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R1819 Rev 0

July 2023

City of Mandurah

Birchley Road Boat Ramp Upgrade Design Report

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Limitations of this Document

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1. Introduction

The City of Mandurah (City) is proposing to replace the existing boat ramp located at the end of Birchley Road in the suburb of Coodanup, on the Serpentine River. The overall vision for the site is to retain the existing parking while replacing and upgrading the Boat Ramp and Jetty, and upgrading the riverine protection adjacent to the structure.

The location of the site is presented in Figures 1.1 and 1.2 below.

Figure 1.1 Site Location

Specialist coastal and marine engineers M P Rogers & Associates Pty Ltd (MRA) have been engaged by the City to design the upgrade, including:

- Single lane Boat Ramp.
- Floating Jetty and Concrete Abutment.
- Rock Revetments.

This report presents the inputs to the design and the standards, assumptions, conditions and methodologies that were used to complete the design of the works.

Figure 1.2 Boat Ramp Area

2. Site Conditions

2.1 Site Location

The project site extends approximately 50 m along the western bank of the Serpentine River, at the end of Birchley Road and approximately 2.9 km upstream from the confluence of the Peel Inlet. The Peel Inlet is hydraulically connected to the Indian Ocean and the site is therefore influenced by the meteorological and oceanographic (Metocean) drivers, as well as the riverine influences of the Serpentine.

2.2 Existing Conditions

MRA completed an inspection of the site on 5 May 2023, to assess the current site conditions. The following section briefly summarises the key observations from this inspection. Photographs of the site are shown in Figure 2.1.

The site currently consists of a single lane concrete boat ramp and an associated fixed timber jetty. The foreshore surrounding the boating infrastructure is partially protected by a timber palisade wall, which has failed in places. Adjacent to the fixed jetty is a launching and retrieval structure for canoeing / kayaking. Further along the foreshore in either direction are a number of private fixed timber jetties, which will need to be protected during the works. The closest of these private jetties dictate the extent of the works.

The foreshore is relatively flat and low lying, at approximately +0.6 mAHD. There is existing vegetation (sedges and trees) along the foreshore where the works is proposed. The existing trees and vegetation are to be protected where possible during construction.

Following the site inspection, discussions were held between the City and MRA regarding the treatment of the site, and the following was noted:

- The existing parking area is to be retained and does not form part of the scope of works. The upgraded boat ramp and jetty are to be tied into the existing road and car park levels.
- The following elements are to be removed / demolished on the Site:
  - Boat Ramp;
  - Timber jetty;
  - Canoe / kayak launching and retrieval structure;
  - Casuarina Tree (in front of the jetty); and
  - Timber palisade wall.
- The new Floating Jetty must provide universal access.

Figure 2.1 Site Photographs

The locality of the new Boat Ramp facility has been designed assuming that the Casuarina Tree located in front the existing fixed jetty will be removed. Removing the tree is seen to improve launching and retrieval operations of the facility, due to its location with respect to the Boat Ramp.

2.3 Survey

A survey of the site to allow design was completed by the City on 3 May 2023, and provided to MRA. The survey highlights the consistent grade along the foreshore of the Site. There also appears to be localised scouring at the end of the Boat Ramp which will need to be considered in the design.

Figure 2.2 shows an extract of the survey provided by the City.

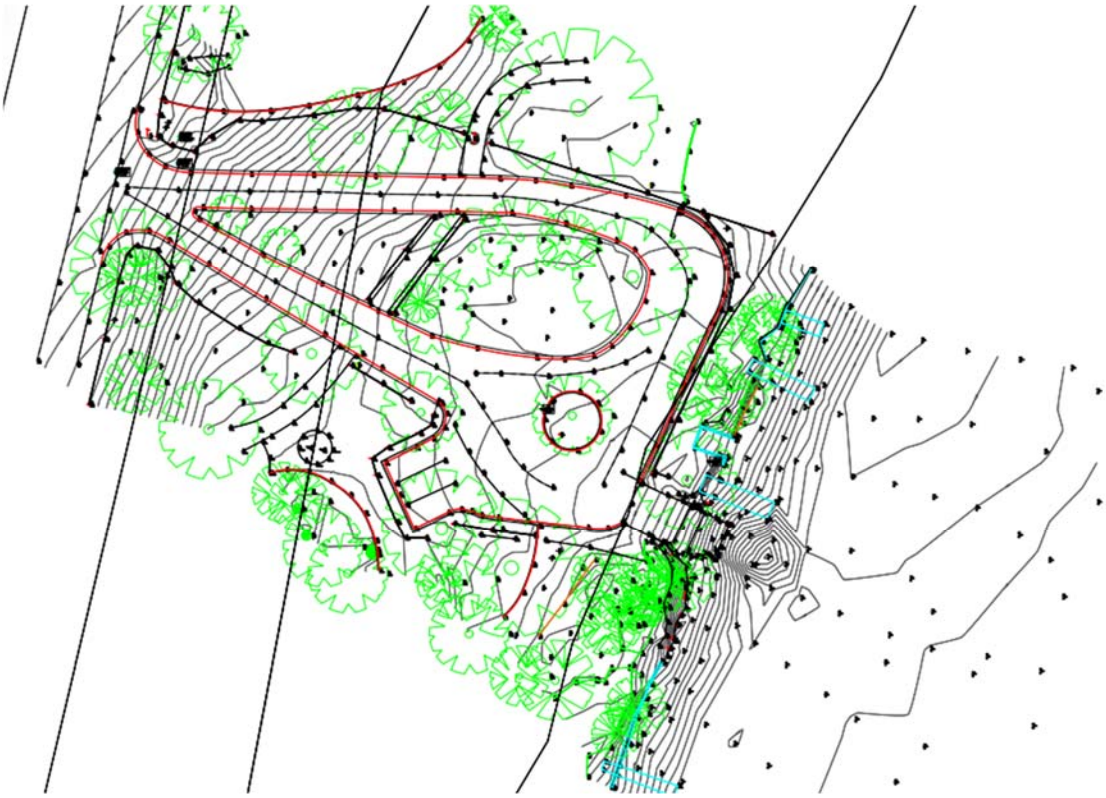

Figure 2.2 Survey Extract

2.4 Geotechnical Conditions

No geotechnical investigations have been undertaken for these works. The geological maps for the area typically show a thin veneer of sand over estuarine deposits. The clays that make up the estuarine deposits can be soft and prone to settlement.

