Engineering Feasibility of Potential Management Actions, Lake Albert and Narrung Narrows

ENGINEERING FEASIBILITY REVIEW

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SINCLAIR KNIGHT MERZ

Engineering Feasibility of Potential Management Actions, Lake Albert and Narrung Narrows

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Executive Summary

The South Australian Lower River Murray region, its communities and the water resources are vital to the sustainable long term survival of the state. The region's assets – its people, infrastructure, industry and environment - and the diverse cultural, environmental, and social values of the region have been impacted by significant threats and drivers of change such as climate change and drought.

Lake Alexandrina and Lake Albert experienced unprecedented conditions during the drought which saw significant pressure and threats posed to the environment and surrounding communities. These conditions resulted in lowering water levels, reduced freshwater inflows from upstream and reduced connectivity with the sea which ultimately led to risks associated with exposed acid sulfate soils, reduced water quality, increased salinity levels, threats to sensitive ecosystems and widespread social, cultural and economic impacts.

As part of the Coorong Lower Lakes and Murray Mouth Long Term Plan, The Department of Environment, Water and Natural Resources (DEWNR) has committed to, and commenced, a twelve month scoping study to explore the most suitable and feasible future management actions to address the recognised threats. The focus of the scoping study is to examine options for sustaining the water quality and the ecological health of Lake Albert and the Narrung Narrows. The results of the study will ultimately recommend feasible strategies for the long-term management of this region.

A key component of the study focusses on the engineering feasibility assessment of potential management actions and concepts including those listed in the Meningie Narrung Lakes Irrigators Association five point plans, which include:

- Dredging of the Narrung Narrows
- Removal or Partial Removal of the Narrung Causeway
- Modification of the Narrung Causeway
- Construction of a Coorong Connector; and
- Construction of a permanent regulating structure in the Narrung Narrows

This report outlines the tasks undertaken as part of the engineering feasibility assessment which was progressed in parallel with water quality modelling by BMT WBM (commissioned by DEWNR) in order to identify a preferred engineering solution and provide a concept design and associated cost estimate. This report does not include the outcomes from the water quality modelling other than discussing the preferred management action based on modelling outcomes for concept design development following consultation with DEWNR.

1. Introduction

1.1 Background

On 2 April 2013, DEWNR engaged Sinclair Knight Merz (SKM) to undertake a two part engineering feasibility study of potential management actions in relation to managing water quality in Lake Albert and the Narrung Narrows comprising of the following tasks:

- Part 1: Engineering Feasibility Review
- Part 2: Concept Design and Costing of the preferred management action

The potential management actions that were considered in the engineering feasibility assessment are as follows:

- Dredging of the Narrung Narrows
- Permanent regulator at the inlet to the Narrung Narrows
- Removal or partial removal of the Narrung Narrows Causeway
- Modification of the Narrung Narrows Causeway
- Coorong Connector alignment 1 (pipe and channel)
- Coorong Connector alignment 2 (pipe and channel)
- Coorong Connector alignment 3 (pipe and channel)

Refer to Figure 1 for indicative Coorong Connector alignment locations.

These options have been considered in the past to varying degrees, each presenting their own risks, benefits, and complexities. This Engineering Feasibility Review aims to provide DEWNR with a greater understanding of each of the potential management actions from an engineering feasibility perspective.

It should be noted that lake cycling has been identified as a viable management action during the modelling phase of the project (by others), however has been excluded from the Engineering Feasibility Study as it does not require any additional infrastructure.

1.1.1 Review

SKM internally reviewed the management actions provided in the project brief along with the additional actions discussed in the *Lake Albert Scoping Study Literature Review* (March 2013). After considering the positives and negatives associated with each action or combination of actions, SKM provided an option review on 23 April 2013 to further the modelling being undertaken by WBM. See Section 1.2 for an overview of the review.

1.1.2 Multi Criteria Analysis

Following the internal review a draft Multi Criteria Analysis (MCA) framework was developed in consultation with DEWNR with which to assess the potential management actions via a quantitative MCA analysis. This was submitted for stakeholder comment on 6 May 2013 and subsequently finalised following stakeholder feedback.

Due to the absence of results for salinity modelling at the time of the MCA, it was agreed with DEWNR that a qualitative analysis would be undertaken in lieu of the quantitative analysis. A qualitative analysis was then undertaken for each management action against the approved criteria, with the final qualitative MCA assessment submitted 10 July 2013 (Appendix E). Further details of the MCA are discussed in Section 2.

1.1.3 Conceptual Level Design

In order to progress the water quality modelling undertaken by BMT WBM, conceptual level designs were produced for the Coorong Connector and the permanent regulating structure at the inlet to the Narrung Narrows. Preliminary channel and pipe sizing was undertaken for the Coorong Connector alignments 1, 2 and 3. The sizing was based on achieving an agreed daily transfer volume of 1 GL from Lake Albert to the Coorong, as confirmed at a meeting between SKM and DEWNR on 15 May 2013. The driving head used in the models was based on a review of historical data. Refer to Section 3 for more information regarding the conceptual design.

1.1.4 Field Investigation

SKM were engaged by DEWNR on 1 August 2013 as part of a separate scope of works to undertake a range of field investigations including an environmental, geotechnical, Acid Sulfate Soil (ASS) and survey assessment for two proposed locations at the southern end of Lake Albert and the inlet to the Narrung Narrows. This investigation is discussed briefly in Section 4 and is detailed in a separate report titled *Lake Albert & Narrung Narrows Field Investigation Report: FINAL* (SKM, 27 November 2013). The study obtained site specific information that was utilised in the concept design and cost estimate development.

1.1.5 Concept Design and Cost Estimate

Following the outcomes from the water quality modelling, the preferred management action identified by DEWNR for concept design and cost estimate development was the Coorong Connector. A concept design and engineering cost estimate of the selected management action was undertaken to a level suitable for the development of a future business case. Details on the concept design can be found in Section 5.

In addition, SKM developed a high level budgetary cost estimate for dredging and disposing of 6 million cubic meters of material from the Narrung Narrows following BMT WBM modelling outputs of this option. The estimate was based on recent experience with similar dredging activities. This is further discussed in Section 5.

During a meeting with DEWNR on 26 September 2013 it was agreed to develop the concept design of the preferred management action to 30% (+/-) confidence in lieu of the 50% (+/-) indicated in SKM's proposal (Part 1) due to the availability of new site specific field data which would enable more accuracy in the estimate.

1.2 Historical Document Review

SKM undertook an internal review of the management actions provided in the project brief along with the additional actions discussed in the *Lake Albert Scoping Study Literature Review* (March 2013) to provide inputs to the development of the concept design. This included considering combinations and variations of management actions.

Following a review of the historical documentation a summary spreadsheet was developed outlining the historical cost estimates and benefits including salinity reduction in Appendix D. SKM undertook an engineering based review of each identified management action addressing the advantages and disadvantages of each management action or combination of actions with which to identify those worthy of progressing for water quality modelling. The following management actions were recommended for further modelling:

1. Dredging of Narrung Narrows in combination with a Coorong Connector (pipe or channel) at location 2 or 3 – targeted dredging at flow restrictions in the Narrung Narrows

2. Coorong Connector (pipe at location 2)

3. Coorong Connector (pipe at location 3)

4. Coorong Connector (channel at location 2)

5. Coorong Connector (channel at location 3)
6. Variations of water levels in Lake Albert and Lake Alexandrina as discussed in the *Lake Albert Scoping Study Literature Review.*

It should be noted that for the Coorong Connector options, three possible locations were considered, however only two were suggested for further investigation. Locations 2 and 3 for the Coorong Connector options are indicatively shown below (Figure 1). Location 2 represents the approximate location of the northern connector identified by DEWNR on 28 March 2013 and location 3 broadly represents the channel alignment investigated by URS in 2006. Location 1 was discounted due to its limited connectivity to Lake Albert at lower water levels based on the bathymetry levels provided. These alignments were indicative only, and were refined in the concept design phase.

In addition, subsequent to the SKM assessment, DEWNR advised that BMT WBM were commissioned to consider the full range of potential management actions.

Figure 1: Indicative Coorong connector locations

2. Qualitative Multi Criteria Analysis

2.1 Overview

In order to asses each potential management action, a qualitative MCA assessment was undertaken, based on the engineering feasibility of each management action and the potential impact of the management action.

A draft MCA framework was developed in consultation with DEWNR with which to assess each potential management action. This was submitted for stakeholder review on 6 May 2013 and subsequently finalised following receiving stakeholder comments.

A qualitative assessment was then undertaken for each management action against the approved criteria, with the final qualitative MCA assessment submitted 10 July 2013. The indicative impact was based on an engineering assessment only, and is relative to the other potential management actions. This level of assessment was agreed between DEWNR and SKM as a suitable initial approach based on the information available, prior to any further investigation and assessment being undertaken.

2.2 Results

A summary of the qualitative MCA is shown in Table 1. The impact ratings given are: High (H), Medium (M), Low (L), None (N) and Positive (P).

For the full qualitative MCA, including comments against each criterion refer to Appendix E.

Table 1: Qualitative Multi Criteria Analysis Summary

Assessment Criteria	**1. Dredging of Narrung Narrows**	**2. Partial or full removal of the Narrung causeway**	**3. Modification of the Narrung causeway**	**4. Coorong connector channel**	**5. Coorong connector pipe**	**6. Permanent regulating structure in Narrung Narrows**
1. Engineering Feasibility						
1.2 Option requires significant on land or submerged disposal increasing the risk of acid sulfate soil (ASS) exposure or mobilisation during construction or associated works	H	H	M	H	M	M
1.3 Is the proposed option able to be assessed as stable, serviceable and structurally adequate	M	M	L	L	L	H
1.4 Option implementation requires ground disturbance which is dependent on variable/unknown ground conditions	L	L	M	H	H	H

Assessment Criteria	1. Dredging of Narrung Narrows	2. Partial or full removal of the Narrung causeway	3. Modification of the Narrung causeway	4. Coorong connector channel	5. Coorong connector pipe	6. Permanent regulating structure in Narrung Narrows
1.5 Impact on surrounding landowners potentially requiring land acquisition / easements	L	L	L	H	H	L
1.6 Impact on infrastructure and/or lake existing usage (e.g. the ferry, recreational and professional fishing, primary industries, public vehicle and boat access, existing services, pipelines etc.)	M	M	M	L	L	H
2. Construction, Operations, and Maintenance						
2.1 Option presents challenging construction, mobilisation access and requirement for unique construction techniques and installation methods	M	L	L	M	H	H
2.2 Expected high level of ongoing maintenance and frequent operation or complexity integrating operation as part of the greater system	M	L	L	M	H	H
2.3 Option presents high OHS safety risk during construction and/or maintenance activities	M	M	L	M	M	H
2.4 Risk of removing management flexibility in lake level operation from option implementation compared to current management regime	N	N	N	P	P	P
3. Financial						
3.1 Relative expected capital costs	M	L	M	H	H	H
3.2 Relative expected operations and maintenance costs	L	L	L	M	M	M

Please note that item 1.1 was originally for '*Risk of option implementation not meeting target salinity level*' but has subsequently removed from the qualitative assessment as the modelling information was unavailable to make that assessment.

2.3 Limitations and Exclusions

The MCA undertaken was qualitative only, based on the engineering feasibility of each management action and an assessment of the potential impact (positive or negative) of the management action. As such the qualitative assessment is not intended to rank the management actions with a score, but rather to assess their anticipated impact from an engineering perspective.

The MCA assessment was limited to the engineering feasibility of each management action only. Environmental and social assessment criteria were excluded, with DEWNR to address these metrics separately.

At the time of the MCA, results from the water quality modelling were unavailable and therefore salinity criteria were also excluded.

The MCA assessed relative expected capital, operations, and maintenance costs; however assessment of other relative expected costs (including planning approval, EIS, indigenous consultation and negotiation, land acquisition, etc.) were excluded as they were being considered through investigation works by DEWNR.

3. Conceptual Level Design

3.1 Preliminary Models

To progress the water quality modelling, conceptual level designs were produced for the Coorong Connector and the permanent regulating structure in Narrung Narrows. The outputs of these conceptual level designs were used as inputs to the water quality modelling.

For the purposes of conceptual modelling the average water levels of Lake Albert and the Coorong were assumed to be +0.72 mAHD and +0.20 mAHD respectively (URS, 2006), as such a driving head of approximately 0.5m.

The Coorong Connector alignments 1 and 2 (Figure 1) are of similar length and location so were considered the same for conceptual modelling purposes.

3.1.1 Coorong Connector Pipe

Conceptual level models of the Coorong Connector Pipe were developed in EPANET for each of the alignments. Head loss was determined using the Darcy-Weisbach equation within EPANET.

For preliminary modelling purposes, polycrete pipes were used, using a roughness value of 0.1 mm. It was found that in order to pass 1 GL/day, three DN2400 pipes would be required at either alignment 1 or 2, or four DN2400 pipes would be required at alignment 3. The details of the Coorong Connecter Pipe models developed for each alignment and the resulting water quality modelling engineering inputs are summarised in Table 2.

3.1.2 Coorong Connector Channel

Conceptual level models of the Coorong Connector Channel were developed in Excel for each of the alignments, modelling the channel with a trapezoidal cross-section using Manning’s formula.

For the conceptual model invert levels were based on those used by URS (2006), -1.0 mAHD at Lake Albert and -1.48 mAHD at the Coorong. Similarly, the average water levels of Lake Albert and the Coorong were assumed to be +0.72 mAHD and +0.20 mAHD respectively (URS, 2006).

The channel base widths required in order to pass 1 GL/day were estimated to be 8 m and 10 m for short alignments (1 and 2) and longer alignment (3) respectively. The details of the Coorong Connecter Channel model developed for each alignment and the resulting salinity modelling engineering inputs are summarised in Table 2.

3.1.3 Narrung Narrows Regulator

A number of options were considered including a regulator positioned at the outlet of the Narrung Narrows into Lake Albert which would enable management flexibility of the entire Narrung Narrows. However this would require a regulator / blocking bank structure some 2,500 m long. As the environmental benefits of locating the regulator at various locations within the Narrows were unknown, and given the existing infrastructure that exists at the Narrung Causeway, shortest construction width and the ease of access at the ferry location, the Narrung Causeway/Ferry alignment location was adopted for modelling purposes.

Nominal dimensions of the regulator were given as salinity modelling engineering inputs based on the bathymetry results provided by DEWNR. Invert levels of the structure were given to be -2.0 to -1.50 mAHD so as to align with the approximate natural current depth upstream and downstream of the ferry. Table 3 summarises the modelling input details for the permanent Narrung Narrows regulator.

3.2 Salinity Modelling Inputs

Table 2 presents the modelling engineering input details for both the channel and pipe Coorong Connector options, while Table 3 presents engineering inputs for the permanent Narrung Narrows regulator.

These details were based on preliminary assessments discussed above, considering the design already undertaken by others in order to progress the salinity modelling being undertaken by BMT WBM.

Table 2: Salinity Modelling Inputs for Coorong Connector

	Channel Alignments 1 and 2	**Channel Alignment 3**	**Pipe Alignments 1 and 2**	**Pipe Alignment 3**	**Comment**
Coorong Elevation (mAHD)	0.2	0.2	0.2	0.2	Water for a Healthy Country - Hydrodynamics of the Coorong & Murray Mouth (2005) - Section 3 notes it is dependent on mouth being open and can fluctuate between 1 mAHD during spring tides and 0.2 mAHD during neap tides.
Lake Albert Elevation (mAHD)	0.72	0.72	0.72	0.72	URS Report (2006) Figure 1 mean water level, range from - 0.6 to 0.9 mAHD. 0.72 mAHD is average Lake Alexandrina Water Level.
Length (m)	2,400	3,500	2,400	3,500	Estimated based on 1 sec SRTM Digital Elevation Model (DEM) (Geoscience Australia, 2011)
Base width (m)	8	10			To achieve approximately 1 GL/day
Side slopes	1 V : 4 H	1 V : 4 H			Manning's n of 0.034 assuming earthen with small growth.
Channel Invert Upstream (mAHD)	-1.0	-1.0			
Channel Invert Downstream (mAHD)	-1.48	-1.48			
Gradient	1 V : 4,615 H	1 V : 6,731 H			
Pipe Size			DN2400	DN2400	
Pipe Material			Polycrete	Polycrete	
No. of Pipes			3	4	To achieve approximately 1 GL/day
Invert (mAHD)			-4.79	-4.79	W3 Long Section
Installation			Pipe Jack	Pipe Jack	As advised by Peter Shepherd during site visit

Table 3: Salinity Modelling Inputs for Narrung Narrows Permanent Regulating Structure

	Permanent Regulating Structure	Comment
Location	At inlet to Narrung Narrows (current ferry location)	Lock would be required for boat access.
Structure Invert (mAHD)	-2.0 to -1.5	From Bathymetry provided by DEWNR (email from TM on 3 April 13). Depth selected to align with the approximate natural current depth upstream and downstream of the ferry based on bathymetry results (2011/2012).
Width (weir length, m)	230	Approximate distance of open water span between ferry platforms.

4. Field Investigation

The field investigation was specifically undertaken to enable the design progression of the various management actions and is captured as a separate report titled *Lake Albert & Narrung Narrows Field Investigation Report: FINAL* (SKM, 27 November 2013)

The field investigation and environmental assessment works covered the following:

- Geotechnical boreholes and testing
- On site Acid Sulfate Soil (ASS) testing
- Survey and spatial assessment
- Desktop review of environmental assets
- Onsite environmental walkover

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5. Concept Design and Cost Estimate (+/- 30%)

5.1 Key Design Criteria

5.1.1 Overview

The design criteria were developed in order to establish an agreed design basis with which to progress the concept design. The two management actions captured in the design criteria are the Coorong Connector and dredging of the Narrung Narrows. The design criterion is presented in Appendix F.

Three of the key design aspects that were fundamental in the concept design development were; agreement on the water levels and hydraulic modelling approach for the Coorong Connector, selection of the connector location and pipe versus channel selection.

The key design criteria are discussed below.

5.1.2 Water Levels

As discussed in Section 1.3.3 of the Design Criteria (Appendix F), a review of the historic tide levels in and around Lake Albert and the Coorong has been undertaken. The figures below present the mean daily tide levels at the following stations:

- Station A4261135 – Coorong at Long Point
- Station A4261034 – Goolwa Barrage Upstream
- Station A4261036 – Goolwa Channel at Beacon 12 (downstream of the barrage)
- Station A4261155 – Lake Albert 2 km North Warringee Point

(All the data was obtained from DEWNR and www.waterconnect.sa.gov.au.)

Figure 2 demonstrates that water levels downstream of the Goolwa Barrage and the Coorong match well.

Figure 3 demonstrates that from around September 2009 Lake Albert is consistently above the Coorong with the exception of a few occurrences.

Figure 4 demonstrates that the water levels upstream of the Goolwa Barrage and Lake Albert align from September 2010. The influence of the drought and associated water level management programs in the region is noted prior to September 2010.

The channel is required to pass 1 GL/day (11.5 m^3/s). The adopted maximum and minimum operating levels applied to the concept design that Lake Albert will be subject to will be +0.80 mAHD (maximum) and +0.50 mAHD (minimum). This was confirmed by DEWNR on 16 October 2013.

Based on the historic tide data reviewed, for the period of September 2007 to September 2013, the maximum, minimum and average tide levels of the Coorong were +0.96 mAHD, -0.421 mAHD, and +0.28 mAHD respectively. However for the purposes of the concept design a static Coorong tide level of +0.30 mAHD will be adopted (refer to Section 1.3.3 of Appendix F).

Based on the discussion above, the following hydro-static levels were used for the concept design criteria:

- Coorong average operating level +0.30 mAHD
- Lake Albert minimum operating level +0.50 mAHD
- Lake Albert maximum operating level +0.80 mAHD

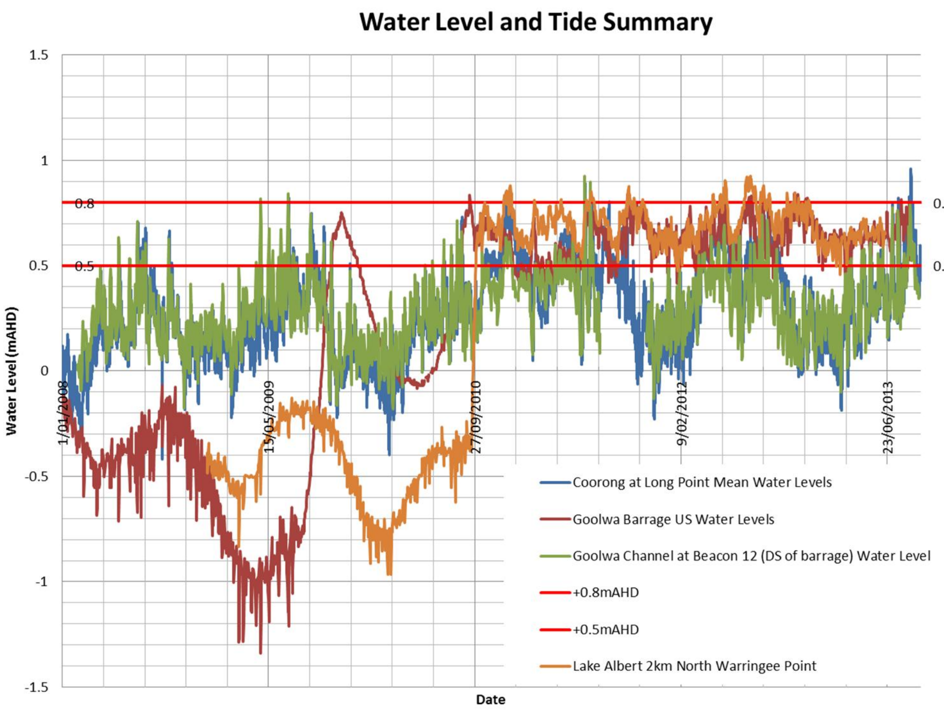

Figure 2: All tide data

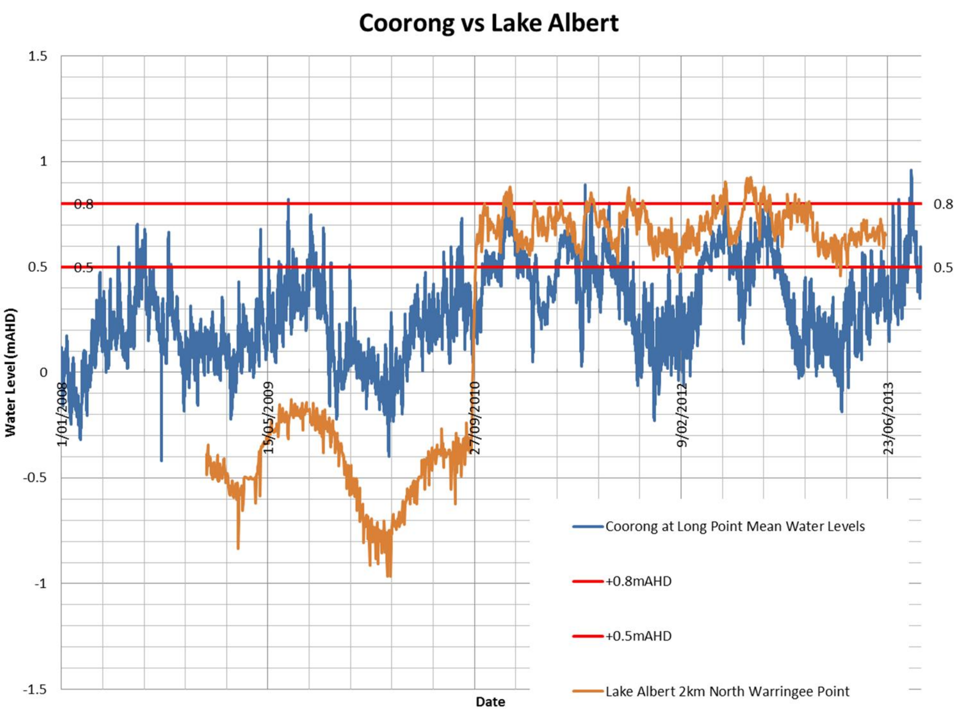

Figure 3: Coorong water level vs. Lake Albert water level

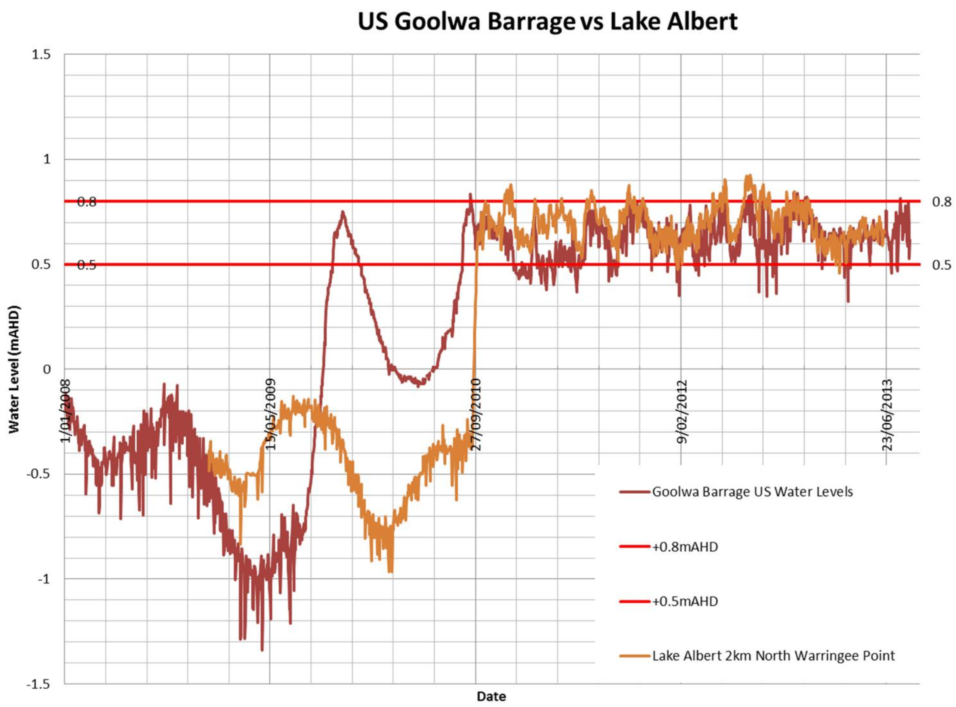

Figure 4: Goolwa Barrage upstream vs. Lake Albert

5.1.3 Coorong Connector: Pipe vs. Channel

As discussed in Section 1.3.4 of the Design Criteria (Appendix F), a channel was selected in preference to a pipe connector on the following basis:

- Control of a piped system would be significantly more complex than that required for a regulator structure associated with a channel.
- Although the excavated volumes would be less, the footprint of the piping would be increased, as a safe horizontal offset would be required for boring. Additional, substantial excavation would be required for driving pits, which would offset the excavation reduction.
- Based on preliminary sizing, it was anticipated that numerous pipes would be required (in the order of 3 x DN2400) to pass 1 GL/day.
- Dredging at the Lake Albert and Coorong ends would still be required along with inlet and outlet structures to stop sedimentation of the pipes.
- In regards to operation and maintenance, pigging of the pipe would be required infrequently. As such provisions would need to be made, adding further capital and operational cost.
- Based on indicative pricing (using Rawlinsons 2012 as a basis) the supply alone of DN1200 GRP PN10 (which is half the size than that required) would cost $2,000 /m. The length of Alignment 2 is 1,825 m; however three pipes require a total length of approximately 5,500 m. This results in a supply only cost of approximately $11 million. This does not consider delivery, installation, testing and commissioning, any valving/control infrastructure, manhole access, inlet or outlet structures and dredging etc. In comparison to the channel option, excavation unit rate is anticipated to be approximately $35 /m^3 (bulk excavation and channel profiling) which results in an excavation only cost of $7 million for 200,000 m^3. Note that the volume of 200,000m^3 was estimated prior to hydraulic channel modelling to confirm final dimensions.

