BMT JFA Consultants

Bribie Gardens Long Term Maintenance Plan - 2016

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Limitations statement

The purpose of this report and the associated services performed by BMT JFA Consultants (BMT JFA) is to provide an updated Long-term Maintenance Plan and associated Maintenance Model for Bribie Gardens in accordance with the scope of services set out in the contract between BMT JFA and Moreton Bay Regional Council ('the Client'). That scope of services was defined by the requests of the Client, and by the time and budgetary constraints imposed by the Client.

In preparing this report, BMT JFA has relied upon and presumed accurate certain information (or absence thereof) relative to the site, provided by the Client and others identified herein. Except as otherwise stated in the report, BMT JFA has not attempted to verify the accuracy or completeness of such information.

No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings, observations and conclusions are based solely upon site conditions and information supplied by the Client in existence at the time of the study.

This Long-term Maintenance Plan has been prepared for the exclusive use of Moreton Bay Regional Council and is subject to and issued in connection with the provisions of the contract between BMT JFA Consultants and Moreton Bay Regional Council. BMT JFA excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report by any third party.

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1 Introduction

1.1 Background

Bribie Gardens Estate (Bribie Gardens) is a residential canal estate located on the western foreshore of Bribie Island, Queensland. The estate incorporates a semi-tidal saline lake, controlled by a lock and weir structure, together with an entrance channel which provides access to Pumicestone Passage. The estate has been progressively developed in stages following original construction which began in the mid 1980's. While the final land allotments have not yet been fully developed, construction of the lake is understood to have been completed in the early-mid 2000's. The canal estate currently has approximately 320 waterfront residential properties.

Moreton Bay Regional Council (MBRC) undertake regular maintenance works at the site. These works include maintenance dredging, maintenance of canal batters, navigation aids and signage, and removal of marine plants and litter. Funding to support the delivery of these maintenance activities is generated through a special levy, paid by waterfront residential properties and commercial entities, together with a contribution from MBRC's general maintenance budget. The levy amount is calculated in consideration of forecast long-term maintenance costs, which are estimated based on a Long-term Maintenance Plan, and associated Maintenance Model.

The Long-term Maintenance Plan provides a high-level plan for forecast maintenance activities, and provides key inputs into the Maintenance Model. The Maintenance Model is a financial calculation tool which essentially comprises a list of maintenance activities, associated unit cost rates, and a forecast program of maintenance activities over the specified planning period. The estimated long-term maintenance costs are calculated in the Model based on the forecast program and estimated unit cost rates. The Long-term Maintenance Plan, including Maintenance Model, is subject to periodic review in order to ensure that the maintenance activities, unit cost rates, and program remain appropriate and up-to-date.

The initial Long-term Maintenance Plan, *Bribie Gardens and Pacific Harbour Canals – Long-term Maintenance Plan* was developed in 2011-12 (KBR 2012a) and formally adopted by MBRC on 1 July 2012. This plan identified the maintenance and eventual replacement of the lock and weir structure, together with dredging and material disposal, as the most significant maintenance issues within the canal estate. However, limited inspection and testing of the lock and weir was commissioned as part of the development of the original maintenance plan, and only a limited number of hydrographic survey datasets were available to inform estimated siltation rates and associated dredging requirements. Subsequently, and in line with the planned 3-5 year review cycle, MBRC commissioned a review and update of the existing Long-term Maintenance Plan for 2015-16.

1.2 Scope

1.2.1 Scope of services

BMT JFA Consultants Pty Ltd (BMT) were commissioned by MBRC in late 2015 to review and update the Bribie Gardens Long-term Maintenance Plan and associated Maintenance Model. Given that a significant proportion of the originally estimated maintenance costs are attributed to

maintenance and replacement of the lock and weir structure, MBRC commissioned a Residual Life Assessment of the existing structure as part of the overall Long-term Maintenance Plan review. Additionally, the LTMP review required assessment of siltation rates, dredging and material disposal strategies, and an overall review and update of all unit cost rates in the Maintenance Model. BMT's proposal (Ref. *Q-P15.74-1 Rev.0*) incorporated the following scope of services:

- Lock and Weir Residual Life Assessment – including separate report and maintenance cost schedule.
- Review of siltation rates
- Assessment of dredging and material disposal options
- Development of a recommended dredging and material disposal strategy
- Development of a proposed dredging schedule for the purposes of informing the Maintenance Model
- Review and update of maintenance costs/rates
- Provision of updated:
  - Dredging schedule
  - Maintenance Model
  - Long-term Maintenance Plan

This Long-term Maintenance Plan (LTMP) documents the outcomes of the completed work, and provides a high-level plan for forecast maintenance activities, together with key inputs into the Maintenance Model. The document is structured as follows:

- Site description – brief description of the site including historical development of the canal estate, and summary of the maintenance activities.
- Lock and Weir Maintenance – summary of the outcomes and recommendations from the Residual Life Assessment.
- Maintenance dredging – summary of past dredging and disposal works, review of siltation rates, recommended dredging and material disposal strategies, and discussion of environmental approval requirements.
- Other maintenance activities – discussion of the broad scope of general maintenance activities and forecast maintenance requirements.
- Maintenance costs – presentation of the estimated long-term maintenance costs, and discussion of key assumptions and sensitivities in the model, together with the accuracy of estimates.
- Conclusions – concise summary of the outcomes of the completed work and the estimated long-term maintenance costs.
- Recommendations – discussion of recommended additional studies and investigations identified during the review and update of the LTMP.

The Lock and Weir residual life assessment study component, including the completed inspections and testing, recommendations, and costed maintenance schedule, has been documented separately to this LTMP. As such, only a summary of the completed assessment and key outcomes are provided within this document (Ref. Section 3). The complete report is provided in Appendix E.

1.2.2 Scope of LTMP

The maintenance activities undertaken by MBRC, and subsequently considered in the LTMP, are limited to the estate waterways and entrance channel, and exclude works within private properties. As outlined in the Project Brief (Ref. *RFQ VP0000000031743*) the following areas and maintenance activities are not included in the scope of the LTMP:

- All concrete revetment walls. These are the responsibility of the associated property owner.
- Bridges and retaining walls at causeway-type road crossings are part of the road network and therefore are not part of the LTMP.
- Pontoons. All pontoons are the responsibility of the associated property owner.
- Drainage outlets and associated infrastructure. These are part of the drainage network and therefore are not part of the LTMP.
- Parkland abutting the canals is part of the park network. Maintenance of these areas is therefore not part of the LTMP.
- The boat ramp off Phoenix Avenue Park is not included in the LTMP.

Additionally, the end of the canal system terminates at the western end of the entrance channel, which is roughly in-line with the end of the adjacent rock groyne.

1.2.3 Limitations

The following limitations apply to the LTMP, including the associated work completed by BMT:

- The LTMP is a high-level planning tool and should not be used for the detailed planning and execution of maintenance activities.
- With the exception of the Lock and Weir Residual Life Assessment, no site-based condition inspections have been completed by BMT in completing this work. The condition of existing structures shall be assessed by others as part of regular inspections and maintenance activities.
- The contracted scope of services was limited to the review and update of the existing LTMP. As such, additional maintenance activities, beyond those included in the existing LTMP and specified in the Project Brief, have not been considered.
- The work completed by BMT has been largely based upon information provided by MBRC, including hydrographic surveys and costing information. While all care has been taken to apply the information appropriately, BMT have not independently verified the accuracy of the supplied information and shall not be liable for any errors in the supplied information including any subsequent calculations or assessments completed by BMT.

- All dollar amounts are presented in 2016 dollars and exclude the Goods and Services Tax (GST). Further, the time value of money and inflation is not taken into account, and therefore, financial modelling is required to be completed by others in order to determine appropriate levy amounts.

This LTMP, including the associated Maintenance Model, has been prepared for MBRC to assist in the long-term planning and funding of maintenance activities in the Bribie Gardens canal estate. While considerable detail is included within the LTMP, it is highlighted that it has been developed as a high-level, long-term planning and costing tool. As such, the LTMP should not be used for the detailed planning and execution of maintenance activities, which will generally require separate detailed planning and design. Further, the LTMP should be reviewed and updated periodically, notionally every 3-5 years, to ensure that the underlying assumptions and cost rates remain appropriate.

2 Site description

2.1 Location

Bribie Gardens is located on the western foreshore of Bribie Island, just south of the Bribie Island Bridge, in the suburb of Bongaree, Queensland. The semi-tidal lake and entrance channel provide access to Pumicestone Passage and Moreton Bay. The location and layout of the canal estate is provided in Figure 2-1.

2.2 Canal development

2.2.1 Overview

The canal estate has been progressively developed in stages following the original construction which began in the mid 1980's. The initial development stages, incorporating the entrance channel, lock and weir, and western lake stages (west of Goodwin Drive) are understood to have been completed between approximately 1984 and 1988. Successive stages to the east of Goodwin Drive were completed from as early as 1989, through to the early 2000's. The estate currently comprises approximately 320 waterfront residential properties.

2.2.2 Tidal planes and water levels

Water levels within Pumicestone Passage fluctuate daily as a result of the tidal movement of water within the passage and the wider Moreton Bay. Tidal planes for Bongaree are published by Maritime Safety Queensland (MSQ) and are provided in Table 2-1. These indicate a maximum tidal range between Lowest Astronomical Tide (LAT) and Highest Astronomical Tide (HAT) of 2.35m.

Table 2-1 Bongaree Tidal Planes

Tidal plane	Level (m LAT)	Level (m AHD)
HAT	2.35	1.25
MHWS	1.87	0.77
MHWN	1.53	0.43
AHD	1.10	0.00
MSL	1.06	-0.04
MLWN	0.65	-0.45
MLWS	0.32	-0.78
LAT	0.00	-1.10

Source: MSQ 2016

The lock and weir structure, located just to the east of Welsby Parade, separates the entrance channel area from the semi-tidal lake and acts to maintain an elevated water level in the lake. While water levels in the entrance channel area (i.e. west of the lock and weir), are subject to the full range of tides experienced in Pumicestone Passage, the minimum water level in the lake is controlled by the weir and is maintained at approximately +0.1mAHD.

Figure 2-1 Bribie Gardens Locality Plan

2.2.3 Waterways and navigation

This section summarises the design characteristics and dimensions of the key waterway areas within the estate, including the entrance channel, lock and weir structure, and the semi-tidal lake, together with the subsequent limitations to vessel navigation within the waterways.

The Bribie Gardens entrance channel is approximately 180m long, extending from Welsby Parade out into Pumicestone Passage. The width of the channel varies from 10m at Welsby Parade, to 20m at its western end, and has a constant design bed level of -3.10 mAHD. The entrance area, just east of Welsby Parade similarly has a design bed level of -3.10 mAHD

The lock provides controlled access to the Bribie Gardens Lake and is a monolithic reinforced concrete structure. Radial gates at each end open and close to allow vessels to enter the lock and pass into the adjacent waterway area. The attached weir is similarly a monolithic reinforced concrete structure which acts to control tidal flows and limit the minimum water level within the lake.

The typical cross-section design within the lake is consistent throughout the development stages and comprises a one metre high 'L' shaped concrete revetment wall, upper rock-armoured embankment, lower-submerged embankment, and a flat lake bed as shown in Figure 2-2. The design bed level is -1.9mAHD throughout all areas of the lake, while the width varies slightly in different areas, with quay-line to quay-line widths generally ranging between 30m to 40m.

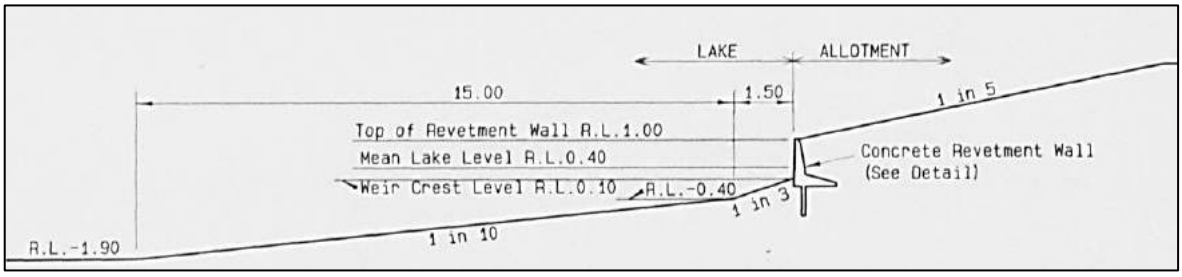

Figure 2-2 Bribie Gardens Typical Design Cross Section (MBRC Ref. 4727848 – Mar 1991)

Navigation of vessels within the estate waterways is restricted by the navigational depths, bridge clearance heights, and the internal dimensions of the lock and weir. The design bed depth is 2.0m at the lowest water level, both in the lake and entrance channel area. This depth includes allowance for siltation, and therefore the minimum navigation depths are less than 2.0m. The maximum vessel length that could be safely accommodated by the internal dimensions of the lock is estimated to be between 8 and 10 metres. Two roads cross the Bribie Gardens waterways; Welsby Parade and Goodwin Drive. The nominated clearance height of the Welsby Parade Bridge is 2.6m, while the nominated clearance height of the Goodwin Drive bridge is not known.

The estate also incorporates a publically accessible boat ramp within the lake area. The ramp is located off Phoenix Avenue, but as outlined in Section 1.2.2, the maintenance of this ramp is outside of the scope of the LTMP.

2.3 Marine environment

The canal estate is located adjacent to marine and national parks, including the Moreton Bay Marine Park, and Bribie Island National Park. While the canal waterways are excised from the Marine Park, it is located directly adjacent to the *Pumicestone Channel* Conservation Park Zone (CPZ02) and Habitat Protection Zone (HPZ04). The canal estate is also located adjacent to the internationally important Moreton Bay RAMSAR wetlands, which extend throughout Pumicestone Passage.

2.4 Maintenance activities

The maintenance activities included in the LTMP and associated Maintenance Model are summarised as follows:

- Lock and weir maintenance
- Maintenance dredging and dredged material disposal
- General maintenance, including:
  - Canal batter maintenance
  - Vegetation removal
  - Litter collection
  - Navigation aids and signage maintenance
- Other general and planning activities, including:
  - Water quality monitoring
  - Periodic review and update of the LTMP
  - Dredging design and planning
  - Environmental approval applications and renewals

The following sections further discuss these maintenance activities, and are arranged as follows:

- Lock and Weir Maintenance
- Maintenance Dredging
- Other Maintenance Activities (including general and planning activities).

3 Lock and Weir Maintenance

3.1 Introduction

The original LTMP included estimated costs for the periodic maintenance of the lock and weir structures together with the anticipated timing and costs for their eventual replacement. These original estimates were based upon visual inspections above the operating water levels and limited inspection by divers below water only, and did not include any testing of elements below the water level. As such, notional allowances for maintenance were included in the original LTMP, together with an allowance for replacement of the structure at the end of an estimated 50 year service life. The estimated replacement cost of the structure was $5,625,000 in 2012 dollars, and given its original construction in 1984-85, the replacement was scheduled for 2035 (KBR 2012a).

Given that the lock and weir maintenance and replacement costs represent a significant proportion of the total estimated maintenance costs, it was considered necessary by MBRC to conduct a more detailed investigation into the residual life of the structure to more accurately predict the long-term costs and timing associated with the structure. BMT JFA Consultants were subsequently engaged to complete a Residual Life Assessment in conjunction with the review and update of the LTMP. This section provides a summary of the completed assessment and outcomes, and the complete report is provided in Appendix E.

3.2 Residual life assessment

3.2.1 Scope

The overall objective of the residual life assessment, as outlined in the project brief, was to:

- Estimate the long term costs and timing associated with maintaining and replacing the lock and weir structure, to inform updates to the LTMP, including:
  - assessment of the residual life of the structure
  - consideration of options to extend the service life
  - estimates of maintenance costs over the remaining life of the structure.

BMT JFA developed an assessment methodology for the residual life assessment based upon the project objectives and extensive experience in the condition assessment and maintenance of marine structures, including lock structures. The adopted methodology included the following key tasks:

- Desktop assessment – including determining an appropriate, standardised, assessment framework and identification of key areas at critical locations for inspection, testing and assessment.
- Condition inspection and testing – visual inspection and non-destructive testing within accessible areas of the dewatered lock, including lock gates, together with accessible areas of the weir.

- Condition assessment – assessment of inspection results and determination of the structure's condition and estimated residual life.
- Costed short-term maintenance schedules – preparation of a costed short term maintenance schedule for items identified during the completed condition inspection and assessment.
- Costed, high-level, long-term maintenance schedule – preparation of a high-level long-term maintenance schedule for future anticipated maintenance activities, including estimated maintenance costs.
- Lock & Weir replacement concept design and cost estimates – preparation of a high-level concept design and associated cost estimates for the eventual replacement of the structure.

3.2.2 Limitations

The completed inspection and testing of the structure was limited to visual and non-destructive testing of the accessible areas of the key structural elements and the lock gates only. The inspection and testing did not include mechanical and electrical components, non-structural elements, appurtenances, and non-accessible areas of the structure, including the external areas of the lock (i.e. areas outside of the lock gates) and all areas of the weir beneath the water-line. Further, the brief specified 'non-destructive' testing and, as such, assessment of chloride ion concentrations in the concrete, which is typically determined via drilling and testing of concrete cores, was not included in the scope.

As such, the conclusions, recommendations, and maintenance schedules are considered sufficient to meet the overall project objectives, but shall not be relied upon for the detailed planning and execution of the long-term maintenance of the structure. Additional defects, to those identified herein, may have existed at the time of the inspection, and future degradation of the structure will also result in further defects and maintenance requirements. Subsequent detailed inspections, assessment, and design of maintenance works, additional to the recommendations and schedules, will be required.

3.2.3 Condition inspection

Inspection of the lock and weir was undertaken on the 20 January 2016 during a scheduled lock dewatering by Justin Fifield (BMT JFA), Dr Zac Couper (BMT JFA) and Dr Bob Boardman (Austest NDT). The inspection included visual inspection of the structures, together with reinforcement cover-meter readings and ultrasonic thickness (UT) testing in key areas of reinforced concrete elements and the steel gates respectively.

The condition inspection and assessments were undertaken in accordance with the *Wharf Structures Condition Assessment Manual* (WSCAM) (Ports Australia 2014). This manual was developed by Ports Australia to provide a consistent methodology for the visual inspection, testing, and condition assessment of marine structures. As such, it provides the most appropriate condition assessment framework for the inspected structures.

While most areas within the dewatered lock were accessible, some areas could not be inspected or tested including the base concrete of the lock (due to the presence of standing water), together

with all external areas of the lock and weir structures below the water-line. Diver inspections were outside of the scope of the completed inspections.

3.2.4 Summary outcomes

Overall condition

The lock and weir structure was assessed to be in an average to good condition based on the applied WSCAM condition rating framework. Key findings regarding the structure's condition included:

- Structural concrete elements generally have low cover to the reinforcement, increasing the structure's susceptibility to defects and deterioration.
- The steel lock gates include thin-walled sections and corrosion has been initiated in some areas.
- A number of small defects were identified and require repair in the short-term.

Maintenance

A maintenance schedule was prepared for the short-term maintenance requirements identified during the condition inspection and assessment, and is included in the full report. High priority maintenance activities identified included: repairs to concrete spalling and cracking in the lock structure, and the replacement of anodes and seals on the lock gates.

A high-level schedule of anticipated medium to long-term maintenance requirements was developed based upon the current condition of the structure, together with BMT JFA's experience of maintaining marine structures. The schedule is included in the full report, and includes periodic condition inspections and maintenance of the key structural elements. In addition, provision for a detailed condition assessment and finalisation of the replacement strategy has been scheduled for 2030. This work would inform the recommended maintenance activities during the anticipated final 10 years of the structure's service life, and confirm the timing for the structure's replacement.

The long-term maintenance costs were estimated based on the developed maintenance schedules. Maintenance costs were estimated using a range sources including quotes, historical rates for past maintenance, and typical industry rates. The estimated total maintenance cost over the expected residual life of the structure to 2041 (as noted below), including condition inspections, is approximately $1,840,000 (in 2016 dollars, where the time value of money and inflation is not taken into account).

Structure replacement

The residual life of the structure is estimated to be 20-25 years based on the adoption of the recommended maintenance regime. At this time, it is estimated that it will be uneconomical to maintain the existing structure in a serviceable state, and replacement of the structure is therefore anticipated in 2041.

A concept design for the replacement of the overall structure was developed and used as the basis to estimate the cost of replacing the structure. The concept design is provided in the full report and

the estimated replacement cost, including demolishment and removal of the existing structure, is $6,550,000 (in 2016 dollars, where the time value of money and inflation is not taken into account).

Recommendations

Sections 7 and 9.2 of the *Residual Life Assessment Report* (Appendix E) detail the recommended maintenance actions together with a summary of the overall recommendations from the completed work. In addition to these recommendations, it is suggested that during planned future maintenance of the concrete elements, MBRC conduct testing of chloride ion concentrations on suitable sections of concrete which require removal or replacement as part of the maintenance works (such as the recommended repairs to concrete spalling). The information from this testing will supplement information gathered during the next scheduled condition assessment in 2018.

4 Maintenance Dredging

4.1 Introduction

Periodic maintenance dredging will be required to ensure that the function and amenity of the Bribie Gardens waterways are maintained. This section discusses maintenance dredging within the estate waterways, including discussion of historical dredging and material disposal activities, sedimentation rates, sediment properties, sedimentation mechanisms, design depths and dredging triggers, the recommended dredging and material disposal strategies, and environmental approvals.

4.2 Historical activities

Available records indicate that removal of material from the entrance channel and adjacent southern beach has been undertaken on a periodic basis since 2003 (KBR 2012a). Additionally, bed levelling in the area immediately to the west of the lock and weir structure was undertaken in 2014/15. Table 4-1 summarises the dates, methodology, and estimated volumes, for the known past maintenance dredging campaigns.

Table 4-1 Summary of past maintenance dredging campaigns

Year	Dredging and material disposal methodology	Estimated volume removed (m^3)
*2003	Small CSD – material pumped to northern foreshore	Approx. 5,000 m^3
*2005	Small CSD – material pumped to northern foreshore	1,900 m^3
2012	Land-based excavator and trucks, plus small CSD – material placed on northern foreshore	7,600 m^3
2014	Barge and excavator – material placed on northern foreshore	2,100 m^3
2014/15	Bed levelling between Welsby Pde Bridge and Lock and weir	N/A

** Source: KBR 2012a*

In addition to the past campaigns presented in Table 4-1, MBRC are planning to undertake maintenance dredging of accumulated sediments from within the Lake in 2016/17. This maintenance dredging will specifically target accumulated material on the southern bank, just upstream (i.e. east) of the lock and weir structure.

4.3 Sedimentation rates

Sediment accumulation rates within the entrance channel area and lake have been previously assessed via direct comparison of hydrographic survey datasets. The results of the previous assessment are documented in KBR (2012a) which found an estimated sediment accumulation rate of 1,050 m^3/annum within the entrance area, and 950 m^3/annum within the lake. Additional hydrographic survey datasets, collected since this earlier assessment, have facilitated further assessment and update of the estimated sediment accumulation rate. This section summarises BMT's completed assessment and outcomes.

The applied assessment methodology comprised direct comparison of hydrographic survey datasets. The hydrographic survey datasets made available by MBRC for BMT's assessment are provided in Table 4-2. Based upon the supplied hydrographic survey datasets, assessment of siltation rates between 2007 and 2014 was undertaken. These two surveys were selected as the 'bounds' for the comparison as the resulting estimated accumulation rates cover the full period of available data, and are therefore considered most representative of the average long-term rates.

The broad methodology for the direct hydrographic survey comparisons is summarised in Table 4-3. The resulting long-term estimated siltation rates for 2007 to 2014 (i.e. G4) are presented in Figure 4-1 and summarised, together with the previous estimates in Table 4-4. The total sediment volumes above design levels, as at 2014, were also estimated using a design digital terrain model (Ref. Appendix A) and the 2014 survey, and are also provided in Table 4-4. Additional discussion of the siltation rates, including sedimentation mechanisms, is provided in the following sections.

An important limitation of the completed assessment is the lack of quantification of sediment accumulation (or removal) from the foreshore to the south of the entrance groyne. The periodic removal of accumulated material from this area forms part of maintaining the entrance channel and it is therefore important to incorporate volumes of accumulated (or removed) sediment in this area in the overall volumes calculations. However, quantification of sediment accumulation in this area has not been possible using the supplied hydrographic survey datasets, as the surveys do not extend over this area. Given this, the estimated sediment accumulation rate presented in Table 4-4 may underestimate the average long-term sediment accumulation rate.

It is recommended that future surveys should cover the adjacent southern and northern foreshore areas, and that this information should subsequently be utilised to review and update the estimated sediment accumulation rates for the entrance area.

In addition to the above limitation, the comparison of the 2014 and 2007 survey datasets, together with the previous comparison between the 2012 and 2007 survey datasets, indicated a possible translation of approximately two metres (i.e. horizontal shift) in the data points of one of the survey datasets. While individual data points are subject to the specified horizontal and vertical accuracy tolerances, an apparent translation of all data points such as this is considered to warrant further investigation or inquiry with the surveyors. Notwithstanding, this apparent translation was taken into consideration, as best as possible, when calculating the siltation volumes.

Table 4-2 Summary of hydrographic survey datasets

Dates	Survey Description	Surveyor (Survey Plan Ref. No.)	Survey Class	Coverage
21/03/2007-19/04/2007	Investigation Survey	PBPL (116471)	C	Full
20/04/2012	Bathymetric Survey	GPS & Hydrographic Services (1163)	-	Full
1/06/2013	Topographic & Hydrographic Detail Survey	MBRC (14-293)	-	Full
1/11/2014	Bathymetric Survey	Mapping & Hydrographic Surveys (MHS) (MH1165)	A	Full

Table 4-3 Summary of assessment methodology – 2007 to 2014

Ref.	Survey Grid Calculation	Applicable area
G1	2014 (01/11/14) **minus** 2007 (21/03/2007)	All areas
G2	Pre-dredge 2012 (20/04/12) **minus** Post-dredge 2013 (01/06/13)	Dredge areas
G3	Total estimated siltation depth 2007 to 2014 = G1 + G2	All areas
G4	Estimated Siltation Rate 2007-2014 = G3 / 7.58 years	All areas

Table 4-4 Estimated sediment accumulation rates and volumes above design

Canal Zones	Description	*Accumulation rate (2007-2012) (m^3/a)	Accumulation rate (2007-2014) (m^3/a)	Volume above design in 2014 (m^3)
1-2	Entrance area	990	1,125	8,300
3-7	Area between lock and Goodwin Dr.	370	260	16,500
8-10	Stretch of lake adj. Hoya Cr.	120	0	3,500
11-15	Eastern area of lake surrounding Pentas Dr.	490	0	3,300

** Source: KBR 2012a Appendix G (dredging schedule Estimated Annual Siltation Volumes)*

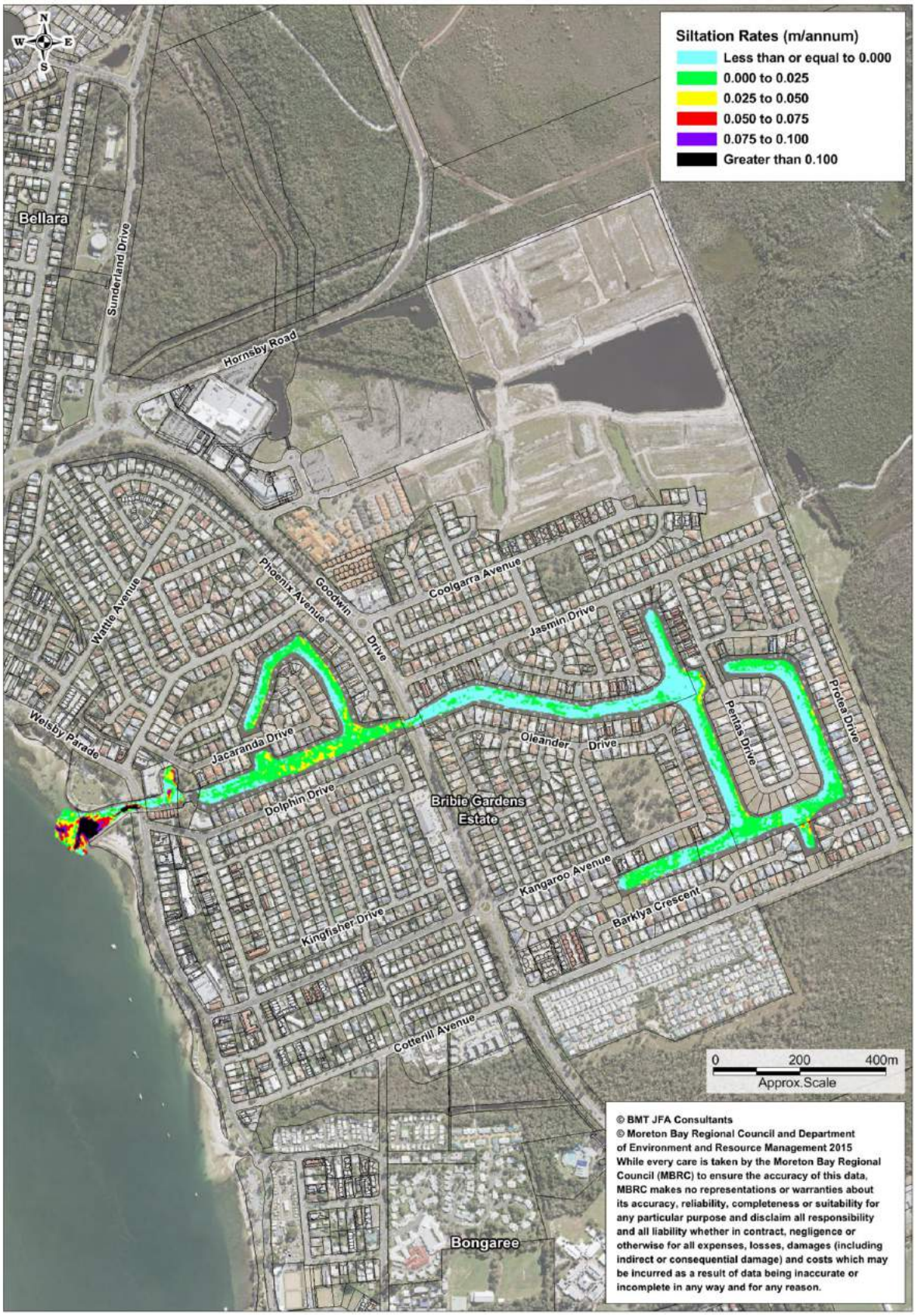

Figure 4-1 Estimated Siltation Rates 2007 to 2014

4.4 Sediment properties

Sediment sampling and analysis has been undertaken on three occasions within the Bribie Gardens estate; October 2010 (KBR), February 2012 (SMEC), and March 2012 (KBR). A total of 7 boreholes were sampled between the two KBR sampling campaigns in 2010 and 2012, with boreholes generally positioned in areas of inferred siltation. The 2010 sampling campaign was completed to provide a preliminary understanding of the physical characteristics of sediments, and therefore included only pH field-on-oxidation (pH_{fox}) and particle size distribution (PSD) testing in addition to standard field classifications. The 2012 KBR sampling campaign was completed in accordance with the recommendations of the *National Assessment Guidelines for Dredging* (NAGD) (2009) and included a comprehensive suite of laboratory testing and analysis.

The February 2012 sediment sampling by SMEC was conducted for the purpose of supporting environmental approval applications for maintenance dredging in the entrance channel and to the south of the groyne. The sampling was comprised of six boreholes, two in the entrance channel, three on the beach area south of the groyne, and one from the proposed placement area on the foreshore north of the entrance channel.

The results of the general field classification and particle size distribution (PSD) tests indicated that sediments within areas of inferred accumulation were comprised of (KBR 2012a):

- Entrance channel (west of Welsby Pde) – medium grained sands with negligible fines
- Area between Welsby Parade and lock & weir – marine clays overlying medium grained sands.
- Lake – silty and clayey sands.

The results of physio-chemical testing of the sediments in areas upstream (i.e. east) of Welsby Parade indicated the following (KBR 2012b):

- Mean contaminant concentrations were all below NAGD screening levels.
- Some of the sediments have appreciable acid generating potential.

Field oxidation tests indicated that the acid generating potential of two samples (BH08 2012, and BH10 2010) was appreciable, while all other test results indicated very limited net acid generating potential. Given this, the sediments were subsequently deemed suitable for unconfined ocean disposal or land-based disposal, on the basis that sediments are appropriately treated for Potential Acid Sulphate Soils (PASS) if disposed on-land.

The results of physio-chemical testing of the sediments in the entrance channel (i.e. west of Welsby Parade) indicated that the material has negligible acid generating potential, and was subsequently deemed suitable for most disposal options, including beach nourishment (KBR 2012a).

