Healthy Coorong, Healthy Basin

Coorong Infrastructure Investigations Project

Feasibility Assessment Report

April 2022

SOUTH AUSTRALIA

Government of South Australia
Department for Environment and Water

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Glossary

CIIP	Coorong Infrastructure Investigations Project
Concept	Unique permutation of an infrastructure option (see option) with specific discharge structures, pipe diameters or combination of options
CNL	Coorong North Lagoon
CSL	Coorong South Lagoon
CSL-SO	Coorong South Lagoon - Southern Ocean
ERAF	Environmental risk assessment framework
FAR	Feasibility Assessment Report
HCHB	Healthy Coorong Healthy Basin
LAC	Lake Albert Connector
MCA	Multi-criteria analysis
Option	High level infrastructure type (such as connector or dredging)

Respect and Reconciliation

Aboriginal people are the First Peoples and Nations of South Australia. The Coorong, connected waters and surrounding lands have sustained unique First Nations cultures since time immemorial. The *Healthy Coorong, Healthy Basin* program acknowledges the range of First Nations' rights, interests and obligations for the Coorong and connected waterways and the cultural connections between Ngarrindjeri Nations and First Nations of the South East peoples across the region and supports their equitable engagement.

Aboriginal peoples' spiritual, social, cultural and economic practices come from their lands and waters, and they continue to maintain their cultural heritage, economies, languages and laws which are of ongoing importance. The Department for Environment and Water (DEW) works across the State with Aboriginal South Australians to conserve and sustain Country. Through this work we seek to improve the relationship between Aboriginal and non-Aboriginal people and build respect based on mutual understanding and acceptance of each other.

This project is part of the South Australian Government's *Healthy Coorong, Healthy Basin* Program, which is jointly funded by the Australian and South Australian governments.

1. Executive Summary

The *Healthy Coorong, Healthy Basin* (HCHB) Program's Coorong Infrastructure Investigations Project (CIIP) is exploring long-term opportunities for operational infrastructure to improve the ecological health of the Coorong. The CIIP is assessing the feasibility of various infrastructure options and a business case for future investment will be developed for options that are deemed feasible and provide the greatest ecological benefit to the Coorong South Lagoon.

This Draft Feasibility Assessment Report summarises the CIIP feasibility studies undertaken as part of Phase 1 of the HCHB Program and will inform the development of a business case, with preferred options and recommendations for further investigations for potential construction in HCHB Phase 2 (subject to relevant funding approval from the Australian Government).

CIIP comprises three stages:

Stage 1: High-level options analysis and shortlisting for further feasibility investigation

A range of major infrastructure and management options have been identified over the past two decades aimed at improving water delivery to the Coorong for ecological benefit. The objectives of each option have varied but they are generally aimed to address two key biotic drivers: salinity and water level. Recently, we have an improved understanding of the role of nutrient loads as a key ecological driver. Work has continued under the HCHB Program to understand nutrient dynamics within the Coorong and its impacts. This improved understanding of nutrient dynamics has informed key findings related to the feasibility of infrastructure in this report.

In June 2020, following a review of the Coorong infrastructure investigations completed to date, and community consultation, five options were shortlisted for further feasibility investigations:

- Permanent connection between the Coorong South Lagoon and Southern Ocean
- Coorong Lagoon dredging to improve connectivity
- Lake Albert – Coorong Connector
- Further augmentation of South East Flows to the Coorong (South East Flows Augmentation, SEFA)
- Additional automated barrage gates.

In shortlisting these, feedback from community consultation confirmed "the options that best contribute to improving the ecology of the South Lagoon as determined by scientific evidence, given water availability and constraints" should be pursued.

Stage 2: Feasibility investigations for prioritised options

From January to December 2021, we undertook the following detailed investigations to address knowledge gaps and establish the feasibility of the shortlisted options:

- Hydrodynamic, biogeochemical and ecological modelling
- Ecological assessments and analyses
- Cultural heritage surveys
- Engineering technical feasibility assessments
- Concept designs
- Preliminary socio-economic assessments
- Risk assessments
- Capital and operating and maintenance cost estimates.

Preliminary hydrodynamic modelling indicated that the following options would not deliver sufficient ecological benefits and were discontinued from investigations in mid-2021:

- Additional automated barrage gates
- Further augmentation of South East Flows to the Coorong (SEFA).

The remaining three options proceeded to full feasibility assessment, which resulted in 13 concepts:

- Passive Lake Albert connector channel (Concept 1A)
- Passive piped Lake Albert Connector (Concept 1B)
- Passive Lake Albert connector channel + Dredge Parnka Point (Concept 1A + 2)
- Passive piped Lake Albert Connector + Dredge Parnka Point (Concept 1B+ 2)
- Pump out (jetty discharge) (Concept 3A)
- Pump out (low visual impact discharge) (Concept 3B)
- Pump out (jetty discharge) + Dredge Parnka Point (Concept 3C)
- Pump out (low visual impact discharge) + Dredge Parnka Point (Concept 3D)
- Pump in or out (separate pumping stations) (Concept 4A)
- Pump in or out (one common pumping station) (Concept 4B)
- Circulation (pump in and out) (jetty discharge) (Concept 5A)
- Circulation (pump in and out) (low visual impact discharge) (Concept 5B)
- Passive Southern Ocean Connector (Concept 6).

These concepts proceeded to concept design and were investigated for feasibility. This Draft Feasibility Assessment Report will help determine whether, individually or collectively, the concepts can form a feasible investment case for maintaining and enhancing the ecological character of the Coorong.

Key Findings

All the concepts we explored provide an overall ecological improvement from the base case (or status quo) across water level and salinity, and some options also provide an in nutrients. In determining a preferred options, we looked at the extent of improvement that each concept can offer.

Key Finding 1: The Lake Albert Connector option (with or without dredging) does not provide ecological improvements to the health of the Coorong South Lagoon to the same extent as the Coorong South Lagoon – Southern Ocean Connector options. It was also found that the Lake Albert Connector concepts are the only concepts that fail to both keep salinity under 100g/L when conditions of the Millennium Drought are simulated, and reduce the risk associated with the elevated nutrient levels in the Coorong ecosystem.

Key Finding 2: Pumping water out of the Coorong South Lagoon is the most effective way of improving and maintaining desired salinity and nutrient concentrations. Pumping out of the Coorong South Lagoon can be achieved through different discharge structure options (i.e. jetty, breakwater or low visual impact FlexMat).

Key Finding 3: Pumping into the Coorong South Lagoon from the Southern Ocean would provide a water source in addition to flows down the River Murray and provide water managers with an additional management lever with which to manage the system. This water would be in addition to water for the environment returned and delivered under the Murray-Darling Basin Plan.

Key Finding 4: Dredging on its own will not deliver sufficient ecological restoration benefits, but in conjunction with other options can improve connectivity and boat accessibility between the Coorong North and South lagoons.

Stage 3: Develop business case

Subject to funding approval, a business case will be developed for the preferred option(s) for consideration by governments. If governments consider the business case to be worthy of investment, the works program will be delivered under HCHB Phase 2.

2. Introduction

2.1. *Healthy Coorong, Healthy Basin* Program

The ecological condition of the Coorong has been in decline for many decades due to over-extraction of River Murray flows and extensive modifications to flow pathways (DEW, 2021c). The extreme drought conditions experienced across southern Australia in the 2000s, now known as the Millennium Drought, had a disastrous effect on the Coorong, exacerbating the decline in its condition.

Since then, increases in natural and managed inflows to the Coorong have allowed some ecological characteristics to return to pre-drought conditions, but strong evidence suggests that key ecological features and values have not recovered or continue to decline. This is particularly evident in the Coorong South Lagoon where key ecological processes and species are still declining and many are under threat (DEW, 2021c). Local communities, including First Nations, have called for the restoration of the health of the Coorong and broader Coorong, Lower Lakes and Murray Mouth (CLLMM) region.

On 14 December 2018, the Australian and South Australian governments jointly agreed to quarantine the remaining unspent South Australian State Priority Project funds, of around $70 million, for measures to support the long-term health of the Coorong via the HCHB Program.

The HCHB Program is seeking provide evidence-based solutions to both immediate threats and to future conditions anticipated under a changing climate. These include options to improve water delivery to the Coorong and enhance the quality of Coorong habitat for fish, waterbirds and plants.

The Coorong provides critical drought refugia and breeding grounds for species that move throughout the Murray-Darling Basin, as well as intercontinental migratory waterbirds. By restoring the Coorong, the HCHB Program aims to achieve broader environmental and social benefits not just at the site, but also the CLLMM region and greater Murray-Darling Basin.

The HCHB Program proposes a combination of activities to meet short, intermediate and long-term restoration objectives for the Coorong.

The best decisions for restoration of the Coorong will be made withstrong community engagement ,gaining community trust, support, cooperation and input into the planning, designing and implementing of the HCHB Program, which is being delivered in two phases; Phase 1 from 2019-2022 and Phase 2 from 2022-2024 (subject to relevant funding approval from the Australian Government).

2.2. Coorong Infrastructure Investigations Project

This Feasibility Assessment Report is the culmination of studies carried out in HCHB Project 4: the Coorong Infrastructure Investigations Project (CIIP).

The CIIP explores long-term benefits of operational infrastructure by investigating the feasibility of various options. A business case will be developed under HCHB Phase 2 for the options that are deemed feasible and that provide the greatest ecological benefit to the Coorong South Lagoon. The business case will be assessed by the Australian and South Australian Governments against due diligence assessment criteria prior to implementation.

The project approach for the CIIP is shown in Figure 1.

A detailed description of each of the stages of the CIIP is in Chapter 4.

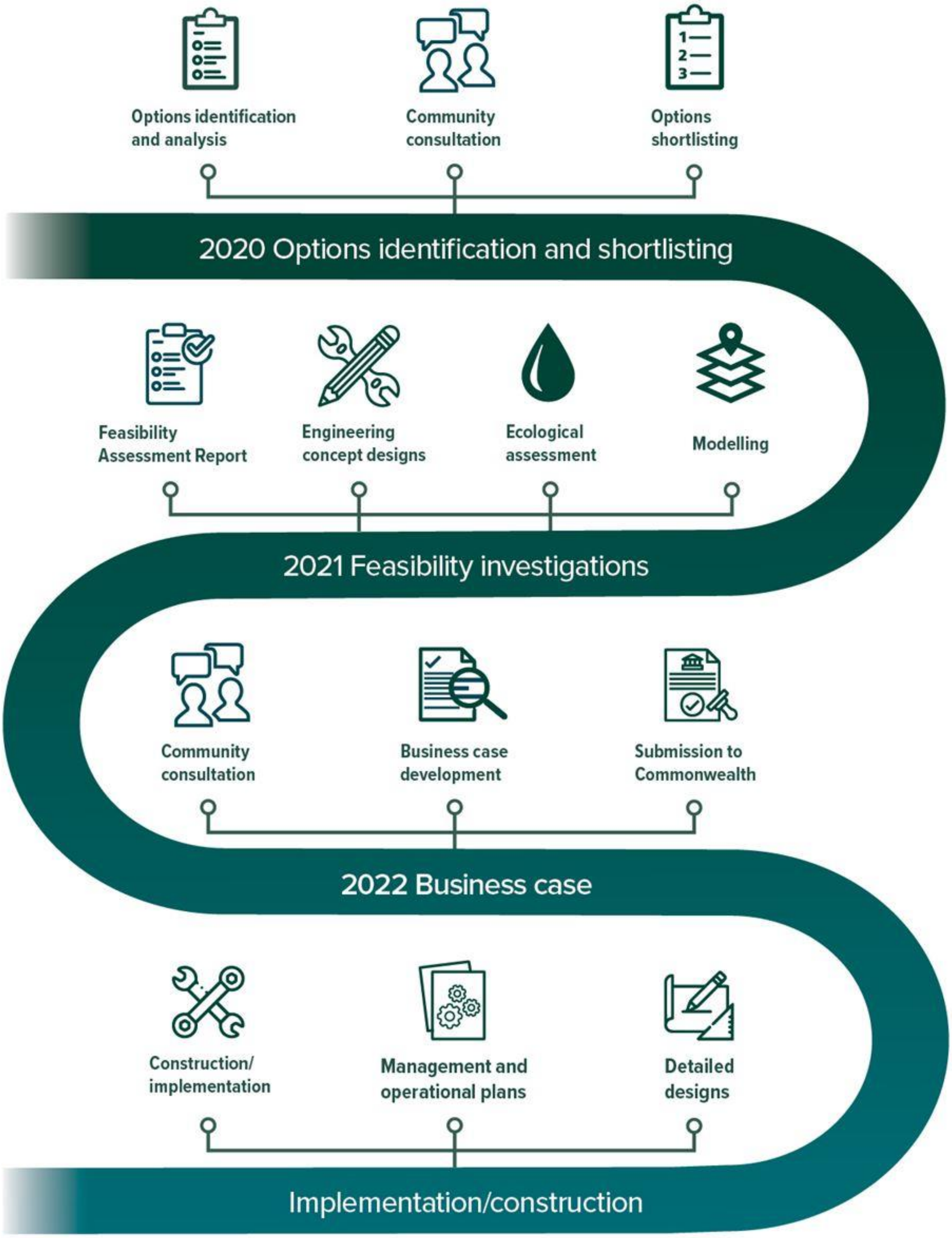

Figure 1: The project approach for the Coorong Infrastructure Investigations Project (CIIP). The project is currently at the 'Feasibility Assessment Report' phase of this diagram.

3. Background

3.1. Site description

The Coorong, Lower Lakes and Murray Mouth

At the end of the Murray-Darling Basin in South Australia is the CLLMM region. The area includes the large freshwater lakes Alexandrina and Albert (the Lower Lakes), two lower tributary regions Currency Creek and Finniss River, which flow into the Goolwa Channel, the Angas and Bremer which flow into Lake Alexandrina (near Milang) and the Coorong. The Coorong is a 140-kilometre long, narrow lagoon separated from the Southern Ocean by a coastal dune barrier (Younghusband Peninsula). A restriction at Parnka Point separates the Coorong into two zones: the Coorong North and South lagoons.

The Murray-Darling Basin and the Coorong

Located at the end of Australia's largest river system, the Coorong is an important part of the Murray-Darling Basin. It relies on flows from the River Murray, Southern Ocean as well as an open Murray Mouth to create healthy habitats for thriving wildlife.

The Coorong receives freshwater from the following sources:

- The primary source of freshwater inflows is the River Murray via the north of Lake Alexandrina, near Wellington
- Small seasonal inflows come from:
    1. tributary streams draining from the Eastern Mount Lofty Ranges (that is, Currency Creek and the rivers Finniss, Angas and Bremer); these are typically less than 2% of the overall inflows into the Lower Lakes
    2. the Upper South East which drains into the Coorong South Lagoon at Salt Creek.
- Rainfall and groundwater provide freshwater but this is minor compared to River Murray inputs (DEW, 2021b).

Water extraction from the River Murray for irrigation and potable water and flow modifications such as dams, locks, weirs and barrages have significantly impacted the hydrology and ecology of the Coorong. The health of the Coorong is a critical indicator of the health of the entire Murray-Darling Basin. Sediment, salinity and nutrient accumulation can have significant upstream impacts when river flows are not sufficient to flush these ecological toxins out to sea. Drinking water and irrigation can be affected along the River Murray by declining water quality, which has implications for health and economic production in South Australia and other basin states. Managing the Coorong must be done holistically within the wider Murray-Darling Basin. It must also consider how drought and future climate change will impact future management and ecological adaptation in the Coorong.

3.2. International obligations

Ramsar Convention

The Ramsar Convention on Wetlands is an intergovernmental treaty that provides a framework for the conservation and wise use of wetlands and their resources. The broad aims of the convention are to halt and, where possible, reverse the worldwide loss of wetlands and to conserve those that remain through wise use and the implementation of management plans. Contracting parties to the convention are required to designate sites containing representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity, to the List of Wetlands of International Importance. These sites are commonly known as Ramsar sites.

Designating a wetland of International Importance carries with it certain obligations, including managing the site to maintain its ecological character and to have procedures in place to detect if any threatening processes are likely to, or have altered the ecological character.

The management of Ramsar sites in Australia is implemented using a series of key documents, including:

- *Ramsar Information Sheet* is a summary of the essential information relating to a site and its management;
- *Ecological Character Description* provides a more detailed and technical description of the ecological character of the site at a given point of time (baseline); and
- *Ramsar Management Plan* documents the management strategies required to maintain and enhance the ecological character of a Ramsar site and build resilience to threats.

Ramsar Status

The Coorong, and Lakes Alexandrina and Albert Wetland was designated as a Wetland of International Importance under the Ramsar Convention in 1985. On 13 December 2006, the Australian Government wrote to the Ramsar Convention Secretariat to inform them of a change in the ecological character of the site in accordance with Article 3.2 of the Ramsar Convention. The notification was based on the findings of the 2006 Ecological Character Description (ECD) for the site, which reported that the site had been in decline for 20 to 30 years prior to listing and that further decline is likely or inevitable. At the time the report was written, eight of the nine Ramsar listing criteria continued to be met.

After the notification in 2006, flows down the River Murray into the Ramsar site were significantly less than extraction and losses from evaporation and seepage. The water levels of Lake Alexandrina and Lake Albert fell to unprecedented lows leading to increased salinity and extensive drying of the Lakes, exposing thousands of hectares of actual and potential acid sulfate soils, and the disconnection of core refuge areas in the southern section of Lake Alexandrina. Falling lake levels and lack of flow over the barrages into the Murray Estuary and the Coorong continued to exacerbate environmental issues in the Coorong such as increasing hypersalinity, loss of submergent vegetation and subsequent changes in bird populations. The challenges facing the site were numerous but were principally driven by the altered hydrological regimes, which were exacerbated by the Millennium Drought.

Other international agreements

The Coorong is subject to the following international agreements:

- Convention on Migratory Species (Bonn Convention) 1983
- Japan-Australia Migratory Bird Agreement 1974
- China-Australia Migratory Bird Agreement 1986
- Republic of Korea-Australia Migratory Bird Agreement 2007
- East Asian-Australasian Flyway Partnership 2006.

3.3. Murray-Darling Basin Plan

The Millennium Drought exposed the limits and weaknesses of how water in the Murray-Darling Basin had been managed and highlighted the need for reform. In response, the Australian Government passed the *Water Act 2007* (Cth). As a requirement of the Act, the Murray-Darling Basin Authority (MDBA) developed the Basin Plan, which was adopted in 2012. The Basin Plan provides a coordinated approach to water management across New South Wales, Queensland, South Australia, Victoria and the Australian Capital Territory. It was a significant step in the ongoing process of managing the basin's water for the benefit of all its users and the environment.

The Basin Plan must promote:

- sustainable use of the Murray-Darling Basin's water resources to protect and restore its ecosystems, natural habitats and species, and to conserve biodiversity
- the wise use of all water resources in the Murray-Darling Basin
- the conservation of declared Ramsar wetlands in the Murray-Darling Basin.

A key objective of the Basin Plan is to ensure that Ramsar wetlands, such as the Coorong, Lakes Alexandrina and Albert Wetland, maintain their ecological character. Full implementation of the Basin Plan, including the continued optimisation of delivery of water for the environment is critical in achieving Basin Plan objectives, including protecting and restoring water-dependent ecosystem and their ecosystem functions to ensure ecosystems like the Coorong are resilient to climate change and other risks and threats.

Long-term watering plans

These plans are a legislative requirement under Chapter 8 of the Basin Plan. The *Long-Term Watering Plan for the SA River Murray Water Resource Plan Area* (DEW, 2020) defines the CLLMM as one of three priority ecological assets in the area. The plan defines the ecological objectives, targets and Environmental Water Requirements in order to achieve a healthy, functioning CLLMM region. For example, the Environmental Water Requirements define metrics on how water for the environment should be delivered to the Lower Lakes and Coorong if we are to achieve ecological objectives and targets. The success of Environmental Water Requirements is measured against optimal flow volume and timing through barrages, and corresponding water level metrics in the Lower Lakes and Coorong (DEW, 2020).

Currently, the CLLMM Environmental Water Requirements are not being met, due to insufficient River Murray flows delivered to the end of the system. The infrastructure explored under the CIIP provides the opportunity to provide an additional management lever to achieve the required Environmental Water Requirements in the Coorong.

3.4. Site management practices

There are a number of agreements, legislation and policies relevant to the management of the site or to species or communities that use or are present at the site. Hydrology, in particular inflows from the River Murray, is a key driver of the ecological character of the site. Flow regulation, consumptive water use (including groundwater extraction) and the delivery of water for the environment in the Murray-Darling Basin are key influences on the hydrology of the Ramsar site, including the volume and seasonality of inflows and outflows, and the water quality of the site.

An overview of the key Ramsar legislation and environmental water management in South Australia are shown in Figure 2 below.

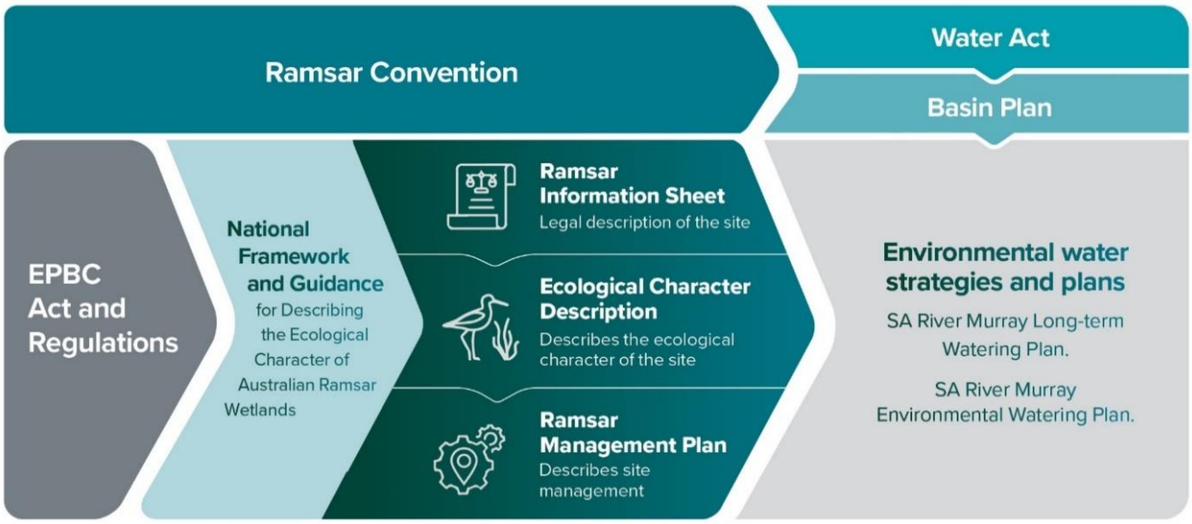

Figure 2 Overview of the key links between legislation for Ramsar and environmental water management in South Australia

3.5. Cultural significance

Aboriginal people are the First Peoples and Nations of South Australia. The Coorong and its connected waters and lands have sustained many First Nations cultures and economies. The HCHB Program acknowledges the range of First Nations rights, interests and obligations for the Coorong and connected waterways and the cultural connections that exist between First Nations peoples across the region and seeks to support their equitable engagement.

The Ngarrindjeri and First Nations of the South East are the Traditional Owners of the lands and waters of the Coorong, and Lake Alexandrina and Albert Wetland Ramsar site. Ngarrindjeri have occupied, enjoyed, managed and used their inherited lands and waters within the area of the River Murray (Murrundi), Lower Lakes, Coorong (Kurangk) and adjacent areas since the Kaldowinyeri (Ngarrindjeri Creation). The First Nations of the South East have traditional ties to the South East region and in particular to the Coorong South Lagoon and the associated ephemeral lakes and wetlands.

Healthy Yarluwar-Ruwe (Sea Country) relies on interconnectivity between land, waters, spirit and all living things (Ruwe/Ruwar). Threats to ecological health can be understood as a threat to the health and wellbeing of the Ngarrindjeri People. Threats to the wellbeing of Ngarrindjeri – especially in terms of governance and the ability to speak as and care for Country – can also be seen as threats to Yarluwar-Ruwe. These threats are not rhetorical or metaphorical, but practical and material in nature, and reflect the intrinsic interconnectedness of Ruwe-Ruwar (DEW, 2021a).

3.6. Current condition of the Coorong

Since the Millennium Drought initiatives including The Living Murray Initiative and environmental water recovery and delivery under the Murray-Darling Basin Plan have improved water management and outcomes for the Coorong, increased environmental flows to the Coorong and addressed some critical knowledge gaps for the region. These initiatives, along with the return of regular flows of freshwater, have resulted in the region showing some signs of recovery and the site continuing to meet eight of the nine Ramsar criteria.

Since 2010, significant flows over the barrages, combined with increased flows from the South East, have reduced salinity in the Coorong South Lagoon and helped to maintain it generally below 100 parts per thousand (ppt) (112,471 EC) for the majority of the time. Although these initiatives, along with the return of regular flows of freshwater, have resulted in the region showing some signs of recovery, the ecosystem has been slow to respond, demonstrating the long-term nature of impacts associated with periods of low River Murray flows and extreme salinity. Several characteristics of the Coorong South Lagoon in particular, have continued to experience substantial and sustained decline. Prolonged hypersaline and hypereutrophic conditions, and inadequate water levels in the Coorong South Lagoon have caused disruptions to key ecological processes, including nutrient cycling and primary production, which has in turn reduced the quality and availability of habitat and food resources for key species within the Coorong South Lagoon. There have also been large reductions in the abundance of some waterbirds, particularly fairy tern and migratory shorebirds. This is associated with the prevalence of filamentous algae that is preventing aquatic plants from completing their life-cycle and interfering with the ability of waterbirds to feed on both plants and invertebrates in mudflats (Brookes, et al., 2018).

Reinstating these key ecological processes and functions through the implementation of management actions and interventions is a key first step, but maintaining the long-term health and resilience of the Coorong may not be achievable through improved knowledge and water resource optimisation alone. Additional management options may be required, particularly in the face of climate change, in order to achieve long-term restoration goals.

4. Project Approach

The CIIP investigates the feasibility of multiple long-term operational infrastructure options to improve the health of the Coorong. The primary output will be one or more business cases for the options deemed feasible and desirable, for consideration by the Australian Government.

Exploring long-term/permanent infrastructure in the Coorong is a complex action. Engagement and consultation with stakeholders and the CLLMM community is very important and community inputs are highly valued.

4.1. Project need

Whilst the Coorong system has improved in the past decade, it lacks ecological resilience and management levers are limited. To improve the health of the Coorong South Lagoon, solutions that can make changes on an ecosystem scale are needed. The CIIP explores the opportunities and feasibility of potential long-term infrastructure options to achieve this ecosystem scale improvement.

4.2. Project methodology

Stage 1: High-level options analysis and shortlisting for further feasibility investigation

A range of major infrastructure and management options have been identified over the past two decades aimed at improving the delivery of water to the Coorong and our ability to manage it for ecological benefit. Most of the options recognise the limitations in our ability to manage water and the long-term threat of climate change. The objectives of each option have varied but generally they aimed to address two key biotic drivers: salinity and water level. Recently, we have an improved understanding of the role of nutrient loads as a key ecological indicator. Work has continued under the HCHB Program to understand nutrient dynamics within the Coorong and its impacts. This improved understanding of nutrient dynamics has informed key findings related to feasibility of infrastructure in this report.

To date, investigations into long-term infrastructure options have been in the context of isolated management issues and individual responses. Investigations rarely considered their combined impact, optimal mix, and interaction with planned infrastructure or impact on the broader site. Until now, the feasibility assessments had also not been revisited and revised to reflect current knowledge on the ecological state of the Coorong. Before CIIP, it was not possible to assess relative or combined merit and risks.

Some of the long-term infrastructure options that were considered for an updated and more integrated assessment were:

- options to maintain an open Murray Mouth, including mitigating the need for dredging and providing greater seawater exchange with the Coorong (for example, training walls)
- a connecting pipe or channel between Lake Albert and the Coorong to improve environmental water delivery to the Coorong (for example, Lake Albert-Coorong Connector)
- improving the connectivity between the Coorong North and South lagoons and the Lower Lakes through dredging
- augmenting the South East Flows Restoration Project with additional water from the South East by extending the Northern Floodway to the south of Blackford Drain
- options to regulate and maintain water levels in the Coorong South Lagoon (for example, Parnka Point Regulator)
- options to pump water from the Coorong South Lagoon to the Southern Ocean to 'reset' the system
- a connecting pipe or channel between the Coorong South Lagoon and the Southern Ocean to enable seawater exchange.

In early March 2020, Tonkin Consulting reviewed the options, including a technical review of previous investigations and development of a high-level summary of each option (Tonkin Consulting, 2020). Eleven infrastructure and management options were identified that could improve our ability to manage the Coorong and enhance its ecological health:

- Permanent connection between the Coorong South Lagoon and Southern Ocean
- Further augmentation of South East Flows to the Coorong (SEFA)
- Coorong Lagoon dredging to improve connectivity
- Temporary pumping from the Coorong South Lagoon to the Southern Ocean (salinity reset)
- Additional automated barrage gates
- Increased dredged Murray Mouth dimensions
- Lake Albert – Coorong Connector
- Water level induced flow from the Southern Ocean water into Coorong
- Training walls for an open Murray Mouth
- Coorong South Lagoon regulator
- Temporary wetting/drying cycling of Coorong South Lagoon.

To narrow these options down, we needed to understand the social, economic and cultural implications of each of them. Following a community engagement process (see Chapter 5) and a multi-criteria analysis process that scored each of the options for constructability, First Nations risks, and benefits and ecological potential, **5 infrastructure options** were shortlisted to proceed to feasibility investigations in 2021:

- Permanent connection between the Coorong South Lagoon and Southern Ocean
- Coorong Lagoon dredging to improve connectivity
- Lake Albert – Coorong Connector
- Further augmentation of South East Flows to the Coorong (SEFA)
- Additional automated barrage gates.

Stage 2: Feasibility Investigations for prioritised options

From January to December 2021, the CIIP addressed knowledge gaps and the feasibility of the five shortlisted options.

Initially, Jacobs Group was engaged to support the project and conducted an engineering case study review to identify Australian and International projects that were designed to achieve similar engineering and environmental outcomes to our shortlisted options. The review found many applications globally where engineering solutions improved the conveyance and water quality of semi-enclosed and enclosed water bodies. However, each example has unique environment and project objectives, and none of the projects were similar to the combination of hydrodynamic regimes and habitats of the Coorong (Jacobs Group, 2021).

Any potential infrastructure project in the Coorong, therefore, needed to be analysed in the unique context of the Coorong environment, and so feasibility investigations proceeded across the following themes:

- Hydrodynamic, biogeochemical and ecological modelling
- Ecological assessments, risk assessment and analyses
- Cultural heritage surveys
- Engineering technical feasibility assessments (including concept designs)
- Preliminary Socio-economic assessments
- Risk assessments
- Capital and operating and maintenance cost estimates.

This Draft Feasibility Assessment Report provides a high-level summary and synthesis of the technical work. See Chapter 6 for the methodology of the investigations. Chapter 7 outlines specific findings on each engineering concept.

The most feasible engineering concept will be recommended for additional funding for a detailed design process from 2022-2024. While we make recommendations that some infrastructure options are feasible in this draft report, this does not guarantee construction. It merely means that some options will undergo further, more detailed assessment. A description of potential further investigations that could occur are under 'Further investigations' headings throughout Chapter 6.

In February 2022, we will seek feedback from community stakeholders on this Draft Feasibility Report, specifically in relation to the preferred option(s), before finalising this report to submit to the Australian government for funding consideration to develop a business case.

Stage 3: Develop business case for HCHB Phase 2

Subject to funding approval, a business case will be developed for the preferred option(s) for consideration by governments to be delivered under HCHB Phase 2.

4.3. Project governance and decision making

The CIIP project guidance and decision-making occurs in-line with the HCHB Program governance framework depicted in Figure 3.

