environmental legacy of the **Silver Lea** works will be to establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level to promote breeding by Black swan and other water birds. It will provide the resources for at least 27 waterbirds including seasonal exposure of mud flats for migratory waders and to control common carp to ensure optimal plant growth. Establish diverse frog communities, including Southern bell frog (*Litoria raniformis*) and to maintain diverse native fish communities and increase passage between wetland, creek and river habitats (adjacent to known deep water fish habitats in river). As well as enabling young River red gums to establish and improve community viability of river red gum communities by optimising the water regime.



Figure 64, Silver Lea works

The specific long term environmental legacy at the **Big Bend** site will be improved control of the common carp (*Cyprinus carpio*) to ensure optimal plant growth, establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants at and below pool level, maintain diverse native fish communities as well as establishing diverse frog communities, including Southern bell frog (*Litoria raniformis*). The works will also contribute towards maintaining a diverse bird community through monitoring and adaptive management as well as being able to test our understanding of drier water regimes, and the benefits and risks to native flora and fauna.



Figure 65, Big Bend regulating structure during handrail installation.

The long term environmental legacy at the **North Caurnamont** site will be the operations of three different water regimes – permanent (southern lagoon), partial dries only (middle lagoon) and a mixture of partial and complete dries (northern lagoon) – to create a mosaic of aquatic habitats within one wetland complex. This would result in the ability to protect and increase three threatened aquatic plant populations, establish a diverse community of underrepresented and threatened emergent, amphibious and submerged plants, establish diverse frog communities, including Southern bell frog (*Litoria raniformis*) and control the common carp (*Cyprinus carpio*) in the northern lagoon to ensure optimal plant growth.



Figure 66, North Caurnamont regulating structure.

The long term environmental legacy at the **Teal Flat** site will be the protection of endangered aquatic plant populations, the establishment of a diverse community of underrepresented and threatened emergent, amphibious and submerged plants as well as maintaining diverse native fish communities. Establish diverse frog communities, including Southern bell frog (*Litoria raniformis*) and to maintain waterbird communities.



Figure 67, The Teal Flat site.

The long term environmental legacy of the **Teal Flat Hut** site will be the establishment of a diverse community of underrepresented and threatened emergent, amphibious and submerged plants and aquatic plant community. The maintenance of diverse native fish communities, improved conditions for water fowl, waders and shorebirds and establishing diverse frog communities, including Southern bell frog (*Litoria raniformis*) as well as control the common carp (*Cyprinus carpio*) to ensure optimal plant growth.



Figure 68, Teal Flat Hut site.

Improved Knowledge

A significant component of the Phase 2 Wetlands PE was to generate improved knowledge and understanding of the Riverine environment which will directly contribute to the long term health of wetlands and the River. Specific areas of improved knowledge and understanding included:

Extensive **ecological monitoring** of all RRP Phase 2 Wetland sites was undertaken between 2016 and 2018. This comprised three rounds of monitoring which was carried out by the SAMDB Floodplain and Wetland Team. The monitoring sampled a general suite of parameters at each of the wetlands including, water levels, surface water, groundwater, vegetation, tree condition, waterbirds, fish and frogs. This monitoring greatly enhanced the knowledge and understanding of each of the 10 wetland sites and is also being used as a baseline to compare post construction hydrological regime ecological responses.

Increased knowledge and understanding relating to the degree of risk that **Acid Sulfate Soils** (ASS) pose to environmental values and water quality at RRP Wetlands was obtained. An investigations project assessed the impacts and management of ASS and soil microbial communities in RRP managed wetlands. This investigations project will enable a greater degree of confidence that the Wetland Management Plans include appropriate management and mitigation actions relating to ASS. A greater understanding of the influence of wet-dry management regimes on soil microbial communities and processes was also achieved. This increased knowledge is being used to inform and support ongoing wetland management and will be reflected in various WMP's as part of their review cycle.

The Phase 2 Wetlands Project also increased knowledge relating to the **efficiency of Carp screens**. Effective wetland-scale management of carp has historically relied on carp screens to prevent entry of large adult carp, coupled with regular (i.e. biennial) drying of the wetland to kill, by desiccation, any carp which are small enough to penetrate the carp screen. RRP has applied novel and improved carp screen designs in new wetland management infrastructure. These new screen designs allow more flexible wetland management practices to occur, removing the need for full wetland drying while still managing carp impacts. The effectiveness of these new screens was investigated, with on ground testing and monitoring validating the anticipated improvements in the new carp screen design.