4.5 Sedimentation mechanisms

4.5.1 Entrance channel area

The accumulation of sands within the Bribie Gardens entrance channel is a result of long-shore sediment transport processes, also referred to as ‘littoral drift’ or ‘long-shore drift’, which result in a

net 'drift' of granular sediment particles (i.e. beach sands) along the shoreline (i.e. long-shore direction). Long-shore sediment transport is principally driven by the combined action of waves and nearshore currents.

The potential long-shore sediment transport rates in this area of the Bribie Island coastline were assessed as part of the *Shoreline Erosion Management Plan for Bongaree, Bellara, Banksia Beach and Sandstone Point* (SEMP) (GHD 2011). The SEMP also included discussion of the accumulation of sand at the entrance to the Bribie Gardens canal estate and recommended management measures.

The reported long-term net average annual potential longshore sediment transport rate in the areas adjacent to the Bribie Gardens entrance is approximately 10,000 to 15,000 m^3 in a northerly direction. 'Potential' long-shore transport rates represent the potential sand transport which will only be realised with a sufficient quantity of material available for transport (i.e. sufficiently nourished beaches). In areas where these conditions are not present, such as eroded beach areas where the shoreline is protected by a seawall, the actual transport rate will be much lower than the 'potential' rate.

In addition to the accumulation of sands in the entrance channel, accumulation of fine marine clays in the area between Welsby Parade and the lock and weir is a result of natural siltation. Siltation is the process of suspended fine sediment particles settling out of suspension and being deposited on the bed and banks of channels, rivers, lakes, and other areas.

4.5.2 Lake

Investigation into the source of accumulated sediments entering the Bribie Gardens canal estate was not part of BMT's scope. Further, no detailed investigations into the sediment sources have been commissioned to-date. The previous siltation assessment by KBR (2012a) included general discussion of the possible sources; however, a clear source of the suspended sediments or cause for the siltation was not identified.

The results of sediment sampling generally indicated silty and clayey sands in areas of apparent siltation and, as such, natural siltation of fine marine clays entering from Pumicestone Passage was discounted as the primary cause of siltation within the lake. Possible sources such as potential erosion of material from the banks and deposition in the lake bed, construction related erosion and deposition, and stormwater runoff were discussed, but none could be confirmed as the key contributing causes. Without detailed investigation using more advanced analysis methods, which might include hydrodynamic and morphological numerical simulation methods, it is generally not possible to confirm the source(s) of suspended sediments, or to estimate the relative contributions from different sources.

The data presented in Table 4-4 indicates that there is accumulated sediment above design levels in Zones 8-10 and 10-15, yet the estimated siltation rates are negligible. This, together with the location and spatial extents of the accumulated sediments, indicate that this material is not the result of natural siltation processes, and may instead be linked with construction activities.

Erosion and re-deposition

A review of erosion and deposition patterns in areas adjacent the lock and weir indicates that material may have been eroded from the bed, due to the increased velocity of tidal flows over the weir, and subsequently deposited in areas adjacent the eroded areas. The potential scour and deposition areas are broadly illustrated in Figure 4-2. In general, the potential scour appears quite limited on the downstream (i.e. western) side of the lock and weir in comparison to the upstream side.

While the original design of the channel and lake beds incorporated rock scour protection in the areas immediately upstream and downstream of the lock and weir, the scour 'holes' should be monitored via hydrographic surveys to ensure that the scour protection is not compromised or the overall structure undermined.

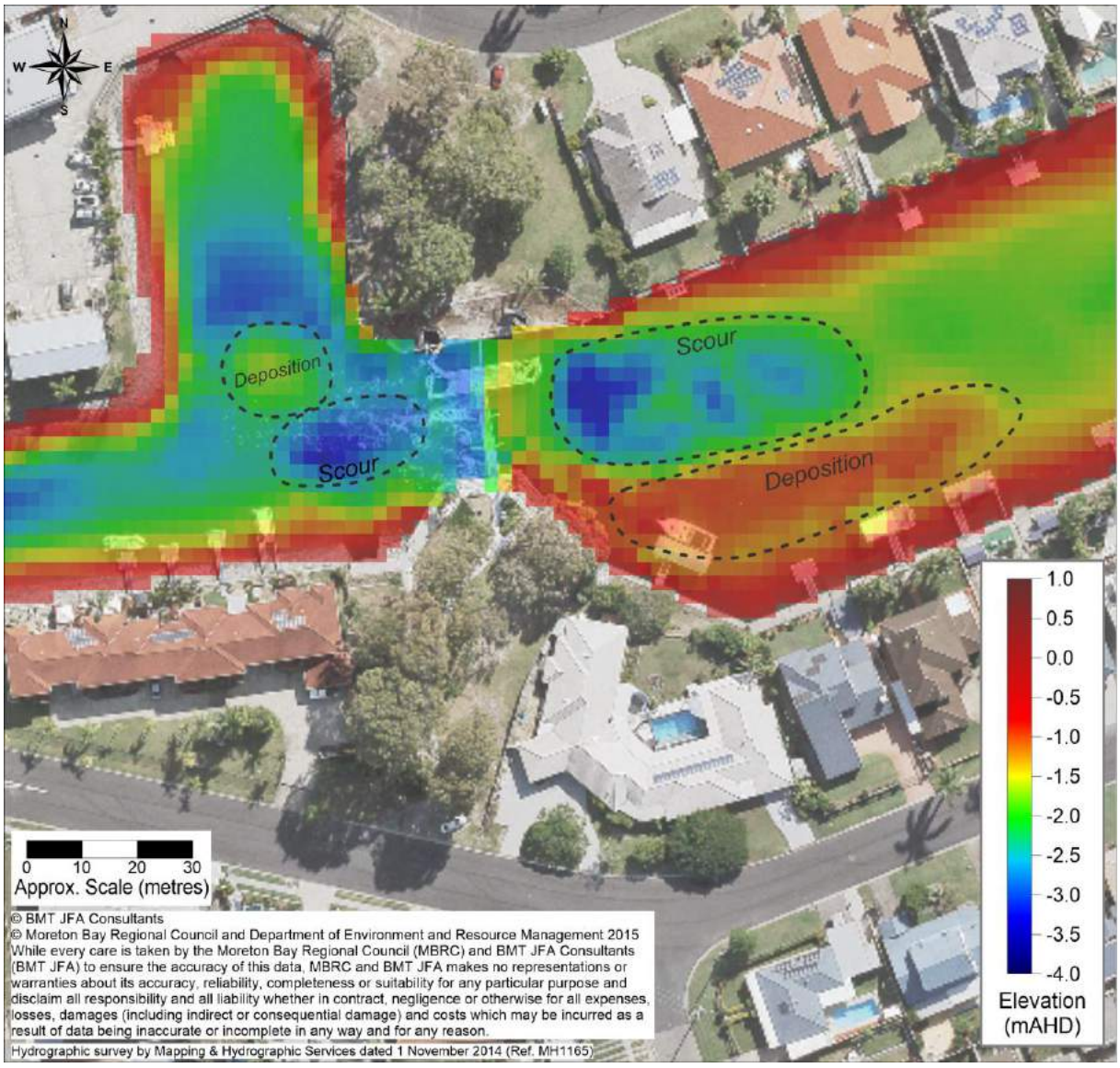

Figure 4-2 Possible scour and deposition areas inferred from hydrographic surveys

4.5.3 Future accumulation rates

Given the complexities in sedimentation processes, it is not possible to accurately forecast future sediment accumulation rates. Therefore, for the purpose of assessing the frequency and volumes of dredging and dredged material disposal campaigns over the specified 50 year planning horizon, rates of 260 m^3/annum and 1,125 m^3/annum have been adopted for the sediment accumulation rates in the lake (between the lock and weir and Goodwin Drive) and entrance channel areas respectively (Refer Table 4-4). The completed siltation assessment indicated siltation volumes in areas east of Goodwin Drive (Zones 8 to 15) which were indiscernible from the inherent survey accuracy limitations. That is, based on the completed assessment, negligible volumes of siltation are expected in these areas within the nominated planning horizon of 50 years, and therefore maintenance dredging of additional accumulated sediment in these areas is unlikely to be required in the next 50 years.

The adopted rate of 1,125 m^3/annum in the entrance channel area, determined from the analysis of survey datasets, compares well with an inferred rate from historical campaigns of approximately 1,050 m^3/annum (approximately 11,600m^3 removed between 2003 and 2014). However, as outlined in Section 4.3, this volume may underestimate the long-term average sediment accumulation rate owing to the lack of inclusion of the southern foreshore in the supplied survey datasets and subsequently calculated volumes. As such, this value should be reviewed, and if necessary updated, following the completion of future hydrographic surveys which include the adjacent foreshore areas.

Future development

While final housing development is ongoing in areas of the estate, it is understood that there are no plans for the expansion of the Bribie Gardens estate beyond its current extent. As such, no allowance for additional siltation associated with future development stages has been considered in BMT's assessment.

4.6 Waterway depths

4.6.1 Design bed levels

Maintenance dredging campaigns will be conducted to remove accumulated sediment from within the waterways and from the southern side of the groyne. Dredging within the waterways will restore the bed levels back to their original design levels to provide a period of immunity against ongoing siltation that may otherwise influence the safe navigation of craft throughout the canal estate. Removal of sediment from the southern side of the groyne will aim to restore an appropriate sediment 'storage' capacity for storage of accumulated sediment between dredging campaigns, minimising sediment 'leakage' around the groyne into the entrance channel.

Based on supplied design and as-constructed drawings, the design bed level throughout the Bribie Gardens estate is -3.1 mAHD downstream of the lock and weir, and -1.9 mAHD upstream of the lock and weir.

In order to compare the 2014 surveyed depths against original design bed levels, and to provide a consistent basis for the design of future dredging works, BMT JFA developed a Digital Terrain

Model (DTM) of the Bribie Gardens estate. This DTM was developed based upon supplied design drawings, and was developed to extend over the waterway areas only (i.e. between the cadastral boundaries). A depth-coloured plan of the DTM is provided in Appendix A.

4.6.2 Minimum desirable bed levels

The minimum desirable bed levels, or 'dredging trigger levels', represent a level above the original design bed level, which triggers the need for dredging. Minimum desirable bed levels were established as part of the original Long-term Maintenance Plan and were determined based on the original design bed levels, the design vessel draughts, and a suitable allowance for under keel clearance at Lowest Astronomical Tide (LAT). The previous 'dredging trigger levels' of -2.5 mAHD and -1.3 mAHD within the entrance area and Lake respectively, were adopted on the basis of a design vessel length of 8 metres, associated design draught of 0.9m, and under keel clearance at lowest water level of 0.5m (KBR 2012a).

As outlined in Section 2.2.3, the design bed depth is 2.0m at the lowest water level, both in the lake and entrance channel area, and the maximum vessel length that can be safely accommodated by the internal dimensions of the lock is estimated to be between 8 and 10 metres.

As part of the updates to the LTMP, BMT have reviewed and updated the original dredging trigger levels. The updated levels are provided in Table 4-5 and presented graphically in Figure 4-3. The following sections summarise the basis for the adopted levels in the entrance channel and remaining areas respectively.

Entrance channel

BMT have reviewed the original dredging trigger levels and recommend a dredging trigger level of -2.4 mAHD in the entrance channel based on the following:

- Design vessel length – 8-10m Powerboat (length limited by the internal dimensions of the lock)
- Design draught - 1.0m (based on Table 3.1 of AS 3962:2001)
- Under keel clearance at LAT - 0.3m (based on Section 3.2 of AS 3962:2001)

In practice, the 'leakage' of sediments around the groyne and accumulation in the entrance channel will result in progressive shoaling of the channel in a general northerly direction. As it may be impractical to remove relatively small amounts of material on a frequent basis, MBRC and the residents may be willing to accept temporarily reduced navigation widths, via installation of temporary navigation aids. This would generally need to be coordinated with the Regional Harbour Master and MSQ. In any event, regular surveys of the entrance channel will be required to ensure appropriate channel depths and widths are maintained.

Remaining areas

Future sediment accumulation within other areas of the waterways is anticipated to be principally comprised of fine sediments. Based on this, and previously adopted dredging trigger levels in other canal estates managed by MBRC, a dredging trigger level of -2.2 mAHD is recommended within area between Welsby Parade and the lock and weir, and -1.0 mAHD within the lake. These levels are both equivalent to a trigger depth of 1.1m at the lowest water level. This recommended

dredging trigger depth is based upon a reduced under keel clearance of 0.1m, together with the previously outlined design vessel length and draught.

The adoption of the lower allowance for under keel clearance is considered a reasonable approach within the canal estate where settled material is comprised of reasonable depths of settled fine sediments overlying the harder substrates. However, should future siltation be comprised of sands, this should be revised to 0.3m as adopted for the entrance channel and as recommended in Section 3.2 of AS 3962:2001.

Table 4-5 Adopted design and dredging trigger levels

Area	Original design bed level (m AHD)	Dredging trigger level (m AHD)
Entrance channel	-3.1	-2.4
Area between Welsby Parade and Weir	-3.1	-2.2
Lake	-1.9	-1.0

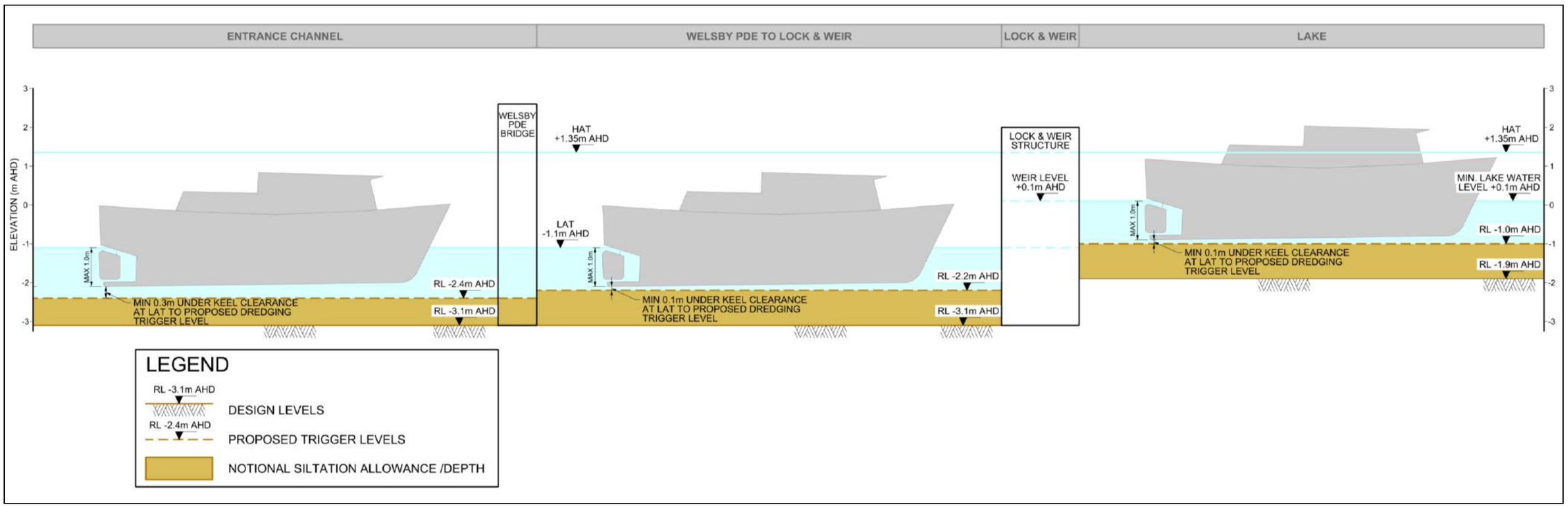

Figure 4-3 Bribie Gardens Design bed levels and adopted dredging trigger levels summary

4.7 Dredging and material disposal options

This section presents a discussion of dredging and dredged material disposal options, covering both the entrance channel and lake areas. The subsequent recommended dredging and material disposal strategies, including additional options incorporated in the Maintenance Model, are presented in Section 4.8.

4.7.1 Constraints

In identifying suitable dredging and material disposal options, BMT have considered the various factors which limit the options available to MBRC. These include:

- Estimated maintenance dredging volumes.
- Dredged material properties.
- Physical and navigational constraints.
- Environmental outcomes and approvals.
- Ultimate disposal / re-use options.
- Economic feasibility.

These factors are broadly discussed in the following sections.

4.7.2 Estimated maintenance dredging requirements

The predicted maintenance dredging requirements influence the scale and intensity of the proposed dredging campaigns, and also define the key dredging areas. The estimated maintenance dredging volumes over the nominated 50 year planning horizon are summarised as follows:

- Entrance channel (Zone 1) – 55,000 m^3 (10 campaigns)
- Remaining areas – 16,000 m^3 (4 campaigns).

These estimated volumes highlight that maintenance dredging within the entrance channel accounts for approximately 75% of the total maintenance dredging requirements, and that relatively low volumes are expected to be dredged from the remaining areas. Further, the anticipated number of dredging campaigns indicates that each campaign will be comprised of relatively low material volumes.

4.7.3 Dredged material properties

The physical properties of the dredged material will affect its suitability for various beneficial re-use options, such as beach nourishment, together with other disposal options. As discussed in Section 4.4, the results of previous sediment sampling show that the materials to be dredged vary in different areas of the estate, as follows:

- Entrance channel – medium grained sands with negligible fines.
- Area between Welsby Parade and lock & weir – marine clays overlying medium grained sands.

- Lake – silty and clayey sands.

Given these material characteristics, it is considered that only material within the entrance channel area will be suitable for placement as beach nourishment, and that the appreciable proportion of fines in the other areas precludes the material from being placed as beach nourishment. However, other beneficial re-use options may still be feasible for the other materials, particularly the silty and clayey sands from within the Lake, provided that any PASS can be effectively treated.

4.7.4 Physical and navigational constraints

The physical dimensions within the canal estate, including navigational depths, canal widths, and the presence of floating jetties and pontoons, potentially limit the available dredging methodologies which can be successfully employed to remove accumulated sediments. Further, navigational access beneath the Welsby Parade and Goodwin Drive bridges, and the presence of the lock and weir, further limit plant selection and the available dredging methodologies.

In general, it is considered that conventional small Cutter Suction Dredgers (CSDs) are most effective in dredging within the narrow confines of canals, and other methodologies such as Grab Dredgers (GDs) (including Clamshell and Backhoe Dredgers) have some limitations, particularly dredging around and beneath jetties and pontoons, and in safely navigating and mooring attendant barges. Notwithstanding, dredging is still possible with both CSDs and GDs. Ultimately, the suitability of a given dredging methodology is subject to the specific plant and methodologies employed by contractors and subsequent effectiveness in removing material from areas which are difficult to access, together with general tolerance control.

The lock and weir structure and relatively narrow access channel generally precludes unconfined offshore disposal via barges, which are typically larger than the internal dimensions of the lock structure. Further, access constraints within the Lake will limit the size of the dredging plant which can be mobilised into the Lake, therefore affecting the practical pumping distances for Cutter Suction Dredgers (CSDs).

4.7.5 Environmental considerations

The assessment of dredging and material disposal options requires consideration of the surrounding environment and potential impacts, together with the regulatory constraints. These are broadly discussed in the following two sections.

Environmental context and impacts

While the Bribie Gardens entrance channel area (i.e. west of the lock and weir) is tidal waters, the waters within the upper canals are blocked from continuous hydraulic exchange by the lock and weir structure. A number of stormwater outlets discharge into the canals from the urban areas to the north and the south. Flows also occur into the site from Bribie Island National Park to the east. Drainage from developed lands to the north (around the Bribie Island shopping centre) does not flow into the canal estate (MBRC, 2014).

The entrance channel is located within Moreton Bay Marine Park (MBMP). This area is zoned Habitat Protection Zone (HPZ) which adjoins the Conservation Park Zone (CPZ) within the main part of Pumicestone Passage. Environmental values (EVs) and water quality objectives (WQOs)

have been scheduled for all of the canal estate, including waters upstream of the weir, under the *Environment Protection (Water) Policy 2009*. Environmental values supported include aquatic ecosystems and primary, secondary and visual recreation.

Previous monitoring in this area (MBRC, 2015) has indicated the following:

- Water quality complies with scheduled Water Quality Objectives within the entrance canal
- Exceedances of scheduled Water Quality Objectives in the Lake in relation to the following parameters:
    - Dissolved oxygen – frequently above of Water Quality Objectives
    - Turbidity and pH – occasionally above of Water Quality Objectives
    - Nutrient levels (ammonia, total nitrogen, total Kjeldahl nitrogen, total phosphorous) frequently above guideline values.
- Occasionally instances of algal formation in the upstream canals requiring ongoing surveillance, though no significant algal blooms have occurred.

Previous sampling in the canal estate (both entrance channel area and Lake) indicated that sediments have a low acid forming capacity (KBR, 2012). KBR (2012) found that sediment in the entrance channel area adjacent the lock and weir was predominantly fine marine sediments (MBRC, 2014) while the Lake contains silty and clayey sands. Both the entrance channel area and Lake had low levels of heavy metals and organic contaminants, with slightly elevated lead levels in the entrance channel area. On the basis of this sampling, sediments were considered uncontaminated and therefore suitable for unconfined ocean disposal in accordance with the *National Assessment Guidelines for Dredging 2009* (NAGD).

Dredging within the estate will create turbid plumes. The Lake experiences reduced hydraulic flushing due to the lock and weir, and therefore turbid plumes created by dredging may be persistent within the Lake area.

Environmental regulatory framework

The identification of dredging and material disposal options requires consideration of environmental regulatory constraints, including assessment and approval requirements for different activities. In the context of Bribie Gardens, as a lock and weir separates the Lake from tidal interaction, there are two separate approval regimes that apply.

MBRC currently hold a permit for the dredging of material from the Bribie Gardens entrance channel (i.e. between Welsby Parade Bridge and the lock and weir). This includes grab dredging (or similar) up to 10,000m^3/yr and placement in an approved land-based facility, and suction dredging up to 100,000m^3 for placement on Bongaree Beach. A marine parks permit is also in place to cover dredging and placement activities, and ongoing maintenance of beaches. Of these, a renewal of the dredging permits would be required 2nd April 2017, the marine park dredging/placement permit 19th June 2022, and the marine park beach maintenance permit 24th April 2024.

In the context of the upstream Lake, no Environmental Authority is required for dredging as the waters are not considered 'natural waters' for the purposes of the *Environment Protection Act 1994*. However, works in the waters are still considered 'tidal works' under the *Coastal Protection and Management Act 1995*, and a dredging permit is required. A permit is also required for any placement of material, including for unconfined ocean disposal at the Mud Island Dredge Material Placement Area (MIDMPA) or at an onshore placement site.

Consistent with the London convention, the NAGD requires the adoption of the waste hierarchy for determining acceptable disposal solutions. Ultimately, however, the physico-chemical and associated geotechnical properties of sediment determine its suitability for beneficial reuse, recycling, land disposal or unconfined ocean disposal. Screening levels related to physico-chemical properties are set by the NAGD in relation to unconfined ocean disposal (i.e. placement at sea), and by the *National Environment Protection (Assessment of Site Contamination) Amendment Measure 1999* (NEPM) and *Queensland Acid Sulfate Soil Technical Manual* (QASSTM) for onshore placement.

As noted above, previous testing has shown material is suitable for both unconfined ocean disposal and onshore placement. The only current location available for unconfined ocean disposal within Moreton Bay is the MIDMPA; however, the long-term use of this site beyond a 30 year planning timeframe is currently uncertain.

4.7.6 Ultimate disposal and beneficial re-use options

There are a limited number of options available for the ultimate disposal and beneficial re-use of the dredged material, owing to the material's inherent properties, together with limited available land or established sites which can receive or store the material.

The *Moreton Bay Dredge Material Placement Study – Stage 2 Report* (KBR 2006) was commissioned by the Queensland Government, in conjunction with the Port of Brisbane, to investigate the future management of material dredged from within Moreton Bay. The study included detailed assessment of the environmental, social and economic issues associated with the options proposed for long-term dredged material disposal, and identification of the most viable options. The study identified a number of possible disposal options, including those applicable to small boat harbours and canal estates, and included (KBR 2006):

- Continued use of the existing Mud Island DMP area (MIDMPA).
- Filling of old mine sites, including Swanbank and Ipswich coal mines.
- Filling of old gravel extraction pits.
- Opportunistic filling of coastal developments.
- Stabilisation and use as controlled/engineered fill – via mixing with cement or lime.

The study provided an overall recommendation to continue the use of the MIDMPA for the disposal of uncontaminated dredged sediments. However, the study acknowledged that access and location issues dictate that some canals would require dredging by small Cutter Suction Dredge, and that this material would need to be pumped to a small local pond, subsequently dried, and then trucked to a land based placement area or disused mine.

The following options for disposal or re-use of material dredged from the Bribie Gardens estate have been identified:

Disposal:

- MBRC's Caboolture waste management facility (25 km)
- Veolia's Ti Tree BioEnergy site (125 km)
- PBPL's Future Port Expansion (FPE) site, Fisherman Islands (approximately 85 km)

Rehabilitation and beneficial re-use:

- Placement as beach nourishment (entrance channel only)
- Winning of sands and redistribution of fine material within dredged 'holes' within the Lake.
- Potential rehabilitation of existing sand/gravel extraction sites/areas.
- Cement (or lime) stabilisation and re-use as general fill or controlled/engineered fill.
- Drying and leeching of salts, mixing with composted green waste, and re-use as garden mulch.

The option for material disposal at the Mud Island Dredged Material Placement Area (MIDMPA) has been precluded given the access constraints for barges and the large shipping distances (and associated costs).

The above options are each briefly discussed in the following sections.

MBRC waste management facilities

MBRC have advised that disposal of material at MBRC's Caboolture waste management facility is possible. However, advice provided from MBRC's waste management section has indicated that the salt content in the material is very likely to interfere with methane production from their landfill and it is therefore quite undesirable and costly to dispose of the dredged material at the Caboolture site (J. Purcell, pers. comm., 7 March 2016).

Ti Tree BioEnergy Site

The Ti Tree BioEnergy site, located approximately 125 km (by road) from Bribie Gardens in Willowbank, is a waste disposal facility located on an existing open-cut coal mine. The site utilises "best practice" bioreactor technology to rapidly stabilise waste while capturing environmentally damaging methane and converting it into electricity (Ti Tree BioEnergy 2009). Initial advice provided by Veolia Environmental Services indicates that much of the material dredged from the estate could be accepted by this site, as either 'Contaminated Soils', or as 'Regulated Waste' (Kimber 2016).

PBPL Future Port Expansion

The Future Port Expansion (FPE) site is a land reclamation which will extend the existing port facilities. PBPL have advised that they would consider receipt of the dredged material for use as reclamation material in the FPE (P. Nella, pers. comm. 28/04/2016). However, the FPE site will have a finite life for receiving dredged material, which is currently estimated to reach capacity in approximately 2040.

Beach nourishment

The preferred and most economical option for the removal of clean sands, comprising negligible or low percentage of fines (i.e. silts and clays), will be dredging and placement as beach nourishment on the northern foreshore. This is consistent with the endorsed SEMP, which recommends periodic removal of accumulated sands within the entrance via small cutter suction dredge, and placement as beach nourishment on the adjacent northern foreshore.

Redistribution

A potential option for the dredging and disposal of material from within the Lake, is the separation of the fine and coarse particles (via hydrocyclones or similar) during dredging, and subsequent placement of fines back into the dredged voids and on-land placement of the coarse particles for eventual beneficial re-use. This option offers the potential advantage that the coarse materials may be utilised for beach nourishment or other beneficial re-use, and the fine materials do not require ultimate disposal (as they are retained within the lake). However, the long-term viability of this option is uncertain given that there is a finite capacity in which to retain the fines. Additionally, utilisation of this method would require further environmental and engineering studies to protect against environmental impacts within the lake and to confirm the long-term capacity.

Rehabilitation of existing sand/gravel extraction sites

As identified in the *Moreton Bay Dredge Material Placement Study*, there are likely to be opportunities to place the material for site rehabilitation within disused areas of sand/gravel extraction sites within the region. Placement of dredged material would generally comprise sub-aqueous placement, but may extend above existing water levels. Known existing sand or gravel extraction operations in the region include sites in Lawnton, Ningi, Toorbul and Donnybrook.

The key advantage of disposal within existing sand/gravel pits, in addition to the obvious beneficial use of the material, is the likely significantly reduced disposal cost compared with other options. However, each site/pit will have a finite capacity, and therefore new sites will need to be identified as existing ones reach capacity.

Stabilised fill material

The treated and dried material may be beneficially re-used as a general fill, or potentially as a controlled fill following stabilisation with cement or lime. Approximately 100,000 m^3 of dried dredged material from the Newport Waterways canal estate has been successfully utilised for general fill at external sites. This material was removed and placed at two different sites over three dredging and material disposal campaigns between 2009 and 2014, and broadly demonstrates that opportunities may exist for using the material as a general fill.

As for the rehabilitation of existing extraction sites, the advantages of utilising the material for general fill include the overall beneficial re-use outcomes together with reduced disposal costs. Similarly however, each site will have a finite capacity and new sites will need to be identified as existing sites reach capacity.

Garden soil

Previous experiments by Kinhill Pty Ltd and PBPL (then Port of Brisbane Corporation) in 1999 have shown that dredged material can be dried and mixed with green waste to produce a soil in which salt tolerant upland plants can grow (KBR 2006). Further, advice from an external consultant has indicated that, subject to confirmation via laboratory scale tests, the material could be treated and subsequently sold as a garden soil which conforms to the requirements of AS 4419 *Soils for Landscaping and Garden Use*. Such treatment would broadly involve mixing the dried dredged material with green waste at a ratio of approximately 1:1, followed by addition of soil conditioners, fertilisers, and stabilisers (Blair 2016). The costs associated with treatment would be a function of the final treatment method, cost of the green waste, mixing plant, etc., together with the potential sale price of, and demand for, the end-product. Treatment of the dredged material could be undertaken at existing waste facilities where green waste is already disposed.

While the low volumes of material to be dredged over the nominated 50 year planning horizon would generally preclude its economic feasibility for Bribie Gardens, this option might be feasible if implemented in conjunction with the re-use of material from other sites (such as Pacific Harbour and Newport).

4.7.7 Economic feasibility

The cost of the various dredging and material disposal options is a key consideration in the overall assessment of the options. In order to compare options, rates have been estimated on the basis of dollars per *in situ* cubic meter for the following dredging and material disposal options:

- grab dredging into small barges or skips which are unloaded to trucks for disposal/re-use as follows:
  - Disposal at MBRC's Caboolture waste management facility
  - Disposal at Ti Tree Bio Energy site
  - Land reclamation at the Future Port Expansion site
  - Rehabilitation of existing extraction sites
  - Stabilisation and re-use as general fill
  - Treatment and re-use as Garden soil
- small cutter suction dredge plus hydrocylone - redistributing fines into the lake and placement of coarse material as beach nourishment.
- small cutter suction dredge plus excavator and trucks – placing directly onto beach (entrance channel only).

Rates were estimated using a range of sources including quotes, historical rates for past projects, and typical industry rates. Estimated disposal only rates are provided in Table 4-6, and the estimated total combined rate for dredging and material disposal are provided in Table 4-7.

The conversion from 'Raw rates' to 'Per *in situ* m^{3}' rates requires mass and/or volumetric conversions between the disposed sediment mass and volume, and the estimated *in situ* volume.

The estimates in Table 4-6 and Table 4-7 assume that the *in situ* material and disposed material have the same bulk density (1.35 t/m^3). That is, the presented rates assume that the material is not dried prior to disposal.

Table 4-6 Estimated disposal only rates

Disposal site/option	Raw rate	Estimated Disposal Only Rate ($ per in situ m^3)
MBRC Caboolture waste management facility	$125/tonne	$170
Ti Tree BioEnergy site	*$43/tonne	$60
Future Port Expansion site	$40/m^3	$40
Sand/Gravel Extraction and General fill sites	$10/tonne	$15
Cement stabilisation (excl. site disposal fees)	$10/m^3	$10

** Applicable rate if final classification is 'Contaminated Soils'. Rate of $79.70/t applies if classified as 'Regulated Waste'*

Table 4-7 Estimated total dredging and disposal rates

Option	Estimated Dredging & Disposal Rate* ($ per in situ m^3)
Grab dredge - MBRC Caboolture waste management facility	$200
Grab dredge - Ti Tree BioEnergy site	$90
Grab dredge - Future Port Expansion site	$70
Grab dredge - Rehabilitation of extraction sites	$45
Grab dredge - Cement stabilisation	$55
† Grab dredge - Garden soil	$60
CSD - Redistribution	$30
CSD plus Excavator and Trucks - Beach nourishment (entrance channel only)	$20

** Rates exclude treatment of PASS and contract execution costs (i.e. mobilisation/demobilisation, survey, project management etc.).*

† Preliminary estimate only – includes cost recovery of soil at approx. $18/m^3

4.7.8 Options assessment

A broad assessment of dredging and dredged material disposal options was completed. The outcomes of the assessment are summarised in Appendix B. The recommended dredging and material disposal strategy was developed following the options assessment, and is presented in the next section.