5.1.4 Alignment Selection

As discussed in Section 1.3.4 of the Design Criteria (Appendix F), an assessment of Alignments 1 and 2 was undertaken to substantiate the appropriate site selection. Based on the survey undertaken as part of the field investigation project (Project Reference: VE23811), long sections of Alignments 1 and 2 (refer to appendices within Appendix F) were developed based on the preliminary channel sizing to achieve 1 GL/day flow with a driving head of 0.5 m. This was undertaken during the engineering review stage in order to provide channel sizing for modelling and excavation volumes(refer email to DEWNR on 28 June 13 titled *VE23776 Engineering Feasibility for Lake Albert & Narrung Narrows – Qualitative MCA Draft and Technical Response in Appendix C*).

A summary of the outcomes is provided below:

Alignment 1:

- Distance = 1,670 m
- Maximum cut height (from channel invert) = 8.7 m
- Total required volume for offsite disposal = 195,349 m^3

Alignment 2:

- Distance = 1,825 m
- Maximum cut height (from channel invert) = 9.3 m
- Total required volume for offsite disposal = 203,131 m^3) – later revised in concept design to 244,000 m^3

It should be noted that the cut and fill volumes and channel dimensions were based on preliminary sizing and were later refined during concept design. As such are presented in this section for comparative purposes only.

Therefore Alignment 2 is 155 m longer and has an additional surplus spoil volume of 7,782 m^3 (approximately 4% more). However it should be noted that potential dredging associated with Alignment 1 is likely to be more extensive than Alignment 2 and therefore is anticipated to have an impact on the cost.

Due to the similar excavation volumes of each option and taking into account the environmental and potential increased dredging impacts associated with Alignment 1, Alignment 2 was adopted for the concept design development.

5.2 Concept Design Development

The proposed concept involves construction of a 1,825 m long channel to transfer water from Lake Albert to the Coorong. The channel alignment runs through two landowner’s property. The channel has a trapezoidal cross section with a 13.3m base width and 1V:4H sloping sides.

Regulating structures located at the upstream and downstream ends of the channel allow flow management and enable the Coorong to be isolated from Lake Albert. Both structures consist of manually operated gates fixed to the upstream side of pre-cast box culverts which provide vehicle access across the channel at both locations. The gates can be opened and closed by a lockable spindle and have been sized to allow operation by a single person. The gates can be operated at various heights with the added ability to control the number of gates open at any one time to regulate flow through the channel.

The design and incorporation of fish passage at both structures has been excluded from the design and estimate at this stage but will be considered should the project progress.

The upstream regulator, located at the point where the proposed channel crosses the existing roadway incorporates a 12m length of culverts (consisting of 5 No 2.4m long units) to provide space for a dual direction single lane trafficable roadway, to match the width of the existing road, with a pedestrian footpath on one side. The culverts attached to the downstream regulator are 4.8m long (consisting of 2 No. 2.4m long units) to provide access for farm vehicles across the channel. The culvert units at both regulators are 4 bays wide and are designed to AS1597.2 with Austroads SM1600 loading through 0.2m to 2.0m fill.

The proposed layout showing the channel alignment, cross section and location of the upstream and downstream regulating structures is included on Dwg VE23776-ECC-DG-00001 in Appendix A. The conceptual layout of the regulating structures is shown on Dwg VE23776-ECC-DG-00005 and 00006 in Appendix A

5.2.1 Gate Selection

Drop logs, flume gates (AWMA lay flat gates) and penstocks (AWMA triple leaf gates) were considered as potential regulation options for the gate structure.

The following criteria were considered in the evaluation of the preferred gate type:

- Uninterrupted vehicle access across the channel is required at each gate location. This may be achieved via a separate culvert structure, or integrated into the design of the control structure.
- Limited power available at the regulator sites. *It is noted that power is available within the region, however it was confirmed following discussions with DEWNR that at this stage of design, selection of a gate system that didn't require power or automation was preferable in order to reduce the cost and complexity of the system.* Solar power may be incorporated in the gate if required, but will increase cost.
- The gate must be operatable by one person alone without creating a manual handling issues (or remotely if solar power plus mechanisation is cost effective)
- Head loss across the gate when fully open must be minimised. Increasing the head loss will increase the channel width, resulting in a significant increase to the channel construction costs.

The advantages and disadvantages of each gate type are summarised in Table 4. AWMA triple leaf gates (positioned clear of the culvert in the open position) were selected as the preferred gate type.

Table 4: Gate selection - Advantages as disadvantages of considered gate types

	Advantages	**Disadvantages**
Stop Logs	• Simple construct with low maintenance requirements • Low cost of stop log structure (negating the cost of secure onsite storage)	• Manual handling issues • High man hours for operation • Storage of stoplogs. The provision of secure on site storage (via small lockable building) is required to reduce the risk of theft. This will significantly increase costs.
Flume gates (AWMA Lay flat gates)	Lay flat gates provide the following advantages <u>when compared to stop logs:</u> • Better sealing performance • Can be automated in future, if required • Ease of single person operation (No manual handling) • Lockable hand wheel	Lay flat gates provide the following disadvantages <u>when compared to Triple Leaf Gates:</u> • Max gate width to allow single person manual operation = 1500mm • Cost - more expensive than triple leaf gates
Penstocks (AWMA undershot triple leaf gates)	• Opening width may be customised to meet requirements • Reduced volume of water displaced during operation allows larger gate widths to be operated by a single person • Cost - cheaper than flume gates • Removed storage issue associated with stop logs	

5.2.2 Material Selection

Due to the highly saline environment, the use of super duplex stainless steel was considered in the material selection for the gate. However, super duplex stainless steel gates would cost approximately three to five times more than marine grade aluminium. For this reason, marine grade aluminium gates have been proposed (and costed in section 5.3.2). These gates will require sacrificial anodes to protect the gates from corrosion.

5.2.3 Concept Description

The main features of the proposed concept are as follows:

- AWMA triple leaf gates provided to control flows
- Pre-cast box culverts provided to allow vehicle crossing at both the upstream and downstream regulating structures
- Gates fixed to upstream side of culverts so bolts are in compression when there is water against the upstream face
- Gate opening width (approx. 3m) sized to match clear width of pre-cast box culverts to minimise head loss
- 3m wide gate width sized to allow single person manual operation

- Culvert obvert level (+1.1mAHD) set to achieve 300mm freeboard at the Lake Albert maximum operating level (+0.8mAHD).
- Sheet pile and clay core cutoff sized to meet seepage requirements based on Lane's Weighted creep analysis. Design parameters for the seepage analysis were as follows:
  - SKM borelogs identify bedding material as fine to medium grained sand
  - Minimum allowable Lane's Weighted creep ratio = 6.5 for fine to medium grained sand
  - Max differential head for upstream structure = 2.0m based on maximum tide level of +1.0mAHD and channel invert level of -1.0mAHD
  - Max differential head for downstream structure = 2.5m (reverse flow) based on maximum tide level of +1.0 mAHD and channel invert level of -1.5 mAHD
- Reno mattress and gabion baskets provided for scour protection upstream and downstream of the structure.

5.2.4 Water Levels Assessed

5.2.4.1 Static Water Levels

As discussed in Section 5.1.2, the following hydro-static levels were used for the concept design development:

- Coorong average operating level +0.30 mAHD
- Lake Albert minimum operating level +0.50 mAHD
- Lake Albert maximum operating level +0.80 mAHD

The channel modelling is further discussed in section 5.2.7. It should be noted that the static water levels used in sizing the channel geometry used a Lake Albert water level of +0.5 mAHD and a Coorong water level of +0.3 mAHD, giving a 0.2 m driving head.

5.2.4.2 Seasonal Water Levels

The 2011 historical water levels, as adopted by BMT WBM in the water quality modelling, were used to model seasonal variation. Refer to Section 1.3.3 in Appendix F.

5.2.5 Regulation and Control

The channel will drain water from Lake Albert to the Coorong, one directional flow. Regulating structures at both ends of the channel provide a means of channel isolation for maintenance and to allow the Coorong to be isolated from Lake Albert. The gates are required to open and close the channel but can be operated at various heights with the added ability to control the number of gates open at any one time to regulate flow through the channel. The gates will be operated in order to maintain the target salinity levels in Lake Albert or to manage infrequent high Coorong water levels versus Lake Albert levels. In addition having gates at both channel extents allows flexibility for channel isolation at either end allowing for the inundation of the channel with Lake Albert or Coorong water during periods when the channel is not in service.

Based on the historic water level data and modelling results, automated gates to manage reverse flow are not considered necessary. However, in unusual cases where Lake Albert water level drops below a trigger level, there may be reverse flow. As such an operational regime during implementation should be developed to manage these events. The need for automated gates to manage reverse flow in lieu of an operational regime can be investigated further in the detailed design stage if deemed necessary.

5.2.6 Dredging Requirements

Dredging at the upstream (Lake Albert) and downstream (Coorong) ends of the channel will be required to achieve suitable invert levels. Based on the proposed channel invert levels, the upstream end of the channel must be dredged to level of -1 mAHD and the downstream end to a level of -1.5 mAHD.

Respective dredging volumes of 25,000 m^3 and 10,000 m^3 for the downstream and upstream ends of the channel were estimated based on dredging the full top width of the channel (at the natural surface level at 0 mAHD) to the depth of the invert levels. At the downstream end it was assumed that the dredging would extend into the Coorong until the invert level of -1.5 mAHD was reached (approximately 700 m into the Coorong). At the upstream end the bathymetry indicates that the lower region of Lake Albert does not reach -1 mAHD and so it was assumed that the dredging would extend into the Lake approximately 200 m from the 0 mAHD level.

5.2.7 Channel Modelling

5.2.7.1 Methodology

The channel was modelled using MIKE 11. Channel dimensions were determined using scenario modelling until the required design flow of 1 GL/d was achieved for the design water level conditions (Section 5.2.4.1), but constrained by the design criteria for depth and bank slope. Water levels were obtained from historical data for a transient run to check the range of flow conditions which could occur, and from the design criteria for sizing the channel.

The model consisted of a 1.8 km long trapezoidal channel with control structures at the up and downstream ends. Figure 5 shows the plan view of the model within the MIKE 11 interface. Trapezoidal cross sections were inserted at 50 m intervals (Figure 6). The regulators were modelled as box culverts, as they will be connected to box culvert vehicle access crossings (Figure 7).

5.2.7.2 Results

The water surface for the design condition of +0.50 mAHD water level in Lake Albert and +0.30 mAHD water level in the Coorong is shown in Figure 8. The model showed that with these water levels and a channel base width was 13.3 m, the flow rate through the channel would be 11.37 m^3/s, or 0.98 GL/day.

Using the 13.3 m base width channel, the 2011 historical water levels were entered in the model in a transient model simulation to develop an understanding of the likely range of flow rates and velocities. A discharge hydrograph was produced (Figure 9), in which it can be seen that flow rates often exceeded the design discharge, to the point of providing double the design flow. There were also short durations in which flow through the channel reversed, when the Coorong water level was higher than the Lake Albert water level. It is expected that reverse flow conditions will be predictable, as tide and lake water levels are known in advance, and thus operators will be able to close gates if necessary to prevent the flow of seawater into the Lake.

A more detailed report on the modelling is provided in Appendix G.

5.2.8 Operations and Maintenance

Sacrificial anodes on the gate structures are to be inspected once every 6 months and replaced if required. It should also be noted that ongoing dredging of the inlet and outlet of the channel will be required infrequently to maintain the invert level and remove sediment build up. Infrequent maintenance of the channel vegetation and removal of debris may also be required.

The gates can be opened and closed independently to regulate flow and can be opened / operated at any height. The operators will be required to undertake regular inspection / monitoring for any obstructions in the gates or channel.

5.2.9 Channel Protection

The channel shall be planted with vegetation to reduce erosion and improve aesthetics. Prior to planting the channel shall be inundated to the maximum level possible for a period of weeks to prepare the substrate. The channel shall then be emptied to be planted. The velocities within the channel must not exceed the scouring velocity at all times while the channel batters are not protected by vegetation.

A sterile rye with a native perennial mix of inundation tolerant species such as *Eleocharis acuta* and *E. sphacelata* shall be seeded along the base of the channel and up the batters to the level of regular inundation (nominally 1.8 m above the base of the channel). The mix along the base of the channel shall be predominantly *E. sphacelata*. The upper region of the channel batter shall be seeded with a tougher, but potentially less inundation tolerant species, such as *Juncus kraussii* and *Ficinia nodosa*. Seeding may be undertaking using blowers with a sand mix.

Melaleuca halmaturorum and *Myoporum insulare* may be planted along the top of the channel to provide long term erosion control and reduce runoff. Suitable windrows should be established along the sides of the channel to reduce runoff into the channel from adjacent farming paddocks in the short term.

A cross-section showing the indicative arrangement of channel vegetation is shown in Drawing VE23776-ECC-DG-00001 in Appendix A.

To assist the vegetation in establishing itself, the channel shall be inundated to the top level of the E*. acuta* and *E. sphacelata* (nominally 1.8 m deep) and the regulators shall be operated to maintain significantly reduced channel velocities. The channel shall be operated in this way for a period of time to allow for the vegetation to be established. This should last for approximately 2 to 3 months, but is dependent on conditions and the decision to begin regular operation should be based on observations at the time.

5.3 Cost Estimation

5.3.1 Dredging the Narrung Narrows

Dredging of the Narrung Narrows to improve flow between Lake Albert and Lake Alexandrina is one of the potential management actions proposed to allow for increased salt export through improved flushing of Lake Albert. It is proposed that dredging and widening of the Narrows to improve hydraulic efficiency would allow a greater mix of water between the lakes and consequently enhance the freshening effect (Ebsary 1983).

Modelling undertaken by McInerney (2005) examined the benefits of dredging the Narrows under a range of scenarios. The upper end scenario required the removal of 1.8 million m^3 of channel material to produce a resulting 60% increase in flow through the Narrows. However, the net salinity benefit from this scenario was unclear.

While a number of different channel widths and profiles have been previously proposed and modelled, recent modelling undertaken by WBM (2013) determined a maximum dredge volume of 6 million m^3 (as provided by DENWR, via email on 24 October 13), with the modelling showing that dredging will yield negligible benefits to Lake Albert salinity.

A preliminary, high-level pre design engineering estimate has been prepared for the dredging option to provide a scale of cost comparison only. As the specific details of this option have not been defined (i.e. dredge, disposal and treatment locations, distances, timing and requirements unknown) the estimate has been based on a series of assumptions and comparative costs from prior dredging projects managed by DEWNR in the Lower Murray / Lower Lakes region.

The preliminary engineering estimate for the dredging and disposal of 6 million m^3 of material from the Narrung Narrows (and associated works) to a disposal site within an assumed distance of 5km's is $104 million plus project delivery and works contingencies of $15 million.

Appendix B provides a breakdown of assumed activities for cost comparison purposes. Note: This is a preliminary estimate only and is not based on engineering design or quantity survey (as instructed by DEWNR). The estimate is based on rates from similar projects (Currency Creek and Clayton Regulator decommissioning) and assumed tasks and cost items. This estimate should not be used for design, procurement or investment decision purposes.

The following assumptions and general program of works have been employed for the purposes of representing this option:

- Dredge volume of 6 million m^3 of slurry material. The mixture of sand/sediment and water (assumed 40% solids for estimate) will be pumped from the dredging operations to the disposal site.
- Dredge distance unknown; assumed to be within 5km. It is assumed that a pipeline will be used to transport the dredged material from the dredging operations to the land based disposal location. It is anticipated that booster pumps (number unknown) will be required to transport the material.
- Disposal site location unknown however assumed will require purchase or lease of a significant parcel of land. Submerged disposal of dredge material has not been considered on advice from DEWNR.
- Disposal site volume requirements assumed to be a minimum of 2.4 million m^3 of solid material (based on 40% solids).
- Disposal site earthworks assumed cut and fill estimate of 112,000 m^3 of material (may require import if not available on site) with disposal site size approximately 2000m x 1500m with nominal 2m high walls (perimeter allowance only).
- Assumed that dewatering, treatment and earthworks processes would be required at disposal site.
- It is noted that based on prior investigations in the Narrung Narrows, it is possible that the dredge material could contain ASS. A nominal figure only has been included for ASS treatment at the disposal site.
- It is assumed that as a minimum, a cutter suction dredger, floating booster stations, supporting barge, anchor handling vessel, service vessel, floating pipeline, excavators, graders, water truck and suitable dump trucks may be required.
- Preliminary requirements assumed project/contract management, environmental management and monitoring and supporting works and measures would also be required. Provisional amounts have been estimated for these items.
- A 10% and 15% contingency has been applied to *Project Delivery* and *Project Construction* items respectively.
- Rates and costs may vary significantly based on actual design of this option.

Internal assessment by DEWNR flagged the following items for consideration with the proposed dredging option (DEWNR, via email on 25 October 13):

- Annual dredging costs may be difficult to determine as the frequency of dredging would need to be estimated based on settlement rate in the narrows
- The feasibility would also need to include cost associated with establishing a suitable land based site for the spoil as a water based site may not be available in the long term. This is due to navigation requirements and impacts on the commercial fishing activities.
- Treatment cost for ASS would need to be also included for any land based disposal for the spoil.
- Regular bathymetrical surveys of the channel would need to be included in the maintenance costs to ensure the channel profile is maintained.
- Potential community concerns and complaints (i.e. due to noise or impacts on the commercial fishing activities)

These items have been considered where relevant in the preliminary estimate.

The dredging option requires significant physical works to achieve the safe and effective extraction and disposal of 6 million m^3 of sediment material, some of which may pose ASS risks. A significant area of land is required to construct and manage a disposal site suitable for the management of the dredged sediment. It is likely that the time required for dredging such volumes and effectively dewatering and disposing of the material would be extensive.

5.3.2 Coorong Alignment 2

An engineering estimate to an accuracy of +/-30% has been prepared for the Coorong Connector Alignment 2. This estimate is summarised in Table 5. Details of the assumptions and breakdown of this estimate are contained in Appendix B. It should be noted that this is an engineering estimate only and not a quantity surveyed cost estimate. The total construction cost is approx. $19m including contingencies as shown in the breakdown below.

It should be noted that the rates applied in the cost estimate do not allow for escalation. Furthermore the estimate is highly sensitive to the unit rate of the bulk excavation, which has a large impact on the overall cost, and further investigations to determine suitable disposal sites and the appropriate rate for landowner compensation are required to confirm these specific items. The cost estimate is based on previous experience with similar projects in the region. Selection of a disposal site has not been identified at this stage.

The design and incorporation of fish passage at both structures has been excluded from the design and estimate at this stage but will be considered should the project progress.

Table 5: Engineering Estimate for the Coorong Connector Alignment 2

Item	Description of Works	Cost	
Section A - General Items			
A1	DEWNR Project Delivery Fees	$	550,000
A2	Approvals and Clearances, Communications, Land Access Agreements	$	125,000
A3	Preliminary Investigations	$	175,000
A4	Other Contractor Managed Works	$	522,000
	SUBTOTAL FOR SECTION A	$	1,372,000
Section B - Earthworks			
B1	Channel Earthworks	$	9,680,764
B2	Inlet and Outlet Works	$	1,115,000
	SUBTOTAL FOR SECTION B	$	10,795,764
Section C - Upstream Regulating Structure			
C1	Civil works	$	229,898
C2	Concrete works	$	191,647
C3	Gates	$	93,000
C4	Miscellaneous Items	$	19,500
	SUBTOTAL FOR SECTION C	$	534,045
Section D - Downstream Regulating Structure			
D1	Civil works	$	115,298

D2	Concrete works	$	92,208
D3	Gates	$	93,000
D4	Miscellaneous Items	$	12,500
	SUBTOTAL FOR SECTION D	$	313,006
	TOTAL DIRECT COST	$	13,014,815
Design Contingencies	30%	$	3,904,445
Contractor Preliminaries, margins and profits	15%	$	1,952,222
Contract Contingencies	5%	$	97,611
	ANTICIPATED TOTAL CONSTRUCTION COST (+/- 30%)	$	18,969,093

5.4 Operation & Maintenance Cost (OPEX) - Coorong Connector

It is anticipated that each of the sites will be operated and maintained by appropriate operational groups of the SA Government, subject to operational, tenure arrangements and the land management agreements as required.

The proposed operators will have suitable experience in this type of work and have instituted techniques and procedures to effectively and safely manage the operation, maintenance and performance of the infrastructure. Detailed Operations and Maintenance Plans will be developed and commissioned for all assets and/or operational functions established for the Coorong Connector.

On-going or recurrent costs refer to additional costs associated with the project post construction and commissioning. These costs will be associated with the ongoing management of the structures and the channel as required to implement the agreed operating regime for the Coorong Connector. As the exact nature and operational frequency of the regulating structures is not yet known, only an indicative estimate for operations and maintenance can be provided. Following a cost analysis for regulating structures and infrastructure on other projects (The Chowilla Floodplain works and Riverine Recovery Project Planning works as minimum benchmarks), it is estimated that operation and maintenance costs may be in the region of approximately **0.6 per cent** of capital cost (this excludes any potential dredging requirements at the inlet and outlet locations). For the Coorong Connector, capital costs are estimated at **$18.97 million** including contingencies. As such, the annual recurrent cost post commissioning is assumed to be approximately **$0.11 million** in real terms.

Siltation of the inlet and outlet locations will be dependent on the frequency of operation of the Coorong Connector and other factors. As such, future dredging requirements are difficult to forecast. For the purposes of the estimate, it is assumed that dredging at the inlet and outlet locations may be required every 5 years to clear these areas. It is assumed that 5,250 m^3 (15% of the original dredged volume) may require dredging with submerged disposal under a 5 year maintenance cycle at an estimated total cost of **$257,500**, distributed as **$51,500** per annum.

Inclusion of the dredging requirement into the ongoing operations and maintenance costs results in an estimated annual average cost post commissioning of approximately **$0.16 million** in real terms, or approximately **0.9 per cent** of capital cost.

It is assumed that the South Australian Government will fund the operational and maintenance liabilities for all assets created under the project, for the duration of their operational lives.

Monitoring of the environmental impacts and system performance following commissioning of the works will be another area where resources may be required. The arrangements for the monitoring and reporting will be critical components in monitoring the performance of the investment at a local and broad scale and will provide a measure to trigger additional management and intervention actions as required. As the requirements for such monitoring and evaluation are unknown, costs have not been included in the preliminary estimate.

6. Conclusions

Following completion of the hydraulic modelling, it was identified that the Coorong Connector was the preferred engineering solution in order to effectively reduce and maintain target salinity levels in Lake Albert. The concept design progressed involved the selection of a channel in lieu of a multiple jacked pipe arrangement at alignment 2 which provided improved Lake Albert connectivity over alignment 1, with a significantly reduced length when compared to alignment 3.

In order to achieve a target flow of 1 GL/day based on a driving head of 200 mm (Lake Albert at +0.5 mAHD and the Coorong at +0.3 mAHD), an excavated channel arrangement with a 13.3 m base and 1V:4H side slopes was developed comprising an offsite disposed volume of 244,000m^3. Two trafficable control structures were positioned at the upstream and downstream extents of the Connector channel to enable isolation and maintenance activities. The gate type selected was a penstock Triple Leaf Gate that enables manual operation without the need for a power source or storage and manual lifting associated with stoplogs. The gates can be opened and closed independently to regulate flow and can be opened / operated at any height.

Sacrificial anodes on the gate structures are to be inspected once every 6 months and replaced if required. The operators will also be required to undertake regular monitoring for any obstructions in the gates or channel. Ongoing dredging of the inlet and outlet of the channel will be required infrequently to maintain the invert level and remove sediment build up.

The engineering estimate for the Coorong Connector Alignment 2 is approx. $19m (+/-30%) including contingencies. This compares to $119 million (including contingency for the dredging and disposal of material from the Narrung Narrows). It should be noted that these are high level engineering estimates intended to provide a scale for cost comparison only.

Proposed vegetation of the channel has been considered which comprises species such as: E. acuta and E. sphacelata along the base of the channel and on the lower inundated region of the batters, Juncus kraussii and Ficinia nodosa on the upper region of the batters, and Melaleuca halmaturorum and Myoporum insulare at the top of the channel. This is to provide bank stability and also minimise surface water erosion of the channel. It should be noted that ongoing dredging of the inlet and out extents will be required infrequently in order to remove sediment build up over time.