Targeted investigations improving the knowledge base for **prioritising environmental watering of wetland** and floodplain trees (tree condition and soil moisture) were undertaken. The future planning and management of delivery of environmental water to halt the decline, and subsequently improve, the condition of existing floodplain trees will be critical to the long term legacy of RRP. This project investigated the effect of wetland management on the relationship between soil moisture and vegetation condition/response in both SAMDB floodplains and wetlands in order to improve the knowledge base for wetland management. Using a combination of historical data (hydrographs, tree condition data), current methods (TLM TCI, soil moisture availability data).

An investigation was undertaken into the historic relationship between **over storey tree condition and inundation**. This investigation explored the response of historical over storey vegetation condition to the management of wetlands, weir pools and floodplains; or unmanaged inundation in order to inform future environmental water management activities. The investigation used historical tree condition data and compared this to historical records of inundation events. Historic tree condition data was extensive; however, there was less data on the provision of water to floodplains and this made it difficult to draw definitive historical conclusions between the provisions of environmental water and tree condition response. The key piece of knowledge generated from this work was the importance of keeping detailed records of inundation of floodplains and wetlands.

Valuable knowledge was generated when developing a translocation strategy to improve the ability to secure the long-term survival of the **Big Little 4 species** [the nationally endangered Murray hardyhead (*Craterocephalus*

fluviatilis), the nationally vulnerable Yarra pygmy perch (*Nannoperca obscura*), southern pygmy perch (*Nannoperca australis*) and southern purple-spotted gudgeon (*Mogurnda adspersa*) across the SA MDB region.

The strategy brought together the quite extensive, but fragmented, practical knowledge gained from rescue / secure population management / translocation efforts to date directed at the four species. While a good understanding had been built around what is needed to successfully establish self-sustaining surrogate refuge populations and implement small-scale wild translocations, this project suggests an approach for translocation and gives suggestions for potential translocation sites for the Big Little 4 species.

An improved understanding of what **aquatic plant species** were missing from or underrepresented in the South Australian River Murray wetlands was achieved. This was achieved by undertaking an analysis of plant community responses to water regime in other MDB wetlands that have lower water resource development impacts (e.g. Macquarie Marshes). This analysis of the vital attributes of the dominant, rare and absent plant species confirmed whether the water regimes in the SA River Murray were suitable for the species that were absent or underrepresented.

The majority of reports referred to above are publicly available via the Waterconnect web-site at <http://www.waterconnect.sa.gov.au/Pages/Home.aspx>.

Community Impact and Understanding

The most relevant change to the local community as a result of the implementation of the Phase 2 Wetlands project was the increased understanding of the RRP and specifically the Phase 2 Wetlands RRP PE. The ways in which this was realised included:

- collaborative working with cultural groups (MACAI and RMMAC) throughout the development, design and construction of the project;
- communicating with wetland landholders;
- conducting meetings, presentations and conversations,
- increasing local, regional and state awareness of RRP activities;
- facilitating partnerships with LAP groups and the Natural Resources MDB to build capacity for future wetland management; and
- facilitate the development of tools that landholders can use to track wetland health and weir pool impacts.

Project Benefits

The Paringa Paddock / Goat Island wetland complex is an important wetland located between Renmark and Paringa. Sitting between Renmark and Paringa, this is an area of interest to the local community, with strong support for management from the Renmark Paringa Council and the First Peoples of the River Murray and Mallee.

Paringa Paddock: A Case Study

A Community Asset

The Paringa Paddock /Goat Island wetland complex is a site of high environmental, social and cultural significance. The site is a prominent community asset that has good visitor numbers and community recreational facilities. It is home to walking, of road cycling and running trails as well as a popular spot for fishing, canoeing, yabbing, frog and bird spotting.

Cultural History and Significance

The site is also highly valued by the traditional owners, the First Peoples of the River Murray and Mallee. The completed RRP works are helping the site to return to a more natural state, which is important to the First Peoples of the River Murray and Mallee, as the area will look and behave more like it did when their ancestors lived in the region. RRP worked closely with the First peoples of the River Murray and Mallee to make sure that the work is carried out in a respectful way and that cultural sites are protected.

The European history of the site also has significance due to the significant works that were done to try and improve the river navigation at the site.

Environmental Importance

Prior to the RRP conducting work at this site the Paringa / Goat Island wetland complex had become disconnected from the main river channel, so important native trees such as river red gums and black box found around the wetland were not getting the water they needed. Wetlands are the nurseries of the river. Improving the connection between the wetlands and the main river channel allows native fish to travel between the deeper water of the river and the safer wetland habitats they need to complete their breeding cycle. Improving water flow helps to flush out any salt or other impurities like dead leaves so that when there is a natural flood in the river there isn't a sudden influx of these in to the main river channel. Dead leaves and other nutrients that are washed off the banks are good for a wide range of bugs which in turn provide food for fish, frogs, bats and reptiles. The bugs, fish and frogs become food for populations of water birds, turtles and yabbies.