It is noted that there is an existing boat ramp at the site and no signs of excessive settlements or geotechnical issues. Subsequently, the design has been completed on the assumption that ground conditions are generally suitable for construction of a new Boat Ramp. The Contractor will be required to confirm that adequate geotechnical conditions are achieved during construction of the works.

2.5 Acid Sulphate Soils

Acid sulphate soils (ASS) are widespread in low lying coastal areas of Western Australia. ASS are harmless when left undisturbed, however when exposed to air, the iron sulphides in the soil oxidise to produce iron compounds and sulfuric acid. This acid can react with other compounds and release harmful substances, including the acids and heavy metals themselves, into the environment and waterway. When actual ASS is identified or disturbed it must be managed by an approved Acid Sulphate Soil Management Plan (ASSMP).

The Department of Water & Environmental Regulation (DWER) Acid Sulphate Soil (ASS) risk dataset of the Swan Coastal Plain (DWER-055) was used to identify the risk of ASS occurring at the site. The ASS map of the site is as shown in the figure below.

Figure 2.3 ASS Map for the Site

The map shows a High to Moderate risk (Class 1 – Red) of ASS occurring at the site. Based on the design, soil and sediment disturbance is likely to be greater than 100 m^3 during these works. Therefore, it is expected that an ASS investigation will be required and the Contractor will be expected to develop an Acid Sulphate Soils Management Plan (ASSMP). The Contractor will be required to demonstrate how the presence of any ASS in the area will be managed and dealt with in their Construction & Environmental Management Plan (C&EMP).

Given the locality of the site, dewatering may be required to complete the Works. If dewatering is required, the Contractor shall expand the ASSMP to include dewatering (ie Acid Sulphate Soils and Dewatering Management Plan (ASS&DMP)).

2.6 Aboriginal Heritage

The Department of Planning Lands & Heritage (DPLH) are responsible for assessing the impact of development on Aboriginal Heritage sites. MRA completed an online search of Registered Aboriginal sites in the area and found that the works will occur within the following registered Aboriginal Site:

- Site 3676 – Coondaup Camps.

As the works have the potential to impact a registered site, consultation with local Aboriginal Representatives will be required. Consent and approval from traditional owners and via DPLH will be required. It is noted that the requirements of Aboriginal Heritage approvals are changing and are currently unclear. The City should commence this process as soon as possible to avoid potential delays to the works.

2.7 Contaminated Sites

An online search of contaminated sites within the Serpentine River catchment area was conducted using the DWER Contaminated Sites Database. No known contamination was indicated at the Site.

3. Design Considerations

The following general functional requirements form the basis of the design.

- The single lane boat ramp is to be replaced, in line with contemporary standards for boat ramp design.
- The fixed jetty is to be replaced with a Floating Jetty, to provide universal access.
- The Floating Jetty will form a holding structure for boats being launched or retrieved at the ramp.
- Protection to the ramp, jetty and adjacent foreshore will be provided with rock revetments.
- No works are proposed to the existing car park or road access, other than tying into the new structures.

3.1 Design Life & Structure Classification

Design life is defined as the period for which a structure or structural element remains fit for use in its intended purpose with appropriate maintenance. At the end of the design life, the structure should have adequate strength to resist ultimate loads and be serviceable, but may have reached a stage where further deterioration will result in inadequate structural capacity. The design life of maritime structures depends on the type of facility and the intended function.

In accordance with *AS4997-2005 Guidelines for the design of maritime structures*, the Boat Launching Facility fits into the following category:

- Facility Category 2 – Small craft facility.

A design life of 25 years is considered appropriate for small craft facilities.

The annual probability of exceedance for the design events is determined using the following structure categories:

- Function Category 1 – Structures presenting a low degree of hazard to life or property (AS4997-2005).
- Importance Level 2 – Normal Structure (AS/NZS1170.0-2002).

Based on these structure categories and the intended design life, the annual probability of exceedance for the design events are provided in the following table.

Table 3.1 Annual Probability of Exceedance for Design Events

Design Event	Ultimate Limit State	Serviceability Limit State
Wave	1/50	1/1
Wind	1/500	1/25

Notes: 1. Wave design event from AS4997-2005.
2. Wind and earthquake design event from AS1170.0-2002.

Therefore, the following section will outline the key design considerations the site is expected to be exposed to (ie waves, water levels and currents).

3.2 Design Waves

The foreshore along the Serpentine River is dominated by the following wave types.

- Locally wind generated waves.
- Boat wakes from passing vessels.

The following sections will discuss both wind and vessel generated waves at the site.

3.2.1 Wind Generated Waves

Locally generated wind waves are generated when winds blow across an area of water, often referred to as fetch. The magnitude of the waves created by the wind is determined by a number of factors, such as:

- Size of the fetch.
- Duration the wind blows across the fetch.
- Wind speed.
- Water depth.

Hindcast Calculation Estimates

The largest wind generated waves are expected to approach the sites from the northeast and southeast directions with the largest fetch. Hindcast calculations were performed for each of the directions. The wind speeds for different return periods were obtained from the Australian Standard AS1170.2 design wind speeds. The design wave conditions at the site for both 1 and 50 year ARIs are summarised in Table 3.2.

Table 3.2 Design Wave Conditions

ARI (Year)	Hindcast Calculations	
	H_s (m)	T_p (s)
1	0.1	0.9
50	0.2	2.9

Note: 1. H_s – Significant Wave Height.
2. T_s – Peak Wave Period.

3.2.2 Boat & Vessel Wake

The resultant wave field from a vessel is largely dependent on the vessel shape, speed, and the water depth in the area (AMC 2009). The Swan River Trust has investigated vessel wake generation and propagation in the river for a number of vessels at different speeds (AMC 2009 & CMST 2010).

The Department of Transport (DoT) prepare boating guides for Mandurah and Inland Waters, indicating navigable waters, recreational boating use areas and surveyed depths. An extract of the boating guide near the Site is presented in Figure 3.1.