Appendix A. Drawings

DESIGN SURFACE LEVEL	6.101	0.739	-1.261	-1.261	-1.261	0.739	3.776
EXISTING SURFACE LEVEL	6.101	4.875	4.445	4.229	4.086	3.920	3.776
OFFSET	-36.099	-14.650	-6.650	0.000	6.650	14.650	26.798

SCALE 1:500 H
SCALE 1:250 V

CH 1000.000

SCALE 1:2500 (A1) 50 25 0 50 100 150 200 250m

PRELIMINARY ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
A	04/12/13	CKR			ISSUE FOR CONCEPT DESIGN

DRAWING NUMBER	REFERENCE DRAWING TITLE

NOTES:
- TOTAL CUT : 244 892m^3
- TOTAL FILL : 3m^3
- BALANCE : 204889m^3
- MAXIMUM CUT HEIGHT : 9.4m
- LENGTH OF ALIGNMENT : 1825m

CLIENT DEPT OF ENVIRONMENT, WATER & NATURAL RESOURCES
PROJECT ENGINEERING FEASIBILTY OF POTENTIAL MANAGEMENT ACTIONS - LAKE ALBERT & NARRUNG NARROWS
DRAWN CKR | DRAWING CHECK | REVIEWED | APPROVED
DESIGNED NA | DESIGN REVIEW JA | DATE | DATE

TITLE
COORONG CONNECTOR CHANNEL REGULATING STRUCTURES GENERAL ARRANGEMENT & TYPICAL SECTION

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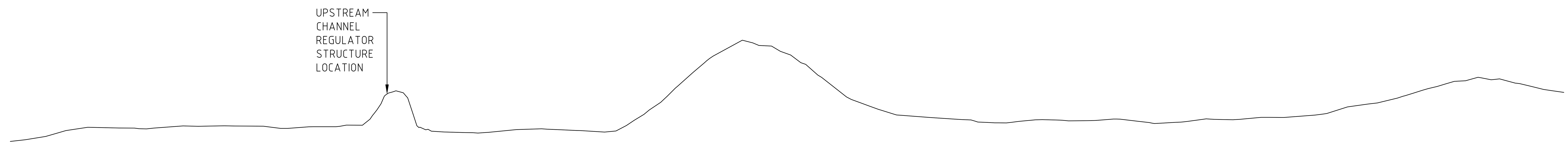

Horiz Curve Data: R500m (361.596 to 557.948); R-400m (596.123 to 660)

Vertical Geometry Grade (%): -0.026%
Vertical Grade Length (m): 1838.345m

Vertical Curve Length (m)
Vertical Curve Radius (m)

DATUM R.L.-12.000

CHAINAGE	0	20	40	60	80	100	120	140	160	180	200	220
NAT. SURFACE ON CHANNEL CENTRELINE	0.840	1.198	1.429	1.397	1.486	1.495	1.414	1.484	2.858	1.271	1.206	1.360
CUT / FILL DEPTH	1.840	2.203	2.439	2.413	2.507	2.521	2.445	2.521	3.900	2.318	2.259	2.418
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.000	-1.005	-1.010	-1.016	-1.021	-1.026	-1.031	-1.037	-1.042	-1.047	-1.052	-1.057

CHAINAGE	240	260	280	300	320	340	360	361.596	380	400	420	440	460
NAT. SURFACE ON CHANNEL CENTRELINE	1.310	1.427	2.856	4.553	4.917	3.938	2.529	2.470	1.943	1.799	1.631	1.763	1.732
CUT / FILL DEPTH	2.373	2.495	3.929	5.631	6.000	5.027	3.623	3.565	3.042	2.903	2.741	2.878	2.852
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.063	-1.068	-1.073	-1.078	-1.084	-1.089	-1.094	-1.094	-1.099	-1.104	-1.110	-1.115	-1.120

CHAINAGE	480	500	520	540	557.948	560	580	596.123	600	620	640	660
NAT. SURFACE ON CHANNEL CENTRELINE	1.689	1.694	1.769	1.863	2.011	2.052	2.470	2.901	3.020	3.474	3.316	2.930
CUT / FILL DEPTH	2.815	2.825	2.905	3.004	3.157	3.198	3.622	4.056	4.177	4.636	4.483	4.103
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.125	-1.131	-1.136	-1.141	-1.146	-1.146	-1.151	-1.156	-1.157	-1.162	-1.167	-1.172

SCALE 1:1000 H
SCALE 1:100 V

LONGITUDINAL SECTION CONCEPT ALIGNMENT 2

PRELIMINARY ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
A	04/11/13	CKR			ISSUE FOR CONCEPT DESIGN

DRAWING NUMBER	REFERENCE DRAWING TITLE

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DRAWN: CKR | DRAWING CHECK | REVIEWED | APPROVED
DESIGNED: NA | DESIGN REVIEW: JA | DATE | DATE

TITLE: COORONG CONNECTOR CHANNEL REGULATING STRUCTURES LONGITUDINAL SECTION CH 0 TO CH 660

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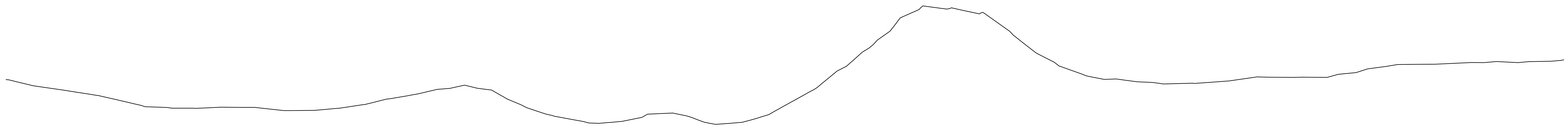

Horiz Curve Data: R-400m; R500m

Vertical Geometry Grade (%): -0.026%
Vertical Grade Length (m): 1838.345m

Vertical Curve Length (m)
Vertical Curve Radius (m)

DATUM R.L.-12.000

CHAINAGE	NAT. SURFACE ON CHANNEL CENTRELINE	CUT / FILL DEPTH	DESIGN LEVELS ON CHANNEL CENTRELINE
640	3.316	4.483	-1.167
660	2.930	4.103	-1.172
680	2.617	3.794	-1.178
700	2.161	3.344	-1.183
720	2.098	3.286	-1.188
740	2.135	3.328	-1.193
760	2.000	3.199	-1.198
780	2.090	3.294	-1.204
800	2.457	3.666	-1.209
820	2.835	4.049	-1.214
840	2.944	4.163	-1.219
860	2.151	3.375	-1.225
880	1.618	2.847	-1.230
895.834	1.497	2.731	-1.234
900	1.534	2.769	-1.235
920	1.884	3.124	-1.240
940	1.425	2.671	-1.245
953.049	1.532	2.780	-1.249
960	1.730	2.981	-1.251
980	2.767	4.023	-1.256
1000	4.229	5.491	-1.261
1020	5.985	7.251	-1.266
1040	6.338	7.609	-1.272
1060	5.735	7.012	-1.277
1080	4.258	5.540	-1.282
1100	3.427	4.714	-1.287
1120	3.219	4.512	-1.292
1140	3.154	4.452	-1.298
1157.962	3.256	4.559	-1.302
1160	3.285	4.588	-1.303
1180	3.412	4.720	-1.308
1200	3.416	4.729	-1.313
1220	3.812	5.130	-1.319
1240	3.964	5.288	-1.324
1260	4.036	5.365	-1.329
1280	4.039	5.373	-1.334
1300	4.153	5.493	-1.339

SCALE 1:1000 H
SCALE 1:100 V

LONGITUDINAL SECTION CONCEPT ALIGNMENT 2

PRELIMINARY ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
A	04/12/13	CKR			ISSUE FOR CONCEPT DESIGN

DRAWING NUMBER	REFERENCE DRAWING TITLE

SKM
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CLIENT: DEPT OF ENVIRONMENT, WATER & NATURAL RESOURCES
PROJECT: ENGINEERING FEASIBILTY OF POTENTIAL MANAGEMENT ACTIONS - LAKE ALBERT & NARRUNG NARROWS

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
CKR			
DESIGNED	DESIGN REVIEW	DATE	DATE
NA	JA		

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REV: A

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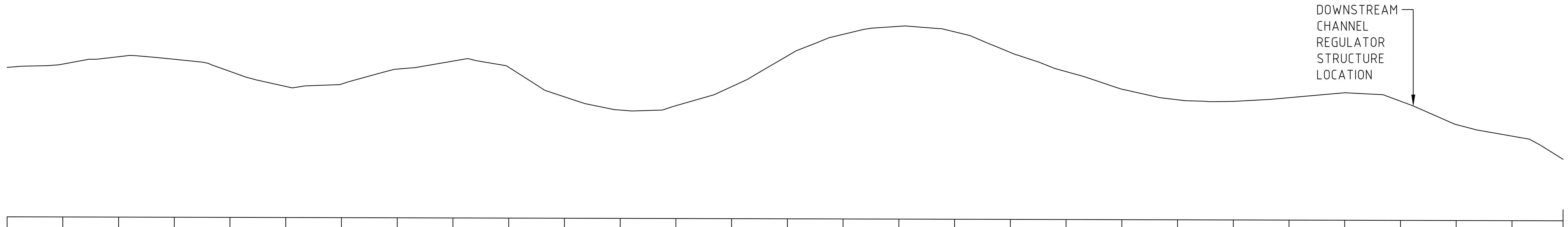

Horiz Curve Data

Vertical Geometry Grade (%) — -0.026%
Vertical Grade Length (m) — 1838.345m

Vertical Curve Length (m)
Vertical Curve Radius (m)

DATUM R.L.-12.000

CHAINAGE	1280	1300	1320	1340	1360	1380	1400	1420	1440	1460
NAT. SURFACE ON CHANNEL CENTRELINE	4.039	4.153	4.419	4.325	3.889	3.349	3.435	3.974	4.259	4.040
CUT / FILL DEPTH	5.373	5.493	5.763	5.675	5.244	4.709	4.800	5.345	5.635	5.421
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.334	-1.339	-1.345	-1.350	-1.355	-1.360	-1.366	-1.371	-1.376	-1.381

CHAINAGE	1480	1500	1520	1540	1560	1580	1600	1620	1640	1660
NAT. SURFACE ON CHANNEL CENTRELINE	2.977	2.502	2.659	3.343	4.446	5.223	5.510	5.313	4.571	3.884
CUT / FILL DEPTH	4.363	3.893	4.056	4.745	5.854	6.635	6.927	6.736	6.000	5.318
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.386	-1.392	-1.397	-1.402	-1.407	-1.413	-1.418	-1.423	-1.428	-1.433

CHAINAGE	1680	1700	1720	1740	1760	1780	1800	1820	1838.345
NAT. SURFACE ON CHANNEL CENTRELINE	3.252	2.870	2.812	2.946	3.125	2.820	1.982	1.565	0.734
CUT / FILL DEPTH	4.690	4.314	4.261	4.401	4.584	4.285	3.452	3.040	2.214
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.439	-1.444	-1.449	-1.454	-1.460	-1.465	-1.470	-1.475	-1.480

SCALE 1:1000 H

SCALE 1:100 V

LONGITUDINAL SECTION CONCEPT ALIGNMENT 2

PRELIMINARY ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
A	04/12/13	CKR			PRELIMINARY ISSUE

DRAWING NUMBER	REFERENCE DRAWING TITLE

SKM
A.C.N 001 024 095
Sinclair Knight Merz
Level 5, 33 King William Street
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AUSTRALIA
Tel: +61 8 8424 3800
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Web: www.globalskm.com

CLIENT: DEPT OF ENVIRONMENT, WATER & NATURAL RESOURCES

PROJECT: ENGINEERING FEASIBILTY OF POTENTIAL MANAGEMENT ACTIONS - LAKE ALBERT & NARRUNG NARROWS

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
CKR			
DESIGNED	DESIGN REVIEW	DATE	DATE
NA	JA		

TITLE: COORONG CONNECTOR CHANNEL REGULATING STRUCTURES LONGITUDINAL SECTION CH 1280 TO CH 1838.345

SCALE: AS SHOWN | DRAWING No: VE23776-ECC-DG-0004 | REV: A

A1

DATE: 4/12/2013 3:58:21 PM LOGIN NAME: RULE, CLINT (SKM)
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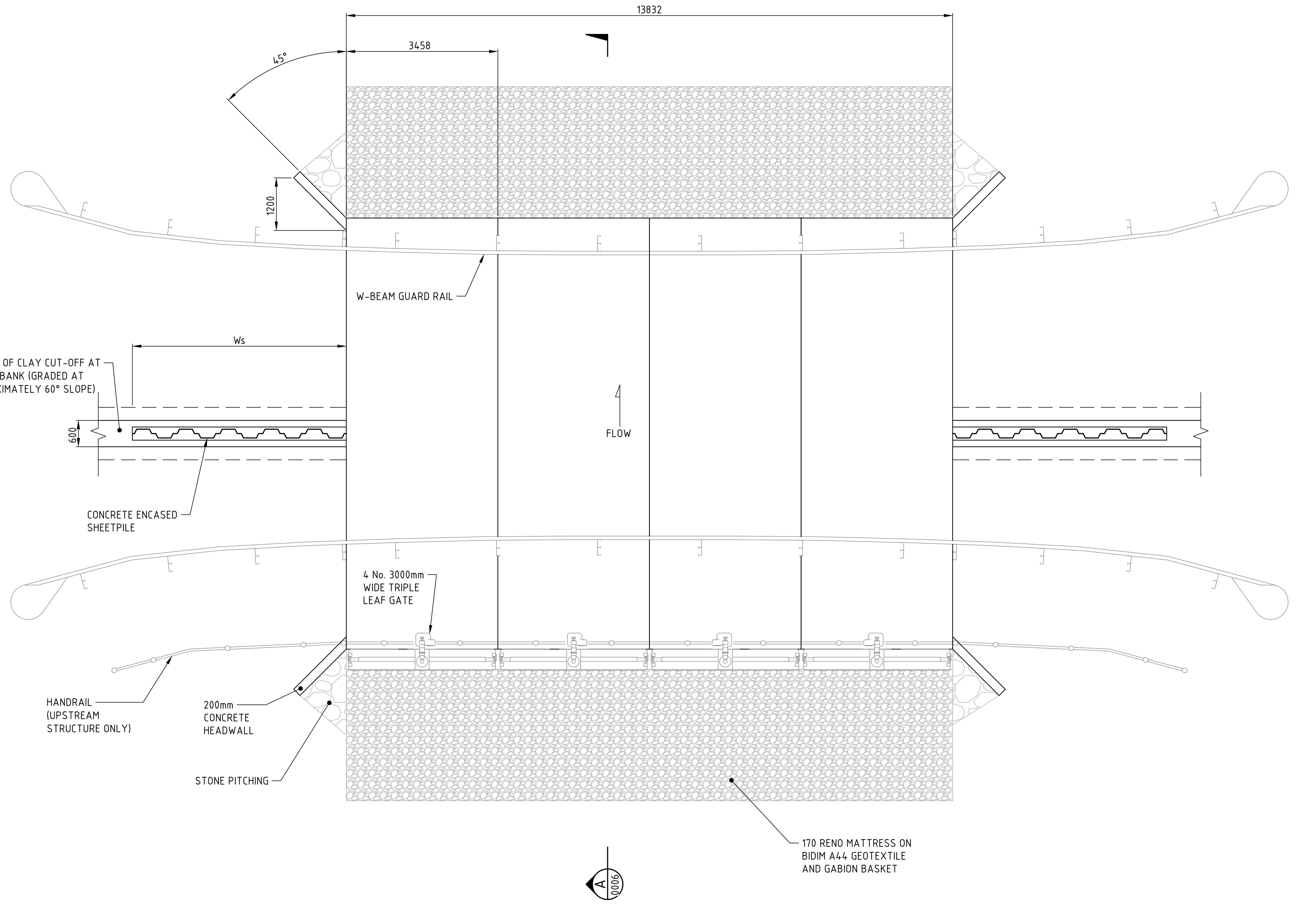

NOTES

1. ALL CONCRETE TO AS3600
2. INSITU CONCRETE STRENGTH 32MPa AT 28 DAYS
3. CLAY CUTOFF TO BE PLASTIC CLAY COMPACTED IN 150mm LAYERS TO 98% SMDD
4. GENERAL BACKFILL FROM EXCAVATION (NOT GRANULAR MATERIAL) COMPACTED TO 95% SMDD IN 150mm LAYERS
5. ALL DIMENSIONS IN MILLIMETRES (mm) UNO

DESIGN DATA

	UPSTREAM STRUCTURE	DOWNSTREAM STRUCTURE
CUIL, CULVERT INVERT LEVEL (mAHD)	-1.0	-1.5
CUOL, CULVERT OBVERT LEVEL (mAHD)	1.1	1.1
RSL, ROAD SURFACE LEVEL (mAHD)	3.0	2.6 (APPROX AT CH 1785m)
$L_{CULVERT}$, LENGTH OF CULVERT (mm)	12000 (5 No. 2.4 LENGTH UNITS)	4800 (2 No. 2.4 LENGTH UNITS)
$H_{CULVERT}$ HEIGHT OF CULVERT (mm)	2700	3000
D_S, DEPTH OF SHEETPILE (mm)	2500	3500
W_S, WIDTH OF SHEETPILE (mm)	5000	6000
W_{FOOT}, WIDTH OF FOOTPATH (mm)	2000	N/A
ROAD SURFACE MATERIAL	BITUMEN	CRUSHED ROCK

SCALE 1:50 (A1) 1000 0 1000 2000 3000 4000 5000mm

PRELIMINARY ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
A	04/12/13	CKR			ISSUE FOR CONCEPT DESIGN

DRAWING NUMBER	REFERENCE DRAWING TITLE
VE23776-ECC-DG-0006	REGULATING STRUCTURES - ELEVATION AND SECTION

SKM
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CLIENT DEPT OF ENVIRONMENT, WATER & NATURAL RESOURCES
PROJECT ENGINEERING FEASIBILTY OF POTENTIAL MANAGEMENT ACTIONS - LAKE ALBERT & NARRUNG NARROWS

DRAWN CKR | DRAWING CHECK | REVIEWED | APPROVED
DESIGNED NA | DESIGN REVIEW JA | DATE | DATE

TITLE
COORONG CONNECTOR CHANNEL REGULATING STRUCTURES PLAN

SCALE 1:50 | DRAWING No VE23776-ECC-DG-0005 | REV A

A1

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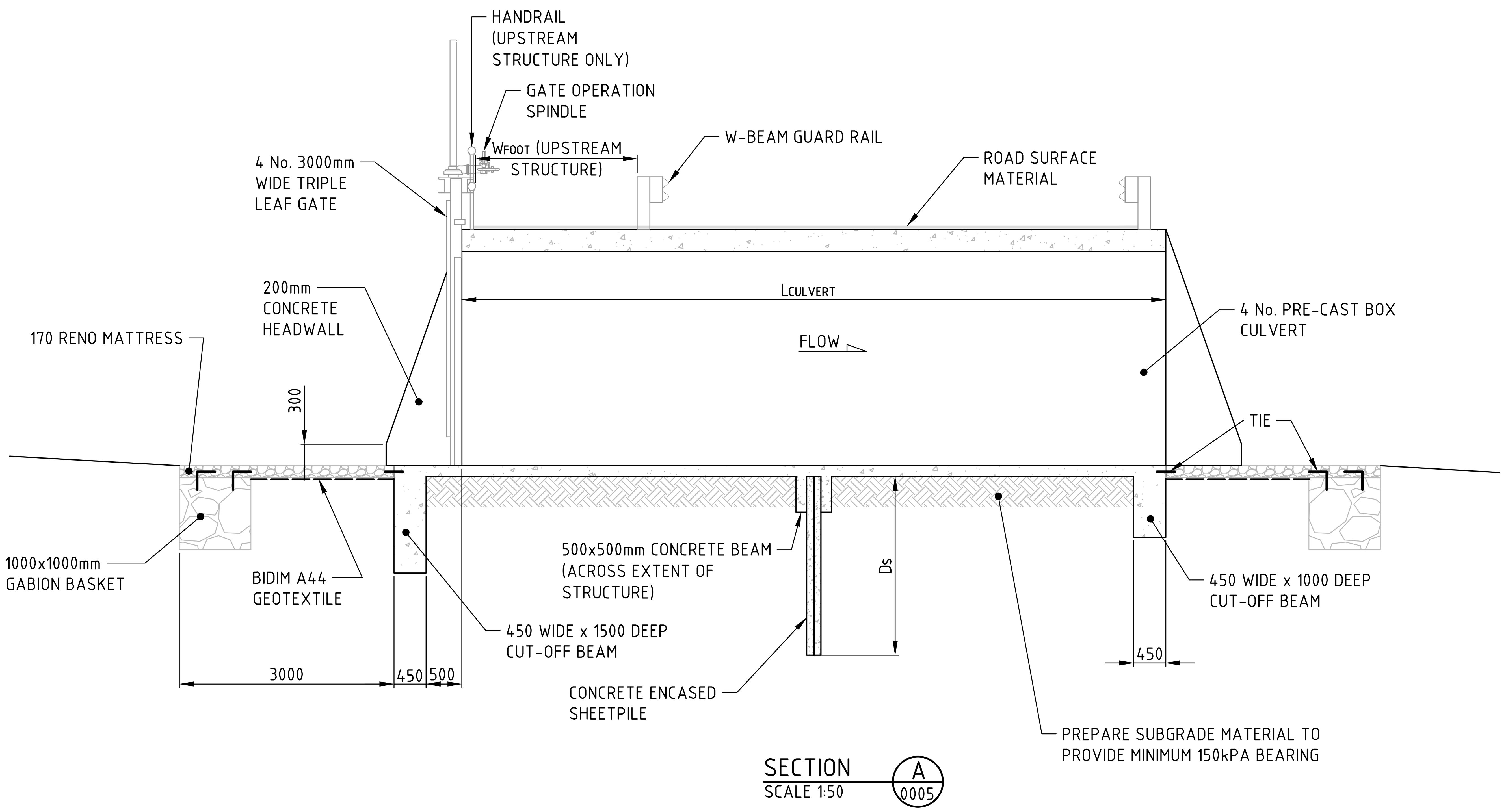
LOCATION: I:\VESA\Projects\VE23776\Deliverables\Drawings\Civil\Dwg\VE23776-ECC-DG-0005.dwg

NOTES

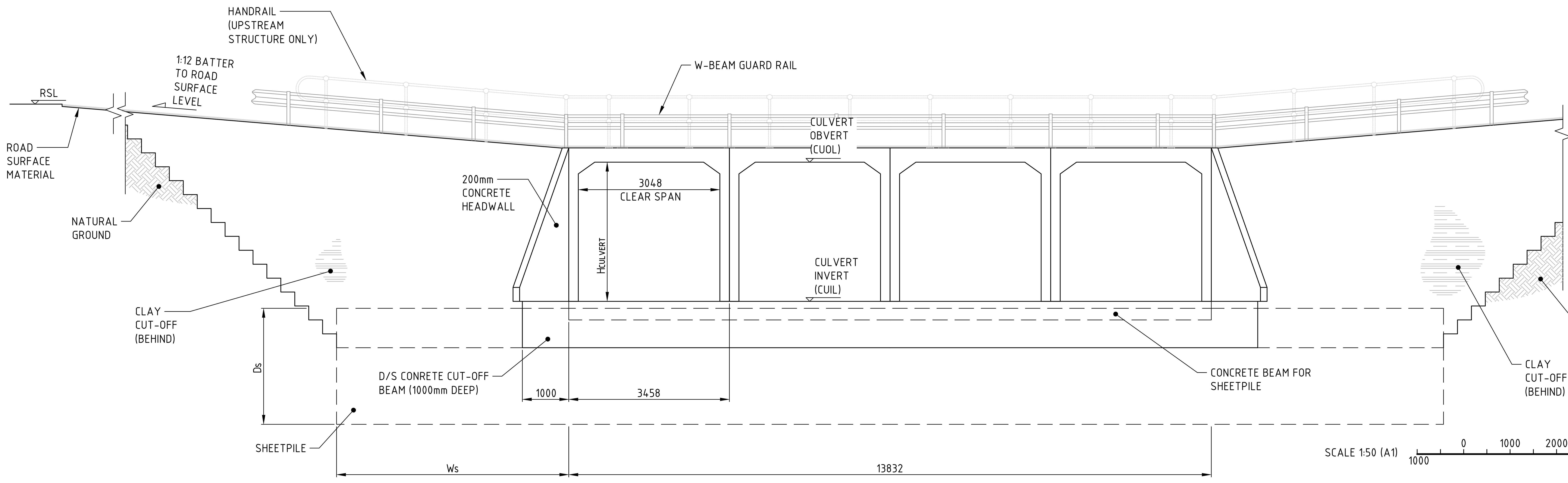
1. ALL CONCRETE TO AS3600
2. INSITU CONCRETE STRENGTH 32MPa AT 28 DAYS
3. CLAY CUTOFF TO BE PLASTIC CLAY COMPACTED IN 150mm LAYERS TO 98% SMDD
4. GENERAL BACKFILL FROM EXCAVATION (NOT GRANULAR MATERIAL) COMPACTED TO 95% SMDD IN 150mm LAYERS
5. ALL DIMENSIONS IN MILLIMETRES (mm) UNO



SECTION A 0005
SCALE 1:50

DESIGN DATA

	UPSTREAM STRUCTURE	DOWNSTREAM STRUCTURE
CUIL, CULVERT INVERT LEVEL (mAHD)	-1.0	-1.5
CUOL, CULVERT OBVERT LEVEL (mAHD)	1.1	1.1
RSL, ROAD SURFACE LEVEL (mAHD)	3.0	2.6 (APPROX AT CH 1785m)
$L_{CULVERT}$, LENGTH OF CULVERT (mm)	12000 (5 No. 2.4 LENGTH UNITS)	4800 (2 No. 2.4 LENGTH UNITS)
$H_{CULVERT}$ HEIGHT OF CULVERT (mm)	2700	3000
D_S, DEPTH OF SHEETPILE (mm)	2500	3500
W_S, WIDTH OF SHEETPILE (mm)	5000	6000
W_{FOOT}, WIDTH OF FOOTPATH (mm)	2000	N/A
ROAD SURFACE MATERIAL	BITUMEN	CRUSHED ROCK



SCALE 1:50 (A1) 1000 0 1000 2000 3000 4000 5000mm

ELEVATION (DOWNSTREAM)

PRELIMINARY ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
A	04/12/13	CKR			ISSUE FOR CONCEPT DESIGN

DRAWING NUMBER	REFERENCE DRAWING TITLE
VE23776-ECC-DG-0005	REGULATING STRUCTURES - PLAN

SKM

A.C.N 001 024 095
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CLIENT: DEPT OF ENVIRONMENT, WATER & NATURAL RESOURCES

PROJECT: ENGINEERING FEASIBILTY OF POTENTIAL MANAGEMENT ACTIONS - LAKE ALBERT & NARRUNG NARROWS

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
CKR			
DESIGNED	DESIGN REVIEW	DATE	DATE
NA	JA		

TITLE: COORONG CONNECTOR CHANNEL REGULATING STRUCTURES ELEVATION AND SECTION

SCALE: 1:50 | DRAWING No: VE23776-ECC-DG-0006 | REV: A

A1

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Appendix B. Cost Estimates

CONSTRUCTION COST ESTIMATE

Project: Engineering feasibility of potential management actions, Lake Albert and Narrung Narrows
Project Number: VE23776
Date: 25-Feb-14
Accuracy: +/-30%
Design Option Description: Coorong Connector Channel (Location 2)

Item	Description of Works	Qty	Unit	Rate	Sub Total	Comment
A	Section A - General Items					
A1	*DEWNR Project Delivery Fees*					
A1a	DEWNR Project Management Costs	1	Item	500,000	500,000	Assumed DEWNR salary and operating expenses to deliver project. Estimated costs for 4 x FTE for 12 months
A1b	Project Management Expenses (Goods & Services, Motor Vehicle Costs, Employee Costs)	1	Item	50,000	50,000	Project office expenses including vehicle hire and travel expenses
A2	*Approvals and Clearances, Communications, Land Access Agreements*					
A2a	Approvals (Licences and Permits)	1	Item	20,000	20,000	All necessary licensing and permitting to undertake works. Specific permits will be required for disposal.
A2b	Cultural heritage	0	Item		-	Specific requirements unknown - DEWNR to advise.
A2c	Community Consultation	1	Item	35,000	35,000	Establishment of signage, community information sessions, landholder consultation. Given the proximity of the site to towns (Narrung etc) effective consultation will be important for project success.
A2d	Ecological and Environmental Advice	1	Item	30,000	30,000	Development and implementation of EHS plan and procedures and related environmental planning and assessment.
A2e	Levy, EPA Fees and permits provision	1	Item	40,000	40,000	
A3	*Preliminary Investigations*					
A3a	Detailed Design of regulating structures and channel, specification, tender documentation, schedule development, other site assessments.	1	Item	150,000	150,000	Development of design, tender specification, tender briefing, disposal site planning and survey, de-watering process design etc
A3b	Finalisation of disposal site locations (and agreements) for excavated channel spoil and dredge spoil.	1	Item	15,000	15,000	Development of land access and disposal agreement legal documentation. Legal fees etc.
A3c	Tender cost estimate review	1	Item	10,000	10,000	If required as part of DEWNR process.
A4	*Other Contractor Managed Works*					
A4a	Traffic Management (incl setting up road closures etc)	1	Item	32,000	32,000	Provisional allowance for traffic management during construction of upstream regulator. Allowance based on $2000 / day for 2 person crew and traffic controller for a 16 day period.
	Traffic Management Plan	1	Item	5,000	5,000	Allowance
A4b	Construction Manager & Site Supervision	1	Item	260,000	260,000	Assume 1 year construction program
A4c	Site survey - if required post works, includes stockpile verification survey	1	Item	25,000	25,000	Provision for additional survey requirements at disposal site. Required for verification of volumes and assumed acceptance by landholder.
A4d	Waste Derived Fill, PASS, density testing	1	Item	50,000	50,000	Requirements for disposal to preferred location and contractors PMP
A4e	Mobilisation and demobilisation	1	Item	150,000	150,000	Allowance
	TOTAL FOR SECTION A C/Forward to Summary				1,372,000	
B	Section B - Earthworks					
B1	*Channel Earthworks*					
B1a	Provisional allowance for temporary access roads	1	Item	75,000	75,000	Allowance for the provision of temporary access roads for bulk excavation works