4.8 Recommended dredging and material disposal strategies

The recommended dredging and material disposal strategies are presented separately for the entrance channel and remaining areas in the following sections.

Entrance channel

The recommended dredging and material disposal strategy for the entrance channel is dredging via small cutter suction dredge (or suction dredge) and land-based excavator and trucks, and placement as beach nourishment on the adjacent foreshore to the north of the entrance channel. The key factors leading to the recommendation of this methodology include:

- A small cutter suction dredge, or suction dredge, will be able to best access accumulated sediments in the channel and discharge directly to the adjacent beach.
- The methodology is consistent with the recommendations of the endorsed SEMP.
- This broad methodology has been successfully employed for all known past campaigns.

In order to inform the Maintenance Model of the timing and material volumes for future maintenance dredging campaigns, a proposed dredging schedule was developed. The proposed schedule is provided in Appendix C and indicates that maintenance dredging of approximately 5,500 m^3 will be required in the entrance channel area approximately every 4-5 years.

While the adopted volumes and timing are considered appropriate for inclusion in the Maintenance Model (i.e. for the long-term planning of maintenance dredging requirements and costs), the actual timing and material volumes for future dredging campaigns should be determined via review and analysis of regularly scheduled hydrographic surveys.

Remaining areas

The recommended dredging and dredged material disposal strategy for the Lake and area between Welsby Parade and the lock and weir comprises dredging using a small Grab (Backhoe) dredge with dredged sediments loaded into trucks and subsequent beneficial re-use of the material. The key factors leading to the selection of this methodology include:

- A backhoe dredge is recommended in place of a small CSD largely due to the absence of a material placement area for dewatering of material dredged via CSD.
- Unloading and direct disposal of the material eliminates double-handling of the material
- Placement of the material for rehabilitation of existing extraction sites, general fill, or other beneficial re-use is considered to represent the most feasible long-term disposal/re-use option.

A long-term opportunistic fill or beneficial re-use site (or sites) has not yet been secured by MBRC for future dredging and material disposal campaigns. However, as advised by MBRC, it has been assumed that a site (or sites) will be identified, and the necessary agreements established, prior to future dredging and material disposal campaigns.

4.8.1 Proposed dredging schedule

A proposed dredging schedule was developed on the basis of the recommended strategy. This proposed schedule was developed in order to inform predicted dredged material volumes applied in the Maintenance Model, together with the dredging areas for the next four dredging campaigns.

The proposed dredging schedule was generated using the existing Excel spreadsheet developed by KBR, with updates to reflect the revised predicted long-term siltation rates, updates to the

original design and trigger levels, bed levels and volumes to design as at 2014, and the proposed dredging strategy. The existing spreadsheet tool utilises surveyed levels and volumes, predicted shoaling rates and siltation volumes, and the canal design and dredging trigger levels to estimate the timing and material volumes for future dredging campaigns within the nominated dredging 'zones'. The schedule was developed to cover a period of 50 years and dredging was scheduled to minimise the number of areas where bed levels exceeded the dredging trigger level.

It is important to note that the 'shoaling rates' applied in the tool/schedule correspond with the rate-of-rise in the area of highest siltation within each zone, not the average siltation rate within the zone, as it is the areas of higher siltation which will shoal more rapidly and cause potential impacts to navigation. Also, the 'siltation volumes' represent the average predicted annual siltation volume over the full dredging zone.

The proposed schedule is provided in Appendix C, and a summary of the estimated dredged material volumes and areas for the next four campaigns is provided in Table 4-8 and in Figure 4-4.

Table 4-8 Proposed dredging schedule – Campaigns 1-4

Campaign	Dredging Areas	Estimated Volume (m^3)
1	Zone 2 – Area between Welsby Parade and lock & weir	2,400
2	Zone 3 – Lake area adjacent lock & weir	1,000
3	Zone 1 – Entrance channel	5,600
4	Zones 1, 3 and 4 – Entrance channel and Lake areas between lock & weir and Goodwin Drive	17,000

While the proposed volumes and timing are considered appropriate for inclusion in the Maintenance Model (i.e. for the long-term planning of maintenance dredging requirements and costs), the actual timing and material volumes for future dredging campaigns will need to be determined via review and analysis of regularly scheduled hydrographic surveys.

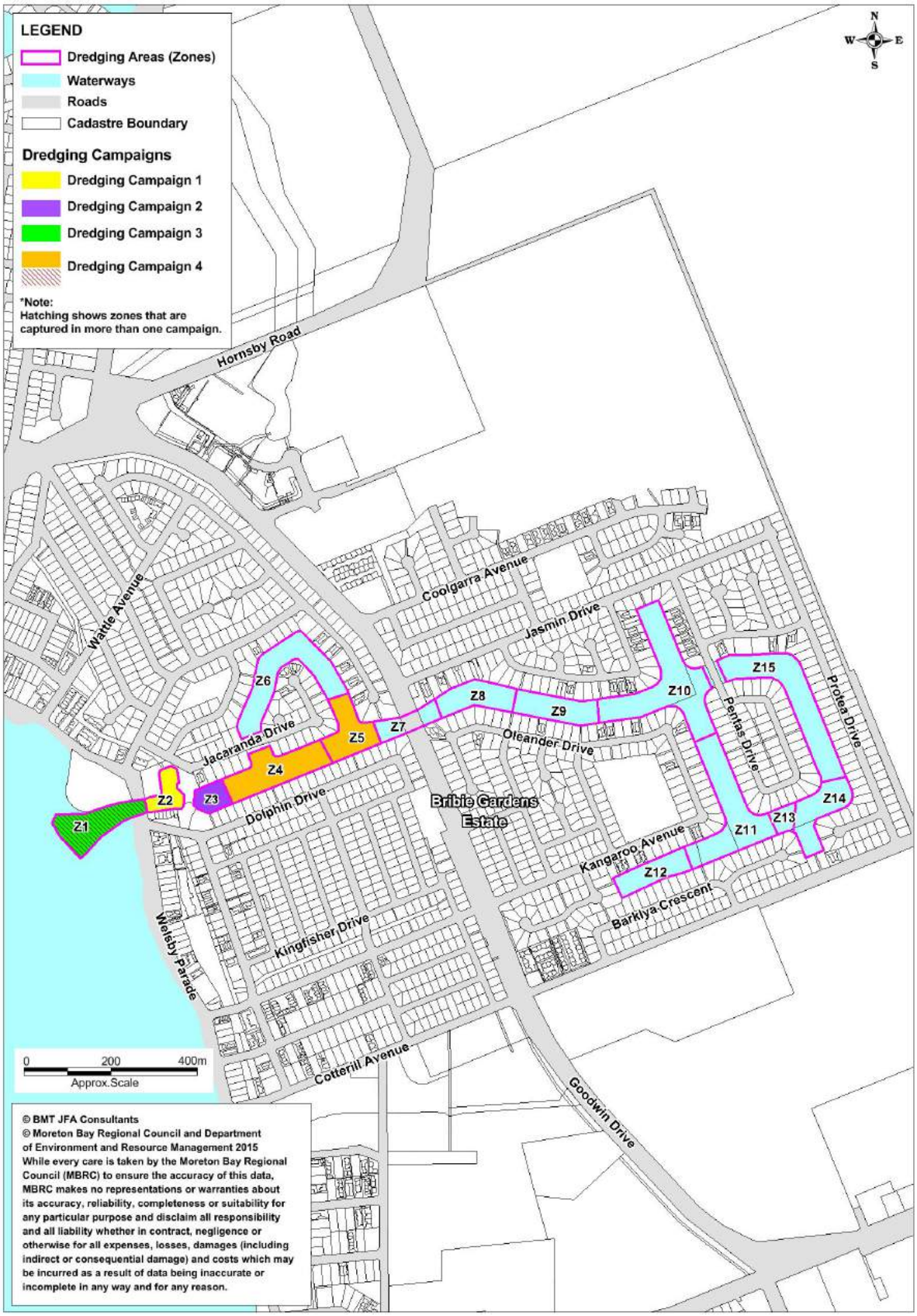

Figure 4-4 Proposed dredging schedule - dredging areas

4.8.2 Alternative options

Two alternative dredging and material disposal options have been included in the Maintenance Model. These options can be selected in the event that the recommended strategy of grab dredging and beneficial re-use is not available. The two alternative options comprise intermediate drying and treatment of the dredged material at the proposed Pacific Harbour dredged material handling facility, followed by ultimate disposal of the material at one of two locations:

- Disposal at landfill site (notionally Ti Tree BioEnergy site)
- Beneficial re-use (re-use as fill material)

These two options will only be available once the proposed dredged material handling facility has been constructed and sufficient capacity is available at the site.

Due to the additional handling required for drying and treatment of the material, the alternative options are estimated to have higher cost rates compared with the recommended option of Grab dredging and direct disposal for beneficial re-use. However, they have been included in the model to provide alternatives in the event that a more cost effective beneficial re-use option is not available to MBRC.

4.9 Environmental approvals

MBRC currently holds the following permits for dredging and placement activities associated with the Bribie Gardens estate:

- EPPR01326613 – Environmental authority for grab dredging up to 10,000t/yr and placement at an approved land-based facility
- SPDE04097412 – Development permit for material change of use for an environmentally relevant activity; suction dredging up to 100,000t/yr and placement on Bongaree Beach (in bunded area above highest astronomical tide)
- SPD-01115-014487 – extension to dredging period of above permits, up to 2nd April 2017
- QS2012/STH8029 – Marine park permit for maintenance dredging of the entrance canal and placement for beach nourishment
- MPW2014/MBMP0052 – Marine park permit for maintenance activities along Bribie Island beaches.

These permits apply only to dredging works in the entrance channel area and limit works to 10,000t/yr when grab dredging, and 100,000t/yr when suction dredging, with placement on land only.

For the purposes of proposed entrance channel dredging, no further permits are required, though these permits will need to be updated as they expire.

Within the Lake, a development permit for tidal works will be required for the dredging, though no environmental authority will be required as the works will not occur in ‘natural waters’. Depending upon the preferred methodology for beneficial reuse, a permit may also be required for the placement site.

4.9.1 Planning and Execution Requirements

As part of each dredging campaign for the Bribie Gardens canals, the following actions are required:

- Preparation of a site-based management plan (SBMP) for the works or review and adaption of an existing SBMP, prior to commencement of works.
- Sediment testing to ensure material is suitable for placement on Bongaree Beach (entrance canal) or for beneficial reuse.
- Water quality monitoring during dredging.

4.9.2 Renewals

EPPR01326613 and SPDE04097412 are due for renewal subject to SPD-0115-014487 2nd April 2017. These permits cover dredging works in the entrance canal.

Marine park permit QS2012/STH8029 for dredging and placement within the MBMP is due for renewal 19th June 2022. MPW2014/MBMP0052, which covers more general beach maintenance activities, including maintenance between dredging campaigns, is due for renewal 24th April 2024.

5 Other Maintenance Activities

5.1 Introduction

In addition to maintenance dredging, MBRC has an ongoing general maintenance program which consists of a number of maintenance activities, including:

- Canal batter maintenance
- Vegetation and litter removal
- Maintenance and replacement of signage and navigation aids
- Water quality monitoring

These maintenance activities are each briefly discussed in the following sections.

5.2 Canal batter maintenance

The canal batters, extending from the property boundaries to the navigation channel, require periodic maintenance to ensure that their function and amenity is maintained. Previous inspections completed for the original LTMP identified a number of areas where the canal batters required maintenance and remedial works. Additionally, the action of boat wakes, stormwater runoff, tidal flows, marine plants, and other factors have the potential to cause erosion and degradation of the canal batters, and maintenance of the batters may subsequently be required in the future.

The original LTMP identified the need for maintenance of the canal batters, principally within the entrance area to the east of Welsby Parade. MBRC subsequently implemented a works program to remediate these areas and the works are understood to have been completed in 2015.

Assessment of the frequency and location of future canal batter maintenance activities was not part of BMT's scope. However, the condition of canal batters will be assessed periodically as part of MBRC's regular maintenance inspections, and maintenance activities will subsequently be carried out to address identified issues. In order to inform the Maintenance Model of the timing and estimated costs for canal batter maintenance, MBRC have advised an estimated annual allowance for maintenance of the canal batters. MBRC's estimated allowance was based on the works completed in 2015, and this amount has been included in the Maintenance Model by BMT.

5.3 Vegetation and litter removal

Marine vegetation is removed from canal batters and other areas within the canal estate on an as required basis. Removal of marine vegetation aims to maintain amenity of the canals, whilst also protecting against potential damage to the canal batters and structures caused by vegetation growth. MBRC have advised a notional annual allowance for vegetation removal based on the cost from previous years and this figure has been included in the Maintenance Model by BMT.

MBRC also collect and dispose of litter from within the canal estate on a regular basis, and have advised an annual allowance for inclusion in the Maintenance Model for this activity based upon the planned frequency of litter collection, and costs from previous years.

5.4 Navigation aids and signage

MBRC are responsible for maintaining navigation aids and signage for the canal estate. Existing navigation aids and signs include one set of fixed lateral markers at the entrance to the canal estate, together with various other signs. In order to inform the Maintenance Model of the timing and estimated costs for maintenance of navigation aids and signage, MBRC have advised an annual allowance based on historical expenditure records and this figure has been included in the Maintenance Model by BMT.

Identification and inspection of navigation aids and signage throughout the canal estate was not part of BMT's scope. As such, the actual timing for maintenance and replacement of navigation aids and signs shall be determined on the basis of routine condition inspections.

5.5 Water quality monitoring

MBRC undertake regular water quality monitoring within Bribie Gardens, as part of a regional water quality monitoring program. The water quality monitoring is an important activity as it provides an indication of water quality and an early warning system for potential environmental problems within the canals. This in turn helps to protect and maintain the amenity of the canal estate.

A critical review of the existing water quality monitoring program and monitoring results was undertaken in 2015 by FRC Environmental. Recommended refinements to the existing monitoring program included quarterly sampling in place of monthly, additional analysis parameters, and the preparation of an annual report card (or similar) summarising the monitoring results (FRC Environmental 2015). MBRC have subsequently advised an estimated annual allowance for a revised monitoring program and this figure has been included in the Maintenance Model by BMT.

5.6 Environmental approvals

Canal batter maintenance

Maintenance activities associated with canal batters are expected to be 'excluded works'[1] for the purposes of the *Sustainable Planning Act 2009* to the extent these works do not include replacing or rebuilding greater than 20% of the structure. Excluded works do not require environmental approvals.

Vegetation and litter removal

Removal of marine vegetation from structures is considered to be self-assessable to the extent it is reasonably necessary for the maintenance of existing structures. These works are required to comply with the Department of Agriculture and Fisheries (DAF) code for self-assessable development MPO2. This code places the following limitations of maintenance works:

- Clearing limited to the footprint of the structure, an area 1m from this footprint and the associated airspace and substrate.
- Notification must be provided to DAF 5-20 days before commencement of works.
- Signage must be displayed at the works site for the duration of the works.

[1] See DEHP guideline: https://www.ehp.qld.gov.au/coastal/development/pdf/gl-excluded-works-em2734.pdf

Where clearing is required to go beyond the area allowed for around a structure, a development permit will be required for the work. This is not expected to be the case for any of the proposed maintenance activities.

Navigation aids and signage

Any works involving interference with markers and aids to navigation should be checked with the Regional Harbour Master (RHM). No other approvals are required.

Water quality monitoring

No permits are required for water quality monitoring conducted within the canal estate. However, where water quality monitoring occurs within the MBMP, a marine parks permit is required.

5.7 Planning activities

Various design, planning, and support tasks are required in executing a number of the maintenance activities. Additionally, periodic review of the overall LTMP is required in order to ensure that the plan, including key assumptions and rates, remains up-to-date. These planning activities are briefly discussed in the following sections.

5.7.1 LTMP reviews

It is recommended that the LTMP, including the Maintenance Model, be reviewed and updated every 3-4 years, and that this work includes the following key tasks:

- Detailed assessment and updates to estimated sediment accumulation rates.
- Review and update/refinement the overall dredging and dredged material disposal strategy, including review of key sensitive parameters/assumptions.
- Review and update the Dredging Schedule.
- Detailed review of historical expenditure records, including executed contract rates and costs.
- Update of the program and rates/costs in the Maintenance Model.

Allowance for periodic review of the LTMP, broadly encompassing these tasks, has been included in the Maintenance Model every 4 years.

5.7.2 Dredging design and planning

Various tasks are required in preparation of and during execution of maintenance dredging works. These include:

- Sediment sampling and analysis – as required by environmental approvals.
- Dredging design and preparation of contract specifications.
- Preparation of the dredging Environmental Management Plan – as required by environmental approvals.
- Tender inputs and assessment (specialist inputs as required to support MBRC).
- Contract support – including independent verification of dredged volumes.

- Environmental monitoring and reporting – as required by environmental approvals.

Accordingly, allowance for the completion of these tasks has been included in the Maintenance Model for each scheduled dredging campaign.

5.7.3 Approvals

Approval for dredging within the entrance channel area will require renewal in April 2017. In addition, marine park permit renewals are required in 2022 (dredging and placement) and 2024 (beach maintenance).

In addition, a development permit (but not environmental authority) is required for dredging within the Bribie Gardens estate upstream of the lock and weir.

5.8 Potential effects of sea level rise

This sub-section has been prepared to briefly discuss the potential impacts of future sea level rise on MBRC's long term maintenance of the canal estate. Sea level rise projections provided in the SEMP are first summarised, followed by discussion of the potential effect on navigation (i.e. maintenance dredging) and general maintenance activities.

5.8.1 Sea level rise projections

Predicted sea level rise is discussed in Section 2.8 of the SEMP (GHD 2011, pp22-25), including projected 50 and 100 year sea level rise amounts and 1:100 year Average Recurrence Interval (ARI) storm tide water levels. The recommended values are summarised in Table 5-1.

Table 5-1 Predicted sea level rise – Bongaree

Year	Projected Sea Level Rise (m)	Mean Sea Level (mAHD)	Storm tide water levels (1:100 yr ARI event) (mAHD)
2000	0.0	-0.04	+1.34
2050	0.3	+0.26	+1.64
2100	0.8	+0.76	+2.14

Source: GHD 2011

On the basis of the projected sea level rise, the mean sea level at the site is expected to rise an average of 6 mm/annum between 2000 and 2050, and 10 mm/annum between 2050 and 2100.

5.8.2 Effect on navigation

The potential effect of sea level rise on the full tidal range (i.e. highest and lowest astronomical tides – HAT and LAT), has not been previously assessed and therefore it is difficult to draw conclusions regarding the subsequent effect on navigation within the estate. Notwithstanding, assuming a linear shift of the tidal planes with the Mean Sea Level, LAT will rise at the same rates and, on the basis of a static bed level, will act to increase navigable depths. As such, sea level rise has the potential to 'offset' siltation within the entrance area.

However, as eluded to above, navigability is principally a function of LAT, not the Mean Sea Level. Further, the sea level rise estimates are predictions only and therefore the actual sea level rise will vary from the predictions. As such, additional assessments would be required to confirm the potential effect of sea level rise on navigation within the canal estate.

5.8.3 Other maintenance activities

The potential effects of sea level rise on MBRC's general maintenance activities is expected to be limited providing existing infrastructure is not materially affected by the expected marginal increases in water levels. The increase in water levels is likely to further limit suitable areas for marine vegetation, and therefore may reduce the frequency and duration of this maintenance activity. No discernible difference in the other maintenance activities is expected as a result of sea level rise.

6 Maintenance Costs

6.1 Cost summary

The estimated annual cost of maintenance for the canal estate over a period of 50 years is $305,000. This cost represents an annual average amount over a 50 year period in 2016 dollars, where the time value of money and inflation is not taken into account. The breakdown of estimated annual maintenance costs into the key areas of lock and weir maintenance, lock and weir replacement, dredging and material disposal for the entrance channel and remaining areas, and general maintenance (including planning and administration, navigation aids and signage, and water quality monitoring), are summarised as follows (costs averaged over the 50 year planning period):

- Lock and weir maintenance - $52,000 /annum
- Lock and weir replacement - $132,000 /annum
- Dredging and material bypassing – Entrance Channel Area - $42,000 /annum
- Dredging and material disposal - Lake - $41,000 /annum
- General maintenance - $40,000 /annum.

The maintenance items and associated rates used in estimating the long-term maintenance costs are detailed in the updated Maintenance Model, which is discussed in the following section. The key assumptions in the Maintenance Model are also discussed in Section 6.2.1.

6.2 Maintenance Model

The previous Maintenance Model has been updated and is provided in Appendix D. The Maintenance Model includes details of the adopted cost-rates and their basis, a program of maintenance activities (including predicted dredging volumes over the defined 50 year planning period), estimated annual costs for each identified maintenance item, and summarised maintenance costs.

6.2.1 Key assumptions

A number of assumptions have been made in updating the Maintenance Model, and subsequently in estimating the long-term maintenance costs. The key assumptions which underpin the model are briefly discussed in this section.

The lock and weir maintenance costs (including replacement costs) represent the largest proportion of total estimated maintenance costs, and are based upon the anticipated maintenance requirements of the structure and replacement schedule. Key assumptions for this component of the maintenance costs include:

- Regular condition inspections and subsequent maintenance activities are undertaken on the existing structure to ensure that it reaches its anticipated serviceable life.

- Condition inspections will be conducted every 5 years, with the exception of the first inspection following construction of the replacement structure, which will be completed 9 years after construction.
- Replacement of the existing lock and weir structure will be completed in 2041/42.
- The final strategy and timing for the lock and weir replacement will be confirmed following condition inspection and associated asset management assessment in approximately 2030.

The maintenance dredging and dredged material disposal costs are based on the proposed dredging schedule and adopted methodology presented in Section 4.8. This includes the outcomes of the completed siltation assessment. Additional key assumptions include:

- The minimum water level within the Lake (i.e. upstream of the lock and weir) is maintained at a height of not less than +0.1 mAHD.
- The *in situ* and disposed material from all areas upstream of Welsby Parade has a bulk density of 1.35 t/m^3.
- The dredged material will require treatment for Potential Acid Sulphate Soils (PASS) via addition of lime or cement stabilisation. Future dredged material has otherwise been assumed to be uncontaminated and suitable for land-based or unconfined ocean disposal.
- The applied rates for the three included material disposal options include allowance for treatment, loading and haulage, and a disposal charge.
- A long-term opportunistic fill or beneficial re-use site (or sites) will be secured by MBRC, for the use of Contractors, prior to future dredging and material disposal campaigns (Ref. Section 4.8).
- As a specific site and strategy has not yet been secured, the applied rate for 'beneficial re-use site' in the Maintenance Model approximately represents an average rate of the specific options presented in Table 4-7.

6.2.2 Model sensitivity

A specific sensitivity analysis has not been completed on the Maintenance Model. However, based on the calculation methods and assumptions applied in the Model, it is considered that the estimated total long-term maintenance costs are most sensitive to the following parameters and inputs:

- Lock and weir maintenance and replacement costs.
- Dredged material volumes – principally the long-term total quantity of material dredged and disposed, which is directly linked to the adopted average long-term sediment accumulation rates.
- Dredged material disposal cost rates – including the treatment, loading and haulage, and disposal charge components.
- Dredging technical parameters – specifically the *in situ* material densities.

6.2.3 Accuracy of estimate

Inherent uncertainty in the future dredged material volumes, dredging and material disposal methodologies, dredged material properties, and various unit cost rates, results in natural uncertainty in the estimated long term maintenance costs. While the original Maintenance Model incorporated a 'Confidence Factor Adjustment' tool to assess the possible range in long-term maintenance costs, BMT have recommended against the application of this existing facility to assess the possible range in cost estimates, owing to the lack of consideration of variability in material volumes and adoption of best practice probabilistic cost estimation methods.

Further, this tool was originally developed and applied as there was previously much greater uncertainty in the unit cost rates for various maintenance activities. The availability of actual costing information for the current LTMP update, via quotes, tendered rates, and expenditure records, has provided a greater degree of certainty in the adopted unit rates, and therefore the overall estimated maintenance costs.

In absence of an appropriate probabilistic cost estimation method, which considers uncertainty in the volumes and dredged material properties, together with the unit cost rates, and applies best practice methods, it is recommended that MBRC adopt an estimated long-term annual maintenance cost of $305,000.

7 Conclusions

BMT JFA were commissioned by MBRC in late 2015 to review and update the Bribie Gardens Long-term Maintenance Plan and associated Maintenance Model. The review and update included review of siltation rates, assessment of dredging and material disposal options, development of a recommended dredging and material disposal strategy, and review and update of maintenance cost rates. The commission also included a Residual Life Assessment of the existing lock and weir structure as part of the overall study.

The Lock and Weir residual life assessment study, including the completed inspections and testing, recommendations, and maintenance schedules, was documented separately to this LTMP and is attached as Appendix E. The outcomes of this work included the estimated residual life of the structure, recommended maintenance activities and costs, and a high-level concept design and cost estimates for the structure's eventual replacement.

The estimated residual life of the structure is 20-25 years, based on the effective implementation of the recommended maintenance regime. The total estimated cost of maintenance activities over the 26 year period to 2041 is approximately $1,840,000 (in 2016 dollars). The concept design for the structure's replacement includes provision for maintaining access during the construction phase, and the estimated cost for replacement of the structure, including demolishment and removal of the existing structure, is $6,550,000 (in 2016 dollars).

Assessment of siltation rates was completed via analysis of hydrographic surveys. The spatial coverage of the survey datasets did not allow determination of sediment accumulation or removal volumes from the beach area south of the entrance groyne, and as such, the calculated sediment accumulation rates may underestimate long-term average rates. Notwithstanding, the completed assessment indicates an average annual siltation rate of approximately 260 m^3/annum within the Lake (east of the lock and weir), and approximately 1,125 m^3/annum within the entrance channel area (west of the lock and weir). The estimated rates correspond to the average annual rate determined from hydrographic surveys spanning the seven year period from 2007 to 2014.

An assessment of dredging and material disposal options was completed, including consideration of site-based constraints such as the navigational constraints of the lock and weir and bridges in the area, plus environmental considerations, ultimate disposal and beneficial re-use options, and the economic feasibility of each option. The subsequent recommended dredging and material disposal strategy comprises dredging campaigns in the entrance channel every four to five years using a small CSD plus land-based excavator and trucks, with dredged material placed as beach nourishment on the adjacent foreshore to the north of the entrance channel. Maintenance dredging of the remaining areas is recommended to be completed via small backhoe dredger with dredged sediments loaded into trucks and subsequent beneficial re-use of the material.

The existing Maintenance Model was subsequently updated with revised unit cost rates, lock and weir maintenance and replacement costs, dredged material volumes, dredging and material disposal strategies, and maintenance program. A detailed review of historical expenditure records, including review of tendered rates for dredging and material disposal contracts at the site, together with obtaining additional cost estimates, was undertaken as part of updating existing, and defining new, unit cost rates in the Model.

The estimated annual cost of maintenance for the canal estate over a period of 50 years, in 2016 dollars where the time value of money and inflation is not taken into account, is $305,000. The maintenance and eventual replacement costs of the lock and weir represent the largest proportion of the estimated maintenance costs. The breakdown of estimated annual maintenance costs into the areas of lock and weir maintenance (including eventual replacement), dredging and dredged material disposal, and general maintenance are $182,000, $83,000, and $40,000 respectively.

8 Recommendations

In preparing the updated LTMP, BMT have identified a number of recommended actions. These cover additional work to enable better definition of the recommended dredged material ultimate disposal methodology (beneficial re-use), reduced uncertainty of the estimated long-term maintenance costs, and adequate quantification of sediment accumulation and bypassing on the southern side of the entrance channel groin. The recommended actions are summarised below:

- Dredged material beneficial use and disposal study
- Revision of the uncertainty analysis function within the existing Maintenance Model.
- Revision to hydrographic survey extents at the entrance

These are each briefly discussed in the following sections.

8.1.1 Dredged material beneficial use and disposal

The recommended material disposal strategy of beneficial re-use is estimated to represent the most cost effective long-term option. However, the specific details of any necessary material treatment or stabilisation, and final placement site(s) have not yet been determined. Given that the dredged material disposal costs are estimated to represent an appreciable proportion of the total maintenance costs, and there is a large possible range in cost rates for this option, it is recommended that MBRC commission a study to refine this broad option, with an aim of securing all required agreements for beneficial use/disposal of the material and, in doing so, obtaining greater certainty of the associated costs.

The study should consider two primary beneficial re-use options:

- Use as general fill or similar.
- Use for rehabilitation of disused areas of sand/gravel extraction sites or other suitable sites.

Additionally, the study could also consider the potential for treatment and use as garden soil.

Given beneficial use as general fill (either un-treated or cement stabilised) may offer the most economically viable option in the long-term, it is recommended that laboratory tests on the dredged material be undertaken to assess the potential for this use, including:

- Assessment of base engineering and physio-chemical properties
- Trials of material improvement using cement and lime

In parallel, it is recommended that MBRC progress the necessary enquiries and investigations to:

- Secure a long-term contract for placement in disused sand/gravel extraction sites as part of a long-term rehabilitation project (or similar); and / or to
- Secure their own specific ultimate dredged material placement site.

It is highlighted that a reliance upon contractors to identify and employ cost effective beneficial re-use strategies may not always yield desirable outcomes, and as such, MBRC should complete

additional investigations and studies in order to secure long-term, cost effective options for land-based disposal of dredged material.

8.1.2 Model uncertainty

Should MBRC wish to adequately understand uncertainty in the estimated long-term maintenance costs, it is recommended that the existing 'Confidence Factor Adjustment' tool within the Maintenance Model be reviewed and updated such that it applies best practice probabilistic cost estimation methods, which consider the inherent uncertainty in the quantities and dredged material parameters as well as the unit cost rates.

8.1.3 Hydrographic survey extents

As outlined in Section 4.3, an important limitation of the completed assessment of sedimentation rates is the lack of quantification of sediment accumulation (or removal) from the foreshore to the south of the entrance groyne. The periodic removal of accumulated material from this area forms part of maintaining the entrance channel and it is therefore important to incorporate volumes of accumulated (or removed) sediment in this area in the overall volumes calculations. However, quantification of sediment accumulation in this area has not been possible using the available hydrographic survey datasets, as the surveys do not extend over this area. Given this, the estimated sediment accumulation rate in the entrance channel may underestimate the average long-term sediment accumulation rate.

It is therefore recommended that future surveys cover the adjacent southern and northern foreshore areas, and that this information should subsequently be utilised to review and update the estimated sediment accumulation rates for the entrance area.