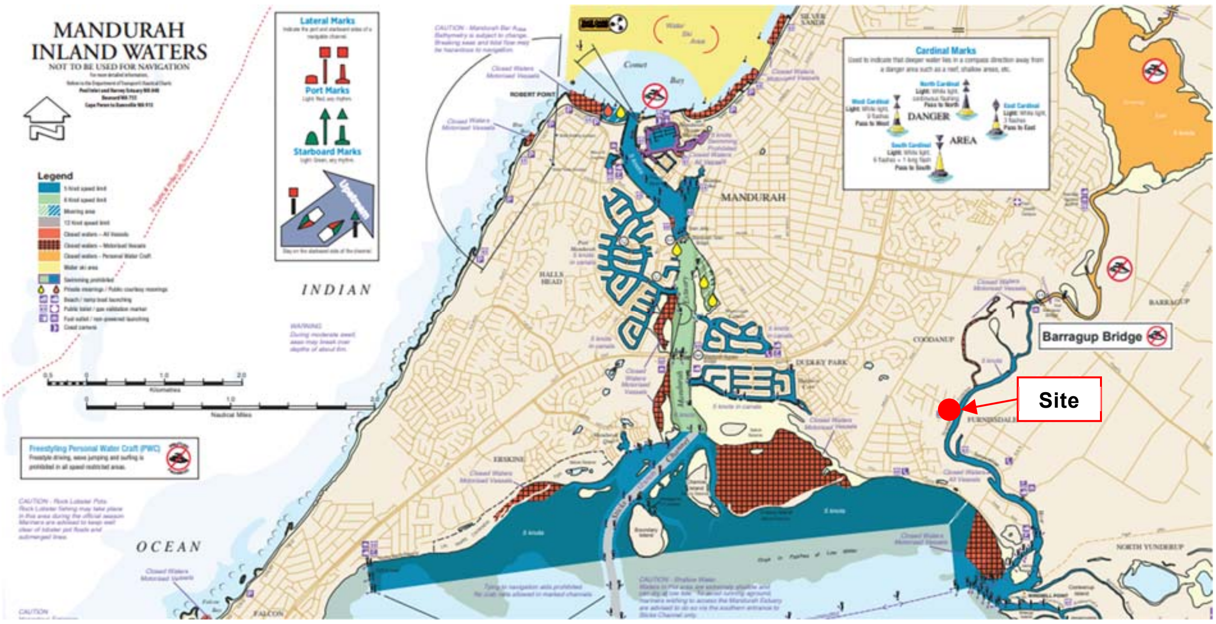

Figure 3.1 Boating Guide for Mandurah Inland Waters

The Boating Guide shows that the speed limit adjacent the site is 5 knots.

The vessel generated waves experienced at the site are also dependent on the distance from the vessel, as these waves generally decrease at a rate inversely proportional to the distance from the vessel. Based on the likely largest vessel expected at the site (Mustang Sports Cruiser 2800), a speed of up to 5 knots and the results from these studies, the maximum vessel generated waves expected at the sites were estimated and presented in Table 3.3 below.

Table 3.3 Vessel Generated Waves

Vessel	Maximum Wave Height, H_{max} (m)	Peak Period, Tp (s)
Mustang Sports Cruiser 2800	0.5	4.0

This shows that boat wakes are likely to be more critical than wind waves at the site for the design of the structures.

3.3 Design Water Levels & Flooding

The estuarine nature of the Serpentine River means that the water level at the site will be influenced by both riverine and ocean drivers. The elevated water levels associated with extreme river flow or ocean storm surge events must be considered as part of the design.

3.3.1 Ocean Influences

Tides

The site is subjected to both marine and riverine influences. The tides in the Peel region are predominantly diurnal, namely one tidal cycle each day, and are relatively limited in range. The range of the tides generally varies over about a 4-week cycle in line with the moon. Spring tides occur when the moon is new or full, resulting in a relatively large tidal range for a number of days. Neap tides occur twice a month, during the moon's first and third quarter phases, resulting in a smaller tidal range for a number of days.

The closest tide gauge to the site is located within the Peel Inlet, which is approximately 5.5 km downstream from the site.

A submergence curve for Peel Inlet has been provided by the DoT and a summary of the tidal characteristics are shown in Table 3.4.

Table 3.4 Peel Inlet Tidal Characteristics

Key Tidal Level	Chart Datum (mCD)	Australian Height Datum (mAHD)
Highest Astronomical Tide (HAT)	0.94	0.36
Mean Sea Level (MSL)	0.57	-0.01
Lowest Astronomical Tide (LAT)	0.31	-0.27
Highest Water Level (16/5/2003)	1.58	1.0
Lowest Water Level (7/2/1998)	0.01	0.57

Note:

1. Taken from DoT Submergence Curve (DOT 1615-17-01, July 2012).

It is expected that the tidal levels experienced at the site will be similar to those within the Peel Inlet.

Seasonal shifts in the sea level occur due to meteorological effects and the action of the Leeuwin Current. Typically, the mean sea level rises 0.1 m during winter and falls 0.1 m during summer. These seasonal fluctuations in water level will also influence water levels at the site.

The Peel Inlet is also influenced by the extreme ocean water levels as the two water bodies are hydraulically linked. In extreme storms, the surge can exceed 1 m above the astronomical tide level. Measurements from Peel Inlet show that the highest recorded water level was 1.0 mAHD (1.58 mCD) in May 2003, associated with the passing of a winter cold front.

Extreme Water Levels

MRA (2018) previously assessed the extreme water levels for the Metropolitan and Peel region. The analysis was based on long term measurements of water levels at a number of locations.

The top 100 instantaneous peak steady water levels were extracted from the datasets. Results from the extreme analysis are provided in Table 3.4.

Table 3.5 Extreme Water Levels for the Perth Metropolitan & Peel Region

Average Recurrence Interval (years)	Peak Steady Water Level (mAHD)
1	0.84
5	1.05
50	1.21
100	1.25

Notes: 1. Water level data period 1950-2017, data length 68 years.
2. Wave data period 1979-2017, data length 39 years.
3. Estimates of events with ARI longer than 2-3 times the data length should be treated with care.