What the works delivered

The RRP works were able to restore connectivity with the main channel by installing or replacing culverts to allow water to flow into and through the wetland, and installing a regulator to manage when and for how long water is held in the wetland. The RRP works also dredged several creeks and removed a creek crossing to improve water flows. By restoring hydrologic connectivity this is enabling the watering of Black Box, Lignum and River Red Gums.

Now that the water is flowing more effectively through Paringa Paddock and Goat Island, it is gradually resulting in improvements to the condition of vegetation and the health of the wetland. This is resulting in more opportunities for the community to enjoy bird and frog spotting and for fishing or yabbing.

Challenges and Lessons Learnt

The Phase 2 Wetlands project encountered several challenges over the course of project implementation and learnt several important lessons.

The Phase 2 Wetlands Project was a large and complicated project with three significant and distinct implementing partners. The Commonwealth Department of Agriculture, Water and the Environment (DAWE) funded the project, the South Australian Department for Environment and Water (DEW) designed and implemented the project and SA Water oversaw all construction work (construction was a very significant component of this project). Ensuring that all three of these implementing partners were on the same page and had everything they needed for their different roles in delivering the project was sometimes difficult. One specific difficulty related to a lack of DEW project control in delivering the construction side of the project and being able to adequately inform DAWE of progress and problems in a timely manner. There were several misunderstandings and difficulties in relation to DEW getting the right information from SA Water in a timely manner. This working relationship was refined and improved over the course of project implementation, but was still not without problems.

A large component of the project was re-introducing wetting and drying regimes to wetlands. Some of these wetlands were relied upon as water sources for households and irrigators, therefore some pumps and related water supply infrastructure needed to be re-located from the project wetlands to the main River channel. On occasion this process was problematic, especially where ageing water supply infrastructure was concerned. If works involving private water supply infrastructure were undertaken again, the project would ensure that comprehensive survey of the existing infrastructure was undertaken to ensure that designs could fully consider any limitations of connecting to existing systems.

The Phase 2 Wetlands project had a significant monitoring and investigation component to it, commissioning seven distinct monitoring and investigation pieces of work. This was an important and valuable suite of work; however, due to the RRP's position as an externally funded project its work was somewhat on the periphery of core Departmental (DEW) Business. This created a situation where some of the valuable findings that were delivered as part of the monitoring and investigations suite of work had trouble gaining traction in central Departmental business. The key lesson learnt in this process was to ensure that prior to monitoring and investigations commencing that sufficient Departmental buy in and long term ownership had been identified and agreed.

6 Financial Information

The below table is a high level summary of the State’s receipt and expenditure of all RRP funds from the commencement to the conclusion of the RRP. The table also provides a high level summary of the total State contribution to the RRP, the total amount spent from all contingency allocations as well as the total interest earned by the State on all received RRP funds.

Financial Summary Table

Total RRP Program Financials 1 July 2011 to 31 December 2019	
Commonwealth contribution of funds	Total: \$75,042,554 (including contingency)
State contribution of funds	Total: \$7,735,987 (including contingency)
Other Contributions	Total: \$508,521
Final State expenditure of funds	Total: \$83,287,062 (including \$2,026,314 in contingency)
Summary of Commonwealth contingency amounts available	Total contingency amount available: \$3,815,390 Total contingency amount expended: \$2,026,314
Interest earned by the State on the Funds: \$2,069,018 of which \$1,500,000 is included as payment offsets within the project, and the remainder transferred to offset payments in other SA State Priority Projects.	

7 Promotional Activities

2011

Ministerial announcements

Date	Nature of announcement
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5 June 2011	On World Environment Day, the Australian Government's Minister for Sustainability, Environment, Water, Population and Communities (the Hon Tony Burke MP) and the Minister for Water (the Hon Paul Caica MP) jointly announced a further investment of \$86.7 million for the Riverine Recovery Project.
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Media coverage

Date	Type of coverage
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6 June 2011	ABC News: Project aims to boost wetlands' health
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6 June 2011	Adelaide Now: \$86m to cut evaporative losses from the River Murray
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6 June 2011	Australian Financial Review: Murray water project given \$86.7m
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6 June 2011	The Advertiser: Windsor river buyback ignored
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6 June 2011	891 ABC Adelaide: Interview with Minister for Sustainability, Environment, Water, Population and Communities (the Hon Tony Burke MP)
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9 June 2011	Murray Valley Standard: Natural fix for wetlands
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16 June 2011	Times Victor Harbor: More funds for Murray health
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7 July 2011	Murray Valley Standard: Opportunity for wetlands
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15 December 2011	Riverland Weekly: River Murray Advisory Committee tours Pike River.
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Presentations / other promotional activities