Item	Description of Works	Qty	Unit	Rate	Sub Total	Comment
B1b	Bulk excavation 1.9km trapezoidal channel with 13.3m base width and 1:4 sloping sides (including transport to disposal site)	244000	m3	35	8,540,000	Allowance for excavation of shallow topsoil overlaying loose to very dense sand with cemented sand which cannot be broken by hand . Allowance includes excavation and disposal of material on a landowners property within 5km of the excavation site. This rate was established following consultation with SKM's quantity surveyor who reviewed the rate against rates for similar projects based on the type of material anticipated and advised an estimate in the range of $25-$35/m3 would be appropriate. Following a meeting with DEWNR on 20/02/2014 and follow up discussions with SKM's quantity surveyor, SKM have revised the unit rate to $35/m3, which represents the upper end of the estimated range.
B1c	*Exclusion - no allowance has been made for temporary fencing (ie cattle fencing) along the top of bank*	0	Item		-	Excluded item
B1d	Groundwater control – pit dewatering (provisional only)	4	Item	25,000	100,000	Provisional estimate for de-watering establishment, pipes and pumps to return water to the lake or a suitable location. Assumed 4 pump out locations at approximately $25k inclusive of all associated costs for the duration of construction. No carting of water has been allowed for.
B1e	Channel profiling	46196.05	m2	5.0	230,980	Allowance for compaction, grading and trimming of the excavated surface
B1f	Channel protection works	4619.605	m3	10.0	46,196	Allowance to strip top soil (100mm) and stockpile locally = $5 / m3. Allowance to dig out unwanted material and re-spread top soil = $5 / m3.
B1g	Hydro seeding	46196.05	m2	3.0	138,588	Planting of base, batters and top of channel.
B1h	Planting on top of banks	18000	m2	8.0	144,000	Average ground cover cost including planting and regional multiplier of 1.05 (p229 Rawlinsons 2012)
B1i	Landowner compensation / Levelling / landform of disposal site and disposal site maintenance	244000	m3	1.5	366,000	Allowance for compaction and grading at the landowners site to provide a profile that matches the land profile present or as required by the landowner. At this stage of the concept, no target disposal sites have been identified and it is assumed that a disposal cost would be required. Based on disposal works for recent lower River Murray projects, a figure of $1.50 / m3 has been assumed. Note that the $1.50/m3 benchmark was for significantly smaller volumes and a decrease in unit rate may be possible based on higher volumes.
B1j	Temporary fencing at disposal site and reinstatement of access roads/alignment to disposal site	1	Item	20,000	20,000	Some level of temporary fencing works likely required at disposal site. Remediation of surrounding area to make good.
B1k	Site clean up / general remediation	1	Item	20,000	20,000	Assumed requirements under project approval conditions. Remediation of surrounding area to make good.
B2	*Inlet and Outlet Works including dredging*					
B2a	Provision for dredging inlet and outlets. Transfer to a suitable disposal site (yet to be identified)	35000	m3	30	1,050,000	Provision for dredging inlet and outlets. Volume based on bathymetry survey allowing for dredging works within 50m of the inlet and outlet. Unit rate based on reviewed rates for dredging and disposal in a similar environment, (and comparison rates provided by DEWNR), within the assumed distance parameters of 5km's from dredge location. Historical ranges reviewed $16 per m3 (Currency Creek and Narrung) , $5 per m3 (Murray Mouth program) to $30 per m3 as provided by DEWNR (including allowance for suction cut dredging, transportation, dewatering). With the exception of the Murray Mouth costs, the other ranges reviewed were based on significantly smaller volume projects. The upper end of the range has been selected due to the unknowns associated with the dredging works for this project. Unit rate likely to change based on efficiency of volume (this has not been factored in) and depending on dredge distance required, number of booster pumps and pipelines etc. Production rates not yet estimated. Figure allows for transfer and dewatering onshore before transport to disposal site.
B2b	Monitoring Framework Development Implementation - water quality, EPA involvement	1	Item	15,000	15,000	Development and implementation of robust monitoring framework to monitor and manage the risks associated with the excavation, dredging and disposal works

Item	Description of Works	Qty	Unit	Rate	Sub Total	Comment
B2c	Provisional allowance for additional works at inlet / outlet	1	Item	50,000	50,000	Allowance to cover need for specialised machinery, modified work procedures etc. in the vicinity of the inlet / outlet
	TOTAL FOR SECTION B C/Forward to Summary				10,795,764	
C	Section C - Upstream Regulating Structure					
C1	*Civil works*					
C1a	Subgrade preparation	3	days	1,500	4,500	Smooth Drum Roller, $1500 per day machine and operator.
C1b	Sheet pile - 2.5m deep concrete encased sheet pile	24	m	1,875	45,000	Permanent sheet piling. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement
C1c	Supply and place clay core cut-off	100	m3	50	5,000	600mm wide at top of bank graded at approx. 60 deg to 1m below top of sheet pile. Assume borrow pit nearby. Unit rate based on engineering judgement.
C1d	170mm thick Reno Mattress on BIDIM A44 geotextile	84	m2	45	3,738	Geotextile includes regional multiplier of 1.05 (p676 Rawlinsons 2012), Reno Mattress estimated based on prices for thin gabion walls on: http://www.gabion1.com.au/gabion_aus_prices.htm
C1e	Gabion Basket - 1m wide x 1m deep	28	m	365	10,220	Unit rate determined with consideration to prices for thick gabion walls on: http://www.gabion1.com.au/gabion_aus_prices.htm (as a base rate) with an additional allowance for installation based on engineering judgement
C1f	Stone pitching	5.8	m2	250	1,440	Granite pitching to embankments 150mm to 200mm thick, embedded in mortar. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
C1g	Road way earthworks, profiling and reinstatement	1	Item	60,000	60,000	Allowance for excavation and grading of 1:12 roadway profile from existing road surface down to top of culvert. Allow excavation and grading of 400m3 material @ $25/m3. Reinstatement of roadway including subgrade and bitumen surface - allow $500/m for 100m length roadway
C1h	Temporary traffic bypass	1	Item	100,000	100,000	Allowance for construction of a temporary traffic bypass
C2	*Concrete works*					
C2a	Supply of 2.7m high x 3.0m wide x 2.4m long precast box culverts	20	Item	6,259	125,172	Price provided by Humes. Includes delivery to site.
C2b	Installation of 20 No. 2.7m high x 3.0m wide x 2.4m long precast box culverts	20	Item	2,000	40,000	Assumed 41.4 t excavator with operator and fuel and 3 x Group 1 labourers working 10h days for 3.5 days. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
C2c	200mm thick cast in situ headwall, incl formwork & earthworks	9.6	m2	500	4,800	4 No. 200mm thick cast in situ headwall, approx. 1.6m long. Wall height tapered from H= 2.7m (at culvert) to H=300mm 32MPa reinforced concrete walls. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
C2d	150mm thick concrete slab	169	m2	75	12,675	32MPa reinforced concrete slabs and thickening on fill. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
C2e	Upstream cut-off-beam - 450mm wide x 1500mm deep	16	m	338	5,400	32MPa reinforced concrete slabs and thickening on fill. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
C2f	Downstream cut-off-beam - 450mm wide x 1000mm deep	16	m	225	3,600	32MPa reinforced concrete slabs and thickening on fill. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
C3	*Gates*					
C3a	Supply, Delivery & Installation of 4No. 3000mm triple leaf gates	1	Item	93,000	93,000	Cost supplied by AWMA based on supply of 4No. 3000mm wide x 2000mm operating level triple leaf gates with marine grade aluminium construction, manual operation via hand wheel through Right angle bevel gearbox, 316 Stainless steel spindle. Cost for delivery and installation includes: Delivery, Mobilisation / Demobilisation, Labour, LA allowances / accommodation, Anchors / consumables, Crane hire.
C4	*Miscellaneous Items*					

Item	Description of Works	Qty	Unit	Rate	Sub Total	Comment
C4a	Guard Rail	50	m	250	12,500	Assume 25m long guard rail to each road edge Curved galvanised steel double corrugated guard rail with bolts and splice plates allowing for 1800mm long steel post every 1.8m and 2 bullnose terminal sections every 25m. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
C4b	Pedestrian Hand Rail	20	m	350	7,000	Tubular handrail including brackets at 1200mm centres fixed to wall - 63.6mm stainless steel handrails. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
	TOTAL FOR SECTION C C/Forward to Summary				534,045	
D	Section D - Downstream Regulating Structure					
D1	*Civil works*					
D1a	Subgrade preparation	3	days	1,500	4,500	Smooth Drum Roller, $1500 per day machine and operator.
D1b	Sheet pile - 3.5m deep concrete encased sheet pile	26	m	2,550	66,300	Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement
D1D	Supply and place clay core cut-off	80	m3	50	4,000	600mm wide at top of bank graded at approx. 60 deg to 1m below top of sheet pile
D1d	170mm thick Reno Mattress on BIDIM A44 geotextile	84	m2	45	3,738	Geotextile includes regional multiplier of 1.05 (p676 Rawlinsons 2012), Reno Mattress estimated based on prices for thin gabion walls on: http://www.gabion1.com.au/gabion_aus_prices.htm
D1e	Gabion Basket - 1m wide x 1m deep	28	m	365	10,220	Unit rate determined with consideration to prices for thick gabion walls on: http://www.gabion1.com.au/gabion_aus_prices.htm (as a base rate) with an additional allowance for installation based on engineering judgement.
D1f	Stone pitching	5.76	m2	250	1,440	Granite pitching to embankments 150mm to 200mm thick, embedded in mortar. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
D1g	Earthworks & profiling for farmers access track	1	Item	25,100	25,100	Allowance for excavation and grading of 1:12 roadway profile from top of culvert to top of existing bank. Allow excavation and grading of 300m3 material @ $25/m3. Formation of crushed rock access track - allow $220/m for 80m length track.
D2	*Concrete works*					
D2a	Supply of 3.0m high x 3.0m wide x 2.4m long precast box culverts	8	Item	6,157	49,253	Price provided by Humes. Includes delivery to site.
D2b	Installation of 8 No. 3.0m high x 3.0m wide x 2.4m long precast box culverts	8	Item	2,000	16,000	Assumed 41.4 t excavator with operator and fuel and 3 x Group 1 labourers working 10h days for 3.5 days. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
D2c	200mm thick cast in situ headwall, incl formwork & earthworks	10.56	m2	500	5,280	200mm thick cast in situ headwall, approx. 1.6m long. Wall height tapered from H= 3m (at culvert) to H=300mm 32MPa reinforced concrete wall. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
D2d	150mm thick concrete slab	169	m2	75	12,675	32MPa reinforced concrete slabs and thickening on fill. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
D2e	Upstream cut-off-beam - 450mm wide x 1500mm deep	16	m	338	5,400	32MPa reinforced concrete slabs and thickening on fill. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
D2f	Downstream cut-off-beam - 450mm wide x 1000mm deep	16	m	225	3,600	32MPa reinforced concrete slabs and thickening on fill. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
D3	*Gates*					

Item	Description of Works	Qty	Unit	Rate	Sub Total	Comment
D3a	Supply, Delivery & Installation of 4No. 3000mm triple leaf gates	1	Item	93,000	93,000	Cost supplied by AWMA based on supply of 4No. 3000mm wide x 2000mm operating level triple leaf gates with marine grade aluminium construction, manual operation via hand wheel through Right angle bevel gearbox, 316 Stainless steel spindle. Cost for delivery and installation includes: Delivery, Mobilisation / Demobilisation, Labour, LA allowances / accommodation, Anchors / consumables, Crane hire.
D4	*Miscellaneous Items*					
D4a	Guard Rail	50	m	250	12,500	Assume 25m long guard rail to each road edge. Curved galvanised steel double corrugated guard rail with bolts and splice plates allowing for 1800mm long steel post every 1.8m and 2 bullnose terminal sections every 25m. Unit rate determined with consideration to Rawlinsons 2012 (as a base rate) and engineering judgement.
	TOTAL FOR SECTION D C/Forward to Summary				313,006	
Direct Cost	SUBTOTAL				13,014,815	
Design Contingencies	30%				3,904,445	
Contractor Preliminaries, margins and profits	15%				1,952,222	Includes insurance, site establishment, contractor margins in addition to the preliminaries listed in Section A
Contract Variation Contingencies	5%				97,611	
	ANTICIPATED TOTAL (+/- 30%)				18,969,093	
Total Construction Cost	ANTICIPATED TOTAL				18,969,093	

PRELIMINARY COST ESTIMATE

Project: Engineering feasibility of potential management actions, Lake Albert and Narrung Narrows
Project Number: VE23776
Date: 4-Dec-13
Design Option Description: Narrung Narrows Dredging Option

Item	Description of Works	Qty	Unit	Rate	Sub Total	Comment	Comments or Risk Flag
A	Section A - General Items						
A1	*DEWNR Project Delivery Fees*						
A1a	DEWNR Project Management Costs	1	Item	$ 500,000.00	$ 500,000.00	Assumed DEWNR salary and operating expenses to deliver project. Estimated costs for 4 x FTE for 12 months	
A1b	Project Management Expenses (Goods & Services, Motor Vehicle Costs, Employee Costs)	1	Item	$ 50,000.00	$ 50,000.00	Project office expenses including vehicle hire and travel expenses	
A2	*Approvals and Clearances, Communications, Land Access Agreements*						
A2a	Approvals (Licences and Permits)	1	Item	$ 10,000.00	$ 10,000.00	All necessary licensing and permitting to undertake works. Specific permits will be required for disposal.	
A2b	Cultural heritage	0	Item		$ -	Specific requirements unknown - DEWNR to advise.	May not be required - DEWNR to advise.
A2c	Lease / land access agreement / disposal of WDF or other material	1	Item	$ 2,400,000.00	$ 2,400,000.00	At this stage of the concept, no target disposal sites have been identified and it is assumed that a disposal cost would be required. Based on disposal works for recent lower River Murray projects, a figure of $1.00 / m3 has been assumed. Note that the $1/m3 benchmark was for significantly smaller volumes and a decrease in unit rate may be possible based on higher volumes.	DEWNR have advised a target dredge volume of 6,000,000 m3 of slurry. For the purposes of the preliminary estimate, a solids percentage of 40% for disposal has been assumed. Risk: Disposal locations have not been identified and assessed. Land disposal and treatment of this volume of material will require a very large area (km's in length and width).
A2d	Community Consultation	1	Item	$ 35,000.00	$ 35,000.00	Establishment of signage, community information sessions, landholder consultation. Given the proximity of the site to towns (Narrung etc) effective consultation will be important for project success.	
A2e	Ecological and Environmental Advice	1	Item	$ 30,000.00	$ 30,000.00	Development and implementation of EHS plan and procedures and related environmental planning and assessment.	
A3	*Preliminary Investigations*						
A3a	Detailed Design of regulating structures and channel, specification, tender documentation, schedule development, other site assessments.	1	Item	$ 100,000.00	$ 100,000.00	Development of design, tender specification, tender briefing, disposal site planning and survey, de-watering process design etc	
A3b	Finalisation of disposal site locations (and agreements) for exacvated channel spoil and dredge spoil.	1	Item	$ 15,000.00	$ 15,000.00	Development of land access and disposal agreement legal documentation. Legal fees etc.	
A3c	Tender cost estimate review	1	Item	$ 10,000.00	$ 10,000.00	If required as part of DEWNR process.	
A4	*Other DEWNR Managed Works*						
A4a	Bathymetrical Surveys	1	Item	$ 50,000.00	$ 50,000.00	Provision for bathymetric surveys during and post dredge works. Number of surveys required unknown	
A4b	Construction Manager	1	Item	$ 130,000.00	$ 130,000.00	Duration unknown	
A4c	Site Supervision	1	Item	$ 130,000.00	$ 130,000.00	Duration unknown	
A5	*Other DEWNR Managed Works*						
A5a	Monitoring Framework Development	1	Item	$ 10,000.00	$ 10,000.00	Development of robust monitoring framework to monitor and manage the risks associated with the dredge and disposal works	
A5b	Monitoring Framework Implementation - water quality, EPA involvement	1	Item	$ 15,000.00	$ 15,000.00	Implementation of robust monitoring framework to monitor and manage the risks associated with the works	
A5c	Ecological monitoring implementation - DEWNR internal, or site supervisor	1	Item	$ 15,000.00	$ 15,000.00	Implementation of robust ecological monitoring to monitor and manage the risks associated with the works	
	TOTAL FOR SECTION A C/Forward to Summary				$ 3,500,000.00		
B	Section B - Site Works						
B1	*Dredging and Disposal Site Works*						
B1a	Mobilisation and demobilisation of Dredge, surface equipment and dredging site establishment	1	Item	$ 250,000.00	$ 250,000.00	Estimate based on rates for mobilisation from recent projects. Will be dependent on type of dredge required.	Risk: Dredge type and availability may impact cost.
B1b	Provision for mobilisation and demobilisation of other equipment for disposal site preparation and other remediation requirements	1	Item	$ 50,000.00	$ 50,000.00	Estimate based on market tested rates for mobilisation of suitable land based plant and equipment for the type and location of works	
B1c	Installation of Silt Curtain	0	Item	$ -	$ -	Assumed not required based on difficulties with silt containment devices in recent lower lakes projects.	Risk - managing water quality.
B1d	Provision for management of silt curtain	0	Item	$ -	$ -	Assumed not required based on difficulties with silt containment devices in recent lower lakes projects.	Risk - managing water quality.

Item	Description of Works	Qty	Unit	Rate	Sub Total	Comment	Comments or Risk Flag
B1e	Dredge works (to a specified depth and width TBC). Transfer to a suitable disposal site (yet to be identified)	6000000	m3	$ 16.00	$ 96,000,000.00	Unit rate based on reviewed rates for dredging and disposal in a similar environment, (and comparison rates provided by DEWNR), within the assumed distance parameters of 5km's from dredge location. Historical ranges reviewed $16 per m3 (Currency Creek and Narrung) , $5 per m3 (Murray Mouth program) to $30 per m3 as provided by DEWNR (including allowance for suction cut dredging, transportation, dewatering). With the exception of the Murray Mouth costs, the other ranges reviewed were based on significantly smaller volume projects. $16 per m3 assumed for this estimate as cost break down for Murray Mouth project unknown. Unit rate likely to change based on efficiency of volume (this has not been factored in) and depending on dredge distance required, number of booster pumps and pipelines etc. Production rates not yet estimated.	Risk: Unit rate may change depending on dredge distance required and number of booster pumps and pipelines etc.
B1f	Preparation for land based disposal site for dredged material, sedimentation/dewatering area as required and contaminated treatment area and additional access tracks if required.	112000	m3	$ 16.00	$ 1,792,000.00	Provision estimate only based on construction of disposal site to contain 6m m3 of material, earthworks bunds with 2m high walls, 2m crest and 1:3 slope, locally won material - volume approx 112,000m3 (L: 2km's, W: 1.5kms). Unit rate based on bulk cut and fill earth works at $16m3 (Currency Creek disposal site works). Specific cost details will not be known until disposal site, de-watering, treatment and associated requirements are further developed.	Risk: Unknown requirements and volumes for potential ASS treatment and actual material volumes or disposal site design.
B1g	nknown and could vary significantly depending on the nature of the material.	1	Item	$ 500,000.00	$ 500,000.00	$500k provisional amount included for site management and treatment This cost item has the potential to change significantly and should be identified as a high risk. Provisional estimate only as treatment and disposal site management method unknown.	Risk: Unknown requirements and volumes for potential ASS treatment and actual material volumes or disposal site design.
B1h	Dewatering management from land disposal location (provision only)	1	Item	$ 100,000.00	$ 100,000.00	De-watering establishment, pipes and pumps to return water to lake or suitable location. Specific cost details will not be known until disposal site and associated requirements are confirmed.	Risk: Specific requirements unknown until disposal location identified.
B1i	Levelling / landform of disposal site and disposal site maintenance	2400000	m3	$ 0.80	$ 1,920,000.00	Unit rate based on works of a similar nature in the region, however smaller scale. Volume assumed to be solid content only.	Risk: Specific requirements unknown until disposal location identified.
B2	*Supporting Site Works - Preferred Option*						
B2a	Site survey - if required post works, includes stockpile verification survey	1	Item	$ 25,000.00	$ 25,000.00	Provision for additional survey requirements at disposal site. Required for verification of volumes and assumed acceptance by landholder	
B2b	Water quality monitoring and testing	1	Item	$ 20,000.00	$ 20,000.00	Requirement under legislation and contractors PMP	
B2c	Waste Derived Fill, PASS, density testing	1	Item	$ 50,000.00	$ 50,000.00	Requirements for disposal to preferred location and contractors PMP	Risk: Unknown requirements and volumes for potential ASS treatment
B2d	Temporary fencing and works along access roads/alignment to disposal site	1	Item	$ 20,000.00	$ 20,000.00	Some level of temporary fencing works likely required at disposal site.	Risk: Specific requirements unknown until disposal location identified.
B2e	Reinstatement/remediation of access tracks at disposal site	1	Item	$ 15,000.00	$ 15,000.00	Assumed requirement under land access approval conditions.	Risk: Specific requirements unknown until disposal location identified.
B2f	Site clean up / fencing / general remediation	1	Item	$ 20,000.00	$ 20,000.00	Assumed requirements under project approval conditions. Remediation of surrounding area to make good.	Risk: Specific requirements unknown until disposal location identified.
B2g	CITL, EPA Fees and permits provision	1	Item	$ 40,000.00	$ 40,000.00	Assumed requirement for construction and dredge works	
	TOTAL FOR SECTION B C/Forward to Summary				$ 100,802,000.00		
Project Delivery Costs					$ 3,500,000.00		
Project Delivery Contingency	10%				$ 350,000.00		Risk: Dredge design, disposal location, modelling, treatment requirements etc have not been undertaken and all estimates are high level.
Project Construction Cost					$ 100,802,000.00		
Project Construction Contingency	15%				$ 15,120,300.00		Risk: Dredge design, disposal location, modelling, treatment requirements etc have not been undertaken and all estimates are high level. In $ value this is a significant contingency, however has been included given the uncertainty around many aspects of this option.
Total Preliminary Estimate					$ 119,772,300.00		

Note: Preliminary estimate not based on engineering design or QS. Estimate based on rates from similar projects (Currency Creek and Clayton) and assumed tasks and cost items only. This estimate should not be used for design or investment decisions or processes.

Appendix C. Kick Off Meeting Minutes & Correspondence

Purpose of Meeting	Project Kick-Off Meeting (Project Team)		
Project	Engineering Feasibility of Potential Management Actions, Lake Albert & Narrung Narrows	**Project No**	130128D1052 / VE23776
Prepared By	Matt Tooley	**Phone No**	08 84243840
Place of Meeting	DEWNR (Rm 2, Level 5 91-97 Grenfell St)	**Date/Time**	3 April 2013 2:30-3:30pm

Present	***DEWNR:*** Theresa Myburgh (TM) John Howard (JH)	***SKM:*** Dan Mollison (DM) Matthew Tooley (MT)
Distribution	As listed above and SKM team	**Apologies**

No.	Meeting Agenda:	Outcome / Action:
1.	Team Member Intro & Roles	Matt introduced the SKM team and discipline leads. Theresa is the client PM with John Howard as the project sponsor/director.
2	Project Scope and Methodology	Matt ran through the project scope of works and methodology. Comments raised / discussed are as outlined below: • **Task 1** – Site visit scheduled tentatively for Thursday 11 April. • **Task 2 –** A list of available documents are referenced in the Literature Review. SKM to provide a list of additional reports required (sent via email on 3 April to TM). DEWNR also to provide bathymetry reports/maps for Narrung Narrows, monitoring station information, CSIRO soil sample test results, 2006 MDBA concept cost review report. Remainder unchanged.

		• **Task 3 –** SKM to consider a combination of options as appropriate from an engineering perspective to achieve project objectives. This may alter the proposed approach following the hold point and will be discussed with DEWNR at that time. Remainder unchanged. • **Task 4 –** SKM to consider at a high level, as appropriate, the additional options as stated in the literature review document (section 6). As advised by JH these have been discounted for various reasons and as such may not be suitable. These additional options will not be included in the MCA, unless they are assessed by the team as worthy of inclusion for further assessment. Internal MCA scoring will be undertaken as a team during the 1 day internal workshop. • **Task 5 -** Unchanged • **Task 6 -** Unchanged • **Task 7 -** Unchanged • **Hold Point -**Unchanged • **Task 8 -** Unchanged • **Task 9 -** Unchanged
3	Project Program	As per the program. Noted that the site visit will be pushed out into the following week commencing 8 April (tentatively proposed for Thursday 11 April).
4	Reporting expectations / Progress reporting	Sent with the invoice. SKM standard PSR (project status report) to be used.
5	Invoicing requirements	4 weekly in electronic version sent to Theresa M with John Howard cc'd.
6	Communication plan	Theresa M will be the point of contact for SKM for this project (John H to be cc in only on correspondence requiring formal decisions, not required on day to day matters). Matt Tooley will be the main SKM point of contact with Dan Mollison as another point of contact as required.

7	General	▪ All media, landowner and local business etc. contact shall be directed to DEWNR. SKM team not to discuss any aspects of the project. ▪ A presentation to the steering committee may be required during the project; DEWNR will provide advanced advice of potential dates. ▪ A 3 way phone discussion is to be arranged by DEWNR for week commencing 8 April between DEWNR / SKM / WBM to discuss modelling interfaces and timing etc. ▪ No salinity modelling results for each of the potential management action (PMA) will be available for the MCA development. As such comparison of the PMA impact to reduce salinity will be based on engineering judgement around water volume transfer only. ▪ Business case to commence in October / November 2013. Noted that there would be value in reviewing the business case requirements prior to hold point 1 to identify efficiencies for DEWNR in commencing the Business Case earlier.