Sea Level Rise

Water levels are expected to increase in the future with sea level rise as a result of climate change. DoT has released recommendations on the appropriate allowances for a sea level rise to be used in coastal planning and development in Western Australia (DoT 2010) presented here in Figure 3.2. DWER has confirmed that these values should be used in planning for estuarine locations.

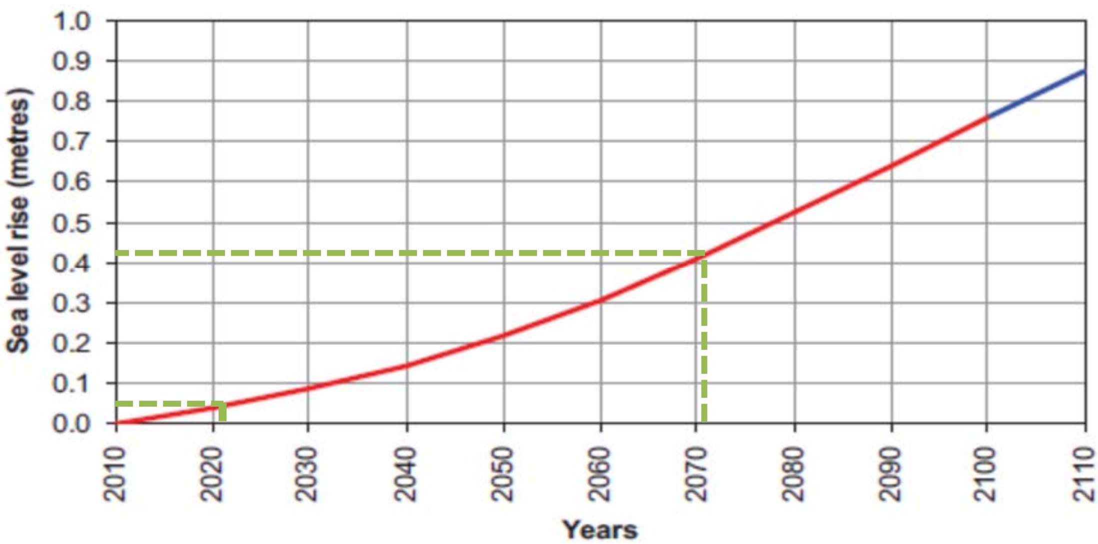

Figure 3.2 Sea Level Rise (DoT 2010)

From Figure 3.2, a sea level rise allowance of approximately 0.39 m has been considered in the design for the coming 50 years.

3.3.2 Riverine Influences

The Murray catchment, which includes the Serpentine and Murray Rivers, is subject to relatively regular flooding events during the winter months, resulting from passing storm fronts (GHD 2010). The rivers can also be subject to flooding in the summer months due to tropical storms, including the passage of ex-tropical cyclones, albeit relevantly infrequent.

The following studies have been undertaken to investigate riverine influences throughout the Serpentine River area.

- Serpentine River Floodplain Management Study (SKM 2010).
- Murray Drainage and Water Management Plan (GHD 2010).

Figure 3.3 below is a long section of the Serpentine River. The figure provides the modelling results for the water levels and flow rates for a 5 and 100 year ARI event. The site is located between Chainage 12 and 13 shown in the figure.

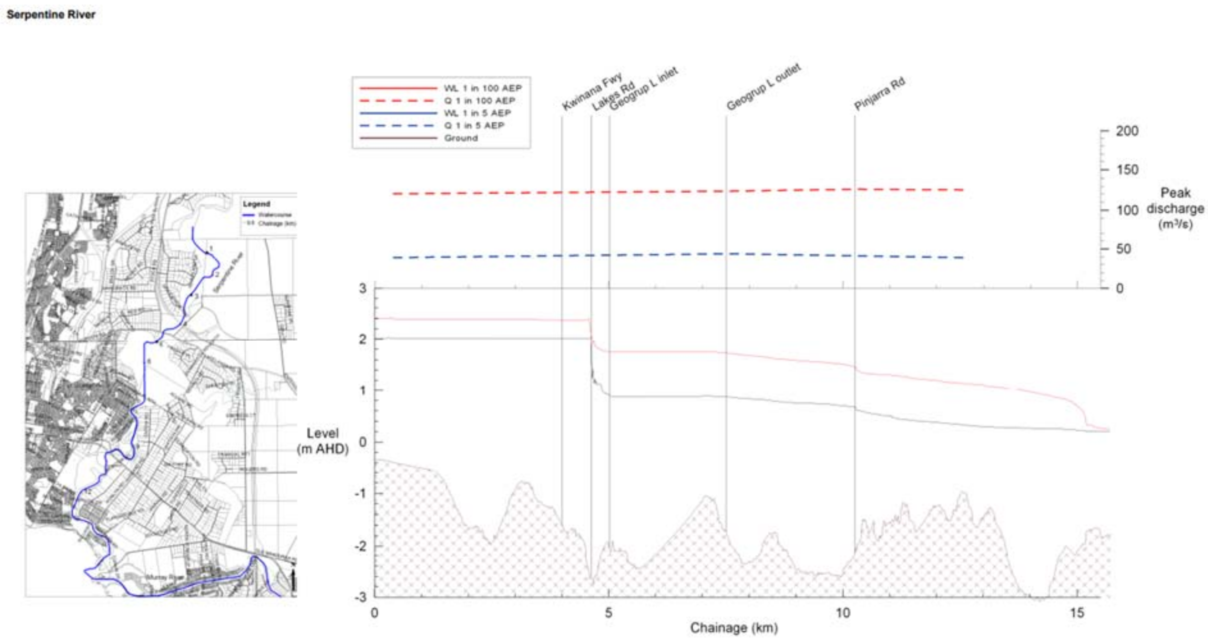

Figure 3.3 Long Section Serpentine River (GHD 2010)

For the purpose of this design, the site is expected to be subject to the following extreme water levels in river flood events.

Table 3.6 Extreme Water Levels – Riverine Influences

Average Recurrence Interval (years)	Peak Water Level (mAHD)
5	0.4
100	1.4

Note: 1. From Serpentine River Floodplain Management Study (GHD2010).

This shows that the more extreme river flood events may be more critical to design than the marine storm surges.