9 References

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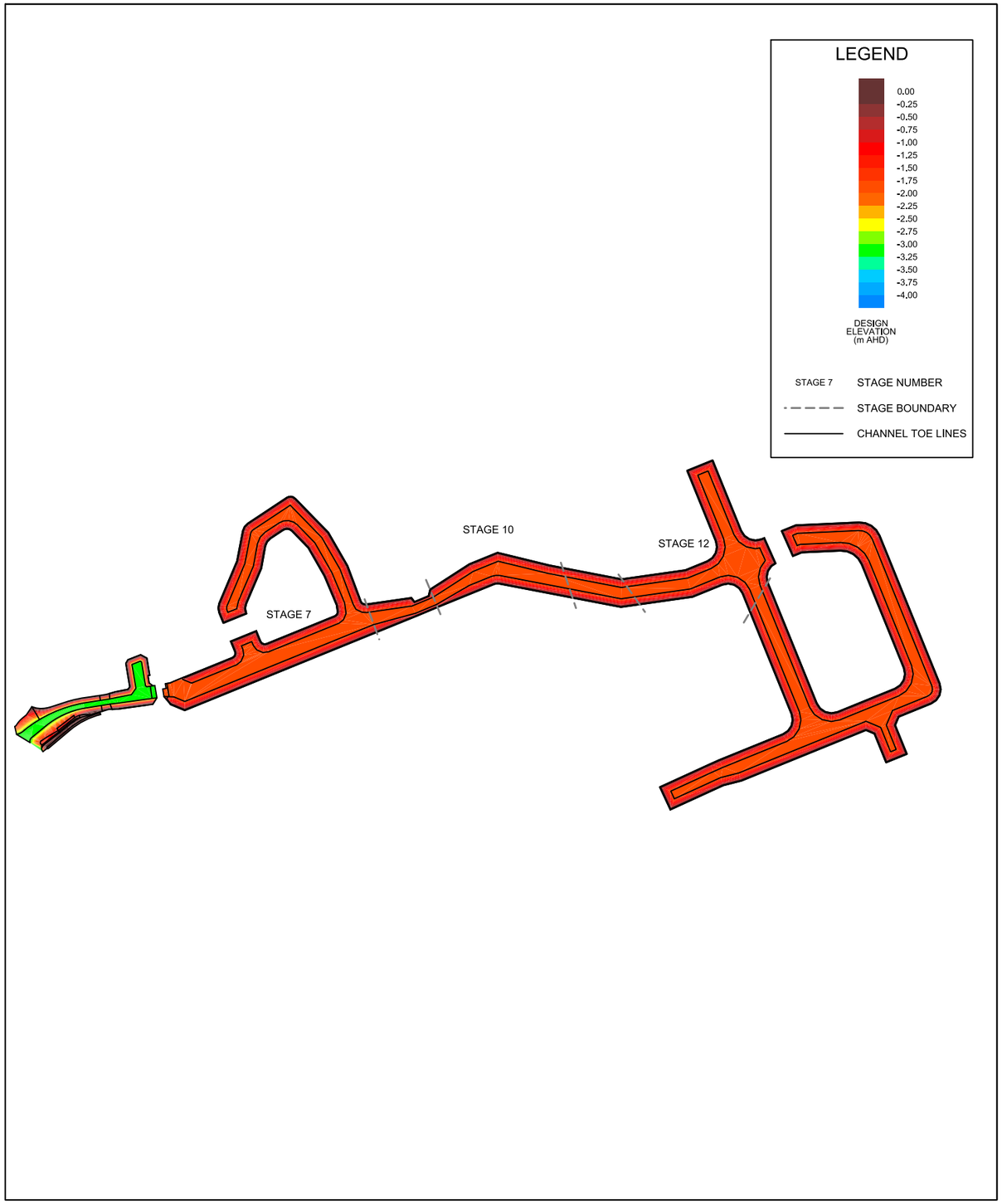
Appendix A Design DTM Plan

BRIBIE GARDENS DESIGN DTM



GENERAL NOTES:

THE DESIGN SURFACE MODEL HAS BEEN DEVELOPED BASED ON AVAILABLE DESIGN DRAWINGS SUPPLIED BY MORETON BAY REGIONAL COUNCIL (REFER TABLE 1 BELOW).
THE SUPPLIED DRAWING SET DOES NOT COVER THE FULL CANAL ESTATE AND THEREFORE ASSUMPTIONS HAVE BEEN MADE IN AREAS NOT COVERED BY THE SUPPLIED DRAWINGS (REFER ASSUMPTIONS BELOW).
IN PREPARING THE DESIGN SURFACE MODEL, BMT JFA CONSULTANTS HAVE NOT INDEPENDENTLY VERIFIED THE ACCURACY OF THE DESIGN DRAWINGS OR THE AS-CONSTRUCTED LEVELS.
THE DESIGN SURFACE MODEL DOES NOT INCLUDE THE LOCATION OF SERVICES, INCLUDING UNDERGROUND SERVICES, DRAINAGE INFRASTRUCTURE AND ROCK ARMOUR SCOUR PROTECTION.
THIS DRAWING HAS BEEN ISSUED IN CONNECTION WITH THE DIGITAL FILES NOTED IN TABLE 2. A COPY OF THIS DRAWING SHALL ALWAYS BE KEPT WITH THE DIGITAL FILES

TABLE 1 - MBRC SUPPLIED DESIGN DRAWINGS

PLAN NUMBERS	
1338/7-7 B	
1338/7-8 B	
1338/7-18 F	
1338/10-9	
1338/12-2	(4/A1/287-7)

TABLE 2 - DIGITAL FILE SUMMARY

DATA	FILE
3D DXF FILE (CONTAINING DESIGN STRINGS, TRIANGLES AND GRID)	BRIBIE_GARDENS_DESIGN_3D.dxf
0.5m GRIDDED DTM TEXT FILE	BRIBIE_GARDENS_DESIGN_POINT5mGRIDDED.txt

ASSUMPTIONS:

IN GENERAL, THE STANDARD CROSS-SECTION DETAIL "TYPICAL SECTION OF LAKE BANK" (DWG.REF 1338/7-18, 1338/10-9, AND 1338/12-2) APPLIES THROUGHOUT THE LAKE.
THE SUPPLIED DESIGN DRAWINGS DO NOT COVER THE LAKE AREA IN THE VICINITY OF THE GOODWIN DRIVE BRIDGE. AS SUCH, THE DESIGN LEVELS HAVE BEEN INFERRED BASED ON THE ADJACENT DESIGN (REF. DWGS 1338/10-9 AND 1338/7-18) AND AVAILABLE HYDROGRAPHIC SURVEY DATASETS.
VARIOUS ASSUMPTIONS HAVE BEEN MADE IN MODELLING THE ENTRANCE CHANNEL BATTERS AND SOUTHERN GROYNE DUE TO OVERLAPPING COMPLEX TRANSITIONS IN THIS AREA AND LACK OF DETAILS FOR THE NORTHERN SEAWALL TOE LEVELS.
FURTHER, IN PREPARING THE DESIGN SURFACE MODEL, A NUMBER OF ASSUMPTIONS HAVE BEEN NECESSARY, MOST COMMONLY AT THE BOUNDARY OF DEVELOPMENT STAGES AND TRANSITIONS BETWEEN AREAS. THESE ASSUMPTIONS ARE BROADLY OUTLINED BELOW:

- ALL BOUNDARIES NOTED ON THE PLANS WERE ASSUMED TO BE CADASTRAL BOUNDARIES UNLESS NOTED OTHERWISE.
- WHERE NOTED ON THE PLANS, DEPTHS, GRADIENTS, AND DISTANCES WERE MAINTAINED. WHERE THERE WERE DISCREPANCIES BETWEEN THESE CONSTRAINTS DEPTH AND GRADIENT WERE GENERALLY MAINTAINED IN FAVOUR OF DISTANCE.
- WHERE THERE WAS NO TRANSITION, OR THE TRANSITION WAS UNCLEAR ON THE PLANS, A CONSTANT GRADIENT WAS MAINTAINED BETWEEN KNOWN POINTS.

DATUMS:

HORIZONTAL DATUM - MAP GRID OF AUSTRALIA BASED ON GDA 94, ZONE 56
VERTICAL DATUM - AUSTRALIAN HEIGHT DATUM

DISCLAIMER:

REV	DATE	AMENDMENT	DRN	APP
0	15/08/16	ISSUE FOR USE	SM	
A	11/06/16	DRAFT ISSUE	SM	

ORIG SIZE A1 | ARCHIVE J15034-04-01_0.dgn

NOTES

SCALE 1 : 5000
100 0 500
METRES

DATUM
VERTICAL AHD
HORIZONTAL MAP GRID OF AUSTRALIA BASED ON GDA 94, ZONE 56

GDA
BebbCart

BMT JFA Consultants
"Where will our knowledge take you?"

ENGINEER	J.STEWART	11/06/2016
DRAWN	S.MOUCHEMORE	11/06/2016
DRAFTING CHECK	G.BEBBINGTON	11/06/2016
ENGINEERING CHECK	J.STEWART	11/06/2016
APPROVED PROJECT MGR	J.STEWART	11/06/2016

CLIENT MORETON BAY REGIONAL COUNCIL
PROJECT LONG TERM MAINTENANCE PLAN
TITLE BRIBIE GARDENS DESIGN DIGITAL TERRAIN MODEL
DRAWING NUMBER J15034 - 04 - 01
REV 0

Appendix B Dredging and Material Disposal Options Assessment Summary

Given the number of potential dredging and material disposal options for maintenance dredging within the estate, a qualitative options assessment was conducted. The objective of the assessment was to identify the preferred options on the basis of nominated key factors. The nominated key factors included:

- Technical feasibility (inherent within the options identified), including availability
- Regulatory feasibility
- Timing, including frequency and time to commence option
- Economic feasibility, based on cost-rate for dredging, disposal and any necessary capital costs
- Environmental impact.

While these factors were all considered, no quantitative multi-criteria analysis or similar was undertaken. Notwithstanding, differing weights and preferences for each of the factors have been accounted for in the qualitative assessment.

The following sections summarise the completed assessment.

B.1.1 Preliminary List of Options

The identified options for maintenance dredging within the estate consist of three basic elements:

(1) Dredging

(2) Handling/interim storage

(3) Ultimate disposal.

The identified options for the estate are presented in Table B-1. This table also identifies the timeframe of the option, categorising all options as either short-term (i.e. ~1 year to commence), medium-term (1-5 years to commence) or long-term (>5 years to commence).

Table B-1 Dredging and material disposal options for Pacific Harbour canal estate

No.	Dredging	Handling/Interim Storage	Disposal	Timing
1	Grab dredge	-	Landfill Site	Short
2	Grab dredge	-	Reclamation site (Future Port Expansion site)	Short
3	Grab dredge	-	Other filling or Rehabilitation Site	Medium
4	Grab dredge	Pacific Harbour Dredged Material Handling Facility	Landfill Site	Medium
5	Grab dredge	Pacific Harbour Dredged Material Handling Facility	Fill Material	Medium
6	Grab dredge	Pacific Harbour Dredged Material Handling Facility	Garden soil	Medium
7	CSD	-	Redistribution	Short
8	CSD plus Excavator and Trucks	-	Beach nourishment (entrance channel only)	Short

B.1.2 Options Assessment

The options in Table B-1 have been assessed based on a number of key factors. Where necessary, notes have been made in regards to the weighting of particular factors. The factors considered include timing, environmental impact and economic feasibility. Each criteria is given a score of **High**, **Medium** or **Low** based on how suitable it is within the context of the criteria:

- *Timing: Assessment is based on a balance of the time to commence against the siltation rates, i.e. a measure of whether the option can be conducted within the timeframe necessary to dredge the canals. 'High' implies a high score as a result of an expectation that the preferred dredging schedule can be met; 'Low' implies a low score as a result of expected delays to the preferred dredging schedule.*
- *Environmental impact: Considers both environmental effects that not been considered by existing permits, and general environmental impacts. 'High' implies a high score as a result of a likely low environmental impact; 'Low' implies a low score as a result of a likely high environmental impact.*
- *Economic feasibility considers the cost, including capital cost, associated with each part of the dredging lifecycle. 'High' implies a high score due to expected lower relative costs. 'Low' implies a low score as a result of expected higher relative costs*

Based on the completed assessment, the preferred options identified for the Bribie Gardens estate are:

- *Most Preferred (Entrance)*: Dredging with a small CSD and bypassing to the foreshore, north of the entrance channel.
- *Most Preferred (west of Welsby Pde)*: Dredging with a small Grab Dredge, and direct disposal for filling/rehabilitation. (Options 2 and 3)

- *Alternative (west of Welsby Pde)*: Dredging with Grab Dredge, drying and treatment at Pacific Harbour Dredged Material Handling Facility, and disposal at landfill. (Option 4).
- *Alternative (west of Welsby Pde)*: Dredging with Grab Dredge, drying and treatment at Pacific Harbour Dredged Material Handling Facility, and re-use as fill material (Option 5).

The option of redistribution may provide a short to medium term solution but, ultimately, may not have long-term benefits as it does not remove all accumulated sediment from the canal system. Given this, and the likely short-term impacts to water quality within the Lake, it has not been recommended as a long-term solution. This option may still be investigated by MBRC as a short to medium-term measure.

Table B-2 Assessment of Bribie Gardens estate dredging and material disposal options

Option	Time to Commence	Economic Feasibility			Environmental Impact
		Dredging cost	Disposal cost	Capital cost	
1. GD to Landfill Site	**High** Expected to be available within a short timeframe, subject to acquisition of a development permit for tidal works for dredging within the lake.	**Medium** Medium cost	**Low** High costs	**High** No costs	**High** Activities not expected to cause impacts in excess of project approvals.
2. GD to Reclamation site	**High** Expected to be available within a short timeframe, subject to acquisition of a development permit for tidal works for dredging within the lake. Also subject to availability of FPE site.	**Medium** Medium cost	**Medium** Medium costs	**High** No costs	**High** Provides for beneficial use of the material. Environmental management and engineering of external site by others.
3. GD to Other filling or Rehabilitation Site	**Medium** Depends on availability of filling/rehabilitation site(s). Also subject to acquisition of a development permit for tidal works for dredging within the lake.	**Medium** Medium cost	**Medium** Medium costs	**High** No costs	**High** Provides for beneficial use of the material. Environmental management and engineering of external site by others.
4. GD to PH DMHF to Landfill Site	**Medium** Option is contingent on the planning, design, and construction of the Pacific Harbour dredged material handling facility, or other suitable material handling area.	**Medium** Medium cost	**Low** High costs	**Medium** Contribution towards construction/usage costs for the Pacific Harbour DMHF	**High** Activities not expected to cause impacts in excess of project approvals.
5. GD to PH DMHF to Fill Material	**Medium** Option is contingent on the planning, design, and construction of the Pacific Harbour dredged material handling facility, or other suitable material handling area. Also depends on availability of fill sites.	**Medium** Medium cost	**Medium** Medium costs	**Medium** Contribution towards construction/usage costs for the Pacific Harbour DMHF	**High** Provides for beneficial use of the material. Environmental management and engineering of external site by others.

Dredging and Material Disposal Options Assessment Summary

Option	Time to Commence	Economic Feasibility			Environmental Impact
		Dredging cost	Disposal cost	Capital cost	
6. GD to PH DMHF to Garden soil	**Medium** Option is contingent on the planning, design, and construction of the Pacific Harbour dredged material handling facility, or other suitable material handling area.	**Medium** Medium cost	**Medium** Medium costs	**Medium** Contribution towards construction/usage costs for the Pacific Harbour DMHF, plus equipment for preparation of garden soil	**High** Activities not expected to cause impacts in excess of project approvals.
7. CSD and Redistribution	**High** Expected to be available within a short timeframe, subject to acquisition of a development permit for tidal works for dredging within the lake.	**Medium** Medium cost to account for additional treatment (separation of fines from coarse sediments)	**High** Low costs	**High** No costs	**Medium** Short-term impacts on water quality within the Lake are expected and would require further investigation to assess expected impacts and appropriate mitigation measures.
8. CSD and excavator to Beach nourishment (entrance channel only)	**High** Option is immediately available.	**High** Low costs	**High** Low costs	**High** No costs	**High** Provides for beneficial use of the material. Activities not expected to cause impacts in excess of project approvals.

NB – in regards to environmental impact, 'High' implies a high score as a result of a likely low environmental impact; 'Low' implies a low score as a result of a likely high environmental impact.

Appendix C Proposed Dredging Schedule

Proposed Dredging Schedule

PROPOSED DREDGING SCHEDULE - BRIBIE GARDENS																
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Canal	Entrance Chanel	Ent Ch - West of Welsby Pde	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	Internal Lake/canal	
Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Dredge Vols
2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2015	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2,400
2016	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1,000
2017	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,600
2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2022	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	17,000
2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2024	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2025	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2026	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2027	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2028	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2029	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2030	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2031	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2032	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2033	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2034	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2036	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2037	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	8,300
2038	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2039	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2041	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2042	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	6,200
2043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2044	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2047	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2049	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2051	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2052	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2053	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2054	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2055	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2056	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2057	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2058	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2059	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2060	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2061	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2062	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2063	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2064	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2065	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Proposed Dredging Schedule

PREDICTED DREDGED MATERIAL VOLUMES																Grand Totals
Initial Volumes (m^3)	2300	2420	960	4560	5260	3180	2520	910	1640	900	320	500	860	350	1250	**27,930**
Est. Annual Siltation Vol (m^3)	1100	25	0	130	80	40	10	0	0	0	0	0	0	0	0	**1,385**
2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2015	-	2,400	-	-	-	-	-	-	-	-	-	-	-	-	-	2,400
2016	-	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	1,000
2017	5,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,600
2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2022	5,500	-	-	5,600	5,900	-	-	-	-	-	-	-	-	-	-	17,000
2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2024	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2025	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2026	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2027	5,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2028	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2029	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2030	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2031	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2032	5,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2033	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2034	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2036	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2037	5,500	-	-	-	-	-	2,800	-	-	-	-	-	-	-	-	8,300
2038	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2039	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2041	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2042	5,500	700	-	-	-	-	-	-	-	-	-	-	-	-	-	6,200
2043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2044	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2047	5,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2049	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2051	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2052	5,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2053	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2054	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2055	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2056	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2057	5,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2058	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2059	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2060	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2061	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2062	5,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,500
2063	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2064	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2065	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
															TOTALS	**71,100**

Appendix D Maintenance Model

BRIBIE GARDENS MAINTENANCE MODEL

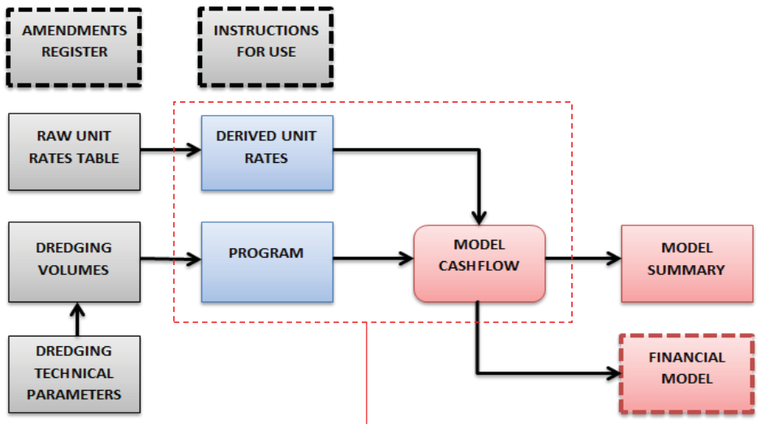
AMENDMENTS REGISTER

DATE	REV No.	BY	DETAILS
05/04/2016	0	BMT JFA	Revised and Updated Maintenance Model - Issued for Use
19/04/2016	1	BMT JFA	Revised Dredging Volumes and Lock & Weir Maintenance Costs - Issued for Use

BRIBIE GARDENS MAINTENANCE MODEL

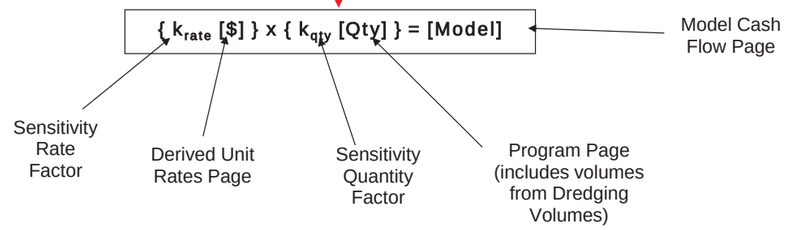
Guidelines on the Use of this Model

Worksheet Data Flow



Note: Worksheet is ordered such that data flows from RIGHT to LEFT. This results in the SUMMARY data being on tabs to the LEFT and INPUT data on tabs to the RIGHT

Governing Equation



Instructions For Use

Prepare the Model and Data Entry

The Spreadsheet is structured so that general input occurs on **RAW UNIT RATES TABLE** and **PROGRAM** pages. Additionally, the **DERIVED UNIT RATES** and **DREDGING VOLUMES** page has adjustable sensitivity factors to model the change of costs and quantities. Otherwise, worksheets show output.

Review **PROGRAM** and **RAW UNIT RATES TABLE** and populate with relevant schedule and costing data respectively. When using the **PROGRAM** worksheet **please note the units** for each item. Only unit-less items may be entered here, as volumes (m^3) are linked to **DREDGING VOLUMES.**

DREDGING TECHNICAL PARAMETERS and **DREDGING VOLUMES** contain information with regards to the major cost item of dredging and spoil disposal. These pages should not be edited without additional geotechnical information, a new dredging schedule, or new spoil disposal systems (except where shown).

Run & Refine Model

The **MODEL CASH FLOW** page is essentially **DERIVED UNIT RATES** x **PROGRAM**, with the addition of subtotals for each section.

The Model may be refined by breaking sections down further or adding new cost items. **This must be done with the care** as data is linked across multiple worksheets to provide relevant output.

Use adjustable sensitivity factor on **DERIVED UNIT RATES** and **DREDGING VOLUMES** pages

Update **AMENDMENTS REGISTER** upon updating model.

Output

MODEL CASH FLOW and **MODEL SUMMARY** pages are output pages, showing a breakdown of costs for given cost items.

It should be noted that all costs shown are 2016 dollars and exclude GST, with no consideration given for inflation

Financial Model Instructions

Instructions for the use of this section are to be written by MBRC as it is developed

Assumptions & Limitations

General

This Maintenance Model has been developed for Moreton Bay Regional Council (MBRC) to assist in the long-term planning and funding of maintenance activities in the Bribie Gardens Canal Estate (Bribie Gardens). While considerable detail is included within the Maintenance Model, it is highlighted that it has been developed as a broad-scale, long-term planning and costing tool. As such, the Maintenance Model should not be used for the detailed planning and execution of maintenance activities - which will generally require separate planning, design, and execution. Further, the Maintenance Model should be reviewed and updated periodically (notionally every 3-4 years) to ensure that the underlying assumptions and rates remain appropriate.

The Maintenance Model should be read and used in conjunction with the associated Long-Term Maintenance Plan report, which documents the key assumptions and parameters that underpin the Model. Additional comments and instructions are also provided within the Maintenance Model worksheets.

BRIBIE GARDENS MAINTENANCE MODEL

MODEL SUMMARY

			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Budget No.	Component No.	ITEM / DESCRIPTON	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
		1. Canal System														
		1.1 General Maintenance	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00
		1.2 Dredging	$ 205,000.00	$ 227,000.00	$ -	$ -	$ -	$ -	$ 670,000.00	$ -	$ -	$ -	$ -	$ 225,000.00	$ -	$ -
		1.3 Dredged Material Disposal	$ 58,000.00	$ -	$ -	$ -	$ -	$ -	$ 667,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		1.4 Water Quality Monitoring	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
		1.5 Administration	$ -	$ -	$ 55,000.00	$ 30,000.00	$ -	$ -	$ 55,000.00	$ 30,000.00	$ -	$ -	$ 55,000.00	$ 30,000.00	$ -	$ -
		TOTAL	$ 290,200.00	$ 254,200.00	$ 82,200.00	$ 57,200.00	$ 27,200.00	$ 27,200.00	$ 1,419,200.00	$ 57,200.00	$ 27,200.00	$ 27,200.00	$ 82,200.00	$ 282,200.00	$ 27,200.00	$ 27,200.00
		2. Canal Walls														
		3.1 Canal Wall Repairs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		3.2 Canal Wall Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		TOTAL	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		4. Lock & Weir														
		4.1 Lock & Weir Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		4.2 Lock & Weir Maintenance	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00
		TOTAL	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00
		GRAND TOTAL	$ 355,200.00	$ 319,200.00	$ 147,200.00	$ 122,200.00	$ 92,200.00	$ 92,200.00	$ 1,484,200.00	$ 122,200.00	$ 92,200.00	$ 92,200.00	$ 147,200.00	$ 347,200.00	$ 92,200.00	$ 92,200.00
		CUMULATIVE TOTAL	$ 355,200.00	$ 674,400.00	$ 821,600.00	$ 943,800.00	$ 1,036,000.00	$ 1,128,200.00	$ 2,612,400.00	$ 2,734,600.00	$ 2,826,800.00	$ 2,919,000.00	$ 3,066,200.00	$ 3,413,400.00	$ 3,505,600.00	$ 3,597,800.00
		RUNNING AVERAGE FROM 2016	$ 355,200.00	$ 337,200.00	$ 273,866.67	$ 235,950.00	$ 207,200.00	$ 188,033.33	$ 373,200.00	$ 341,825.00	$ 314,088.89	$ 291,900.00	$ 278,745.45	$ 284,450.00	$ 269,661.54	$ 256,985.71

Instructions for Model Summary Worksheet
DO NOT MODIFY CELL CONTENTS DIRECTLY
MODIFY RAW UNIT RATES AND PROGRAM SHEETS TO UPDATE DATA.
TO SIMULATE EFFECTS OF COST VARIATION, USE SENSITIVITY FACTORS ON DERIVED UNIT RATES AND DREDGING VOLUMES PAGES (FOR RATES AND QUANTITIES RESPECTIVELY)

BRIBIE GARDENS MAINTENANCE MODEL

MODEL SUMMARY

			15	16	17	18	19	20	21	22	23	24	25	26	27	28
Budget No.	Component No.	ITEM / DESCRIPTON	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
		1. Canal System														
		1.1 General Maintenance	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 21,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00
		1.2 Dredging	$ -	$ -	$ 225,000.00	$ -	$ -	$ -	$ -	$ 409,000.00	$ -	$ -	$ -	$ -	$ 346,000.00	$ -
		1.3 Dredged Material Disposal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 162,400.00	$ -	$ -	$ -	$ -	$ 40,600.00	$ -
		1.4 Water Quality Monitoring	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
		1.5 Administration	$ 55,000.00	$ 30,000.00	$ -	$ -	$ 55,000.00	$ 30,000.00	$ -	$ -	$ 55,000.00	$ 30,000.00	$ -	$ -	$ 25,000.00	$ 30,000.00
		TOTAL	$ 82,200.00	$ 57,200.00	$ 252,200.00	$ 27,200.00	$ 82,200.00	$ 46,200.00	$ 16,200.00	$ 587,600.00	$ 71,200.00	$ 46,200.00	$ 16,200.00	$ 16,200.00	$ 427,800.00	$ 46,200.00
		2. Canal Walls														
		3.1 Canal Wall Repairs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		3.2 Canal Wall Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		TOTAL	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		4. Lock & Weir														
		4.1 Lock & Weir Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6,500,000.00	$ -	$ -	
		4.2 Lock & Weir Maintenance	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ -	$ -	$ -
		TOTAL	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 6,500,000.00	$ -	$ -
		GRAND TOTAL	$ 147,200.00	$ 122,200.00	$ 317,200.00	$ 92,200.00	$ 147,200.00	$ 111,200.00	$ 81,200.00	$ 652,600.00	$ 136,200.00	$ 111,200.00	$ 81,200.00	$ 6,516,200.00	$ 427,800.00	$ 46,200.00
		CUMULATIVE TOTAL	$ 3,745,000.00	$ 3,867,200.00	$ 4,184,400.00	$ 4,276,600.00	$ 4,423,800.00	$ 4,535,000.00	$ 4,616,200.00	$ 5,268,800.00	$ 5,405,000.00	$ 5,516,200.00	$ 5,597,400.00	###########	###########	$ 12,587,600.00
		RUNNING AVERAGE FROM 2016	$ 249,666.67	$ 241,700.00	$ 246,141.18	$ 237,588.89	$ 232,831.58	$ 226,750.00	$ 219,819.05	$ 239,490.91	$ 235,000.00	$ 229,841.67	$ 223,896.00	$ 465,907.69	$ 464,496.30	$ 449,557.14

Instructions for Model Summary Worksheet
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BRIBIE GARDENS MAINTENANCE MODEL

MODEL SUMMARY

			29	30	31	32	33	34	35	36	37	38	39	40	41	42
Budget No.	Component No.	ITEM / DESCRIPTON	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057
		1. Canal System														
		1.1 General Maintenance	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00
		1.2 Dredging	$ -	$ -	$ -	$ 225,000.00	$ -	$ -	$ -	$ -	$ 225,000.00	$ -	$ -	$ -	$ -	$ 225,000.00
		1.3 Dredged Material Disposal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		1.4 Water Quality Monitoring	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
		1.5 Administration	$ -	$ -	$ 25,000.00	$ 30,000.00	$ -	$ -	$ 55,000.00	$ 30,000.00	$ -	$ -	$ 55,000.00	$ 30,000.00	$ -	$ -
		TOTAL	$ 16,200.00	$ 16,200.00	$ 41,200.00	$ 271,200.00	$ 16,200.00	$ 16,200.00	$ 71,200.00	$ 46,200.00	$ 241,200.00	$ 16,200.00	$ 71,200.00	$ 46,200.00	$ 16,200.00	$ 241,200.00
		2. Canal Walls														
		3.1 Canal Wall Repairs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		3.2 Canal Wall Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		TOTAL	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		4. Lock & Weir														
		4.1 Lock & Weir Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		4.2 Lock & Weir Maintenance	$ 65,000.00	$ -	$ -	$ 65,000.00	$ -	$ -	$ 65,000.00	$ -	$ 65,000.00	$ -	$ 65,000.00	$ -	$ 65,000.00	$ 65,000.00
		TOTAL	$ 65,000.00	$ -	$ -	$ 65,000.00	$ -	$ -	$ 65,000.00	$ -	$ 65,000.00	$ -	$ 65,000.00	$ -	$ 65,000.00	$ 65,000.00
		GRAND TOTAL	$ 81,200.00	$ 16,200.00	$ 41,200.00	$ 336,200.00	$ 16,200.00	$ 16,200.00	$ 136,200.00	$ 46,200.00	$ 306,200.00	$ 16,200.00	$ 136,200.00	$ 46,200.00	$ 81,200.00	$ 306,200.00
		CUMULATIVE TOTAL	$ 12,668,800.00	$ 12,685,000.00	$ 12,726,200.00	$ 13,062,400.00	$ 13,078,600.00	$ 13,094,800.00	$ 13,231,000.00	$ 13,277,200.00	$ 13,583,400.00	$ 13,599,600.00	$ 13,735,800.00	$ 13,782,000.00	$ 13,863,200.00	$ 14,169,400.00
		RUNNING AVERAGE FROM 2016	$ 436,855.17	$ 422,833.33	$ 410,522.58	$ 408,200.00	$ 396,321.21	$ 385,141.18	$ 378,028.57	$ 368,811.11	$ 367,118.92	$ 357,884.21	$ 352,200.00	$ 344,550.00	$ 338,126.83	$ 337,366.67

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BRIBIE GARDENS MAINTENANCE MODEL

MODEL SUMMARY

			43	44	45	46	47	48	49	50
Budget No.	Component No.	ITEM / DESCRIPTON	2058	2059	2060	2061	2062	2063	2064	2065
		1. Canal System								
		1.1 General Maintenance	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00	$ 10,200.00
		1.2 Dredging	$ -	$ -	$ -	$ -	$ 225,000.00	$ -	$ -	$ -
		1.3 Dredged Material Disposal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		1.4 Water Quality Monitoring	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
		1.5 Administration	$ 55,000.00	$ 30,000.00	$ -	$ -	$ 55,000.00	$ 30,000.00	$ -	$ -
		TOTAL	$ 71,200.00	$ 46,200.00	$ 16,200.00	$ 16,200.00	$ 296,200.00	$ 46,200.00	$ 16,200.00	$ 16,200.00
		2. Canal Walls								
		3.1 Canal Wall Repairs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		3.2 Canal Wall Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		TOTAL	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		4. Lock & Weir								
		4.1 Lock & Weir Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		4.2 Lock & Weir Maintenance	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00
		TOTAL	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00
		GRAND TOTAL	$ 136,200.00	$ 111,200.00	$ 81,200.00	$ 81,200.00	$ 361,200.00	$ 111,200.00	$ 81,200.00	$ 81,200.00
		CUMULATIVE TOTAL	$ 14,305,600.00	$ 14,416,800.00	$ 14,498,000.00	$ 14,579,200.00	$ 14,940,400.00	$ 15,051,600.00	$ 15,132,800.00	$ 15,214,000.00
		RUNNING AVERAGE FROM 2016	$ 332,688.37	$ 327,654.55	$ 322,177.78	$ 316,939.13	$ 317,880.85	$ 313,575.00	$ 308,832.65	$ 304,280.00

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BRIBIE GARDENS MAINTENANCE MODEL