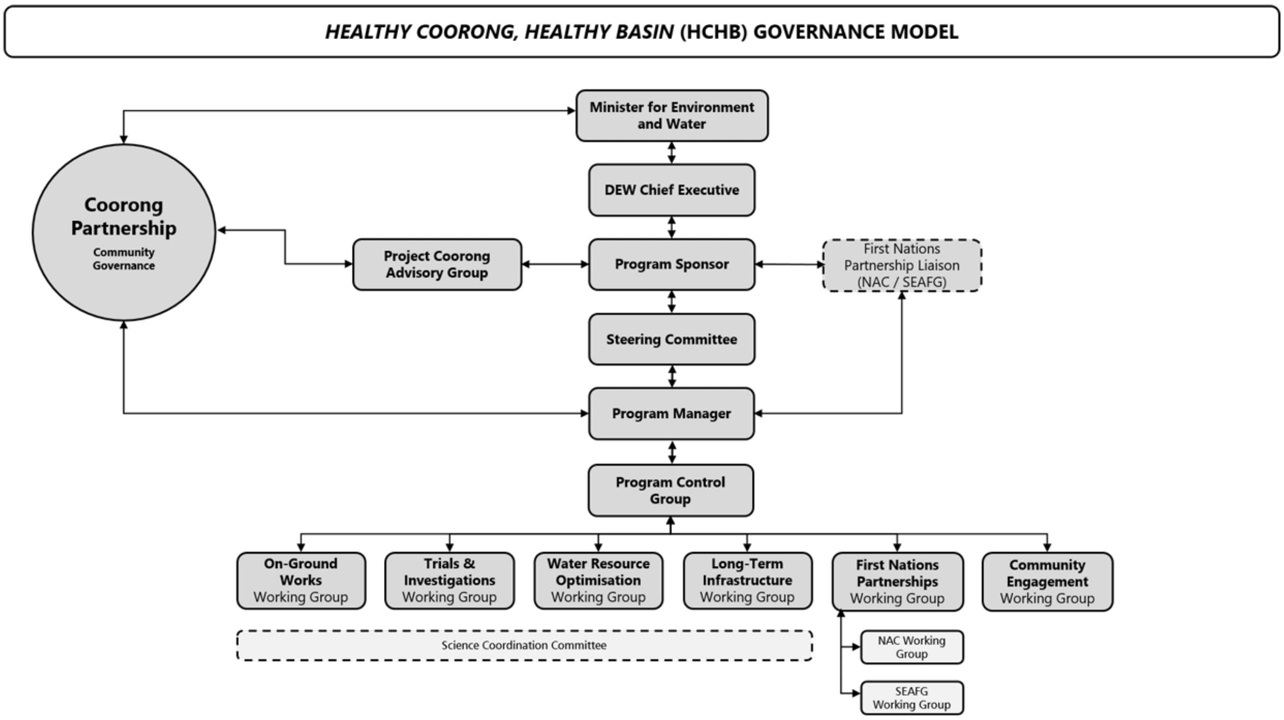

Figure 3 Governance framework for the *Healthy Coorong, Healthy Basin* Program. The HCHB projects (On-Ground Works, Trials and Investigations, Water Resource Optimisation, Long-Term Infrastructure, First Nations Partnerships, Community Engagement) are responsible for delivery.

Coorong Partnership: community governance

Communities in the CLLMM and beyond have valuable knowledge and experience in environmental issues facing the region and ideas on how to tackle those issues. This information must be considered in planning and decision-making.

The HCHB Program (and Project Coorong, more broadly) is guided by the Coorong Partnership, which represents a range of interests and expertise including conservation, recreation, science, agriculture, local government, tourism, fishing, heritage and First Nations culture.

The HCHB Program projects have adopted a co-design approach with the Coorong Partnership wherever possible. The partnership provides local communities and groups with unprecedented opportunities to help shape the plans and activities for the ecosystem. For example, it has a key role in providing ideas and insights into each key milestone of the CIIP and receives regular updates on the progress of each component of the investigations.

5. Community Engagement

5.1. Engagement strategy and overview

Community advocacy and involvement in the long-term management of the Coorong are fundamental to its health and sustainability. Communities must be supported to become caretakers of the precious wetland.

The HCHB Community Partnerships project aims to:

- **inform** the community throughout the process – through our quarterly HCHB updates and communications after significant milestones
- **involve** the Coorong Partnership, First Nations Partners, and targeted stakeholders where appropriate, ahead of any major review/decision point that significantly changes an option, or any review of whether to continue with an option
- **consult** the community on the final feasibility evaluation/assessment of infrastructure options – through community workshops, meetings and the YourSAy online consultation hub
- **be flexible** in our approach - willing to change the approach to suit evolving needs of the project and community.

CIIP has engaged communities at each stage of the project via the Coorong Partnership (see Chapter 4.3) and invited people to have a conversation with us about their ideas and concerns.

5.2. Engagement outcomes

5.2.1. Options identification and shortlisting (June 2020)

In the first stages of consultation, we worked with the community and the Coorong Partnership to determine what communities deemed to be the essential outcome from any infrastructure works for the Coorong South Lagoon. Community members were surveyed, and then a voluntary group of people met online to discuss and summarise the results of that survey.

In mid-2020, we sought community input to assess and shortlist infrastructure options for further investigation. The criteria identified through the survey and volunteer group were applied to a second survey, this time in YourSAy. This survey asked South Australians to nominate their preferred 3 options (1st/2nd/3rd) and to identify (by ticking a box) the criteria the option best met from the following:

- I think it will best contribute to improving the ecology of the South Lagoon as determined by scientific evidence, given water availability and constraints
- I think it will protect sites and areas of all cultural, Indigenous and broader community significance
- I think it will reflect the needs of the community
- I think it will provide a long-term solution that can be sustainably managed
- I think it will grow/support local economic opportunities and education now and into the future
- I think it will enable the continuation and enhancement of use of the wetland in a sustainable manner
- I think it will be adaptable, flexible and is aesthetically sensitive.

The essential outcome of the CIIP, according to the survey and voluntary group, is finding the option/s *"That best contribute to improving the ecology of the South Lagoon as determined by scientific evidence, given water availability and constraints."*

A number of other key values or criteria were also determined by the voluntary group. These formed the basis of the next steps of engagement where the community were invited to rank or prioritise the 11 options.

From the survey, we collated a prioritised list of community preference of the options (1 to 11) along with the criteria the community felt the options met the best. This was compared with the preliminary multi-criteria analysis to assist in shortlisting.

After analysing all the feedback, and combining it with a technical multi-criteria analysis, the following 5 infrastructure options were shortlisted for detailed feasibility assessment investigation:

- Permanent connection between the Coorong South Lagoon and Southern Ocean
- Coorong Lagoon dredging to improve connectivity
- Lake Albert – Coorong Connector
- Further augmentation of South East Flows to the Coorong (SEFA)
- Additional automated barrage gates.

5.2.2. Early concept details and draft multi-criteria analysis (July 2021)

HCHB hosted 4 community discussion sessions on 14-15 July 2021 at Goolwa, Meningie, Robe and Salt Creek. The sessions were well attended with over 140 community members.

The sessions aimed to:

- update the community on CIIP progress
- outline the infrastructure options proceeding to concept design and cost estimation
- revisit the community values and check their alignment with the shortlisted options
- ask people to consider how well the proposed criteria to assess the infrastructure options reflect what matters to them.

We recognise that the Coorong is critical to both the ecological health of the Murray-Darling Basin, and to local communities. We began each session by asking participants what was on their minds and what they would like to know. Their answers helped shape the nature of our engagement going forward.

Community update presentations - What we shared

At the community discussion sessions, the Department for Environment and Water set the scene for each session with an overview of 'The desired state of the Southern Coorong – discussion paper'. This paper, by the HCHB Trials and Investigations Integration team, provides a shared understanding of:

- the current state of the Southern Coorong
- what happens if we do nothing to intervene with the declining ecosystem health
- our view on what is the 'desired state'
- principles on how to achieve the desired state based on the science available.

The HCHB team then presented on the progress of the CIIP, including:

- project overview
- hydrological modelling
- ecological investigations
- infrastructure options shortlisted for concept design.

Participants asked questions, offered feedback and raised some concerns about the options being investigated. This feedback has been used to inform our investigations and the final infrastructure Feasibility Assessment Report.

After the presentations, participants broke up into groups to discuss the proposed evaluation criteria and how well they reflect community values. See Chapter 8 for an explanation of a multi-criteria analysis, and the outcomes of how the community input informed the final criteria we assessed.

5.3. First Nations engagement

The Ngarrindjeri and First Nations of the South East are the Traditional Owners of the Coorong and surrounding region. HCHB acknowledges the First Nations' rights to, and interests and obligations in the Coorong and connected waterways and the cultural connections between First Nations peoples across the region, and supports their equitable engagement.

HCHB has strong working relationships with the primary First Nations representative bodies and has put in place protocols to allow for cultural communication between the two nations:

- Ngarrindjeri Aboriginal Corporation – Ngarrindjeri are Native Title holders of much of the Kurangk (Coorong), including the potential work areas in this project area. In infrastructure feasibility investigations that occur on Ngarrindjeri Country, the Ngarrindjeri Aboriginal Corporation are the primary contact for that study and will inform, where appropriate, the First Nations of the South East.
- South East Aboriginal Focus Group – First Nations of the South East are Native Title claimants of the southern portion of the Coorong and associated wetlands. For investigations on First Nations of the South East Country, the South East Aboriginal Focus Group are the primary contact and will inform, where appropriate, the Ngarrindjeri Aboriginal Corporation.
- There exists an overlapping native title claim area between the Ngarrindjeri determination and First Nations of the South East native title claim. None of the CIIP options currently under consideration are within this overlapping claim area.

HCHB has a First Nations Partnership Project to support engagement and involvement of Ngarrindjeri and First Nations of the South East. The project administers formal partnership arrangements through grant agreements with prescribed bodies corporate for Ngarrindjeri (through the Ngarrindjeri Aboriginal Corporation) and First Nations of the South East (through Burrandies Aboriginal Corporation) to ensure they can apply their cultural knowledge, values and interests to shape, inform and be involved in implementing initiatives across the 6 HCHB Phase 1 projects.

Systems are in place to manage sensitivities and protect traditional knowledge when disseminating and storing cultural information. This is guided by DEW's Data Handling Guidelines – Managing Sensitive Aboriginal Cultural Data and Guidelines for Protecting Aboriginal Cultural Knowledge, which is part of DEW's Information Management Framework and Managing Environmental Knowledge (MEK) procedure.

All CIIP information is being offered to the Ngarrindjeri Working Group and the South East Aboriginal Focus Group, and the CIIP Team will be guided by them on opportunities to collaborate across the project.

There are many Aboriginal and Torres Strait Islander people who live in the project area but are not First Nations of the South East or Ngarrindjeri. They have been encouraged to participate in the HCHB community engagement process (described in Chapter 5.1), or can connect through the Ngarrindjeri Aboriginal Corporation or First Nations of the South East if preferred.

5.4. Additional engagement activities

Community updates

HCHB releases a community update each month. Throughout CIIP, this update has been used to inform communities of progress against investigation milestones:

- Outcomes of the July consultation – July 2021
- Update on the concept designs – October 2021.

Landholder letters

Targeted letters were sent to landholders with property within 2.5 km of the Coorong South Lagoon. The letters advised of upcoming consultation activities, and of investigations that occurred in late 2021.

Engagement with other reference groups

HCHB staff provided verbal updates and presentations on CIIP progress at regular CLLMM Community Advisory Panel and Scientific Advisory Group meetings in 2020 and 2021. This has been a way to communicate to a wider range of community members and scientists, who were able to provide feedback.

6. Investigations

Investigations to assess the feasibility of infrastructure options and to refine the design of options were carried out in 2021. Designs were optimised to maximise improvements to the Coorong South Lagoon in a manner that is feasible to construct, cost-effective and minimises social, cultural and environmental impacts. This chapter summarises our approach for each phase of investigations. Specific findings for each infrastructure option are explored in Chapter 7.

The intent of these investigations is to inform feasibility. More detailed investigations will occur to refine construction, operations, maintenance and monitoring matters as well as provide information for legislative consideration, once a preferred option is recommended. This will be the focus of CIIP in 2022 and beyond.

6.1. Ecological investigations summary

Ecological investigations were undertaken by the Department for Environment and Water (DEW) in two phases:

1. Phase 1 assessed and compared the benefits and risks of the shortlisted options (and combinations thereof) to the Coorong ecosystem, with a focus on the Coorong South Lagoon (DEW, 2021d)

2. Phase 2 optimised the shortlisted CIIP options based on findings from Phase 1 and evaluated the long-term performance of these options and potential risk and uncertainties to the system. (DEW, 2021e)

Both phases were informed by modelling of Coorong conditions: hydrodynamic (DEW, 2021f), biogeochemical and habitat (BMT, 2021). An ecological risk assessment framework (ERAF) (Butcher & Cottingham, 2021) was also developed and used to support the analysis and evaluation of the modelling outputs in both phases.

Phase 1 included additional ecological interpretation to infer, based on expert advice, the expected responses of key ecosystem components (such as sediment quality, nutrients, aquatic macrophytes, macroinvertebrates, fish) that either could not be modelled accurately or at all.

A refined ERAF evaluation methodology was developed for Phase 2 so results could provide direct inputs to the broader multi-criteria analysis process.

6.1.1. Modelling

Hydrological, biogeochemical and ecological models are used to inform decision-making for aquatic ecosystems and predict responses to management interventions. A review of existing models for the Coorong found the Coorong Dynamics Model to be the most sophisticated ecosystem model. This model and its hydrodynamic platform (TUFLOW-FV) were used to support our investigations.

TUFLOW-FV is a 2 or 3-dimensional model that simulates the movement of water and predicts water level and depth, salinity, velocity, temperature and Murray Mouth morphology in response to inflows, tides, wind, waves, evaporation and rainfall (BMT 2019). The model is very flexible and is the most detailed hydrodynamic model of the Coorong.

The Coorong Dynamics Model dynamically links the TUFLOW-FV model with the AED2 Biogeochemistry and Habitat Model. It simulates the hydrodynamic conditions, water clarity (light and turbidity), nutrients (organic and inorganic), chlorophyll-a, filamentous algae and *Ruppia* habitat quality in the Coorong at high-resolution (Hipsey, Busch, Huang, & Gibbs, 2020).

6.1.2. Ecological risk assessment framework

A risk-based approach was used to select CIIP options for concept engineering and construction feasibility. An ecological risk assessment framework (ERAF) (Butcher & Cottingham, 2021) was developed to establish the principles and methods by which ecological and environmental outcomes (benefits or impacts) would be assessed.

The ERAF evaluates the changes in the level of ecological risk in the Coorong (salinity, water level and nutrients) under a CIIP option, where risk is measured as a departure from the achievement of ecological objectives for the Coorong. It allows us to evaluate the change in the ecological risk profile under each proposed CIIP option compared to the base case (or status quo). It enables better decision-making, factoring in uncertainty regarding model validity, future climatic and inflow conditions, and expected performance of infrastructure options. Benefit and risk for each proposed CIIP option was determined by comparing the risk profile with the base case scenario.

The ERAF defines benefit and risk as follows:

- **Benefit** – an increase in the likelihood of minimal or nil deviation from desired ecological objectives, and a decrease in the likelihood of a significant deviation from desired ecological objectives.
- **Risk** - a decrease in the likelihood of minimal or zero deviation from desired ecological objectives and an increase in the likelihood of a significant deviation from desired ecological objectives.

The ERAF established generic criteria for five levels of consequence (catastrophic, major, moderate, minor, and insignificant). The lowest level (insignificant) describes the goal condition, which is achievement of ecological objectives in the Coorong. The highest level (very significant) is the worst conceivable ecological outcome over the assessment timeframe.

The ERAF also identified five risk assessment end-points, which are indicators of ecological condition. They were selected based on links with key ecological outcomes for the site. The end-points considered in CIIP ecological investigations were:

- Coorong South Lagoon water levels
- Coorong South Lagoon salinity
- Coorong North Lagoon salinity
- Coorong South Lagoon nutrients
- Coorong North Lagoon nutrients.

6.1.3. Phase 1 Ecological investigations

The approach for Phase 1 ecological investigations is summarised below (and presented in Figure 4). The technical report for these investigations is available here.

The intention of Phase 1 was to provide a preliminary insight into which of the 5 infrastructure options may be feasible. Short-term (3-year) model runs provided preliminary insights into the feasibility of options, prior to a more detailed and directed look at feasible options in Phase 2.

Ecological investigations in Phase 1 were comprised of 3 steps:

1. Model runs simulating ecological parameters in the Coorong under different CIIP ecological options and climate scenarios

2. Ecological interpretation: a qualitative interpretation of the modelled ecological conditions in the Coorong under each CIIP option, based on qualitative expert judgement

3. Ecological risk assessment: A semi-quantitative evaluation of changes in level of ecological risk in the Coorong (with respect to the ecosystems key hydrological and biogeochemical parameters: salinity, water level and nutrients) under a CIIP option compared with the 'base case'.

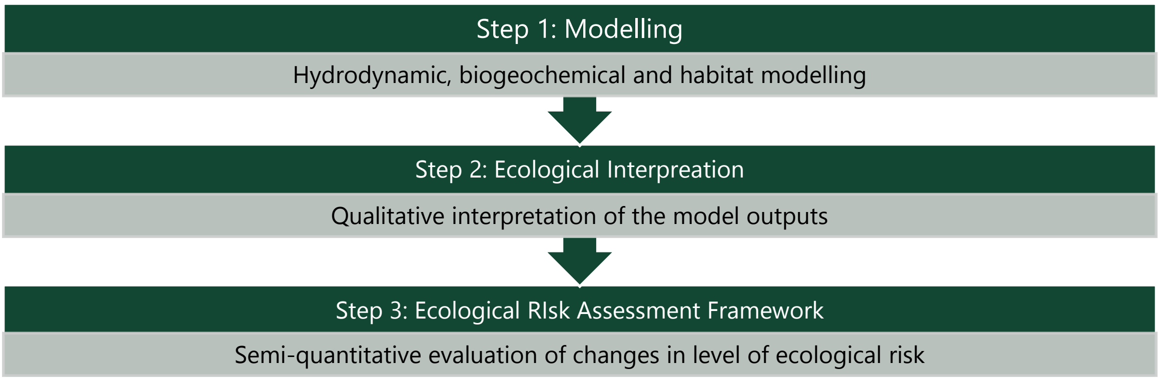

Figure 4 The process for the Phase 1 of ecological investigations.

Step 1: Modelling

We defined a series of scenarios for each CIIP option and/or combination of options to run through the TUFLOW-FV model and/or the Coorong Dynamics Model.

The modelled scenarios were simulated for ~3-year periods considering a range of flow and climate conditions, including observed, typical and dry conditions (DEW, 2021f).

Step 2: Ecological Interpretation

DEW and other ecologists selected ecosystem components during a workshop for ecological interpretation of model outputs:

- Sediment quality
- Nutrients (water column)
- Aquatic macrophytes
- Macroinvertebrates
- Fish

Each component was considered critical to the function and recovery of the Coorong ecosystem. The ecological drivers that affect the condition of these components can be modelled with confidence. The model outputs represent a simulation based on the most available information (with updates throughout 2021 informed by the HCHB Trials and Investigations project. Expert elicitation of predicted responses of the components under each infrastructure option, using the model outputs therefore also carries a moderate level of confidence. Drivers that influence the condition of the components were also identified.

Technical matter experts documented expected ecological responses for each ecosystem component in the short-term (<3 years) and long-term (>10 years). Interpretations were based on directly modelled values (DEW, 2021d). Expected outcomes for the ecological conditions were assessed with reference to the discussion paper on 'Desired State of the Coorong' (DEW 2021c) that provided a contemporary synthesis of processes and targets to be reinstated through the HCHB activities.

Step 3: ERAF

The risk assessment team interpreted model outputs of salinity, water level and nutrients according to the criteria for each level of risk consequence criterion. The team visually examined model outputs and assigned a level of likelihood to each of the risk consequence levels. This was done for each CIIP option (and combinations of them) and each climate/flow scenario. When assessing likelihood, the team considered the level of certainty in model predictions and the impact of temporal factors, such as starting conditions and trends over time.

The final output of the analysis was a table with risk score for each CIIP option, inflow scenario, end-point variable and geographic location.

The team recommended the options that best reduced the risk to the Coorong ecosystem. Options were recommended (pending further investigation) if they could provide a level of benefit (reduction in risk) irrespective of whether trade-offs were also incurred, provided they could be mitigated. At this point, automated barrage gates and South-East flows augmentation were discontinued from further investigation. The rationale behind this is explained in Chapter 7.3.

6.1.4. Phase 2 Ecological investigations

The approach for Phase 2 ecological investigations is summarised below (and presented in Figure 5). The technical report for these investigations is available here.

Phase 2 had the following objectives:

- optimise the infrastructure and management options that were progressed to concept design based on the outcomes from Phase 1;
- evaluate the long term performance (30 years) of shortlisted infrastructure and management options in achieving desired salinities, water levels and nutrient concentrations in the Coorong;
- identify potential risks and uncertainties to the Coorong ecosystem under the operation of an infrastructure and management option; and
- inform a multi-criteria analysis (MCA) established by Kellogg, Brown and Root (KBR) to assist in the prioritisation of infrastructure and management options to progress to business case development.

Ecological investigations involved refining and further evaluating the 3 CIIP options shortlisted in Phase 1:

1. Model runs simulating ecological parameters in the Coorong under different options and climate scenarios. This step was divided in 2 stages:
   - Stage 1: Optimisation and stress testing
   - Stage 2: Long term analysis
2. Analysis of model outputs using ERAF methodology
3. Evaluation of ERAF results to input into multi-criteria analysis (MCA); which included identifying environmental risks. At this stage, red flags were identified as outcomes that would lead to ecological harm over and above the scored outputs.

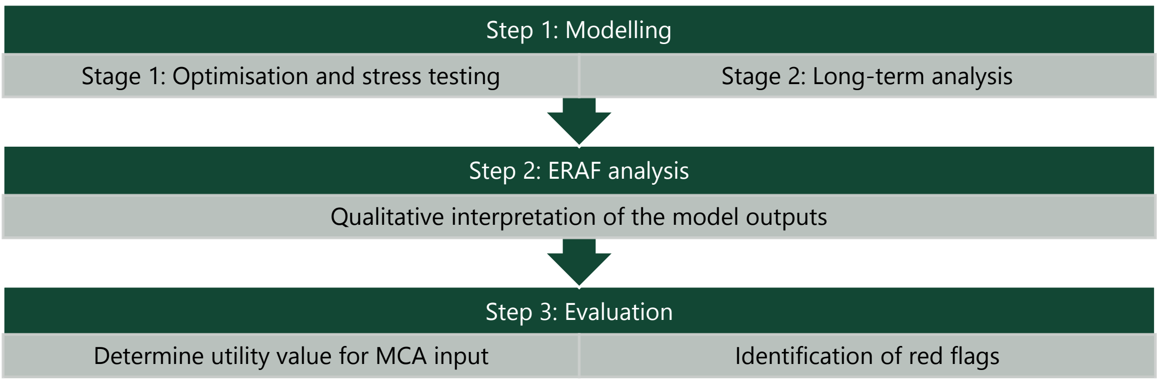

Figure 5 The process for Phase 2 of ecological investigations.

Step 1: Modelling

There were 2 batches of model runs:

1. Identifying optimum CIIP pumping regimes and stress testing

The aim was to optimise pumping regimes of the three CIIP options that progressed to Phase 2 to meet desired salinities and water levels. The optimisation process was informed by three-year hydrodynamic simulations using TUFLOW-FV

Model. Refined CIIP options were then further stress-tested under a range of scenarios simulating expected climate and inflow conditions. The method and results for this optimisation process are described in more detail in Phase 1 Ecological Investigations (DEW, 2021d). This optimisation process identified seven options that were then subject to additional (long-term analysis).

2. Long-term analysis to inform ERAF evaluation

The first modelling batch (as above) identified seven options for long-term analysis. This is fewer than the number that proceeded to concept design (13), as there was no need to differentiate between the types of discharge structure (that is, channel versus pipes) when understanding the potential for ecological improvement. Section 7.1 explores the differentiation options ecologically modelled as opposed to options concept-designed by engineers.

Longer term runs were carried out using both the Coorong Dynamics Model and TUFLOW-FV (six and 30 years, respectively) for each of the seven options and the base case to compare performance over a representative range of climatic conditions including both dry and wet periods and under climate change assumptions. These runs also reduced any bias caused by starting conditions as there was a sufficiently long simulation period to achieve an equilibrium state so that the subsequent evaluation could focus on long-term performance.

Step 2: ERAF analysis

The Phase 1 ERAF process was updated in this step to match the longer simulation periods. Phase 1 water level and nutrients outcomes for each consequence level were also updated to take into account the latest knowledge available.

In Phase 1, a risk analysis team (five DEW science staff) estimated the probability distribution across the five consequence levels of the ERAF criteria by visually assessing time series plots to classify likelihood of consequence levels for each case. In Phase 2, this approach was impractical given the longer simulation periods and the broader range of conditions. A robust quantitative analysis approach was developed based on summary statistics of consequence conditions over the time series and criteria for assigning likelihood based on these statistics.

The Phase 2 ERAF analysis therefore comprised a two-step process to analyse this data:

1. Excel Workbook Queries to produce summary statistics of the years and months where model output exceeded thresholds for each of the 5 consequence levels
2. Assign likelihood and consequence.

The analysis disregarded the first two years of all scenario analyses to avoid being biased by the starting conditions (i.e. the system will exhibit an initial 'shock' and then stabilise). This is consistent with the principle that the investigations are comparing the long-term performance of the ecological options.

Likelihood was assigned to each risk consequence level based on the duration (number of months or years) that the level of risk was exceeded.

Step 3: Evaluation

This step evaluated the likelihood distributions for level of risk to the ecosystem posed by water levels, salinity and nutrients from the ERAF analysis into scores against the Kellogg, Brown & Root Pty Ltd (KBR) MCA performance criteria (that is, ecological risk and benefit in the Coorong South Lagoon and North Lagoon, respectively). The MCA scoring process is outlined in Chapter 8.1.

Likelihood distributions of level of risk to the ecosystem posed by water levels, salinity and nutrients were converted into scores by:

- assigning weighting values to the different end-points informing the two MCA performance criteria based on ecological functions of each ERAF end-point for that performance criteria
- assigning utility values for the five consequence levels for each ERAF end-point, where the worst outcome (very significant deviation) is 1 and the desired state (insignificant deviation) is 10

- calculating the expected value score (1-10) for each ERAF end-point, option and climate (inflow) scenario by multiplying the likelihood of each of the five consequence levels with its likelihood and summing the results
- calculating scores for each of the KBR MCA environmental performance criteria as the weighted sum of the expected values for the related ERAF end-points in the Coorong South and North lagoons, respectively.

Ecological benefit was indicated when an option has a higher expected utility value than the base case for a given end-point. Conversely, ecological risk is indicated when an option has a lower expected ecological utility value than the base case.

Further Investigations (Ecological investigations)

Project 2 under the HCHB program, the Trials and Investigations Project, includes $10 million for scientific investigations to fill knowledge gaps and provide the scientific evidence-base to inform future management actions, including CIIP. The project brings together over 50 researchers from research and other organisations through the Goyder Institute for Water Research.

Findings from these investigations improved the models used in the ecological investigations, ensuring that our understanding of the options that best contribute to improving the ecology of the South are underpinned by the best available science. These investigations, included a further refined and developed Coorong Dynamics Model are due to conclude in June 2022. This will better our understanding of the ecological impact and benefits that an infrastructure option could have, and help to optimise operations.

6.2. Cultural heritage

The Indigenous Land Use Agreement (ILUA) between the South Australian Government and the Ngarrindjeri and Others requires notification of significant soil disturbance also known as notifiable acts. The First Nations of the South East are currently in the process of native title negotiation with a claim being lodged on 10 November 2017. The active claim requires DEW to work with the First Nations of the South East under future acts.

CIIP has worked closely with the First Nations of the South East and the Ngarrindjeri Aboriginal Corporation, the Prescribed Body Corporate acting on behalf of the Ngarrindjeri, to determine if Aboriginal Heritage Surveys and other heritage protection measures are required (and these are described in the program-level response document).

Cultural heritage survey

Cultural heritage surveys were conducted in August 2021 to identify sites of cultural significance along potential infrastructure alignments, and to recommend areas of minimal cultural impact. This was guided by Independent Heritage Consultants through the Ngarrindjeri Aboriginal Corporation. Eight infrastructure alignments were surveyed over 6 days by the Ngarrindjeri Aboriginal Corporation, Ngarrindjeri representatives, and First Nations of the South East representatives.

The survey team inspected the project areas on foot, walking transects (10m-30m apart), stopping at points of interest to inspect landforms with elevated archaeological potential, record sites, and discuss cultural concerns. Sites were recorded using hand-held GPS units, digital photography and detailed field notes by Independent Heritage Consultants (IHC) staff.

The survey team identified sites of cultural significance throughout the survey area and used a site avoidance methodology to find locations the most appropriate alignments for potential infrastructure. Using the survey results, the alignments were prioritised according to reduce the likelihood of impacting sites of cultural significance.

Prior to the commencement of the on ground survey, IHC requested a search of the Department of Premier and Cabinet – Aboriginal Affairs and Reconciliation (DPC-AAR) Taa Wika Register of Aboriginal sites and objects for known sites in the project area. This search highlights known areas of tangible and intangible cultural heritage which helped to inform the survey and potential risk locations.

The results of the survey have informed the alignment of infrastructure under consideration, with the intent to minimise impact to sites of cultural significance. Four preferred alignment locations were identified during the survey by the Ngarrindjeri and First Nations of the South East survey representatives: one at Parnka Point North, one at Parnka Point South, and 2 at Woods Well.

Further investigations

The South Australian *Aboriginal Heritage Act 1988* provides protection for all Aboriginal heritage sites, objects and remains whether registered or not. The main requirement for this project to comply with the Act is to not damage, disturb or interfere with Aboriginal heritage sites, objects or remains. If sites cannot be avoided, DEW in consultation with the Ngarrindjeri Aboriginal Corporation and DPC-AAR, can follow the agreed measures that will be set out in a cultural heritage management plan.

Cultural heritage management plan

Ngarrindjeri Aboriginal Corporation will be asked to nominate their preferred heritage specialist to develop a cultural heritage management plan for the options that progress to construction. The plan will recognise the cultural heritage values and the profound cultural significance of the Coorong region, and opportunities to recognise First Nations aspirations for managing significant cultural assets. Engagement and collaboration will compel the plan to reflect First Nations aspirations.

Cultural heritage survey and monitoring

First Nations partners will be asked to nominate people to undertake cultural heritage monitoring during investigations and construction at the Coorong works areas where appropriate. Cultural heritage monitors will be present during ground disturbance works requested by the cultural heritage specialist. Their role will include:

- installing, modifying, or removing site protection measures
- providing advice and responding to contractor/construction crew requests
- monitoring the condition of site protection measures
- monitoring compliance with the traffic management plan
- calling a stop to work when there is risk to a heritage site.

6.3. Preliminary socio–economic analysis

Potential social and economic impacts to the region as a result of each infrastructure option were explored in a socio-economic assessment. BDO Econsearch reviewed published, peer reviewed literature in consultation with DEW to identify potential impacts. Impacts (both positive and negative) were broadly explored under 5 themes, largely reflecting the socio-economic criteria used in the MCA (see Chapter 8 for details).

1. Regional economy and tourism – opportunity for economic growth and financial benefits in the region (for example, employment opportunities, economic activity during construction, tourism and education opportunities)
2. Commercial enterprises – potential negative impacts to commercial enterprises operating in the region (mainly Coorong, Lower Lakes and Southern Ocean fisheries)
3. Visual amenity – is the expected change in visual amenity due to the infrastructure options acceptable?
4. Land acquisition and access restrictions – the extent of land acquisition or access restrictions that may be required (both during construction and for the life of the infrastructure)
5. Recreation activities – the impact on recreational activities, including recreational fishing, boating, birdwatching, bushwalking and camping.

Impact 1 was estimated using input-output (I-O) models, which are widely used to assess the economic contribution of existing or changing levels of economic activity. RISE models for The Coorong Local Government Area (LGA) and South Australia were used to assess the economic activity associated with each option. The key economic activity indicators considered in the analysis are gross regional product (GRP) and employment. When looking at impacts at the state level for South Australia, GRP is replaced with gross state product (GSP).

GRP is a measure of the contribution of an activity to the economy and is calculated as value of gross output (business revenue) less the cost of goods and services (including imports) used in producing the output. Employment numbers are reported as full time equivalent (FTE) units. An FTE of 1.0 means that the person is equivalent to a full-time worker, while an FTE of 0.5 signals that the worker is only half-time. In our analysis, 1.0 FTE is equivalent to 37.5 hours worked each week.