Date	Type of presentation / promotional activity
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4 August 2011	Presentation to Ngarrindjeri Regional Authority
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8 July and 9 September 2011	Presentation to River Murray Advisory Committee
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14 July 2011	Presentation to Murray-Darling Basin Division, Department for Water
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31 August 2011	Presentation to Science, Monitoring and Information Division, Department for Water
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9 September 2011	Presentation to River Murray Advisory Committee
23 September 2011	Presentation to Inside Infrastructure
5 October 2011	Presentation to SAMDB NRM Board – Wetlands Team
6 October 2011	Presentation to DENR Executive Team
27 October 2011	Presentation to Department of Treasury and Finance (DTF)
11 November 2011	Presentation to River Murray Advisory Committee and CEWH directors were taken on tour of the Pike Floodplain Project Element
18 November 2011	Presentation to Community Action for the Rural Environment (CARE) Group
21 November 2011	Presentation to Joint presentation to the Goyder Institute and the South Australian Research and Development Institute (SARDI)
29 November 2011	Presentation to MDBA and SA Water representatives were taken on tour of the Pike Floodplain Project Element

2012

Ministerial announcements

Date	Nature of announcement
19 March 2012	A renewed commitment to Picturesque Pike Floodplain (Minister Caica – re-signing of the Pike Memorandum of Understanding).

Media coverage

Date	Type of coverage
20 March 2012	ABC Radio (South East): Re-signing of Pike Floodplain MOU
21 March 2012	Loxton News, Loxton: Floodplain MOU signed
22 March 2012	Riverland Weekly, Riverland: Pike Floodplain could be used as shining example in basin plan
23 March 2012	Murray Pioneer, Renmark: Pike Floodplain rehabilitation guaranteed
23 March 2012	Murray Pioneer, Renmark: Lock 4 reserve to close today
23 March 2012	Stock Journal: Renewed commitment to Pike Floodplain

13 April 2012	Department for Water – CE News: Riverine Recovery survey will help ensure a healthy future for River Murray wetlands
28 May 2012	Department for Water Media Release: New lease of life for Riverland floodplain
29 May 2012	ABC Radio (Riverland, South East and Adelaide): Interview with Mr P Conniff regarding land acquisition at the Pike Floodplain
29 May 2012	Murray Pioneer, Renmark: Greener future for local floodplain
29 May 2012	ABC News: Protection boost from Riverland floodplain purchase
31 May 2012	DFW Inside News: Land acquisition spells end of livestock grazing on Pike Floodplain
1 June 2012	The Advertiser, Adelaide: \$50 million for Murray projects
7 June 2012	Riverland Weekly, Riverland: Floodplain works delayed
Presentations / other promotional activities	
Date	Type of presentation / promotional activity
4 August 2011	Presentation to Ngarrindjeri Regional Authority
7 February 2012	Presentation to Melaka Water Board (Syarikat Air Melaka Berhad) international delegation
6 March 2012	Presentation to International Centre of Excellence in Water Resources Management (ICEWaRM): Indonesian delegation
18 April 2012	Presentation to River Murray Operations Working Group, Government of South Australia
25 May 2012	Presentation to Joint leadership meeting of the Science, Monitoring and Information Division and the Operations and Major Programs Division, Department for Water
13 August 2012	Presentation to Mid Murray Council
16 August 2012	Presentation to Riverland West Local Action Planning Group

18 August 2012	Presentation to Beldora Station landowners
11 October 2012	Presentation to Department of Planning, Transport and Infrastructure (DPTI)
18 October 2012	Presentation to Ngarrindjeri Regional Authority
31 October 2012	Presentation to First Peoples of the River Murray and Mallee Region – Board of Directors.

2013

Ministerial announcements

Date	Nature of announcement
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NA

Media coverage

Date	Type of coverage
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22 February 2013	Media release - Reduced flows leads to frenzy of activity on the Pike Floodplain
2 July 2013	Media release - Wetland Management Element - 'Monitoring shows big rise in native fish in Pike River'
9 July 2013	Media release - Wetland Management Element - 'Riverine Recovery Project to boost wetland health'
8 August 2013	Media release - Pike Floodplain Element - 'Pike River trials test salt management methods'
13 September 2013	Media release - Katfish Reach Element - 'Wetlands in focus at Murray River National Park'
25 October 2013	Media release - Pike Floodplain Element - 'Pike River Floodplain in focus at community event'
8 August 2013	Radio coverage -
16 August 2013	Radio coverage -
Presentations / other promotional activities	
Date	Type of presentation / promotional activity
22 January 2013	Presentation to Eastern Hills & Murray Plains Catchment Group Inc