Tooley, Matthew (SKM)

From:	Tooley, Matthew (SKM)
Sent:	Friday, 28 June 2013 5:37 PM
To:	Myburgh, Theresa (DEWNR) (Theresa.Myburgh@sa.gov.au)
Cc:	Mollison, Daniel (SKM); Argue, Jerome (SKM)
Subject:	VE23776 Engineering Feasibility for Lake Albert & Narrung Narrows - Qualitative MCA Draft and Technical Response
Attachments:	MCA Qualitative_DRAFT 28Jun13.pdf

Hi Theresa,
Please find below (under the email from Rohan titled 'Info req for model meshes'), SKM's response to the technical queries in RED regarding the Coorong connector (channel and pipe) and the permanent regulating structure. Please note that 2 options have been considered for the Coorong connector (in line with the Coorong Connector modelling flow chart):

- Longest alignment (URS 2006 channel alignment)
- Shortest alignment (Peter Shepherd location 1 / second location observed during the site visit).

Please also find attached the qualitative MCA assessment in draft for your review and comment prior to distribution to the Steering Committee. We are more than happy to catch up early next week to discuss the outcomes.

Cheers,

Matthew Tooley
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E mtooley@globalskm.com
www.globalskm.com

From: Myburgh, Theresa (DEWNR) [mailto:Theresa.Myburgh@sa.gov.au]
Sent: Friday, 14 June 2013 3:22 PM
To: Tooley, Matthew (SKM)
Subject: FW: Info req for model meshes

Hi Matt,
Please see below. I've highlighted the questions that relate to your work, the rest I shall source answers to.
Thanks for today
Cheers
Theresa

From: Rohan M. Hudson [mailto:Rohan.Hudson@bmtwbm.com.au]
Sent: Friday, 14 June, 2013 1:25 PM
To: Myburgh, Theresa (DEWNR)
Subject: RE: Info req for model meshes

Hi Theresa,

The time frames sound reasonable / achievable.

Information required includes:

Info for scenarios

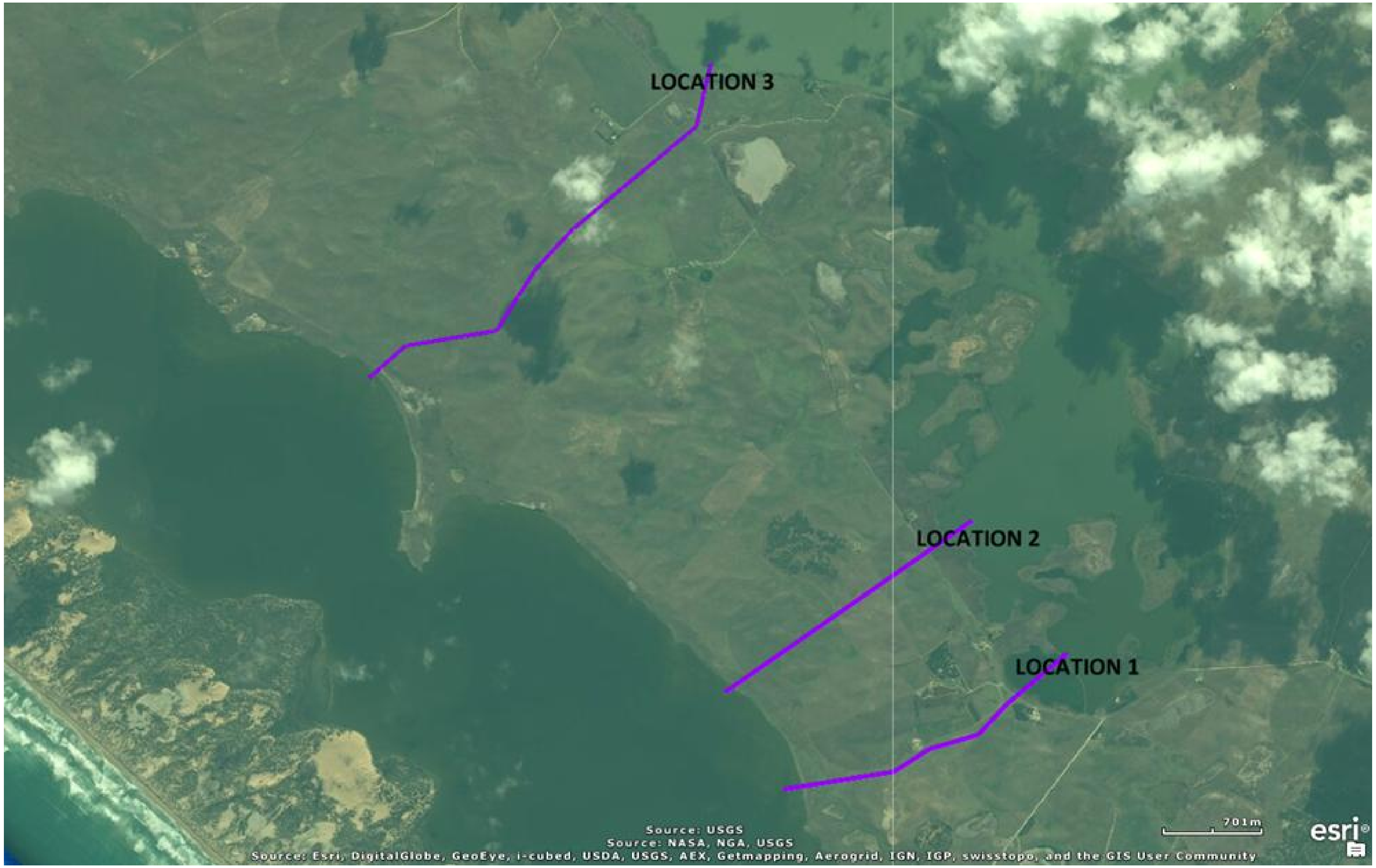
- Coorong Connector – location (i.e approx. alignment), channel invert and width and structure invert and width. I will also need some info regarding its operation (i.e either a time series of when (and to what degree) it is open. Or a description of structure opening vs water level targets (you may need to refer to the automated barrage report for this). As a first pass it may be possible to just draw 3 GL/day (or whatever required discharge is) through the channel (using a pump structure). If the option looks good we could do further refinement at a later stage.

SKM Response: Pipe and Channel:
The following table present the modelling input details requested for both the channel and pipe. The references for various inputs are sited. Please note that these are based on preliminary assessments considering the design already undertaken by others in order to progress the modelling.

	Channel - Long Alignment	Channel - Short Alignment	Pipe - Long Alignment	Pipe Short Alignment	Comment
Coorong Elevation, mAHD	0.2	0.2	0.2	0.2	Water for a Healthy Country - Hydrodynami (2005) - Section 3 notes it is dependent on r between 1mAHD during spring tides and 0.2

Lake Albert Elevation, mAHD	0.72	0.72	0.72	0.72	URS Report (2006) Figure 1 mean water leve 0.72mAHD is average Lake Alexandrina Wat
Map Reference	Location 3	Location 1/2			Location 3 - URS(2006); Location 1/2 - DEWI
Length, m	3500	2400			
Base width	10	8			
Side slopes	1 V : 4 H	1 V : 4 H			
Channel Invert Upstream	-1 m AHD	-1 m AHD			
Channel Invert Downstream	-1.48 m AHD	-1.48 m AHD			
Gradient	1 V : 6731 H	1 V : 4615 H			
Pipe Size			DN2400	DN2400	
Pipe Material			Polycrete	Polycrete	
No. of Pipes			4	3	To achieve approx 1GL/day
Invert			-4.79	-4.79	W3 Long Section
Installation			Pipe Jack	Pipe Jack	As advised by Peter Shepherd during site vis

Location map:



- Permanent Narrung structure - location (i.e approx. alignment), structure invert and width (i.e weir length). I will also need some info regarding its operation (i.e a time series of when (and to what degree) it is open.

SKM Response: Permanent Narrung structure

The following table present the modelling input details requested for the permanent Narrung regulator. A number of options were considered including a regulator positioned at the outlet of the Narrung Narrows into Lake Albert which would enable management flexibility of the entire Narrung Narrows. However this would require a regulator / blocking bank structure some 2,500m long. The location can be refined should it be identified that environmental benefit of managing all or part of the Narrows can be achieved. As this is unknown, and given the existing infrastructure that exists, ease of access etc a position at the inlet to the Narrow's was selected for modelling purposes.

Narrung Narrows Permanent Regulating Structure		Comment
Location	At inlet to Narrung Narrows (current ferry location)	Lock would be required for boat access.
Structure Invert, mAHD	(-) 2 to (-) 1.5	From Bathymetry provided by DEWNR (email from TM on 3 April 13). Depth selected to align with the approximate natural current depth upstream and downstream of the ferry based on bathymetry results (2011/2012).
Width (weir Length)	230m	Approximate distance of open water span between ferry platforms.

Location map:

Model setup and BC's

- A Start date – while I would like to start on 18/4/2013 (to match existing BC's) I am will to be flexible if required!
- I'll need the latest salinity transect data (this is likely to influence the start date - but not necessarily) and murray mouth data. I can request this direct if you want.
- I'll need a time series: of target lake levels, wellington inflows (and any lake extractions) and net evaporation

Bathymetry / Survey Data

- Narrung Narrows - Survey from October, 2011 and any subsequent is required.
- Clayton Regulator – Any survey data collected in 2012 or 2013. I believe there was a October 2012 survey undertaken.
- Currency Creek – any recent data since regulator removal

- Recent Murray Mouth Data (for mesh update).

Cheers,

Rohan Hudson
Senior Engineer
BMT WBM Pty Ltd

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BMT WBM Pty Ltd, 126 Belford Street, Broadmeadow, Newcastle NSW 2292 Australia

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From: Myburgh, Theresa (DEWNR) [mailto:Theresa.Myburgh@sa.gov.au]
Sent: Friday, 14 June 2013 11:43 AM
To: Rohan M. Hudson
Cc: Higham, Jason (DEWNR)
Subject: Info req for model meshes

Hi Rohan

Could you please send me a list of the information you need in order to create the model meshes for each of the management actions. I met with the engineers this morning, and they will be able to answer these by 28 June.

By way of timing, I'm thinking;
Contract to you by Fri 21 June
Week 1 - model meshes of straight forward mgmt actions (those that don't have lots of engineering questions surrounding them, IE dredging/causeway removal)
End week 1, by 28 June receive engineering advice/answers to your questions on mgmt actions eg permanent structure invert, location…
Week 2-4 create models and test
Monday 22 July commence scenario modelling tasks.

Cheers

Theresa

Theresa Myburgh
Project Manager, Lake Albert
Partnerships | Major Projects |Department of Environment, Water and Natural Resources
Level 5, 91-97 Grenfell Street Adelaide SA 5000 | GPO Box 1047, Adelaide SA 5001
Tel: 08 8463 4435 | Mobile: 0433 221 109| Email: theresa.myburgh@sa.gov.au

Appendix D. Literature Review of Management Actions – Costs and Benefits

Table 6: Appendix B. Literature Review of Management Actions – Costs and Benefits

	Detail	Capital Cost ($M)	Annual Cost ($M)	EC Reduction	Benefit ($M)	Benefit/ Cost	Level of design and assumptions
Dredging of Narrung Narrows	(i) All sections smaller than causeway section dredged to the same area as the causeway section	1.1		115	0.74	0.67	1D energy equation model using 14 locations and steady, gradually varied flow $2/m3 for dredging + $0.5 million for hire of equipment, design, survey, and supervision
	(ii) All sections (except causeway section) smaller than 1000 m2 dredged to area of 1000 m2	4.1		330	2.11	0.52	As above
Coorong connector pipe	Seven Mile Rd alignment - Pump and Pipe - Coorong to Lake Albert	16.2	9				Pumping from Coorong into Lake Albert
	Long Point Rd alignment - Pump and Pipe - Coorong to Lake Albert	31.5	10.6				Pumping from Coorong into Lake Albert
	Location 1 - 2.4 km DN2400 x 2 directional drilled						Unknown - refer to longitudinal section table that specifies indicative flows for a range of differential heads on W3 DWG 210096-001.
Coorong connector channel	1.6 km long channel at southern end 15 GL/month	1.5	0.032	660	4.22	2	Refer Literature Review (2013)
	1.6 km long channel at southern end 90 GL/month	4.6	0.099	960	6.14	0.95	Refer Literature Review (2013)
	1.6 km long channel at southern end 150 GL/month	7.1	0.153	980	6.27	0.63	Refer Literature Review (2013)
	3.85 GL/d channel near Location 3 (URS)	89		~500-1000			Below base case. Two models RMA and CLT box models.
Variations of water levels	(i) Lower lake level to EL 0.5 prior to arrival of a flow greater than 15000 ML/d. Also lower level to EL 0.5 every other month if flow is greater than 15000 ML/d for more than two consecutive months.	0	Small	300	1.9	>> 1	15000 ML/d was chosen as the threshold flow to allow for losses downstream of Lock and to give sufficient margin of safety in the event that the predicted flow was overestimated. Low estimates of EC reduction due to factor of safety. Equation 5.4 of Ebsary (1983): $\Delta\$ = 6400\Delta EC$
	(ii) Fluctuate lake level between EL 0.64 and EL 0.84 if flow at Lock 1 greater than 15000 ML/d for a month.	0	Small	340	2.2	>> 1	As above

Appendix E. Qualitative Multi Criteria Analysis

Qualitative Multi Criteria Analysis Summary - Lake Albert and Narrung Narrows Potential Management Action Engineering Feasibility

Introduction

This is a qualitative MCA assessment only, based on the engineering feasibility of each management action and the potential impact of the management action. As such the qualitative assessment is not intended to rank the management actions with a score but rather to assess their anticipated impact from an engineering perspective.

Impact Ranking

The impact of each management action was assessed against a range of criteria. The indicative impact was based on an engineering assessment only, and is relative to the other management actions. The impact ratings given are: High (H), Medium (M), Low (L), None (N) and Positive (P). This level of assessment was agreed between DEWNR and SKM as a suitable initial approach based on the information available, prior to any further investigation and assessment being undertaken.

Assessment Criteria	1. Dredging of Narrung Narrows	2. Partial or full removal of the causeway	3. Modification of the causeway	4. Coorong connector (channel)	5. Coorong connector (pipe)	6. Permanent regulating structure in Narrung Narrows
1. Engineering Feasibility						
1.2 Option requires significant onland or submerged disposal increasing the risk of acid sulphate soil (ASS) exposure or mobilisation during construction or associated works	H	H	M	H	M	M
1.3 Is the proposed option able to be assessed as stable, serviceable and structurally adequate	M	M	L	L	L	H
1.4 Option implementation requires ground disturbance which is dependant on variable/unknown ground conditions	L	L	M	H	H	H
1.5 Impact on surrounding landowners potentially requiring land acquisition / easements	L	L	L	H	H	L
1.6 Impact on infrastructure and/or lake existing usage (e.g. the ferry, recreational and professional fishing, primary industries, public vehicle and boat access, existing services, pipelines etc.)	M	M	M	L	L	H
2. Construction, Operations and Maintenance						
2.1 Option presents challenging construction, mobilisation access and requirement for unique construction techniques and installation methods	M	L	L	M	H	H
2.2 Expected high level of ongoing maintenance and frequent operation or complexity integrating operation as part of the greater system	M	L	L	M	H	H
2.3 Option presents high OHS safety risk during construction and/or maintenance activities	M	M	L	M	M	H
2.4 Risk of removing management flexibility in lake level operation from option implementation compared to current management regime	N	N	N	P	P	P
3. Financial						
3.1 Relative expected capital costs	M	L	M	H	H	H
3.2 Relative expected operations and maintenance costs	L	L	L	M	M	M

Management Option	
1. Dredging of Narrung Narrows	

Qualitative Assessment Summary

Assessment Criteria - Engineering Assessment	Comments
1. Engineering Feasibility	
1.2 Option requires significant onland or submerged disposal increasing the risk of acid sulphate soil (ASS) exposure or mobilisation during construction or associated works	High Impact - Significant dredging/excavation is associated with this management action. High risk of exposure of PASS material and mobilisation with this option based on CSIRO preliminary results. As has been experienced with recent works within the channel and lakes, the complexities and costs of disposal of dredged material are significant and may be more than the dredging costs themselves. The risks associated with treatment and management of a disposal site will require careful consideration (Currency Creek Regulator Decommissioning is a sound example). It is assumed that submerged disposal would be the preferred approach as the treatments and environmental considerations of land based disposal are significant. Submerged disposal, likely to be at low points within the lakes may require large discharge distances and challenges with silt containment. A potential disposal option is side casting into the reeded sections of the Narrows, however this would be subject to environmental impact assessment and the material would have to remain submerged.
1.3 Is the proposed option able to be assessed as stable, serviceable and structurally adequate	Medium Impact - This management action does not require any new structures or modification to existing structures. Silt containment measures in the lower lakes region in recent times have been problematic to manage. Dredge profile design would likely be required to ensure sustainment of target profile.
1.4 Option implementation requires ground disturbance which is dependant on variable/unknown ground conditions	Low Impact - This management action requires no permanent ground construction works other than minor bank modifications associated with construction activities if on land disposal is required. Geotechnical sampling in the Narrows at target dredging locations would be required prior to works commencing in order to ensure the appropriate dredging method and profile for the insitu material is adopted. If land based disposal is pursued, land access alignments for discharge lines and dewatering/settlement/treatment ponds would be required potentially requiring extensive processing and treatment over time.
1.5 Impact on surrounding landowners potentially requiring land acquisition / easements	Low Impact - Local landowner negotiations / liaison would be required for on land disposal.
1.6 Impact on infrastructure and/or lake existing usage (e.g. the ferry, recreational and professional fishing, primary industries, public vehicle and boat access, existing services, pipelines etc.)	Medium Impact - Disruptions during dredging on the ferry and recreational use of the Narrows due to required dredging exclusion zones. The impact may be greater to recreational and commercial fishermen depending on the timing of the dredging works. Sediment plume mobilisation may also impact primary industries for a short duration during dredging works. Management of silt by silt curtains in the Narrows has been found to be difficult in the past.
2. Construction, Operations and Maintenance	
2.1 Option presents challenging construction, mobilisation access and requirement for unique construction techniques and installation methods	Medium Impact - Mobilisation is not considered significant due to the facilities at the ferry and access for dredge equipment unlikely to be an issue. The challenge will be sourcing a suitable dredger and associated management equipment (e.g. cutter suction, barges etc.) pending option selected.
2.2 Expected high level of ongoing maintenance and frequent operation or complexity integrating operation as part of the greater system	Medium Impact - Additional dredging may be required in the future to maintain increased flows following sediment build-up. If land based disposal is pursued, dewatering/settlement/treatment ponds may potentially require extensive processing and treatment over time.
2.3 Option presents high OHS safety risk during construction and/or maintenance activities	Medium Impact - Dredging and excavation have inherent risks associated with working on water in potential unstable sediments. Different levels of risk would be evident dependant on the method selected (e.g. cutter suction dredge vs. barge based excavation).
2.4 Risk of removing management flexibility in lake level operation from option implementation compared to current management regime	No Impact - No expected impact on operating flexibility associated with dredging. No flexibility will exist for lake level manipulation following implementation of this management action.
3. Financial	
3.1 Relative expected capital costs	Medium Impact - The cost of dredging and disposal is expected to be significant. These costs are also highly variable, being dependant upon ground conditions (ease of dredging), dredging method adopted, estimation of dredging volumes (extent of dredging), and sediment quality (disposal and treatment requirements), discharge distance (pipeline length, booster pumps), land access agreements, silt containment.
3.2 Relative expected operations and maintenance costs	Low Impact - As mentioned in Criterion 2.2, additional dredging may be required in the future to maintain increased flows following sediment build-up and to manage and close out disposal sites if any are land based.
3.3 Other relative expected costs (including planning approval, EIS, indigenous consultation and negotiation, land acquisition, etc.) *	Assessment of these aspects are being considered through investigation works by DEWNR.

Management Action	
2. Partial or full removal of the causeway	

Qualitative Assessment Summary

Assessment Criteria - Engineering Assessment	Comments
1. Engineering Feasibility	
1.2 Option requires significant onland or submerged disposal increasing the risk of acid sulphate soil (ASS) exposure or mobilisation during construction or associated works	High Impact - Significant excavation is associated with this management action. This may also require dredging of the Narrows and areas adjacent to the causeway due to restrictions in order to make this option effective. High risk of PASS exposure and mobilisation with this option based on CSIRO preliminary results. As has been experienced with recent works within the channel and lakes, the complexities and costs of disposal of dredged material are significant and may be more than the dredging costs themselves. The risks associated with treatment and management of a disposal site will require careful consideration (Currency Creek Regulator Decommissioning is a sound example). Preferably the dredged material would be disposed of in an area where it can remain submerged.
1.3 Is the proposed option able to be assessed as stable, serviceable and structurally adequate	Medium Impact - Any modifications will impact ferry operation requiring modifications. Removal of the Narrung bund in close proximity highlighted geotechnical complexities in working in this environment.
1.4 Option implementation requires ground disturbance which is dependant on variable/unknown ground conditions	Low Impact - Dependent upon ground conditions, however no additional structure required with this management action. On ground works may be required for partial removal, however is considered manageable. Stability of sides of excavation during construction is a risk due to expected soft soils.
1.5 Impact on surrounding landowners potentially requiring land acquisition / easements	Low Impact - Local landowner negotiations / liaison would be required for on land disposal and treatment of material if required.
1.6 Impact on infrastructure and/or lake existing usage (e.g. the ferry, recreational and professional fishing, primary industries, public vehicle and boat access, existing services, pipelines etc.)	Medium Impact - Require ferry to be shutdown for construction and modifications. The length of ferry crossing would be increased and it is unknown at this point if this will be feasible or acceptable from a DPTI and planning perspective. This ferry has the longest alternative route in SA and as alternative access across the Narrows would be required during construction works this would be a significant impact (alternative access route approximately 45 km). Disruption to recreational users and commercial fishing during construction activities. Sediment plume mobilisation may also impact primary industries for a short duration during dredging works.
2. Construction, Operations and Maintenance	
2.1 Option presents challenging construction, mobilisation access and requirement for unique construction techniques and installation methods	Low Impact - Site has good access and standard processes for removal.
2.2 Expected high level of ongoing maintenance and frequent operation or complexity integrating operation as part of the greater system	Low Impact - Additional dredging may be required in the future to maintain increased flows following sediment build-up. There will likely be additional ferry operation maintenance requirements associated with lengthening of the ferry route.
2.3 Option presents high OHS safety risk during construction and/or maintenance activities	Medium Impact - Dredging and excavation have inherent risks associated with working on water in potential unstable sediments. Different levels of risk would be evident dependant on the method selected (e.g. cutter suction dredge vs. barge based excavation).
2.4 Risk of removing management flexibility in lake level operation from option implementation compared to current management regime	No Impact - No expected impact on operating flexibility associated with this management action compared to the current state. No flexibility will exist for lake level manipulation following implementation of this management action.
3. Financial	
3.1 Relative expected capital costs	Low Impact - Likely to be the lowest cost of all the management actions due to standard removal processes and good site access. If dredging is also required as part of this option within the Narrows, this would add significant cost. Dredging costs are also highly variable, being dependant upon ground conditions (ease of dredging), dredging method adopted, estimation of dredging volumes (extent of dredging), and sediment quality (disposal and treatment requirements), discharge distance (pipeline length, booster pumps), land access agreements, silt containment.
3.2 Relative expected operations and maintenance costs	Low Impact - Minimal maintenance costs for the causeway. As mentioned in Criterion 2.2, additional dredging may be required in the future to maintain increased flows following sediment build-up. There will likely be additional ferry operation maintenance costs associated with lengthening of the ferry route.
3.3 Other relative expected costs (including planning approval, EIS, indigenous consultation and negotiation, land acquisition, etc.) *	Assessment of these aspects are being considered through investigation works by DEWNR.

Management Action
3. Modification of the causeway

Qualitative Assessment Summary

Assessment Criteria - Engineering Assessment	Comments
1. Engineering Feasibility	
1.2 Option requires significant onland or submerged disposal increasing the risk of acid sulphate soil (ASS) exposure or mobilisation during construction or associated works	Medium Impact - Minimal excavation of natural material expected. Removal of imported material would be required. Reed removal is anticipated to be required downstream of the causeway to facilitate this option. As such dredging works would be required in parallel, there is a high risk of PASS exposure and mobilisation with this option based on CSIRO preliminary results. As has been experienced with recent works within the channel and lakes, the complexities and costs of disposal of dredged material are significant and may be more than the dredging costs themselves. The risks associated with treatment and management of a disposal site will require careful consideration (Currency Creek Regulator Decommissioning is a sound example). Preferably the dredged material would be disposed of in an area where it can remain submerged.
1.3 Is the proposed option able to be assessed as stable, serviceable and structurally adequate	Low Impact - Due to the replacement of all or part of the causeway with concrete culverts, stability review of the structure would be required. The structure will be accessible for maintenance and operation activities as it is part of the existing access road. However, removal of the Narrung bund in close proximity highlighted geotechnical complexities in working in this environment. Risk of insufficient bearing and/or differential settlement if additional loads are to be imposed by culverts which is to be investigated.
1.4 Option implementation requires ground disturbance which is dependant on variable/unknown ground conditions	Medium Impact - This option will be dependent on ground conditions for culvert installation and bedding and also may require piling. Removal of the Narrung bund in close proximity highlighted geotechnical complexities in working in this environment.
1.5 Impact on surrounding landowners potentially requiring land acquisition / easements	Low Impact - Not considered to be a risk with this option. Off site disposal may be needed requiring landowner negotiations for spoil disposal.
1.6 Impact on infrastructure and/or lake existing usage (e.g. the ferry, recreational and professional fishing, primary industries, public vehicle and boat access, existing services, pipelines etc.)	Medium Impact - Require access road to be shut down or restricted for periods during construction, impacting ferry operation. Alternative access across the Narrows may be required during works. Disruption to recreational users during construction activities may be required. If dredging is required, sediment plume mobilisation may also impact primary industries for a short duration during dredging works.
2. Construction, Operations and Maintenance	
2.1 Option presents challenging construction, mobilisation access and requirement for unique construction techniques and installation methods	Low Impact - Site has good access and standard processes for removal. Modifications to the existing causeway however could be complex depending on available foundation etc. Coffer dam installation (if required) may be challenging given recent experiences with bunding in this region.
2.2 Expected high level of ongoing maintenance and frequent operation or complexity integrating operation as part of the greater system	Low Impact - Potential for increased requirement for maintenance of the modified structure compared to the current state but considered minimal, as additional dredging may be required in the future to maintain increased flows following sediment build-up.
2.3 Option presents high OHS safety risk during construction and/or maintenance activities	Low Impact - Standard on land works required. A coffer dam upstream and downstream may be required.
2.4 Risk of removing management flexibility in lake level operation from option implementation compared to current management regime	No Impact - No expected negative impact on operating flexibility associated with this management action compared to the current state. No flexibility will exist for lake level manipulation following implementation of this management action.
3. Financial	
3.1 Relative expected capital costs	Medium Impact - Standard excavation and installation process with good site access. Box culverts can be sized and combined for a range of width and length requirements. Cost risks associated with suitable foundations may exist following further investigation. The extent of dredging (unknown) within the Narrows, would add significant cost. Dredging costs are also highly variable, being dependant upon ground conditions (ease of dredging), dredging method adopted, estimation of dredging volumes (extent of dredging), and sediment quality (disposal and treatment requirements), discharge distance (pipeline length, booster pumps), land access agreements, silt containment.
3.2 Relative expected operations and maintenance costs	Low Impact - Potential for increased requirements for operations and maintenance of the modified structure. As mentioned in Criterion 2.2, additional dredging may be required in the future to maintain increased flows following sediment build-up.
3.3 Other relative expected costs (including planning approval, EIS, indigenous consultation and negotiation, land acquisition, etc.) *	Assessment of these aspects are being considered through investigation works by DEWNR.