The total economic impact reported in the socio-economic assessment includes both direct and total contribution. Direct contribution includes construction and downstream activities (such as manufacturing and transport). Flow-on contribution includes the economic effects in other sectors of the economy (such as trade and professional services) generated by the construction industry activities, that is, the multiplier effects.

Impacts 2-5 were informed by the literature review, but also by conversations with DEW and the Coorong Partnership. While this assessment provides a preliminary insight into potential socio-economic impacts, further insights will be gleaned from the community during the 2022 consultation to inform the recommendation of options.

Further investigations (Socio-economic analysis)

The analysis to date provides a foundation and gap analysis to inform a more detailed socio-economic assessment, Regional Impact Assessment Statement and Cost-Benefit Analysis of options which proceed to business case in 2022.

6.4. Engineering design summary

Kellogg, Brown & Root Pty Ltd (KBR) were engaged by DEW for engineering design services to support feasibility investigations and deliver concept designs for infrastructure concepts throughout 2021.

Basis of design

Before the concept design process commenced (KBR, 2021a), a Basis of Concept Design Report was prepared to define design inputs, performance criteria, assumptions and functional requirements used as the basis for the concept design.

Results from the hydrodynamic and biogeochemical modelling (see Chapter 6.1 for details) informed the critical adopted flow metrics for each infrastructure option (this is the optimisation process described in Chapter 6.1.4). DEW provided the metrics to KBR to dictate the hydraulic sizing of channels, pipework, pumps and ancillary intake/discharge infrastructure.

The magnitude and timing of flows were refined throughout the modelling process to enhance ecological benefits. Given the large number of infrastructure options considered, the flows and timing may not be optimal and therefore further refinement and testing will occur before the engineering detailed design process commences for the preferred options.

Site locations and alignments

Before the investigative field works, sites were selected for the infrastructure options in-line with observations from site visits, stakeholder consultations and cultural heritage observations (see Chapter 6.2 on Cultural Heritage survey). We also considered the engineering design complexities, construction feasibility and environmental impacts during the site and alignment selection process.

The proposed alignments for the Lake Albert – Coorong Connector option fall on private land. Limited risk to cultural heritage was identified.

Potential areas identified for the Coorong South Lagoon – Southern Ocean Connector were Round Island, Woods Well (Fat Cattle Point), Policeman Point, Parnka Point, Jack's Point and Salt Creek. Though sites vary slightly in terms of Coorong lagoon width and Younghusband Peninsula dune height and width, the magnitude of these features were substantial in all locations.

Combining cultural heritage survey findings with engineering and construction benefits and constraints reviews, and proximity to power, 2 sites were selected for the Coorong South Lagoon – Southern Ocean concept designs: one ~950 m north of Parnka Point (relevant only to concepts 5A and 5B, and one opposite Fat Cattle Point (Woods Well).

Note that any Southern Ocean connection infrastructure will be situated in South Australian waters and not in Commonwealth waters, which commences from 3 nautical miles (5.56 km) offshore. Also, if constructed the infrastructure will not encroach into the Upper South East Marine Park Zone, which commences adjacent to Salt Creek and runs in a south-easterly direction along the coast.

Civil and mechanical considerations

Coorong South Lagoon infrastructure location

To determine where the infrastructure in the Coorong South Lagoon could be built, KBR discussed possible locations with its construction partners Fulton Hogan and Maritime Constructions. They considered pumping infrastructure on the eastern and western sides of the Coorong South Lagoon.

Infrastructure on the eastern side of the Coorong South Lagoon could be constructed by having a pump station on land adjacent to the Princes Highway or in the Coorong South Lagoon on the eastern side. The benefits of pumping on the eastern side are that most of the materials for construction would not need to be transported across Coorong South Lagoon and access to the pump station for construction, operation and maintenance will not require a boat or barge. However, a downside is that the pump station discharge pipeline will need to be installed across the width of the Coorong and will result in increased pumping costs along the additional length of pipe. A large bore pipeline across the Coorong would be very difficult and expensive to construct and therefore KBR and KBR construction partners deemed this unfeasible. Installing a floating pipeline across the Coorong that would inhibit boating access on the Coorong, or burying a pipe below the Coorong bed was also considered impractical. Consequently, a pump station located on the eastern side of the Coorong South Lagoon was not pursued.

The western side of the Coorong South Lagoon is the preferred location. The benefit is that the discharge pipeline would not need to be constructed across the Coorong, so we avoid creating navigation hazards. The main downside is that the materials to construct the infrastructure will need to be transported to the Younghusband Peninsula. The proposed approach is to use a purpose-built barge system which could service both construction and ongoing operational needs.

Various discharge structures were considered in order to provide the intended flow yield. The discharge structures considered are listed in Table 1.

Table 1 Coorong South Lagoon infrastructure considered

Intent	Structure	Objective	Engineering considerations	Discontinued options
Pump	Coorong South Lagoon Pump	Pump water in or out of the Coorong South Lagoon.	We selected pontoon-mounted pumps after considering water conditions, construction methodology and operational flexibility. Due to the shallow depth, one-off dredging is required around the pumps to make it deep enough for pump suctions and fish exclusion screens.	We considered a jetty extending from the Younghusband Peninsula into the Coorong with pumps mounted to the end of the structure, but this is an expensive option and would take longer to construct.
	Southern Ocean pump	Pump water in or out of the Southern Ocean.	We selected vertical turbine pumps for pumping from the Southern Ocean because they are commonly used for seawater pumping and the pump column can be customised so that the pump suction can be sufficiently submerged from the high jetty deck height.	We considered jet pumps and submersible pumps, but these options were discounted mainly due to lower operating efficiencies which would mean much greater operating costs for the long duration pumping of large volumes needed.
Discharge	Breakwater	Provide a permeable wall to dissipate wave energy from the Southern Ocean. This would reduce the quantity of sand entering the breakwater and entrained into the pumps.	We considered various methods of armour layer construction. We selected pre-fabricated concrete units in preference to traditional natural rock because of challenges sourcing and transporting rocks 10 – 15 tonnes in weight (the quantity required) and the high quality needed for the high energy environment. The breakwater structure would terminate ~50 m shoreward of the coastline to allow for temporary shoreline recession. This 50 m section is proposed to transition to tie into the existing beach levels at the foot of the dune.	This differs from a conventional breakwater, which has multiple layers of armour and a fine, granular core which typically has low permeability but is difficult to construct in high wave climates due to loss of material.
	Caisson	Reduce the amount of sand entering the caisson and reduce the quantity of sand entrained into the pumps.	We considered the depth of caisson below the seabed, and the removal of any sand that enters. Because of the shallow beach profile of the Southern Ocean, pumps would need to be located a long distance from the shore to achieve the required depth of suction. By constructing the caisson in the seabed, the required depth of suction would be achieved closer to the shore.	N/A

	Jetty	Support the proposed pumps and pipework for intake and outfall. A jetty can provide stability as well as access to the pumps for maintenance. The jetty will extend into the highly active surf zone of the Southern Ocean which is beneficial for dispersing the hypersaline outflows pumped from the Coorong.	For infrastructure options which include pumping from the Southern Ocean, a 350 m long jetty is proposed, with the pumps located at the end of the jetty. For options with only discharge to the Southern Ocean, a shorter 150 m jetty is proposed for economy with additional protection to inhibit sand entrainment, and also because there's no pump infrastructure to support Minimum elevation of the jetty is required to be +10 metres Australian Height Datum (mAHD) and is selected based on maintaining a safe airgap between the storm tide and maximum wave crest levels and with sea level rise for the life of the structure. For the infrastructure options which have discharge only, or separate discharge and intake, the hypersaline Coorong water is discharged directly to the ocean through a diffuser nozzle on the end of the outfall pipework mounted on a jetty.	Buried pipework in the high wave energy marine environment.
	Beach discharge outfall	For infrastructure options which have discharge-only marine infrastructure, and no requirement to pump in from the Southern Ocean, we considered a lower cost discharge solution with lower visual impact and simpler construction.	The outfall involves discharging water from the Coorong onto the foreshore via a concrete culvert with headwall, apron and wingwalls. The structure would be founded on piles to prevent settlement or erosion of the structure over time. Water would discharge through the culvert and onto a FlexMat system (pre-fabricated concrete block matting) to protect the foreshore from erosion due to the high outflows. The FlexMat is partially buried and anchored in place to prevent sand erosion below the mat and reduce the visual impact to the beach.	N/A

Fish Exclusion	Fish exclusion	Fish exclusion screens are to be included on all pump suctions to prevent mortality of aquatic species.	The screens have a typical aperture width of 2 mm, but sizing can be adjusted to suit the project requirements. The screens also come installed with self-cleaning wire brushes that rotate around the screen to clean off any debris clogging the apertures. As the fish exclusion screens are typically mounted to the pump suction, this adds length to the pump suction. This will increase the amount of required dredging below the pontoon mounted pumps in the Coorong. To reduce the amount of dredging required, cone screens are preferred as they are the shortest screen type. For the vertical turbine pumps installed in the Southern Ocean, there is no water depth restriction as the concrete caisson structure will be dredged to provide a suitable water depth. For this reason, cylinder screens installed at the caisson inlet are proposed as they are commonly used and can be manufactured at lengths to suit the project. It is also anticipated that the fish screens will provide some assistance in minimising sand intake into the system. A separate power supply is required for the self-cleaning apparatus.	N/A

Further investigations (Basis of design)

Further design activities will focus the preferred option(s) that proceed to the business case to refine the scope of works and confirm infrastructure capital and operational costs. Elements to consider include piping support, pressure surge mitigation, thrust block design and site layout details including provision of power supplies and routing of buried services.

If dredging at Parnka Point is a part of a preferred option the alignment can be further refined to optimise the width, depth and extent of dredging required to achieve the required connectivity between the two Coorong lagoons. This will include hydrodynamic modelling using a finer mesh (higher resolution) through the dredge alignment.

6.4.1. Concept design development and refinement

Based on the different water source connections and initial results of hydrodynamic modelling, nineteen concepts were developed and considered at a Concept Design Selection Workshop in June 2021. The workshop was attended by staff from DEW, KBR, SA Water and MDBA. We used an assessment matrix to consider the following seven key elements to compare and rank the infrastructure concepts:

- Ecological interpretation
- Ecological risk assessment
- Hydrological/hydrodynamic considerations
- Engineering infrastructure scope of works
- Location and access considerations
- Operational considerations
- Environmental impact considerations (including visual amenity, vegetation disturbance, etc.).

At the workshop, seven infrastructure concepts were endorsed for further consideration (KBR, 2021b).

Throughout the development of the concept designs several changes were made to the scope of the selected options based on concurrent investigations and results of modelling, stakeholder recommendations and technical considerations as well as revisions agreed at a Concept Refinement Workshop in August 2021 and attended by staff from DEW and KBR. Detailed descriptions of the thirteen concepts that have undergone full feasibility assessment are provided in Section 7.3.

6.4.2. Constructability

KBR worked with construction partners Fulton Hogan and Maritime Constructions to investigate the constructability of each of the proposed infrastructure options. Key considerations are explored in Chapter 3 of the Concept Design Report and construction methodologies for each option are in appendices H and I of the Concept Design Report (KBR, 2021c).

Construction in the Southern Ocean and Coorong South Lagoon will be challenging and in some ways unprecedented. Plans must consider the topography, access and haul routes, ground conditions, weather, wave climate, water levels within the Coorong and ocean and the sheer scale of the infrastructure.

While each methodology has its own challenges, the following is a summary of the constructability issues to consider:

- Size of the machinery required to transport the equipment and materials to site, and whether this is best transported via an ocean vessel (unlikely considering sea state) or freighted along the Southern Ocean Beach (oceanside) or via barge or smaller vessel (across the Coorong) from a logistics hub where trucks, plant and equipment can be delivered adjacent to the Princes Highway
- Access tracks, barge mooring and loading/offloading infrastructure are required, or a bridge across narrow locations within the Coorong lagoon
- Avoiding or minimising impacts to cultural heritage sites and native vegetation
- Size of laydown areas and where they are best located, noting the undulating dune environment, cultural heritage sites, native vegetation and protected fauna and flora species
- Limited beach access due to high energy wave environment, narrow beach and high dunes
- Seasonal variation of water levels within the Coorong and Lake Albert
- Avoiding disturbance of fragile dune vegetation where possible
- The high energy wave environment in the Southern Ocean, which limits the number of optimal weather days (anecdotally two weeks of optimal weather in any given year)
- Presence of acid sulfate soils.

Construction footprint

The footprint for a construction site, excluding the area required to construct the works, will vary slightly between options, but there are standard inclusions. About 2 hectares is typical for a construction office, amenities, parking, and materials stockpiles and storage. For the Younghusband Peninsula options, the construction site is likely to be separated between each side of the Coorong allowing site parking and laydown adjacent to a barge point on each side. For marine options, an additional 1 hectare is likely required to cater for marine construction equipment and extra material. The exact construction footprint of each concept is detailed in Table 4 (Chapter 7).

A significant additional area is required for the construction work fronts. The size will vary considerably for the different options depending on location, topography and type of construction activity. A summary of likely footprints for the various activities involved in constructing the proposed options is in Section 3.4 of the Concept Design Report (KBR, 2021c).

Construction risks and mitigation measures

Through concept design, high-level construction risks were identified and mitigation measures proposed for construction of the proposed works (refer Table 14 in the Concept Design Report (KBR, 2021c)). The list is not exhaustive and will be reviewed and updated as further design progresses for the selected concept design options.

Further investigations (Constructability)

The constructability investigations above are preliminary in scope. Further construction planning will be required once a preferred option is recommended.

6.4.3. Operations and maintenance

6.4.3.1. Energy

In October 2021, an energy supply assessment workshop was held at KBR with DEW team members to analyse energy supply options. Before the workshop, we set principles about the scope of power supply options under consideration, anticipating that:

- the Younghusband Peninsula is unsuitable for establishing a renewable power supply given it is part of the Coorong National Park
- SA Power Networks will only provide a service point on the mainland (that is, north-eastern side of the Coorong lagoons) adjacent to Princes Highway.

Therefore, the power supply will need to be located on the mainland and power reticulated across the Coorong South Lagoon and peninsula to the pumping infrastructure.

Pumping infrastructure must be able to operate 24 hours per day, so the following energy supply options were considered:

- A grid connection
- A grid connection supplemented by renewable energy source
- Renewable energy systems (wind or solar) with battery storage or diesel generator backup.

Seven concepts that fall within the scope were considered at the workshop. The goal is for the primary source to meet the full demand of the pump loads and the secondary supply be there only to supplement, for example, at night and during days of low irradiance levels (solar PV) and when wind strength is low (wind turbines) (KBR, 2021c).

To consider the renewable energy sources, indicative footprints were estimated for the highest and lowest demand options. For the highest demand (Option 3A, Pump out (jetty discharge)) either 7,000 x 400 W solar panels covering about 7.5 hectares, or 3 x 4 MW wind turbines covering about 240 hectares would be required. For the lowest demand (Option 4B, Pump in or out (one common pumping station)) either 630 x 400 W solar panels covering about 0.6 hectares or 2 0.5 MW wind turbines covering an about 20 hectares would be required.

Reducing carbon emissions of energy supply

At the energy supply assessment workshop, DEW's Climate Change Unit staff advised that:

- the SA electricity grid is decarbonising rapidly and expected to be approaching net zero carbon by 2030

- the project could participate in the wholesale market such as demand management and negative pricing events
- under the existing DEW electricity supply contract from ZEN Energy, low-cost offset certificates are available
- there is a general trend of electrification to maximise emissions reduction and reduce cost rather than build standalone renewable energy supply infrastructure
- there is an option to assess commercial arrangements beyond the existing supply contracts.

The workshop decided that a grid-connected supply should be used for the lifecycle cost estimate process with a range of possible enhancements that could be considered to improve the value of this grid connection to DEW in operation and maintenance of the infrastructure. The concept designs have therefore been based on energy being provided from the SA Power Networks grid.

6.4.3.2. Access

KBR construction partners Fulton Hogan and Maritime Constructions provided advice on access requirements for each of the options. They considered the unique Coorong environment and the type of equipment needed for construction.

Site access to infrastructure locations is essential for both construction and ongoing operation and maintenance. While day-to-day attendance at the operating sites will be minimised, there will be routine maintenance and inspections to ensure ongoing safe and reliable operations.

Site access to Younghusband Peninsula sites will be challenging, and although 4-wheel drive access along unmade tracks is possible it is not desirable because of the long distances and likely damage to the natural environment. Therefore, access across the Coorong is preferable, which would involve constructing barge or boat launches, and mooring and retrieval facilities on both sides of the Coorong South Lagoon. Some of the site accesses created for construction could become permanent to provide operations and maintenance access.

Access for Lake Albert – Coorong Connector options would be less difficult than for the pumping options, with access either along the public Seven Mile Road or across undulating open farming land.

First Nations communities will be consulted in any access track planning. Also, community and recreation user access must be considered. Access limitations are explored in the socio-economic assessment (Chapter 6.3).

6.4.3.3. Operating regimes

Operating regimes were determined from DEW hydrodynamic modelling results. For pumped options, the flow rate and timing were varied to optimise ecological benefits and used for concept design and determining operating costs. The final operating regimes are presented for each option in Chapter 7.

Hydrodynamic modelling was undertaken for a range of climate and development scenarios, including climate changes projected by 2050 and current conditions (i.e. full Basin Plan implementation) development with the Murray-Darling Basin. For each modelling scenario, the average number of days per year of operation for each option was computed over the modelling period from 1990 to 2020.

To ensure pumping infrastructure operates as intended, key parameters will be monitored during operations to ensure the pumps are healthy and operating within their boundaries. Instrumentation will be included in the design to allow measurements to be monitored remotely.

Data from instrumentation will be recorded and used to inform operating procedures through the Supervisory control and data acquisition (SCADA) system. A Cloud/web-based SCADA system would be ideal for unmanned pumping infrastructure, as 3G and 4G services in the area are limited.

6.4.3.4. Maintenance programming

Infrastructure will need to be maintained to ensure functionality over the design life. Jetties have been designed to require minimal maintenance, although the pumping and intake/discharge elements attached to the jetty will require maintenance. Jetty structures have been designed with increased structural support width (pylons) to allow for sacrificial corrosion rather than use paintings and coatings. Coatings are not considered appropriate because of the highly corrosive metocean (that is, combined wind, wave, etc.) climate and the difficulties with recoating applications in the field.

6.4.3.5. Safety

Safety has been incorporated in the concept designs. The following initiatives to protect the safety of personnel in operations and maintenance have been included:

- Guardrails each side of Narrung Road to allow a protected zone for maintenance and operation of the penstocks and lay-flat gates associated with the regulator
- Jetty infrastructure with a deck height of +10 mAHD to maintain a safe airgap between the design wave crest levels and the headstock; this includes allowance for expected sea level rise associated with climate change
- Vehicle access along the jetty infrastructure to allow crane and other operational vehicles access to the pumps, pipes and valves present on the jetty
- Construction access tracks retained through Younghusband Peninsula to facilitate operations and maintenance
- Barge access points retained each side of the Coorong South Lagoon to allow mooring of vessels for the transfer of personnel, vehicles and equipment across Coorong South Lagoon and avoid the need for 4-wheel drive access from the south of Younghusband Peninsula
- A gantry crane system in the Option 4B pump room for valve and pump installation and removal and maintenance activities; other sites will likely require a crane access pad where frequent cranage is required
- Delineation and warning signs where beach conditions change because of the proposed infrastructure
- Jetty access ladders at appropriate spacing's as per the published standard for 'Guidelines for the design of maritime structure' (AS 4997 Cl 3.4.5) for emergency use
- Access platforms within pump room to enable safe access over large bore pipes
- Infrastructure in the Southern Ocean designed to not require diver access for operation and maintenance in open waters
- Longshore drift (and erosion of sand adjacent to structure) could affect personnel safety where undermining occurs; operations personnel will periodically inspect this via surveillance and inspection of sand movement
- Fish screens installed on rails in the Southern Ocean to allow lifting up of the fish screens for cleaning and inspection
- Slurry pumps included in the caisson structure to allow agitation and removal of any sand that accumulates
- Access to breakwater top is to be provided via the concrete access way to allow maintenance and inspection access beyond the crest wall
- Pontoon pumps will allow the entire pumping unit to be de-coupled from the pipework and floating walkway and towed to the other side of the Coorong to allow removal from the water and transport via truck for overhaul and maintenance operations
- Public access in the vicinity of pumping infrastructure will require signage and lighting to alert watercraft to in-water pumping stations and submarine cables (within Coorong South Lagoon)
- Public access along the beach with dredgeate (that is, material excavated during dredging) disposal pipework will require temporary exclusion areas and a possible bypass track for vehicles to minimise public interaction with operation and maintenance activities
- Public access to jetty infrastructure may be permissible if handrails can be installed that do not impede operational access
- Public access along the beach in the vicinity of permanent infrastructure (for example, jetty or breakwater) will likely require a separate bypass access track around infrastructure into the dunes.

Further Investigations (Operations and maintenance)

Operating and maintenance procedures will be developed in conjunction with DEW's Infrastructure Management team, and refined over the life of the infrastructure.

6.4.4. Engineering supporting investigations

A range of investigations were undertaken in the development of the concept designs to determine site information and other inputs for concept design. These were managed by KBR but carried out on-the-ground by subcontracted suppliers with appropriate expertise. A summary of investigations, key findings and outcomes is provided below.

6.4.4.1. Geotechnical studies

Desktop geotechnical assessments for the Lake Albert – Coorong Connector options and Coorong dredging were completed by CMW Geosciences and included the review of existing geological and geotechnical information to determine scope for further intrusive geotechnical investigations.

Following this, geotechnical field investigations were conducted along Seven Mile Road for the Lake Albert – Coorong Connector option, and in the vicinity of Parnka Point for the dredging option.

Four boreholes were drilled along the Seven Mile Road alignment to 6 m below ground level using a 4WD-mounted drill rig, and dynamic cone penetrometer tests were carried out adjacent to each borehole to a depth of 1.5 m. The results indicated that resistance to excavation may vary across the site with natural soils able to be dug using conventional earthmoving equipment such as backhoes and excavators. A hard calcrete layer was encountered at shallow depth of 0.6 m near the Coorong and therefore slower production rates can be expected here. The results also suggested that permanent excavations with batter slopes no steeper than 1 (vertical) to 3 (horizontal) would be stable.

Seventeen dynamic cone penetrometer tests were done along the proposed dredging alignment through Parnka Point to a depth of 1.5 m. One of the tests encountered refusal, but this was at a depth below the expected dredge depth. All other tests indicated soft sediments.

During both investigations, soil samples were collected for subsequent acid sulfate soil and contamination laboratory testing. Environmental and soil testing investigations are presented in Chapter 6.4.5.5.

Full findings of the geotechnical investigations are in appendices D (Geotechnical Investigation Report - Lake Albert Connector Seven Mile Road Investigation Report), E (Geotechnical Investigation Report - Coorong Dredge Alignment Desktop Assessment), and F (Geotechnical Investigation Report - Coorong Dredge Alignment Investigation Report) of the Concept Design Report (KBR, 2021c).

6.4.4.2. Geophysical studies

Geophysical surveys were completed:

- in the Southern Ocean for a proposed infrastructure alignment (4 km long x 1 km wide expected survey extent) adjacent to Fat Cattle Point
- of two terrestrial alignments on Younghusband Peninsula for proposed infrastructure (800 m long transects) – one opposite Fat Cattle Point (near Woods Well) and one ~1 km north of Parnka Point.

6.4.4.3. Dispersion modelling

KBR investigated the impacts of the discharge of hypersaline water and dredgeate from the Coorong in the Southern Ocean with high-level conceptual modelling. They used mid to far-field modelling to predict the dilution of salinity as a result of diffusion, and the dispersion of sediment from dredgeate disposal, in the nearshore environment. Several scenarios were modelled which simulated the different flow rates and disposal locations of the various infrastructure options.

The findings show in all scenarios, under steady state conditions, the hypersaline brine discharge is diluted to 1,000 milligrams per litre (mg/L) above ocean salinity of 35,000 mg/L within ~1 km of the source location under lower flow scenarios. For the 1,000 megalitres per day (ML/d) scenarios, the brine discharge is diluted to 36 parts per thousand within ~1.3 km of the source location. The jetty discharges provided the greatest mixing, with the plume diluted to 1,000 mg/L above background salinity within ~700 m from the outfall. This improved mixing compared to the other scenarios is due to the outfall being in deeper water.

The modelling also showed that the breakwater structure had little impact on the far-field dispersion of the plume.

The shape of the plume for all scenarios modelled is roughly symmetric around the outfall due to cross-shore mixing by rips being more important than the longshore drift under conditions modelled.

The modelling of the fine sediment showed that steady state conditions were reached within 12 hours, after which the change in the plume is minimal. The modelling indicates suspended sediment concentrations up to 200 mg/L above background levels within 100 m from the outfall.

6.4.4.4. Bathymetric survey

In April 2021, Maritime Constructions did a bathymetric survey of the Coorong lagoons along most of the 18 km dredge corridor length in the vicinity of Parnka Point.

Shallow water has been identified through much of this alignment with indication of a centrally deeper channel. This channel has generally been adopted as the dredge alignment for concept design Option 2 with some refinement and optimisation.

6.4.4.5. Environmental soil testing

Soil samples were collected during the two geotechnical investigations summarised in Chapter 6.4.5.1. In total, 29 samples were collected from the Seven Mile Road boreholes and 17 samples from the top 150 mm of sediment along the Coorong dredge alignment.

The soil samples were analysed by Australian Laboratory Services, who are NATA accredited for the analytical testing undertaken, and the results were reviewed by Fyfe.

Five samples from the Coorong dredge alignment returned arsenic concentrations above the National Assessment Guidelines for Dredging (NAGD, 2009) of 20 milligrams per kilogram. This does not mean the dredged material cannot be disposed of to the ocean because the suitability for unconfined sea disposal is not based on whether individual samples exceed the screening level but on the '95% upper confidence limit of the mean' calculated from all analysis results representative of the dredge volume. As the Coorong samples were only collected in the top 150 mm of the proposed dredged material, additional testing is required over the full range of dredge depths before it can be determined if the dredgeate can be disposed to the ocean.

Leachate testing was completed for the sample which recorded the highest arsenic concentration, and this didn't detect any release of soluble arsenic. This indicates the arsenic may not be very bioavailable when dispersed in sea water.

Unconfined sea disposal of dredgeate is therefore likely to be acceptable but requires further testing over the full dredge extent and depth to fully assess the '95% upper confidence limit of the mean'.

One sample from Three Mile Road and 2 from the Coorong indicated the presence of acid sulfate soils. As the dredged Coorong sediments are proposed to be disposed of via pipeline to the sea and not exposed to oxygen there is no need for acid sulfate soil treatment. However, for the Lake Albert – Coorong Connector, an acid sulfate soil management plan will be required for the excavation, with disposal/spoil pathways and potential treatment processes.

Further investigations (Engineering supporting investigations)

The dispersion model is uncalibrated; field data and calibrated modelling will be required to further explore the near-shore disposal options for both hypersaline flows and dredgeate. This will support environmental impact studies during the detailed design stage.

Geophysical surveys along the proposed dredge alignment within the Coorong Lagoons will need to identify if there are zones of harder material within the proposed dredge area to inform prospective tenderers.

Further geotechnical testing and environmental sampling over the full depth extent of dredging is required to justify ocean disposal.

Further geotechnical testing on Younghusband Peninsula at sites of proposed infrastructure will need to identify factors such as presence and depth of groundwater, horizontal and vertical bearing pressures, native soil modulus, slope stability analysis, solubility, dispersion potential and other engineering design parameters.

6.4.5. Environmental impact

We need to understand the potential impacts of the infrastructure options on the environment, during both construction and the life of the infrastructure. They may include vegetation disturbance and clearance, impacts to migratory shorebird breeding sites, and management of acid sulfate soils exposed through any dredging operations. Fulfilling obligations under legislation, and getting the appropriate approvals, will help mitigate potential impacts.

A desktop review of the environmental characteristics of each option was undertaken to establish the potential presence of terrestrial species, marine/estuarine species, and communities of conservation significance in the vicinity of each option.

Sources part of the desktop review included:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool – Department of Agriculture, Water and the Environment (Appendix J of the Concept Design Report)
- NatureMaps, Enviro Data SA, NatureMaps 3.0, Department for Environment and Water, Government of South Australia
- Seamap Australia – National Marine Benthic Habitat Map
- Atlas of Living Australia.

In addition, data and reports in the public domain were reviewed to help assess environmental values and potential impacts of the construction and operation of each concept design option.

6.4.5.1. Preliminary environmental risk identification

KBR conducted a preliminary environmental risk identification as part of the Concept Design Report (KBR, 2021c). It considered risks in the categories: coastal/lake processes (currents, tides, wind and wave conditions), marine processes (currents, tides, wind and wave conditions), sediment characteristics, water quality, flora, fauna, noise, visual amenity and energy emissions.

The findings indicate there are potential risks with each option. However, refinement of the infrastructure design, environmental legislative approvals, and adaptive management throughout construction and operation will mitigate these risks.

Further investigations (Environmental impact)

A full Environmental Impact Assessment will be required prior to the construction of any infrastructure.

6.5. Legislative requirements

We conducted a desktop assessment of Australian and State legislation to define the approvals needed for construction and operation of all the infrastructure options under consideration. The exact approvals required and sought will be determined once a decision on which infrastructure option may proceed to further investigation and construction. Relevant approvals are detailed in tables 4 and 5.

Further investigations (Legislative requirements)

All required approvals will be finalised prior to work occurring on site.

Table 2 Approval requirements for all options

Legislation	Issue	Approval	Why is it Required?
Parliamentary Committees Act 1991	**Public works**	Public Works Committee Approval	• Required where funding applied to construction is more than $4 million
Native Title Act 1993 (Cth) *Native Title Act 1994* (SA)	**Native title and First Nations engagement**	Notification to Native Title Holder/Claimant or Indigenous Land Use Agreement (ILUA) Notification	• ILUA notification required for any action within the definition of 'future act' under the *Native Title Act 1993* (an action that validly affects native title in relation to land or waters to any extent)
Landscape South Australia Act 2019	**Water affecting activity**	Water Affecting Activity Permit/Well Permits	• Activities requiring water affecting activity permits include: • erection, construction or placement of any building or structure in a watercourse or lake or on the floodplain of a watercourse • draining or discharging water directly or indirectly into a watercourse or lake • depositing or placing an object or solid material in a watercourse or lake • obstructing a watercourse or lake in any other manner • excavating or removing rock, sand or soil from a watercourse or lake or the floodplain of a watercourse
Planning, Development and Infrastructure Act 2016	**N/A**	N/A	• Not required due to exemption for works in connection with the River Murray system
SA Heritage Places Act 1993	**Australian, state and local heritage**	N/A	• Preliminary NatureMaps search indicates there are 4 state heritage sites along the Coorong, but these are not within site alignments
Water Act 2007	**Murray-Darling Basin**	Clause 49 and 63 MDBA approval	• Clause 49 approval required where works may significantly affect the flow, use, control or quality of any water in the River Murray • Clause 63 approval required for works within the banks of the River Murray • All sites are in the River Murray as defined in the Murray-Darling Basin Agreement as 'river' and 'tributary' respectively include affluent, effluent creek, anabranch or extension of, and any lake or lagoon connected with, the river or tributary'
Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cwth) and Aboriginal Heritage Act 1988 (SA)	**Cultural heritage**	Section 23 approval determination is required from AARD or RAAB and/or approval to disturb a site is required	• Approval required if damage to Aboriginal heritage is unavoidable • There is a risk that construction works could damage cultural heritage
Native Vegetation Act 1991 *Native Vegetation Regulations 2017*	**Native vegetation**	Application for exemption to clear native vegetation [11 (25)] OR under another Regulation/the Act	• Required where native vegetation is required to be cleared

		OR notification pursuant to Schedule 1, Division 2	
Environment Protection Act 1993	**Environment protection**	Contractor Licenses for "prescribed activities of environmental significance"; Schedule 1 Part A, Clause 8(7) - Discharges to Marine or Inland Waters	• Requirement to not cause environmental harm, including from disturbing acid sulfate soils • Acid sulfate soils are present in soil samples; management will be required during construction • Arsenic was found in samples between the Coorong North and South Lagoons • Dredging, disposal of dredgeate, saline water to ocean disposal, potential acid sulfate soils
Environment Protection and Biodiversity Conservation (EPBC) Act 1999	**Nationally threatened species and ecological communities**	EPBC Referral to Australian Government or self-assessment	• Required for works likely to impact on Matters of National Environmental Significance • Department of Agriculture Water and the Environment Marine Parks have confirmed approval is not required in relation to the nearby Murray Marine Park as the project does not fall within the footprint of that park
Harbours and Navigation Act 1993	**Exclusive use of waters required obstruction to waterway**	Aquatic Activity Licence (section 26) and Section 25	• Required where exclusive use of a watercourse is needed or where works have potential to obstruct navigation
National Parks and Wildlife Act 1972	**National parks**	National Parks Approval	• Approval required for use of a vehicle off track in a national park, digging or intentionally disturbing soil, removing soil, rock, mineral, wood, mulch, dead vegetation, fossil or archaeological remains • All options involve works in a national park

Table 3 Approval requirements for some options

Legislation	Issue	Approval	Why is it required?
Local Government Act 1999	**Council land**	Council Permit to undertake works (s 221 for road reserve)	**Relevant for Lake Albert – Coorong Connector options** • Required for works in a road reserve • Both Lake Albert – Coorong Connector alignments include road reserves (one includes unmade road reserves)
Crown Land Management Act 2009	**Crown land**	Section 56A Approval	**Relevant for Lake Albert – Coorong Connector options** • Required where excavation of Crown land, damage to Crown land, erect structure, damage trees • The bed of Lake Albert is Crown land • Not required for dredging path or Ocean Connector options as all land parcels are dedicated to the Minister for Environment and Water in the Coorong National Park
Land Acquisition Act 1969	**Land acquisition**	Acquisition of land or easement	**Relevant for Lake Albert – Coorong Connector options** • May need to acquire land/easement for Lake Albert – Coorong Connector options • Unlikely to be required for dredging and Ocean Connector options as these do not involve privately held land
River Murray Act 2003	**Entry onto land not vested in the Minister (including Private property) Management Agreements**	Management Agreement prepared under section 18 of the Act (for DEW owned assets) Licence Agreement (for assets to be owned by other entity)	**Relevant for Lake Albert – Coorong Connector options** • Required for options involving works on private land (as an alternative to land/easement acquisition)
Historic Shipwrecks Act Approval	**Shipwrecks**	Section 15 permit	**Relevant for Southern Ocean Connector options** • Permit required to interfere with or damage a historic shipwreck • Shipwrecks are present along the Coorong coast but exact locations are unknown
Environment Protection (Sea Dumping) Act, 1981 (Commonwealth)	**Dumping to sea**	Environment Protection Sea Dumping	**Relevant for dredging options** • Required to dispose of dredgeate in Australian waters • Ocean disposal of dredgeate is under consideration
Marine Parks Act 2007 (Zoning Regs 2012) (SA)	**National and marine parks**	National Parks Approval Marine Parks Approval	**Relevant for Southern Ocean Connector and Dredging options** • Permit required for some activities such as depositing dredged materials or construction of infrastructure within a Sanctuary Zone of a Marine Park

6.6. Cost estimates

KBR has produced cost estimates for each infrastructure option under consideration.