30 Jan to 8 Feb 2013	Presentation to Katfish Reach display at the McCormick Environmental Centre for World Wetlands Day
11 February 2013	Presentation to Major Projects' Planning Day
20 February 2013	Presentation to Native Vegetation Assessment Plan (Pike Floodplain Project Element and Wetlands Project Element Phases 1A and 1B)
21 to 22 March 2013	Presentation to River Murray Youth Council Ecological Education camp at Katarapko as part of the NRM education program
8 May 2013	Presentation to Native Vegetation Assessment Panel (Wetlands Project Element Phase 1C)
28 May 2013	Presentation to Minister for Water and the River Murray's Office
14 June 2013	Presentation to River Murray Advisory Committee.
20 June 2013	Presentation to Briefing to Mid-Murray Council
8 August 2013	Presentation to the Coorong Lower Lakes Murray Mouth Community Advisory Panel
4 September 2013	Presentation to the Public Works Committee regarding Wetlands Phase 1B Infrastructure
26 September 2013	Presentation to River Murray Operations Working Group RRP Weir Pool Manipulation Event
27 September 2013	Presentation to Murray Darling Basin Authority - RRP Wetlands management and works
12 August 2013	RRP Project Managers attended a site visit to the Blanchetown Caravan Park to meet the owners and discuss support for the Weirpool Manipulation and Enhanced River Operations Project Element. This was also used as an opportunity to discuss the Wetland Management Project Element.
Internal DEW 'The Weekly' articles:	
15 July 2013	Pike Floodplain Element: Edition 37- "Recovery project team hails six-fold increase in native golden perch"
22 July 2013	Wetland Management Element: Edition 38- "Riverine Recovery Project to boost wetland health"

4 November 2013 General RRP: Edition 53 - "Riverine Recovery Project Team wins prestigious award"

Signage at sites

The signs at Katfish Reach were developed by the Katfish Reach Steering Group (community group). Murray Futures has been acknowledged as a partner of the Katfish Reach project.

2014

Ministerial announcements

Date	Nature of announcement
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NA	NA
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Media coverage

Date	Type of coverage
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20 February 2014	Media release - Wetland Management Element - 'Iconic Wetlands undergo recovery works'.
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16 January 2014	Radio coverage - Early Works- Yatco - Yatco Lagoon Updated (ABC Riverland)
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11 February 2014	Radio coverage - Wetlands Management Element - Marks Landing Wetland Management Update (ABC Riverland)
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21 February 2014	Radio coverage - Wetland Management Element - Wetlands 1B Construction works commencement (ABC Riverland)
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25 February 2014	Radio coverage - Wetlands Management Element- Wetlands 1B Construction works commencement (5RM Berri)
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10 April 2014	Radio coverage - Pike Floodplain Element -10/04/2014 - Soil Monitoring on the Pike update (ABC Riverland).
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16 June 2014	Media release - 'A day on the Kat' - following a day in which 80 canoeing and walking enthusiasts joined the "Day on the Kat" community event.
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11 August 2014	Media release - 'Work to start to improve ecology of the Pike anabranch' - 11 August 2014 – start of work on the Deep Creek structure.
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26 November 2014	Media release - 'Pike Floodplain environmental works gain momentum' - update on Deep Creek regulator and fish way and introducing works on regulators on Pike Floodplain.
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5 September 2014	Media release - 'Returning River Murray ecosystems to health' - Weir Pool raising at locks 1 and 2.
19 September 2014	Media release - 'New Lake Merreti infrastructure to benefit wetlands, floodplains and weir pools'- Joint news release by Minister Ian Hunter (SA Minister for Water and the River Murray) and Senator Simon Birmingham, Parliamentary Secretary to the Minister for the Environment.
28 August 2014	Radio coverage - Pike Floodplain Project Element - a six minute interview on "Riverland Today" (ABC Riverland).
-	Radio coverage - Yatco Lagoon Project Element - Interview (Sarah Price, Project Manager RRP) on managing water flows into the Yatco Lagoon (ABC Riverland).
24 September 2014	Radio coverage - Pike Floodplain Project Element - Update interviews explaining progress on construction works at Deep Creek '(5RM and ABC Riverland).
13 October 2014	Radio coverage - Interview with Program Leader RRP and SARFIIP, Glenn Shimmin – (Radio Adelaide).
26 November 2014	Radio coverage - Pike Floodplain Project Elements - Interviews on update of Deep Creek regulator and fish way and introducing works on regulators on Pike Floodplain (ABC Riverland News and Riverland Today).