Management Action
4. Coorong connector (channel)

Qualitative Assessment Summary

Assessment Criteria - Engineering Assessment	Comments
1. Engineering Feasibility	
1.2 Option requires significant onland or submerged disposal increasing the risk of acid sulphate soil (ASS) exposure or mobilisation during construction or associated works	High Impact - Significant excavation is required, the majority is on land, with likely reduced PASS exposure risk. Excavation and grading of sediments within Lake Albert and Coorong will be required around the inlet and outlet locations and PASS risk managed appropriately. As has been experienced with recent works within the channel and lakes, the complexities and costs of disposal of excavated material are significant and may be more than the excavation costs themselves.
1.3 Is the proposed option able to be assessed as stable, serviceable and structurally adequate	Low Impact - This options requires the construction of a regulator and bridge(s), depending on location required to allow access across the channel. Stability assessments would be required for the channel and associated infrastructure to ensure adequately designed for ground conditions. Regulating structure may require piles to resist uplift due to buoyancy when the ground water level is higher than the channel water level. Regulators to be positioned with consideration to accessibility and operability e.g. automation.
1.4 Option implementation requires ground disturbance which is dependant on variable/unknown ground conditions	High Impact - Highly dependent upon ground conditions for channel excavation and also regulator and bridge(s) installation. This could be a significant cost item as excavation technique/machinery is dependent on ground profile (see below), which varies significantly across alignment options.
1.5 Impact on surrounding landowners potentially requiring land acquisition / easements	High Impact - Land acquisition / easements will be required for the entire length of the channel as well as for soil disposal.
1.6 Impact on infrastructure and/or lake existing usage (e.g. the ferry, recreational and professional fishing, primary industries, public vehicle and boat access, existing services, pipelines etc.)	Low Impact - Minor road closure/disruptions during construction of bridge(s). Minimal impact on primary industries and landholder activity in close proximity. No impact on ferry and recreational use of the Narrows.
2. Construction, Operations and Maintenance	
2.1 Option presents challenging construction, mobilisation access and requirement for unique construction techniques and installation methods	Medium Impact - Significant construction works required but not complex processes. The spoil volumes will be extensive and disposal will be a challenge, however suitable disposal arrangement have been reached for excavation works recently in the region. Significant dewatering will be required during construction.
2.2 Expected high level of ongoing maintenance and frequent operation or complexity integrating operation as part of the greater system	Medium Impact - A significant level of additional maintenance required for new channel, bridge and regulator. Regulator would also require regular onsite operation during periods of flow passage. Automation of the regulator may be a consideration.
2.3 Option presents high OHS safety risk during construction and/or maintenance activities	Medium Impact - Significant increase in maintenance work associated with working on or near water. Significant level of construction works has inherent risks. In addition, the channel may need to be fenced to stop live stock or community access (to be negotiated with the land owner and dependent on batter slope adopted).
2.4 Risk of removing management flexibility in lake level operation from option implementation compared to current management regime	Positive Impact - This option is a wholesale change to the historical operation of the lake through connection to the Coorong. However there will be increased management flexibility with the installation of a regulator in the channel.
3. Financial	
3.1 Relative expected capital costs	High Impact - The cost of excavation and disposal is expected to be significant. These costs are also highly variable, being dependant upon ground conditions (ease of excavation), estimation of excavation volumes (extent of excavation), and spoil quality (disposal requirements). Other significant capital costs include the new regulating structure and bridge(s).
3.2 Relative expected operations and maintenance costs	Medium Impact - As mentioned in Criterion 2.2, additional maintenance and operation will be required for the new infrastructure. This could be reduced over asset lifecycle cost via gate automation.
3.3 Other relative expected costs (including planning approval, EIS, indigenous consultation and negotiation, land acquisition, etc.) *	Assessment of these aspects are being considered through investigation works by DEWNR.

Management Action
5. Coorong connector (pipe)

Qualitative Assessment Summary

Assessment Criteria - Engineering Assessment	Comments
1. Engineering Feasibility	
1.2 Option requires significant onland or submerged disposal increasing the risk of acid sulphate soil (ASS) exposure or mobilisation during construction or associated works	Medium Impact - Although significant excavation is associated with a trenching option (less with directional drilling), majority is on land with reduced PASS exposure risk. Excavation within Lake Albert and Coorong will be required and PASS risk managed appropriately. As has been experienced with recent works within the channel and lakes, the complexities and costs of disposal of excavated material are significant and may be more than the excavation costs themselves.
1.3 Is the proposed option able to be assessed as stable, serviceable and structurally adequate	Low Impact - Below ground pipelines are more difficult to access for service compared to above ground or shallow buried pipe lines. Careful consideration to pipe material / type of valves etc. that are suitable to the environment would be required, in addition considering defouling requirements.
1.4 Option implementation requires ground disturbance which is dependant on variable/unknown ground conditions	High Impact - Highly dependent upon ground conditions. Geotechnical risk for directional drilling as limited jacking ability. May need to consider full depth trenching, shallow burial or above ground installation options to reduce geotechnical risks and also spoil removal and disposal.
1.5 Impact on surrounding landowners potentially requiring land acquisition / easements	High Impact - Land acquisition / easements will be required for the entire length of the pipe as well as for soil disposal.
1.6 Impact on infrastructure and/or lake existing usage (e.g. the ferry, recreational and professional fishing, primary industries, public vehicle and boat access, existing services, pipelines etc.)	Low Impact - Minor road closure/disruptions during construction of pipeline. Minimal impact on primary industries and landholder activities in close proximity to the construction site. No impact on ferry and recreational use of the Narrows.
2. Construction, Operations and Maintenance	
2.1 Option presents challenging construction, mobilisation access and requirement for unique construction techniques and installation methods	High Impact - Pipe jacking would require significant temporary works, including jacking and receiving pits, and possibly sheet pile cofferdams. Other pipe jacking risks include confined space work, ingress of water and deviation of alignments (due to voids/groundwater/rock). If trenching was undertaken significant dewatering would be required during construction.
2.2 Expected high level of ongoing maintenance and frequent operation or complexity integrating operation as part of the greater system	High Impact - Additional maintenance required for new pipe. Regulating valves would also require frequent operation. Automation of the valves may be a consideration.
2.3 Option presents high OHS safety risk during construction and/or maintenance activities	Medium Impact - Significant level of construction works has inherent risks. Maintenance activities would be limited to the regulating and isolation valves/equipment.
2.4 Risk of removing management flexibility in lake level operation from option implementation compared to current management regime	Positive Impact - This option is a wholesale change to the historical operation of the lake through connection to the Coorong. However there will be increased management flexibility with the installation of regulating valves/equipment.
3. Financial	
3.1 Relative expected capital costs	High Impact - Significant cost items for this management action include the supply and delivery of very large pipework and valving, incorporating multiple number of pipes to achieve the flow capacity requirements. The valve and pipe material need to be suitable for the environment they will be exposed to, allowance for defouling may also be required. In addition to this the cost of excavation and disposal is expected to be significant but less than the channel option. These costs are also highly variable, being dependant upon ground conditions (ease of excavation), estimation of excavation volumes (extent of excavation and installation method), and spoil quality (disposal requirements).
3.2 Relative expected operations and maintenance costs	Medium Impact - As mentioned in Criterion 2.2, additional maintenance and operation will be required for the new infrastructure. This could be reduced via valve automation when compared to asset lifecycle cost.
3.3 Other relative expected costs (including planning approval, EIS, indigenous consultation and negotiation, land acquisition, etc.) *	Assessment of these aspects are being considered through investigation works by DEWNR.

Management Action
6. Permanent regulating structure in Narrung Narrows

Qualitative Assessment Summary

Assessment Criteria - Engineering Assessment	Comments
1. Engineering Feasibility	
1.2 Option requires significant onland or submerged disposal increasing the risk of acid sulphate soil (ASS) exposure or mobilisation during construction or associated works	Medium Risk - Risk of PASS exposure and mobilisation with this option based on CSIRO preliminary results. Dredging would be required at and around the regulator location. As has been experienced with recent works within the channel and lakes, the complexities and costs of disposal of dredged material are significant. The risks associated with treatment and management of a disposal site will require careful consideration (Currency Creek Regulator Decommissioning is a sound example). Preferably the dredged material would be disposed of in an area where it can remain submerged.
1.3 Is the proposed option able to be assessed as stable, serviceable and structurally adequate	High Impact - This options requires the construction of a regulator within the Narrows, located in poor ground conditions. If existing ground conditions are unfavourable the regulator could be founded on suitable deep foundations (e.g. timber piles). Long piles are likely required. This option would have a significant serviceability requirement compared to other options, that would require on-water activities for access. If the regulator is required to be trafficable there would be additional serviceability and stability challenges.
1.4 Option implementation requires ground disturbance which is dependant on variable/unknown ground conditions	High Impact - Highly dependent upon ground conditions affecting e.g. cut off sheet pile depth, pile depth, excavation extents, footing design etc.
1.5 Impact on surrounding landowners potentially requiring land acquisition / easements	Low Impact - Depending on the location selected, some right of access / easements may need to be negotiated. Considered minor.
1.6 Impact on infrastructure and/or lake existing usage (e.g. the ferry, recreational and professional fishing, primary industries, public vehicle and boat access, existing services, pipelines etc.)	High Impact - Depending on location selected, ferry may be disrupted during construction. Alternative access across the Narrows may be required during works. The regulator extending the full width will also require a lock for boat access but will impact free movement for recreational use and primary industries. If the ferry is to be decommissioned, the regulator may need to be trafficable to the required transport standards. This may require additional automation or onsite personnel.
2. Construction, Operations and Maintenance	
2.1 Option presents challenging construction, mobilisation access and requirement for unique construction techniques and installation methods	High Impact - Challenging construction method in poor ground conditions. Require dredging and barge works with significant on water activities. Depending on location, site access may be difficult requiring construction road access. Works would be complex depending on available foundation etc. Coffer dam installation for dewatering may be challenging given recent experiences with bunding in this region.
2.2 Expected high level of ongoing maintenance and frequent operation or complexity integrating operation as part of the greater system	High Impact - Depending on the regulator size and how often it is operated (management regime), significant additional maintenance and frequent onsite gate operation may be required. Automation of the gates should be considered. Additional controls / communications with larger system may be required depending on management regime adopted (Tauwitchere barrage, Goolwa regulator etc.). May require additional operational staff.
2.3 Option presents high OHS safety risk during construction and/or maintenance activities	High Impact - Construction of regulator has inherent risks associated with working on water. Significant increase in maintenance work associated with working on or near water. Careful selection of gate type to minimise operator manual handling.
2.4 Risk of removing management flexibility in lake level operation from option implementation compared to current management regime	Positive Impact - Allow lake level operating flexibility in Lake Albert (at and below pool or Lake Alexandrina level). Allow poor quality water to be diverted as flood waters rise. Create a physical barrier to separate the two lakes.
3. Financial	
3.1 Relative expected capital costs	High Impact - The cost of the regulator is expected to be significant. The cost is highly dependent on the location selected e.g. At the inlet (230m) or the Narrows outlet (2500m).
3.2 Relative expected operations and maintenance costs	Medium Impact - Significant operations and maintenance costs for the new structure and gate operation. This could be reduced by gate automation. Savings may also be possible if the ferry can be replaced by a trafficable regulator at the inlet.
3.3 Other relative expected costs (including planning approval, EIS, indigenous consultation and negotiation, land acquisition, etc.) *	Assessment of these aspects are being considered through investigation works by DEWNR.

Appendix F. Design Criteria

Appendix G. Modelling Results

Software

Channel design is typically undertaken using engineering design software to solve hydraulic equations for a range of input parameters and optimise channel dimensions and slopes. Two common 1-dimensional software packages are HEC-RAS and MIKE 11.

HEC-RAS is a freely available software package developed by the US Army Corps of Engineers. Given channel dimensions, hydraulic structure dimensions, flow rates, and downstream water levels, HEC-RAS will produce water surface profiles and stream velocity. HEC-RAS can be used either as a GIS add-in to create georeferenced model, or in a non-georeferenced interface if project requirements are more basic.

MIKE 11 is a commercial 1-dimensional hydraulic modelling tool which is a part of the MIKE ZERO software package. Given channel dimensions, hydraulic structure dimensions, and either flow rates or water levels, MIKE 11 will similar outputs to HEC-RAS. MIKE 11 operates in a georeferenced interface, and can be linked with MIKE 21 to provide 2-dimensional flood maps if required.

The Coorong Connector Channel at Alignment 2 was modelled using MIKE 11 as the boundary conditions for the design consisted of water levels at each end of the channel, and flow rates were an output from the model.

Input Data

The primary input data to the MIKE 11 model were:

- Up and downstream water levels
- Channel dimensions
- Gate dimensions and type.

Channel dimensions were determined using trial and error until the required design flow was achieved for the design water level conditions, but constrained by the design criteria for depth and bank slope. Water levels were obtained from historical data provided by BMT for a transient run to check the range of flow conditions which could occur, and from the design criteria for sizing the channel.

Several gate options were obtained from AWMA. Criteria for choice of gates were:

- Low head loss
- Cost effective
- Can be operated by a single operator manually
- Do not require power

The chosen gates are discussed in more detail in Section 5.2.1.

Model Construction

The model consisted of a 1.8 km long trapezoidal channel with control structures at the up and downstream ends. Figure 5 shows the plan view of the model within the MIKE 11 interface. Trapezoidal cross sections were inserted at 50 m intervals (Figure 6).

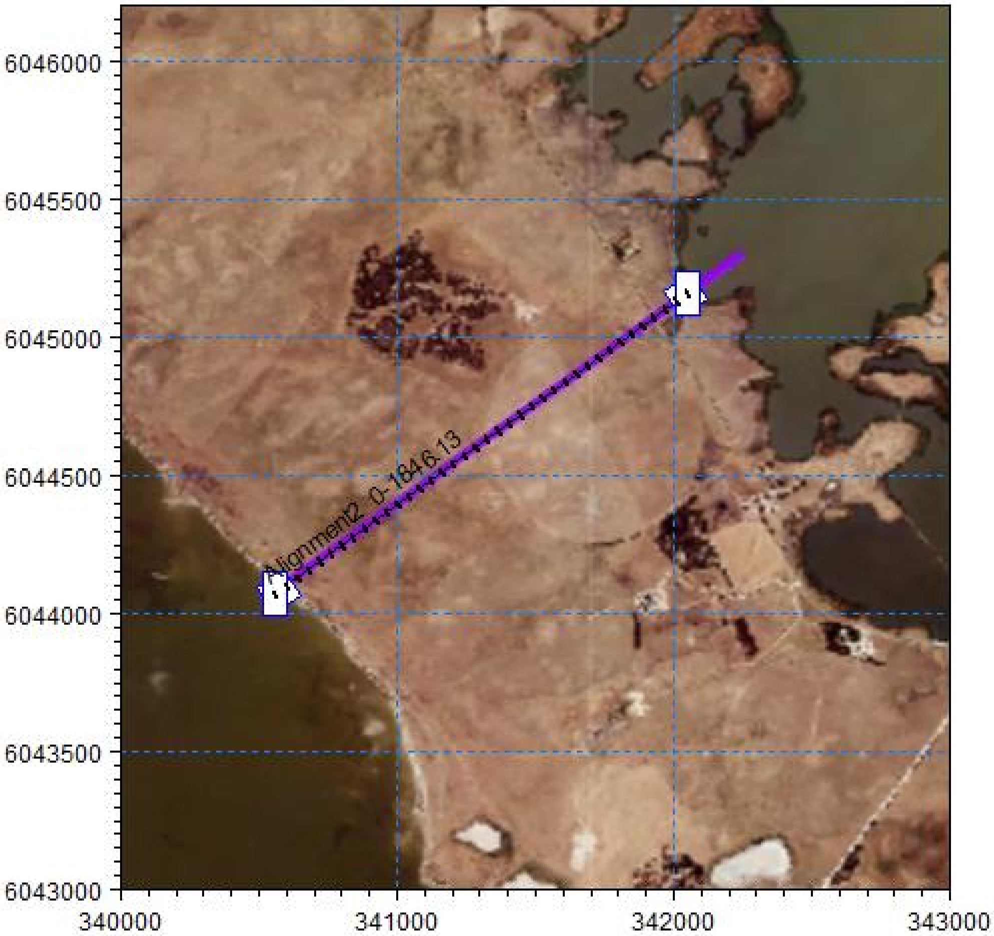
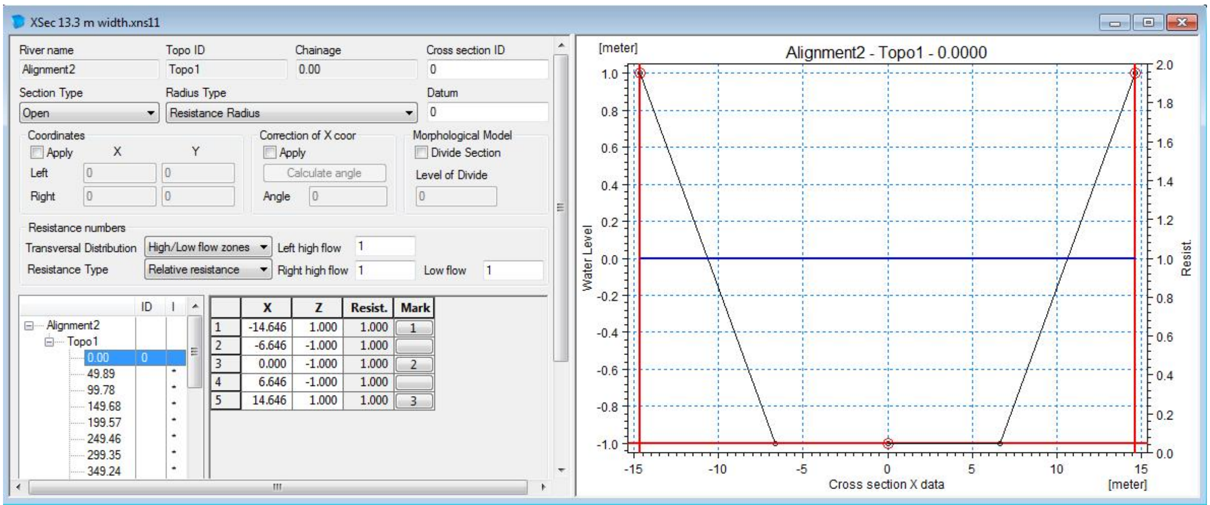


Figure 5: MIKE 11 model layout with cross section widths and structure locations



	X	Z	Resist.	Mark
1	-14.646	1.000	1.000	1
2	-6.646	-1.000	1.000	
3	0.000	-1.000	1.000	2
4	6.646	-1.000	1.000	
5	14.646	1.000	1.000	3

Figure 6: MIKE 11 cross section view

The regulators were entered as box culverts as they will be connected to box culvert car access crossings (Figure 7). When open, the gates will lay flat and provide minimal hydraulic interference, so it was not necessary to include an undershot, overshot, or weir type structure in the model.

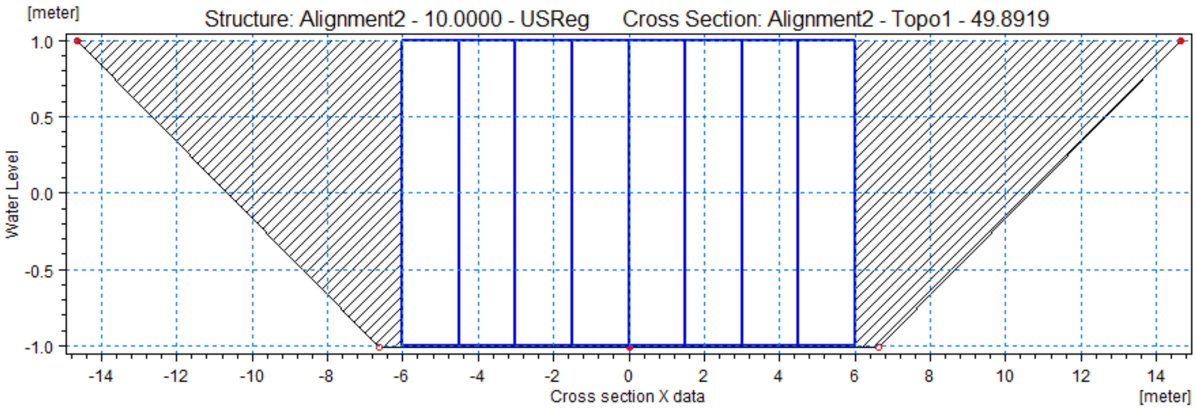


Figure 7: MIKE 11 view of upstream regulator

Manning's roughness 'n' value of 0.035 was used, which is appropriate for a grassed channel with a few weeds but generally well maintained and unobstructed.

Model Results

The water surface for the design condition of +0.5 mAHD water level in Lake Albert and +0.3 mAHD water level in the Coorong is shown in Figure 8. The model showed that with these water levels and a channel base width was 13.3 m, the flow rate through the channel would be 11.37 m^3/s, or 0.98 GL/day.

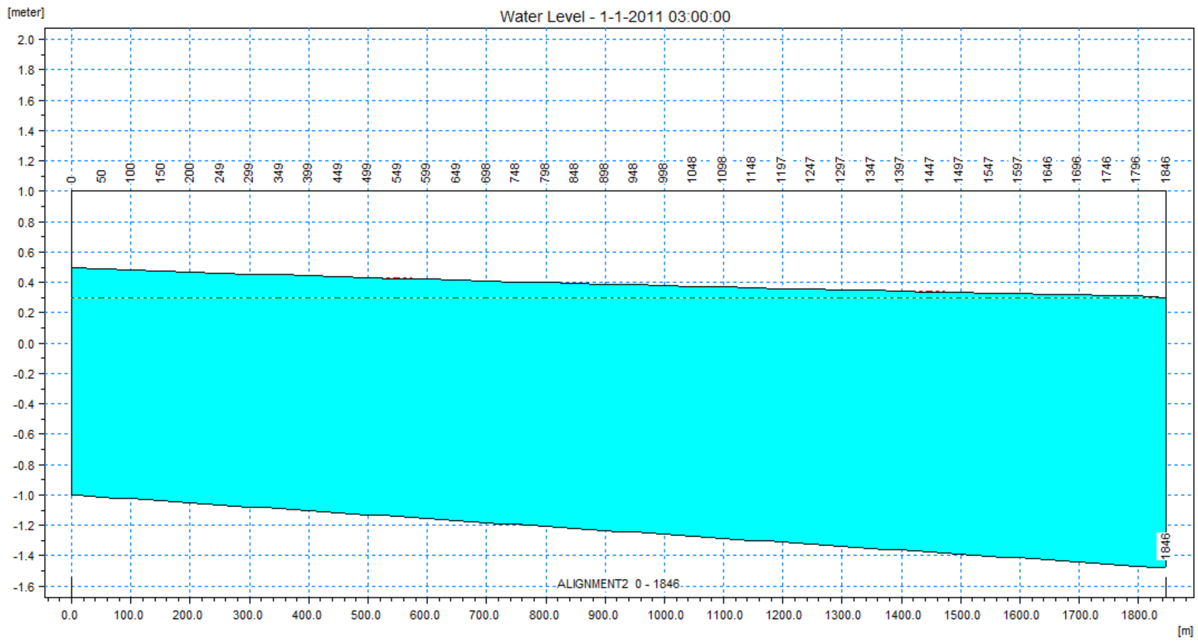


Figure 8: Channel model water surface results for design criteria conditions

Using the 13.3 m base width channel, 2011 historical water levels were entered in the model in a transient model simulation to develop an understanding of the likely range of flow rates and velocities. Figure 9 shows the discharge hydrograph, in which it can be seen that flow rates often exceeded the design discharge, to the point of providing double the design discharge. There were also short durations in which flow through the channel reversed, when the Coorong water level was higher than the Lake Albert water level. It is expected that reverse flow conditions will be predicted as tide and lake water levels are known in advance, and thus operators will be able to close gates if necessary to prevent the flow of seawater into the lake.

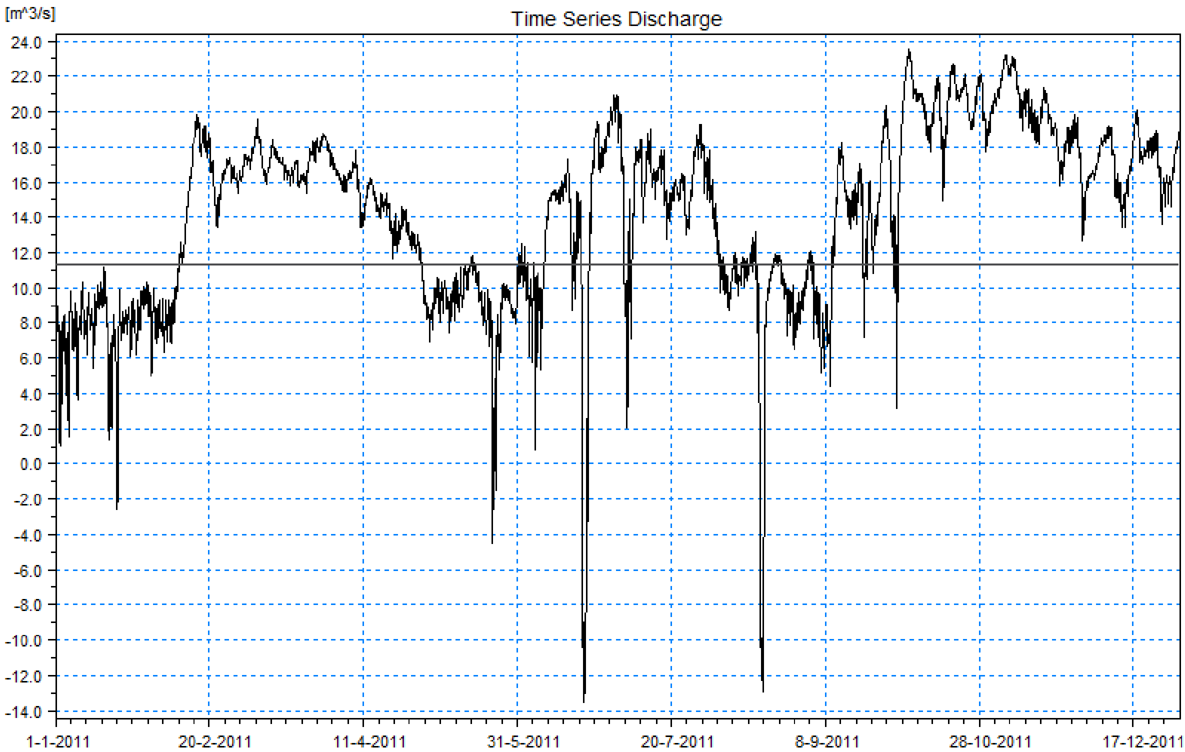


Figure 9: Modelled discharges given 2011 water levels, with design flow rate shown at 11.4 m^3/s

A histogram and cumulative distribution plot for the 2011 transient model is shown in Figure 10, in which it can be seen that flow exceeded the design condition of 11.4 m^3/s 70% of the time, and that reverse flow occurred 1.2% of the time. Figure 11 shows the relationship between flow rate and driving head developed from the 2011 data, in which it can be seen that there is some scatter in the flow rate produced by a given difference in head between the Coorong and Lake Albert. The range of flow rates which could be generated by an identical water level difference is due primarily to differences in channel depth as a 0.3 m water level difference could be caused by Lake Albert at +0.5 mAHD with the Coorong at +0.2 mAHD, or by Lake Albert at +0.1 mAHD and the Coorong at -0.2 mAHD.