The estimates are based on the scope of work provided by KBR engineering, concept design drawings and Concept Design Report (KBR, 2021d).

The following information were used to develop quantities and scope for costings:

- Concept Design Drawing Pack
- Coorong Infrastructure Feasibility Investigations Concept Design Report (KBR reference; AEG155 01 TD WR REP 0002)
- Partial material take off (MTO).

Costs are presented with the following detail:

- Construction (including capital and indirect construction support, administration and insurances)
- Operations and maintenance.

The cost estimates will be further refined in line with design and operations considerations throughout the business case development.

7. Infrastructure concepts

7.1. Summary of options

Following options shortlisting (Stage 1 of the CIIP), eleven options were evaluated and five proceeded to feasibility investigations:

- Permanent connection between the Coorong South Lagoon and Southern Ocean
- Coorong Lagoon dredging to improve connectivity
- Lake Albert – Coorong Connector
- Further augmentation of South East Flows to the Coorong (SEFA)
- Additional automated barrage gates.

Initial ecological feasibility (Chapter 6.1.3) indicated that the following options did not provide sufficient improvement to the ecological health of the Coorong South Lagoon and were discontinued from further investigation (and thus engineering concept deign):

- Further augmentation of South East Flows to the Coorong (SEFA)
- Additional automated barrage gates.

The remaining three options proceeded to full feasibility investigation. Ecological investigations indicated that dredging alone would not provide sufficient ecological improvement, thus dredging is only considered in conjunction with the Lake Albert – Coorong Connector and Coorong South Lagoon – Southern Ocean Connector options.

After assessing the three options, we produced thirteen engineering concepts designs. This is due to slight differences in the combinations of pumps and discharge structures that could be investigated for feasibility. This chapter provides a summary of findings of each of the feasibility investigations for the thirteen engineering concepts.

Only seven ecological concepts have been modelled as it does not matter which type of discharge structure is used when simulating future scenarios. For example, both pumping out concepts are designed to deliver 1,000 ML/d, and operate intermittently. In ecological modelling, there is no difference whether there is a jetty discharge or low visual impact discharge.

Table 6 details the pathway by which the eleven shortlisted options, were narrowed down to five options that progressed to feasibility assessment, and the subsequent concepts that were engineering concept designed and ecologically modelled.

Table 7 provides greater detail on the engineering and operating differences between the thirteen engineering concepts.

It is critical to remember that this Feasibility Assessment Report will help determine whether, individually or collectively, the concepts can form a feasible investment case for maintaining and enhancing the ecological character of the Coorong.

Further investigations to refine details of infrastructure deemed feasible and address knowledge gaps for approvals will need to occur prior to construction.

Table 4 How the infrastructure options under consideration translate to the concepts investigated

Option shortlisting (completed in 2020)	**Proceed to feasibility** (Feasibility investigations throughout 2021)	**Proceed to engineering concept design** (Mid 2021)	**Ecological concept** (Mid 2021)	**Engineering concept** October 2021
(11 options)	**(5 options)**	**(3 options)**	**(7 concepts)**	**(13 concepts)**
Permanent connection between the Coorong South Lagoon and Southern Ocean	Permanent connection between the Coorong South Lagoon and Southern Ocean	Permanent connection between the Coorong South Lagoon and Southern Ocean	Pump out with water level triggers	Pump out (jetty discharge)
				Pump out (low visual impact discharge)
			Pump in or out (not simultaneous)	Pump in or out (separate pumping stations)
				Pump in or out (one common pumping station)
			Circulation (in and out)	Circulation (pump in and out) (jetty discharge)
				Circulation (pump in and out) (low visual impact discharge)
			Passive Connector	Passive Southern Ocean Connector
Coorong Lagoon dredging to improve connectivity	Coorong Lagoon dredging to improve connectivity	Coorong Lagoon dredging to improve connectivity	Dredge and pumping out	Pump out (jetty discharge) + dredge Parnka Point
				Pump out (low visual impact discharge) + dredge Parnka Point
			Dredging and Lake Albert Connector	Passive Lake Albert Connector channel + dredge Parnka Point
				Passive piped Lake Albert Connector + dredge Parnka Point
Lake Albert – Coorong Connector	Lake Albert – Coorong Connector	Lake Albert – Coorong Connector	Lake Albert – Coorong Connector	Passive Lake Albert Connector channel
				Passive piped Lake Albert Connector
Further augmentation of South East Flows to the Coorong	Further augmentation of South East Flows to the Coorong			
Additional automated barrage gates	Additional automated barrage gates			
Temporary pumping from the Coorong South Lagoon to the Southern Ocean				
Increased dredged Murray Mouth dimensions				
Water level induced flow from the Southern Ocean water into Coorong				
Training walls for an open Murray Mouth				
Coorong South Lagoon regulator				
Temporary wetting/drying cycling of South Lagoon				

Table 5 Summary of designs for shortlisted infrastructure options. (* = subject to operational requirements)

Option		Concept #	Description	**Connector details**		**Dredging details**		**Discharge structure**			**Pump**		**Proposed operation**		
				Number of pipes	**Diameter**	**Dredging - length**	**Dredge width**	**FlexMat (low visual impact)**	**Jetty**	**Breakwater**		**Number of pumps**	**Target Flow (maximum possible)**	**Typical Flow Days (current conditions)**	**Typical Flow Days (climate change)**
Lake Albert Connector		*1A*	Passive Lake Albert connector channel	1	Channel 13.3 m base width						Passive		1,000 ML/d	241 days	143 days
Lake Albert Connector		*1B*	Passive piped Lake Albert Connector	7	2.1 m						Passive		1,000 ML/d	241 days	143 days
Lake Albert Connector		*2*	*Dredge Parnka Point*	Dredging is not considered on its own – Dredging details are summarised for 1A+2, 1B+2, 3C, 3D										2 year operation (365 days)	
Lake Albert Connector	Dredging	*1A+2*	Passive Lake Albert Connector channel + dredge Parnka Point	1		17.5 km	100 m – 300 m				Passive		1,000 ML/d	241 days	143 days
Lake Albert Connector	Dredging	*1B+2*	Passive piped Lake Albert Connector + dredge Parnka Point	7	2.1 m	17.5 km	100 m – 300 m				Passive		1,000 ML/d	241 days	143 days
Coorong South Lagoon – Southern Ocean Connector		*3A*	Pump out (jetty discharge)	1	2.2 m				1 x 150m		Intermittent pump	8 (Coorong)	1,000 ML/d	137 days	189 days
Coorong South Lagoon – Southern Ocean Connector		*3B*	Pump out (low visual impact discharge)	1	2.2 m			1			Intermittent pump	6 (Coorong)	1,000 ML/d	137 days	189 days
Coorong South Lagoon – Southern Ocean Connector	Dredging	*3C*	Pump out (jetty discharge) + Dredge Parnka Point	1	1.2 m	17.5 km	100 m – 300 m		1 x 150m		Constant pump	3 (Coorong)	250 ML/d	365 days	365 days
Coorong South Lagoon – Southern Ocean Connector	Dredging	*3D*	Pump out (low visual impact discharge) + Dredge Parnka Point	1	1.2 m	17.5 km	100 m – 200 m	1			Constant pump	3 (Coorong)	250 ML/d	365 days	365 days
Coorong South Lagoon – Southern Ocean Connector		*4A*	Pump in or out (separate pumping stations)	1	1.4 m				1 x 350m		Bidirectional pump	4 (Coorong) 4 (Ocean)	350 ML/d	365 days* (alternating direction)	365 days* (alternating direction)
Coorong South Lagoon – Southern Ocean Connector		*4B*	Pump in or out (one common pumping station)	1	1.6 m					1 (250 x 50 m)	Bidirectional pump	4 (Young Husband Peninsula)	350 ML/d	365 days* (alternating direction)	365 days* (alternating direction)
Coorong South Lagoon – Southern Ocean Connector	Dredging	*5A*	Circulation (pump in and out) (jetty discharge)	2	1.4 m	9 km			1 x 350m (in) 1 x 150m (out)		Bidirectional pump	4 (Coorong) 4 (Ocean)	350 ML/d	365 days*	365 days*
Coorong South Lagoon – Southern Ocean Connector	Dredging	*5B*	Circulation (pump in and out) (low visual impact discharge)	2	1.4 m	9 km		1	1 x 350m (in)		Bidirectional pump	3 (Coorong) 4 (Ocean)	350 ML/d	365 days*	365 days*
Coorong South Lagoon – Southern Ocean Connector		*6*	Passive Southern Ocean Connector	10	2 m					1 (220 x 130) m	Passive	N/A	Variable	365 days	365 days
Discontinued		*South East Flows Augmentation*		*This option did not progress to concept design as the option was discontinued on the basis that is did not provide sufficient benefit to the Coorong South Lagoon*											
Discontinued		*Automated Barrage Gates*		*This option did not progress to concept design as the option was discontinued on the basis that is did not provide sufficient benefit to the Coorong South Lagoon*											

Table 6 Summary of key parameters for infrastructure options under consideration to improve the health of the Coorong South Lagoon (✔ ✔ ✔ = greatest ecological improvement, from the base case ✔ ✔ moderate ecological improvement from the base case ✔ minimal ecological improvement from the base case)

		Concept Design #	**Description**	**Ecological Improvement**	**Construction disturbance footprint (hectares)**	**Capital Costs**	***Operations and maintenance* costs**	**GRP contribution (Coorong LGA)**	**GRP contribution (SA)**	**Employment contribution (Coorong LGA)**	**Employment contribution (SA)**	**Estimated maximum power demand (kW)**	**Annual energy consumption (MWhr)**	**Annual greenhouse gas emissions (t eCO_2)**
Lake Albert Connector		*1A*	Passive Lake Albert connector channel	✔	39.5	$50M-$100M	$0.1M-$0.25M	$13.4M	$41.9M	36	288	2	5.3	2
		1B	Passive piped Lake Albert Connector	✔	25.8	$100M-$150M	$0.5M-$1M	$34.4M	$140.6M	208	1180	2	5.3	2
	Dredging	*2*	*Dredge Parnka Point*	*Dredging is not considered on its own – Dredging details are summarised for 1A+2, 1B+2, 3C, 3D*										
		1A+2	Passive Lake Albert connector channel + dredge Parnka Point	✔	39.5 + 20	$150M-$200M	$0.1M-$0.25M	$29.3M	$92.7M	41	583			
		1B+2	Passive piped Lake Albert Connector + dredge Parnka Point	✔	25.8 + 20	$200M-$250M	$0.5M-$1M	$50.2M	$191.3M	213	1474			
Coorong South Lagoon – Southern Ocean Connector		*3A*	Pump out (jetty discharge)	✔ ✔	10.7	$200M-$250M	$10-$12.5M	$27.3M	$84.3M	34	575	2,820	11,100	3,860
		3B	Pump out (low visual impact discharge)	✔ ✔	9.7	$150M-$200M	$5M-$7.5M	$23.7M	$67.2M	29	451	1,140	4,500	1,560
	Dredging	*3C*	Pump out (jetty discharge) + dredge Parnka Point	✔ ✔	10.7 +20	$150M-$200M	$ 5-$7.5M	$42.5M	$123.9M	34	771	570	5,000	1,740
		3D	Pump out (low visual impact discharge) + dredge Parnka Point	✔ ✔	9.7+20	$150M-200M	$2.5-$5M	$38.4M	$108.5M	25	662	500	4,400	1,520
		4A	Pump in or out (separate pumping stations)	✔ ✔	10.7	$300M-$350M	$10M-$12.5M	$35.2M	$128.7M	71	931	1,020 (out) 1,250 (in)	9,600	3,350
		4B	*Pump in or out (one common pumping station)*	✔ ✔	11.7	$450M-$500M	$2.5M-$5M	$36.3M	$218.9M	66	1606	250 (pump out and pump in)	2,200	750
	Dredging	*5A*	Circulation (pump in and out) (jetty discharge)	✔ ✔ ✔	28.2	$500M-$550M	$15M-$17.5M	$76.8M	$222.4M	107	1461	920 (out), 1250 (in)	13,800	4,840
		5B	Circulation (pump in and out) (low visual impact discharge)	✔ ✔ ✔	27.2	$450M-$500M	$10M-$15M	$76.0M	$212.7M	103	1383	480 (out) 1250 (in)	10,000	3,480
		6	Passive Southern Ocean Connector	✔ ✔ ✔	*16.2*	$550M-$600M	$2.5M-$5M	$96.9M	$276.1M	172	*1773*	2	10.1	4
Discontinued		*South East Flows Augmentation*		*This option did not progress to concept design as the option was discontinued on the basis that is did not provide sufficient benefit to the Coorong South Lagoon*										
		Automated Barrage Gates		*This option did not progress to concept design as the option was discontinued on the basis that is did not provide sufficient benefit to the Coorong South Lagoon*										

7.2. Infrastructure options

Base Case – Do Nothing

Chapter 3 of this report describes the current context of the CLLMM region and the management options currently available to water managers. In modelling the potential ecological improvement that shortlisted infrastructure options may provide, results were compared to a 'base case' (or status quo), that is, a scenario in which no infrastructure is constructed.

Four 'do nothing' scenarios have been modelled; these are the benchmark for comparing the performance of infrastructure options (DEW, 2021f):

1. 'Normal', the observed inflows from the barrages and Salt Creek. This is a relatively low flow period in the context of barrage flow, with an annual average of 1,524 gigalitres per year (GL/yr) and maximum of 2,201 GL/yr for the calendar years of 2013-2015, compared to a long-term (1963-2020) average of 4,312 GL/yr
2. 'Extreme dry' with no barrage or Salt Creek inflow, representing extreme conditions (such as a Millennium drought) when the infrastructure options are likely to be of most value
3. 'Climate change', representing changes to evaporation from the Coorong (increase by 5%) and sea level rise (increase of 0.24 m) projected to occur by 2050, under the representative concentration pathway (RCP) 8.5 scenario (Pannell & Green, 2020). This scenario does not attempt to reflect climate change impacts on available flows from the River Murray, and adopts 'normal' scenario inflows from the barrages and Salt Creek. For time horizons up to 2050, Pannell & Green, 2020 recommend considering high emissions scenarios (that is, RCP 8.5)
4. Climate change with increased bed levels at the Murray Mouth, representing the conditions described in the point above, but acknowledging the plentiful supply of sand offshore may result in a consistent depth of water at the Murray Mouth, and as such the bathymetry in the active zone (directly inside the mouth between the Goolwa and Tauwitchere channels) of the model increased by the same amount as the sea level rise.

South East Flows Augmentation

Description

The South East Flows Restoration project was completed in 2018. It constructed a channel that diverted flow from the Blackford Drain in the South East drainage network towards the Coorong.

Further augmentation of flows from the South East drainage network could divert additional volumes from the Drain L and K catchments into the Coorong to reduce salinity and nutrients concentrations in the Coorong South Lagoon.

The South East Flows Augmentation (SEFA) option seeks to improve the health of the Coorong South Lagoon by diverting drainage flows currently discharged into the sea, routing them into the Coorong South Lagoon via Salt Creek.

Ecological implications

During Phase 1 of ecological investigations (Chapter 6.1.3) this infrastructure option was assessed through hydrodynamic and detailed biogeochemical – ecological habitat modelling. Modelling outcomes were assessed and evaluated through ecological interpretation and using the Ecological Risk Assessment Framework.

It was anticipated that 10 GL/year is likely to be available for the Coorong under an enhanced Lake Hawdon hydrograph and dry climate change scenarios. Key SEFA results of hydrodynamic and biogeochemical modelling indicate that the:

- augmented flow helps freshen the Coorong South Lagoon, but does not reduce salinity consistently below 100 g/L
- water levels in the Coorong South Lagoon are slightly higher with augmented flows over the spring months, but otherwise there is negligible change.

Qualitative and quantitative assessments of Phase 1 Ecological investigations against the base case concluded that SEFA would have limited or no benefits to the system

Climate change impacts on South East yields to the Coorong

A priority for the CIIP has been to revise previous SEFA yield modelling through a contemporary interpretation of likely climate change to 2050. The intent is to provide a revised indication of whether SEFA is viable from a 'yield to the Coorong' - and therefore environmental benefit - perspective.

An investigation into the climate change impacts on South East Flows Restoration Project yields to the Coorong South Lagoon (Whiting, 2021) assessed potential climate change impacts on surface water yields to the Coorong from the restoration project and SEFA. Existing hydrological and flow routing models developed for the restoration project and surrounding catchments were used to estimate the impact on yield from the outputs of 3 Global Climate Models, as presented in the SA Climate Ready database.

An assessment of yield under historic climate, by adopting hindcast climatic data, demonstrated that estimates of yield are likely to be lower than earlier modelling. This is in part due to different methodologies and because previous modelling used a much longer (127-year) time series, while recent work has adopted a more contemporary and pragmatic period (30-year) that reflects a step change more representative of the current climate. This revised yield modelling:

- provides a lower average yield estimate (~7 GL/yr) than was estimated in the hydrodynamic and biogeochemical modelling (10 GL/yr)
- reinforces that, at these yield volumes, SEFA is expected to have limited to no ecological benefits to the Coorong South Lagoon and would therefore not halt or reverse the trajectory of continued system decline.

Discontinuation of option

SEFA was discontinued from the scope of the CIIP investigations. We have not proceeded with engineering concept designs, or associated considerations of cultural heritage, legislative requirements or costs.

Additional Automated Gates at the Barrages

Description

This option involves the installation of 20 more automated barrage gates at Tauwitchere barrages, and 3 more at Goolwa barrages. The intent would be to provide more efficient 'pulsing' of water during times of favourable operational conditions (that is, advantageous tide and wind combinations) to assist in pushing water into the Coorong.

Ecological implications

Hydrodynamic modelling in May 2021 (DEW, 2021f) analysed the water level and salinity over the whole Coorong (from the barrages in the north, to Salt Creek in the south). Results revealed that it was very difficult to decipher any significant deviation between actual and modelled data, with and without additional barrage automation, indicating we could expect very little change to salinity or water levels from extra automated barrage gates.

In addition, further automation of barrage gates would not shift either salinity or water levels closer to the target levels.

Pulsing of barrage flow has been found in the modelling to have a short-term freshening effect in the Coorong North Lagoon, extending as far as Long Point (approximately halfway along the North Lagoon). The pulsing means that to create an increase in flow, there is a corresponding period of decreased flow compared to a more continuous flow, and these periods of reduced flow tend to offset any freshening achieved from the pulse.

The hydrodynamic report summarised the findings as follows:

> *"The modelled options for 'additional automated barrage gates' assumed three best case operational scenarios, none of which were able to sufficiently reduce salinities in the Coorong, despite doubling the number of automatic gates. Positive benefits to operating the gates in this way may be experienced only at a very local level."*
>
> *"None of the operational rules modelled for 'additional automated barrage gates' were able to reduce salinity in the Coorong South Lagoon. Some differences are apparent in the North Lagoon, but this is representative of only a temporary dilution effect, rather than a persistent influence on the southern end of the water body."*

Discontinuation of option

Additional automated barrage gates were discontinued from the scope of the CIIP investigations. We have not proceeded with engineering concept designs, or associated considerations of cultural heritage, legislative requirements or costs.

Concept 1A. Passive Lake Albert connector channel

Description
The Lake Albert to Coorong North Lagoon passive connector channel would have a 1.95 km long, 13 m base width open channel connection between Bascombe Bay (in Lake Albert) and the Coorong North Lagoon. The open channel design would be similar to that of the South East Drainage Network, and as such the channel would not be lined. At the Lake Albert end is an upstream regulator structure and fishway to control flow. A Narrung Road culvert crossing would be installed to permit traffic driving over the channel. The structure is designed to deliver flow up to 1,000 ML/d. This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is flow up to 1,000 ML/d when flow over barrages is greater than 2,000 ML/d (May to February) or the first 1,000 ML/d scheduled to be released through barraged (March and April). ML/d. The likely operating duration is 241 days (current conditions) or 143 days (under climate change conditions); these are approximate calculations based on modelling, and actual operating days will depend on factors such as weather conditions and operational protocols.

Figure 6 Visual representation of Concept 1A demonstrating the passive channel that would connect Lake Albert to the Coorong North Lagoon

Image developed by XCS Australia Pty Limited

Concept 1A. Passive Lake Albert connector channel

Design considerations

General design summary

The channel discharges from near the southern extent of Lake Albert (Bascombe Bay) via an inlet flow regulating structure with fishway which sits beneath Narrung Road. On discharge from the structure, the channel continues across open grazing country with a constant grade and alignment and then discharges into the Coorong North Lagoon. A trapezoidal channel, up to 8 m deep in sections, with base width of 13.3 m and side slopes of 1 (vertical) to 4 (horizontal) was adopted after considering the assessment by SKM 2014.

The expected flow velocity in the channel at normal operating levels is 0.35 to 0.4 m/s and this, coupled with the relatively flat batter slopes, minimises the potential for channel erosion.

The regulating structure consists of 5 concrete box culverts each measuring 2.7 m x 2.7 m and equipped with a combination of penstocks and lay-flat gates to allow precise control of flow to the Coorong. The fishway is a rock riffle type with resting pools to allow fish to negotiate the change in water level between Lake Albert and the Coorong.

Construction

Traditional excavation using medium-sized excavators or scrapers is required to construct the channel. The estimated volume of excavation of the open channel is approximately 270,000 m^3 with a further 30,000 m^3 of dredging required in Lake Albert and the Coorong North Lagoon to ensure adequate connectivity. The removed material is likely to be acid sulfate soil/potential acid sulfate soil, which will require treatment before disposal.

Spoil disposal and management will significantly add to construction duration due to the depth of excavation. Spoil disposal on-site adjacent to the alignment is preferred but this will require a significant area and landscaping to minimise ongoing maintenance.

Energy

As the regulating structure has manual operated flow control gates there is no requirement for large quantities of power. About 2 kW for the system monitoring and communications is required and could be supplied from an SA Power Networks single phase service or a small local solar supply with battery backup.

Operations and maintenance

The discharge from Lake Albert to the Coorong will be controlled by the inlet regulator, which comprises 2 culvert bays with lay-flat gates and 3 culvert bays with a vertical penstock. The lay-flat gates will allow automated control of flow when a specific flow rate is required. The flow should not need to be changed more than once a day.

The additional culverts with vertical penstocks can be opened when required to allow greater volumes of flow if necessary under certain operating conditions (for example, in a flood). The vertical penstocks are not intended to regulate flow in undershot mode but instead to be either fully open or closed.

Legislative considerations

Several Australian and South Australian legislative approvals apply to the infrastructure options being considered. Approvals common to all options are in Table 2. Approvals unique to Lake Albert options include land acquisition or other landholder access agreements, Crown land approval and local council approval. This is because the Lake Albert Connector options fall primarily on private land, not National Park land (as seen in the Coorong South Lagoon – Southern Ocean Connector options).

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

Concept 1A. Passive Lake Albert connector channel

The passive Lake Albert connector (LAC) channel significantly reduced the risk associated with salinity in the CNL and CSL under the current climate scenario, however, under the climate change scenario, the LAC did not alleviate risk to the ecosystem posed by salinity.

The risk posed by inadequate water levels in the CSL under this concept were equal to that of the base case.

This concept poses a greater risk to nutrient conditions in the CNL compared with the base case scenario (that is, worse than base case). However, this risk is not found in the LAC improved scenario; where water quality of Lake Alexandrina was used to represent future water quality of Lake Albert after being flushed by the connector

Overall, Lake Albert Connector options score one of the lowest of all infrastructure and management options due to poor salinity outcomes in the Coorong South Lagoon under the climate change inflow scenario and limited effectiveness in reducing nutrients. Consequently, they have limited effectiveness at improving the health of the Coorong South Lagoon.

Cost estimate

The cost estimate for construction of the Lake Albert to Coorong North Lagoon passive connector channel is $50 M - $100 M. Operations and maintenance is estimated to be $0.1 M - $0.25 M/year (over 25 years). This preliminary estimate was developed before detailed design and is only intended to be an indication for cost range comparison between options.

First Nations

The Lake Albert to Coorong North Lagoon passive connector channel was considered to have moderate impacts to cultural heritage due to its location and minimal size of construction impact. Ngarrindjeri Working Group involvement has been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database found no known sites along the alignments but a further cultural heritage survey increased our understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on-ground cultural heritage survey which was attended by Ngarrindjeri representatives. The survey method follows the standard procedure of pedestrian transects with varied spacing depending on ground surface and visibility. Sites of significance were recorded and a site avoidance philosophy used to protect areas of most concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

A Lake Albert to Coorong North Lagoon passive connector channel provides the potential for a $13.4 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP) during construction, along with an estimated 36 full-time equivalent (FTE) employment opportunities created. The benefits more broadly for South Australia during construction increase to $41.9 M contribution to GRP, and 288 FTE employment opportunities. Long-term opportunities for the community arising from ecological improvement have not been quantified.

There are short-term, localised potential impacts to commercial enterprises due to the risk to turbidity and subsequent gill clogging for commercial and recreationally caught fish. Also, maintenance dredging poses a risk of acid sulfate soils, but this would be mitigated during operations.

Visual amenity impacts are likely to be minimal because much of the channel extent lies on privately owned land.

There are limited impacts to access during construction, because the work would occur on privately owned land. Long-term access issues can be mitigated and subject to landholder requirements; a bridging structure may also be built across the channel to allow pedestrian access across the channel.

Concept 1B. Passive piped Lake Albert connector

Description
The Lake Albert to Coorong North Lagoon passive piped connection would consist of 7 x 2.1 m diameter pipes laid across a 1.5 km long stretch between Bascombe Bay (within Lake Albert) and the Coorong North Lagoon. At the Lake Albert end is an upstream regulator structure (5 off 2.7 m x 2.7 m penstocks and 2 off lay-flat gates) intended to control flow. There is no fishway, because fish are unlikely to traverse through closed dark pipes (as opposed to the Lake Albert to Coorong North Lagoon passive connector channel which would be open to daylight). The structure is designed to deliver flow up to 1,000 ML/d. This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is flow up to 1,000 ML/d when flow over barrages is greater than 2,000 ML/d (May to February) or the first 1,000 ML/d scheduled to be released through barraged (March and April). ML/d. The likely operating duration is 241 days (current conditions) or 143 days (under climate change conditions). These are approximate calculations based on modelling, and actual operating days will depend on factors such as weather conditions and operational protocols.

Figure 7 Visual representation of Concept 1B demonstrating the piped Lake Albert connector that would connect Lake Albert to the Coorong North Lagoon

Image developed by XCS Australia Pty Limited

Concept 1B. Passive piped Lake Albert connector

Design considerations

General design summary

Flow would discharge from the southern extent of Lake Albert (Bascombe Bay) into a short length of open channel and through a flow regulating structure which sits beneath Narrung Road. On discharge from the flow regulating structure, flow enters 7 x 2,100 mm diameter reinforced concrete pipes within the Seven Mile Road corridor before discharging into Coorong North Lagoon via an outlet headwall structure.

The regulating structure is the same as that for the open channel Lake Albert option, but does not include a fishway. The structure would consist of 5 concrete box culverts measuring 2.7 m x 2.7 m equipped with a combination of penstocks and lay-flat gates to allow precise control of flow to the Coorong.

The pipe invert levels (-2.0 m AHD at Lake Albert and -2.2 m AHD at the Coorong) have been selected so that the pipes will be submerged at each end under all operating conditions, which results in an outlet control condition governing the flow in the pipe. At the design flow of 1,000 ML/day the velocity through the pipes will be about 0.5 m/s.

Construction

An efficient form of construction is open cut excavation with stockpiling of material to backfill and cover the 7 pipes. Excavation depths of up to 12 m will be encountered and the estimated volume of excavation is about 250,000 m^3. There will be surplus excavated material after backfill of the pipes, and spoil disposal nearby is preferred. Also, there will be 30,000 m^3 of dredging required to connect the open channel to Lake Albert and Coorong North Lagoon. The removed material is likely to be acid sulfate soil/potential acid sulfate soil and will therefore require treatment before disposal.

Energy

As the regulating structure has manual operated flow control gates, large quantities of power are not needed. About 2 kW for the system monitoring and communications is required and could be supplied from an SA Power Networks single phase service or a small local solar supply with battery backup.

Operations and maintenance

The discharge from Lake Albert to the Coorong will be controlled by the inlet regulator, which comprises 2 culvert bays with lay-flat gates and 3 culvert bays with a vertical penstock. The lay-flat gates will allow automated control of flow when a specific flow rate is required. The flow should not need to be changed more than once daily.

The additional culverts with vertical penstocks can be opened when required to allow greater volumes of flow if necessary under certain operating conditions (for example, in a flood). The vertical penstocks are not intended to regulate flow in undershot mode but instead to be either fully open or closed.

Legislative considerations

Several Australian and South Australian legislative approvals apply to the infrastructure options being considered. Approvals common to all options are in Table 2. Approvals unique to Lake Albert options include land acquisition or other landholder access agreements, Crown land approval and local council approval. This is because the Lake Albert Connector options fall primarily on private land, not National Park land (as seen in the Coorong South Lagoon – Southern Ocean Connector options).

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

The passive Lake Albert connector (LAC) channel significantly reduced the risk associated with salinity in the CNL and CSL under the current climate scenario, however, under the climate change scenario, the LAC did not alleviate risk to the ecosystem posed by salinity.

Concept 1B. Passive piped Lake Albert connector

The risk posed by inadequate water levels in the CSL under this concept were equal to that of the base case.