Presentations / other promotional activities

Date	Presentation
14 April 2014	Presentation to the Mid Murray Council regarding RRP with a focus on the RRP Phase 2 proposal
28 April 2014	Presentation to the Natural Resources SAMDBNRM Board regarding RRP with a focus on the RRP Phase 2 proposal
<i>Other promotional activities</i>	
10 February 2014	Wetland Management Element - 'Marks Landing Wetland Update' (newspaper article- The River News).
12 March 2014	The Pike Floodplain Project Manager contributed to the development of a draft video produced by the Murray-Darling Basin Authority in relation to the Sea to Hume Fishways Opening. The Pike Floodplain Project Manager spoke about the Riverine Recovery Project with specific mention on fish passage.
4/5 April 2014	RRP Staff attended the Karoonda Farm Fair to promote RRP projects and provide an opportunity to discuss the projects with community members.

3 September 2014	'Works Committee tours region' story in Loxton News - discussing a visit by SA Parliament's Public Works Committee who visited major projects in the region including RRP (newspaper article - Loxton News).
17 September 2014	Weir Pool raising at locks 1 and 2 story in River News, Waikerie - promoting the weir pool raising (newspaper article – River News).
19 November 2014	Story in The River News – River rise upsets locals - included response from Glenn Shimmin, Program Leader RRP and SARFIIP (newspaper article – River News).
26 November 2014	Update on Deep Creek regulator and fish way and introducing works on regulators on Pike Floodplain - story in Murray Pioneer "Pike Floodplain Works Flowing" (newspaper article – Murray Pioneer).

Signage at sites

The signage for Pike Floodplain was completed and installed.

2015

Ministerial announcements

Date	Nature of announcement
5 & 26 June, 2015.	The Minister for Water and the River Murray (the Hon. Ian Hunter MP) issued two media releases (<i>Science detective work uncovers rare fish & One hundred years of lock work celebrated as Pike regulators completed</i>) as detailed below under Media Coverage.

Media coverage

Date	Type of coverage
21 April 2015	Media release - 'Major Riverland Infrastructure projects to be officially opened' – Joint State and Federal Ministerial release announcing the commissioning of the regulator at Yatco North and the regulator and fish way at Deep Creek.
13 May 2015	Media release - 'Murray Cod discovered in the Pike River System' - following results from electro-fishing monitoring.
5 June 2015	Media release - One hundred years of lock work celebrated as Pike regulators completed – News Release from the Minister for Water and the River Murray on 5 June 2015. <i>Three new regulating structures near Renmark and Paringa have been completed as part of a series of major infrastructure projects designed to improve the long-term ecological health of the Pike Floodplain.</i>

26 June 2015	Media release - Science detective work uncovers rare fish – News Release from Minister for Sustainability, Environment and Conservation, Minister for Water and the River Murray, and Minister for Climate Change on 26 June 2015. <i>Researchers have re-detected the critically endangered Murray hardyhead fish in areas along the River Murray thanks to a new technique involving environmental DNA (eDNA).</i>
5 June 2015	Radio Coverage - ABC Riverland interview with Minister Ian Hunter – Pike Floodplain Infrastructure.
29 June 2015	Radio Coverage - ABC Riverland interview with Minister Ian Hunter – Researchers are re-discovered the Murray Hardyhead in wetland around Mannum and Murray Bridge.
Late 2015	Media release - Juvenile Murray Cod discovered in Pike system
Late 2015	Media release - Record numbers of endangered Murray hardyhead recorded in the Riverland
Late 2015	Media release - New regulator and fishway completed at Log Crossing
Late 2015	Media release - New works helping to restore the Katarapko Floodplain
Late 2015	Media release - Weir pool raising: a further step in returning the River Murray to health
Late 2015	Media release - Benefiting wetlands with existing infrastructure – article for Wetlands Australia
Late 2015	Radio and media coverage - ABC Radio and Murray Pioneer covered news releases on Juvenile Murray Cod in Pike, Record numbers of Murray hardyhead, new works to Katarapko and Weir pool raising.

Presentations / other promotional activities

Date	Presentation
Late 2015	Approximately 20 local presentations were made to Riverland community organisations, agencies, industry groups and other stakeholders as identified in the stakeholder analysis on weir pool raising, its benefits and impacts, building support for the program.
Late 2015	Presentation to SAMDB Natural Resources Management Board.
Late 2015	Presentations to Pike Community Reference Committee and Katfish Reach Steering Group.