MAINTENANCE MODEL CASH FLOW

ITEM / DESCRIPTION	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. Bribie Gardens Canal System																	
1.1 General Maintenance																	
Rock Wall Maintenance	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00
Litter collection	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00
Navigation Aid and Signage maintenance	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
Vegetation removal	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00
Routine canal batter maintenance	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00
1.2 Dredging																	
Survey	$ 25,000.00	$ 25,000.00	$ -	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ -	$ 25,000.00
Contract Execution Costs - Dredging & Bypassing	$ -	$ 40,000.00	$ -	$ -	$ -	$ -	$ 40,000.00	$ -	$ -	$ -	$ -	$ 40,000.00	$ -	$ -	$ -	$ -	$ 40,000.00
Dredging & Bypassing - via Dredge and Trucks	$ -	$ 112,000.00	$ -	$ -	$ -	$ -	$ 110,000.00	$ -	$ -	$ -	$ -	$ 110,000.00	$ -	$ -	$ -	$ -	$ 110,000.00
Contract Execution Costs - Grab (Backhoe) Dredge and Barge	$ 100,000.00	$ -	$ -	$ -	$ -	$ -	$ 100,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Grab Dredging	$ 30,000.00	$ -	$ -	$ -	$ -	$ -	$ 345,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredging Design, Approvals & Monitoring	$ 50,000.00	$ 50,000.00	$ -	$ -	$ -	$ -	$ 50,000.00	$ -	$ -	$ -	$ -	$ 50,000.00	$ -	$ -	$ -	$ -	$ 50,000.00
1.3 Dredged Material Treatment & Disposal\Re-use (Excl. Entrance)																	
Option A - Handling Facility - Dry - Dispose Dry Material at Landfill Site	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Option B - Handling Facility - Dry - Dispose Dry Material at Opportunistic	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Option C - Dispose Wet Material at Opportunistic Fill / Beneficial Re-use S	$ 58,000.00	$ -	$ -	$ -	$ -	$ -	$ 667,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredged Material Handling Facility - Approvals, Design and Construction	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredged Material Handling Facility - Land Acquisition & Offsets	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
1.4 Water Quality Monitoring	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
1.5 Administration																	
Investigation Hydrographic Survey	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -	$ -
Review and Update of Maintenance Model	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -
Lock & Weir Condition Inspection and Reporting	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -
TOTAL	$ 290,200.00	$ 254,200.00	$ 82,200.00	$ 57,200.00	$ 27,200.00	$ 27,200.00	$ 1,419,200.00	$ 57,200.00	$ 27,200.00	$ 27,200.00	$ 82,200.00	$ 282,200.00	$ 27,200.00	$ 27,200.00	$ 82,200.00	$ 57,200.00	$ 252,200.00
2. Canal Walls																	
2.1 Canal Wall Repair	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2.2 Canal Wall Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4. Lock & Weir Replacement																	
4.1 Lock & Weir Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4.2 Lock & Weir Maintenance	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00
TOTAL	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00
GRAND TOTAL	$ 355,200.00	$ 319,200.00	$ 147,200.00	$ 122,200.00	$ 92,200.00	$ 92,200.00	$ 1,484,200.00	$ 122,200.00	$ 92,200.00	$ 92,200.00	$ 147,200.00	$ 347,200.00	$ 92,200.00	$ 92,200.00	$ 147,200.00	$ 122,200.00	$ 317,200.00
CUMULATIVE TOTAL	$ 355,200.00	$ 674,400.00	$ 821,600.00	$ 943,800.00	$ 1,036,000.00	$ 1,128,200.00	$ 2,612,400.00	$ 2,734,600.00	$ 2,826,800.00	$ 2,919,000.00	$ 3,066,200.00	$ 3,413,400.00	$ 3,505,600.00	$ 3,597,800.00	$ 3,745,000.00	$ 3,867,200.00	$ 4,184,400.00
RUNNING AVERAGE FROM 2016	$ 355,200.00	$ 337,200.00	$ 273,866.67	$ 235,950.00	$ 207,200.00	$ 188,033.33	$ 373,200.00	$ 341,825.00	$ 314,088.89	$ 291,900.00	$ 278,745.45	$ 284,450.00	$ 269,661.54	$ 256,985.71	$ 249,666.67	$ 241,700.00	$ 246,141.18

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BRIBIE GARDENS MAINTENANCE MODEL

MAINTENANCE MODEL CASH FLOW

ITEM / DESCRIPTION	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051
1. Bribie Gardens Canal System																			
1.1 General Maintenance																			
Rock Wall Maintenance	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00
Litter collection	$ 5,000.00	$ 5,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Navigation Aid and Signage maintenance	$ 6,000.00	$ 6,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Vegetation removal	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00
Routine canal batter maintenance	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00
1.2 Dredging																			
Survey	$ -	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ -
Contract Execution Costs - Dredging & Bypassing	$ -	$ -	$ -	$ -	$ 40,000.00	$ -	$ -	$ -	$ -	$ 40,000.00	$ -	$ -	$ -	$ -	$ 40,000.00	$ -	$ -	$ -	$ -
Dredging & Bypassing - via Dredge and Trucks	$ -	$ -	$ -	$ -	$ 110,000.00	$ -	$ -	$ -	$ -	$ 110,000.00	$ -	$ -	$ -	$ -	$ 110,000.00	$ -	$ -	$ -	$ -
Contract Execution Costs - Grab (Backhoe) Dredge and Barge	$ -	$ -	$ -	$ -	$ 100,000.00	$ -	$ -	$ -	$ -	$ 100,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Grab Dredging	$ -	$ -	$ -	$ -	$ 84,000.00	$ -	$ -	$ -	$ -	$ 21,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredging Design, Approvals & Monitoring	$ -	$ -	$ -	$ -	$ 50,000.00	$ -	$ -	$ -	$ -	$ 50,000.00	$ -	$ -	$ -	$ -	$ 50,000.00	$ -	$ -	$ -	$ -
1.3 Dredged Material Treatment & Disposal\Re-use (Excl. Entrance)																			
Option A - Handling Facility - Dry - Dispose Dry Material at Landfill Site	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Option B - Handling Facility - Dry - Dispose Dry Material at Opportunistic F	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Option C - Dispose Wet Material at Opportunistic Fill / Beneficial Re-use S	$ -	$ -	$ -	$ -	$ 162,400.00	$ -	$ -	$ -	$ -	$ 40,600.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredged Material Handling Facility - Approvals, Design and Construction	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredged Material Handling Facility - Land Acquisition & Offsets	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
1.4 Water Quality Monitoring	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
1.5 Administration																			
Investigation Hydrographic Survey	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -
Review and Update of Maintenance Model	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00
Lock & Weir Condition Inspection and Reporting	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 30,000.00	$ -
TOTAL	$ 27,200.00	$ 82,200.00	$ 46,200.00	$ 16,200.00	$ 587,600.00	$ 71,200.00	$ 46,200.00	$ 16,200.00	$ 16,200.00	$ 427,800.00	$ 46,200.00	$ 16,200.00	$ 16,200.00	$ 41,200.00	$ 271,200.00	$ 16,200.00	$ 16,200.00	$ 71,200.00	$ 46,200.00
2. Canal Walls																			
2.1 Canal Wall Repair	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2.2 Canal Wall Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4. Lock & Weir Replacement																			
4.1 Lock & Weir Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6,500,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4.2 Lock & Weir Maintenance	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ -	$ -	$ -	$ 65,000.00	$ -	$ -	$ 65,000.00	$ -	$ -	$ 65,000.00	$ -
TOTAL	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 6,500,000.00	$ -	$ -	$ 65,000.00	$ -	$ -	$ 65,000.00	$ -	$ -	$ 65,000.00	$ -
GRAND TOTAL	$ 92,200.00	$ 147,200.00	$ 111,200.00	$ 81,200.00	$ 652,600.00	$ 136,200.00	$ 111,200.00	$ 81,200.00	$ 6,516,200.00	$ 427,800.00	$ 46,200.00	$ 81,200.00	$ 16,200.00	$ 41,200.00	$ 336,200.00	$ 16,200.00	$ 16,200.00	$ 136,200.00	$ 46,200.00
CUMULATIVE TOTAL	$ 4,276,600.00	$ 4,423,800.00	$ 4,535,000.00	$ 4,616,200.00	$ 5,268,800.00	$ 5,405,000.00	$ 5,516,200.00	$ 5,597,400.00	###########	###########	###########	###########	###########	###########	###########	###########	###########	###########	###########
RUNNING AVERAGE FROM 2016	$ 237,588.89	$ 232,831.58	$ 226,750.00	$ 219,819.05	$ 239,490.91	$ 235,000.00	$ 229,841.67	$ 223,896.00	$ 465,907.69	$ 464,496.30	$ 449,557.14	$ 436,855.17	$ 422,833.33	$ 410,522.58	$ 408,200.00	$ 396,321.21	$ 385,141.18	$ 378,028.57	$ 368,811.11

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BRIBIE GARDENS MAINTENANCE MODEL

MAINTENANCE MODEL CASH FLOW

ITEM / DESCRIPTION	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
1. Bribie Gardens Canal System														
1.1 General Maintenance														
Rock Wall Maintenance	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 5,000.00
Litter collection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Navigation Aid and Signage maintenance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Vegetation removal	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00	$ 1,200.00
Routine canal batter maintenance	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 4,000.00
1.2 Dredging														
Survey	$ 25,000.00	$ -	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -
Contract Execution Costs - Dredging & Bypassing	$ 40,000.00	$ -	$ -	$ -	$ -	$ 40,000.00	$ -	$ -	$ -	$ -	$ 40,000.00	$ -	$ -	$ -
Dredging & Bypassing - via Dredge and Trucks	$ 110,000.00	$ -	$ -	$ -	$ -	$ 110,000.00	$ -	$ -	$ -	$ -	$ 110,000.00	$ -	$ -	$ -
Contract Execution Costs - Grab (Backhoe) Dredge and Barge	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Grab Dredging	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredging Design, Approvals & Monitoring	$ 50,000.00	$ -	$ -	$ -	$ -	$ 50,000.00	$ -	$ -	$ -	$ -	$ 50,000.00	$ -	$ -	$ -
1.3 Dredged Material Treatment & Disposal\Re-use (Excl. Entrance)														
Option A - Handling Facility - Dry - Dispose Dry Material at Landfill Site	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Option B - Handling Facility - Dry - Dispose Dry Material at Opportunistic F	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Option C - Dispose Wet Material at Opportunistic Fill / Beneficial Re-use S	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredged Material Handling Facility - Approvals, Design and Construction	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Dredged Material Handling Facility - Land Acquisition & Offsets	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
1.4 Water Quality Monitoring	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
1.5 Administration														
Investigation Hydrographic Survey	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -	$ 25,000.00	$ -	$ -	$ -
Review and Update of Maintenance Model	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -
Lock & Weir Condition Inspection and Reporting	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -	$ 30,000.00	$ -	$ -	$ -
TOTAL	$ 241,200.00	$ 16,200.00	$ 71,200.00	$ 46,200.00	$ 16,200.00	$ 241,200.00	$ 71,200.00	$ 46,200.00	$ 16,200.00	$ 16,200.00	$ 296,200.00	$ 46,200.00	$ 16,200.00	$ 16,200.00
2. Canal Walls														
2.1 Canal Wall Repair	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2.2 Canal Wall Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4. Lock & Weir Replacement														
4.1 Lock & Weir Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4.2 Lock & Weir Maintenance	$ 65,000.00	$ -	$ 65,000.00	$ -	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00
TOTAL	$ 65,000.00	$ -	$ 65,000.00	$ -	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00	$ 65,000.00
GRAND TOTAL	$ 306,200.00	$ 16,200.00	$ 136,200.00	$ 46,200.00	$ 81,200.00	$ 306,200.00	$ 136,200.00	$ 111,200.00	$ 81,200.00	$ 81,200.00	$ 361,200.00	$ 111,200.00	$ 81,200.00	$ 81,200.00
CUMULATIVE TOTAL	############	############	############	############	############	############	############	############	############	############	############	############	############	############
RUNNING AVERAGE FROM 2016	$ 367,118.92	$ 357,884.21	$ 352,200.00	$ 344,550.00	$ 338,126.83	$ 337,366.67	$ 332,688.37	$ 327,654.55	$ 322,177.78	$ 316,939.13	$ 317,880.85	$ 313,575.00	$ 308,832.65	$ 304,280.00

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BRIBIE GARDENS MAINTENANCE MODEL

MAINTENANCE MODEL PROGRAM (QUANTITIES TIME SERIES)

ITEM / DESCRIPTION	Units	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
1. Bribie Gardens Canal System																																
1.1 General Maintenance																																
Rock Wall Maintenance	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Litter collection	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Navigation Aid and Signage maintenance	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vegetation removal	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Routine canal batter maintenance	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.2 Dredging																																
Survey	(-)	1	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-
Contract Execution Costs - Dredging & Bypassing	(-)	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-
Dredging & Bypassing - via Dredge and Trucks	m^3	-	5,600	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-
Contract Execution Costs - Grab (Backhoe) Dredge and Barge	(-)	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-
Grab Dredging	m^3	1,000	-	-	-	-	-	11,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,800	-	-	-	-	700	-	-	-	-
Dredging Design, Approvals & Monitoring	(-)	1	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-
1.3 Dredged Material Treatment & Disposal\Re-use (Excl. Entrance Bypassing)																																
☐ Option A - Handling Facility - Dry - Dispose Dry Material at Landfill Site	m^3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
☐ Option B - Handling Facility - Dry - Dispose Dry Material at Opportunistic Fill / Beneficial Re-use Site	m^3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
☑ Option C - Dispose Wet Material at Opportunistic Fill / Beneficial Re-use Site	m^3	1,000	-	-	-	-	-	11,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,800	-	-	-	-	700	-	-	-	-
Dredged Material Handling Facility - Approvals, Design and Construction	(-)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dredged Material Handling Facility - Land Acquisition & Offsets	(-)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.4 Water Quality Monitoring	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.5 Administration																																
Investigation Hydrographic Survey	(-)			1				1				1				1				1				1				1				1
Review and Update of Maintenance Model	(-)				1				1				1				1				1				1				1			
Lock & Weir Condition Inspection and Reporting	(-)			1				1				1				1				1				1								
2. Canal Walls																																
2.1 Canal Wall Repair	m																															
2.2 Canal Wall Replacement	m																															
4. Lock & Weir																																
4.1 Lock & Weir Replacement	# of																										1					
4.2 Lock & Weir Maintenance	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1		

Instructions for Model Sensitivity Worksheet
MODIFY DIMENSIONLESS EVENTS BY INSERTING THE NUMBER OF EVENTS FOR THAT YEAR.
DO NOT MODIFY CELLS IN THIS SPREADSHEET WHICH APPEAR IN BROWN, AS THEY ARE LINKED TO DREDGING VOLUMES WORKSHEETS. MODIFY BLUE CELLS.

THIS WORKSHEET IS THEN MULTIPLIED BY THE COSTS WORKSHEET TO PRODUCE COSTS FOR EACH ITEM
IN EVENT THAT COSTS ITEMS ARE SHARED BETWEEN SECTIONS,
PLACE A FRACTION IN EACH CELL FOR DISTRIBUTION OF COSTS (TO SUM TO 1)

BRIBIE GARDENS MAINTENANCE MODEL

MAINTENANCE MODEL PROGRAM (QUANTITIES TIME SERIES)

ITEM / DESCRIPTION	Units	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
1. Bribie Gardens Canal System																				
1.1 General Maintenance																				
Rock Wall Maintenance	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Litter collection	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Navigation Aid and Signage maintenance	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vegetation removal	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Routine canal batter maintenance	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.2 Dredging																				
Survey	(-)	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-
Contract Execution Costs - Dredging & Bypassing	(-)	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-
Dredging & Bypassing - via Dredge and Trucks	m^3	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-
Contract Execution Costs - Grab (Backhoe) Dredge and Barge	(-)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grab Dredging	m^3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dredging Design, Approvals & Monitoring	(-)	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-
1.3 Dredged Material Treatment & Disposal\Re-use (Excl. Entrance Bypassing)																				
☐ Option A - Handling Facility - Dry - Dispose Dry Material at Landfill Site	m^3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
☐ Option B - Handling Facility - Dry - Dispose Dry Material at Opportunistic Fill / Beneficial Re-use Site	m^3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
☑ Option C - Dispose Wet Material at Opportunistic Fill / Beneficial Re-use Site	m^3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dredged Material Handling Facility - Approvals, Design and Construction	(-)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dredged Material Handling Facility - Land Acquisition & Offsets	(-)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.4 Water Quality Monitoring	(-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.5 Administration																				
Investigation Hydrographic Survey	(-)				1				1				1				1			
Review and Update of Maintenance Model	(-)	1				1				1				1				1		
Lock & Weir Condition Inspection and Reporting	(-)				1				1				1				1			
2. Canal Walls																				
2.1 Canal Wall Repair	m																			
2.2 Canal Wall Replacement	m																			
4. Lock & Weir																				
4.1 Lock & Weir Replacement	# of																			
4.2 Lock & Weir Maintenance	(-)	1			1		1		1		1	1	1	1	1	1	1	1	1	1

Instructions for Model Sensitivity Worksheet
MODIFY DIMENSIONLESS EVENTS BY INSERTING THE NUMBER OF EVENTS FOR THAT YEAR.
DO NOT MODIFY CELLS IN THIS SPREADSHEET WHICH APPEAR IN BROWN, AS THEY ARE LINKED TO DREDGING VOLUMES WORKSHEETS. MODIFY BLUE CELLS.

THIS WORKSHEET IS THEN MULTIPLIED BY THE COSTS WORKSHEET TO PRODUCE COSTS FOR EACH ITEM
IN EVENT THAT COSTS ITEMS ARE SHARED BETWEEN SECTIONS,
PLACE A FRACTION IN EACH CELL FOR DISTRIBUTION OF COSTS (TO SUM TO 1)

BRIBIE GARDENS MAINTENANCE MODEL

MAINTENANCE MODEL DERIVED UNIT RATES

ITEM / DESCRIPTION	Source	Units	RATE	SENSITIVITY: RATE FACTOR	COMMENT
1. Bribie Gardens Canal System					
1.1 General Maintenance					
Rock Wall Maintenance	xiv	/annum	$ 5,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xiv * (1 + Adopted Confidence Percentage)]
Litter collection	xv	/annum	$ 5,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xv * (1 + Adopted Confidence Percentage)]
Navigation Aid and Signage maintenance	xvi	/annum	$ 6,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xvi * (1 + Adopted Confidence Percentage)]
Vegetation removal	xviii	/annum	$ 1,200.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xviii * (1 + Adopted Confidence Percentage)]
Routine canal batter maintenance	xix	/annum	$ 4,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xix * (1 + Adopted Confidence Percentage)]
1.2 Dredging					
Survey	ii	(-)	$ 25,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate ii * (1 + Adopted Confidence Percentage)]
Contract Execution Costs - Dredging & Bypassing	iii	/campaign	$ 40,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate iii * (1 + Adopted Confidence Percentage)]
Dredging & Bypassing - via Dredge and Trucks	iv	/m^3	$ 20.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate iv * (1 + Adopted Confidence Percentage)]
Contract Execution Costs - Grab (Backhoe) Dredge and Barge	v	/campaign	$ 100,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate v * (1 + Adopted Confidence Percentage)]
Grab Dredging	vi	/m^3	$ 30.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate vi * (1 + Adopted Confidence Percentage)]
Dredging Design, Approvals & Monitoring	i	/campaign	$ 50,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate i * (1 + Adopted Confidence Percentage)]
1.3 Dredged Material Treatment & Disposal\Re-use (Excl. Entrance Bypassing)					
Option A - Handling Facility - Dry - Dispose Dry Material at Landfill Site	miii	/m^3	$ 219.00	1	Derived Rate = Sensitivity Rate Factor * Derived Unit Rate miii (below)
Option B - Handling Facility - Dry - Dispose Dry Material at Opportunistic Fill / Beneficial Re-use Site	miv	/m^3	$ 106.00	1	Derived Rate = Sensitivity Rate Factor * Derived Unit Rate miv (below)
Option C - Dispose Wet Material at Opportunistic Fill / Beneficial Re-use Site	mv	/m^3	$ 58.00	1	Derived Rate = Sensitivity Rate Factor * Derived Unit Rate mv (below)
Dredged Material Handling Facility - Approvals, Design and Construction	xii	(-)	$ 3,850,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xii * (1 + Adopted Confidence Percentage)]
Dredged Material Handling Facility - Land Acquisition & Offsets	xiii	(-)	$ 3,950,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xiii * (1 + Adopted Confidence Percentage)]
1.4 Water Quality Monitoring	x	/annum	$ 6,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate x * (1 + Adopted Confidence Percentage)]
1.5 Administration					
Investigation Hydrographic Survey	ii	(-)	$ 25,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate ii * (1 + Adopted Confidence Percentage)]
Review and Update of Maintenance Model	xxii	(-)	$ 30,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xxii * (1 + Adopted Confidence Percentage)]
Lock & Weir Condition Inspection and Reporting	xxiii	(-)	$ 30,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xxiii * (1 + Adopted Confidence Percentage)]
2. Canal Walls					
2.1 Canal Wall Repair	xx	/m	$ 1,100.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xx * (1 + Adopted Confidence Percentage)]
2.2 Canal Wall Replacement	xxi	/m	$ 5,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xxi * (1 + Adopted Confidence Percentage)]
4. Lock & Weir					
4.1 Lock & Weir Replacement	xxv	(-)	$ 6,500,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xxv * (1 + Adopted Confidence Percentage)]
4.2 Lock & Weir Maintenance	xxvi	/annum	$ 65,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate xxvi * (1 + Adopted Confidence Percentage)]

CALCULATED UNIT RATES FOR SPOIL DISPOSAL SYSTEMS

ITEM / DESCRIPTION	Source	Units	RATE	REF NO.	COMMENT
Transport to Handling Facility - Spread & Dry - Haul Dry Material to Landfill Site - Option A					Assuming drying necessary to be trucked to Dakabin Landfill site
Treat	vii	$/$m^3$	$ 5.00		Treat dredged material (PASS)
Transport to Handling Facility - Material handling (spread & dry) - Haul to Landfill Site	viii	$/$m^3$	$ 145.00		Estimate based on double-handling to Material Handling Facility - drying - then disposal at Ti Tree Bio Energy site - Willowbank (approx. 125km haulage distance)
Dispose at Landfill Site	mxi	$/$m^3$	$ 68.80		Derived unit rate shown below
		$/$m^3$	$ 219.00	miii	Rounded total
Transport to Handling Facility - Spread & Dry - Haul Dry Material to Opportunistic / BR Site - Option B					Assuming drying necessary to be trucked to Dakabin Landfill site
Treat	vii	$/$m^3$	$ 5.00		Treat dredged material (PASS)
Transport to Handling Facility - Material handling (spread & dry) - Haul to Opportunistic Fill / BR Site	iix	$/$m^3$	$ 85.00		Estimate based on double-handling to Material Handling Facility - drying - then disposal at Opportunistic Fill/Beneficial Re-use - assuming approx. 50 km haulage distance
Dispose at Opportunistic Fill / BR Site	mxii	$/$m^3$	$ 16.00		Derived unit rate shown below
		$/$m^3$	$ 106.00	miv	Rounded total
Transport Wet Material direct to Opportunistic Fill / BR Site - Option C					Excess material to be taken to land fill while wet.
Treat	vii	$/$m^3$	$ 5.00		Treat dredged material (PASS)
Haul to Opportunistic Fill / BR Site	ix	$/$m^3$	$ 40.00		Estimate based on 2014 tendered rates and approx. 50km haulage distance
Dispose at Opportunistic Fill / BR Site	mxiii	$/$m^3$	$ 13.50		Derived unit rate shown below
		$/$m^2$	$ 58.00	mv	Rounded total

CALCULATED UNIT RATES - CONVERSION FOR $/T TO $/M^3

ITEM / DESCRIPTION	Source	Units	RATE	REF NO.	COMMENT
Disposal at Landfill - Dried Material	x	$/$m^3$	$ 68.80	mxi	Quote from Veolia for disposal at Ti Tree Bio Energy site
Disposal at Opportunistic Fill or Beneficial Re-use Site - Dried Material (Material Density approx. 1.60 t/m3)	xi	$/$m^3$	$ 16.00	mxii	Estimate - notional amount to cover disposal fees at nominated site
Disposal at Opportunistic Fill or Beneficial Re-use Site - Wet Material (Material Density approx. 1.35 t/m3)	xi	$/$m^3$	$ 13.50	mxiii	Estimate - notional amount to cover disposal fees at nominated site

MAINTENANCE MODEL DERIVED UNIT RATES
USER MODIFY CELLS IN RED
DO NOT MODIFY RATE CELLS DIRECTLY AS THESE ARE LINKED TO RAW UNIT RATES
COSTS SHOWN ARE UNIT RATES WITH CERTAINTY FACTOR APPLIED

Instructions for Model Sensitivity Worksheet
1 . Use the coloured cells to apply a factor to the adjacent item.

2. Unchanged cells (=1.0) will be displaced as light green, while cells with a factor applied will be displaced as light brown

BRIBIE GARDENS MAINTENANCE MODEL

RAW UNIT RATES TABLE

ALL RATES ARE IN 2016 DOLLARS AND EXCLUDE GST

REF NO.	ITEM	UNIT	RATE	CONFIDENCE LEVEL	ORIGIN / REFERENCE / DATE
	Dredging				
i	Dredging Design, Approvals & Monitoring	$	50,000.00	4	Estimate based on current understanding of required environmental approvals and likely scope of planning, design, and monitoring tasks
ii	Dredge survey	$	25,000.00	1	Estimate based on Nov 2014 Survey and 2014 dredging tender rates
iii	Contract Execution Costs - Dredging & Bypassing	$	40,000.00	3	Estimate based on 2012 and 2014 Entrance Bypassing Works
iv	Dredging and Bypassing (via Small CSD/Excavator) including Beach Nourishment	$/m^3	20.00	2	Estimate based on 2012 Entrance Bypassing Works
v	Contract Execution Costs - Grab (Backhoe) Dredge and Barge	$	100,000.00	1	Estimate based on 2014 tendered rates
vi	Grab Dredging (Backhoe) to Barge and unload to land	$/m^3	30.00	1	Estimate based on 2014 tendered rates
	Dredged Material Treatment & Disposal\Re-use (Excl. Entrance Bypassing)				
vii	Treat dredged material (PASS)	$/m^3	5.00	3	Estimate based on treatment via addition of agricultural lime - assumes sufficient mixing occurs during subsequent drying/placement
viii	Transport to Material Handling Facility - Spread & Dry - Haul to Landfill Site as Dry Material - Option A	$/m^3	145.00	5	Estimate based on double-handling to Material Handling Facility - drying - then disposal at Ti Tree Bio Energy site - Willowbank (approx. 125km haulage distance)
ix	Transport to Material Handling Facility - Spread & Dry - Haul to Opportunistic Fill/Beneficial Re-use Site - Option B	$/m^3	85.00	5	Estimate based on double-handling to Material Handling Facility - drying - then disposal at Opportunistic Fill/Beneficial Re-use - assuming approx. 50 km haulage distance
ix	Transport Wet Material direct to Opportunistic Fill/Beneficial Re-use Site - Option C	$/m^3	40.00	2	Estimate based on 2014 tendered rates and approx. 50km haulage distance
x	Disposal cost at Landfill Site - Option A	$/tonne	43.00	1	Quote from Veolia for disposal at Ti Tree Bio Energy site
xi	Disposal cost at Opportunistic Fill or Beneficial Re-use Site - Option B	$/tonne	10.00	5	Estimate - notional amount to cover disposal fees at nominated site
xii	Dredged Material Handling Facility - Approvals, Design and Construction	$	3,850,000.00	4	MBRC Estimate - Apportioned in PROGRAM sheet using item ref. xxvii
xiii	Dredged Material Handling Facility - Land Acquisition & Offsets	$	3,950,000.00	5	MBRC Estimate - Apportioned in PROGRAM sheet using item ref. xxvii
	General Canal Maintenance				
xiv	Rock Wall Maintenance	$/annum	5,000.00	2	MBRC Estimate
xv	Litter Collection	$/annum	5,000.00	2	MBRC Estimate
xvi	Navigation Aid and Signage maintenance	$/annum	6,000.00	2	MBRC Estimate
xviii	Vegetation Removal	$/annum	1,200.00	2	MBRC Estimate
xix	Routine canal batter maintenance	$/annum	4,000.00	2	MBRC Estimate
	Canal Walls				
xx	Canal Wall Repairs	$/m	1,100.00	4	Not Applied in Model - Rate from Previous Estimate - BEJ009 - Unit Cost Estimate - doc #: TD-MN-CAL-0001
xxi	Canal Wall Replacement	$/m	5,000.00	5	Not Applied in Model - Rate from Previous Estimate - Basic estimate cost for good accessibility areas - *cost could reach ~$15,000/m3 for poor accessibility etc.*
	Administration				
xxii	Review and Update of Maintenance Model	$	30,000.00	2	Estimate based on 2015-16 review
xxiii	Lock & Weir Condition Inspection and Reporting	$	30,000.00	2	Estimate based on 2016 Condition Inspection and Reporting
	Canals Environmental				
xxiv	Water Quality Monitoring	$/annum	6,000.00	2	MBRC Estimate
	Canal Infrastructure				
xxv	Lock & Weir Replacement	$	6,500,000.00	2	Estimated cost from Bribie Gardens Lock & Weir - Residual Life Assessment Report - Report Ref: *R-J15034-1*
xxvi	Lock & Weir Maintenance	$	65,000.00	4	Annualised Estimated Maintenance Cost from Bribie Gardens Lock & Weir - Residual Life Assessment Report - Report Ref: *R-J15034-1* (excl. Routine Condition Inspection & Reporting)

RAW (NON COSTING) DATA

REF NO.	ITEM	UNIT	VALUE	ORIGIN / REFERENCE / DATE
	Other			
xxvii	Estimated total volume of material disposed from Pacific Harbour Canal Estate into Bribie Island Dredged Material Handling Facility	m^3	392,200	Estimated total volume over 50 years - Refer Pacific Harbour Dredging Schedule and Maintenance Model. Volume applied in PROGRAM sheet for apportionment of Handling Facility Capital Costs

CONFIDENCE		Optimistic (P10)	Pessimistic (P90)	Adopted Confidence	Indicative Situation
Very High	0	-2%	5%	**0.33%**	Clear, concise scope supported by fixed quotes & labour rates, etc.
High	1	-5%	10%	**0.00%**	Some minor uncertainty exists regarding scope and/or estimate process, etc.
Moderate	2	-10%	20%	**0.00%**	Scope moderately clear, estimate based on mix of quotes & prices from similar jobs.
Low	3	-15%	30%	**0.00%**	Low scope confidence. Estimate based on factoring from other non-identical jobs.
Very Low	4	-20%	40%	**0.00%**	Vague / uncertain scope, prices factored from other similar (not identical) projects.
Order of Magnitude	5	-25%	50%	**0.00%**	Based on the best guess of experienced employees or similar methods.

DEFINITION

Optimistic - P10 = 90% Probability of exceedance
Pessimistic - P90 = 10% Probability of exceedance

CONFIDENCE FACTOR ADJUSTMENT

Optimistic ‹ › **Pessimistic**

THIS PAGE CONTAINS RAW COSTING DATA
EACH COST ITEM HAS A CONFIDENCE ATTACHED TO ACCOUNT FOR UNCERTAINTY (SEE ABOVE)
UNIT RATES MAY BE UPDATED AS NEW DATA BECOMES AVAILABLE, HOWEVER REFERENCE AND DATE TO BE RECORDED.