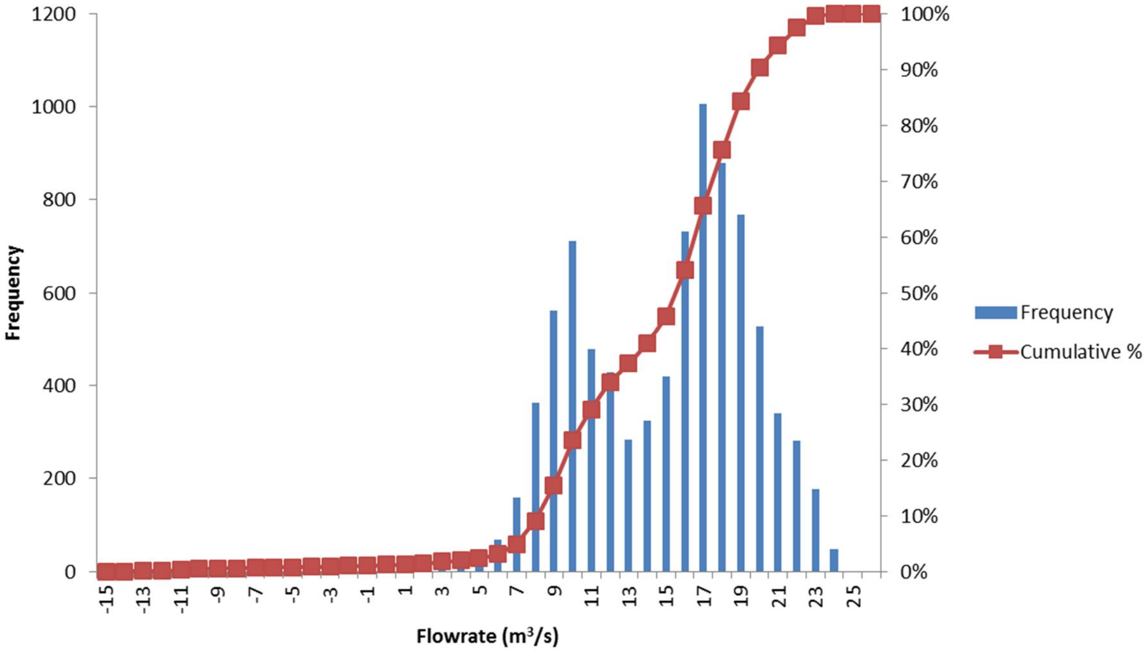


Figure 10: Channel flow rate histogram and cumulative distribution

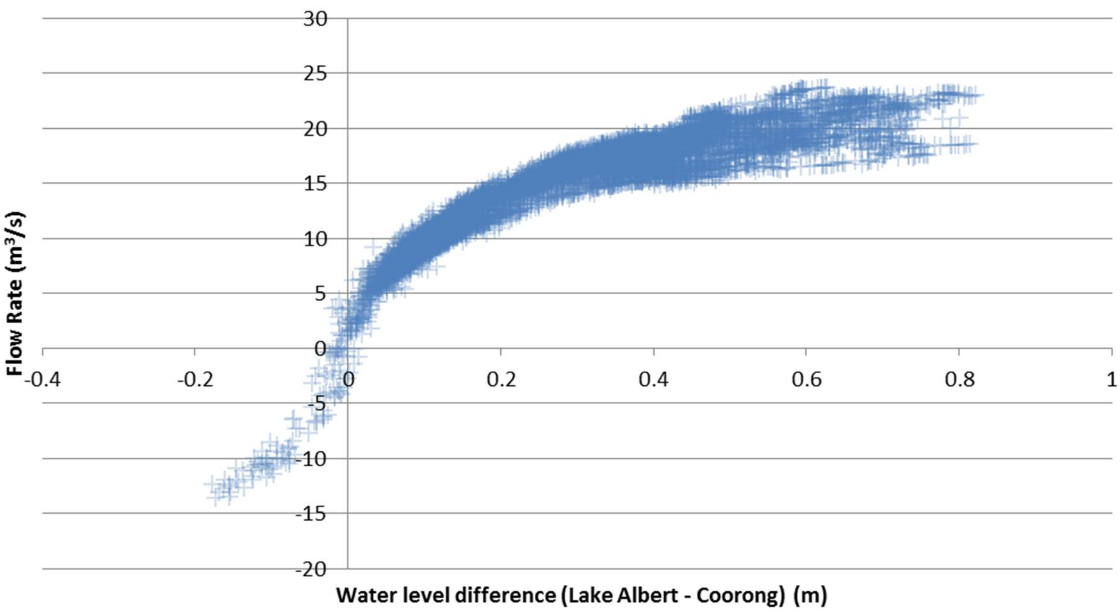


Figure 11: Flow rate through the channel for the range of measured water level differences

PROJECT: ENGINEERING FEASIBILITY OF POTENTIAL MANAGEMENT ACTIONS, LAKE ALBERT & NARRUNG NARROWS

Rev D	Final	30 October 2013
Rev C	Client Review DRAFT	23 October 2013
Rev B	Internal Review	11 October 2013
Rev A	Draft	9 October 13

1.0 DESIGN CRITERIA

1.1 INTRODUCTION

A number of potential management actions are being investigated in order to improve the water quality and environmental health of Lake Albert and the Narrung Narrows. Modelling of five potential management actions has been undertaken (by others) which have identified two actions that offer environmental benefit following implementation. The two management actions are:

- Selective dredging of the Narrung Narrows
- A Coorong connector

The concept design works associated with the Lake Albert and Narrung Narrows management actions shall meet the general and specific design criteria presented below.

It should be noted that lake cycling has been identified as a viable management action during the modelling phase of the project (by others), however has been excluded from the Engineering Feasibility Study (this project) as it doesn’t require any additional infrastructure.

1.2 GENERAL DESIGN CRITERIA

The general design criteria require that:

- The design shall be the most cost effective based on the whole-of-life costs
- The design shall be in accordance with the appropriate Australian Standards
- The design shall comply with existing statutory and regulatory requirements
- A design life of at least 15 years for mechanical equipment
- Operation of infrastructure shall take into consideration manual lifting and frequency of operation
- Vandalism can be a problem - material selection and structural elements to be designed to minimise risk of theft or tampering
- Appropriate consideration of corrosion design for all components

- Ease of maintenance and access for maintenance for all components
- The cost estimate will be based on engineering judgement and will not be prepared by a quantity surveyor.

1.3 SPECIFIC DESIGN CRITERIA

There are a number of specific design requirements that shall be met in the design of the associated works. These criteria are set out below. However, it should be noted that these criteria would be subjected to revisions throughout the design processes as they evolve.

1.3.1 Foundation Conditions

Information from the field investigation project (VE23811) shall be used to obtain the required geotechnical parameters for design.

1.3.2 Seismic Load Case

A seismic risk assessment will not be undertaken for this project. Due to the nature of the structures being investigated (excluding the permanent regulator – which will be addressed if this option proceeds to concept design) seismic loading will not be considered in the design as it represents very little risk for this type of structure. In addition a liquefaction assessment will not be carried out.

1.3.3 Design Water Levels

A review of the historic tide levels in and around Lake Albert and the Coorong have been undertaken. The figures below present the mean daily tide levels at the following stations:

- Station A4261135 – Coorong at Long Point
- Station A4261034 – Goolwa Barrage Upstream
- Station A4261036 – Goolwa Channel at Beacon 12 (downstream of the barrage)
- Station A4261155 – Lake Albert 2 km North Warringee Point

(All the data was obtained from DEWNR and www.waterconnect.sa.gov.au.)

The adopted maximum and minimum operating levels applied to the concept design that Lake Albert will be subject to will be +0.8 mAHD (maximum) and +0.5 mAHD (minimum). As advised by DEWNR on 16 October 2013.

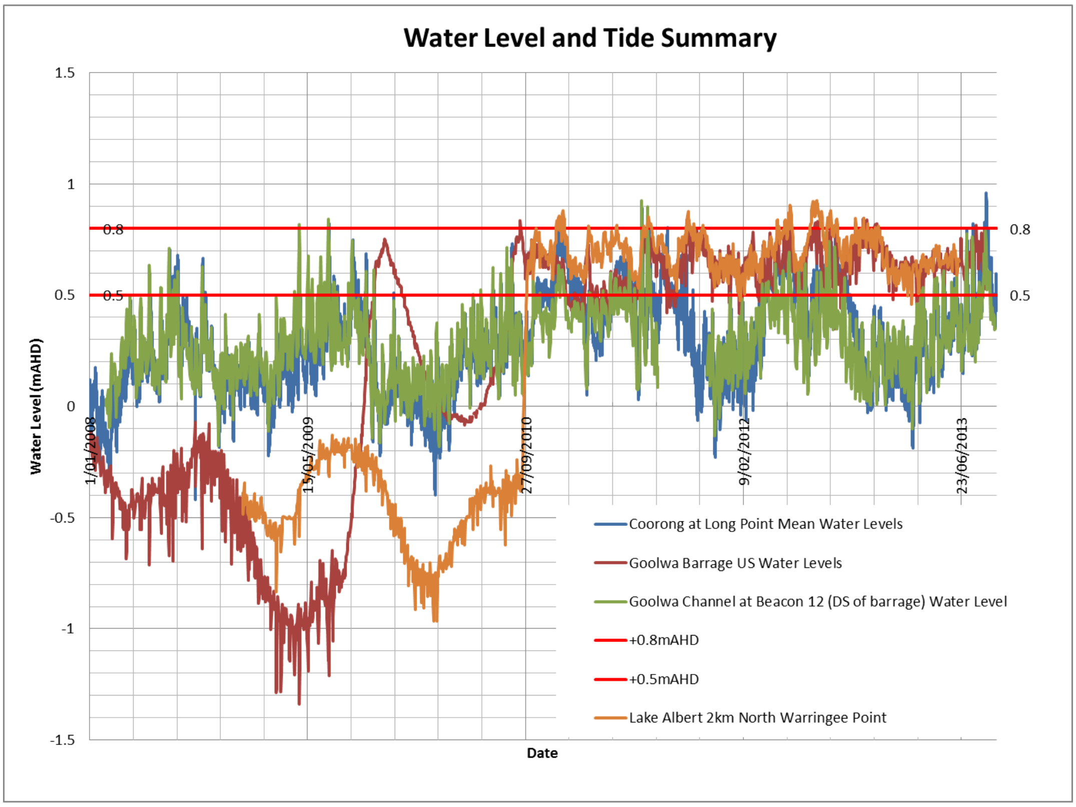


Figure 1: All tide data

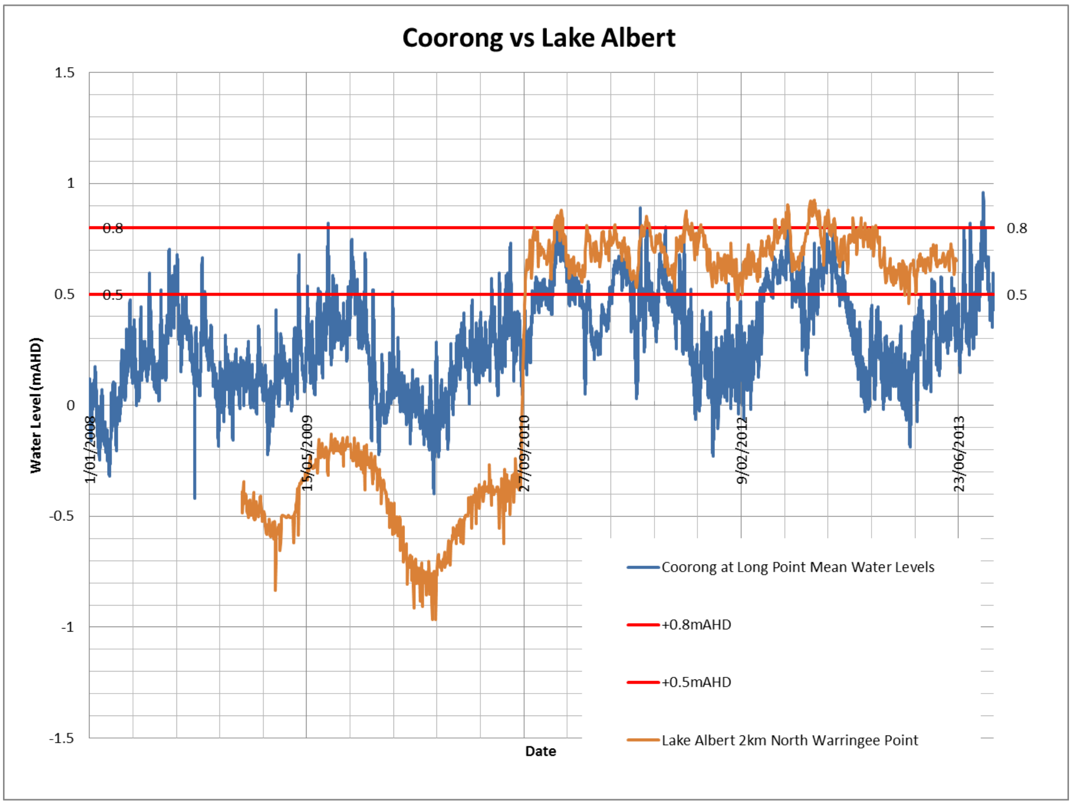


Figure 2: Coorong water level vs. Lake Albert water level

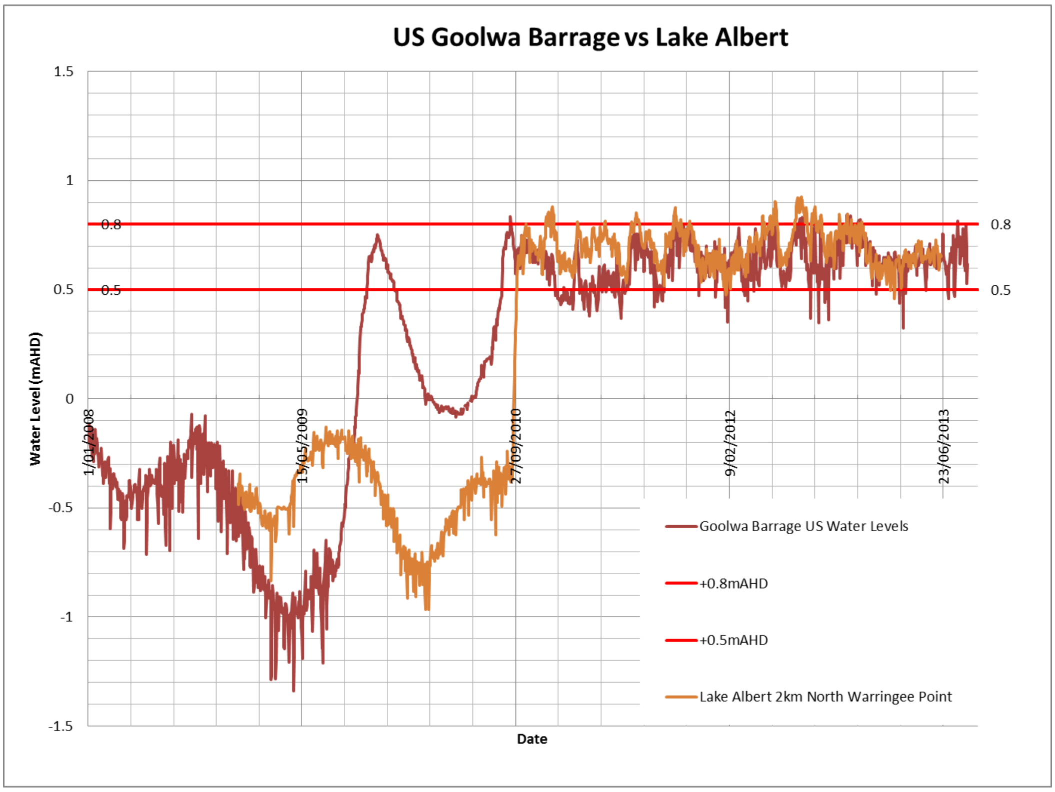


Figure 3: Goolwa Barrage upstream vs. Lake Albert

Figure 1 demonstrates that water levels downstream of the Goolwa Barrage and the Coorong match well (green and blue lines).

Figure 2 demonstrates that from around September 2009 Lake Albert is consistently above the Coorong with the exception of a few occurrences.

Figure 3 demonstrates that the water levels upstream of the Goolwa Barrage and Lake Albert align from September 2010.

Note: The influence of the drought and associated water level management programs in the region are noted prior to September 2010.

The following hydro-static levels will be applied:

Coorong Water Levels

Based on the historic tide data reviewed, for the period of September 2007 to September 2013, the maximum, minimum and average tide levels were +0.96 mAHD, -0.421 mAHD and +0.28 mAHD respectively.

However for the purposes of the concept design a static Coorong tide level of +0.3 mAHD will be adopted (refer to Section 1.3.4 below).

Lake Albert Water Levels

Maximum operating level +0.8 mAHD
Minimum operating level +0.5 mAHD

Reference – as advised by DEWNR on 16 October 2013.

1.3.4 Coorong Connector

An assessment of Location 1 and 2 was undertaken to substantiate the appropriate site selection. Based on the survey undertaken as part of the field investigation project (VE23811), long sections of location 1 and 2 (refer to Appendix A) were developed based on the preliminary channel sizing to achieve 1 GL/day passage with a driving head of 0.5 m. *This was undertaken during the engineering review stage in order to provide channel sizing for modelling (refer email to DEWNR on 28 June 13 titled 'VE23776 Engineering Feasibility for Lake Albert & Narrung Narrows – Qualitative MCA Draft and Technical Response')*.

A summary of the outcomes is below:

- LOCATION 1:
    - Distance = 1670 m
    - Maximum cut height (from channel invert) = 8.7 m
    - Cut / fill balance = 195,349 m^3 (in surplus)
- LOCATION 2:
    - Distance = 1825 m
    - Maximum cut height (from channel invert) = 9.3 m
    - Cut / fill balance = 203,131 m^3 (in surplus)

Please note that the cut and fill volumes and channel dimensions were based on preliminary sizing and will need to be refined during concept design. As such have been presented for comparative purposes.

Therefore Location 2 is 155 m longer and has an additional surplus spoil volume of 7,782 m^3 (approximately 4% more). However it should be noted that potential dredging associated with Location 1 is likely to be more extensive than Location 2 and therefore is anticipated to have an impact on the cost.

Due to the similar excavation volumes and noting the environmental and potential increased dredging impacts associated with Location 1, SKM's recommendation is to proceed with Location 2 for the concept design.

A summary of the specific design criteria are listed below:

- Location 2 is to be adopted
- A channel (in lieu of a pipe or series of pipes) is to be adopted.

  A channel was selected on the following basis:

    - *Control of a piped system would be significantly more complex than that required for a regulator structure associated with a channel*
    - *Although the excavated volumes would be less, the footprint of the piping would be increased as a safe horizontal offset would be required for boring. Additional substantial excavations would be required for driving pits, which would offset the excavation reduction.*
    - *Based on preliminary sizing, it is anticipated that numerous pipes would be required (in the order of 3 x DN2400) to pass 1GL/day.*

  - *Dredging at the Lake Albert and Coorong ends would still be required along with inlet and outlet structures to stop sedimentation of the pipes.*
  - *In regards to operation and maintenance, pigging of the pipe would be required infrequently. As such provisions would need to be made, adding further capital and operational cost.*
  - *Based on indicative pricing (using Rawlinsons 2012 as a basis) the supply alone of DN1200 GRP PN10 (which is half the size than that required) would cost $2,000/m. The length of Location 2 is 1,825m; however requiring 3 pipes means a total length of approximately 5,500m. This results in a supply only cost of approximately $11 million. This does not consider delivery, installation, testing and commissioning, any valving / control infrastructure, manhole access, inlet or outlet structures etc. In comparison to the channel option, excavation unit rate is anticipated to be approximately $35/m3 which results in an excavation only cost of $7 million for 200,000m3. Carting and disposal have been excluded but would be common to both.*

- Daily flow allowance will be 1000 ML/day (over 24 hours)
- Based on the historic water level data and Bigmod modelling outcomes (provided by DEWNR on 21 October 2013) presented, automated gates to manage reverse flow are not required. Stoplogs will be provided for at the upstream culvert crossing (Lake Albert end) and downstream control structure (Coorong end). This will allow for channel isolation for maintenance but also allow the Coorong to be isolated from Lake Albert in unusual cases were Lake Albert water level drops below a trigger level, which may result in reverse flow.
- The channel dimensions will be sized to cater for 1000 ML/day discharge based on a 0.2 m driving head (as requested by DEWNR).
- The hourly Coorong and Lake Albert levels used by BMTWBM for modelling (as provided in excel on 30 September 2013) for a period of 2008 to 2011 will be utilised in development of a HECRAS model. The following will be undertaken:
    - Based on the 2010-2011 data, the average Coorong Level is +0.3 mAHD. As such the design case for sizing the connector with a 0.2 m head differential (as requested by DEWNR) will be a static Lake Albert level of +0.5 mAHD and a static Coorong level of +0.3 mAHD.
    - The Coorong connector will then be run over a yearly period utilising the hourly tide data provided by BMTWBM for a representative year. 2011 Lake Albert and Tide data will be selected for this case. This will produce an exceedance curve to understand the flow range for a range of probabilities.
    - A range of flows will then be tabulated for a number of static Coorong tide and Lake Albert operating level cases for example

maximum and minimum tide levels during summer and winter for the representative year.

- A control structure at the outlet to the Coorong (one only)
- Channel will be unlined. A velocity check for the range of flows to confirm if scour is likely and if so, the need for rock armouring or hydro-mulching

  A slope of 1V:4H for the channel batters will be adopted. The need for benching will be considered for slope maintenance activities. This will enhance slope stability but also enable blending into the natural landscape
- Groundwater control during construction will be considered in the cost development. Groundwater was encountered between +1.5mAHD and -0.5mAHD during drilling investigations.
- Allowance for dredging at the inlet and outlet of the channel will be considered.
- Fish passage will be excluded but may want to be considered in future design stages.

1.3.5 Dredging

A summary of the specific design criteria are listed below:

- The dredging volumes and locations will be based on the information provided by BMT WBM on 30 September 13 (via email).
- Based on the cut/fill data supplied by WBM, the dredging volume is estimated to be just over 6 million cubic meters, which will be considered to be a slurry volume.
- The cost estimate will consider land disposal only assuming a location close to the extraction site.
- The approach for developing a cost estimate will be to identify a $/m3 rate from recent similar projects in the region. A sensibility check will then be undertaken in consultation with DEWNR to confirm a suitable rate for this application.
- As the specific dredging requirements and disposal locations are yet to be developed, detailed method statements will not be prepared for this option.