Other promotional activities

3 March 2015	A community event to celebrate the filling of Beldora lagoon following the opening of the new regulator.
21 April 2015	<p>A formal infrastructure commissioning events at Deep Creek Regulator and Fishway and Yatco North Regulator by the SA Minister for Water and the River Murray with acknowledgement to the Parliamentary Secretary to the Minister for Environment.</p> <ul style="list-style-type: none"> • Deep Creek event attended by 40 people. • Yatco event attended by 25 people.
NA	Capture of video footage to document works.
NA	Communication action plans and stakeholder analyses for Pike and Katfish Reach were reviewed and revised to ensure local activities are coordinated.
July 2015	Dr Glenn Shimmin, Program Leader for RRP and SARFIIP presented an update to the Natural Resources SAMDB Board.
Late 2015	Website pages updated
Late 2015	Reviewed and revised local engagement action plans and stakeholder analyses for Pike and Katfish Reach activities to ensure local activities are coordinated
18/19 September 2015	Attended Riverland Field Days –focus on the theme: Water up, Water down – how our tools and mechanisms for managing water levels and flows are helping restore our wetlands and floodplains, approximately 2000 people entered the DEW stand.
Late 2015	Pike Community Reference Committee and LAP members toured Pike Floodplain and RRP projects
Late 2015	Katfish Reach Steering Group toured Katarapko Floodplain RRP sites
21-23 September 2015	Australian River Symposium 21-23 September with presentation around Ngarrindjeri engagement in RRP and specifically Sugar Shack Wetland Management Plan development
November/December 2015	2015 Ecological Society of Australia Conference, with two presentations around Ngarrindjeri engagement in RRP and specifically Sugar Shack WMP development.
Late 2015	Natural Resources SAMDB Board visited the Pike floodplain.

Late 2015

Weir pool manipulation communication and engagement strategy implementation for 2015 events, included presentations to approximately 20 community and Local Action Planning groups, committees, local government and associations

- 400 letters sent to landholders in the affected reaches notifying dates, expected impacts and benefits and providing a contact point for further information
- 100 letters to houseboat owners notifying dates, expected impacts and benefits and providing a contact point for further information
- 750 follow-up letters to 2014 stakeholders and landowners with survey results from monitoring of event
- Signage for public sites at Renmark notifying the public of the proposed raising event, expected affects, and explaining the purpose of the event
- Frequently asked questions document developed and circulated to staff, uploaded to website as a ready reference for questions about weir pool raising
- Capture of the event using remote cameras, time-lapse cameras and drone footage
- Advertising in local newspapers to alert the general public of the event

Signage at sites

- Interpretive Signage installed at Deep Creek Regulator and Fishway
- Interpretive signage installed at Lake Carlet
- Signage was placed at public sites to alert the public to the timing of weir pool raising, what to expect to see, and the expected benefits

2016

Ministerial announcements

Date	Nature of announcement
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19 August 2016	The Minister for Water and the River Murray (the Hon Ian Hunter MP) issued a media release to signal the commencement of RRP Phase 2 Wetlands. This was undertaken in consultation with the Commonwealth and an associated launch was held in the region at two Phase 2 Wetlands sites.
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Media coverage

Date	Type of coverage
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Early 2016	Media release - The Future's Bright for Fish in the Pike
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Early 2016	Media release - Renmark-Paringa Wetlands Improve after Watering
19 August 2016	Green Light for RRP2
21 October 2016	Pike's got flow
Late 2016	Radio Coverage - A number of interviews with ABC Radio Riverland were undertaken in response to news releases and events – interviews were undertaken by Dr Glenn Shimmin (Program Leader) and Brad Hollis (Pike Floodplain Manager).

Presentations / other promotional activities

<i>Date</i>	<i>Presentation</i>
Late 2016	Update presentation prepared for internal presentation to Branch.

Other promotional activities

Late 2016	RRP was represented on the Major Projects stand at the Riverland Field Days with 16,000 people attending the field days in August 2016. The stand was part of the NR SAMDB region's exhibition, which won best exhibition at the field days.
Late 2016	A letter was sent to stakeholders announcing the launch of Phase 2 Wetlands and the expected implications for site landholders and arrangements for ongoing communication.
Late 2016	A fact sheet was drafted for use at Riverland Field Days.

Signage at sites

Signage was in place at public sites to alert the public to the timing of weir pool raising, what to expect to see, and the expected benefits. The signage was removed, after the event, in February 2016.

2017

Ministerial announcements

<i>Date</i>	<i>Nature of announcement</i>
Early 2017	River Murray Community Funding
Early 2017	Grant Murray Health
Early 2017	River Murray Funding
11 October 2017	'Community has final say on River Murray Projects' – Senator Anne Ruston, The Hon Ian Hunter MLC