3.4 Design Current Speeds

Figure 3.4 above has also been used to estimate the design current speeds at the site, summarised in the table below.

Table 3.7 Current Speeds

Average Recurrence Interval (years)	Peak Steady Water Level (mAHD)
5	0.63
100	1.3

Note: 1. From Serpentine River Floodplain Management Study (GHD 2010).

4. Detailed Design

This section outlines the key design requirements and standards required for the Birchley Road Boat Ramp upgrade.

4.1 Standards & Guidelines

4.1.1 General

Numerous standards apply for the design of structures in the marine environment. Due to the nature of the proposed works and the materials proposed for construction, the most relevant Australian Standards for the design are included in the following table.

Table 4.1 Design Standards

Standard No.	Standard Name
AS/NZS1163-2016	Cold-formed structural steel hollow sections
AS/NZS1170.0-2002	Structural design actions – General principles
AS/NZS1170.1-2002	Structural design actions – Permanent, imposed and other actions
AS/NZS1170.2-2021	Structural design actions – Wind actions
AS2159-2009	Piling – Design and installation
AS3600-2018	Concrete Structures
AS3962-2020	Marina Design
AS4100-2020	Steel structures
AS4997-2005	Guidelines for the design of maritime structures

A number of other publications and design guidelines are also applicable to the design. These include:

- Coastal Engineering Manual (USACE 2006).
- Guidelines for the Design of Fender Systems:2002 (PIANC 2002).
- Guidelines for the Design of Boat Launching Facilities in Western Australia below the 25th Parallel (Department of Transport (DoT) 2009).

Where appropriate these guidelines have been considered in the design.

4.2 Design Life

The works shall be required to withstand the harsh estuarine environment and provide the following functional design life with an appropriate maintenance regime, which may include some component replacement.

Table 4.2 Design Life

Structure	Design Life (years)
Boat Ramp & Floating Jetty	25
Rock Revetment	50

4.3 Boat Ramp & Floating Jetty

4.3.1 Design Vessel

The design vessel for the Boat Ramp shall be as detailed in the following table.

Table 4.3 Design Vessel

Parameter	Value
Vessel Length	8.0 metres
Vessel Beam	3.4 metres
Vessel Draught	0.9 metres
Vessel Displacement	5 tonnes

4.3.2 Vessel Mooring / Berthing

It has been assumed that vessels will not be moored at the Floating Jetty during severe storm conditions. However, there is a risk that in unusual circumstances recreational vessels may moored against the structure during storms. The 50 year ARI wind and wave conditions have been adopted as the limiting condition for boats moored at the Floating Jetty. The City will need to manage the facility to ensure vessels are not moored against the structure during storm events.

4.3.3 Nearshore Bathymetry & Navigation

The site survey provided to MRA by the City shows that the accessible areas of the Floating Jetty are located in water depths of around -0.7 to -1.4 mAHD. The natural seabed level in front of the Boat Ramp is -1.2 mAHD. Subsequently, the riverbed levels around the site are unlikely to restrict the navigation of the design vessel.

4.3.4 Existing Car Park

The level of the parking area varies from approximately 0.6 mAHD at the intersection of the existing Boat Ramp, to 2.8 mAHD at the intersection of the road. MRA (2018) has shown that extreme water levels within the Metropolitan & Peel region can be over 0.8 mAHD for a 1 year ARI event. Therefore, the car park and Boat Ramp are expected to be inundated at times each year. The City will need to manage inundation events and use of the Facility at the site.

4.3.5 Boat Ramp

AS 3962 provides guidelines for the development of Boat Ramp facilities. These include the following:

- The ramp should be located such that:

- It is aligned directly into dominant waves from swell, sea and boat wash.
- It is sheltered from waves larger than 0.2 m.
- Land approaches permit queuing without blocking other traffic.
- Water approaches have sufficient area to allow queuing and low speed manoeuvres without blocking fairways and channels.

- The head of the ramp should be 500 mm above highest astronomical tide (HAT).
- The ramp toe should be at least 1 m below chart datum but requires extension to at least 600 mm below lowest astronomical tide (LAT).
- The grade of the ramp should be between 1:7 and 1:9, preferably 1:8.
- A single lane ramp should be a minimum width of 4.0 m wide between kerbs, or at least 4.5 m for a single lane without kerbs. Multi lane ramps should have a minimum width per lane of 3.7 m.
- Efficiency of ramp usage can be increased by providing a boat holding jetty structure.
- The provision of rigging space, queuing lanes to the ramp approach, boat derigging and trailer bays on the exit route from the ramp approach should be provided. The arrival path to the ramp approach should be designed to provide adequate sight distance for optimum safety.
- Vehicle manoeuvring areas should be cognisant of the required vehicle turning path.

Key features adopted for the proposed upgrade design include the following.

- The head of the ramp has been set at a level of 0.6 mAHD to tie into the existing car park levels.
- The ramp toe has been set at a level of -1.43 mAHD.
- The grade of the ramp has been set at 1V:8H.
- The width between kerbs for each of the ramps has been set at approximately 4.0 m.

As detailed previously in Section 3.2, the site will be exposed to waves greater than the 0.2 m as required by AS 3962 (Boat & Vessel wake).

4.3.6 Floating Jetty

The DoT has published "*Guidelines for the Design of Boat Launching Facilities in Western Australia below the 25th Parallel*" (DoT, 2009). Key requirements of this guideline in relation to Floating Jetties are summarised below.

- Jetty width of minimum 1200 mm between kerbs or chafers.

The recommendation has been incorporated in the design of the Floating Jetty.

DoT (2009) recommends that the jetty be of sufficient length to hold three boats. Meeting this requirement at the Birchley Road facility would mean the Floating Jetty would extend into trafficable areas of the river, considered to be a significant potential risk to river and facility users. The City therefore confirmed that providing space for 2 boats was appropriate.

In line with industry standards, the detailed design of the Floating Jetty will be completed under a Design & Construct arrangement. Detailed design requirements are set out in the Technical Specifications.

The Floating Jetty will be required to accommodate pedestrian crowds. In accordance with AS4997 and AS/NZS1170.1, the following deck load design actions have been used in the Floating Jetty design requirements:

- Distributed Load: 5 kPa.
- Concentrated Load: 4.5 kN.