This concept poses a greater risk to nutrient conditions in the CNL compared with the base case scenario (that is, worse than base case). However, this risk is not found in the LAC improved scenario; where water quality of Lake Alexandrina was used to represent future water quality of Lake Albert after being flushed by the connector

Overall, Lake Albert Connector options score one of the lowest of all infrastructure and management options due to poor salinity outcomes in the Coorong South Lagoon under the climate change inflow scenario and limited effectiveness in reducing nutrients. Consequently, they have limited effectiveness at improving the health of the Coorong South Lagoon.

Cost estimate

The cost estimate for construction of the Lake Albert to Coorong North Lagoon passive piped connection is $100 M - $150 M. Operations and maintenance is estimated to be $0.5 M - $1 M/year (over 25 years). This preliminary estimate was developed before detailed design and is only intended to provide an indication for cost range comparison between options.

First Nations

The Lake Albert – Coorong Connector was considered to have moderate impacts to cultural heritage due to its location and minimal size of construction impact. Ngarrindjeri Working Group involvement has been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database found no known sites along the alignments but a further cultural heritage survey increased our understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on-ground cultural heritage survey which was attended by Ngarrindjeri representatives. The survey method follows the standard procedure of pedestrian transects with varied spacing depending on ground surface and visibility. Sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

A Coorong North Lagoon passive piped connection provides the potential for a $34.4 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP) during construction, along with an estimated 208 full-time equivalent (FTE) employment opportunities created. The benefits more broadly for South Australia during construction increase to $140.6 M contribution to GRP, and 1,180 FTE of employment opportunities. Long-term opportunities for the community arising from ecological improvement have not been quantified.

There are short-term, localised potential impacts to commercial enterprises due to the risk to turbidity and subsequent gill clogging for commercial and recreationally caught fish. Also, maintenance dredging poses a risk of acid sulfate soils, which would be mitigated during operations.

Visual amenity impacts are likely to be minimal because much of the channel extent lies on privately owned land.

There are limited impacts to access during construction, mainly arising from traffic controls that would occur along Narrung Road. There are no anticipated long-term access issues because the pipes would be buried.

Concepts 1A. Passive Lake Albert connector channel + 2. Dredge Parnka Point

Description
The Lake Albert to Coorong North Lagoon passive connector channel would have a 1.95 km long, 13 m base width open channel connection between Bascombe Bay (in Lake Albert) and the Coorong North Lagoon. The open channel design would be similar to that of the South East Drainage Network, as such the channel would not be lined. At the Lake Albert end is an upstream regulator structure and fishway to control flow. A Narrung Road culvert crossing would also be installed to permit traffic driving over the channel. The structure is designed to deliver flow up to 1,000 ML/d. This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is flow up to 1,000 ML/d when flow over barrages is greater than 2,000 ML/d (May to February) or the first 1,000 ML/d scheduled to be released through barraged (March and April). ML/d. The likely operating duration is 241 days (current conditions) or 143 days (under climate change conditions). These are approximate calculations based on modelling, and actual operating days will depend on factors such as weather conditions and operational protocols. The proposed dredging alignment is a 17.5 km long stretch around Parnka Point (from approximately The Needles to Round Island). The target depth of dredging will be between 1.2 mAHD and 1.4 mAHD to varying width (typically 100 m – 200 m, up to 250 m – 300 m in greatest extents). The 17.5 km stretch could be dredged in ~2 years (assuming 365 days operation). Note that dredging is not considered an option on its own, only in conjunction with Lake Albert or Southern Ocean connector options.

Figure 8 Visual representation of Concept 1A + 2 demonstrating the passive Lake Albert connector channel that would connect Lake Albert to the Coorong North Lagoon [top], and the 17.5km dredge alignment either side of Parnka Point [bottom]

Image developed by XCS Australia Pty Limited

Concepts 1A. Passive Lake Albert connector channel + 2. Dredge Parnka Point

Design considerations

General design summary

Passive Lake Albert connector channel

The channel discharges from near the southern extent of Lake Albert (Bascombe Bay) via an inlet flow regulating structure with fishway which sits beneath Narrung Road. On discharge from the structure, the channel continues across open grazing country with a constant grade and alignment and then discharges into the Coorong North Lagoon. A trapezoidal channel, up to 8 m deep in sections, with base width of 13.3 m and side slopes of 1 (vertical) to 4 (horizontal) was adopted after considering the assessment by SKM 2014.

The expected flow velocity in the channel at normal operating levels is 0.35 to 0.4 m/s and this, coupled with the relatively flat batter slopes, minimises the potential for channel erosion.

The regulating structure consists of 5 concrete box culverts each measuring 2.7 m x 2.7 m and equipped with a combination of penstocks and lay-flat gates to allow precise control of flow to the Coorong. The fishway is a rock riffle type with resting pools to allow fish to negotiate the change in water level between Lake Albert and the Coorong.

Dredging Parnka Point

Early hydrodynamic modelling highlighted an 18.5 km long section through The Narrows where the shallow depth of the Coorong was limiting hydraulic connectivity between the Coorong North and South lagoons to be the most suitable location for dredging (DEW, 2021d). After comparing the impact of different dredge options and considering the dimensions of the mesh grid used in the hydrodynamic modelling, a dredge alignment 17.5 km long has been adopted. The dredge width varies between 100 m and 200 m and depth to between -1.2 m AHD and -1.4 m AHD. Allowing for a 200 mm over dredge during construction, the total dredged volume of bed material is estimated to be 2.25 million m^3.

Early modelling indicated a volume of about 2.8 million m^3 would need to be dredged from the Coorong and therefore disposal of this material would be a significant issue. Discussions were held with the South Australian Environmental Protection Agency (EPA) and Maritime Constructions, as specialists in marine construction and dredging, to consider the options for disposal. It was concluded that the land-based discharge of dredgeate be discounted for the following reasons:

- Challenges in identifying and purchasing suitable land that could be used for construction of sedimentation basins, including proximity to the dredging works, elevation and grade of available land and the required vegetation clearance and farmland displacement
- Cost of land acquisition, construction of sedimentation basins, infrastructure and pumping
- Challenges in treating acid sulfate soils at this scale
- Cost of remediating the disposal site following completion of the dredging campaign
- Likely approvals process to allow land-based discharge considering the ongoing environmental implications of land-based disposal (for example, soft silts and clays remaining in a waterlogged state, hypersaline water/retained salt within the sedimentation basins, discharge water monitoring prior to disposal and acid sulfate soil treatment).

The EPA guidance indicated that offshore disposal would be preferred from an environmental approvals perspective. However, for the cutter suction dredge methodology offshore disposal is not appropriate. Offshore disposal of dredged material is typically completed via a trailing suction hopper dredge which is a dredge vessel that collects the dredged product within the vessel hull before transportation to a defined disposal area where it can release the dredged product through opening doors in the vessel's hull to deposit on the seabed. One challenge with this is the vessel draught required to allow a trailer suction hopper dredge to operate effectively is typically 3 m to 4 m of draught once laden and this is not achievable in the Coorong lagoon environment.

Concepts 1A. Passive Lake Albert connector channel + 2. Dredge Parnka Point

Near-shore disposal, using pump and discharge pipeline from the dredge across Younghusband Peninsula is therefore the preferred dredgeate disposal pathway. This method also has the benefit of not exposing the dredged material to oxygen and therefore management of acid sulfate soil/potential acid sulfate soil sediments is not required.

The dredged slurry can only be pumped a limited distance and so the discharge pipeline and onshore pump will need to be moved as the dredging progresses along the 17.5 km alignment. The discharge pipeline to the Southern Ocean would need to be moved about 5 times. Each movement will require cultural heritage and environmental surveys of Younghusband Peninsula to ensure items or zones of heritage or environmental value are adequately managed.

Construction

For the construction of the channel, traditional excavation using medium-sized excavators or scrapers is required to construct the channel. The estimated volume of excavation of the open channel is approximately 270,000 m^3 with a further 30,000 m^3 of dredging required in Lake Albert and the Coorong North Lagoon to ensure adequate connectivity. The removed material is likely to be acid sulfate soil/potential acid sulfate soil and will therefore require treatment before disposal.

Spoil disposal and management will significantly add to construction duration due to the depth of excavation. Spoil disposal on-site adjacent to the alignment is preferred but will require a significant area and landscaping to minimise ongoing maintenance.

For the dredging operation, a cutter suction dredge is the most appropriate dredge for the Coorong because it operates in shallower water than other dredge types. The pump and pipeline disposal of dredgeate also provides more flexibility than other dredges and causes less environmental disturbance. The cutter suction process fluidises and removes the dredged sediment by pumping a slurry through pipelines to disposal locations. These disposal locations would be assessed in terms of cultural and environmental risk prior to any dredging occurring.

Once the dredge is mobilised it will operate 24/7 and a production rate of 40,000 m^3 per week is expected, allowing for downtime associated with relocation of the dredge and dredgeate disposal pipework.

It is possible that the dredge access to Parnka Point will be from Goolwa via the Murray Mouth and dredging may be required through shallow water zones depending on the water depth at the time of mobilisation.

Energy

For the channel, the regulating structure has manual operated flow control gates, and as such large quantities of power are not needed. About 2 kW for the system monitoring and communications is required and could be supplied from an SA Power Networks single phase service or a small local solar supply with battery backup.

There is no on-going power requirement for dredging.

Operations and maintenance

The discharge from Lake Albert to the Coorong via the channel will be controlled by the inlet regulator, which comprises 2 culvert bays with lay-flat gates and 3 culvert bays with a vertical penstock. The lay-flat gates will allow automated control of flow when a specific flow rate is required. The flow should not need to be changed more than once daily.

The additional culverts with vertical penstocks can be opened when required to allow greater volumes of flow if necessary under certain operating conditions (for example, in a flood). The vertical penstocks are not intended to regulate flow in undershot mode but instead to be either fully open or closed.

For dredging, monitoring of the dredged profile will be required to check if sedimentation is occurring but it is not expected that the Parnka Point alignment will require further dredging to maintain the desired hydraulic connectivity.

Legislative considerations

Several Australian and South Australian legislative approvals apply to the infrastructure options being considered. Approvals common to all options are in Table 2. Approvals unique to Lake Albert options include land acquisition or

Concepts 1A. Passive Lake Albert connector channel + 2. Dredge Parnka Point

other landholder access agreements, Crown land approval and local council approval. This is because the Lake Albert Connector options fall primarily on private land, not National Park land (as seen in the Coorong South Lagoon – Southern Ocean Connector options).

Additional approvals would be required for the dredging activities, including a permit to dispose the dredgeate to sea and EPA approvals.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

This option performs very similarly to Passive Lake Albert connector channel (concept 1A) without dredging, demonstrating a salinity reduction in the Coorong South Lagoon under the current climate inflow scenario. However, there is no improvement to salinity observed from base case under the climate change inflow scenario. No significant benefit to salinity has been observed in the modelling scenarios by adding dredging at Parnka Point for connectivity.

Models predict a negative impact in the water level parameters in the Coorong South Lagoon under current inflow conditions, therefore we assume this is caused by the dredging.

This option creates a detrimental impact to the Coorong North Lagoon nutrients parameters (that is, worse than base case). This option was not tested with improved water quality parameters but it is expected to perform in a similar manner to the Lake Albert Connector regarding improvements of water quality to Lake Albert.

The Lake Albert options, when combined with dredging are the least effective of all infrastructure and management options in improving the health of the Coorong due to poor salinity outcomes in the Coorong South Lagoon under the climate change inflow scenario and limited effectiveness in reducing nutrients (under both current and future climate scenarios). Consequently, they have limited effectiveness at improving the health of the Coorong South Lagoon.

Cost estimate

The cost estimate for the Lake Albert to Coorong North Lagoon passive connector channel and dredging operation is $150 M - $200 M. Operations and maintenance is estimated to be $0.1 M - $0.25 M/year (over 25 years) (note that dredging has no operations and maintenance requirements). This preliminary estimate was developed before detailed design and is only intended to provide an indication for cost range comparison between options.

First Nations

The Lake Albert – Coorong Connector with dredging was considered to have moderate impacts to cultural heritage due to its location and minimal size of construction impact. Ngarrindjeri Working Group involvement has been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database found no known sites along the alignments but a further cultural heritage survey increased our understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on-ground cultural heritage survey which was attended by Ngarrindjeri representatives. The survey method follows the standard procedure of pedestrian transects with varied spacing depending on ground surface and visibility. Sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern. The dredging of Parnka Point is yet to be assessed through a specific survey of multiple pipeline alignments across Younghusband Peninsula of concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Concepts 1A. Passive Lake Albert connector channel + 2. Dredge Parnka Point

Socio economic
A Lake Albert to Coorong North Lagoon passive connector channel, in conjunction with a 2-year dredging operation provides the potential for a $29.3 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 41 full-time equivalent (FTE) employment opportunities created. The benefits more broadly for South Australia during construction increase to $92.7 M contribution to GRP, and 583 FTE employment opportunities. Long-term opportunities for the community arising from ecological improvement have not been quantified. There are short-term, localised potential impacts to commercial enterprises due to the risk to turbidity and subsequent gill clogging for commercial and recreationally caught fish. Also, maintenance dredging poses a risk of acid sulfate soils, but this would be mitigated during operations. The impacts that dredgeate disposal may have on key commercial and recreational fish species, particularly pipis, would be localised and short term (during dredging). A full environmental impact assessment and further consultation with the EPA would occur prior to dredging, minimising the impact of this risk. A benefit of the location of the proposed dredge alignment is the potential to improve boat access by improving connectivity through The Narrows. Visual amenity impacts are likely to be minimal, noting that much of the channel extent lies on privately owned land. There are limited impacts to access during construction, because the work would occur on privately owned land. Long-term access issues can be mitigated and subject to landholder requirements, a bridging structure may also be built across the channel to allow pedestrian access across the channel.

Concepts 1B. Passive piped Lake Albert connector + 2. Dredge Parnka Point

Description
The Lake Albert to Coorong North Lagoon passive piped connection would consist of 7 x 2.1 m diameter pipes laid across a 1.5 km long stretch between Bascombe Bay (within Lake Albert) and the Coorong North Lagoon. At the Lake Albert end is an upstream regulator structure (5 off 2.7 m x 2.7 m penstocks and 2 off lay-flat gates) intended to control flow. There is no fishway for this option, because fish are unlikely to traverse through closed dark pipes (as opposed to the Lake Albert to Coorong North Lagoon passive connector channel which would be open to daylight). A Narrung Rd culvert crossing would also be installed to permit driving traffic over the channel. The structure is designed to deliver flow up to 1,000 ML/d. This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is flow up to 1,000 ML/d when flow over barrages is greater than 2,000 ML/d (May to February) or the first 1,000 ML/d scheduled to be released through barraged (March and April). ML/d. The likely operating duration is 241 days (current conditions) or 143 days (under climate change conditions). These are approximate calculations based on modelling, and actual operating days will depend on factors such as weather conditions and operational protocols. The proposed dredging alignment is a 17.5 km long stretch around Parnka Point (from approximately The Needles to Round Island). The target depth of dredging will be between 1.2 mAHD and 1.4 mAHD to varying width (typically 100 m – 200 m, up to 250 m – 300 m in greatest extents). The 17.5 km stretch could be dredged in ~2 years (assuming 365 days operation). Note that dredging is not considered as an option on its own, only in conjunction with Lake Albert or Southern Ocean connector options.

Figure 9 Visual representation of Concept 1B+2 demonstrating the piped Lake Albert connector that would connect Lake Albert to the Coorong North Lagoon [top] and the 17.5km dredge alignment either side of Parnka Point [bottom]

Image developed by XCS Australia Pty Limited

Concepts 1B. Passive piped Lake Albert connector + 2. Dredge Parnka Point

Design considerations

General design summary

Passive piped Lake Albert connector

Flow discharges from the southern extent of Lake Albert (Bascombe Bay) into a short length of open channel and through a flow regulating structure which sits beneath Narrung Road. On discharge from the flow regulating structure, flow enters 7 x 2100 mm diameter reinforced concrete pipes within the Seven Mile Road corridor before discharging into Coorong North Lagoon via an outlet headwall structure.

The regulating structure is the same as that for the open channel Lake Albert option, but does not include a fishway. The structure consists of 5 concrete box culverts measuring 2.7 m x 2.7 m equipped with a combination of penstocks and lay-flat gates to allow precise control of flow to the Coorong.

The pipe invert levels (-2.0 m AHD at Lake Albert and -2.2 m AHD at the Coorong) have been selected so that the pipes will be submerged at each end under all operating conditions, which results in an outlet control condition governing the flow in the pipe. At the design flow of 1,000 ML/day the velocity through the pipes will be about 0.5 m/s.

Dredging Parnka Point

Early hydrodynamic modelling highlighted an 18.5 km long section through The Narrows where the shallow depth of the Coorong was limiting hydraulic connectivity between the Coorong North and South lagoons to be the most suitable location for dredging (DEW, 2021d). After comparing the impact of different dredge options and considering the dimensions of the mesh grid used in the hydrodynamic modelling, a dredge alignment 17.5 km long has been adopted. The dredge width varies between 100 m and 200 m and depth to between -1.2 m AHD and -1.4 m AHD. Allowing for a 200 mm over dredge during construction, the total dredged volume of bed material is estimated to be 2.25 million m^3.

Early modelling indicated a volume of about 2.8 million m^3 would need to be dredged from the Coorong and therefore disposal of this material would be a significant issue. Discussions were held with the South Australian Environmental Protection Agency (EPA) and Maritime Constructions, as specialists in marine construction and dredging, to consider the options for disposal. It was concluded that the land-based discharge of dredgeate be discounted for the following reasons:

- Challenges in identifying and purchasing suitable land that could be used for construction of sedimentation basins, including proximity to the dredging works, elevation and grade of available land and the required vegetation clearance and farmland displacement
- Cost of land acquisition, construction of sedimentation basins, infrastructure and pumping
- Challenges in treating acid sulfate soils at this scale
- Cost of remediating the disposal site following completion of the dredging campaign
- Likely approvals process to allow land-based discharge considering the ongoing environmental implications of land-based disposal (for example, soft silts and clays remaining in a waterlogged state, hypersaline water/retained salt within the sedimentation basins, discharge water monitoring prior to disposal and acid sulfate soil treatment).

The EPA guidance indicated that offshore disposal would be preferred from an environmental approvals perspective. However, for the cutter suction dredge methodology offshore disposal is not appropriate. Offshore disposal of dredged material is typically completed via a trailing suction hopper dredge which is a dredge vessel that collects the dredged product within the vessel hull before transportation to a defined disposal area where it can release the dredged product through opening doors in the vessel's hull to deposit on the seabed. One challenge with this is the vessel draught required to allow a trailer suction hopper dredge to operate effectively is typically 3 m to 4 m of draught once laden and this is not achievable in the Coorong lagoon environment.

Near-shore disposal, using pump and discharge pipeline from the dredge across Younghusband Peninsula is therefore the preferred dredgeate disposal pathway. This method also has the benefit of not exposing the dredged material to oxygen and therefore management of acid sulfate soil/potential acid sulfate soil sediments is not required.

Concepts 1B. Passive piped Lake Albert connector + 2. Dredge Parnka Point
The dredged slurry can only be pumped a limited distance and so the discharge pipeline and onshore pump will need to be moved as the dredging progresses along the 17.5 km alignment. The discharge pipeline to the Southern Ocean would need to be moved about 5 times. Each movement will require cultural heritage and environmental surveys of Younghusband Peninsula to ensure items or zones of heritage or environmental value are adequately managed.
Construction
For pipe laying, an efficient form of construction is open cut excavation with stockpiling of material to backfill and cover the 7 installed pipes. Excavation depths of up to 12 m will be encountered and the estimated volume of excavation is about 250,000 m^3. There will be surplus excavated material after backfill of the pipes, and spoil disposal nearby is preferred. Also, there will be a further 30,000 m^3 of dredging required to connect the open channel to the adjoining water bodies of Lake Albert and Coorong North Lagoon. The removed material is likely to be acid sulfate soil/potential acid sulfate soil and will therefore require treatment before disposal. For dredging near Parnka Point a cutter suction dredge is the most appropriate dredge to use in the Coorong because it operates in shallower water than other dredge types. The pump and pipeline disposal of dredgeate also provides more flexibility than other dredges and causes less environmental disturbance. The cutter suction process fluidises and removes the dredged sediment by pumping a slurry through pipelines to disposal locations. Once the dredge is mobilised it will operate 24/7 and a production rate of 40,000 m^3 per week is expected, allowing for downtime associated with relocation of the dredge and dredgeate disposal pipework. It is likely that the dredge access to Parnka Point will be from Goolwa via the Murray Mouth and we might have to dredge through shallow water zones depending on the water depth at the time of mobilisation.
Energy
For the connector, the regulating structure has manual operated flow control gates, large quantities of power are not needed. About 2 kW for the system monitoring and communications is required and could be supplied from an SA Power Networks single phase service or a small local solar supply with battery backup. There is no on-going power requirement for this dredging.
Operations and maintenance
The discharge from Lake Albert to the Coorong via the connector will be controlled by the inlet regulator, which comprises 2 culvert bays with lay-flat gates and 3 culvert bays with a vertical penstock. The lay-flat gates will allow automated control of flow when a specific flow rate is required. The flow should not need to be changed more than once daily. The additional culverts with vertical penstocks can be opened when required to allow greater volumes of flow if necessary under certain operating conditions (for example, in a flood). The vertical penstocks are not intended to regulate flow in undershot mode but instead to be either fully open or closed. For dredging, monitoring of the dredged profile will be required to check if sedimentation is occurring but it is not expected that the Parnka Point alignment will require further dredging to maintain the desired hydraulic connectivity.
Legislative considerations
Several Australian and South Australian legislative approvals apply to the infrastructure options being considered. Approvals common to all options are in Table 2. Approvals unique to Lake Albert options include land acquisition or other landholder access agreements, Crown land approval and local council approval. This is because the Lake Albert Connector options fall primarily on private land, not National Park land (as seen in the Coorong South Lagoon – Southern Ocean Connector options). Additional approvals would be required for the dredging activities, including a permit to dispose the dredgeate to sea and EPA approvals.
Ecological implications

Concepts 1B. Passive piped Lake Albert connector + 2. Dredge Parnka Point

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

This option performs very similarly to Passive Lake Albert connector channel (concept 1A) without dredging, demonstrating a salinity reduction in the Coorong South Lagoon under the current climate inflow scenario. However, there is no improvement to salinity observed from base case under the climate change inflow scenario. No benefit to salinity has been observed in the modelling scenarios by adding dredging at Parnka Point for connectivity.

Models predict a negative impact in the water level parameters in the Coorong South Lagoon under current inflow conditions, therefore we assume this is caused by the dredging.

This option creates a detrimental impact to the Coorong North Lagoon nutrients parameters (that is, worse than base case). This option was not tested with improved water quality parameters but it is expected to perform in a similar manner to the Lake Albert Connector regarding improvements of water quality to Lake Albert.

The Lake Albert options, when combined with dredging are the least effective of all infrastructure and management options in improving the health of the Coorong due to poor salinity outcomes in the Coorong South Lagoon under the climate change inflow scenario and limited effectiveness in reducing nutrients (under both current and future climate scenarios). Consequently, they have limited effectiveness at improving the health of the Coorong South Lagoon.

Cost estimate

The cost estimate for the Lake Albert to Coorong North Lagoon piped connection and dredging operation is $200 M - $250 M. Operations and maintenance is estimated to be $0.5 M - $1 M/year (over 25 years) (note that dredging has no operations and maintenance requirements). This preliminary estimate was developed before detailed design and is only intended to provide an indication for cost range comparison between options.

First Nations

The Lake Albert – Coorong Connector with dredging was considered to have moderate impacts to cultural heritage due to its location and reduced size of construction impact. Ngarrindjeri Working Group involvement has been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database found no known sites within the alignments but a further cultural heritage survey increased our understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on-ground cultural heritage survey which was attended by Ngarrindjeri representatives. The survey method follows the standard procedure of pedestrian transects with varied spacing depending on ground surface and visibility. Sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern. The dredging of Parnka Point is yet to be assessed through a specific survey of multiple pipeline alignments across Younghusband Peninsula of concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

The construction of Lake Albert to Coorong North Lagoon piped connector in conjunction with a 2-year dredging operation provides the potential for a $50.2 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 213 full-time equivalent (FTE) employment opportunities created. The benefits more broadly for South Australia during construction increase to $191.3 M contribution to GRP, and 1,474 FTE of employment opportunities. Long-term opportunities for the community arising from ecological improvement have not been quantified.

Concepts 1B. Passive piped Lake Albert connector + 2. Dredge Parnka Point

There are short-term, localised potential impacts to commercial enterprises due to the risk to turbidity and subsequent gill clogging for commercial and recreationally caught fish. Also, maintenance dredging poses a risk of acid sulfate soils, which would be mitigated during operations.

The impacts that dredgeate disposal may have on key commercial and recreational fish species, particularly pipis, would be localised and short term (during dredging). A full environmental impact assessment and further consultation with the EPA would occur prior to potential dredging, minimising the impact of this risk. A benefit of the proposed dredge alignment is the potential to improve boat access through improving connectivity through The Narrows.

Visual amenity impacts are likely to be minimal because much of the channel extent lies on privately owned land.

There are limited impacts to access during construction, because the work would occur on privately owned land. Long-term access issues can be mitigated and subject to landholder requirements, a bridging structure may also be built across the channel to allow pedestrian access across the channel.

Concept 3A. Pump out (jetty discharge)

Description

The pump out (jetty discharge) option involves pumping out from Coorong South Lagoon to the Southern Ocean. On the Coorong side will be a floating pontoon with 8 pumps and 8 fish exclusion screens. The location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). Traversing Younghusband Peninsula will be one 2.2 m diameter pipe, 920 m in length. At the Southern Ocean end is a 150 m long jetty outfall structure.

The structure is designed to deliver flow up to 1,000 ML/d. This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is to only pump out when the water level in Coorong South Lagoon is higher than 0.3 m AHD.

The likely operating duration is 137 days (current conditions) or 189 days (under climate change conditions). These are approximate calculations based on modelling, and actual operating days will depend on factors such as weather conditions and operational protocols.

Figure 10 Visual representation of Concept 3A demonstrating the pump out concept with a 150m jetty discharge in the Southern Ocean

Image developed by XCS Australia Pty Limited

Concept 3A. Pump out (jetty discharge)

Design considerations

General design summary

As the proposed location for the Coorong pumps is the western side of the Coorong South Lagoon this requires transporting all the required materials and equipment across the Coorong to Younghusband Peninsula. The benefit of pontoon mounted pumps is that they float and can be towed to the required location with an appropriate vessel, pending Coorong water depths at the time. This reduces the effort and cost required to transport the pumping infrastructure compared to other options such as a jetty system.

Construction

For the pumps located within the Coorong South Lagoon, pontoon mounted pumps have been used. The construction benefit of pontoon mounted pumps is that they are assembled and delivered as a complete unit. The pontoon is supplied with the required instrumentation and safety features. The only construction required on site is connecting the pontoon pipework to the common discharge manifold that will be installed on the floating walkway supplied with the pontoon mounted pumps, as well as installing guide piles for the pontoons.

For the pipework that connects the pipes located in the Coorong, to the Southern Ocean, the KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is not a feasible option due to the size of equipment required, the structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment.

Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day.

The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

It is envisaged that conventional methods for transporting and laying of the submarine cable may not be appropriate for this location. The lagoon is relatively shallow and access via water is severely restricted. This is likely to result in the cable having to be transported by road to the site (normally completed by ship) and a barge, or vessel with a relatively small draught, being used for the cable installation. As barging is likely to be required for construction equipment and transport of construction materials associated with the infrastructure proposed on the peninsula, the barge would serve a dual purpose.

For jetty construction, an ‘over the top’ installation methodology has been adopted to avoid the requirement for floating plant to be present within an open ocean environment. This would involve constructing the jetty gradually from land, into the ocean.

Energy

This option has the greatest power demand of all options as it has the greatest number of pumps and large static head as the discharge is from the jetty at an elevation of 10 m AHD. The overall power consumption is similar to other high use options because pumping is not continuous

Operations and maintenance

It is expected that the velocity within the pipeline will be sufficient to remove marine growth and maintain hydraulic efficiency.

The pumps are mounted on individual pontoons which are attached to a floating access walkway. A single pontoon or all the pontoons can be readily disconnected from the common discharge manifold and towed to different locations where they can be used for other purposes or disconnected for maintenance if required.

Although the fish screens at the pump suctions have a self-cleaning mechanism (mechanical scraper/rake) they will require regular maintenance to remove marine growth.

Legislative considerations

Concept 3A. Pump out (jetty discharge)

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

Pumping out of the Coorong South Lagoon significantly reduced the risk associated with reaching undesired salinity levels in the CNL and CSL under both the current climate and climate change scenarios, with salinities in both lagoons approaching desired conditions.

This option can reduce the risk posed by nutrients in the CNL and CSL compare with base case; it was acknowledged the risk associated with nutrient removal would require further design considerations and investigations.

Water levels in the Coorong South Lagoon are not negatively impacted nor improved from the base case.

Consequently, this concept has the potential to improve the health of the Coorong South Lagoon.

Cost estimate

A cost estimate for the construction of the pump out (jetty discharge) option is $200M-$250 M. Operations and Maintenance is estimated to be $10M-$12.5 M/year (25 years). This preliminary estimate was developed prior to any concept or detailed design being undertaken for this option and is only intended to provide an indication for cost range comparison between options.

First Nations

The Pump out (jetty discharge) was considered to have high impacts to cultural heritage due to its location in the landscape and size of construction impact. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives.

The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

The construction of the pump out (jetty discharge) concept provides the potential for a $27.3M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 34 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $84.3M contribution to GRP, and a 575 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water discharged into the Southern Ocean, would provide limited impacts to fishing activities. This would be further investigated to confirm prior to construction.

Concept 3A. Pump out (jetty discharge)
This concept would alter the visual amenity, however noting the 140 km extent of the Younghusband Peninsula, these impacts would be spatially, quite limited. There is no consideration of land acquisition noting the alignment falls within the Coorong National Park. There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse under the jetty would be provided, limiting the long term access restrictions.

Concept 3B. Pump out (low visual impact discharge)

Description
The pump out (low visual impact discharge) option involves pumping out from Coorong South Lagoon to the Southern Ocean. On the Coorong side, will be a floating pontoon with 6 pumps and 6 fish exclusion screens. The location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). Traversing Younghusband Peninsula will be one 2.2 m diameter pipe, 750 m in length. At the Southern Ocean end is a concrete outfall structure and FlexMat across the intertidal zone. When compared with the pump out (jetty discharge) option, this option involves less pumps as a result of a lesser distance to pump water, attributed to the fact there is no jetty. The structure is designed to deliver flow up to 1,000 ML/d. This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is to only pump out when the water level in Coorong South Lagoon is higher than 0.3 m AHD. The likely operating duration is 137 days (current conditions) or 189 days (under climate change conditions). These are approximate calculations based on modelling, and actual operating days will depend on factors such as weather conditions or operational protocols.

Figure 11 Visual representation of Concept 3B demonstrating the pump out concept with a FlexMat discharge into the Southern Ocean

Image developed by XCS Australia Pty Limited

Concept 3B. Pump out (low visual impact discharge)

Design considerations

General design summary

As the proposed location for the Coorong pumps is the western side of the Coorong South Lagoon this requires transporting all the required materials and equipment across the Coorong to Younghusband Peninsula. The benefit of pontoon mounted pumps is that they float and can be towed to the required location with an appropriate vessel, pending Coorong water depths at the time. This reduces the effort and cost required to transport the pumping infrastructure compared to other options such as a jetty system.

A key advantage of the beach discharge is that it eliminates the need for construction within the Southern Ocean environment, with all works proposed within the beach and intertidal area. Construction would follow conventional civil construction techniques for trenching, either in situ or precast installation of headwalls and aprons and piling equipment required for foundations.

Construction

The construction benefit of pontoon mounted pumps is that they are assembled and delivered as a complete unit. The pontoon is supplied with the required instrumentation and safety features. The only construction required on site is connecting the pontoon pipework to the common discharge manifold that will be installed on the floating walkway supplied with the pontoon mounted pumps, as well as installing guide piles for the pontoons.

The KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is not a feasible option due to the size of equipment required, the structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment.

Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day.

The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

It is envisaged that conventional methods for transporting and laying of the submarine cable may not be appropriate for this location. The lagoon is relatively shallow and access via water is severely restricted. This is likely to result in the cable having to be transported by road to the site (normally completed by ship) and a barge, or vessel with a relatively small draught, being used for the cable installation. As barging is likely to be required for construction equipment and transport of construction materials associated with the infrastructure proposed on the peninsula, the barge would serve a dual purpose.