Media coverage

Date	Type of coverage
10 March 2017	Radio Coverage - ABC Riverland radio promotion of Fund My Project
15 March 2017	Print Media Coverage - Murray Pioneer, article about Fund My Project
16 March 2017	Print Media Coverage - River News, article about Fund My Project
4 April 2017	Print Media Coverage - Loxton News, article about Fund My Project
20 April 2017	Radio Coverage - 5RM radio Berri, promotion of Fund My Project
12 May 2017	Print Media Coverage - Murray Pioneer, article about Fund My Project voting
17 May 2017	Print Media Coverage - River News, article about Fund My Project voting
8 August 2017	Print Media - Murray Pioneer, Renmark, Big Plans set for Bookmark Creek
12 October 2017	Radio Coverage - ABC Radio, Riverland, Fund My Project groups announced
12 October 2017	Radio Coverage - 5RM Radio, Berri, Fund My Project funding for Bookmark Creek Action Group
17 October 2017	Print Media - Murray Pioneer, Renmark, Funds boost waterway projects
18 October 2017	Print Media - River News, Waikerie, Maize Island project receives funds
17 November 2017	Print Media - Murray Pioneer, Renmark, Local students revamp Maize Island
22 November 2017	Print Media - River News, Waikerie, Students revamp Maize Island

Presentations / other promotional activities

Date	Presentation
NA	NA

Other promotional activities

February / March 2017 Promotion for the participatory budgeting program 'Fund My Project' was undertaken during February and March 2017, and project applications were submitted between 8 March and 26 April 2017. The community assessment phase was then open between 28 April and 31 May 2017.

Signage at sites

Signage promoting the 'Fund my Project' program listed above, was installed on ferries during the application period.

2018

Ministerial announcements

<i>Date</i>	<i>Nature of announcement</i>
NA	NA

Media coverage

<i>Date</i>	<i>Type of coverage</i>
19 January 2018	Media Release - Works begin at 10 priority wetland sites – Department for Environment and Water.
21 May 2018	First Community-selected River Murray Project Launched - Department for Environment and Water.
19 January 2018	Print - Murray Pioneer, Renmark, Riverine Recovery Project to begin after delays
19 January 2018	Radio – ABC Riverland, Riverine Recovery Project to begin after delays
19 January 2018	Radio – 5RM Berri Radio, Riverine Recovery Project to begin after delays
18 May 2018	Print - Murray Pioneer, Creek clearing set for launch (Bookmark Creek)
21 May 2018	Radio – ABC Riverland, First of 12 Fund My Projects worth a total of \$200,000 has been completed
21 June 2018	Radio – 5RM Berri, A new walking trail in the Maize Island Lagoon Conservation Park
22 June 2018	Print - Murray Pioneer, Renmark, Riverland students create a-Maize-ing new walking trail
15 August 2018	Murray Valley Standard, provided information about the Murrundi Reserve RRP Fund My Project
19 September 2018	ABC Riverland, Pre-recorded interview with the Program Leader RRP & SARFIIP about RRP
24 October 2018	Print – Murray Pioneer, Environmental works to start around November 2018 at Paringa Paddock and Goat Island
9 November 2018	Media release - Environmental works underway at Paringa Paddock.

Presentations / other promotional activities

<i>Date</i>	<i>Presentation</i>
NA	NA

Other promotional activities

NA	NA
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2019

Ministerial announcements

Date	Nature of announcement
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Media coverage

Date	Type of coverage
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23 August 2019	<ul style="list-style-type: none"> Interview with Glenn Shimmin re Riverine Recovery Project completion (Radio: ABC Riverland SA, Renmark, Breakfast)
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Presentations / other promotional activities

Date	Presentation
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NA	NA
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Other promotional activities

May 2019	<p>Two nominations were prepared and submitted for the Water Industry Alliance Smart Water Awards for the following categories:</p> <ul style="list-style-type: none"> Environmental Impact Award – Riverine Recovery Project Alliancing Award – Riverine Recovery, Fund My Project.
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7 June 2019	<p>The RRP was the successful winner of the Environmental Impact Award at the Water Industry Alliance Smart Water Awards announced on 7 June 2019.</p>
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Finalising legacy promotional material including:

- Website updated and content transitioned to promote ecological outcomes.
- Both the 3D model and the animation will be tested at Young Environmental Leaders forums along the river. Once that feedback has been assessed, information on their availability will be made public and we will start to promote their use at schools up and down the river and more broadly. A range of shorter videos tailored to specific RRP sites have been made to support the overarching Story video and these will be distributed to the participants and also via the same channels as the original Story.
- Infographic outlining statistics from some RRP key achievements will be distributed through social media channels and via the DEW website.
- A Ministerial or departmental media release will be distributed regarding the Woolshed Brewery play space and its official launch.

22 June 2019	<p>Project closure/completion event: Starting at the Renmark Club with an introduction by Dr Glenn Shimmin and Minister Whetstone, local member and Minister for Primary Industries and Regional Development, then moving to Paringa Paddock for a number of activities including guided walks to the new structures built there. Around 70 people attended including key stakeholders and local landholders and prior and current project staff.</p>
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