4.3.7 Abutment

A concrete Abutment will provide access from the Boat Ramp to the Floating Jetty via a Gangway. Both the Abutment and Gangway must provide universal access for a maximum of 80 percent of the time in accordance with AS 3962:2020 Table 3.5.

The Gangway must be fixed to the concrete Abutment using a pin connection, whereas, the connection between the Gangway and Floating Jetty must use a roller connection.

The Abutment must be constructed with reinforced concrete, with cover and steel reinforcement suitable for the marine environment. The Abutment must also be provided with a rough broom texture to provide a non slip surface.

4.3.8 Typical Boat Ramp & Jetty Section

A typical section of the Boat Ramp is presented below in Figure 4.1 to show the features outlined in the above sections.

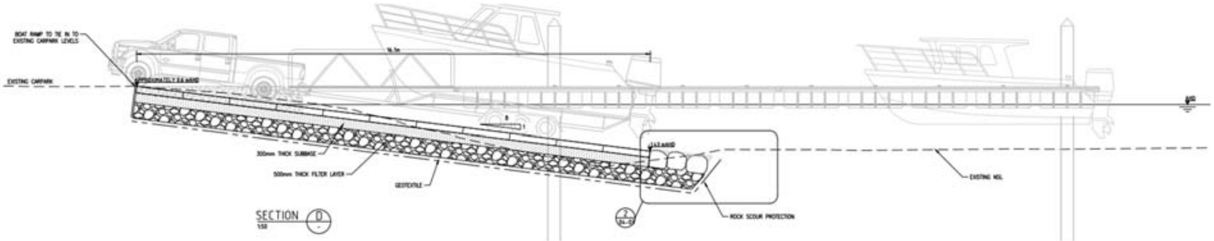

Figure 4.1 Typical Boat Ramp Section

4.4 Rock Revetment

Rock protection will be provided to the foreshore edges either side of the Boat Ramp, and around the extent of the Boat Ramp itself.

4.4.1 Rock Type

Laterite was chosen by the City as the preferred rock material for the Rock Revetment.

All rock used in the Works shall have a Saturated Surface Dry Density (SSDD) of 2.35 tonnes/m^3 or greater, and a Point Load Index Strength, Is(50), of 0.7 MPa or greater.

4.4.2 Crest Level

The crest level was designed to tie in to existing infrastructure and surrounding features. The crest level ranges from 0.6 mAHD at the northern end of the site and reduces locally at the southern end of the site to 0.4 mAHD.

The Revetment is still expected to dissipate energy and protect the foreshore at the site, however, is expected to become inundated by extreme weather events. The City will be required to manage inundation events.

4.4.3 Treatment to Existing Vegetation & Trees

There are a number of established trees in the vicinity of the Works. The Revetment is to be locally modified at the southern end (if required) to protect the trees in this area.

Where the trees are located within the Revetment and modifying the Revetment will mean the structure will encroach further into the river, the trees have been marked for removal. The removal of the trees will be undertaken by the City prior to the commencement of the Works.

4.4.4 Armour Design

Armour rocks need to be sufficient size to withstand the forces applied by wave and current actions. The required armour size under wave action was calculated using the Hudson and Van der Meer formulae (CIRIA 2007).

For current action, the required armour size was calculated using Pilarczyk, Escarameia & May and Maynord formulas (CIRIA 2007). The required representative armour size (W_{50}) is approximately 0.4 t. This assumes the armour will be placed in two layers and that a geotextile is used, reducing the structures permeability. MRA have found that an armour range of $\pm$50% provides a reasonable grading of armour and can be readily sourced from quarries.

The recommended Laterite armour size is shown below.

Table 4.4 Recommended Armour Rock Size

W_{50} (t)	Range (t)
0.4	0.3 – 0.5

4.4.5 Filter Design

The filter size was designed in accordance with the recommendations and filter rules of CIRIA (2007) and Pilarczyk (1990). These ensure that internal stability is achieved as well as ensuring that the filter is large enough to limit loss of fines through the armour. The general requirements for the filter design are as follows.

- Well graded run of quarry between 0.05 and 0.3 m.
- At least 50% greater than 0.25 m.
- Not more than 20% by volume less than 0.1 m.

4.4.6 Geotextile

Geotextile is to be installed underneath the filter layer to reduce the permeability of the structure. The recommended material to be used is Texcel 900R or a similar approved material.

4.4.7 Typical Rock Revetment Section

A typical section of the revetment is presented below in Figure 4.2 to show the features outlined in the above sections.

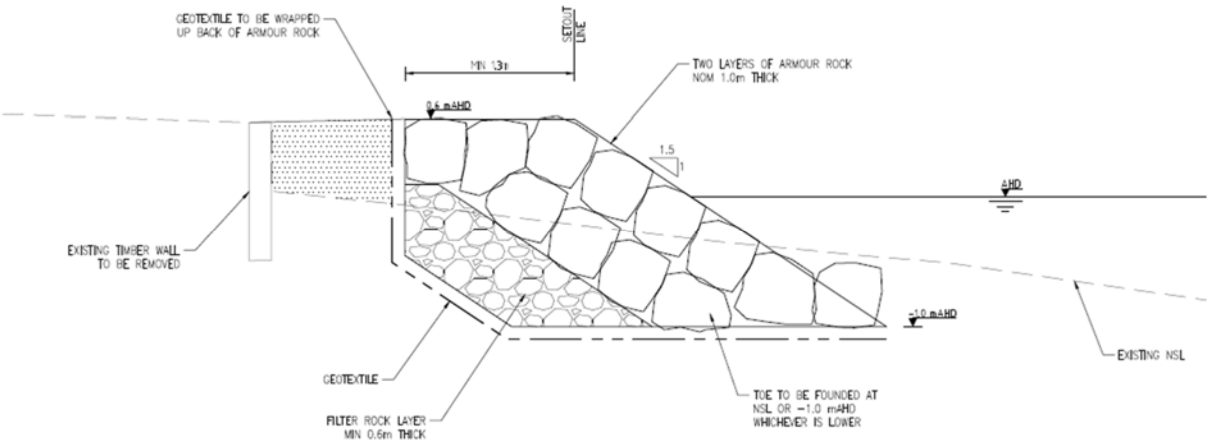

Figure 4.2 Typical Rock Revetment Section

4.4.8 Backfill & Planting Behind the Revetment

The Works will include backfilling behind the Rock Revetment. The fill should be profiled to the height of the Revetment at the rear of the crest and then blend in to natural surface levels directly behind the crest.