Appendix A – Location 1 and 2 Long Sections

REV	DATE	DRAWN	DRAFT CHECK	ENG CHECK	LEAD ENG	APP'D	REVISION

DRAWING NUMBER	REFERENCE DRAWING TITLE

NOTES:

- TOTAL CUT : 195 355m³
- TOTAL FILL : 6m³
- BALANCE : 195 349m³
- MAXIMUM CUT HEIGHT : 8.67m
- LENGTH OF ALIGNMENT : 1670m

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CLIENT: DEPARTMENT of ENVIRONMENT, WATER & NATURAL RESOURCES

PROJECT: ENGINEERING FEASIBILITY for LAKE ALBERT and NARRUNG NARROWS

DRAWN	DRAFTING CHECK	ENGINEERING MANAGER	PROJECT MANAGER
JSL			
DESIGN ENGINEER	ENGINEERING CHECK		
OM			

TITLE: LAKE ALBERT PROPOSED CHANNEL ALIGNMENT
ALIGNMENT 1

SCALE	DRAWING No	REV
1:100	VE23776-ALIGNMENT01-001	B

A1

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LOCATION: I:\VESA\Projects\VE23811\Technical\Survey\CAD\VE23776 LONG SECTION ALIGNMENT 1 Rev B.dwg

Horiz Curve Data: R500m

Vertical Geometry Grade (%): -0.029%
Vertical Grade Length (m): 1669.866m

Vertical Curve Length (m)
Vertical Curve Radius (m)

DATUM R.L.-12.000

CHAINAGE	NAT. SURFACE ON CHANNEL CENTRELINE	CUT / FILL DEPTH	DESIGN LEVELS ON CHANNEL CENTRELINE
0	0.840	1.840	-1.000
20	1.334	2.340	-1.006
40	1.807	2.818	-1.011
60	2.245	3.263	-1.017
80	1.652	2.675	-1.023
100	1.514	2.543	-1.029
120	2.381	3.415	-1.034
140	2.245	3.286	-1.040
160	2.306	3.352	-1.046
180	1.854	2.906	-1.052
200	1.850	2.907	-1.057
220	1.908	2.971	-1.063
240	2.091	3.160	-1.069
260	2.160	3.234	-1.075
260.985	2.182	3.257	-1.075
280	2.436	3.516	-1.080
300	2.954	4.040	-1.086
320	3.515	4.607	-1.092
340	3.674	4.772	-1.098
360	3.895	4.999	-1.103
380	3.771	4.880	-1.109
400	3.891	5.006	-1.115
404.285	3.873	4.989	-1.116
420	3.954	5.075	-1.121
440	4.235	5.362	-1.126
460	4.380	5.512	-1.132
480	4.532	5.669	-1.138
500	4.584	5.728	-1.144
520	4.444	5.594	-1.149
540	4.491	5.646	-1.155
560	4.583	5.744	-1.161
580	4.666	5.833	-1.167
600	4.601	5.774	-1.172
620	4.380	5.558	-1.178
640	3.968	5.152	-1.184
660	3.849	5.039	-1.190

LONGITUDINAL SECTION CONCEPT ALIGNMENT 1

REV	DATE	DRAWN	DRAFT CHECK	ENG CHECK	LEAD ENG	APP'D	REVISION

DRAWING NUMBER	REFERENCE DRAWING TITLE

SINCLAIR KNIGHT MERZ
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CLIENT: DEPARTMENT of ENVIRONMENT, WATER & NATURAL RESOURCES

PROJECT: ENGINEERING FEASIBILITY for LAKE ALBERT and NARRUNG NARROWS

DRAWN: JSL | DRAFTING CHECK | ENGINEERING MANAGER | PROJECT MANAGER

DESIGN ENGINEER: OM | ENGINEERING CHECK

TITLE: LAKE ALBERT PROPOSED CHANNEL ALIGNMENT ALIGNMENT 1

SCALE: 1:50 | DRAWING No: VE23776-ALIGNMENT01-002 | REV: B

A1

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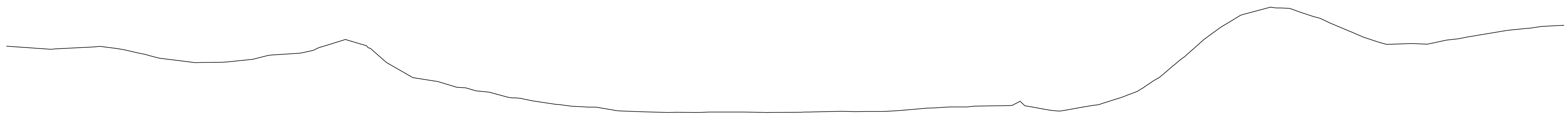

Horiz Curve Data: R1000m

Vertical Geometry Grade (%): -0.029%
Vertical Grade Length (m): 1669.866m

Vertical Curve Length (m)
Vertical Curve Radius (m)

DATUM R.L.-12.000

CHAINAGE	640	660	680	700	720	740	760	780	800	820	840	860
NAT. SURFACE ON CHANNEL CENTRELINE	3.968	3.849	3.955	3.585	3.274	3.366	3.642	4.141	3.360	2.511	2.060	1.710
CUT / FILL DEPTH	5.152	5.039	5.150	4.786	4.481	4.579	4.860	5.365	4.590	3.747	3.302	2.958
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.184	-1.190	-1.195	-1.201	-1.207	-1.213	-1.218	-1.224	-1.230	-1.236	-1.241	-1.247

CHAINAGE	880	900	920	940	960	980	1000	1020	1040	1040.96	1060	1080
NAT. SURFACE ON CHANNEL CENTRELINE	1.419	1.225	1.161	1.175	1.159	1.174	1.194	1.251	1.391	1.391	1.437	1.294
CUT / FILL DEPTH	2.672	2.484	2.426	2.445	2.435	2.456	2.481	2.544	2.690	2.690	2.742	2.605
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.253	-1.259	-1.264	-1.270	-1.276	-1.282	-1.287	-1.293	-1.299	-1.299	-1.305	-1.310

CHAINAGE	1100	1120	1140	1160	1180	1200	1220	1240	1260	1280	1300
NAT. SURFACE ON CHANNEL CENTRELINE	1.448	2.098	3.587	5.102	5.590	4.996	4.190	4.062	4.371	4.680	4.860
CUT / FILL DEPTH	2.764	3.420	4.915	6.436	6.929	6.341	5.541	5.419	5.733	6.048	6.234
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.316	-1.322	-1.328	-1.333	-1.339	-1.345	-1.351	-1.356	-1.362	-1.368	-1.374

LONGITUDINAL SECTION CONCEPT ALIGNMENT 1

REV	DATE	DRAWN	DRAFT CHECK	ENG CHECK	LEAD ENG	APP'D	REVISION

DRAWING NUMBER	REFERENCE DRAWING TITLE

SINCLAIR KNIGHT MERZ
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CLIENT: DEPARTMENT of ENVIRONMENT, WATER & NATURAL RESOURCES

PROJECT: ENGINEERING FEASIBILITY for LAKE ALBERT and NARRUNG NARROWS

DRAWN	DRAFTING CHECK	ENGINEERING MANAGER	PROJECT MANAGER
JSL			
DESIGN ENGINEER	ENGINEERING CHECK		
OM			

TITLE: LAKE ALBERT PROPOSED CHANNEL ALIGNMENT ALIGNMENT 1

SCALE	DRAWING No	REV
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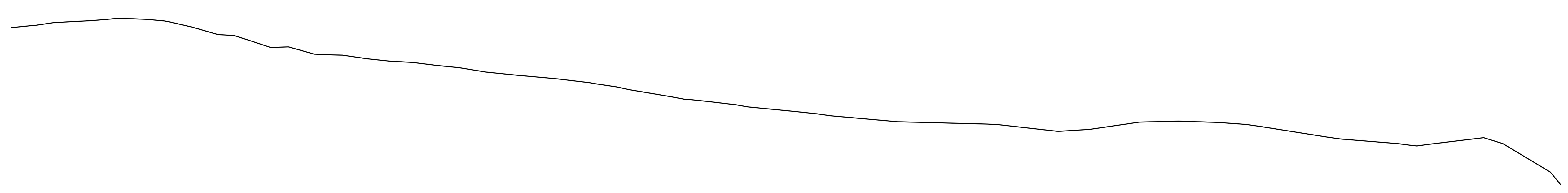

Horiz Curve Data — R1000m

Vertical Geometry Grade (%) — -0.029%

Vertical Grade Length (m) — 1669.866m

Vertical Curve Length (m)

Vertical Curve Radius (m)

DATUM R.L.-12.000

NAT. SURFACE ON CHANNEL CENTRELINE	4.680	4.860	4.820	4.353	4.000	4.000	3.811	3.555	3.358	3.041	2.762
CUT / FILL DEPTH	6.048	6.234	6.199	5.738	5.391	5.391	5.208	4.957	4.766	4.455	4.182
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.368	-1.374	-1.379	-1.385	-1.391	-1.391	-1.397	-1.402	-1.408	-1.414	-1.420
CHAINAGE	1280	1300	1320	1340	1360	1360.127	1380	1400	1420	1440	1460

NAT. SURFACE ON CHANNEL CENTRELINE	2.537	2.338	2.265	2.101	2.248	2.306	2.100	1.830	1.781	1.471	
CUT / FILL DEPTH	3.962	3.769	3.702	3.544	3.697	3.760	3.560	3.295	3.253	2.948	
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.425	-1.431	-1.437	-1.443	-1.448	-1.454	-1.460	-1.466	-1.471	-1.477	-1.480
CHAINAGE	1480	1500	1520	1540	1560	1580	1600	1620	1640	1660	1669.866

LONGITUDINAL SECTION CONCEPT ALIGNMENT 1

REV	DATE	DRAWN	DRAFT CHECK	ENG CHECK	LEAD ENG	APP'D	REVISION

DRAWING NUMBER	REFERENCE DRAWING TITLE

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CLIENT: DEPARTMENT of ENVIRONMENT, WATER & NATURAL RESOURCES

PROJECT: ENGINEERING FEASIBILITY for LAKE ALBERT and NARRUNG NARROWS

DRAWN: JSL | DRAFTING CHECK | ENGINEERING MANAGER | PROJECT MANAGER

DESIGN ENGINEER: OM | ENGINEERING CHECK

TITLE: LAKE ALBERT PROPOSED CHANNEL ALIGNMENT ALIGNMENT 1

SCALE: 1:50 | DRAWING No: VE23776-ALIGNMENT01-004 | REV: B

A1

REV	DATE	DRAWN	DRAFT CHECK	ENG CHECK	LEAD ENG	APP'D	REVISION

DRAWING NUMBER	REFERENCE DRAWING TITLE

NOTES:

- TOTAL CUT : 203 135m³
- TOTAL FILL : 4m³
- BALANCE : 203 131m³
- MAXIMUM CUT HEIGHT : 9.31m
- LENGTH OF ALIGNMENT : 1825m

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CLIENT: DEPARTMENT of ENVIRONMENT, WATER & NATURAL RESOURCES

PROJECT: ENGINEERING FEASIBILITY for LAKE ALBERT and NARRUNG NARROWS

DRAWN	DRAFTING CHECK	ENGINEERING MANAGER	PROJECT MANAGER
JSL			
DESIGN ENGINEER	ENGINEERING CHECK		
OM			

TITLE: LAKE ALBERT PROPOSED CHANNEL ALIGNMENT
ALIGNMENT 2

SCALE	DRAWING No	REV
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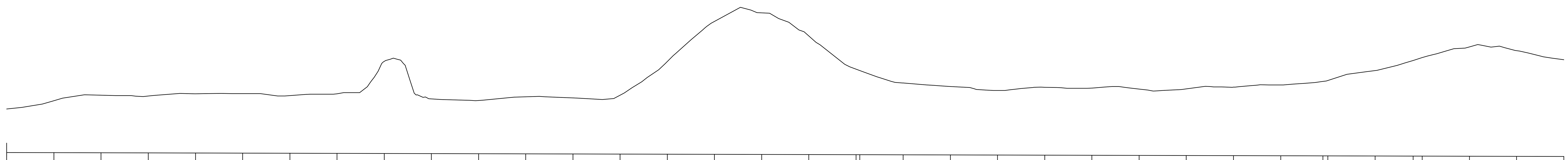

Horiz Curve Data: R500m; R-400m

Vertical Geometry Grade (%): -0.026%
Vertical Grade Length (m): 1838.345m

Vertical Curve Length (m)
Vertical Curve Radius (m)

DATUM R.L.-12.000

NAT. SURFACE ON CHANNEL CENTRELINE	0.840	1.198	1.429	1.397	1.486	1.495	1.414	1.484	2.858	1.271	1.206	1.360
CUT / FILL DEPTH	1.840	2.203	2.439	2.413	2.507	2.521	2.445	2.521	3.900	2.318	2.259	2.418
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.000	-1.005	-1.010	-1.016	-1.021	-1.026	-1.031	-1.037	-1.042	-1.047	-1.052	-1.057
CHAINAGE	0	20	40	60	80	100	120	140	160	180	200	220

NAT. SURFACE ON CHANNEL CENTRELINE	1.310	1.427	2.856	4.553	4.917	3.938	2.529	2.470	1.943	1.799	1.631	1.763
CUT / FILL DEPTH	2.373	2.495	3.929	5.631	6.000	5.027	3.623	3.565	3.042	2.903	2.741	2.878
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.063	-1.068	-1.073	-1.078	-1.084	-1.089	-1.094	-1.094	-1.099	-1.104	-1.110	-1.115
CHAINAGE	240	260	280	300	320	340	360	361.596	380	400	420	440

NAT. SURFACE ON CHANNEL CENTRELINE	1.732	1.689	1.694	1.769	1.863	2.011	2.052	2.470	2.901	3.020	3.474	3.316	2.930
CUT / FILL DEPTH	2.852	2.815	2.825	2.905	3.004	3.157	3.198	3.622	4.056	4.177	4.636	4.483	4.103
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.120	-1.125	-1.131	-1.136	-1.141	-1.146	-1.146	-1.151	-1.156	-1.157	-1.162	-1.167	-1.172
CHAINAGE	460	480	500	520	540	557.948	560	580	596.123	600	620	640	660

LONGITUDINAL SECTION CONCEPT ALIGNMENT 2

REV	DATE	DRAWN	DRAFT CHECK	ENG CHECK	LEAD ENG	APP'D	REVISION

DRAWING NUMBER	REFERENCE DRAWING TITLE

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CLIENT: DEPARTMENT of ENVIRONMENT, WATER & NATURAL RESOURCES
PROJECT: ENGINEERING FEASIBILITY for LAKE ALBERT and NARRUNG NARROWS

DRAWN	DRAFTING CHECK	ENGINEERING MANAGER	PROJECT MANAGER
JSL			
DESIGN ENGINEER	ENGINEERING CHECK		
OM			

TITLE: LAKE ALBERT PROPOSED CHANNEL ALIGNMENT ALIGNMENT 2

SCALE: 1:50
DRAWING No: VE23776-ALIGNMENT02-002
REV: B

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DATE: 17/10/2013 12:04:57 PM LOGIN NAME: LANGMAN, JAMES (SKM)
LOCATION: I:\VESA\Projects\VE23811\Technical\Survey\CAD\VE23776 LONG SECTION ALIGNMENT 2 Rev B.dwg

Horiz Curve Data: R-400m; R500m

Vertical Geometry Grade (%): -0.026%
Vertical Grade Length (m): 1838.345m

Vertical Curve Length (m)
Vertical Curve Radius (m)

DATUM R.L.-12.000

CHAINAGE	NAT. SURFACE ON CHANNEL CENTRELINE	CUT / FILL DEPTH	DESIGN LEVELS ON CHANNEL CENTRELINE
640	3.316	4.483	-1.167
660	2.930	4.103	-1.172
680	2.617	3.794	-1.178
700	2.161	3.344	-1.183
720	2.098	3.286	-1.188
740	2.135	3.328	-1.193
760	2.000	3.199	-1.198
780	2.090	3.294	-1.204
800	2.457	3.666	-1.209
820	2.835	4.049	-1.214
840	2.944	4.163	-1.219
860	2.151	3.375	-1.225
880	1.618	2.847	-1.230
895.834	1.497	2.731	-1.234
900	1.534	2.769	-1.235
920	1.884	3.124	-1.240
940	1.425	2.671	-1.245
953.049	1.532	2.780	-1.249
960	1.730	2.981	-1.251
980	2.767	4.023	-1.256
1000	4.229	5.491	-1.261
1020	5.985	7.251	-1.266
1040	6.338	7.609	-1.272
1060	5.735	7.012	-1.277
1080	4.258	5.540	-1.282
1100	3.427	4.714	-1.287
1120	3.219	4.512	-1.292
1140	3.154	4.452	-1.298
1157.962	3.256	4.559	-1.302
1160	3.285	4.588	-1.303
1180	3.412	4.720	-1.308
1200	3.416	4.729	-1.313
1220	3.812	5.130	-1.319
1240	3.964	5.288	-1.324
1260	4.036	5.365	-1.329
1280	4.039	5.373	-1.334
1300	4.153	5.493	-1.339

LONGITUDINAL SECTION CONCEPT ALIGNMENT 2

REV	DATE	DRAWN	DRAFT CHECK	ENG CHECK	LEAD ENG	APP'D	REVISION

DRAWING NUMBER	REFERENCE DRAWING TITLE

SINCLAIR KNIGHT MERZ
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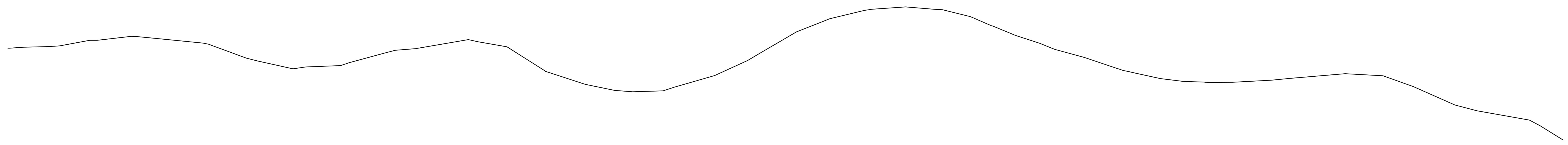
CLIENT: DEPARTMENT of ENVIRONMENT, WATER & NATURAL RESOURCES
PROJECT: ENGINEERING FEASIBILITY for LAKE ALBERT and NARRUNG NARROWS
DRAWN: JSL | DRAFTING CHECK | ENGINEERING MANAGER | PROJECT MANAGER
DESIGN ENGINEER: OM | ENGINEERING CHECK

TITLE: LAKE ALBERT PROPOSED CHANNEL ALIGNMENT ALIGNMENT 2
SCALE: 1:50
DRAWING No: VE23776-ALIGNMENT02-003
REV: B

A1

DATE: 17/10/2013 12:05:16 PM LOGIN NAME: LANGMAN, JAMES (SKM)
LOCATION: I:\VESA\Projects\VE23811\Technical\Survey\CAD\VE23776 LONG SECTION ALIGNMENT 2 Rev B.dwg



Horiz Curve Data

Vertical Geometry Grade (%)
Vertical Grade Length (m)

-0.026%
1838.345m

Vertical Curve Length (m)
Vertical Curve Radius (m)

DATUM R.L.-12.000

NAT. SURFACE ON CHANNEL CENTRELINE	4.039	4.153	4.419	4.325	3.889	3.349	3.435	3.974	4.259	4.040	2.977	2.502	2.659	3.343
CUT / FILL DEPTH	5.373	5.493	5.763	5.675	5.244	4.709	4.800	5.345	5.635	5.421	4.363	3.893	4.056	4.745
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.334	-1.339	-1.345	-1.350	-1.355	-1.360	-1.366	-1.371	-1.376	-1.381	-1.386	-1.392	-1.397	-1.402
CHAINAGE	1280	1300	1320	1340	1360	1380	1400	1420	1440	1460	1480	1500	1520	1540

NAT. SURFACE ON CHANNEL CENTRELINE	4.446	5.223	5.510	5.313	4.571	3.884	3.252	2.870	2.812	2.946	3.125	2.820	1.982	1.565	0.734
CUT / FILL DEPTH	5.854	6.635	6.927	6.736	6.000	5.318	4.690	4.314	4.261	4.401	4.584	4.285	3.452	3.040	2.214
DESIGN LEVELS ON CHANNEL CENTRELINE	-1.407	-1.413	-1.418	-1.423	-1.428	-1.433	-1.439	-1.444	-1.449	-1.454	-1.460	-1.465	-1.470	-1.475	-1.480
CHAINAGE	1560	1580	1600	1620	1640	1660	1680	1700	1720	1740	1760	1780	1800	1820	1838.345

LONGITUDINAL SECTION CONCEPT ALIGNMENT 2

REV	DATE	DRAWN	DRAFT CHECK	ENG CHECK	LEAD ENG	APP'D	REVISION

DRAWING NUMBER	REFERENCE DRAWING TITLE

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CLIENT DEPARTMENT of ENVIRONMENT, WATER & NATURAL RESOURCES

PROJECT ENGINEERING FEASIBILITY for LAKE ALBERT and NARRUNG NARROWS

DRAWN	DRAFTING CHECK	ENGINEERING MANAGER	PROJECT MANAGER
JSL			
DESIGN ENGINEER OM	ENGINEERING CHECK		

TITLE LAKE ALBERT PROPOSED CHANNEL ALIGNMENT ALIGNMENT 2

SCALE	DRAWING No	REV
1:50	VE23776-ALIGNMENT02-004	B

A1

DATE: 17/10/2013 12:05:37 PM LOGIN NAME: LANGMAN, JAMES (SKM)
LOCATION: I:\VESA\Projects\VE23811\Technical\Survey\CAD\VE23776 LONG SECTION ALIGNMENT 2 Rev B.dwg

Appendix H. Client Comments & Response

The client comments and SKM response received on 14 February 2014 are presented below.

Project: VE23776 Engineering Feasibility of Potential Management Actions, Lake Albert and Narrung Narrows

Reviewers: SA Water, MDBA, Major Projects
Date: 14-Feb-14
Response: SKM - Matt Tooley, Nicole Anderson, Dan Mollison (Review - Jerome Argue)
Date: 20-Feb-14

No.	Reference	SA Water / MDBA Comment	SKM Response
1	Section 5.2	Section 5.2 talks about a single lane roadway on the regulator nearest the Lake. I would have thought that given it is on a regional main road, it should be two lane, with pedestrian walkway and access to operate gates. This will affect the cost.	The length of the regulator has been designed to accommodate the width of the existing roadway (as determined by the site survey) with allowance for a pedestrian footpath on the downstream (coorong side) of the control structure. The existing roadway is dual direction single lane roadway (e.g. 1 lane in each direction) and the upstream control structure has been sized to provide the same number of lanes (e.g. one lane (3m width) in both directions).
2	Section 5.2.5 'Regulation and Control'	There is no need to have two regulators. There only needs to be one, on the upstream side. If access is to be provided on the Coorong end, it could be by box culverts only. Again this affects the costs.	Two structures have been allowed in order to provide a means of channel isolation for maintenance and to allow the Coorong to be isolated from Lake Albert. Both structures comprise box culverts. The downstream structure also provides access for farm vehicles.
3	Section 5.2.5 'Regulation and Control'	The regulator should be on the Lake end to ensure the bulk of the channel is filled with Coorong water when it is not operating to minimise reed growth in the channel and hence minimise maintenance on the channel.	The concept proposes isolation from the downstream end so that during times of isolation the connector is full with 'fresher' water rather than saline seawater. It also provides the ability to keep the connector dry during this period if required. However as control structures are currently provided at both ends, isolation from either end is possible.
4	Section 5.2.1 'Gate Selection'	The report says that there is no power available. I would be surprised if there is not a power supply running along the length of the Narrung Peninsular. Power to the regulator opens up a lot more options.	It is noted that power is available with in the region. However, following discussion with DEWNR a gate type was selected that did not require power or automation in order to reduce the cost and complexity of the structures. It is proposed that further power and automated regulation investigation is addressed in detailed design should this be required.
5	Section 5.2.5 'Regulation and Control'	The consequences of a reverse head event could potentially be quite severe. If the structure is to be operated by SA Water staff at the Barrages, it is a 45-60 minute drive from Goolwa. Staff are not going to travel to open and close gates according to the tides. The report says that the number of reverse head instances is small, but I am not sure if this takes into account daily tidal fluctuations or if this is based on a daily water level. Consideration should be given to installing gates that close automatically on reverse head. (TA further comment – the community has since provided feedback to suggest local conditions (mainly wind) may cause more reverse head situations than accounted for).	Historical water level data for Lake Albert and the Coorong were provided by BMT WBM via DEWNR on 30 September 2013, along with Bigmod modelling outcomes on 21 October 2013, which formed the basis for the reverse flow review and concept design modelling. The Bigmod modelling showed that no backflow occurred during the modelled operating days. The MIKE11 model developed for the Coorong Connector by SKM (which utilised the 2011 historical water levels provided by BMT WBM) showed that there were only a few occasions were reverse flow occurred for a short duration. As such automated gates to manage reverse flow were not considered necessary at this stage. An operational regime during implementation was selected as the management option for these events in lieu of automated gates to cater for reverse flow. However this can be investigated or further addressed in the detailed design stage.
6	Section 5.3 'Cost Estimate'	SA Water doesn't have a lot to add re costs and suggests MDBA is better placed as they have access to figures for similar projects. However, SA Water's feeling is that some costs are low without full justification/being quantified.	Statement. No response provided.
7	Section 5.3.2 'Coorong Alignment 2'	Baseline cost would be $20m plus	Statement. No response provided.
8	Section 5.3.2 'Coorong Alignment 2'	Regulator costs would be a fair bit more	Statement. No response provided.
9	Appendix B	Dewatering needs consideration (will likely be working in water due to level of groundwater). This adds to cubic metre rate costs	Refer to item B1e of the estimate. A provisional allowance of $100,000 has been allowed for de-watering establishment, pipes and pumps to return ground water to the lake or a suitable and approved location. For the concept design it was assumed that 4 pump out locations at approximately $25k each inclusive of associated costs for the duration of construction would be required. No carting of water was allowed for.
10	Appendix B	The rate of $30m3 seems a bit on the low side, especially if taking wet sediment up to 5km away. Maybe to 1km is okay.	Refer to item B1c (bulk excavation) of the estimate. This rate was established following consultation with SKM's quantity surveyor who reviewed the rate against rates for similar projects based on the type of material anticipated and advised an estimate in the range of $25-$35/m^3 would be appropriate. The $30/m^3 adopted in SKM's December 2013 cost estimate was selected as the mid point of this range. Following a meeting with DEWNR on 20/02/2014 and follow up discussions with SKM's quantity surveyor, SKM have revised the unit rate to $35/m3, which represents the upper end of the estimated range. Increasing the unit rate for bulk excavation (item B1c) from $30/m^3 to $35/m^3 increases the estimated total cost of the Coorong Connector Channel from $16.9million to $18.7 million. (Note - additional amendments to the estimate, discussed in SKM's response to Comment #14 in this document, resulted in further adjustments to the total estimated construction cost.)
11	Appendix B	Question regarding using Rawlinsons – this isn't often used these days and the low estimates may be attributed to this.	As per SKM's scope, noted in the design criteria (section 1.2) and the proposal (Task 5) the estimate was to be based on engineering design and judgement and was not a quantity surveyed estimate. Consequently, unit rates for items Blh / C1a / C1b / C1d / C1f / C2b / C2c / C2d / C2e / C2f / C4a / C4d / D1a / D1b / D1d / D1f / D2b / D2c / D2d / D2e / D2f / D4a of the estimate were obtained from Rawlinsons and the overall estimate was reviewed by SKM's Principal Civil Engineer for a sensibility check based on engineering judgement and previous project experience. If a higher level of estimate is required, SKM are happy to carry out a quantity surveyed estimate noting that this was not provisioned for in the current contract as agreed with DEWNR.
12	Appendix B	Account for landowner compensation	Refer item B1i of the estimate. An allowance of $1.50/m^3 (totalling $366,000) has been made to provision for landowner compensation, levelling and landform of the disposal site and disposal site maintenance. The $1.50/m3 was selected based on compensation rates for recent DEWNR projects in the lower lakes region.
13	Appendix B	Dredging would likely be more than $30m3 Some of the civil works costs seem low, eg subgrade prep.	Refer to item B2a of the estimate - the unit rate was based on reviewed rates for dredging and disposal in a similar environment from previous projects along with comparison rates provided by DEWNR. As the disposal site was/is unknown, a nominal distance of 5km's from the dredge location was selected. Historical ranges included $16 per m^3 (Currency Creek and Narrung bund) , $5 per m^3 (Murray Mouth program (noting scale differential)) to $30 per m^3 as provided by DEWNR (including allowance for suction cut dredging, transportation, dewatering).
14	Appendix B	In terms of examples the MDBA uses – Gunbower Icon site works included a freespan bridge across a channel of similar size for $1m (engineering estimate was $1.5m). The traffic bypass required during construction was $100,000. The regulator at Gunbower was about $3m (but this was for a higher head).	SKM have reviewed the component costs for the regulators (Section C and D of the estimate) and revised the unit rates, as appropriate, based on further review, known assumptions and engineering judgement. As discussed with DEWNR, the original estimate presented supply and install costs separate from preliminaries and associated costs. When combined, the revised component costs for the upstream and downstream regulators, including contingencies and preliminaries are approximately $1.45 million and $1.13 million respectively. The assumed construction sequence is that the new upstream (Lake end) control structure crossing would be constructed prior to the channel immediately downstream being excavated in order to provide a traffic bypass. The downstream section would then be subsequently excavated and profiled. An allowance of $100k has been included in the revised estimate for a temporary traffic bypass for the upstream regulator.
15		$5.74/m2 of stone for a 14m wide channel is not a sensible number	SKM assume this query relates to the estimated area of stone pitching, which is shown as 5.76m2 in items C1f and D1f of the estimate with a unit rate of $76.65/m^2. The concept design allows for stone pitching adjacent to each concrete headwall (only). Protection across the base of the channel is provided by means of a reno mattress.
16		Needs to be allowance for mobilisation/demobilisation. This could be $20-50k	Refer to item B1a of the estimate - a mobilisation / demobilisation allowance of $150k has been provided, which is intended to cover mobilisation / demobilisation of the regulator works as well as channel earthworks. This line item (B1a) can be moved to Section A - General Items.
17		Revised OPEX	Following the changes agreed above, the amended OPEX has been revised to $0.11 million per annum.