BRIBIE GARDENS MAINTENANCE MODEL

ESTIMATED DREDGED MATERIAL VOLUMES

ITEM / DESCRIPTION	Units	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
SENSITIVITY: QUANTITIES FACTOR		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DREDGED MATERIAL VOLUMES (In situ Density)	(m^3)	**1,000**	**5,600**	**-**	**-**	**-**	**-**	**17,000**	**-**	**-**	**-**	**-**	**5,500**	**-**	**-**	**-**	**-**	**5,500**	**-**	**-**	**-**	**-**	**8,300**	**-**	**-**	**-**	**-**	**6,200**	**-**	**-**	**-**	**-**	**5,500**
DREDGING METHOD & CORRESPONDING VOLUMES																																	
CUTTER SUCTION DREDGE VOLUMES - BYPASSING	(m^3)	-	5,600	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500
GRAB DREDGE VOLUMES	(m^3)	1,000	-	-	-	-	-	11,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,800	-	-	-	-	700	-	-	-	-	-
DREDGED MATERIAL VOLUMES PROPORTION ENTRANCE CHANNEL	%	0%	100%	0%	0%	0%	0%	32%	0%	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%	0%	0%	0%	66%	0%	0%	0%	0%	89%	0%	0%	0%	0%	100%
DREDGED MATERIAL VOLUMES PROPORTION UPSTREAM OF WELSBY PDE	%	100%	0%	0%	0%	0%	0%	68%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	34%	0%	0%	0%	0%	11%	0%	0%	0%	0%	0%
INCREASED OR REDUCED SILTATION																																	
INCREASED/REDUCED SILTATION - factored by: 25%	(m^3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FACTORED DREDGED MATERIAL VOLUMES (In situ Density)																																	
Total Volumes to be Dredged	(m^3)	1,000	5,600	-	-	-	-	17,000	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	8,300	-	-	-	-	6,200	-	-	-	-	5,500
Entrance Channel Volumes to be Dredged	(m^3)	-	5,600	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500
Upstream of Welsby Pde Bridge Volumes to be Dredged	(m^3)	1,000	-	-	-	-	-	11,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,800	-	-	-	-	700	-	-	-	-	-
DISPOSAL																																	
DREDGED MATERIAL VOLUME TRUCKED TO HANDLING FACILITY OR DIRECT WET DISPOSAL																																	
Upstream of Welsby Pde Bridge Dredged Material Volumes		1,000	-	-	-	-	-	11.500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,800	-	-	-	-	700	-	-	-	-	-
DREDGED MATERIAL VOLUME PLACED AS BEACH NOURISHMENT																																	
Entrance Channel Volume (Zone 1)		-	5,600	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500
DRY MATERIAL DISPOSAL (<20% MC & BULKED)																																	
Total Volumes - Dried material	(m^3)	436	-	-	-	-	-	5,015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,221	-	-	-	-	305	-	-	-	-	-

DREDGING VOLUMES INPUT

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Total	(m^3)	1,000	5,600	-	-	-	-	17,000	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	8,300	-	-	-	-	6,200	-	-	-	-	5,500
Cutter Suction Dredge Volumes (Entrance Channel)	(m^3)	-	**5,600**	-	-	-	-	**5,500**	-	-	-	-	**5,500**	-	-	-	-	**5,500**	-	-	-	-	**5,500**	-	-	-	-	**5,500**	-	-	-	-	**5,500**
Grab Dredge Volumes (All Other Areas)	(m^3)	**1,000**	-	-	-	-	-	**11,500**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2,800**	-	-	-	-	**700**	-	-	-	-	-

Instructions for Dredging Volumes Worksheet
DREDGING VOLUMES INPUT TABLE IS BASED ON DREDGING SCHEDULE - VALUES CAN ALSO BE MANUALLY INPUT (CELLS SHOWN IN BOLD RED FONT AND BLUE SHADING)
MANUAL INPUT IS ONLY ADVISABLE IF THE USER HAS A KNOWLEDGE OF THE DREDGING SCHEDULE AND DREDGING AND DISPOSAL CONSTRAINTS
THE SPOIL VOLUMES FOR EACH DISPOSAL METHOD ARE TRACKED THROUGH AND FACTORED BY THE DREDGING TECHNICAL PARAMETERS
DREDGED MATERIAL AND MATERIAL VOLUMES DIRECTLY INFORM THE PROGRAM SHEET, AND THEREFORE AFFECTS COSTS

BRIBIE GARDENS MAINTENANCE MODEL

ESTIMATED DREDGED MATERIAL VOLUMES

ITEM / DESCRIPTION	Units	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
SENSITIVITY: QUANTITIES FACTOR		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DREDGED MATERIAL VOLUMES (In situ Density)	(m^3)	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-
DREDGING METHOD & CORRESPONDING VOLUMES																			
CUTTER SUCTION DREDGE VOLUMES - BYPASSING	(m^3)	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-
GRAB DREDGE VOLUMES	(m^3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DREDGED MATERIAL VOLUMES PROPORTION ENTRANCE CHANNEL	%	0%	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%	0%	0%	0%	100%	0%	0%	0%
DREDGED MATERIAL VOLUMES PROPORTION UPSTREAM OF WELSBY PDE	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
INCREASED OR REDUCED SILTATION																			
INCREASED/REDUCED SILTATION - factored by: 25%	(m^3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FACTORED DREDGED MATERIAL VOLUMES (In situ Density)																			
Total Volumes to be Dredged	(m^3)	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-
Entrance Channel Volumes to be Dredged	(m^3)	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-
Upstream of Welsby Pde Bridge Volumes to be Dredged	(m^3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DISPOSAL																			
DREDGED MATERIAL VOLUME TRUCKED TO HANDLING FACILITY OR DIRECT WET DISPOSAL																			
Upstream of Welsby Pde Bridge Dredged Material Volumes		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DREDGED MATERIAL VOLUME PLACED AS BEACH NOURISHMENT																			
Entrance Channel Volume (Zone 1)		-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-
DRY MATERIAL DISPOSAL (<20% MC & BULKED)																			
Total Volumes - Dried material	(m^3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

DREDGING VOLUMES INPUT

		2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	Total	% of Total
Total	(m^3)	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	71,100	
Cutter Suction Dredge Volumes (Entrance Channel)	(m^3)	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	-	5,500	-	-	-	55,100	77%
Grab Dredge Volumes (All Other Areas)	(m^3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16,000	23%

Instructions for Dredging Volumes Worksheet

DREDGING VOLUMES INPUT TABLE IS BASED ON DREDGING SCHEDULE - VALUES CAN ALSO BE MANUALLY INPUT (CELLS SI
MANUAL INPUT IS ONLY ADVISABLE IF THE USER HAS A KNOWLEDGE OF THE DREDGING SCHEDULE AND DREDGING AND D
THE SPOIL VOLUMES FOR EACH DISPOSAL METHOD ARE TRACKED THROUGH AND FACTORED BY THE DREDGING TECHNIC
DREDGED MATERIAL AND MATERIAL VOLUMES DIRECTLY INFORM THE PROGRAM SHEET, AND THEREFORE AFFECTS COST

BRIBIE GARDENS MAINTENANCE MODEL

DREDGING VOLUMES - TECHNICAL PARAMETERS TABLE

Volume Conversion Factors - Dredge Spoil			
Spoil Location	**From *In situ* to the following:**	**M.C. %**	**% Air Volume**
In situ	1.00	152	0.00
C/S Dredge	2.95	525	0.00
Pond wet	0.89	130	0.00
Pond Crust on Batter	0.36	20	7.24
Pond Crust in Truck - Bulked	0.44	10	22.85

Assuming:

Bulking Factor	1.2
Density of Spoil (t/m^3)	1.6

Instructions for Technical Parameters Worksheet
DO NOT MODIFY CELL CONTENTS WITHOUT NEW GEOTECHNICAL DATA
BULKING FACTOR APPLIED FOR TRUCKING VOLUMES

SUPPORTING GEOTECHNICAL CALCULATIONS

ρ_{solids} = 2.600 t/m^3 ρ_{water} = 1.025 t/m^3

Location	Total V(m^3)	ρ_{bulk} (t/m^3)	Solids (t/m^3)	Water (t/m^3)	% Solids Mass	% Solids Vol	% Water Vol	% Air Vol	M.C. (%)	Total Mass (t)	Solids Mass (t)
In situ	***1,000***	***1.350***	0.537	0.813	39.74	20.63	79.37	***0.00***	152	1,350	537
C/S Dredge	2,955	***1.135***	0.182	0.953	16.00	6.98	93.02	***0.00***	525	3,353	537
Pond wet	887	1.391	0.605	0.786	43.48	23.27	76.73	***0.00***	***130***	1,234	537
Spadeable	363	1.919	1.476	0.443	76.92	56.79	43.21	***0.00***	***30***	697	537
Pond Crust	335	***1.920***	1.600	0.320	83.33	61.54	31.22	7.24	***20***	644	537
Heaped Dry	335	1.760	1.600	0.160	90.91	61.54	15.61	22.85	***10***	590	537

Note : Bold and italic is the assumed or known value

Appendix E Bribie Gardens Lock & Weir Residual Life Assessment Report

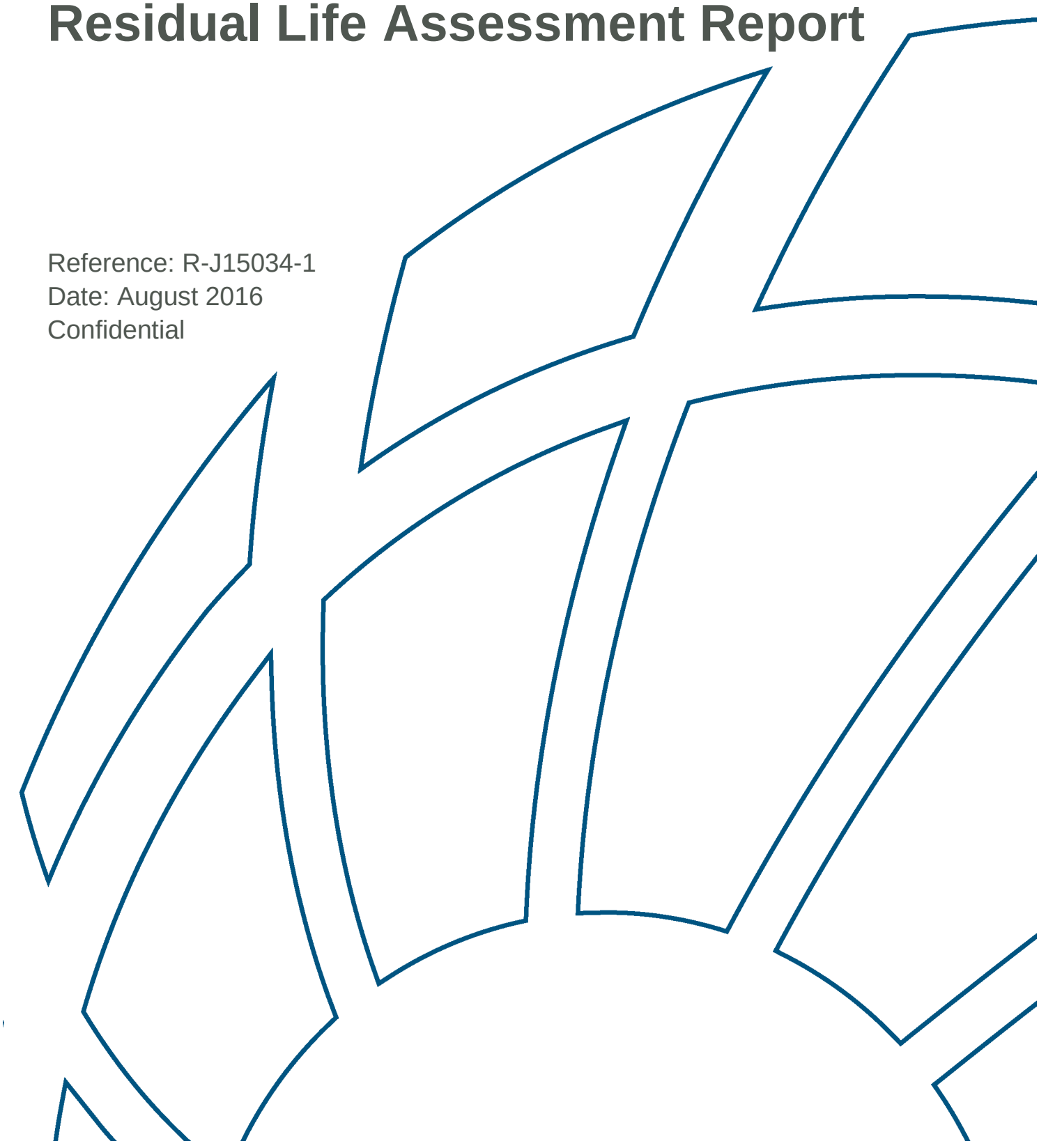
BMT JFA Consultants

"Where will our knowledge take you?"

BRIBIE GARDENS LOCK & WEIR

Residual Life Assessment Report

Reference: R-J15034-1
Date: August 2016
Confidential



MORETON BAY REGIONAL COUNCIL

BRIBIE GARDENS LOCK & WEIR

RESIDUAL LIFE ASSESSMENT REPORT

Prepared for

Moreton Bay Regional Council

By

BMT JFA Consultants

Rev	Issue	Prepared by	Submitted to	Date	Copies
A	Draft for First Review	J Fifield	Internal	18/3/16	1elec
B	Draft for Client Comment	J Fifield	MBRC	21/3/16	1elec
0	Issued For Use	J Fifield	MBRC	12/4/16	1elec
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TABLE OF CONTENTS

1 INTRODUCTION

1.1 Project Background

Moreton Bay Regional Council (MBRC) are responsible for the maintenance of the Bribie Gardens canal waterway. In order to forecast maintenance activities and costs, MBRC previously commissioned the preparation of a Long-term Maintenance Plan (LTMP) and associated expenditure model (Model). This existing LTMP identified that the greatest proportion of the maintenance costs is attributed to the maintenance and eventual replacement of the lock and weir.

The maintenance estimates included in the original LTMP were based upon visual inspections above the operating water levels only, and did not include any inspection or testing of elements below the water level. As such, notional allowances for maintenance were included in the original LTMP, together with an allowance for the full replacement of the lock and weir structure at the end of an estimated 50 year service life. Given the substantial influence of the replacement costs and timing on the expenditure model, it was considered necessary by MBRC to conduct a more detailed investigation into the residual life of the structure to more accurately predict the long term costs and timing associated with the structure, and that this would be conducted in conjunction with the scheduled review and update of the LTMP.

BMT JFA Consultants Pty Ltd (BMT JFA) were subsequently engaged by MBRC to review and update their existing LTMP for the Bribie Gardens canal estate. The scope of the review included a residual life assessment of the lock and weir structure to inform updates to the previous LTMP and expenditure model.

Inspection of the lock and weir was undertaken on the 20 January 2016 during a scheduled lock dewatering by Justin Fifield (BMT JFA), Dr Zac Couper (BMT JFA) and Dr Bob Boardman (Austest NDT). The condition inspection and assessments were undertaken in accordance with the Ports Australia Wharf Structures Condition Assessment Manual (WSCAM) 2014.

1.2 Bribie Gardens Lock and Weir Site Description

The Bribie Gardens canal estate is located on the western side of Bribie Island, to the south of the Bribie Island Road Bridge. The lock and weir is located near the canal entrance, approximately 100m west of Welsby Parade, and acts to control the minimum water level upstream of the structure to approximately +0.1 mAHD.

The lock and weir are aligned approximately east (upstream) to west (downstream). The lock and weir are situated adjacent to the north and south banks of the Bribie Gardens Lake Entrance respectively (Refer Figure 1-1).

The Bribie Gardens lock and weir was constructed in 1984/5. It is a monolithic reinforced concrete structure, with no movement joints, and is backfilled on both banks. There is a lock island between the lock and the weir filled with compacted sand with a concrete slab topping. The lock has radial gates at each end which, when open, swing into gate recesses in the lock walls on either side.

Figure 1-1: Aerial View of Lock and Weir Location (MBRC 2016)

1.3 Scope

1.3.1 Project Objectives

The overall objective of the residual life assessment, as outlined in the project brief, was to:

- Estimate the long term costs and timing associated with maintaining and replacing the lock and weir structure, to inform updates to the LTMP, including:
  - assessment of the residual life of the structure
  - consideration of treatments to extend the service life
  - estimates of maintenance costs over the remaining life of the structure.

1.3.2 Scope of Services

BMT JFA's investigation subsequently aimed to achieve the following outcomes:

- Greater certainty of the forecast operational life of the existing structure than provided in the original LTMP
- Improved understanding and forecasts of maintenance requirements between now and the end of the structure's operational life
- A more accurate basis for the eventual timing and cost of replacement compared with the estimates in the original LTMP.

BMT JFA developed an assessment methodology for the residual life assessment based upon these aims and extensive experience in the condition assessment and maintenance of marine structures, including lock structures. The adopted methodology included the following key tasks:

- High level assessment of the structural components of the structure including targeted non-destructive testing
- Identification of repairs and maintenance activities required on the structural components and identified treatments that would extend its operational life
- Preparation of a costed maintenance schedule for the structure to the end of its estimated operational life
- Preparation of a concept design and cost estimate for the replacement of the lock and weir structure when it reaches the end of its operational life.

This report summarises the outcomes of the completed work, and is structured as follows:

- **Condition assessment framework** – details the adopted condition assessment framework
- **Desktop review** – outcomes of the completed desktop review
- **Lock** – condition inspection summary and discussion of key areas of the lock structure
- **Weir** – condition inspection summary and discussion of key areas of the weir structure
- **Asset management strategy** – outlines the broad asset management principles for the condition ratings and recommended actions
- **Maintenance actions** – summary of the recommended maintenance strategy and details of recommended short to medium-term maintenance actions
- **Lock and Weir Replacement Concept Design** – details of the lock and weir replacement concept design and estimated replacement costs
- **Conclusions and Recommendations** – summary of the key conclusions and recommendations.

1.3.3 Limitations

The completed inspection and testing of the structure was limited to visual and non-destructive testing of the accessible areas of the key structural elements and the lock gates only. The inspection and testing did not include mechanical and electrical components, non-structural elements, appurtenances, and non-accessible areas of the structure, including the external areas of the lock (i.e. areas outside of the lock gates) and all areas of the weir beneath the water-line.

As such, the conclusions, recommendations, and maintenance schedules provided in this report are considered sufficient to meet the overall project objectives, but shall not be relied upon for the detailed planning and execution of the long term maintenance of the structure. Additional defects, to those identified herein, may have existed at the time of the inspection, and future degradation of the structure will also result in further defects and maintenance requirements. Subsequent detailed inspections, assessment, and design of maintenance works, additional to the recommendations and schedules provided in this report, will be required.

2 CONDITION ASSESSMENT FRAMEWORK

The Wharf Structure Condition Assessment Manual (WSCAM) has been developed by Ports Australia to provide best practice and consistent methods for the visual inspection, testing, and condition assessment of marine structures. WSCAM was therefore used to set the framework for this condition assessment, and a 'Basic Visual Assessment' of the lock and weir structure was completed as part of this assessment. The WSCAM rates the condition of various elements from 1 (New) to 7 (Failed). The condition rating scale is detailed in Figure 2-1 and Figure 2-2.

Rating the structural components using this condition assessment framework provides guidance on an assessment of the expected remaining life as a percentage of the original design life (refer - Figure 2-1 and Figure 2-2).

CONDITION STATE	DESCRIPTION	EXPECTED REM. LIFE (% of original design life)	RECOMMENDED ACTIONS
1	New with no visible defects/damage.	100	No repairs required. Re-inspection at next scheduled inspection may be considered.
2	As new. Hairline cracks (<0.1mm). No exposed reinforcement or surface evidence of corrosion of reinforcement. Minor efflorescence, no observable dampness or leakage.	55-100	No repairs required. Re-inspection at next scheduled inspection may be considered.
3	Fine cracking (0.1mm - <0.3mm), surface staining from weathering, minor voids, rust stains, minor surface erosion or honeycombing.	40-55	Planned and preventative maintenance works may be considered.
4	Medium cracking (0.3mm - 0.5mm) and rust staining present. Minor spalling and exposed reinforcement affecting less than 5 percent of surface area; <20% of surface area undergoing delamination. Moderate surface erosion.	25-40	Further testing; reactive maintenance and some minor upgrades may be considered.
5	Large cracks (>0.5mm - 2mm), moderate concrete spalling and exposed reinforcement affecting up to 20% of surface area. Moderate delamination up to 50% surface area. Up to 10% section loss of reinforcement.	15-25	Structural assessment is recommended. Further investigation may be required to inform the structural assessment. Maintenance; upgrade or rehabilitation works may be considered.
6	Major cracks (>2mm), severe concrete spalling and exposed reinforcement affecting up to 50% of surface area. Severe delamination >50% surface area. 10- 20% section loss of reinforcement.	0-15	Structural assessment is recommended. Further investigation may be required to inform the structural assessment. Rehabilitation or renewal works may be considered.
7	Very severe concrete spalling with exposed reinforcement and reinforcement section loss of > 20%. Component has failed.	0	Rehabilitation required immediately or replace component/asset. Structural assessment is recommended where rehabilitation works are to be undertaken. Further investigation may be required to inform the structural assessment.

Notes:

1. The expected remaining life provided in the table is indicative only. Predictive modelling based on physical assessment would be required to obtain an accurate indication of the expected remaining life.
2. A steel section loss of 20% has been assumed as the safety factor on steel reinforcement and structural steel. Individual assets or components may however have higher or lower steel tolerances. To confirm the appropriate time to intervene, it is recommended that a structural assessment be carried out on specific assets or components.
3. Where an asset or asset component has been visually assessed as having a condition state of 2 or 3 following patch repairs, it may be inspected at the same frequency as an asset or component with a higher rating as the patch repair may deteriorate at a higher rate than the original concrete.

Figure 2-1: Concrete Condition Rating Scale (WSCAM 2014)

CONDITION STATE	DESCRIPTION	EXPECTED REM. LIFE (% of original design life)	RECOMMENDED ACTIONS
1	New with no visible defects/damage. No rust stains, coating intact and free from defects.	100	No repairs required. Re-inspection at next scheduled inspection may be considered
2	As new. Paint still in-tact, with little or no chalking. Minor fading or discoloration may be present	55-100	Re-inspection at next scheduled inspection may be considered. Possible long-term structural impact, if no action is taken in the first stages of deterioration of the coating.
3	Coating deterioration to <10% of surface area; minor substrate adhesion failure and/or minor intercoat adhesion failure; advanced chalking of top coat, scattered/surface corrosion to < 5% of total surface area.	40-55	Planned and preventative maintenance works may be considered. Touch up of coating may be undertaken. Possible long-term structural impact, if no action is taken in the first stages of deterioration of the coating.
4	Coating deterioration to >10% of surface area; advanced substrate adhesion failure and/or advanced intercoat adhesion failure and/or scattered/surface corrosion of base metal to 5-10% of surface area, especially at welds and along edges.	25-40	Further testing; reactive maintenance and some minor upgrades may be considered.
5	Widespread scattered/surface corrosion (10-30% of surface area) and/or corrosion with scale rust formation and frequent pitting (<10% section loss), and minor pitting along welds.	15-25	Structural assessment is recommended. Further investigation may be required to inform the structural assessment. Maintenance; upgrade or rehabilitation works may be considered.
6	Widespread scattered/surface corrosion (>30% of surface area) and/or widespread corrosion with scale rust formation and frequent pitting (10-20% section loss), and major pitting along welds. Evidence of ALWC. Minor to moderate crack in metal or at welds.	0-15	Structural assessment is recommended. Further investigation may be required to inform the structural assessment. Rehabilitation or renewal works may be considered.
7	Localised metal loss exceeding 20% of section thickness or as otherwise indicated by structural analysis. Severe crack in metal or at welds. Component has failed.	0	Structural assessment is recommended. Further investigation may be required to inform the structural assessment. Rehabilitation or renewal works may be considered.

Notes:

1. The expected remaining life provided in the table is indicative only. Predictive modelling based on physical assessment would be required to obtain an accurate indication of the expected remaining life.
2. A steel section loss of 20% has been assumed as the safety factor on structural steel. Individual assets or components may however have higher or lower steel tolerances. To confirm the appropriate time to intervene, it is recommended that a structural assessment be carried out on specific assets or components.
3. Where a steel component has been re-coated and visually assessed as having a condition rating of 2 or 3, it may be inspected at the same frequency as an asset or component with a higher rating as the re-coat may deteriorate at a higher rate than the original coating.
4. The rating scale assumes a maintenance philosophy which requires regular maintenance of the paint. The inspector may need to confirm the validity of this assumption with the asset owner.
5. ALWC typically occurs at levels ranging between +0.5m LAT and LAT. The appearance of ALWC is identified on the steel surface by bacteria colonies which have a bright orange colour (refer to Figure 2.1 – Wharf Structures Condition Assessment Manual). Removal of the surface layer reveals a black sludge of corrosion product often with a smell of sulphur and a bright shiny steel surface with localised pits.

Figure 2-2: Steel Condition Rating Scale (WSCAM 2014)

As part of the Basic Visual Assessment, all major elements were inspected where access was possible. Where defects were identified during the condition inspection a maintenance rating was attributed in accordance with WSCAM (see Figure 2-3). In addition to completing the visual inspections, targeted non-destructive testing of key elements was also undertaken.

MAINTENANCE RATING	DESCRIPTION	TYPICAL EXAMPLES
A	No maintenance items identified.	Pile with no wrapping or jacket. Steel walkway welded to steel beams, with no bolts and fixings. Reinforced concrete deck with no joints and no services attached to it.
B	Maintenance items unlikely to have direct impact on short-term operation, structural integrity or durability.	Wear and tear or minor damage to wrapping or jacket above tidal zone of pile. Minor rust staining of bolts and fixings with no visible section loss.
C	Maintenance items likely to have minor impact on short-term operation, structural integrity or durability.	Wear and tear or moderate damage to wrapping or jacket in tidal zone of pile. Minor corrosion (<5% section loss) of bolts and fixings; <10% missing or loose bolts.
D	Maintenance items likely to have moderate impact on short-term operation, structural integrity or durability.	Wear and tear or severe damage to wrapping or jacket in tidal zone of pile. Severe corrosion (5-20% section loss) of bolts and fixings; 10-30% missing or loose bolts.
E	Maintenance items likely to have major impact on short-term operation and/or structural integrity or safety.	Very severe corrosion (>20% section loss) of bolts and fixings; >30% missing or loose bolts.

Figure 2-3: Maintenance Rating Scale (WSCAM 2014)

3 DESKTOP REVIEW

A desktop review was undertaken of the available Lock and Weir design drawings to identify critical areas for inspection and assessment. This included an assessment of where on the 31 year old (of MBRC's assumed 50 year service life) structure defects are likely to have developed.

Prior to the inspection the lock and weir drawings (Cardno & Davies series 1338/7 drawings 7, 8, 18 and 42-45) were reviewed to identify areas of key structural function, and zones where defects were more likely to be encountered. This enabled the initial visual inspection and non-destructive testing to be targeted at critical locations.

The areas identified as most susceptible to critical defects on the lock structure (through either structural function or environmental degradation) were:

- Areas adjacent to the gate hinge (pintle) connections.
- Steel gates at lowest extent where the forces are greatest, in particular the lower truss connections where the likelihood of fatigue cracking is greatest (a sample of critical welds was subject to magnetic particle inspection (MPI) to determine if fatigue cracking was present).
- Steel gates in the splash zone; in particular, hollow elements with thin wall thickness (ultrasonic thickness (UT) testing undertaken to a sample of critical locations to determine section loss).
- Concrete in the splash zone where wicking from wetting and drying is most likely to enable corrosion related deterioration.
- Non-vertical faces of lock and weir (flare wider at the base), which can result in areas with low cover owing to construction complexities (covermeter testing was undertaken to a sample of key areas).

The areas identified as most likely to have critical defects on the weir were:

- Areas around the integral walkway deck support connections which are susceptible to cracking induced by restraint (shrinkage, creep and thermal effects).

4 LOCK

4.1 Condition Inspection Summary

The condition inspection schedule (Sch-J15034-1) and maintenance programme (Sch-J150134-2) provide full details of the lock structure defects. These are provided in Appendix A.

The concrete components of the lock consist of the base, walls, and gate recesses. The following defects were identified on the lock concrete structure:

- Spalling of concrete at handrail support at corner of southeast gate recess (Safety Critical - Figure 4-2)
- Spalling of concrete wall in southeast gate recess
- Cracking of concrete in the upper areas of the southwest gate recess
- Very low cover/ exposed reinforcement in localised areas of gate recesses
- Low cover throughout the concrete structure
- Air bubbles present on the majority of reinforced concrete wall faces.

The steel components are comprised of the gates, hinges and connections. The following defects were identified on the steel structures:

- Coating deterioration and corrosion to lock gates in splash zone
- Greater than 90% utilisation of all sacrificial anodes
- Scattered coating deterioration and corrosion to gate hand railing.

Ancillary lock items include ladders, fenders and cleats. The following defects were identified:

- Lower sections of fenders are deteriorated and the connections have failed
- Ladder access is partially fouled by stainless steel cables between fenders
- Cleats are mounted on cracked and spalling concrete
- Fencing is mounted on cracked concrete.

Due to the water level in the lock after dewatering the base concrete of the lock was not inspected in detail. No defects were identified adjacent to the lower gate hinge (pintle) connections.

4.2 Discussion

4.2.1 Concrete Lock Structure

The majority of the lock structure concrete was given a WSCAM condition rating of 3 with localised areas reaching a rating of 4. Based on the condition rating of 4 this suggests a remaining life of at least 25-40% of original design life. If the maintenance repairs identified in Schedule Sch-J15034-2 are undertaken to a high standard the overall condition rating could be revised to 3 suggesting a remaining life of 40-55% of original design life. Good maintenance could allow the structure to last 20-25 years.

Spalling and Low Cover

The concrete is 31 years through an assumed 50 year design life (WSCAM Table C1.4 – Expected Life). While the drawings specify 65mm cover, the covermeter tests undertaken identified that, this is consistently lower than specified. In several areas cover was found to be 40mm or less. Corrosion has occurred at a number of locations in the splash zone including one location in the south-eastern gate recess where spalling has resulted (Figure 4-1).

Figure 4-1: Lock SE Gate Recess 20/01/16 – Spall repair starting to fail at west end inner south wall of SE Recess

Figure 4-2: Lock Island Walkway SE Gate Recess 20/01/16 – Spall beneath handrail stanchion

In other areas where cover is almost zero (the majority of cases were in the gate recesses in areas near to the gate pintle in the splash zone– see Figure 4-3) only minor corrosion has occurred to exposed bars. The limited corrosion is potentially due to the good maintenance practice of painting the face of the concrete in the splash/spray zone (from 1m below LAT up to 1m above HAT).

Figure 4-3: Lock Island SW Gate Recess 20/01/16 – Poor compaction and very low/zero cover on gate attachment wall, corrosion staining visible

Cracking

Cracking has been identified at two locations on the concrete in the southwestern gate recess. On the soffit of the cantilevered slab there is a long crack which could be an indication of a single long spall (Figure 4-4). The hand rail is connected at this outer edge, therefore, if the crack was to deteriorate it could compromise the safety of the hand rail. The crack, of greater concern, is located adjacent to the upper SW gate hinge (pintle) connection (Figure 4-5). This is a fine crack at present but there is the potential for it to cause structural problems.

At the south-eastern gate recess on the top face of the slab there is a transverse crack south of the gate hinge (pintle) connection that has been repaired. This crack should be monitored especially for propagation into the adjacent vertical wall of the recess.

Figure 4-4: Lock SW Gate Recess 20/01/16 – Crack on walkway cantilever slab section

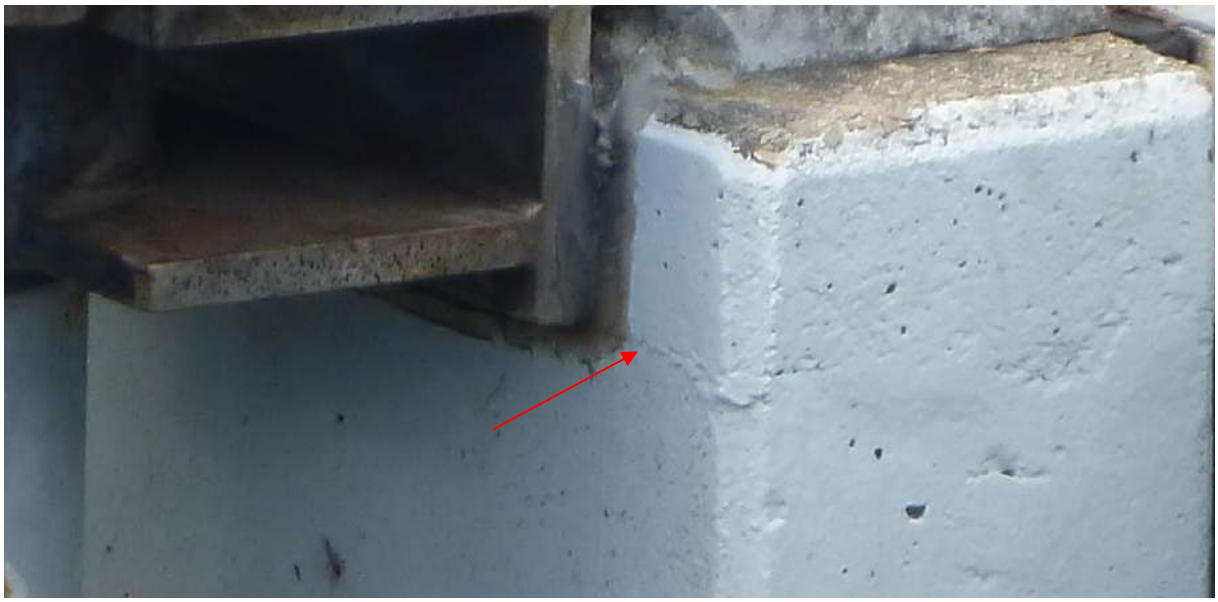


Figure 4-5: Lock SW Gate Recess 20/01/16 – Crack at top to the north of gate hinge connection (identified by red arrow)

General

The majority of the vertical concrete faces have air bubbles in the face. This indicates there was poor compaction during construction with limited vibration, exacerbated by the flared shape of the wall design, hindering air escaping. At each air bubble formed into the surface of the concrete the cover distance to the reinforcement is reduced by the air bubble's diameter. This reduces the effective cover to the reinforcement and accordingly the distance for the reactants of corrosion; oxygen, and water, as well as the catalyst; chlorides.

While low cover was also identified lower in the structure, where the internal forces are greatest in the lock walls, no defects were identified. The defects identified were all above low water level; it is anticipated that this is due to a combination of wicking of corrosion reactants by the wetting and drying, and the greater likelihood of mechanical damage from floating objects. This concrete above lowest astronomical tide is, for these reasons, where corrosion can occur more rapidly and where maintenance activities should be concentrated as a preventative measure.