An advantage of the beach discharge is that it eliminates the need for construction within the Southern Ocean environment, with all works proposed within the beach and intertidal area. Construction would follow conventional civil construction techniques for trenching, either in situ or precast installation of headwalls and aprons and piling equipment required for foundations.

Energy

This option has less power demand than Option 3A because of less static head due to discharge at beach level rather than from the jetty at an elevation of 10 m AHD. The overall power consumption is the second lowest of the pumping options.

Operations and maintenance

It is expected that the velocity within the pipeline will be sufficient to remove marine growth and maintain hydraulic efficiency.

Concept 3B. Pump out (low visual impact discharge)

The pumps are mounted on individual pontoons which are attached to a floating access walkway. A single pontoon or all the pontoons can be readily disconnected from the common discharge manifold and towed to different locations where they can be used for other purposes or disconnected for maintenance if required.

Although the fish screens at the pump suctions have a self-cleaning mechanism (mechanical scraper/rake) they will require regular maintenance to remove marine growth.

While the beach discharge outfall option offers a lower cost solution for initial construction, it will require frequent inspection and maintenance to ensure the beach conditions remains safe. FlexMat has the benefit of being flexible to conform to the beach during sand movements, but may also be susceptible to movement, erosion or dislodgement during severe storm events. Frequent inspection and closure of the beach may be required for forecast storm events or during discharge to prevent access to the site.

Legislative considerations

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

Pumping out of the Coorong South Lagoon significantly reduced the risk associated with reaching undesired salinity levels in the CNL and CSL under both the current climate and climate change scenarios, with salinities in both lagoons approaching desired conditions.

This option can reduce the risk posed by nutrients in the CNL and CSL compared with base case; it was acknowledged the risk associated with nutrient removal would require further design considerations and investigations.

Water levels in the Coorong South Lagoon are not negatively impacted nor improved from the base case.

Consequently, this concept has the potential to improve the health of the Coorong South Lagoon.

Cost estimate

A cost estimate for the construction of the pump out (low visual impact discharge) option is $150M-$200M. Operations and Maintenance is estimated to be $5M-$7.5M / year (25 years). This preliminary estimate was developed prior to any detailed design being undertaken for this option and is only intended to provide an indication for cost range comparison between options.

First Nations

Pump out (low visual impact discharge) was considered to have high impacts to cultural heritage due to its location in the landscape and size of construction impact. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives.

The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern.

Concept 3B. Pump out (low visual impact discharge)

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

The construction of the pump out (low visual impact discharge) concept provides the potential for a $23.7M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 29 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $67.2M contribution to GRP, and a 451 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water discharged into the Southern Ocean, would provide limited impacts to fishing activities. This would be further investigated to confirm prior to construction.

As the low visual impact concept, there would be minimal impact to the visual amenity. There is no consideration of land acquisition noting the alignment falls with the Coorong National Park.

There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse across the FlexMat would be provided, limiting the long term access restrictions.

Concept 3C. Pump out (jetty discharge) + Dredge Parnka Point

Description
The pump out (jetty discharge) with dredging option involves pumping out from Coorong South Lagoon to the Southern Ocean, in conjunction with a 17.5 km dredge alignment centred around Parnka Point. On the Coorong side, will be a floating pontoon with 3 pumps and 3 fish exclusion screens. The location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). Traversing Younghusband Peninsula will be one 1.2m diameter pipe, 920m in length. At the Southern Ocean end is a 150m long jetty outfall structure. The structure is designed to deliver flow up to 250 ML/d. This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is to pump permanently (24 hours per day). The likely pump operating duration is 365 days (for both current conditions and climate change conditions). This is based on modelling, and actual operating days will depend on factors such as weather conditions and operational protocols. The proposed dredging alignment is a 17.5 km long stretch around Parnka Point (from approximately The Needles to Round Island). The target depth of dredging will be between 1.2 mAHD and 1.4 mAHD to varying width (typically 100 m – 200 m, up to 250 m – 300 m in greatest extents). The 17.5 km stretch could be dredged in ~2 years (assuming 365 days operation). Note that dredging is not considered an option on its own, only in conjunction with Lake Albert or Southern Ocean connector options.

Figure 12 Visual representation Concept 3C demonstrating the pump out concept with a 150m jetty discharge into the Southern Ocean, and the 17.5km dredge alignment either side of Parnka Point

Image developed by XCS Australia Pty Limited

Concept 3C. Pump out (jetty discharge) + Dredge Parnka Point

Design considerations

General design summary

As the proposed location for the Coorong pumps is the western side of the Coorong South Lagoon this requires transporting all the required materials and equipment across the Coorong to Younghusband Peninsula. The benefit of pontoon mounted pumps is that they float and can be towed to the required location with an appropriate vessel, pending Coorong water depths at the time. This reduces the effort and cost required to transport the pumping infrastructure compared to other options such as a jetty system.

For dredging, early modelling indicated a volume of about 2.8 M m^3 to be dredged from the Coorong and therefore disposal of this material would be a significant issue. Discussions were subsequently held with the EPA and Maritime Constructions, as specialists in marine construction and dredging, to consider the options for disposal. It was concluded that the land based discharge of dredgeate be discounted for the following reasons;

- Challenges in identifying and purchasing suitable land that could be used for construction of sedimentation basins, including proximity to the dredging works, elevation and grade of available land and the required vegetation clearance and farmland displacement
- Cost of land acquisition, construction of sedimentation basins, infrastructure and pumping
- Challenges in treating acid sulfate soils at this scale
- Cost of remediating the disposal site following completion of the dredging campaign
- Likely approvals process to allow land-based discharge considering the ongoing environmental implications of land-based disposal (for example, soft silts and clays remaining in a waterlogged state, hypersaline water/retained salt within the sedimentation basins, discharge water monitoring prior to disposal and acid sulfate soil treatment).

The EPA guidance provided indicated that offshore disposal would be preferred from an environmental approvals perspective. However, for the cutter suction dredge methodology offshore disposal is not appropriate. Offshore disposal of dredged material is typically completed via a trailing suction hopper dredge which is a dredge vessel that collects the dredged product within the vessel hull before transportation to a defined disposal area where it can release the dredged product through opening doors in the vessel's hull to deposit on the seabed. One challenge with this dredge methodology is the vessel draught required to allow a trailer suction hopper dredge to operate effectively is typically 3 m to 4 m of draught once laden and this is not achievable in the Coorong lagoon environment.

Near-shore disposal, using pump and discharge pipeline from the dredge across Younghusband Peninsula has therefore been adopted as the preferred dredgeate disposal pathway. This method also has the benefit of not exposing the dredged material to oxygen and therefore additional management of acid sulfate soil/potential acid sulfate soil sediments is not required.

The dredged slurry can only be pumped a limited distance and therefore the discharge pipeline and onshore pump needs to be moved as the dredging progresses along the 17.5 km alignment. It is anticipated that the discharge pipeline to the Southern Ocean would need to be moved about 5 times. Each movement of the disposal pipeline will require cultural heritage and environmental surveys of Younghusband Peninsula to ensure items or zones of heritage or environmental value are adequately managed.

Construction

The construction benefit of pontoon mounted pumps is that they are assembled and delivered as a complete unit. The pontoon is supplied with the required instrumentation and safety features. The only construction required on site is connecting the pontoon pipework to the common discharge manifold that will be installed on the floating walkway supplied with the pontoon mounted pumps, as well as installing guide piles for the pontoons.

For the pipeline, KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is not a feasible option due to the size of equipment required, the structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment. Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum

Concept 3C. Pump out (jetty discharge) + Dredge Parnka Point

jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day. The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

It is envisaged that conventional methods for transporting and laying of the submarine cable may not be appropriate for this location. The lagoon is relatively shallow and access via water is severely restricted. This is likely to result in the cable having to be transported by road to the site (normally completed by ship) and a barge, or vessel with a relatively small draught, being used for the cable installation. As barging is likely to be required for construction equipment and transport of construction materials associated with the infrastructure proposed on the peninsula, the barge would serve a dual purpose.

For jetty construction, an 'over the top' installation methodology has been adopted to avoid the requirement for floating plant to be present within an open ocean environment. This would involve constructing the jetty gradually from land, into the ocean.

For dredging, a cutter suction dredge is considered the most appropriate equipment to use in the Coorong because it operates in shallower water than other dredge types. The pump and pipeline disposal of dredgeate also provides more flexibility than other dredges and causes less environmental disturbance. The cutter suction process fluidises and removes the dredged sediment by pumping a slurry through pipelines to disposal locations.

Once the dredge is mobilised it will operate 24/7 and a production rate of 40,000 m^3 per week is expected, allowing for downtime associated with relocation of the dredge and dredgeate disposal pipework.

It is likely that the dredge access to Parnka Point will be from Goolwa via the River Murray mouth and it may be required to dredge through shallow water zones depending on the water depth at the time of mobilisation.

Energy

This option has a low power demand as it has the least number of pumps. The overall power consumption is about half that of the high use options. Estimated maximum power demand is 570kW.

Operations and maintenance

It is expected that the velocity within the pipeline will be sufficient to remove marine growth and maintain hydraulic efficiency.

The pumps are mounted on individual pontoons which are attached to a floating access walkway. A single pontoon or all the pontoons can be readily disconnected from the common discharge manifold and towed to different locations where they can be used for other purposes or disconnected for maintenance if required.

Although the fish screens at the pump suctions have a self-cleaning mechanism (mechanical scraper/rake) they will require regular maintenance to remove marine growth.

Monitoring of the dredged profile will be required to check if sedimentation is occurring but it is not expected that the Parnka Point alignment will require further dredging to maintain the desired hydraulic connectivity.

Legislative considerations

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

Additional approvals would be required for the dredging activities, including a permit to dispose of the additional dredgeate to sea and EPA approvals.

Ecological implications

Concept 3C. Pump out (jetty discharge) + Dredge Parnka Point

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

This option significantly reduced the risk associated with salinity in the CNL and CSL under both the current climate and climate change scenarios, with salinities in both lagoons approaching desired conditions.

This option can reduce the risk posed by nutrients in the CNL and CSL compare with base case, performing slightly better for nutrient improvement than just pumping out on its own; it was acknowledged the risk associated with nutrient removal would require further design considerations and investigations.

Modelling indicated an increased risk inadequate water levels in the CSL under this concept, however the detrimental ecological impact was assessed marginal and that could be mitigated through operational controls (i.e. pumping would not occur when water levels are too low).

Consequently, this concept provides potential to improve the health of the Coorong South Lagoon.

Cost estimate

A cost estimate for the construction of the pump out (jetty discharge) with dredging option is $150M-$200M. Operations and Maintenance is estimated to be $5M-$7.5M / year (25 years). This estimate is less than the pump out jetty discharge) concept without dredging, noting that there are less pumps, and the intention is for pumping out to occur intermittently (as opposed to constant without dredging) This preliminary estimate was developed prior to any detailed design being undertaken for this option and is only intended to provide an indication for cost range comparison between options.

First Nations

The pump out (jetty discharge) in conjunction with dredging Parnka Point was considered to have high impacts to cultural heritage due to its location in the landscape and size of construction impact. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives.

The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern. The dredging of Parnka Point is yet to be assessed through specific survey with multiple pipeline alignments across Younghusband Peninsula of concern

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

The construction of pump out (jetty discharge) in conjunction with a 2 year dredging operation provides the potential for a $42.5M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 34 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $123.9M contribution to GRP, and 771 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water discharged into the Southern Ocean, would provide limited impacts to fishing activities. This would be further investigated to confirm prior to construction.

Concept 3C. Pump out (jetty discharge) + Dredge Parnka Point

This concept would alter the visual amenity, however noting the 140km extent of the Younghusband peninsula, these impacts would be spatially, quite limited. There is no consideration of land acquisition noting the alignment falls with the Coorong National Park.

There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse under the jetty will be provided, limiting the long term access restrictions.

Concept 3D. Pump out (low visual impact discharge) + Dredge Parnka Point

Description

The pump out (low visual impact discharge) with dredging option involves pumping out from Coorong South Lagoon to the Southern Ocean, in conjunction with a 17.5 km dredge alignment centred around Parnka Point. On the Coorong side, will be a floating pontoon with 3 pumps and 3 fish exclusion screens. The location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). Traversing Younghusband Peninsula will be one 1.2m diameter pipe, 750m in length. At the Southern Ocean end is a concrete outfall structure and FlexMat across the intertidal zone.

The structure is designed to deliver flow up to 250 ML/d. This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is to pump permanently (24 hours per day).

The likely pump operating duration is 365 days (for both current conditions and climate change conditions). This is based on modelling, and actual operating days will depend on factors such as weather conditions or operational protocols.

The proposed dredging alignment is a 17.5 km long stretch around Parnka Point (from approximately The Needles to Round Island). The target depth of dredging will be between 1.2 mAHD and 1.4 mAHD to varying width (typically 100 m – 200 m, up to 250 m – 300 m in greatest extents).

The 17.5 km stretch could be dredged in ~2 years (assuming 365 days operation). Note that dredging is not considered an option on its own, only in conjunction with Lake Albert or Southern Ocean connector options.

Figure 13 Visual representation Concept 3D demonstrating the pump out concept with a low visual impact FlexMat discharge into the Southern Ocean [top], and the 17.5km dredge alignment either side of Parnka Point [bottom]

Image developed by XCS Australia Pty Limited

Concept 3D. Pump out (low visual impact discharge) + Dredge Parnka Point

Design considerations

General design summary

For the pumps, the proposed location is the western side of the Coorong South Lagoon this requires transporting all the required materials and equipment across the Coorong to Younghusband Peninsula. The benefit of pontoon mounted pumps is that they float and can be towed to the required location with an appropriate vessel, pending Coorong water depths at the time. This reduces the effort and cost required to transport the pumping infrastructure compared to other options such as a jetty system.

A key advantage of the beach discharge is that it eliminates the need for construction within the Southern Ocean environment, with all works proposed within the beach and intertidal area. Construction would follow conventional civil construction techniques for trenching, either in situ or precast installation of headwalls and aprons and piling equipment required for foundations.

For dredging, early modelling indicated a volume of about 2.8 M m^3 to be dredged from the Coorong and therefore disposal of this material would be a significant issue. Discussions were subsequently held with the EPA and Maritime Constructions, as specialists in marine construction and dredging, to consider the options for disposal. It was concluded that the land-based discharge of dredgeate be discounted for the following reasons;

- Challenges in identifying and purchasing suitable land that could be used for construction of sedimentation basins, including proximity to the dredging works, elevation and grade of available land and the required vegetation clearance and farmland displacement
- Cost of land acquisition, construction of sedimentation basins, infrastructure and pumping
- Challenges in treating acid sulfate soils at this scale
- Cost of remediating the disposal site following completion of the dredging campaign
- Likely approvals process to allow land-based discharge considering the ongoing environmental implications of land-based disposal (for example, soft silts and clays remaining in a waterlogged state, hypersaline water/retained salt within the sedimentation basins, discharge water monitoring prior to disposal and acid sulfate soil treatment).

The EPA guidance indicated that offshore disposal would be preferred from an environmental approvals perspective. However, for the cutter suction dredge methodology offshore disposal is not appropriate. Offshore disposal of dredged material is typically completed via a trailing suction hopper dredge which is a dredge vessel that collects the dredged product within the vessel hull before transportation to a defined disposal area where it can release the dredged product through opening doors in the vessel's hull to deposit on the seabed. One challenge with this dredge methodology is the vessel draught required to allow a trailer suction hopper dredge to operate effectively is typically 3 m to 4 m of draught once laden and this is not achievable in the Coorong lagoon environment.

Near-shore disposal, using pump and discharge pipeline from the dredge across Younghusband Peninsula is therefore adopted as the preferred dredgeate disposal pathway. This method also has the benefit of not exposing the dredged material to oxygen and therefore management of acid sulfate soil/potential acid sulfate soil sediments is not required.

The dredged slurry can only be pumped a limited distance and so the discharge pipeline and onshore pump needs to be moved as the dredging progresses along the 17.5 km alignment. The discharge pipeline to the Southern Ocean would need to be moved about 5 times. Each movement will require cultural heritage and environmental surveys of Younghusband Peninsula to ensure items or zones of heritage or environmental value are adequately managed.

Construction

The construction benefit of pontoon mounted pumps is that they are assembled and delivered as a complete unit. The pontoon is supplied with the required instrumentation and safety features. The only construction required on site is connecting the pontoon pipework to the common discharge manifold that will be installed on the floating walkway supplied with the pontoon mounted pumps, as well as installing guide piles for the pontoons.

The KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is not a feasible option due to the size of equipment required, the

Concept 3D. Pump out (low visual impact discharge) + Dredge Parnka Point

structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment.

Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day.

The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

It is envisaged that conventional methods for transporting and laying of the submarine cable may not be appropriate for this location. The lagoon is relatively shallow and access via water is severely restricted. This is likely to result in the cable having to be transported by road to the site (normally completed by ship) and a barge, or vessel with a relatively small draught, being used for the cable installation. As barging is likely to be required for construction equipment and transport of construction materials associated with the infrastructure proposed on the peninsula, the barge would serve a dual purpose.

An advantage of the beach discharge is that it eliminates the need for construction within the Southern Ocean environment, with all works proposed within the beach and intertidal area. Construction would follow conventional civil construction techniques for trenching, either in situ or precast installation of headwalls and aprons and piling equipment required for foundations.

For dredging, a cutter suction dredge is considered the most appropriate equipment to use in the Coorong because it operates in shallower water than other dredge types. The pump and pipeline disposal of dredgeate also provides more flexibility than other dredges and causes less environmental disturbance. The cutter suction process fluidises and removes the dredged sediment by pumping a slurry through pipelines to disposal locations.

Once the dredge is mobilised it will operate 24/7 and a production rate of 40,000 m^3 per week is expected, allowing for downtime associated with relocation of the dredge and dredgeate disposal pipework.

It is likely that the dredge access to Parnka Point will be from Goolwa via the Murray Mouth and it may be required to dredge through shallow water zones depending on the water depth at the time of mobilisation.

Energy

This option has a low power demand as it has the least number of pumps. The overall power consumption is about half that of the high use options.

Operations and maintenance

It is expected that the velocity within the pipeline will be sufficient to remove marine growth and maintain hydraulic efficiency.

The pumps are mounted on individual pontoons which are attached to a floating access walkway. A single pontoon or all the pontoons can be readily disconnected from the common discharge manifold and towed to different locations where they can be used for other purposes or disconnected for maintenance if required.

Although the fish screens at the pump suctions have a self-cleaning mechanism (mechanical scraper/rake) they will require regular maintenance to remove marine growth.

While the beach discharge outfall option offers a lower cost solution for initial construction, it will require frequent inspection and maintenance to ensure the beach conditions remains safe. FlexMat has the benefit of being flexible to conform to the beach during sand movements, but may also be susceptible to movement, erosion or dislodgement during severe storm events. Frequent inspection and closure of the beach may be required for forecast storm events or during discharging to prevent access to the site.

Concept 3D. Pump out (low visual impact discharge) + Dredge Parnka Point

Monitoring of the dredged profile will be required to check if sedimentation is occurring but it is not expected that the Parnka Point alignment will require further dredging to maintain the desired hydraulic connectivity.

Legislative considerations

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

Additional approvals would be required for the dredging activities, including a permit to dispose of the additional dredgeate to sea and EPA approvals.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

This option significantly reduced the risk associated with salinity in the CNL and CSL under both the current climate and climate change scenarios, with salinities in both lagoons approaching desired conditions.

This option can reduce the risk posed by nutrients in the CNL and CSL compare with base case, performing slightly better for nutrient improvement than just pumping out on its own; however it was acknowledged the risk associated with nutrient removal would require further design considerations and investigations.

Modelling indicated an increased risk inadequate water levels in the CSL under this concept, however the detrimental ecological impact was assessed marginal and that could be mitigated through operational controls (i.e. pumping would not occur when water levels are too low).

Consequently, this concept provides potential to improve the health of the Coorong South Lagoon.

Cost estimate

A cost estimate for the construction of the pump out (low visual impact discharge) with dredging option is $150 M - $200 M. Operations and maintenance is estimated to be $2.5 M - $5 M/year (over 25 years). This preliminary estimate was developed before detailed design and is only intended to be an indication for cost range comparison between options.

First Nations

The Pump out (low visual impact discharge) with a dredge Parnka Point alignment was considered to have high impacts to cultural heritage due to its location in the landscape and size of construction impact. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives. The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern. The dredging of Parnka Point is yet to be assessed through specific survey with multiple pipeline alignments across Younghusband Peninsula are of concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Concept 3D. Pump out (low visual impact discharge) + Dredge Parnka Point

Socio economic

The construction of a pump out (low visual impact discharge) concept in conjunction with a 2 year dredging operation provides the potential for a $38.4M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 25 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $108.5M contribution to GRP, and a 662 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water from pumping operations and dredgeate from dredging discharged into the Southern Ocean, would provide limited, potentially localised impacts to fishing activities. This would be further investigated to confirm prior to construction.

As this is a low visual impact discharge structure, the impact to visual amenity is minimised. There is no consideration of land acquisition noting the alignment falls with the Coorong National Park.

There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse across the FlexMat will be provided, limiting the long term access restrictions.

Concept 4A. Pump in or out (separate pumping stations)

Description

The pump in or out (separate pumping stations) option consists of a bidirectional pipe with pumps at either end, with the intention that water can be pumped in or out of the Coorong South Lagoon, based on water requirements. For this option there are two pumping stations, one within the Coorong South Lagoon and one within the Southern Ocean. On the Coorong side, will be a floating pontoon with 4 pumps and 4 fish exclusion screens. The location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). Traversing Younghusband Peninsula will be one 1.4m diameter pipe, 1.15km in length. At the Southern Ocean end a 350m jetty, 4 vertical turbine pumps, and 3 fish exclusion screens. At the end of the jetty is also a concrete caisson stilling well (20 m x 19.8 m x 16.2 m).

The structure is designed to deliver flow up to 350 ML/d (into or out of the Coorong). This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is to pump permanently (24 hours per day).

The likely operating duration is 365 days (for both current conditions and climate change conditions), with an intention to pump out from May to September, and fluctuate pump in for 23 days and pump out for 25 days from October to April. This would mean an overall pump out for 265 days and pump in for 100 days a year. These are approximate calculations based on modelling, and actual operating days will depend on factors such as weather conditions or operational protocols.

Figure 14 Visual representation of Concept 1A demonstrating the passive channel that would connect Lake Albert to the Coorong North Lagoon

Image developed by XCS Australia Pty Limited

Concept 4A. Pump in or out (separate pumping stations)

Design considerations

General design summary

As the proposed location for the Coorong pumps is the western side of the Coorong South Lagoon this requires transporting all the required materials and equipment across the Coorong to Younghusband Peninsula. The benefit of pontoon mounted pumps is that they float and can be towed to the required location with an appropriate vessel, pending Coorong water depths at the time. This reduces the effort and cost required to transport the pumping infrastructure compared to other options such as a jetty system.

Construction

The construction benefit of pontoon mounted pumps is that they are assembled and delivered as a complete unit. The pontoon is supplied with the required instrumentation and safety features. The only construction required on site is connecting the pontoon pipework to the common discharge manifold that will be installed on the floating walkway supplied with the pontoon mounted pumps, as well as installing guide piles for the pontoons.

For pipeline construction, the KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is not a feasible option due to the size of equipment required, the structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment. Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day.

The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

Jetty construction is proposed as "over-the-top" construction only to avoid the use of water vessels in the high energy wave climate and shallow depths. It is proposed to use a single crawler crane plus a canti-traveller or similar so that construction can commence from the shore and progress out to sea while working above the storm surge and wave heights. A canti-traveller is a purpose-built working platform structure that installs piles into the seabed using an 'over-the-top' cantilevered construction method which is common for constructing typical pile and deck jetty structures. The use of the canti-traveller also eliminates the need to have divers working in the severe ocean conditions.

The 4.5 m wide jetty deck is sized to enable access for the crawler crane back to the land side once constructed. It also provides access for maintenance cranes that may be required to maintain the pumps and components at the head of the jetty structure.

Construction of the caisson at the jetty head is proposed using pre-cast elements, to be stacked over pile guides. The base of the caisson, which is at approximately -5 mAHD, would require "jetting" in of precast elements approximately 350 m offshore.

It is envisaged that conventional methods for transporting and laying of the submarine cable may not be appropriate for this location. The lagoon is relatively shallow and access via water is severely restricted. This is likely to result in the cable having to be transported by road to the site (normally completed by ship) and a barge, or vessel with a relatively small draught, being used for the cable installation. As barging is likely to be required for construction equipment and transport of construction materials associated with the infrastructure proposed on the peninsula, the barge would serve a dual purpose.

Energy

Both the pump in and pump out components have a power demand mid-range of all pumping options. The overall power consumption is at the high end of all pumping options as at least one pump is operating all of the time.

Operations and maintenance

Concept 4A. Pump in or out (separate pumping stations)

It is expected that the velocity within the pipeline will be sufficient to remove marine growth and maintain hydraulic efficiency.

The Coorong pumps are mounted on individual pontoons which are attached to a floating access walkway. A single pontoon or all the pontoons can be readily disconnected from the common discharge manifold and towed to different locations where they can be used for other purposes or disconnected for maintenance if required.

Although fish screens have a self-cleaning mechanism (mechanical scraper/rake) they will require regular maintenance to remove marine growth.

Legislative considerations

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

This option significantly reduced the risk associated with salinity in the CNL and CSL under both the current climate and climate change scenarios, with salinities in both lagoons approaching desired conditions.

This option can reduce the risk posed by nutrients in the CNL and CSL compare with base case, but it was acknowledged the risk associated with nutrient removal would require further design considerations and investigations.

Modelling indicated an increased risk inadequate water levels in the CSL under this concept, however the detrimental ecological impact was assessed marginal and that could be mitigated through operational controls (i.e. pumping would not occur when water levels are too low).

Consequently, this concept provides potential to improve the health of the Coorong South Lagoon.

Cost estimate

A cost estimate for the construction of the pump in or out (separate pumping stations) option is $300M-$350M Operations and maintenance is estimated to be $10 M-$12.5 M/year (over 25 years). This preliminary estimate was developed prior to any detailed design being undertaken for this option and is only intended to provide an indication for cost range comparison between options.

First Nations

The pump in or out (separate pumping stations) was considered to have high impacts to cultural heritage due to its location in the landscape and size of construction impact. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives. The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Concept 4A. Pump in or out (separate pumping stations)

Socio economic

The construction of pump in or out (separate pumping stations) provides the potential for a $35.2 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 71 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $128.7 M contribution to GRP, and a 931 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water discharged into the Southern Ocean, would provide limited impacts to fishing activities. This would be further investigated to confirm prior to construction.

This concept would alter the visual amenity, however noting the 140km extent of the Younghusband Peninsula, these impacts would be spatially, quite limited. There is no consideration of land acquisition noting the alignment falls with the Coorong National Park.

There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse under the jetty will be provided, limiting the long term access restrictions.

Concept 4B. Pump in or out (one common pumping station)

Description
The pump in or out (one common pumping station) option consists of a bidirectional pipe with a single pumping station within the dunes of the Younghusband Peninsula, with the intention that water can be pumped in or out of the Coorong South Lagoon, based on water requirements. On the Coorong side would be an open discharge/intake outlet with 1 fish exclusion screen. The location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). Traversing Younghusband Peninsula will be one 1.6 m diameter pipe, 1.07 km in length. Within Younghusband Peninsula the common pumping station, comprised of a dry well and 4 pumps. At the Southern Ocean end a 200 m x 50 m breakwater containing an open discharge/intake outlet with 1 fish exclusion screen. The intention of the breakwater is to exclude sand from the pipe, whilst being permeable enough to allow the movement of water whilst pumping out or in.   The structure is designed to deliver flow up to 350 ML/d (into or out of the Coorong). This would not be the realised flow yield, due to factors such as water availability and seasonality. Proposed operation is to pump permanently (24 hours per day).   The likely operating duration is 365 days (for both current conditions and climate change conditions), with an intention to pump out from May to September, and fluctuate pump in for 23 days and pump out for 25 days from October to April. This would mean an overall pump out for 265 days and pump in for 100 days each year. These are approximate calculations based on modelling, and actual operating days will depend on factors such as weather conditions or operational protocols.

Figure 15 Visual representation of Concept 4A demonstrating a central pumping station in the Young Husband Peninsula and a breakwater at the Southern Ocean discharge

Image developed by XCS Australia Pty Limited

Concept 4B. Pump in or out (one common pumping station)

Design considerations

General design summary

For this single bi-directional pump option it was determined that the most effective way to do this was to place a pump station within Younghusband Peninsula, with pipework connecting the pump station to both the Southern Ocean and the Coorong South Lagoon whilst managing the reverse flow conditions with valving and pipework.

As there is a single pipe connecting the Southern Ocean to the Coorong South Lagoon and the pump station is required to pump in both directions, each pipe acts as both a discharge pipe and a suction pipe depending on the pumping direction. For this reason, a flooded suction is required at both ends of the pipe to satisfy the net positive suction head requirements of the pumps. This means the pipework must be submerged within both bodies of water, hence a breakwater has been included in the Southern Ocean to reduce the sand intake when this pipe acts as a suction pipe and to facilitate construction in a calmer ocean environment.

To facilitate pumps approximately 3 m below sea level within dunes which are 5 m above sea level requires a pump station about 10 m deep. Preliminary structural design indicates that the pump station walls would be 2.2 m thick and the base slab 2.0 m thick to withstand soil forces and prevent buoyancy.

While pre-cast concrete tetrapod units are proposed for the primary armour of the breakwater, a large quantity of high-quality rock will still be required for the core and toe of the breakwater structure. It is likely the closest available suitable rock source is in Adelaide and procuring it will be challenging. Marine-grade armour stone is typically a low-production product due to the high specifications required and as such requires a significant lead time of up to seven years to source and stockpile prior to construction.

Construction

The KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is not a feasible option due to the size of equipment required, the structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment.

Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day.

The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

Construction of a breakwater using marine plant and equipment does post a safety risk to construction personnel due to the high energy wave climate and should not be contemplated unless very large plant and equipment is used, and such size plant and equipment would not be economical for this project. It is therefore proposed to construct the breakwater using plant and equipment exclusively from land.

A typical breakwater cross section is constructed by first dumping the core material then placing the armour layers. This process will typically require placement in sections to minimise loss of underlayer materials. It is advantageous to allow placed rock to settle before placing additional rock as this will minimise post-construction settlement which may unlock the interlocked rocks and compromise the integrity of the breakwater.

The concrete armour units can be transported to site or cast on site. Either way, it is economically efficient to have a consistent amount of the units ready for placement at the same speed that they are being placed on the breakwater. This reduces the amount of space required for stockpiling the units and reduces the amount of time the units are exposed to the construction environment.

It is envisaged that conventional methods for transporting and laying of the submarine cable may not be appropriate for this location. The lagoon is relatively shallow and access via water is severely restricted. This is likely to result in the cable having to be transported by road to the site (normally completed by ship) and a barge, or vessel with a relatively

Concept 4B. Pump in or out (one common pumping station)

small draught, being used for the cable installation. As barging is likely to be required for construction equipment and transport of construction materials associated with the infrastructure proposed on the peninsula, the barge would serve a dual purpose.

Energy

This option has the lowest power demand of all pumping options because of the low static lift due to the pumps and intakes/discharges being located below sea level. The overall power consumption is also the lowest of all pumping options.

Operations and maintenance

It is expected that the velocity within the pipeline will be sufficient to remove marine growth and maintain hydraulic efficiency.

Normal maintenance of the breakwater structure is expected over the functional design life to maintain the integrity of the structure. Allowable damages up to 5% of the primary armour layer are considered acceptable over the life of the structure.

The structure is considered effective to manage high volumes of sand in suspension within the near-shore zone but the porosity of the structure still allows the movement of bed sands into and out of the structure. Due to the calm conditions inside the breakwater there is a reduced mobilisation of material, leading to accumulation over time. Periodic maintenance of sand within the breakwater will be required to manage the sand accumulation. Maintenance is likely to involve slurry pumping.

An allowance for approximately 50 m of shoreline retreat has been incorporated in the design; however, it is anticipated that periodic management of sand via manual bypassing will also be required, both to minimise erosion impacts, and to maintain a continual movement of sand along the coastline. This could involve movement of accumulated sand via excavators and dump trucks or installation of temporary slurry pumps and pipelines to bypass sand from one side of the breakwater to the other side.