Planting of the backfilled area is to be undertaken by the City at a later date.

5. Construction Considerations

The plant and methodology used in the construction of the works will be at the discretion of the successful Contractor. Marine Contractors in Western Australia and the Peel Region have varying preferred plant and methods, and to ensure value for money we would not recommend prescribing the construction methodology.

However, the following provides an indicative general methodology for the works.

5.1 Demolition

The following general methodology is proposed for the demolition of the existing structures:

- A temporary stockpile area may be required for storage of material generated during demolition, noting that the material would contain contaminated materials such as ASS that may require management and treatment prior to disposal. This stockpile area may require lining dependent on the use.
- Remove and dispose of the following:
  - Boat Ramp;
  - Timber jetty;
  - Canoe / kayak launching and retrieval structure;
  - Casuarina Tree (in front of the jetty); and
  - Timber palisade wall.

The City has confirmed that they will remove any trees requiring clearing prior to the works, including the large Casuarina.

5.2 Boat Ramp Construction

The Boat Ramp works could be completed in the wet, or in the dry via dewatering. Both methods have been successfully used for similar works around the Perth Metropolitan and Peel Regions recently.

The Boat Ramp Panels would be pre-cast concrete, fabricated off site and transported to site. It is expected these would commence early in the construction process.

The following is a general methodology for the Boat Ramp works.

- Trimming of slopes and confirmation of sub-grade.
- Placement of Geotextile.
- Placement of Filter Layer.
- Placement of Sub-Base.
- Placement of pre-cast Concrete Panels, including connections.

- Installation of kerbs.
- Placement of Armour Rock as Scour Protection.
- Grouting between Armour Rock and Concrete Panels.

5.3 Revetment Construction

The Revetment works are likely to be completed along with or immediately following the Boat Ramp works.

The following is a general methodology for the Revetment works.

- Trimming of excavated slopes, including filling if required.
- Placement of Geotextile.
- Placement and trimming of Filter Layer.
- Placement of Armour Rock.

Where required, backfill behind the revetment is expected to be completed in finishing works to tidy the site.

Some of the Revetment works may be difficult to complete in and around existing trees. Nevertheless, the trees are to be protected where possible and the revetment may need to be modified locally.

5.4 Floating Jetty Installation

The Floating Jetty component of the works will be design and construct. The Contractor will be required to complete their detailed design and submit this to the Superintendent early in the Contract to gain approval, prior to fabrication. It is expected that the Floating Jetty and Gangway will be manufactured off-site, potentially locally, and transported to the site for installation.

The following is a general methodology for the Floating Jetty works.

- Construction of the concrete abutment and infill panel on shore.
- Installation of piling, including testing and sleeving.
- Installation of the floating pontoons.
- Installation and connection of the gangway.
- Installation of light and other ancillary features.

It is expected that the Floating Jetty would be the last component installed.

5.5 ASS Management

ASS Management will be required throughout the works. This will include disposal of any surplus material and treatment of any material which is exposed for over 18 hours.

5.6 Dewatering

The construction methodology is at the discretion of the Contractor. Therefore, depending on how they propose to construct the Facility, dewatering may or may not be required. Should the Contractor propose a methodology that includes dewatering, they will be responsible for all components of the dewatering works, including:

- Any investigations and planning.
- Gaining any necessary approvals.
- Protection of the works.
- Creation, management and removal of dewatering bunds.
- Dewatering operations.

6. Construction Cost Estimate

The construction cost estimate for the Facility upgrade was prepared based on the assumptions outlined in this report. The quantities are based on the plan layouts and sections shown in the Drawings. The rates are based on those recently received from Contractors for similar works in the Perth Metropolitan and Peel regions.

The construction cost estimate is presented in Table 6.1.

The following should be considered regarding the construction cost estimate:

- The cost estimate is based on tendered rates over several years. There has been a recent increase in material and labour prices over the past year. These have been included, but additional increases should be considered by the City.
- Some basic allowance has been made for removal and disposal of surplus excavated materials due to ASS issues or contamination. No allowance has been included for extensive treatment of ASS or contaminated soil.
- The cost for any other approvals or management of the works has not been included.
- A 20% contingency has been included for a detailed design cost estimate. This is used to cover uncertainty such as material costs, mobilisation costs, and site conditions.
- Future escalation has not been included. As the marine construction industry in WA has limited resources and is currently in high demand, prices can vary significantly from one project to another.

The current demand for marine works is high, and a number of experienced marine Contractor have advised that there is limited capacity to undertake further works in 2023. Therefore, given the current high demand and limited resource in the marine construction industry, it is recommended that the City allow sufficient time in the schedule for both the tender and construction phase of this project to ensure the most cost-effective outcome can be achieved.