4.2.2 Steel Gates

The majority of the lock gate steel was given a WSCAM condition rating of 2 with small areas reaching ratings of 4 and 5. Based on the condition ratings of 4 and 5 this suggests an expected remaining life of at least 15-40% of original design life. If maintenance repairs are continued and undertaken to a high standard the overall condition rating could be revised to 3, suggesting a remaining life of 40-55% of original design life. With regular programmed maintenance of coatings and replacement of anodes (as identified in maintenance schedule Sch-J15034-1) the life of the structure is expected to be 20-25 years. However, this would require periodic recoating of the whole paint system (last fully recoated 12 years ago) and regular periodic maintenance coating of areas where the system has locally broken down prior to recoating.

Steel Structural Elements

The steel gates have only shown coating deterioration and corrosion within the splash zone. The paint system has deteriorated allowing oxygenated seawater to corrode the steel. The findings of the ultrasonic thickness (UT) testing showed that while corrosion is visible no noticeable section loss had occurred to plate steel, open or hollow sections when a sample of locations were tested (Figure 4-6). The paint system has failed in the most active corrosion area, the tidal zone, where wetting and drying results in accelerated corrosion rates. This area is also not protected by the cathodic protection in place because it is not submerged. The maintenance crew present during the inspection were grinding out corrosion product, with the intention to apply a maintenance coat to the affected sections of the gates.

BMT JFA understand the most recent complete paint system recoating was 12 years ago. This complete recoating is due in the next 2-4 years as deterioration has commenced. Steel coating systems have a maximum life of 10-15 years in the marine environment (as detailed in AS2312 Table 6.3). Regular maintenance touch up coating is a labour intensive method of minimising steel section loss until a new coating system can be applied following full blasting preparation of the substrate metal.

Figure 4-6: Lock NE Gate 20/01/16 – Gate to Gate seal pulled back to reveal extent of corrosion on vertical parallel flange channel member – ultrasonic thickness measurements identified negligible section loss to steel members

The MPI testing of the gates' hollow section connections, where forces were identified to be greatest, found no signs of fatigue cracking.

All anodes were found to have expired completely or be utilised beyond 90%. The deeper western gates had complete utilisation of all anodes (Figure 4-7). It is understood that all anodes were replaced following the inspection.

Figure 4-7: Lock NW Gate 20/01/16 – Inside face, 3 anodes (2 vertical, 1 horizontal – identified with red arrows) completely expired

Mechanical and Electrical Elements

Mechanical and Electrical items were not inspected as part of this assessment; BMT JFA understands that MBRC has stockpiled sufficient spares of components with long lead times (Actuator, reduction gearbox and worm drives (both hands)) to allow timely repair of any single gate breakdown.

Connections

The connections into the concrete generally appear sound with only two areas of concern:

- A repaired crack nearby south-eastern gate top connection
- A fine crack located adjacent to south-western gate top connection (Figure 4-5)

The south eastern gate top crack should be checked at each subsequent lock inspection. The fine crack to the south-western gate top concrete should be repaired.

Seals

The curtain seals appeared to be in working condition, however, these and the vertical gate seals should continue to be replaced at regular intervals (vertical seals every five years, horizontal curtain seals every 12 years) to minimise leakage. Vertical seals were generally in a functional but worn condition. The south-east gate to recess seal had become unbolted and damaged at the top. The maintenance crew were in the process of removing and refitting all vertical seals to allow grinding out of corrosion during the inspection.

4.2.3 Appurtenances

Fenders and Ladders

The north and south lock wall rubber faced timber fenders were found to have missing or severely deteriorated connections (Figure 4-8). The lock gates' timber fenders were in good condition.

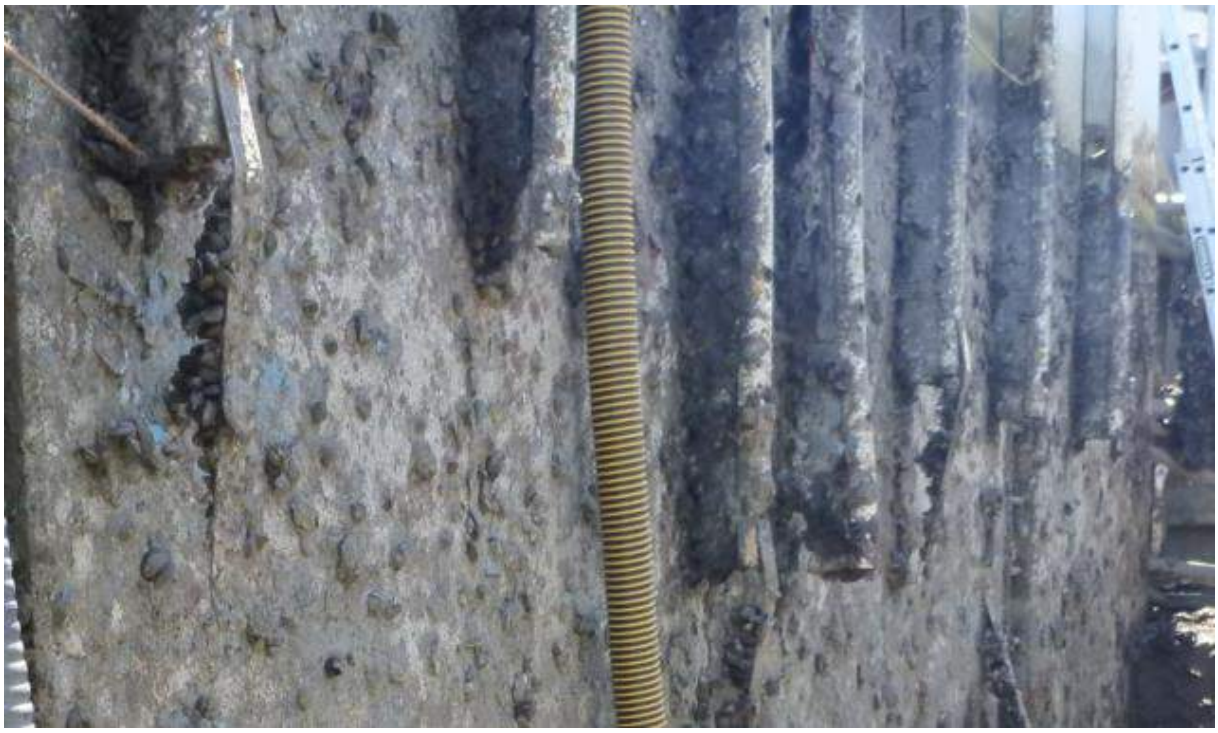


Figure 4-8: Lock N Wall Fenders 20/01/16 – Lower fender connections missing and failed

The north lock wall ladders are fouled by stainless steel wire rope running between the fenders (Figure 4-9). The stainless steel wires should be stop-ended at the ladders as they are considered a safety hazard to anyone entering or exiting the water by ladder.

Figure 4-9: Lock N Wall Ladders 20/01/16 – Ladders fouled by stainless steel wire rope between fenders

The SE gate recess outer ladder, on inspection of the photographs should be checked as the lower connection appears missing (Figure 4-10).

Figure 4-10: Lock SE Gate Recess 20/01/16 – Outer ladder lower connection appears missing

Topping slabs and associated appurtenances

The lock island has an approximately 50mm deep concrete topping slab, onto which the mooring cleats as well as fencing and hand railing have been bolted. This deck topping has deteriorated, significantly weakening the connections. If the mooring cleats are used they will not meet the expected loads which could be a safety issue. These should either be; decommissioned if they are no longer required, or, replaced with appropriate fixings. Any loose concrete spalls should be removed to eliminate the risk of falling onto vessels/lock users.

While fencing and hand railing is not part of the lock and weir structure (and therefore not explicitly part of the scope, of this assessment) additional defects were noted on the island and maintenance area to the north of the lock. The following defects were identified in these areas:

- Cracking to concrete adjacent to cleats, fencing and hand rail fixings (Figure 4-11 and Figure 4-12)
- Corrosion to galvanized steel hand railing
- Deterioration of fencing infill mesh.

Figure 4-11: Lock S Wall (Lock Island) 20/01/16 – Cracking and growth on lock island topping adjacent to cleats and other fixings

Figure 4-12: Lock Island (view from weir) 20/01/16 – cracking and spalling to edge of lock island topping slab adjacent to fencing fixings

The fenced area to the north of the lock has a similar issue with degradation of the slab. The fencing itself is also showing deterioration and it is advised that this be replaced to ensure sound edge protection to the lock structure for safety of users and maintenance team.

5 WEIR

5.1 Condition Inspection Summary

The condition inspection schedule (Sch-J15034-1 Page 2) and maintenance programme schedule (Sch-J15034-2) provide full details of the weir structure defects. These are provided found in Appendix A.

The concrete components of the weir are the base, walls, flow separating walls and walkway. The following defects were identified on the weir concrete structure:

- Impact damage to the upstream side of both central flow separating concrete weir walls at high water level and localised fine cracking
- Medium cracking to the concrete walkway deck
- Medium cracking to the south wall of the weir (repairs appear to have been previously undertaken)
- Air bubbles are present on the majority of the weirs vertical concrete surfaces (though not as severe as the lock).

During the inspection heavy growth was identified on the weir walls below high water reducing visibility. Additionally, no access to view/photograph the soffit of the deck was possible.

5.2 Discussion

5.2.1 Concrete Weir Structure

Currently the condition rating of the weir concrete to WSCAM is as high as 5. This would equate to a remaining life of 15-25% of the original design life. If maintenance repairs are undertaken, as described in schedule Sch-J15034-2, to a high standard the condition rating could be revised to a 3, equivalent to an expected remaining life of 40-55% of original design life. Therefore with good maintenance these concrete elements could be expected to last 20-25 years.

Cracking

The cracking to the south wall is most likely due to long term creep under loading induced by restraint of drying shrinkage or thermal effects in combination with bending induced on the wall by soil and walkway loads. This cracking is a consequence of the integral concrete construction method/design and at this stage of the structure's design life is expected to be stable. The repairs undertaken to the south weir wall to date appear to be effective.

The walkway deck slab cracking (Figure 5-1) appears to be concentrated around the weir walls and could be a combination of flexure and long term drying shrinkage or thermal effects from the integral connections. The cracking is locally between 0.3 and 0.5mm in width. As this walkway is used by the public for fishing, seawater is likely to be splashed on the deck. This is likely to result in wicking, due to repetitive wetting and drying, which could allow dissolved chlorides and oxygen to ingress into the concrete. With the low cover identified on the deck concrete (as low as 45mm) and the identified cracking, the reinforcement is considered to be at risk of corrosion.

Figure 5-1: Weir Walkway 20/01/16 – Cracking of top of walkway deck at weir wall support

The horizontal fine cracking identified on the flow separating weir walls could be caused by the combined thermal effects of casting fresh against hardened concrete, exacerbated by differential wall lengths through the vertical plane. Given the age of the structure, and that these cracks are currently less than 0.3mm in width, these repairs could be advised in the future following a subsequent condition inspection (unless the situation worsens).

Impact damage

Impact damage has been identified on the upstream side of both flow separating weir walls. This damage, particularly on the south weir wall (Figure 5-2), has reduced the effective cover substantially. This loss of cover could allow corrosion to be initiated resulting in further damage from spalling.

Figure 5-2: South Weir Wall 20/01/16 – Impact damage to upstream side

General

In a similar, but less severe fashion to the lock walls, the vertical walls of the weir have air bubbles in the face. This reduces the effective cover to the reinforcement increasing the likelihood of corrosion reactants reaching the reinforcing bars resulting in further deterioration.

5.2.2 Appurtenances

Hand Rails

The galvanized steel hand rails are showing the early signs of corrosion. If the structure is to be kept open for a further 25 years it would be anticipated that the hand rail would require replacement during that time period to ensure public safety.

Weir Grates

The three steel weir grates are showing only limited signs of corrosion and did not appear to be blocked with excessive debris.

6 ASSET MANAGEMENT STRATEGY

6.1 Introduction

This section provides background principles for framing the condition ratings and actions detailed in the preceding and following sections and the attached schedules.

Maritime and navigation structures are constructed from mostly steel and concrete, as is the case here, and are situated in one of the most aggressive environments for these materials. Attack from biological, chemical and physical pathways requires appropriate durability design, construction and maintenance to ensure the envisaged service life is achieved.

To effectively manage the marine based asset over its lifetime, it is necessary to understand the degradation of the materials and elements comprising the structure so that one can predict the future working life of the structure and plan regular actions to reach the expected life or rehabilitation to extend its life. Asset management strategies can generally fall under the following categories (CIRIA C674 – The use of concrete in maritime engineering):

- No future maintenance
- Preventative measures to limit further maintenance and/or extend the asset life
- Routine maintenance and repair i.e. partial restoration, full restoration, upgrading or reconstruction
- Construction of a replacement.

The choice of strategy is made with reference to the nature and criticality of the asset, budgets, and current condition and performance and may change over time due to changes in these criteria.

The chart in Figure 6-1 shows the concepts of a variation in loss of functionality with time with a range of strategies and highlights the impact of various interventions. Even with good durability design and construction, a structure may be assumed to approach some limiting criteria based on functionality, capacity, failure mode and often safety. The strategy employed must ensure that management actions are optimised over its defined life and economic decisions can be framed around its later performance with regard to rehabilitation or replacement (CIRIA C674).

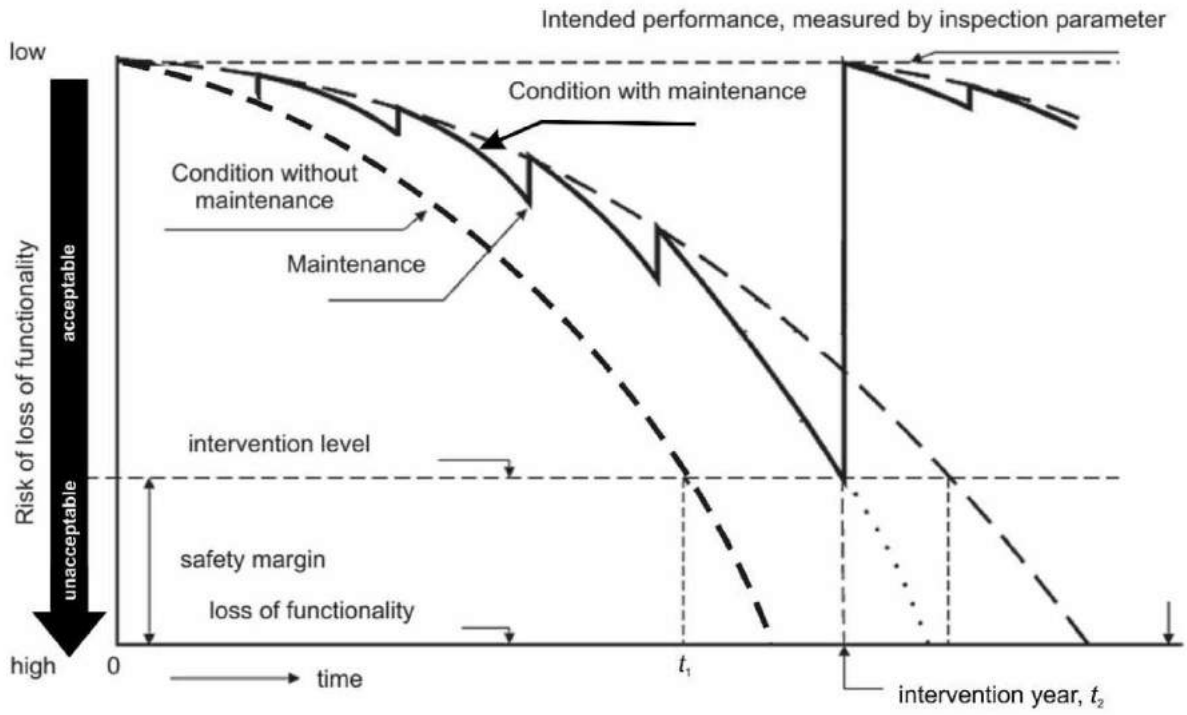


Figure 6-1: Ageing of a structure - sources CIRIA (C674 & The Rock Manual)

6.2 Defect Drivers

The intent of this section is to give the asset manager an understanding of the key drivers behind the observed defects and the proposed actions within this report.

Steel

In the marine environment, the corrosion rate of carbon steel is at its highest in the tidal/ splash zone. This is due to the continual wetting and drying of the surface of the steel and the increased aeration caused by wave action leading to high concentrations of sodium chloride on the metal surface.

Corrosion rates in the tidal/splash zone can be controlled by the application of a suitable coating (or other physical barrier) and/or the application of cathodic protection. It should be noted that the cathodic protection system will only control corrosion when the element being protected is submerged. Typically, unsubmerged sections of steel are coated for this reason.

Generally, corrosion of coated or galvanised mild steel assets is preceded by damage, breakdown or depletion of the protection system. (WSCAM 2014).

Concrete

Corrosion of steel reinforcement is the most common cause of structural damage to reinforced concrete elements. Steel reinforcement embedded in concrete is inherently protected from corrosion by a thin oxide film that forms around it at as a result of the highly alkaline environment that is generated from the hydration of cement. Corrosion may initiate when breakdown of the passive film occurs, either as a result of the ingress of chloride ions or through a loss in alkalinity, predominantly by the diffusion of atmospheric carbon dioxide.

Cracking occurs when concrete experiences tensile strains as a result of volumetric changes or applied loads which exceed its tensile strain capacity. Cracking can provide a direct route for aggressive agents to enter the concrete. This is of particular importance when the concrete is located in an aggressive environment or when a long service life is required.

In addition to cracking, concrete may also delaminate or spall as the result of corrosion of steel reinforcement. Delamination refers to a discontinuity of the surface concrete which is substantially separated but not detached from the reinforced concrete. Visibly it may appear as a solid surface but can be identified by a hollow sound when subjected to hammer tapping.

Spalling occurs when a fragment of concrete has detached from reinforced concrete component and is characterised by sharp edges. Spalled concrete will typically expose corroded reinforcement (WSCAM 2014).

Common design/construction issues that may result in the degradation of concrete elements (WSCAM 2014) include:

- Inadequate or insufficient design;
- Insufficient cover to reinforcement;
- Inadequate mix design;
- Poor concrete compaction (honeycombing);
- Use of unscreened reactive aggregates;
- Poor quality control procedures;
- Inadequate treatment of identified defects; and
- Premature exposure of concrete to aggressive environments.

6.3 Strategy

BMT JFA have prepared a maintenance strategy (refer maintenance cost estimate schedule Sch-J15034-3 in Appendix A) which is anticipated to keep the structure operable for an estimated 20-25 years. The maintenance strategy incorporates a number of proactive measures (additional to current routine maintenance activities) to treat the identified construction weaknesses and resulting defects. Such measures should be enacted in the short term to ensure the benefits of the overall maintenance strategy are realised.

When the structure does reach the end of its serviceable life the structure must be replaced to continue functional access to the Bribie Gardens lake/canal, this will be a high capital cost. Towards the end of the lock and weir's life the number of defects will likely be significantly greater and the costs to repair these to keep the structure open, functional and safe for users, will increase year on year. There is a point where it no longer becomes economically viable to continue maintenance of the old structure but cheaper, over the long term, to construct a replacement, at high initial capital cost, but which will require little maintenance for approximately the first 10-15 years.

The general condition of the lock and weir structure was found to be good to average, however, the majority of concrete has low cover. Even with measures to enhance impermeability of the concrete it is expected that the number of defects will rise substantially once the low cover has been infiltrated, the passivating film lost and corrosion initiated. At this stage the number of maintenance and repair actions required are very likely to escalate sharply and similarly so will the costs. With age, mechanical defects are likely to occur more regularly and the repair and replacement costs are likely to increase as well. Increasing numbers of defects at the latter stages of the structure's serviceable life will require more regular dewatering and shutdown periods reducing the functionality for users.

The increases in maintenance activities required and subsequent costs over time and their regularity have been estimated and shown in schedule Sch-J15034-3. The accuracy of estimations further into the future reduces as the defect behavior of the structure, particularly the concrete, has unknowns in both what type of remedial maintenance is required as well as over how much physical area. This variance in estimate confidence is shown in schedule Sch-J15034-3 with the shading demarcating the relative confidence in the estimates provided. Further inspection and condition assessments would be required in the future to determine the specific repairs required and to what areas. Beyond the timeframe shown on the schedule the maintenance costs could be expected to escalate much further unless the structure was left to fail or be replaced.

Towards the latter stages of the structure's life BMT JFA recommend a detailed condition assessment be undertaken to evaluate the structure in this critical stage. The recommended assessment would investigate whole of life costing and identify; where repairs are required for safety and functionality; and, where defects are benign and may be left until the structure is replaced. Such an evaluation would allow targeted repairs to be planned and undertaken to continue operability of the structure and offer savings where repairs are not required. Schedule Sch-J15034-3 has an estimate for this assessment in 2030 to inform the anticipated final 10 years of the structures service life.

The previous long-term maintenance plan adopted by MBRC included allowance for the replacement of the lock and weir in 2035. Using the recommended strategy, undertaking the maintenance actions in accordance with schedules Sch-J15034-2 & 3 and outlined in Section 7 of this report, it is estimated that the replacement could be delayed until 2041.

7 MAINTENANCE ACTIONS

7.1 Introduction

BMT JFA have provided a breakdown of maintenance tasks based on the strategy required to ensure that the structure will remain in a functional condition for 20-25 years. This remaining useful life is in line with the assumed 50 year design life of the structure. The maintenance tasks that are necessary to ensure this operational life, including their priority, and timeframes in which they should be undertaken, have been identified in Sch-J15034-2 (refer to Appendix A).

The maintenance regime currently in place has ensured the structure remains in good to average condition after 31 years. As the structure reaches the latter stage of its design life the maintenance requirements are increased, and to enable life extension pro-active measures are required. These proactive measures include measures to counteract the low concrete cover found on many of the structure's faces and high quality repainting of the steel gates.

This strategy is shown in schedule Sch-J15034-3 which includes cost estimates for;

- Continuing the existing level of maintenance
- Repair of the defects identified during this condition assessment
- Proactive maintenance activities to susceptible areas in the splash zone (eg application of silane/paint to lock external and internal walls)
- Periodic inspection and assessment of the structure to identify any new defects and changes to critical defects and recommend required repairs
- Future maintenance and repair activities expected to be required as the structure ages (the amount of repairs has been estimated based on BMT JFA's experience of working with similar structures over the whole of life).

Each estimated defect repair and maintenance cost has been calculated based on BMT JFA's archive of recent wharf maintenance and repair projects. As necessary, liaison with suppliers of specialist products has been undertaken to achieve greater accuracy for non-standard repairs and maintenance tasks. This schedule also allows for further repairs in the future, which are expected to be necessary, and includes allowances for general maintenance based on MBRC advised costs and mechanical component replacement works which are likely to be necessary over the remaining expected life of 20-25 years.

For the 25 year period included in schedule Sch-J15034-3 the total estimated maintenance cost is approximately $1.8m (at 2016 costs) with an associated uncertainty range of -10% and +20% (approximately $1.7m to $2.2m).

A summary of recommended maintenance for the concrete, steel and ancillary elements is provided in the following section.

7.2 Concrete Repairs

7.2.1 General

The cover has been identified as low in the majority of locations and air bubbles have been identified throughout the concrete structure. As the structure ages the low cover areas are increasingly susceptible to damage, as has already occurred in the SE gate recess. Measures to prevent further defects of this nature are required to increase the life of the structure and limit the extent to which further reactive maintenance is required.

Lock Internal Walls

The following measures should be applied to the areas 0.5m below LAT and above, as described below:

- Removal of all growth
- Preparation of surface (to manufacturer recommendations)
- Application of primer filler (to fill all air bubbles)
- Application of two coats of epoxy concrete protective paint (Sikaguard 62 or approved equivalent).

Concrete Surfaces External to Lock (Including Weir)

The following measures should be applied to the areas from LAT and above, as described below:

- Removal of all growth
- Preparation of surface (to manufacturer recommendations)
- Application of two coats of penetrating silane (thixotropic gel/cream) (Sikagard 706T or approved equivalent).

7.2.2 Spalled Concrete and Very Low Cover Areas

Repair of these areas is critical to the longevity of the structure and prevention of further deleterious action to the steel reinforcement. The repair process should occur to the areas identified and 200mm around as described below:

- Removal of all growth
- Scabble back to 20mm behind reinforcement bars
- Clean and prepare reinforcement bars
- Install protective anode to reinforcement bars (Sika Ferrogard 510 or approved equivalent)
- Clean and prepare concrete surface
- Apply grout repair mixture (Sika MonoTop 412 NFG or approved equivalent)
- Wet cure repair for seven days.

7.2.3 Cracked Concrete

A pressure injected crack repair grout should be used to repair all crack repairs identified in the maintenance schedule. The repair process should be undertaken as described below:

- Cracks to be prepared and be blown out with compressed air
- Injector flanges to be fixed to the surface of the crack and surface crack filled to seal according to manufacture instructions
- Inject Sikadur-52 resin (or approved equivalent) until the resin flow is visible
- Fully cure and level surface of concrete.

7.3 Steel Repairs

The immediate maintenance requirements for the steel gates were being undertaken during the inspection. In the affected areas of the gates, in the splash zone, the corrosion product was being ground out and it is understood the steel was to be recoated. To prevent this becoming a requirement every time the lock is dewatered the gates should be blasted and recoated to a high standard in accordance with AS2312 for category E conditions (marine splash zone), this would give a coating system design life of 10-15 years. The recoating process (which would be best achieved in a controlled environment) would be undertaken as described:

- Remove all growth
- Blast all steel surface to SA2.5
- Apply primer coat immediately following blast preparation
- Apply Interzone 954 (or approved equivalent) in coat thickness(s) in accordance with AS2312 and manufacturers specifications.

The majority of the gates' cathodic protection anodes had expired completely and should be replaced at the first available opportunity in accordance with original construction specification (it is understood anodes were replaced following inspection).

7.4 Repairs to Ancillary Elements

7.4.1 Fenders and Ladders

All safety critical fender and ladder defects identified in Section 4.4.1 should be checked and rectified as soon as possible.

The fender lower connections on the north and south lock walls should be replaced during the next scheduled lock dewatering.

7.4.2 Topping slabs and associated appurtenances (hand railing and fences)

All safety critical defects that affect cleats or could result in falling debris should be rectified as soon as possible.

To ensure the fencing remains in place the fencing connections should be checked and topping repaired. To prevent future failure of the fencing connections replacement of the deck topping and suitable reinforcement detailing may be required. If the structure lasts, as expected, for a further 20-25 years this is a good investment to prevent the possibility of members of the public accessing the dangerous lock area. Replacement of the fencing and hand rail members that have suffered deterioration for both lock and weir during such an overhaul would also be prudent.

8 LOCK AND WEIR REPLACEMENT CONCEPT DESIGN

8.1 Introduction

The existing lock system is functional, appropriate and likely to surpass its design life. Similar lock designs are being constructed in Queensland currently. It is proposed that the replacement system constitute a direct replacement, subject to minor adjustments to cater for current design standards and durability approaches. This section focuses on the construction staging of the replacement structure.

One of the requirements outlined by MBRC is to maintain access into the waterway throughout the construction and demolition works (as far as practicable). This will enable the residents to keep using the lock and canal while the new lock is being constructed.

8.2 Concept design

To enable the continued access to the canal, the proposed approach is to construct the replacement lock on the opposite (southern) side of the lake entrance while the existing lock (on the north side of the entrance) remains functional. It will also be important to keep the weir open to allow the canal to fill at high tide and drain in the event of a storm.

The proposed concept is to construct the new lock on the opposite bank through a section of the park area. To ensure access can be gained to the lock past the moorings on the south side of the canal it will be necessary to construct part of the lock across one section of the weir. To ensure that there is capacity within the weir to cope with any flood conditions, a hydraulic study should be undertaken to ensure there is capacity within the remaining two sections of the weir. If there is an issue with drainage for storm conditions, additional capacity should be considered as temporary measure until the new section of weir has been constructed where the old lock was. The suggested solution to this would be an overflow pipe south of the new lock which can be temporary until the new section of weir is constructed; or, if a tidal flap valve is fitted, it could be left in place.

The lock replacement procedure is proposed in four stages as shown on drawing J15034-01-01 (Refer Appendix C). The stages shown on the drawing are as follows:

- Stage 1 – Install temporary flood bypass pipe (if found necessary from fluvial studies). Form piled cofferdam around the new lock position partly on the southern bank park area and southern weir section. Demolish and remove the existing weir section. The new lock structure can then be constructed within the cofferdam. Once the new lock is complete, the cofferdam can be removed and the new lock can be put into service.
- Stage 2 – Construct cofferdam around the old lock structure. Once in place, the structure can be demolished. While the cofferdam is still in place the new weir section can be constructed within the cofferdam.
- Stage 3 – Remove cofferdam around old lock structure. Construct cofferdam around remaining old weir section. Demolish old weir and construct new weir section.
- Stage 4 – Remove cofferdam and expose the new weir section to the tidal flows. Remove or decommission temporary flood overflow pipe.

8.3 Cost estimate for New Lock and Weir Construction

A representative cost purely for the new lock construction has been obtained from a contractor currently constructing a near identical lock on the Gold Coast. The cost estimate includes all temporary works, civil and structural works, new lock gates, electrical fit-out and commissioning. Additional cost has been added to the estimate for the temporary overflow, demolition of the old lock and constructing a new section of weir. An uncertainty range of -10% and +20% has been applied to the cost estimate to allow for market pricing variance and construction risk.

The cost estimate is based on 2016 rates and is shown in Table 8-1. No net present value allowance has been made.

Table 8-1: Bribie Gardens Lock and Weir Replacement – Cost Estimate

Item	Description	Estimated Cost *
Construct New Lock	The construction costs for a new lock has been obtained from a contractor currently building a lock in the northern part of the Gold Coast. The cost includes all temporary works including the construction of a cofferdam to build the lock in. The cost is also inclusive of all concrete works, new gates, electrical fit-out and commissioning.	$5,000,000 *($4,500,000 to $6,000,000)*
Temporary Overflow Pipe	Allowance for the construction of a temporary overflow pipe (should it be required for flood alleviation).	$50,000 *($45,000 to $60,000)*
Demolish Old Lock and Weir	This is an estimated cost and includes for the construction of a cofferdam to enable work to proceed.	$1,000,000 *($900,000 to $1,200,000)*
Construct New Weir	Once the lock is demolished new sections of weir can be constructed before the overflow pipe is removed.	$500,000 *($450,000 to $600,000)*
Total Estimated Cost (at 2016 rates)		**$6,550,000** (***$5,900,000*** *to* ***$7,900,000)***

* Uncertainty range in brackets

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The 31 year old lock and weir structure is in an average to good condition. The key areas to note regarding the structure's current condition are:

- The concrete structural elements generally have low cover increasing susceptibility to defects, particularly in the splash zone, where localised defects have already occurred such as spalling, cracking and impact damage.
- The steel gates are constructed of thin walled sections and corrosion has been initiated in the splash zone albeit with no identifiable loss of section at the present time.
- A number of small defect repairs are required in the short term.

The structure's remaining life is expected to be of the order 20-25 years based on the recommended (and best practice) maintenance regime. The residual life of the structure could be appreciably less if targeted proactive maintenance is not undertaken on vulnerable areas of the structure. Over a remaining life of 25 years the total estimated maintenance costs, based on the recommended maintenance regime, are expected to be between $1.7m and $2.2m at 2016 market prices.

The estimated cost of a replacement lock and weir structure is expected to be between $5.9m and $7.9m at 2016 rates.

9.2 Recommendations

The following recommendations are made to ensure that the structure meets, and potentially surpasses, the remaining 19 years of its assumed design life:

Undertake a proactive maintenance strategy of repairing current defects and application of treatments to the most vulnerable elements to extend the life of the structure. The immediate safety critical actions required are:

- All safety critical handrail support, fender, ladder and mooring cleat defects should be rectified as soon as possible.

The recommended maintenance strategy actions required are:

- The concrete cracking, spalling, no cover and impact damage defects identified should be rectified in the short term
- The steel corrosion and anode defects should be rectified in the short term
- All concrete structural elements in the splash zone should be protected with waterproofing products in the short term to help redress the low cover identified across the structure
- All steel gate elements should be blasted and painted in the short to medium term to prevent section loss occurring to the thin walled hollow and open steel sections
- An overhaul of the lock island and north lock deck slabs should be undertaken replacing the concrete topping with a durable surfacing product and replacement of all associated hand railing, fencing and other appurtenances

- Inspection and condition assessment at four yearly intervals to identify any new or worsening defects and preparation of updated maintenance schedules.