To access the discharge structure within the breakwater for cleaning and maintenance, it is expected that operators will need to travel to the structures on a small water vessel within the breakwater structure and clean the structures from the vessel.

Legislative considerations

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

This option significantly reduced the risk associated with salinity in the CNL and CSL under both the current climate and climate change scenarios, with salinities in both lagoons approaching desired conditions.

This option can reduce the risk posed by nutrients in the CNL and CSL compare with base case, but it was acknowledged the risk associated with nutrient removal would require further design considerations and investigations.

Modelling indicated an increased risk inadequate water levels in the CSL under this concept, however the detrimental ecological impact was assessed marginal and that could be mitigated through operational controls (i.e. pumping would not occur when water levels are too low).

Concept 4B. Pump in or out (one common pumping station)

Consequently, this concept provides potential to improve the health of the Coorong South Lagoon.

Cost estimate

A cost estimate for the construction of the pump in or out (one common pumping station) option is $450M-$500M. Operations and Maintenance is estimated to be $2.5M-$5M/ year (25 years). This preliminary estimate was developed prior to any detailed design being undertaken for this option and is only intended to provide an indication for cost range comparison between options.

First Nations

The pump in or out (one common pumping station) concept was considered to have high impacts to cultural heritage due to its location in the landscape and size of construction impact. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives. The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

The construction of the pump in or out (one common pumping station) concept provides the potential for a $36.3 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 66 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $218.9 M contribution to GRP, and a 1606 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water discharged into the Southern Ocean, would provide limited impacts to fishing activities. This would be further investigated to confirm prior to construction.

This concept would alter the visual amenity, however noting the 140km extent of the Younghusband peninsula, these impacts would be spatially, quite limited. There is no consideration of land acquisition noting the alignment falls with the Coorong National Park.

There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse the pipe structure and breakwater will be provided, limiting the long term access restrictions.

Concept 5A. Circulation (pump in and out) (jetty discharge)

Description

The circulation (pump in and out) (jetty discharge) option consists of two pumping locations, enabling water to be pumped in from the Southern Ocean at the South of the Coorong South Lagoon, and pumped out North of Parnka Point into the Southern Ocean, creating a circulation effect.

The pumping into the Coorong South Lagoon location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). On the Southern Ocean side of this location is a 350 m jetty, 4 vertical turbine pumps, and 3 fish exclusion screens. At the end of the jetty is also a concrete caisson stilling well (20 m x 19.8 m x 16.2 m). Traversing Younghusband Peninsula will be one 1.4 m diameter pipe, 1.1km in length. At the Coorong South Lagoon end will be an open discharge/intake outlet.

The pumping out of the Coorong alignment is located North of Parnka Point. On the Coorong side is a floating pontoon with 4 pumps and 4 fish exclusion screens. Traversing Younghusband Peninsula will be a 1.4 m diameter pipe, 1.2 km in length. At the Southern Ocean end is a 150 m long jetty outfall structure.

The structure is designed to deliver flow up to 350 ML/d (at both locations into or out of the Coorong). This would not be the realised flow yield, due to factors such as water availability and seasonality.

For pumping in, the proposed operation is to pump permanently (24 hours per day). The likely operating duration is 365 days (for both current conditions and climate change conditions). These are approximate calculations based on modelling, and realised operating days will depend on factors such as weather conditions and operational protocols.

For pumping out, the proposed operation is to only pump out when the water level in the Coorong South Lagoon is higher than 0.3 m AHD. The likely operating duration is 222 days (current conditions) or 166 days (under climate change conditions). These are approximate calculations based on modelling, and realised operating days will depend on factors such as weather conditions and operational protocols.

A 9km dredge alignment North of Parnka Point was also considered, improving connectivity of this circulation option. Hydrodynamic modelling has indicated that dredging would not be required to optimise this concept.

Figure 16 Visual representation of Concept 5A demonstrating pumping in to the Coorong South Lagoon (via a 350m jetty) in the south [top], and pumping out of the Coorong South Lagoon in the North with a 150m jetty discharge [bottom].

Image developed by XCS Australia Pty Limited

Concept 5A. Circulation (pump in and out) (jetty discharge)

Design considerations

General design summary

As the proposed location for the Coorong pumps is the western side of the Coorong South Lagoon this requires transporting all the required materials and equipment across the Coorong to Younghusband Peninsula. The benefit of pontoon mounted pumps is that they float and can be towed to the required location with an appropriate vessel, pending Coorong water depths at the time. This reduces the effort and cost required to transport the pumping infrastructure compared to other options such as a jetty system.

Construction

Pump stations (for pumping out of the Coorong (north of Parnka Point)

The construction benefit of pontoon mounted pumps is that they are assembled and delivered as a complete unit. The pontoon is supplied with the required instrumentation and safety features. The only construction required on site is connecting the pontoon pipework to the common discharge manifold that will be installed on the floating walkway supplied with the pontoon mounted pumps, as well as installing guide piles for the pontoons.

Pipelines (for pumping in and out)

For construction of the pipeline, The KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is not feasible due to the size of equipment required, the structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment. Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day.

The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

Jetty construction (350m for pumping in, and 150 for pumping out)

Jetty construction is proposed as "over-the-top" construction only to avoid the use of water vessels in the severe ocean conditions and shallow depths. It is proposed to use a single crawler crane plus a canti-traveller or similar so that construction can commence from the shore and progress out to sea while working above the storm surge and wave heights. A canti-traveller is a purpose-built working platform structure that installs piles into the seabed using an 'over-the-top' cantilevered construction method which is common for constructing typical pile and deck jetty structures. The use of the canti-traveller also eliminates the need to have divers working in the severe ocean conditions.

The 4.5 m wide jetty deck is sized to enable access for the crawler crane back to the land side once constructed. It also provides access for maintenance cranes that may be required to maintain the pumps and components at the head of the jetty structure.

Power supply (for pumping in and out)

Conventional methods for transporting and laying the submarine cable may not be appropriate for this location. The lagoon is relatively shallow and access via water is severely restricted. The cable will likely have to be transported by road to the site (normally completed by ship) and a barge, or vessel with a relatively small draught, will be needed for cable installation. As barging is likely to be required for construction equipment and transport of construction materials associated with the infrastructure proposed on the peninsula, the barge would serve a dual purpose.

Concept 5A. Circulation (pump in and out) (jetty discharge)

Caisson construction (for pumping in)

Construction of the caisson at the jetty head is proposed using pre-cast elements, to be stacked over pile guides. The base of the caisson, which is at approximately -5 mAHD, would require "jetting" in of precast elements approximately 350 m offshore.

Energy

The power demand for each component of this option is similar to that for Option 4A but the overall power consumption is the highest of all options because two pumps are operating; one of them continuously.

Operations and maintenance

It is expected that the velocity within the pipeline will be sufficient to remove marine growth and maintain hydraulic efficiency.

The Coorong pumps are mounted on individual pontoons which are attached to a floating access walkway. A single pontoon or all the pontoons can be readily disconnected from the common discharge manifold and towed to different locations where they can be used for other purposes or disconnected for maintenance if required.

Although fish screens have a self-cleaning mechanism (mechanical scraper/rake) they will require regular maintenance to remove marine growth.

Legislative considerations

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

If the 9km dredge alignment were to proceed, additional approvals would be required for the dredging activities, including a permit to dispose of the additional dredgeate to sea and EPA approvals.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

This concept significantly reduced the risk associated with salinity in the CNL and CSL under both the current climate and climate change scenarios, with salinities in both lagoons approaching desired conditions.

The circulation concept was the most effective at reducing the risk posed by nutrients across the CNL and CSL. It was acknowledged the risk associated with nutrient removal would require further design considerations and investigations.

The risk posed by inadequate water levels in the CSL under this option was equal to that of the base case.

Consequently, this concept provides potential to improve the health of the Coorong South Lagoon, and in particular is the best at reducing the risk of reaching excessive nutrient levels in the system.

Cost estimate

A cost estimate for the construction of circulation (pump in and out) (jetty discharge) option is $500M-$550M. Operations and Maintenance is estimated to be $15M-$17.5M / year (25 years). This preliminary estimate was developed prior to any detailed design being undertaken for this option and is only intended to provide an indication for cost range comparison between options.

First Nations

The Circulation (pump in and out) (jetty discharge) concept was considered to have high impacts to cultural heritage due to its location in the landscape and size of construction impact. This has an increased risk due to the addition of a

Concept 5A. Circulation (pump in and out) (jetty discharge)

second pumping location. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives.

The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

The construction of a Circulation (pump in and out) (jetty discharge) concept provides the potential for a $76.8 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 107 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $222.4 M contribution to GRP, and 1461 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water discharged into the Southern Ocean, would provide limited impacts to fishing activities. This would be further investigated to confirm prior to construction.

This concept would alter the visual amenity, however noting the 140km extent of the Younghusband peninsula, these impacts would be spatially, quite limited. There is no consideration of land acquisition noting the alignment falls with the Coorong National Park.

There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse under the both jetties will be provided, limiting the long term access restrictions.

Concept 5B. Circulation (pump in and out) (low visual impact discharge)

Description

The circulation (pump in and out) (low visual impact discharge) option consists of two pumping locations, enabling water to be pumped in from the Southern Ocean at the South of the Coorong South Lagoon, and pumped out North of Parnka Point into the Southern Ocean, creating a circulation effect.

The pumping into the Coorong South Lagoon location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). On the Southern Ocean side of this location is a 350m jetty, 4 vertical turbine pumps, and 3 fish exclusion screens. At the end of the jetty is also a concrete caisson stilling well (20 m x 19.8 m x 16.2 m). Traversing Younghusband Peninsula will be one 1.4 m diameter pipe, 1.1 km in length. At the Coorong South Lagoon end will be an open discharge/intake outlet.

The pumping out of the Coorong alignment is located North of Parnka Point. On the Coorong side is a floating pontoon with 4 pumps and 4 fish exclusion screens. Traversing Younghusband Peninsula will be a 1.4 m diameter pipe, 1.2 km in length. At the Southern Ocean end is a concrete outfall structure and FlexMat across the intertidal zone.

The structure is designed to deliver flow up to 350 ML/d (at both locations into or out of the Coorong). This would not be the realised flow yield, due to factors such as water availability and seasonality.

For pumping in, the proposed operation is to pump permanently (24 hours per day). The likely operating duration is 365 days (for both current conditions and climate change conditions). These are approximate calculations based on modelling, and realised operating days will depend on factors such as weather conditions and operational protocols.

For pumping out, the proposed operation is to only pump out when the water level in the Coorong South Lagoon is higher than 0.3 m AHD. The likely operating duration is 222 days (current conditions) or 166 days (under climate change conditions). These are approximate calculations based on modelling, and realised operating days will depend on factors such as weather conditions and operational protocols.

A 9km dredge alignment North of Parnka Point was also considered, improving connectivity of this circulation option. Hydrodynamic modelling has indicated that dredging would not be required to optimise this concept.

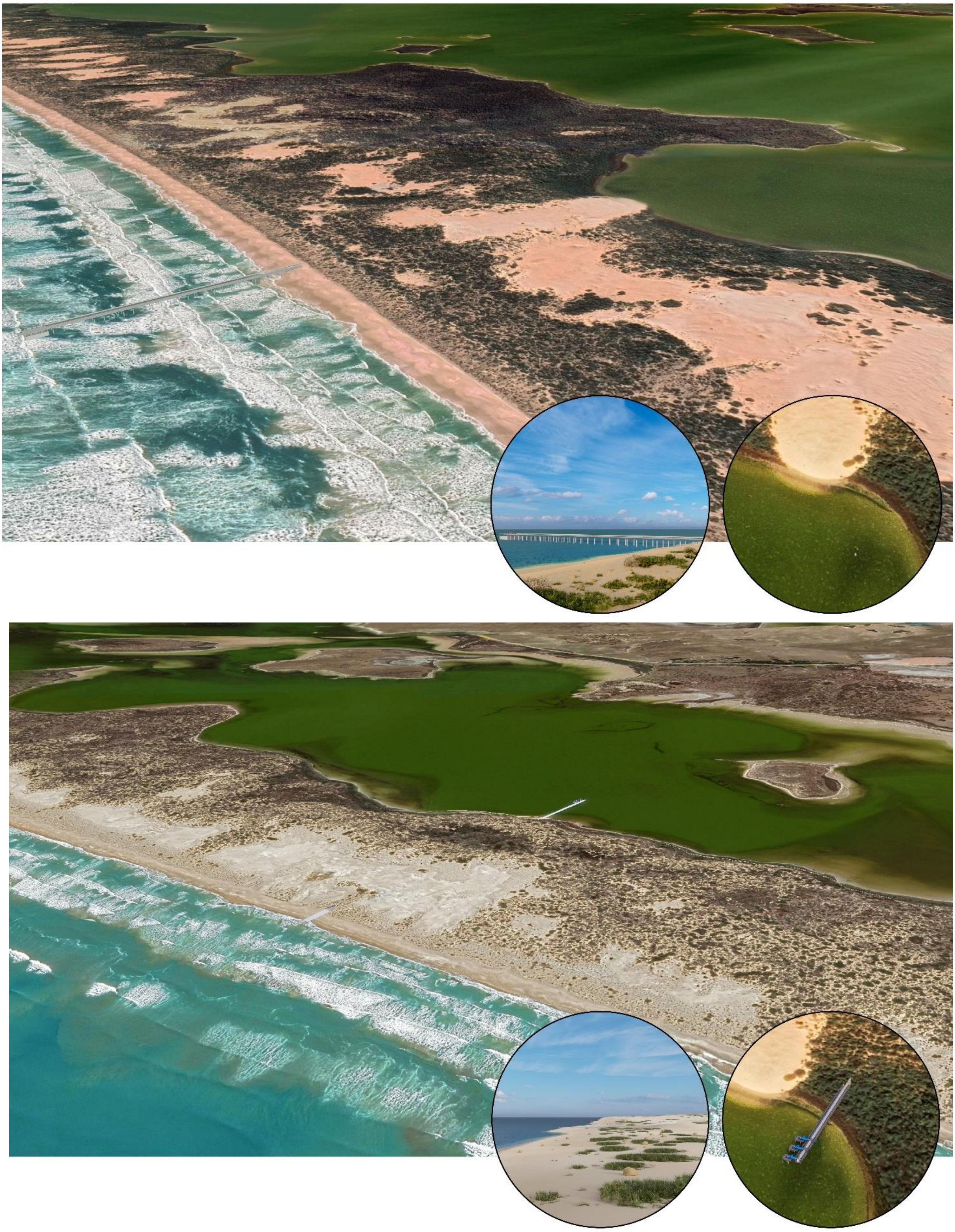

Figure 17 Visual representation of Concept 5B demonstrating pumping in to the Coorong South Lagoon (via a 350m jetty) in the south [top], and pumping out of the Coorong South Lagoon in the North with a low visual impact FlexMat discharge [bottom].

Image developed by XCS Australia Pty Limited

Concept 5B. Circulation (pump in and out) (low visual impact discharge)

Design considerations

General design summary

As the proposed location for the Coorong pumps is the western side of the Coorong South Lagoon this requires transporting all the required materials and equipment across the Coorong to Younghusband Peninsula. The benefit of pontoon mounted pumps is that they float and can be towed to the required location with an appropriate vessel, pending Coorong water depths at the time. This reduces the effort and cost required to transport the pumping infrastructure compared to other options such as a jetty system.

Construction

Pump stations (for pumping out of the Coorong (north of Parnka Point)

The construction benefit of pontoon mounted pumps is that they are assembled and delivered as a complete unit. The pontoon is supplied with the required instrumentation and safety features. The only construction required on site is connecting the pontoon pipework to the common discharge manifold that will be installed on the floating walkway supplied with the pontoon mounted pumps, as well as installing guide piles for the pontoons.

Pipelines (for pumping in and out)

For the pipeline, the KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is not a feasible option due to the size of equipment required, the structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment. Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day.

The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

Jetty construction (350m for pumping in)

Jetty construction is proposed as "over-the-top" construction only to avoid the use of water vessels in the severe ocean conditions and shallow depths. It is proposed to use a single crawler crane plus a canti-traveller or similar so that construction can commence from the shore and progress out to sea while working above the storm surge and wave heights. A canti-traveller is a purpose-built working platform structure that installs piles into the seabed using an 'over-the-top' cantilevered construction method which is common for constructing typical pile and deck jetty structures. The use of the canti-traveller also eliminates the need to have divers working in the severe ocean conditions.

The 4.5 m wide jetty deck is sized to enable access for the crawler crane back to the land side once constructed. It also provides access for maintenance cranes that may be required to maintain the pumps and components at the head of the jetty structure.

Caisson construction (for pumping in)

Construction of the caisson at the jetty head is proposed using pre-cast elements, to be stacked over pile guides. The base of the caisson, which is at approximately -5 mAHD, would require "jetting" in of precast elements approximately 350 m offshore.

Power supply (for pumping in and out)

It is envisaged that conventional methods for transporting and laying of the submarine cable may not be appropriate for this location. The lagoon is relatively shallow and access via water is severely restricted. This is likely to result in the cable having to be transported by road to the site (normally completed by ship) and a barge, or vessel with a relatively small draught, being used for the cable installation. As barging is likely to be required for construction equipment and

Concept 5B. Circulation (pump in and out) (low visual impact discharge)

transport of construction materials associated with the infrastructure proposed on the peninsula, the barge would serve a dual purpose.

Flexmat Discharge (for pumping out of the Coorong South Lagoon)

An advantage of the beach discharge is that it eliminates the need for construction within the Southern Ocean environment, with all works proposed within the beach and intertidal area. Construction would follow conventional civil construction techniques for trenching, either in situ or precast installation of headwalls and aprons and piling equipment required for foundations.

Energy

Because the pump out component discharges to the beach rather than an elevated jetty the power demand is lower than for Option 5A. The overall power consumption is the third highest of all options because two pumps are operating.

Operations and maintenance

It is expected that the velocity within the pipeline will be sufficient to remove marine growth and maintain hydraulic efficiency.

The Coorong pumps are mounted on individual pontoons which are attached to a floating access walkway. A single pontoon or all the pontoons can be readily disconnected from the common discharge manifold and towed to different locations where they can be used for other purposes or disconnected for maintenance if required.

Although fish screens have a self-cleaning mechanism (mechanical scraper/rake) they will require regular maintenance to remove marine growth.

While the beach discharge outfall option offers a lower cost solution for initial construction, it will require frequent inspection and maintenance to ensure the beach conditions remains safe. FlexMat has the benefit of being flexible to conform to the beach during sand movements, but may also be susceptible to movement, erosion or dislodgement during severe storm events. Frequent inspection and closure of the beach may be required for forecast storm events or during discharging to prevent access to the site.

Legislative considerations

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

If the 9km dredge alignment were to proceed, additional approvals would be required for the dredging activities, including a permit to dispose of the additional dredgeate to sea and EPA approvals.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

This concept significantly reduced the risk associated with salinity in the CNL and CSL under both the current climate and climate change scenarios, with salinities in both lagoons approaching desired conditions.

The circulation concept was the most effective at reducing the risk posed by nutrients across the CNL and CSL. However, nutrients still pose significant residual risk to the Coorong ecosystem even under this best performing option.

The risk posed by inadequate water levels in the CSL under this option was equal to that of the base case.

Consequently, this concept provides potential to improve the health of the Coorong South Lagoon, and in particular is the best at reducing the risk of reaching excessive nutrient levels in the system.

Concept 5B. Circulation (pump in and out) (low visual impact discharge)

Cost estimate

A cost estimate for the construction of circulation (pump in and out) (low visual impact discharge) option is $450M-$500M. Operations and Maintenance is estimated to be $10M-$15M / year (25 years). This preliminary estimate was developed prior to any detailed design being undertaken for this option and is only intended to provide an indication for cost range comparison between options.

First Nations

The Circulation (pump in and out) (low visual impact discharge) was considered to have high impacts to cultural heritage due to its location in the landscape and size of construction impact. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives. The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

The construction the circulation (pump in and out) (low visual impact discharge) concept provides the potential for a $76.0 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 103 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $212.7 M contribution to GRP, and 1383 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water discharged into the Southern Ocean, would provide limited impacts to fishing activities. This would be further investigated to confirm prior to construction.

This concept would alter the visual amenity, however noting the 140 km extent of the Younghusband peninsula, these impacts would be spatially, quite limited. There is no consideration of land acquisition noting the alignment falls with the Coorong National Park.

There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse under the jetty will be provided, limited the long term access restrictions.

Concept 6. Passive Southern Ocean Connector

Description

The passive Southern Ocean Connector consists of ten 2 m diameter, 1 km long passive pipes (as such there is no pumping infrastructure for this option). On the Coorong side is the outlet of the pipes, fitted with ten isolation valves, so that the pipes can be closed if necessary (there are no fish exclusion screens noting the absence of pumps). The location is the bay in Younghusband Peninsula opposite Fat Cattle Point (south of Woods Well Road). At the Southern Ocean end is a 240x 160 m breakwater. Contained in the breakwater will be the outlets of the pipes, fitted with ten isolation valves, so that the pipes can be closed if necessary. The intention of the breakwater is to exclude sand from the pipe, whilst being permeable enough to allow the movement of water whilst pumping out or in.

As there would not be any pumps there is no ability to manage the flow yield delivered either into or out of the Coorong, as such it will be variable.

Whether water flows into or out of the Coorong South Lagoon will depend on the difference in water level between the Coorong South Lagoon and Southern Ocean. The likely direction of flow has been calculated 1,620/720 in/out [units] (under current conditions) and 3,760/880 [units] in/out (climate change).

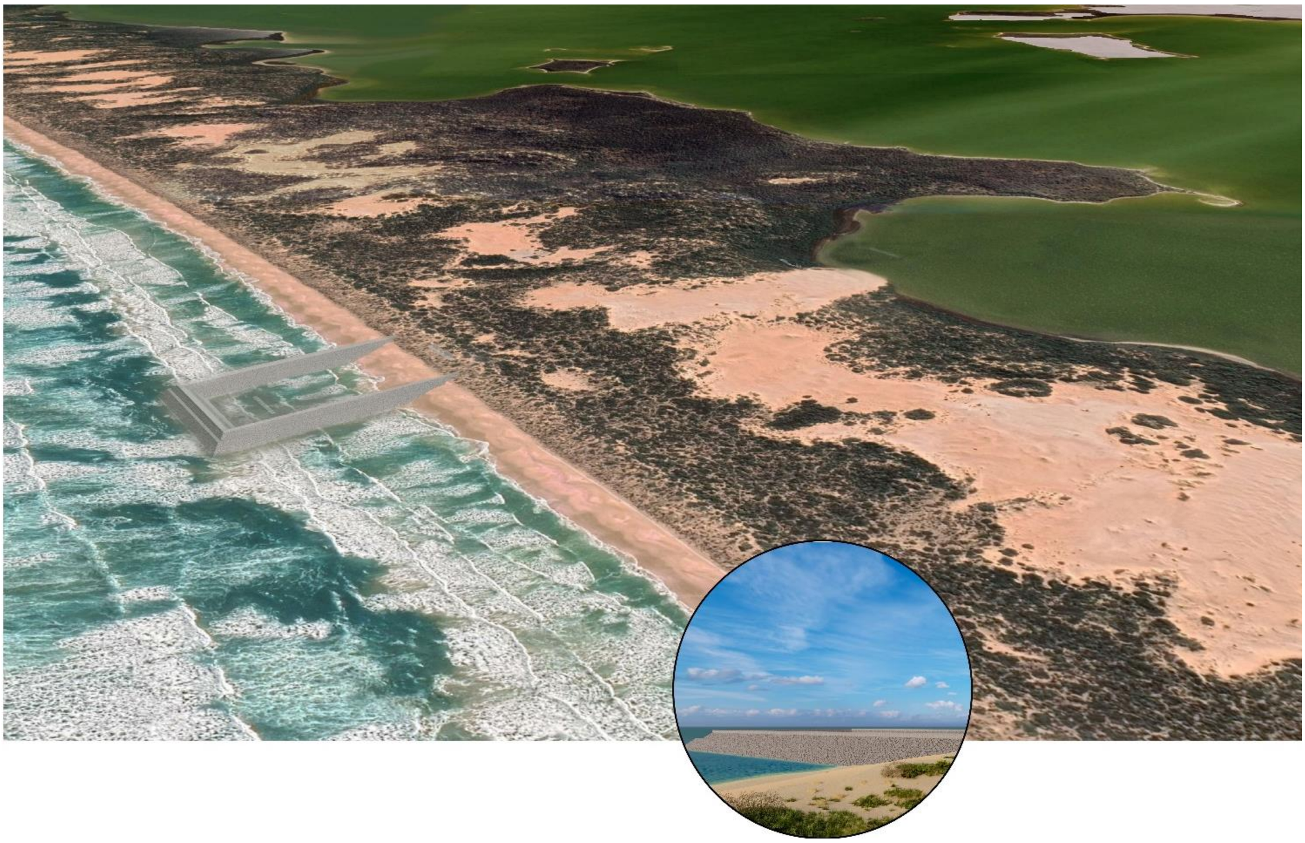

Figure 18 Visual representation of Concept 6 the passive piped connection with a breakwater in the Southern Ocean.

Image developed by XCS Australia Pty Limited

Concept 6. Passive Southern Ocean Connector

Design considerations

General design summary

As there is no pumped flow to frequently scour the pipelines, there is an inherent risk of sand entering the pipelines from the Southern Ocean and building up within the pipelines and reducing their effectiveness to transfer water between the Coorong and the ocean. For this reason, a breakwater has been included in the ocean.

While pre-cast concrete tetrapod units are proposed for the primary armour of the breakwater, a large quantity of high-quality rock will still be required for the core and toe of the breakwater structure. It is likely the closest available suitable rock source is in Adelaide and procuring it will be challenging. Marine-grade armourstone is typically a low-production product due to the high specifications required and as such requires a significant lead time of up to seven years to source and stockpile prior to construction.

The design includes manually operated isolation valves on each pipeline both sides of Younghusband Peninsula. The valves are housed in individual concrete pits.

Construction

The KBR construction partners suggest that tunnel boring through the Younghusband Peninsula dunes and into deeper ocean water to the end of the proposed jetties is unfeasible due to the size of equipment required, the structural stability of the native soil, the presence of groundwater and operating challenges handling the plant and equipment.

Microtunnelling is the preferred method for the Younghusband Peninsula. Microtunnelling can be completed for pipes up to 3000 mm diameter and would require an intermediate jacking station as the maximum jacking length is about 700 m. For the proposed pipes sizes it is estimated that 6 to 9 m of pipe could be laid per day.

The pipelines could be laid by the traditional open trenching method, but because the depth of excavation is up to 8 m the excavation would require battering at 1 (vertical) to 4 (horizontal) and therefore involved significant volumes of material to be removed and replaced after placing the pipes.

The KBR construction partners suggest that constructing a breakwater using marine plant and equipment is very dangerous due to the severe ocean conditions and should not be contemplated unless very large plant and equipment is used, and such size plant and equipment would not be economical for this project. It is therefore proposed to construct the breakwater using plant and equipment exclusively from land.

A typical breakwater cross section is constructed by first dumping the core material then placing the armour layers. This process will typically require placement in sections to minimise loss of underlayer materials. It is advantageous to allow placed rock to settle before placing additional rock as this will minimise post-construction settlement which may unlock the interlocked rocks and compromise the integrity of the breakwater.

The concrete armour units can be transported to site or cast on site. Either way, it is economically efficient to have a consistent amount of the units ready for placement at the same speed that they are being placed on the breakwater. This reduces the amount of space required for stockpiling the units and reduces the amount of time the units are exposed to the construction environment.

Energy

About 2 kW for the system monitoring and communications is required and could be supplied from a small local solar supply with battery backup.

Operations and maintenance

Normal maintenance of the breakwater structure is expected over the functional design life to maintain the integrity of the structure. Allowable damages up to 5% of the primary armour layer are acceptable over the life of the structure.

The structure is considered effective to manage high volumes of sand in suspension within the near-shore zone but the porosity of the structure still allows the movement of bed sands into and out of the structure. Due to the calm conditions inside the breakwater there is a reduced mobilisation of material, leading to accumulation over time. Periodic

Concept 6. Passive Southern Ocean Connector

maintenance of sand within the breakwater will be required to manage the sand accumulation. Maintenance is likely to involve slurry pumping.

As the velocity in the pipelines will be very low, marine growth will become a concern over time. Sand accumulation will also be an issue as the breakwater is porous and allows wave over-topping.

To access the discharge structures in the ocean and the Coorong for cleaning and maintenance, it is expected that operators will need to travel to the structures on a small water vessel to clean the structures from the vessel. The breakwater will provide a suitable environment for vessel-based maintenance.

An allowance for approximately 50 m of shoreline retreat has been incorporated in the design; however, it is anticipated that periodic management of sand via manual bypassing will also be required, both to minimise erosion impacts, and to maintain a continual movement of sand along the coastline. This could involve movement of accumulated sand via excavators and dump trucks or installation of temporary slurry pumps and pipelines to bypass sand from one side of the breakwater to the other side.

Legislative considerations

Legislative approvals that are common across all options are detailed in Table 2. The required approvals are consistent for each of the Coorong South Lagoon – Southern Ocean Connector options, however, the magnitude of investigation, impact and required mitigation would change, subject to the footprint, location and construction timeframe of the relevant option.

Ecological implications

Using our understanding of the desired state of the Coorong, key ecological parameters have been modelled, in order to determine if implementing the infrastructure will help us to reach the desired state of a healthy Coorong.

The passive connection option was the most effective at reducing the risk posed by salinity in the CSL, and also significantly reduced risk in the CNL with salinities in both lagoons approaching desired conditions. This option was effective under both current climate and climate change scenarios.

Bi-directional connection in or out was also one of the best options for reducing risk posed by nutrients to the CNL and CSL. However, it was acknowledged the risk associated with nutrient removal would require further design considerations and investigations.
The risk posed by inadequate water levels in the CSL under this option was equal to that under the base case.

Consequently, this concept provides potential to improve the health of the Coorong South Lagoon, and in particular is the best at reducing the risk of reaching undesired salinity levels in the system.

Cost estimate

A cost estimate for the construction of passive Southern Ocean Connector is $550M-$600M. Operations and Maintenance is estimated to be $2.5M-$5M / year (25 years). This preliminary estimate was developed prior to any detailed design being undertaken for this option and is only intended to provide an indication for cost range comparison between options.

First Nations

The Passive Southern Ocean Connector is considered to have high impacts to cultural heritage due to its location and size of construction impact. The Ngarrindjeri Working Group have been critical in the planning and site selection of the alignments with specific meetings and site visits used to reduce potential risk to cultural heritage. This option specifically was seen to have increased risk due to the size of the construction zones and impacts to the visual amenity.

The initial search of the Aboriginal cultural heritage database highlighted no known sites within the alignment and further cultural heritage survey increased this understanding. IHC were procured by Ngarrindjeri Aboriginal Corporation to facilitate the on ground cultural heritage survey which was attended by Ngarrindjeri representatives.

Concept 6. Passive Southern Ocean Connector

The survey method follows the standard procedure of pedestrian transects with varied spacing of participants dependent on ground surface and visibility. Any sites of significance were recorded and a site avoidance philosophy used to best protect areas of most concern.

The Ngarrindjeri Working Group and the South East Aboriginal Focus Group highlighted the need for the Coorong Ramsar site to be protected. Both groups are keen to work together to get the best cultural outcomes for the site and note that construction in this area needs to be culturally appropriate.

Socio economic

The construction of a passive Southern Ocean Connector connection provides the potential for a $96.9 M contribution to the Coorong Local Government Area (LGA) Gross Regional Product (GRP), with an estimated 72 Full Time Equivalent employment opportunities created. The benefits more broadly for South Australia increase to $276.1 M contribution to GRP, and a 1773 FTE of employment opportunities. These are the benefits only during construction. Long term opportunities for the community arising from ecological improvement have not been quantified in terms of employment or contribution to GDP.

Preliminary modelling suggested that the hypersaline water discharged into the Southern Ocean, would provide limited impacts to fishing activities. This would be further investigated to confirm prior to construction.

This concept would alter the visual amenity, however noting the 140km extent of the Younghusband peninsula, these impacts would be spatially, quite limited. There is no consideration of land acquisition noting the alignment falls with the Coorong National Park.

There will be access restrictions whilst the construction is occurring. Once the infrastructure is constructed an alternate access route that does not traverse the pipe structure and breakwater will be provided, limiting the long term access restrictions.

8. Multi-Criteria Assessment (MCA)

8.1. MCA process

MCA is a method by which problems with multiple desired criteria or considerations can be assessed. It allows qualitative and/or quantitative aspects of the problem to be included in the decision-making process. It is a valuable tool for determining the preferred options from the shortlisted infrastructure options being considered. In the context of the CIIP, this enables us to recommend options that provide the greatest balance across all criteria, from their potential to improve health of the Coorong South Lagoon to their potential benefits to communities including First Nations.

MCA was used early in the CIIP in 2020 to shortlist infrastructure options for feasibility investigations in 2021. This section only discusses the MCA process for further shortlisting recommended options to proceed to the Australian Government for consideration of funding.

CIIP contains several concurrent, complex investigations (such as engineering feasibility, ecological outcomes). Whilst improvement to the health of the Coorong South Lagoon is the primary objective of the project, other criteria must also be taken into account, including the cost-effectiveness of the infrastructure to build, operate and monitor, minimising impacts to environment during construction and operation, and optimising benefits to communities and First Nations.

MCA is based on the principle that if you can source the right information, involve the right decision-makers, stakeholders and reference groups, and ensure that decisions are made by consensus, then the best decision will be reached.

MCA criteria and weightings

The six evaluation criteria were defined, and weighting agreed to following technical input by members of the CIIP Working Group (see section 4.3 for project governance). The agreed criteria assessed as part of this process (and their relative weightings) are:

1. Financial (10%)
2. Constructability and Approvals (10%)
3. Operations and Maintenance (10%)
4. Environmental and Ecological (40%)
5. Social and Economic (10%)
6. First Nations (20%).

The Environmental and Ecological criterion is the most highly weighted, reflecting its importance to the community, as determined in the 2020 YourSAy consultation process and given that the overarching objective of HCHB is to improve the ecological health of the Coorong South Lagoon.

8.1.1. Community input on MCA criteria

The proposed evaluation criteria discussed in the July 2021 community workshops were divided into the below categories each with their own sub-criteria. These will be used to make a comparative evaluation of each infrastructure design option:

- Environment/Ecological
- Financial
- Socio-Economic
- First Nations
- Constructability
- Operations and Maintenance.

We asked the participant groups how well the proposed criteria reflected what matters to their community. Most participants agreed that the criteria reflected the community values “really well”. Not one of the participating groups indicated “not really” or “not at all”.

Every group in all locations identified the Environmental/Ecological criterion as their first priority. Overall, the top 3 criteria identified were:

1. Environmental/Ecological
2. First Nations
3. Constructability.

However, note that 'First Nations' and 'Constructability' were ranked as equally with 'Environment/Ecological' for 3 groups involved in the discussions.

In groups, the participants were asked to evaluate ways the criteria could be strengthened or improved. Suggestions included additional sub-criteria and improvements to the detail of the criteria. This feedback has been adopted.

The final performance criteria for each evaluation criterion are detailed in Table 5.

Table 7 Multi-criteria analysis criteria used (Adapted from MCA Outcomes report **(KBR, 2021e)**)

Evaluation criteria	Performance criteria	Weighting
Financial	Capital cost impact (capital cost assessed as a net present value (NPV) over 25 years)	40%
	Operating cost impact (operating cost assessed as a net present value (NPV) over 25 years, including power & labour)	60%
Constructability & Approvals	Difficulty to construct the infrastructure in the expected environment (e.g. ocean construction, trenchless construction, access requirements, temporary land uses, etc.).	40%
	Difficulty to construct the proposed infrastructure with no significant or long lasting negative environmental impacts (e.g. dredgeate disposal locations, interruption to longshore drift, etc.).	30%
	Difficulty to achieve required approvals to implement the proposed infrastructure (e.g. environmental, legislative, land use / acquisition, First Nations, etc.).	30%
Operations & Maintenance	Difficulty to vary operational parameters of proposed infrastructure to target achievement of project objectives (e.g. flow rates, water level set-points, etc.).	25%
	Difficulty to achieve reliability of the proposed infrastructure considering installation environment, changes in water quality, varying climate conditions, etc.	25%
	Difficulty to safely access, maintain and operate the proposed infrastructure.	40%
	Quantum of greenhouse gas emissions from operation of the proposed infrastructure.	10%
Environmental & Ecological	Opportunity for the proposed infrastructure to improve the ecological character and reduce risk of environmental consequences and/or loss of key ecological values of the Coorong South Lagoon.	75%
	Opportunity for the proposed infrastructure to improve the ecological character and reduce risk of environmental consequences and/or loss of key ecological values of the Coorong North Lagoon.	25%
Social & Economic	Risk that the community does not accept the change in visual amenity associated with the proposed infrastructure.	10%
	Risk that the community does not accept the impact to adjacent landholders associated with the proposed infrastructure (e.g. land acquisition, access restrictions, etc.).	10%
	Risk that the community does not accept the impact to recreational activities associated with the proposed infrastructure (e.g. fishing, four wheel driving, etc.).	20%
	Risk that the proposed infrastructure negatively impacts commercial enterprises currently operating in the region (e.g. Lakes, Coorong and Southern Ocean fisheries, etc.).	40%

	Opportunity for economic growth and financial benefits within the region (e.g. increased employment opportunities, increased economic activity during construction, improved tourism and education opportunities, etc.).	20%
First Nations	Opportunity for the proposed infrastructure to contribute to cultural values of First Nations' lands and waters being healthy and spiritually alive.	50%
	Opportunity for the proposed infrastructure to contribute to building positive relationships between First Nations people and within the community.	16.667%
	Risk that sites of First Nations cultural heritage and significance are negatively impacted through construction or operation of the proposed infrastructure.	16.667%
	Risk that the proposed infrastructure negatively impacts Native Title rights and cultural heritage values.	16.667%

8.2. MCA options evaluation

Scoring process

For each of the six evaluation criteria, a scoring workshop was held. Experts used their expertise and preliminary findings from the feasibility investigations (see Chapter 7) to score each shortlisted infrastructure option from 1 to 10, for each of the performance criteria listed. A rating of 1 represents a high risk, impact or difficulty or low likelihood of positive benefits or outcomes (that is, less favourable) option. A rating of 10 represents a low risk, impact or difficulty, or a high likelihood of positive benefits or outcomes (that is, more favourable) option.

The scoring workshops were held in-person and over Microsoft Teams to allow maximum participation by the reference and stakeholder groups. Over 60 individuals from the following organisations took part:

- Department for Environment and Water (including National Parks and Wildlife Service)
- Environmental Protection Authority
- SA Water
- Engineering consultants
- Members of the community and local government (Coorong Partnership)
- First Nations representatives (Ngarrindjeri Aboriginal Corporation & the First Nations of the South East)
- The University of Adelaide.

The scores for each workshop are detailed in Table 7.

Table 8 Final scores for each multi-analysis criteria (adapted from MCA Outcomes report (KBR, 2021e).

Evaluation criteria	**Weighting (%)**	**1 (1A)**	**2 (1B)**	**3 (1A+2)**	**4 (1B + 3**	**5 (3A)**	**6 (3B)**	***7 (3C + 2)***	**8 (3D + 2)**	**9 (4A)**	**10 (4B)**	**11 (5A)**	**11A (5A-dredge)**	**12 (5B)**	**12A (5B – dredge)**	**13 (6)**
1. Financial																
Capital cost impact (capital cost assessed as a net present value (NPV) over 25 years)	40	9.6	8.7	8.0	7.2	6.6	7.6	*5.9*	6.5	5.2	3.5	1.7	2.4	2.6	2.9	2.0
Operating cost impact (operating cost assessed as a net present value (NPV) over 25 years, including power & labour)	60	9.9	9.5	9.9	9.5	3.7	7.1	*7.0*	7.4	4.2	7.3	1.5	1.5	3.5	3.5	8.1
2. Constructability & Approvals																
Difficulty to construct the infrastructure in the expected environment (e.g. ocean construction, trenchless construction, access requirements, temporary land uses, etc.)	40	8.0	7.0	7.0	6.0	5.0	7.0	*4.0*	6.0	3.5	2.0	2.0	3.0	2.5	3.5	1.0
Difficulty to construct the proposed infrastructure with no significant or long lasting negative environmental impacts (e.g. dredgeate disposal locations, interruption to longshore drift, etc.)	30	6.0	7.0	4.0	5.0	6.0	6.0	*4.0*	4.0	6.0	3.5	2.0	3.0	2.5	3.5	3.0
Difficulty to achieve required approvals to implement the proposed infrastructure (e.g. environmental, legislative, land use / acquisition, First Nations, etc.)	30	4.0	6.0	2.0	4.0	7.0	7.0	*5.0*	5.0	7.0	5.0	3.0	5.0	3.0	5.0	4.0
3. Operations & Maintenance																
Difficulty to vary operational parameters of proposed infrastructure to target achievement of project objectives (e.g. flow rates, water level set-points, etc.)	25	6.0	6.0	6.0	6.0	8.0	8.0	*7.5*	7.5	7.5	7.5	8.5	8.5	8.5	8.5	4.0

Evaluation criteria	Weighting (%)	1 (1A)	2 (1B)	3 (1A+2)	4 (1B + 3	5 (3A)	6 (3B)	*7 (3C + 2)*	8 (3D + 2)	9 (4A)	10 (4B)	11 (5A)	11A (5A-dredge)	12 (5B)	12A (5B – dredge)	13 (6)
Difficulty to achieve reliability of the proposed infrastructure considering installation environment, changes in water quality, varying climate conditions, etc.	25	8.5	7.5	8.5	7.5	6.5	7.0	*6.5*	7.0	5.5	6.5	4.5	4.5	5.0	5.0	6.5
Difficulty to safely access, maintain and operate the proposed infrastructure	40	9.0	5.0	9.0	5.0	5.0	6.0	*5.0*	6.0	4.0	5.0	4.0	4.0	4.5	4.5	2.0
Quantum of greenhouse gas emissions from operation of the proposed infrastructure	10	10	10	10	10	3.0	7.1	*6.8*	7.2	3.9	8.6	1.2	1.2	3.7	3.7	9.9
4. Environmental & Ecological																
Opportunity for the proposed infrastructure to improve the ecological character, and reduce risk of environmental consequences and/or loss of key ecological values of the Coorong South Lagoon	75	4.0	4.0	3.9	3.9	5.5	5.5	*5.8*	5.8	6.0	6.0	6.4	6.4	6.4	6.4	6.3
Opportunity for the proposed infrastructure to improve the ecological character, and reduce risk of environmental consequences and/or loss of key ecological values of the Coorong North Lagoon	25	5.0	5.0	4.8	4.8	5.8	5.8	*6.0*	6.0	5.6	5.6	5.6	5.6	5.6	5.6	5.6
5. Social & Economic																
Risk that the community does not accept the change in visual amenity associated with the proposed infrastructure	10	2.5	4.0	2.5	4.0	4.0	5.5	*2.5*	4.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0
Risk that the community does not accept the impact to adjacent landholders associated with the proposed infrastructure (e.g. land acquisition, access restrictions, etc.)	10	2.5	2.5	2.5	2.5	7.0	7.0	*7.0*	7.0	7.0	7.0	8.5	8.5	8.5	8.5	8.5

Evaluation criteria	Weighting (%)	1 (1A)	2 (1B)	3 (1A+2)	4 (1B + 3	5 (3A)	6 (3B)	*7 (3C + 2)*	8 (3D + 2)	9 (4A)	10 (4B)	11 (5A)	11A (5A-dredge)	12 (5B)	12A (5B – dredge)	13 (6)
Risk that the community does not accept the impact to recreational activities associated with the proposed infrastructure (e.g. fishing, four wheel driving, etc.)	20	4.0	4.0	5.5	5.5	4.0	5.5	*4.0*	5.5	4.0	2.5	4.0	2.5	4.0	2.5	4.0
Risk that the proposed infrastructure negatively impacts commercial enterprises currently operating in the region (e.g. Lakes, Coorong and Southern Ocean fisheries, etc.)	40	2.5	2.5	2.5	2.5	7.0	7.0	*5.5*	5.5	7.0	4.0	5.5	5.5	4.0	4.0	4.0
Opportunity for economic growth and financial benefits within the region (e.g. increased employment opportunities, increased economic activity during construction, improved tourism and education opportunities, etc.)	20	5.5	5.5	7.0	7.0	7.0	8.5	*7.0*	8.5	8.5	7.0	7.0	7.0	7.0	7.0	7.0
6. First Nations																
Opportunity for the proposed infrastructure to contribute to cultural values of First Nations' lands and waters being healthy and spiritually alive	50	4.0	4.5	5.0	5.5	4.5	4.5	*5.0*	5.0	6.0	4.0	4.0	4.5	4.0	4.5	3.0
Opportunity for the proposed infrastructure to contribute to building positive relationships between First Nations people and within the community	16.667	3.5	4.5	4.0	5.0	5.0	4.5	*5.5*	5.0	5.5	3.5	5.0	4.5	4.5	4.0	2.5
Risk that sites of First Nations' cultural heritage and significance are negatively impacted through construction or operation of the proposed infrastructure	16.667	4.0	5.0	3.5	4.5	3.5	3.5	*3.0*	3.0	3.5	2.0	1.0	1.5	1.0	1.5	1.0
Risk that the proposed infrastructure negatively impacts Native Title rights and cultural heritage values	16.667	4.0	6.0	4.5	6.5	4.0	4.0	*4.5*	4.5	4.0	3.5	3.5	3.0	3.5	3.0	2.0

Evaluation criteria	Weighting (%)	1 (1A)	2 (1B)	3 (1A+2)	4 (1B + 3	5 (3A)	6 (3B)	*7 (3C + 2)*	8 (3D + 2)	9 (4A)	10 (4B)	11 (5A)	11A (5A-dredge)	12 (5B)	12A (5B – dredge)	13 (6)
SUM OF RAW RATINGS		**112**	**114**	**110**	**112**	**108**	**124**	***108***	**117**	**107**	**95**	**80**	**83**	**85**	**88**	**86**
SUM OF WEIGHTED RATINGS		**36**	**35**	**35**	**34**	**33**	**38**	***33***	**35**	**33**	**29**	**24**	**26**	**26**	**27**	**26**

8.3. Sensitivity testing

The purpose of sensitivity testing was to determine whether there would be a marked difference if the weightings used in the analysis were changed. The results of the MCA were analysed under alternative weightings to gain a sense of how robust the MCA findings were. The final MCA weightings were not changed from those in Table 8; this exercise was simply to see if things would change dramatically if the weightings were different. The sensitivity tests were:

- Analysis 1 - Financial – increase in weighting from 10% to 40% (+ 30%)
- Analysis 2 - Constructability & Approvals – Increase in weighting from 10% to 40% (+ 30%)
- Analysis 3 - Operations & Maintenance – Increase in weighting from 10% to 40% (+ 30%)
- Analysis 4 - Environmental & Ecological – Reduction in weighting from 40% to 0% (- 40%)
- Analysis 5 - Social & Economic – Increase in weighting from 10% to 40% (+ 30%)
- Analysis 6 - First Nations – Increase in weighting from 20% to 50% (+ 30%)
- Analysis 7 - Environmental & Ecological – Increase in weighting from 40% to 55% (+ 15%)
- Analysis 8 - All criteria – Application of an equal weighting across all criteria (16.667% each).

The findings of the sensitivity analysis reinforce that the rankings of concepts do not change significantly when weightings are altered. This reinforces the robustness of the process.

8.4. Evaluation outcomes

The top concepts following the MCA process, ranked by the weighted assessment and reinforced by the sensitivity analysis are as follows:

- **Pump out (low visual impact discharge)** (MCA description 3B: Intermittent pumped connection out of Coorong South Lagoon – low visual impact discharge structure – most preferred)
- **Pump out (low visual impact discharge) + dredge Parnka Point** (MCA description 3D+2: Pumped connection out of Coorong South Lagoon (low visual impact discharge structure) + Dredge Parnka Point
- **Pump in or out (separate pumping stations)** (MCA description 4A: Bi-directional pumped Southern Ocean connection – one location, separate pumping stations, pump in location with caisson structure)
- **Pump out (jetty discharge) + dredge Parnka Point** (MCA description 3C+2: Pumped connection out of Coorong South Lagoon – near-shore discharge structure + Dredge Parnka Point).

This list does not represent the final ranking of preferred options that will proceed to business case. The MCA rankings need to be interpreted in conjunction with the findings of the feasibility investigations, and the outcomes of the February 2022 community consultation prior to a final decision on the concepts proceeding to business case being finalised.

9. Summary of Findings

9.1. Key Findings

All concepts explored provide an ecological improvement from the base case (or status quo). To determine a preferred concept, points of differentiation come down to the extent of improvement that each concept offers, varying constructability considerations and thus risks to environment and cultural heritage, and subsequent financial implications. Table 8 summarises the key findings for each option, with further detail explored below the table.

Table 9 Summary of key findings for each concept under feasibility investigation

<table>
<tr><th>Concept</th><th>Traffic light</th><th>Key finding</th></tr>
<tr><td>Passive Lake Albert connector channel</td><td>🔴</td><td rowspan="4">Benefits
Reduced salinity risks in the North and South Lagoons under current climate conditions (but salinity risks not alleviated under climate change conditions).
Additional considerations
Risks to the ecosystem posed by inadequate water levels in the South Lagoon was equal to a no-build scenario, but the LAC and dredging options increased risk under current conditions.
The risk posed by nutrients to the ecosystem in both the North and South Lagoons was not reduced under any LAC option.
The potential for greater system connectivity under dredging options is enhanced under conditions when infrastructure is non-operational.
The dredging alignment coincides with some of the most extensive habitat for aquatic plants, waterfowl and shorebirds in the Coorong, and direct and in-direct impacts to these aquatic flora and fauna during operations may arise.</td></tr>
<tr><td>Passive piped Lake Albert Connector</td><td>🔴</td></tr>
<tr><td>Passive Lake Albert connector channel + dredge Parnka Point</td><td>🔴</td></tr>
<tr><td>Passive piped Lake Albert Connector + dredge Parnka Point</td><td>🔴</td></tr>
<tr><td>Pump out (jetty discharge)</td><td>🟢</td><td rowspan="2">Benefits
Benefits to the ecosystem through reduced risk associated with salinity in the North and South Lagoons under both current climate and climate change scenarios.
Marginal reduction in the risk posed by nutrients in the North and South Lagoons.
Additional considerations
No change in the risk associated with inadequate water levels in the Coorong South Lagoon.
A managed pumping regime is needed to avoid an increase in risk of water levels dropping at critical time periods for the ecosystem (e.g. when pumping out water in summer).
Construction for a low visual impact concept would not proceed into the surf zone as far as a jetty (150m) would.</td></tr>
<tr><td>Pump out (low visual impact discharge)</td><td>🟢</td></tr>
<tr><td>Pump out (jetty discharge) + dredge Parnka Point</td><td>🟢</td><td rowspan="2">Benefits
Benefits to the ecosystem through reduced risk associated with salinity in the North and South Lagoons under both current climate and climate change scenarios.</td></tr>
<tr><td>Pump out (low visual impact discharge) + dredge Parnka Point</td><td>🟢</td></tr>
</table>

<table>
<tr><th></th><th></th><th></th></tr>
<tr><td></td><td></td><td>One of the best options for reducing risk posed by nutrients to the North and South Lagoons through ongoing flushing associated with greater system connectivity.
Additional considerations
The risk posed by inadequate water levels in the South Lagoon increased under this option. A managed pumping regime would mitigate this adverse impact.
The potential for greater system connectivity is enhanced under conditions when infrastructure is non-operational.
The dredging alignment coincides with some of the most extensive habitat for aquatic plants, waterfowl and shorebirds in the Coorong, and direct and in-direct impacts to these aquatic flora and fauna during operations may arise.
Greater connectivity is beneficial for boat access.</td></tr>
<tr><td>Pump in or out (separate pumping stations)</td><td></td><td>Benefits
Third highest ranked option for reducing the overall risk posed to the Coorong ecosystem.
This option was effective at reducing the risk posed by salinity and nutrients in the North and South Lagoons.
Pumping water from the Southern Ocean to the Coorong South Lagoon would provide a water source in addition to River Murray flows. This provides water managers with an additional management lever to manage the system.
Additional considerations
This option slightly increased the risk associated with inadequate water levels in the South Lagoon. A managed pumping regime would likely avoid or mitigate this adverse impact.</td></tr>
<tr><td>Pump in or out (one common pumping station)</td><td></td><td>Benefits
Ecological evaluation of this option is the same for Pump in or out (separate pumping stations) and therefore it was the third highest ranked option.
Additional considerations
Breakwaters are designed at a height where they could be overtopped by waves. This poses significant safety risks to the public and operations and maintenance staff access.</td></tr>
<tr><td>Circulation (pump in and out) (jetty discharge)</td><td></td><td rowspan="2">Benefits
Highest ranked option for reducing the overall risk posed to the Coorong ecosystem.
This option significantly reduced the risk posed by salinity and nutrients in the North and South Lagoons, and was not associated with any change in the risk to South Lagoon water levels.
Additional considerations
Two separate alignments (one for pumping in at the Coorong South Lagoon and the other pumping in North of Parnka Point) provide greater risks to impacts on the Younghusband Peninsula (vegetation impact and Cultural Heritage) during construction.</td></tr>
<tr><td>Circulation (pump in and out) (low visual impact discharge)</td><td></td></tr>
</table>

		• 22 hectares of vegetation clearance would be needed compared with 11 hectares for single pipe concepts.
Passive Southern Ocean Connector	🔴	**Benefits** • Second highest ranked option for reducing the overall risk posed to the Coorong ecosystem. • This option was effective at reducing the risk posed by salinity and nutrients in the North and South Lagoons, and was not associated with any change in the risk to South Lagoon water levels. **Additional considerations** • Breakwaters are designed at a height where they could be overtopped by waves. This poses significant safety risks to the public and operations and maintenance staff access.

🔴 Limitations to feasibility (that cannot be resolved with design improvements)

🟡 Limitations to feasibility (that can be resolved with design improvements)

🟢 Feasible option that may improve the health of the Coorong South Lagoon

The Lake Albert Connector concepts demonstrate no improvement to salinity in the Coorong South Lagoon under climate change. Importantly, the Lake Albert Connector concepts are the only concepts that fail to keep salinity under 100g/L when conditions of the Millennium Drought are simulated, reinforcing the limited improvements that can be made to salinity under this infrastructure. There is also no improvement from a Lake Albert Connector to nutrient levels in the Coorong South Lagoon or North Lagoon compared to the base case. Combining dredging with a Lake Albert Connector concept (concept 1A +2, & 1B + 2) does not improve the ecological outcomes.

The Lake Albert Connector concepts pose the fewest risks to environmental impact and cultural heritage during both construction and operations. This is primarily because this infrastructure would be located on private farmland, not the Younghusband Peninsula in the Coorong National Park (as for the Coorong South Lagoon – Southern Ocean Connector concepts). Despite these advantages, the Lake Albert Connector concepts are limited in their contribution to the primary objective relative to other options of the project: to improve the health of the Coorong South Lagoon.

Key Finding 1: The Lake Albert Connector option (with or without dredging) does not provide ecological improvements to the health of the Coorong South Lagoon to the same extent as the Coorong South Lagoon – Southern Ocean Connector options. It was also found that the Lake Albert Connector concepts are the only concepts that fail to keep salinity under 100g/L when conditions of the Millennium Drought are simulated, and also fail to reduce the risk associated with the nutrient conditions in the Coorong ecosystem.

Each Coorong South Lagoon – Southern Ocean Connector concept provides ecological improvements. While there are some risks of reaching worse water level outcomes for pumping out options, the risks can be mitigated by operating procedures.

Key Finding 2: Pumping water out of the Coorong South Lagoon is the most effective way of improving and maintaining desired salinity and nutrient concentrations. Pumping out of the Coorong South Lagoon can be achieved through different discharge structure options (i.e. jetty, breakwater or low visual impact FlexMat).

Ecological risk can be mitigated by operating plans, so the points of separation between each of the Coorong South Lagoon – Southern Ocean connector concepts are non-ecological factors such as location of infrastructure alignment, constructability, risks to environment (that is, dune damage during construction, operations and maintenance), cultural heritage, impacts to the community (that is, access restrictions and impacts to commercial enterprises) and difficulty to operate, maintain and monitor.

Concepts including a breakwater (that is, pump in or out (one common pumping station) (concept 4B), and passive Southern Ocean Connector (concept 6)) are not preferred due to the difficulty in construction. There would be a 5 to 8-year lag for procurement of rock, and each rock would have to be transported (likely from Marino, near Adelaide), raising costs. Plus, there would be a long-term impact to the Younghusband Peninsula dune system - both for the environment and cultural heritage. The breakwaters would be constructed at a height where they could be overtopped by waves (while the jetties under consideration are not), posing risks to public access and operations and maintenance staff access. The passive Southern Ocean Connector provided the greatest ecological improvement due to having the greatest impact on Coorong South Lagoon salinity under current conditions and improvement to nutrients. But this benefit is marginal and not observed under future climate conditions. Despite the expected ecological improvement, the difficulties in constructability and cost of construction mean that the passive Southern Ocean Connector option is not preferred

Concepts with alignments at 2 locations (that is, the circulation options – concepts 5A & 5B) involve two separate alignments (one for pumping in at the Coorong South Lagoon and one pumping out north of Parnka Point) provide greater risks to impacts on the Younghusband Peninsula (both for the vegetation impact and cultural heritage) during construction. The circulation option provides the greatest ecological improvement, with the best performance for managing Coorong South Lagoon nutrient levels during operation. The constructability difficulties and subsequent cost will be weighed against the ecological improvement for concepts including two separate pipe locations.

After discontinuing the 4 Coorong South Lagoon – Southern Ocean Connector concepts above, the remaining options are pumping out (all discharge concepts with or without dredging) and pumping in or out (jetty discharge). These concepts also reflect the top scoring concepts of the MCA.

Pumping in or out (jetty discharge) (concept 4A) is differentiated from the remaining preferred concepts (all pump out concepts) because it provides the flexibility to pump in. The pump out options, and pump in or out (bidirectional) options are on the same alignment across the Younghusband Peninsula, so there will be comparable constructability risks (both for the environment and cultural heritage), and comparable regional benefits for employment and contributions to Gross Regional Product during construction. With the likely reduction in flows to the Coorong under future climate scenarios there is merit in considering a water source that can support the flushing needed for salinity and nutrient reductions.

Key Finding 3: Pumping into Coorong South Lagoon from the Southern Ocean would provide a water source in addition to flows down the River Murray, and provide water managers with an additional management lever with which to manage the system. This water would be in addition to water for the environment returned and delivered under the Murray-Darling Basin Plan.

Should pumping in or out (jetty discharge) (concept 4A) not proceed as a preferred concept, this would leave only the pumping out options (concepts 3A, 3B, 3C, 3D), which are differentiated by the discharge options (low visual impact concrete FlexMat or jetty) and whether or not to dredge. The ecological implications for these options are considered equal since residual risks are only marginally different and of less relevance when considering modelling and analysis uncertainty. The low visual impact options would provide the least impact to visual amenity. Construction would not proceed into the surf zone as far as jetty construction would. If pumping in or out (jetty discharge) does not proceed as a preferred concept, it is recommended that the discharge structure be the low visual impact FlexMat.

The proposed dredging alignment would take approximately 2 years to complete. There is an opportunity to conduct dredging at any time during the construction or it could be phased in following a couple of years of pumping (so as not to let poor quality water from the Coorong South Lagoon into the Coorong North Lagoon). This could provide hydraulic connectivity that supports improvements delivered to the system under pumping. Advantages in addition to the potential improvement to nutrients include improved connectivity, potentially enhancing commercial and recreational boat access. Note that dredging alone has not yet been considered and therefore modelled in conjunction with pumping in or out (jetty discharge). If this concept were to proceed, further modelling investigations and concept refinement would need to occur.

Key Finding 4: Dredging on its own will not deliver sufficient ecological restoration benefits, but in conjunction with other options can improve connectivity and boat accessibility between the Coorong North and South lagoons.

Ultimately, any of the proposed concepts have potential to improve the health of the Coorong South Lagoon. There is an opportunity to proceed with a preferred option that not only improves the health of the lagoon, but also minimises impacts to the environment and cultural heritage, while optimising benefits to the community through minimal access restrictions and employment opportunities (beyond any benefits realised to the local community, simply through having a healthy ecosystem).

Following the 4 findings above would take us to a concept that optimises environmental, social and financial considerations, and therefore provide benefits to the broader Coorong system.

10. Consultation

During February 2022, a draft of this Feasibility Assessment Report was released for feedback from community, First Nations and stakeholders to:

- inform the community about the outcomes of the feasibility investigations
- help deepen understanding of the options being investigated, including their impacts and benefits
- understand which options the community is prepared to accept
- understand which issues still need to be resolved for the community
- inform the community of the ways that they can continue to contribute to the process.

Consultation and community input occurred through a number of mechanisms:

- Two webinars provided the opportunity to outline key investigations and findings to community. The webinars were recorded with recordings available online, and questions asked by community collated into a frequently asked questions document.
- Four online open house sessions were held and provided community with the opportunity to have one on one conversations with experts, to better understand and provide feedback on infrastructure options. Attendees to these open house sessions were provided entry and exit polls to understand how their understanding and acceptance of proposed infrastructure may have changed as a result of engaging with experts.
- An online survey was also made available over 4 weeks in February 2022 in order to allow community to provide further input.
- Submissions were received via the projectcoorong@sa.gov.au email address.

10.1 Consultation Summary

Common themes of feedback received via the consultation sessions, the survey and written submissions included:

- A strong message about action. People want a solution delivered, not just talked about. While most people expressed this view, some were still not confident that all options had been fully investigated and wanted preferred options subjected to a more detailed assessment.
- There was concern about the Lake Albert options, mainly due to the (un)reliability of Murray-Darling Basin system flows, both now and into the future.
- There was a general preference for options/structures which are the less intrusive (visually, size/scale, noise), and have minimal environmental impact, especially on birdlife.
- Although the community see the benefit of leveraging the Southern Ocean to improve the Coorong South Lagoon, there was concern about the potential impact that pumping hypersaline and/or nutrient rich water (or dredgeate) may have on the nearshore ocean environment, including the Pipi and Southern Rock Lobster fisheries. There is some sentiment in the community that they would like more investigations into any possible negative environmental impacts. (*Note: Further investigation of potential environmental impacts has always been scheduled to occur during the next stage of the project and will form a critical component of any future decision making process*).
- There was support to minimise ongoing operational funding requirements. People supported passive options based on the perception that they would cost less to construct and operate. (*Note: The feasibility investigations have clearly indicated that passive options are a higher cost*).
- Whilst there was recognition that First Nations have been closely engaged throughout the investigations, there is interest from community to hear more from First Nations about their views and perspectives.

There is a consensus that the community understand that there is a need to take action to improve the health of the Southern Lagoon and the wider Coorong and its surrounding marine environments.

11. Recommendations

The *Healthy Coorong, Healthy Basin (HCHB*) Coorong Infrastructure Investigations Project (CIIP) is exploring long-term opportunities for operational infrastructure to improve the ecological health of the Coorong.

This Coorong Infrastructure Investigations Project Feasibility Assessment Report summarises a range of technical and consultative investigations into a variety of infrastructure options, synthesising these through a multi-criteria analysis, to inform an overall assessment of feasibility.

Whilst all 13 concepts investigated have been optimised in their design to provide ecological improvements to the Coorong, many of the options have limitations. In assessing feasibility, differentiation comes down to the extent of ecological improvement that each concept offers, their varying constructability considerations and the risks to environment and cultural heritage.

It is recommended that Lake Albert Connector variations are discontinued from further consideration, as these concepts do not provided sufficient ecological improvement.

Additionally, it is recommended that concepts that contain a breakwater (bidirectional with separate pumping stations and a passive Southern ocean connector) be discontinued from further investigation, noting the feasibility challenges of constructing a breakwater and the safety risks posed by this structure being overtopped by waves.

This Feasibility Assessment Report has therefore identified feasibility potential of the following options for improving the health of the Coorong:

- Pump out (multiple discharge options)
- Bidirectional (separate pumping stations)
- Circulation (multiple discharge options)
- Dredging, in conjunction with the above options

These feasible infrastructure options will be considered by the South Australian Government to determine the most appropriate next steps.

Should a decision be made to progress a specific option or options, a Business Case may be developed to support further investigation, detailed design and environmental impact assessment.

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