APPENDIX A:
INSPECTION AND MAINTENANCE SCHEDULES

Authority	Moreton Bay Regional Council				Document No.		Sch-J15034-1							Page	1	
Structure	Bribie Gardens Lock				Asset Manager		Tarik Ibrahim / Peter Marsh									
Inspection Date	20/01/2016				Summary Comments		Generally average to good condition with limited deterioration									
Inspector Name(s)	Justin Fifield, Zac Couper				Recommendations		See - Bribie Gardens Lock and Weir Residual Life Assessment Report - R-J15034-1									
			Visual Condition Rating (est.% affected)													
Component Description	Material	Cover (mm)	1	2	3	4	5	6	7	Mntnce Rating	Photo Nos.	Comments/Observations		Criticality	Actions	Safety Issue (Y/N)
Northeast Gate	Steel			90		8	2			B	161,162, 165, 166, 168, 170, 172, 192, 195, 196, 199, 233-241, 310, 311	Corrosion visible on areas around tidal zone especially behind seal plates, no significant loss of section from UT test - ED. Negative MPI. Sacrificial anodes 3 inside face 90-100% expended, outer face 100% expended. Growth present below water level.		L (Repaint) M (Anodes) M	Remove corrosion deposits and repaint & replace anodes	N
Southeast Gate	Steel			90		8	2			C	163, 166, 167, 169, 171, 197, 198, 200-203, 209-221, 312, 313, 317	Corrosion visible on areas around tidal zone especially behind seal plates, no significant loss of section from UT test - ED. grease stain at top of gate pintle. Sacrificial anodes 3 inside face 90-100% expended, outer face 100% expended. Growth present below water level. Gate to recess wall vertical seal unbolted and potentially damaged at top - MD.		L (Repaint) M (Anodes) M	Remove corrosion deposits and repaint & replace anodes	N
Southwest Gate	Steel			92		6	2			B	173, 174, 175, 177-180, 245-251, 262-267, 269-272,274-281, 308	Corrosion visible on areas around tidal zone especially behind seal plates, no significant loss of section from UT test - ED. Negative MPI. All sacrificial anodes 100% expended. Growth present below water level.		L (Repaint) M (Anodes) M	Remove corrosion deposits and repaint & replace anodes	N
Northwest Gate	Steel			92		6	2			B	181-183, 187, 273, 282-296, 302, 303, 307, 318-320	Corrosion visible on areas around tidal zone especially behind seal plates, no significant loss of section from UT test - ED. Negative MPI. Outer upper diagonal has blistered corrosion area mid length. All sacrificial anodes 100% expended. Growth present below water level.		L (Repaint) M (Anodes) M	Remove corrosion deposits and repaint & replace anodes	N
Northeast Gate Recess	Concrete	Top 65, Mid height 55, Lower east 40, lower north 63, lower west 40			98	2				B	164, 189-191, 222-230	Air bubbles on painted inside surface, poor compaction area top of west wall and areas of low cover - CD. Two rust spots located SE where gate seals approx. 1.5m from floor		L (Repaint) M	Continue to undertake painting as part of maintenance to counter low cover of concrete	N
Southeast Gate Recess	Concrete	Mid 63, lower east 48, lower south 61, lower west 53			88	12				C	171, 193, 204-208,	Inner north-eastern corner top 100mm section removed under post - MD, Inner south western corner (north face) top spall repair is delaminating - ED (T. Ibrahim identified that there was low cover and spall was repaired). Repaired crack on top slab near gate pintle - ED. Air bubbles on painted inside surface and low cover - CD. Outside wall, poor compaction at outer east - ED and leakage through lock island wall outer south face(see weir condition assessment)		L (Repaint) M (Spall) M	Repair spalling. Continue to undertake painting as part of maintenance to counter low cover of concrete. Repair to exposed reinforcement area include anode.	Y-Spall under post N - other defects
Southwest Gate Recess	Concrete	lower east 70, lower south 51, lower west 25, lower west p 50			92	8				C	174, 176, 252-261, 268, 314-316	Air bubbles on painted inside surface, poor compaction area top of west wall - CD. Two rust spots located at poor compaction location indicating low/zero cover - CD/ED. Cracking to cantilever slab soffit mostly <0.3mm some 0.3-0.5mm (314-316). Horizontal crack at top north of gate hinge <0.3mm (174) - ED. Outside wall, no defects noted.		L (Repaint) M	Continue to undertake painting as part of maintenance to counter low cover of concrete. Repair cantilever slab cracks	N
Northwest Gate Recess	Concrete	top west p 33, top west 70, top north 50, top east 70, lower west p 29 lower west 28 lower north 55 lower east 64			95	5				B	298-300, 304, 325	Air bubbles on painted inside surface, areas of low cover identified - CD. Rust spots at top of west wall (east face), potential exposed reinforcement in one location -CD/ED.		L (Repaint) M (Low cover) M	Continue to undertake painting as part of maintenance to counter low cover of concrete. Repair to exposed reinforcement area include anode.	N
North Wall	Concrete	lower east 75, lower middle 59, lower west 55, lower west corner 32			98	2				B	242, 244, 297, 305	Air bubbles on painted inside surface and low cover identified in some areas - CD. Fenders missing bottom connections - ED.		L (Repaint) M	Continue to undertake painting as part of maintenance to counter low cover.	N
South Wall	Concrete	lower east 72, lower middle 75, lower west 72			95	5				B	184, 188. 243, 306, 309, 321-324	Air bubbles on painted inside surface and low cover - CD. Leakage mark top east end - ED. Fenders missing bottom connections at lower end - ED.		L (Repaint) M	Continue to undertake painting as part of maintenance to counter low cover.	N
Lock Island Slab	Concrete				80	15	5			C	176, 184, 188, 321-324	Cracking particularly at edges and vegetation in voids created likely >0.5mm - ED		L	Repair cracks	N
Slab - North of Lock	Concrete				80	18	2			B	176, 185, 186,	Cracking to slab top 0.3-0.5mm in some areas, Some >0.5mm west of lock - ED.		L	Repair cracks	N
Hand railing (Perimeter)	Steel			70	30					C	321-324	Galvanising starting to deteriorate, localised rust staining widespread - ED. Wire mesh panelling coming loose in places - MD.		L	Repair panelling mesh	N
Lock gate walkway including hand railing	Steel			98	2					B	160-164, 324	Localised paint loss and corrosion to hand railing (southeast and northwest gates) - ED		L	Remove corrosion deposits and repaint	N
Ladders	Stainless Steel			80				20		C	242, 244, 297, 305	Stainless steel fender wires cause minor obstruction to ladder use. SE exterior ladder appears to be missing connection		H	Remove obstruction from ladders + check all connections	Y
Mooring Cleats	Stainless Steel (Assumed)						100			D	184, 188	Mooring cleats bolted into topping slab near edge, cracking is present		M	Provide alternative fixings if moorings are required, however, cleats appear unused.	Y

Note:

1 The maintenance rating has been recorded in accordance with WSCAM (Figure 2-3 in Bribie Gardens Lock and Weir Residual Life Assessment Report - R-J15034-1)
2 The cataloguing of photo numbers refers to the final 3 digits of the files provided to MBRC
3 Comments/Observations column - CD = construction related defect
ED = Exposure environment-related defects

Authority	Moreton Bay Regional Council		Document No.	Sch-J15034-1	Page	2
Structure	Bribie Gardens Weir		Asset Manager	Tarik Ibrahim / Peter Marsh		
Inspection Date	20/01/2016		Summary Comments	Generally average to good condition with limited deterioration		
Inspector Name(s)	Justin Fifield, Zac Couper		Recommendations	See - Bribie Gardens Lock and Weir Residual Life Assessment Report - R-J15034-1		

Component Description	Material	Cover (mm)	Visual Condition Rating (est.% affected) 1	2	3	4	5	6	7	Mntnce Rating	Photo Nos.	Comments/Observations	Criticality	Actions	Safety Issue (Y/N)
Walkway deck	Concrete	North 60, Middle 60, South 45			90	10				B	326, 327, 335	The deck has isolated transverse cracking adjacent to weir wall supports generally <0.3mm but locally 0.3-0.5mm width - ED	Low	Monitor progression of cracking, repair	N
Walkway soffit	Concrete									-		*Not accessed*	Low		N
Lock Island Wall East	Concrete				85	10	5			B	330, 331, 333, 334	Lock island topping slab in some sections has cracked and spalled - ED. Heavy residue from leakage through wall adjacent to east end of lock - ED.	Low	Repair spalled and delaminating sections	N
Lock Island Wall West	Concrete				87	10	3			B	332	Lock island topping slab in some sections has cracked and is delaminating in places - ED	Low	Repair spalled and delaminating sections	N
N Weir Wall (East)	Concrete	north face 80			90	10				B	342, 343, 348	One long fine horizontal circumferential crack visible <0.3mm - ED. minor impact damage in one location - MD	Low	Local concrete repair	N
N Weir Wall (West)	Concrete	south face 75			95	5				B	337, 338, 339	Localised fine cracking <0.3mm - ED	Low	Monitor cracking, repair if widens	N
S Weir Wall (East)	Concrete				95		5			B	346, 347	Chipped concrete from impact - MD	Low	Local concrete repair	N
S Weir Wall (West)	Concrete				95	5				B	337, 344	Localised fine cracking <0.3mm - ED	Low	Monitor cracking, repair if widens	N
South Waterway Wall East	Concrete	by walkway - 50			100					B	329	Air bubbles in concrete face - CD	Low		N
South Waterway Wall West	Concrete	west 60, middle 60, east (by walkway) 60			80		20			B	328, 340, 341	Cracking in concrete some areas have been repaired previously - ED, Air bubbles in concrete face -CD	Low	Monitor progression of cracking, repair again if cracking widens	N
Handrail	Steel			80		20				B	337	Galvanising starting to deteriorate, localised rust staining widespread - ED	Low		N
Weir Grates	Steel			100						B	337	Limited debris caught in grates, limited indication of corrosion in splash zone	Low		N

Note:

1 The maintenance rating has been recorded in accordance with WSCAM (Figure 2-3 in Bribie Gardens Lock and Weir Residual Life Assessment Report - R-J15034-1)
2 The cataloguing of photo numbers refers to the final 3 digits of the files provided to MBRC
3 Comments/Observations column - CD = construction related defect
ED = Exposure environment-related defects
MD = Mechanical or impact related defect
4 The criticality of identified defects has been recorded as high (H) medium (M) or low (L)
5 Weir Wall refers to the flow separating walls between each of the 3 weirs

	Sch-J15034-2		**Moreton Bay Regional Council**			
			BMT JFA CONSULTANTS	**Job No.**	**J15034**	
			Lock and Weir Maintenance Programme	**Date**	**12/08/2016**	
	Revision	1		By	JF	

							2016			2017				2018				2019			
							Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Category	**Item**	**Condition**	**Activity**	**Report Ref**	**Priority**																
				R-J15034-1																	
Lock and Weir Entire Structure																					
	Inspection and Testing	-	Inspection		1	2-4 Years															
		-	Further testing (carbonation)		1	2-4 Years															
Lock																					
	Internal lock walls above low water	3/4	Clean and prepare walls, fill air pockets with filler, paint with two coats of epoxy paint		2	24 Months															
Lock - concrete Structure																					
	North Inner Wall	3/4	Repair/replace fenders and connections (adjust cables to allow ladders to be used safely)		2	24 Months															
	South Inner Wall	3/4	Repair/replace fenders and connections (adjust cables to allow ladders to be used safely)		2	24 Months															
	Northeast Gate Recess	3/4	Repair areas with no cover W wall		2	24 Months															
	Southeast Gate Recess	3/4	Repair spall NE cnr hand rail post with repair grout		5	Immediate															
		3/4	Repair spall inner S wall at west corner (N face) with repair grout		2	24 Months															
	Northwest Gate Recess	3/4	Repair areas with no cover and exposed reinforcement		2	24 Months															
	Southwest Gate Recess	3/4	Repair areas with no cover W wall (nr top gate hinge)		2	24 Months															
		3/4	Repair cracking to cantilever slab soffit and north end nr top hinge		4	6 Months															
	Outer Lock Island Wall (SW and SE)	3/4	Prepare and apply penetrating silane to all areas above low water		2	24 Months															
	Lock Island Slab	3-5	Repair/replace topping slab install new deck furniture (cleats etc.)		1	2-4 Years															
	Slab North of Lock	3-5	Repair/replace topping slab		1	2-4 Years															
Lock Gates - Steel																					
	All Gates	7	Replace anodes		5	Immediate															
	Northeast Gate	4/5	Blast and repaint in accordance with AS 2312 category E		2	24 Months															
	Southeast Gate	4/5	Blast and repaint in accordance with AS 2312 category E		2	24 Months															
		5	Vertical outer seal unbolted and damaged at top end		4	6 Months															
	Northwest Gate	4/5	Blast and repaint in accordance with AS 2312 category E		2	24 Months															
	Southwest Gate	4/5	Blast and repaint in accordance with AS 2312 category E		2	24 Months															
	Gate walkway handrails (All)	2	Grind back corrosion and touch up paint system and general repairs		1	2-4 Years															
Lock and Lock Island Appurtenances																					
	Perimeter Hand railing	3	Inspect hold down connections, replace infill		3	12 Months															
	Perimeter Fencing	3	Inspect hold down connections		3	12 Months															
	Lock Internal Ladders	3	Stop-end stainless steel wires so ladders are not obstructed		3	12 Months															
	Lock External Ladders	6	Check lower connections of ladders		5	Immediate															
	Mooring Cleats	5	Decommission or replace cleats with effective fixings		5	Immediate															
Weir Concrete																					
	All Concrete	3	Prepare and apply penetrating silane to all areas above low water		2	24 Months															
	Walkway Deck and Soffit	3	Repair cracking - injection grouting		2	24 Months															
	Weir walls	4	Repair impact damage		3	12 Months															
Weir Appurtenances																					
	Hand rails (public area)	3	Replace corroded sections		1	2-4 Years															

	Sch-J15034-3		Moreton Bay Regional Council			
			BMT JFA CONSULTANTS	Job No.	J15034	
			Lock and Weir Maintenance Cost Estimate Schedule	Date	11/04/2016	
	Revision	0		By	JF	

No. Units	Item	Condition	Activity	Report Ref	Priority		2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	Total
				R-J15034-1																																	
Lock and Weir Entire Structure																																				-
	Inspection and Testing	-	Regular Inspection		1	2-4 Years								$30,000				$30,000				$30,000				$100,000				$30,000				$30,000				250,000
Lock																																				-
	Internal lock walls splash zone	3/4	Clean and prepare walls, fill air pockets with filler, epoxy paint two coats		2	24 Months								$27,000																								27,000
Lock - concrete Structure																																				-
	North Inner Wall	3/4	Repair/replace fenders and connections (adjust cables to allow ladder use)		2	24 Months								$6,000								$6,000								$6,000				$18,000		$25,000		61,000
	South Inner Wall	3/4	Repair/replace fenders and connections		2	24 Months								$5,000								$5,000								$5,000				$15,000		$20,000		50,000
	Northeast Gate Recess	3/4	Repair area with no cover W wall		2	24 Months								$2,000								$2,000								$2,000				$8,000		$15,000		29,000
	Southeast Gate Recess	3/4	Repair spalls NE cnr hand rail post with repair grout		5	Immediate	$1,500															$3,000								$3,000				$10,000		$18,000		35,500
		3/4	Repair spall inner S wall at west corner (N face) with repair grout		2	24 Months								$2,000								$1,500								$4,500				$5,000		$10,000		23,000
	Northwest Gate Recess	3/4	Repair area with no cover and exposed reinforcement		2	24 Months								$3,000								$3,000								$6,000				$10,000		$15,000		37,000
	Southwest Gate Recess	3/4	Repair area with no cover W wall (nr top gate hinge)		2	24 Months								$3,000								$3,000								$6,000				$18,000		$25,000		55,000
		3/4	Repair cracking to cantilever slab soffit and north end nr top hinge		4	6 Months		$2,000														$2,000								$6,000				$25,000		$30,000		65,000
	Outer Lock Island Wall (SW and SE)	3/4	Prepare and apply penetrating silane to all areas above low water		2	24 Months								$5,000																								5,000
	Lock Island Slab	3-5	Repair/replace topping slab install new deck furniture (cleats)		1	2-4 Years										$30,000																						30,000
	Slab North of Lock	3-5	Repair/replace topping slab install new deck furniture (cleats)		1	2-4 Years										$20,000																						20,000
																																				-
																																				-
Lock Gates - Steel																																				-
	All Gates	7	Replace anodes (Undertaken January 2016 - T, Ibrahim)		5	Immediate	$4,400																															4,400
	Northeast Gate	4/5	Blast and repaint (AS 2312 category E) / 4 yearly paint touch up		2	24 Months								$20,000				$800				$800				$20,000				$800				$800				43,200
	Southeast Gate	4/5	Blast and repaint (AS 2312 category E) / 4 yearly paint touch up		2	24 Months								$20,000				$800				$800				$20,000				$800				$800				43,200
		5	Vertical outer seal unbolted and damaged at top end (Replace all seals)		4	6 Months		$7,500																														7,500
	Northwest Gate	4/5	Blast and repaint (AS 2312 category E) / 4 yearly paint touch up		2	24 Months								$20,000				$800				$800				$20,000				$800				$800				43,200
	Southwest Gate	4/5	Blast and repaint (AS 2312 category E) / 4 yearly paint touch up		2	24 Months								$20,000				$800				$800				$20,000				$800				$800				43,200
	Gate walkway handrails (All)	2	Grind back corrosion and touch up paint system and general repairs		1	2-4 Years								$12,000																								12,000
																																				-
Lock and Lock Island Appurtenances																																				-
																																				-
	Perimeter Hand railing	3	Inspect hold down connections, replace infill + future replacement		3	12 Months				$2,500							$36,000																					38,500
	Perimeter Fencing	3	Inspect hold down connections + future replacement		3	12 Months				$2,500							$35,000																					37,500
	Lock Internal Ladders	3	Stop-end stainless steel wires so ladders are not obstructed		3	12 Months	$400																															400
	Lock External Ladders	6	Check lower connections of ladders		5	Immediate	$200																															200
	Mooring Cleats	5	Decommission or replace cleats with effective fixings		5	Immediate	$2,000																															2,000
																																				-
Weir Concrete																																				-
	All Concrete	3	Prepare and apply penetrating silane to all areas above low water		2	24 Months								$10,000										$10,000						$10,000				$30,000		$40,000		100,000
	Walkway Deck and Soffit	3	Repair cracking - injection grouting		2	24 Months								$1,500										$1,500						$5,000				$15,000		$20,000		43,000
	Weir walls	4	Repair impact damage		3	12 Months								$1,500										$1,500						$5,000				$15,000		$20,000		43,000
																																				-
Weir Appurtenances																																				-
	Hand rails (public area)	3	Replace corroded sections		1	2-4 Years										$12,000																						12,000
																																				-
General																																				-
	Gates		Periodic Replacement of Mechanicals															$64,500								$64,500				$64,500				$64,500				258,000
	Gen. Annual Mntnce (Averaged)		Replace gate edge seals		As Required									$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	75,000
	Gen. Annual Mntnce (Averaged)		Electrical repairs		As Required				$3,000					$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	78,000
	Gen. Annual Mntnce (Averaged)		Repairs and callouts related to the PLC		As Required				$2,000					$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	52,000
	Gen. Annual Mntnce (Averaged)		Fence Repairs		As Required				$300					$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	7,800
	Gen. Annual Mntnce (Averaged)		Card Reader System		As Required				$500					$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	13,000
	Gen. Annual Mntnce (Averaged)		MBRC staff callouts		As Required				$2,000					$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	52,000
	General Maintenance		Lock Dewatering		As Required									$20,000				$20,000				$20,000				$20,000				$20,000				$20,000				140,000
						Total	$ 8,500	$ 9,500	$ 7,800	$ 5,000	$ -	$ -	$ -	$ 10,800	$ 218,800	$ 10,800	$ 72,800	$ 81,800	$ 128,500	$ 10,800	$ 10,800	$ 10,800	$ 89,500	$ 10,800	$ 23,800	$ 10,800	$ 275,300	$ 10,800	$ 10,800	$ 10,800	$ 187,000	$ 10,800	$ 10,800	$ 10,800	$ 297,500	$ 10,800	$ 268,800	$ 10,800	1,836,600

Maintenance Estimate Confidence: MODERATE | VERY LOW | ORDER OF MAGNITUDE

Note:
1 Allowance has been included for expense of dewatering of the lock at 4 yearly intervals for maintenance activities that require this to be undertaken
2 Where costs for specific repairs are repeated this is an allowance for repair of similar or other defects occurring in the future to this element
3 Maintenance estimate confidence reduces over time as indicated by High, Medium and Low shading. These brackets correspond with LTMP confidence descriptions

Moderate	Scope moderately clear, estimate based on mix of quotes & prices from similar jobs.
Very Low	Vague / uncertain scope, prices factored from other similar (not identical) projects.
Order of Magnitude	Based on the best guess of experienced employees or similar methods.

APPENDIX B:
AUSTEST NON DESTRUCTIVE EXAMINATION REPORT

AUSTEST NDT PTY LTD
P.O. Box 9120
Wynnum Plaza Qld
Australia 4178
Ph: + 61 7 3348 2562
Mob: 0408 968 854
Email: austest1@bigpond.com

ABN: 23 107 908 074
ACN: 107 908 074

REPORT

THE
NON DESTRUCTIVE EXAMINATION OF NOMINATED BRIBIE GARDENS LOCH GATE STRUCTURE
AT
BRIBIE ISLAND

23rd January 2016

Technician:	Dr. Bob Boardman PhD Structural / Mech Eng Hons, MIEAust, MIDiagE, IWS, P ENG MSPE Technical Director NDT Level III
Report Filename:	z3638 bribie is canal maintenance.doc
Site Contact:	Justin Fifield
Job Number:	3638
Order Number:	Refer J15034-002
Job Identification:	Bribie Gardens Loch and weir Bribie Islane
Procedure Reference:	NDT026, NDT 031 & NDT035
Work sheet reference:	1907
Date/s; period:	20th January 2016
Test Location:	Bribie Island
Client Contact:	Mr Justin Fifield
Phone:	+ 61 (8) 6163 4900
Fax:	+ 61 (8) 6163 4979
E-mail:	
Address:	level 3 20 Parkland Rd Osborne Park WA 6017
Report Distribution:	1 x email report to Mr Justin FiField

1 Technical Data

1.1 Visual Inspection

Test standard: AS3978

Austest Test Procedure:	NDT026 - Visual Examination
Identification & % examined:	Nominated butt weld to pile PW4A
Surface Preparation:	cleaned
Manufacture / surface history:	New fabrication
Viewing conditions	
Lighting:	Natural
Acceptance Standard:	AS1554.1 Cat SP

1.2 Magnetic Particle

Test Specification:	AS1171
Austest Test Procedure:	NDT035 - Magnetic Particle Examination of Ferromagnetic Components
Current Type:	A.C
Media:	Ardrox 800/3 Black Magnetic Ink, Batch # 424062 Ardrox White Lacquer Background, Batch # B/458243
Technique:	Magnetic flow - Sustained magnetisation
Identification of nominated test areas:	As nominated
Surface condition:	Satisfactory
Method of Magnetisation:	Magnetic flow
Surface preparation:	Sandblasted, degrease / Cleaned
Demagnetised:	Not applicable
Material Specification:	Carbon steel not further specified
Acceptance Standard:	To determine items of cracking

1.3 Ultrasonic Examination

Test specification:	AS2207			
Test Procedure:	NDT031 - Ultrasonic Examination of Fusion Butt Welds Join			
Probe 1:	Normal	4mhz	Serial#	17241
Probe 2:	MWB70º	4mhz	Serial#	22355
Probe 3:	MWB60º	4MHZ	Serial#	07902
Probe 4:	MWB45º	4mhz	Serial#	34716
Couplant:	Polycell			
Specific test method:	UMB Positions 1 & 2			
Sizing method:	6db			
Material Thickness:	A Max 0f 8mm			
Material Specification:	AS1163 Grade 300			
Manufacturing specification:	AS1554.1 Cat SP			
Identification of test area:	Nominated at lower sections of frame			
Compliance of surface condition:	AS2207 SP1			
Type of surface preparation:	Scraped			
Details of any repairs:	Nil repairs			
Details of retests:	Nil			
Acceptance standard:	AS1554.1 Cat SP			

2 Visual & Ultrasonic Examination

DESCRIPTION		INTERPRETATION		QUALITY
The visual, Magnetic Particle & Ultrasonic random examination of nominated pipe frame butt welds **Magnetic Particle examination** 1. East end - two sections of the gate frame were nominated – paint ground off and examined 2. West end -two sections of the gate frame were		No appreciable loss of material detected No recordable discontinuities were detected		Complies

nominated – paint ground off and examined		North end two sections of the gate frame were nominated – paint ground off and examined		
Ultrasonic Thickness examination				Complies
Ultrasonic thickness examination revealed no loss of parent metal to pipe members of the gate frame		No loss of parent metal was noticeable		Complies

Note General Visual examination to gates frames showed no visible loss of material. Some area showed some surface rusting / corrosion -These corrosion areas / rusting were ground back and examined

General examination of the structural components of the structural gate confirms there was some corrosion build up beneath the rubber seals. Recommend the rubber seals be removed and the rust corrosion be ground back and coated to stop any further action.

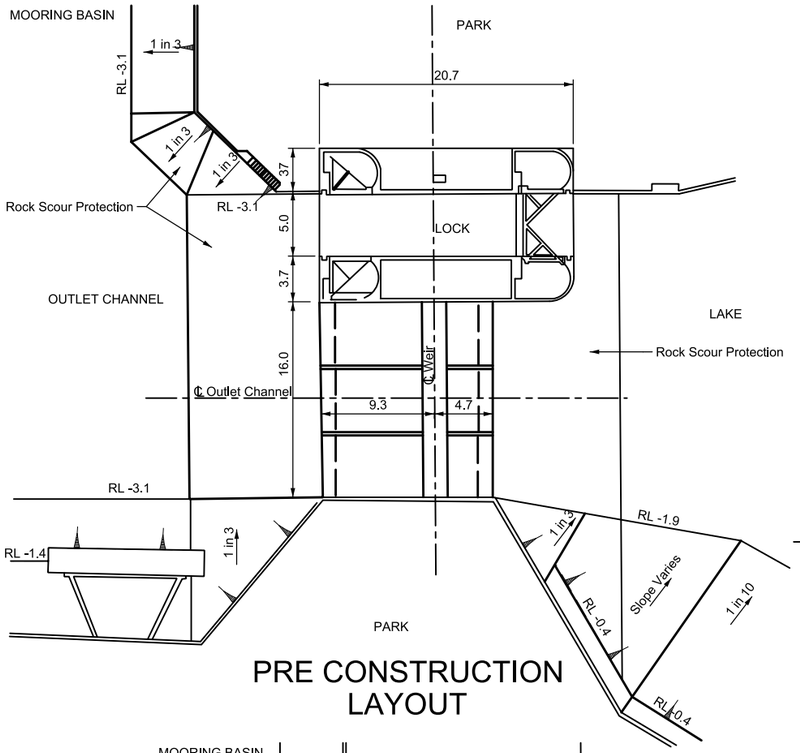
Signature

Dr. R.A. Boardman PhD Structural / Mech Eng (Hons), MIEAust, MIDiagE, AU/IWS 00120 P Eng UK MSPE

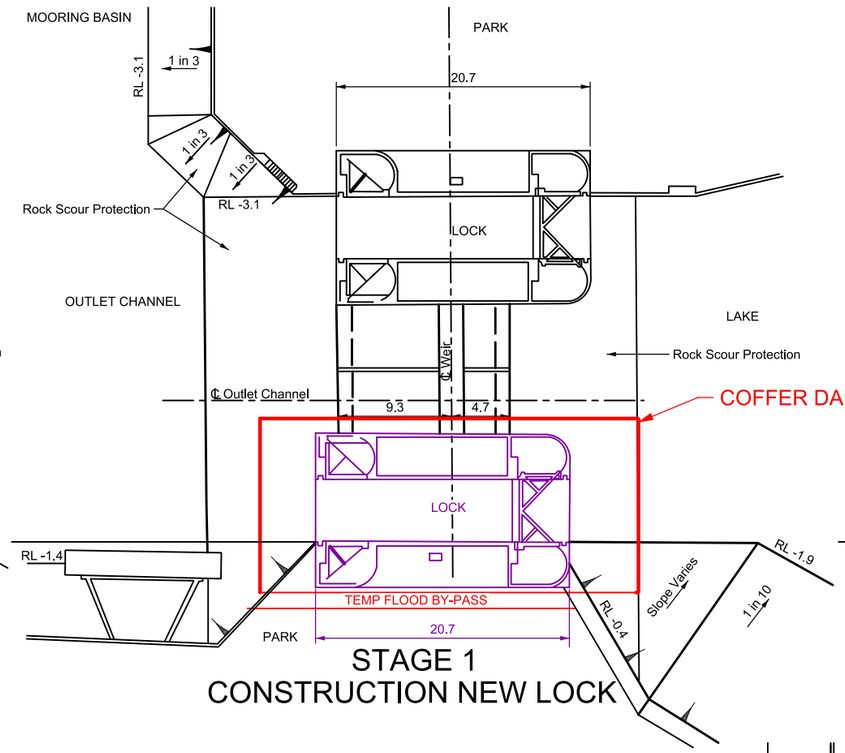
ENGINEERS AUSTRALIA Engineering Office MEMBER

This laboratory is registered in Queensland, Australia. The test(s) reported herein have been performed in accordance with the terms of Austest's registration. This document shall not be reproduced except in full.

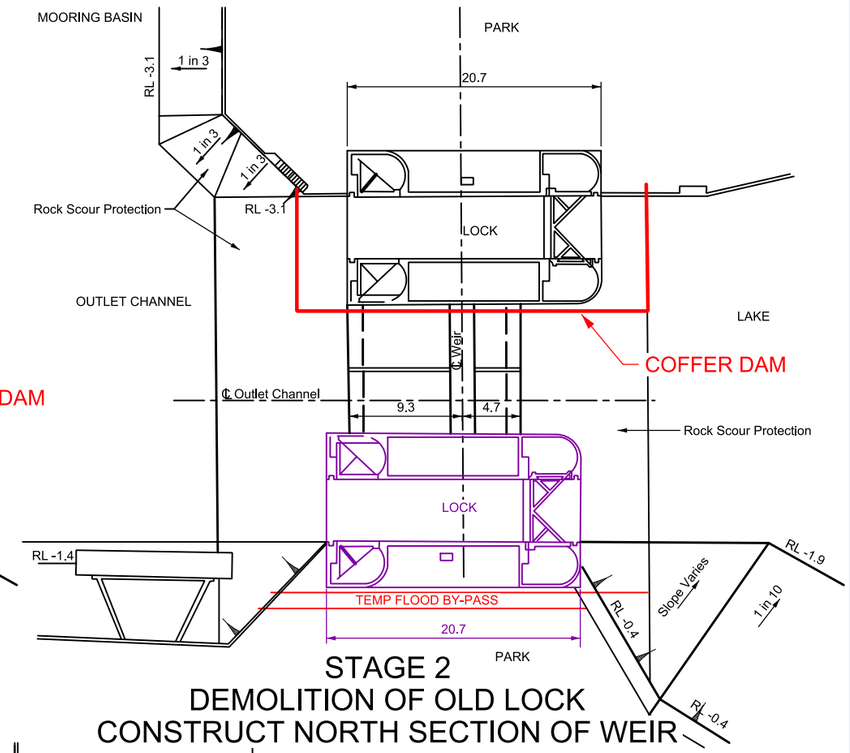
APPENDIX C:
NEW LOCK CONSTRUCTION SEQUENCE DRAWING



PRE CONSTRUCTION LAYOUT



STAGE 1
CONSTRUCTION NEW LOCK



STAGE 2
DEMOLITION OF OLD LOCK
CONSTRUCT NORTH SECTION OF WEIR

STAGE 3
DEMOLISH & REPLACE CENTRE SECTION OF WEIR

STAGE 4
OPEN FULL WIDTH OF WEIR

REV	DATE	AMENDMENT	DRN	APP
B	06/04/16	STAGE 4 ADDED		
A	15/03/16	INITIAL ISSUE	GKB	

ORIG SIZE A1 | ARCHIVE J15034-01-01A.DGN

NOTES
1. DATA FROM CARDNO & DAVIES PLAN 1338/7-41

SCALE 1 : 250
5 0 20
METRES

DATUM
VERTICAL AHD
HORIZONTAL NA

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ENGINEER	M.Chambers	15/03/2016
DRAWN	G.Bebbington	15/03/2016
DRAFTING CHECK		
ENGINEERING CHECK		
APPROVED PROJECT MGR		

CLIENT: MORETON BAY REGIONAL COUNCIL
PROJECT: BRIBIE GARDENS LOCK AND WEIR
TITLE: RESIDUAL LIFE ASSESSMENT
NEW LOCK CONSTRUCTION SEQUENCE
DRAWING NUMBER: J15034-01-01
REV: B

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