Table 6.1 Construction Cost Estimate

Item	Activity	Quantity	Units	Unit Rate	Subtotal	Total for Item
1	**Preliminaries**					**$ 125,000**
1.1	Insurances & preliminaries.	1	item	$ 20,000	$ 20,000	
1.2	Management plans.	1	item	$ 15,000	$ 15,000	
1.3	Design and documentation of floating jetty.	1	item	$ 10,000	$ 10,000	
1.4	Survey.	1	item	$ 10,000	$ 10,000	
1.5	Mobilisation.	1	item	$ 10,000	$ 10,000	
1.6	Site Establishment, including fencing.	1	item	$ 10,000	$ 10,000	
1.7	Environmental compliance during works (incl ASS).	1	item	$ 40,000	$ 40,000	
1.8	Demobilisation & site clean-up.	1	item	$ 10,000	$ 10,000	
2	**Demolition, Earthworks & Preparation**					**$ 93,318**
2.1	Removal of existing timber structures (ie timber palisade wall, canoe/kayak launching & retrieval facility, ect).	37	m	$ 500	$ 18,500	
2.2	Removal of existing boat ramp panels.	25	m^2	$ 544	$ 13,600	
2.3	Removal of existing timber jetty.	13	m^2	$ 990	$ 12,870	
2.4	Removal, stockpile & reuse existing rock protection.	15	m	$ 544	$ 8,160	
2.5	Excavate for works (revetment & boat ramp).	180	m^3	$ 31	$ 5,508	
2.6	Management & disposal of surplus excavated material.	170	m^3	$ 204	$ 34,680	
3	**Rock Revetment**					**$ 73,023**
3.1	Supply & install Geotextile.	385	m^2	$ 30	$ 11,550	
3.2	Supply & placement of filter layer (revetment & boat ramp).	70	m^3	$ 225	$ 15,750	
3.3	Supply & placement of armour rock.	225	t	$ 203	$ 45,563	
3.4	Backfill excavated material.	8	m^2	$ 20	$ 160	
4	**Boat Ramp & Floating Jetty**					**$ 459,305**
4.1	Placement of sub base.	23	m^3	$ 40	$ 915	
4.2	Construct single lane boat ramp.	11	panels	$ 13,200	$ 145,200	
4.3	Complete stone pitching.	52	m^2	$ 845	$ 43,940	
4.4	Construct concrete abutment.	7	m^3	$ 4,500	$ 29,250	
4.5	Supply & install of floating jetty system.	80	m^2	$ 3,000	$ 240,000	
5	**Miscellaneous**					**$ 3,225**
5.1	Solar light.	1	item	$ 3,225	$ 3,225	
	Subtotal 1				**$ 753,870**	**$ 753,870**
	Contingencies	**20**	**%**		**$ 150,774**	**$ 150,774**
	Subtotal 2				**$ 904,645**	**$ 904,645**
	Goods & Services Tax				**$ 90,464**	**$ 90,464**
	Total Estimated Cost				**$ 995,109**	**$ 995,109**

7. Safety in Design

7.1 Introduction

The current legislation within Australia requires designers to demonstrate that they have identified the risks in construction, use, management, maintenance and demolition of their design and that they have taken appropriate measures to eliminate or reduce these risks. In particular, the Occupational Safety and Health Regulations 2022 require designers to provide the following information to the Client.

- The hazards that the designer has identified:
  - As part of the design process.
  - That arise from the construction of the design.
  - To which a person at the construction site may be exposed.
  - In the use of the structures.
  - In the maintenance of the structures.
  - In the demolition of the structures.
- The designer's assessment of the risk of injury or harm to a person resulting from identified hazards.
- The measures the designer has taken to reduce the risks.
- Any hazards where the designer has not done anything to reduce the risks.

Therefore, to meet the legislative requirements and to help the Client quantify, understand and manage these risks, a Safety in Design (SID) assessment as described in the following sections has been completed.

The following outlines the different stages of the SID assessment and presents the outcomes from this assessment. It is important that the Client understands these risks and the uses of the Facility for which they apply. These risks should be communicated to any parties involved in the future construction, management, maintenance, management or demolition of the Facility.

7.1.1 Principles of Safe Design

The key principles that impact on achieving SID have been identified by the Australian Safety and Compensation Council and are summarised in the following table.

Table 7.1 Principles of Safe Design

Principle	Description
1: People With Control	People with influence or control over the design have responsibility to ensure safe design.
2: Product Life Cycle	Safe design applies to every stage in the life cycle, from design to demolition. It involves eliminating or minimising risks as early in the life cycle as possible.
3: Systematic Risk Management	Application of risk identification, assessment and control processes to achieve safe design.
4: Safe Design Knowledge and Capability	Either demonstrated or accessed by any person with control or influence over design.
5: Information Transfer	Effective communication and documentation of design and risk control information between all party involved in the life cycle is essential for safe design approach.

7.1.2 Qualifications

The design documentation process includes various project stages and involves different parties who provide input and decisions to arrive at the final design. Such inputs may positively or negatively impact the safety however it is understood all parties have responsibility for health and safety in the design documentation stage and have each met their obligation under the Health & Safety Legislation.

This report does not in any way mitigate the Builders, Contractors or End Users obligations and responsibilities under the legislation to ensure safe work practices and the provision of a safe work environment as required by the OSH Act and the OSH Regulations.

All parties are required by law to ensure, as far as practicable, that any information received about the hazards that have been identified and the risk control measures that have been considered and / or put in place, are passed on to the parties responsible for construction, operation and use. In providing this report MRA has discharged its obligations under the Act and responsibility to ensure ongoing compliance passes onto the Construction Contractors and Owner / Developer / End User.

It shall be noted that anyone who alters or modifies the design documentation without consulting MRA will assume the duties of the designer. Any changes to the design documentation may affect the health and safety of those who work on or use the design documentation and must therefore be considered by the party altering or modifying the design.

7.2 Basis of Safety in Design Assessment

The following section outlines the basis of the design considered in the SID assessment. This includes the considered uses, construction, maintenance and demolition methodologies and any key assumptions.

This SID assessment should be updated throughout the life cycle of the design and particularly should there be any changes to the items outlined below. Any uses of the design, construction methodologies and maintenance, management or demolition activities outside of these may require further consideration of the risks to safety. The responsibility for the SID of those additional activities or items rests with the designer of those items.

7.2.1 Document List

A list of the design documents for the Facility that formed the basis of the SID assessment are presented in the following table.

Table 7.2 List of Design Documents

Document Number	Document Title
Report R1819	Birchley Road Boat Ramp Upgrade Design Report (This Report)
Report R1820	Birchley Road Boat Ramp Upgrade Technical Specification
D2069-01-01	Drawing List & Locality Plan
D2069-02-01	Existing Conditions & Demolition Plan
D2069-03-01	General Arrangement
D2069-04-01	Sections & Details – Sheet 1 of 3
D2069-04-02	Sections & Details – Sheet 2 of 3
D2069-04-03	Sections & Details – Sheet 3 of 3
D2069-05-01	Boat Ramp Details
D2069-06-01	Floating Jetty – Layout & Sections
D2069-06-02	Abutment Details

7.3 Safety in Design Assessment

To complete the SID assessment, MRA adopted the approach presented in Figure 7.1.

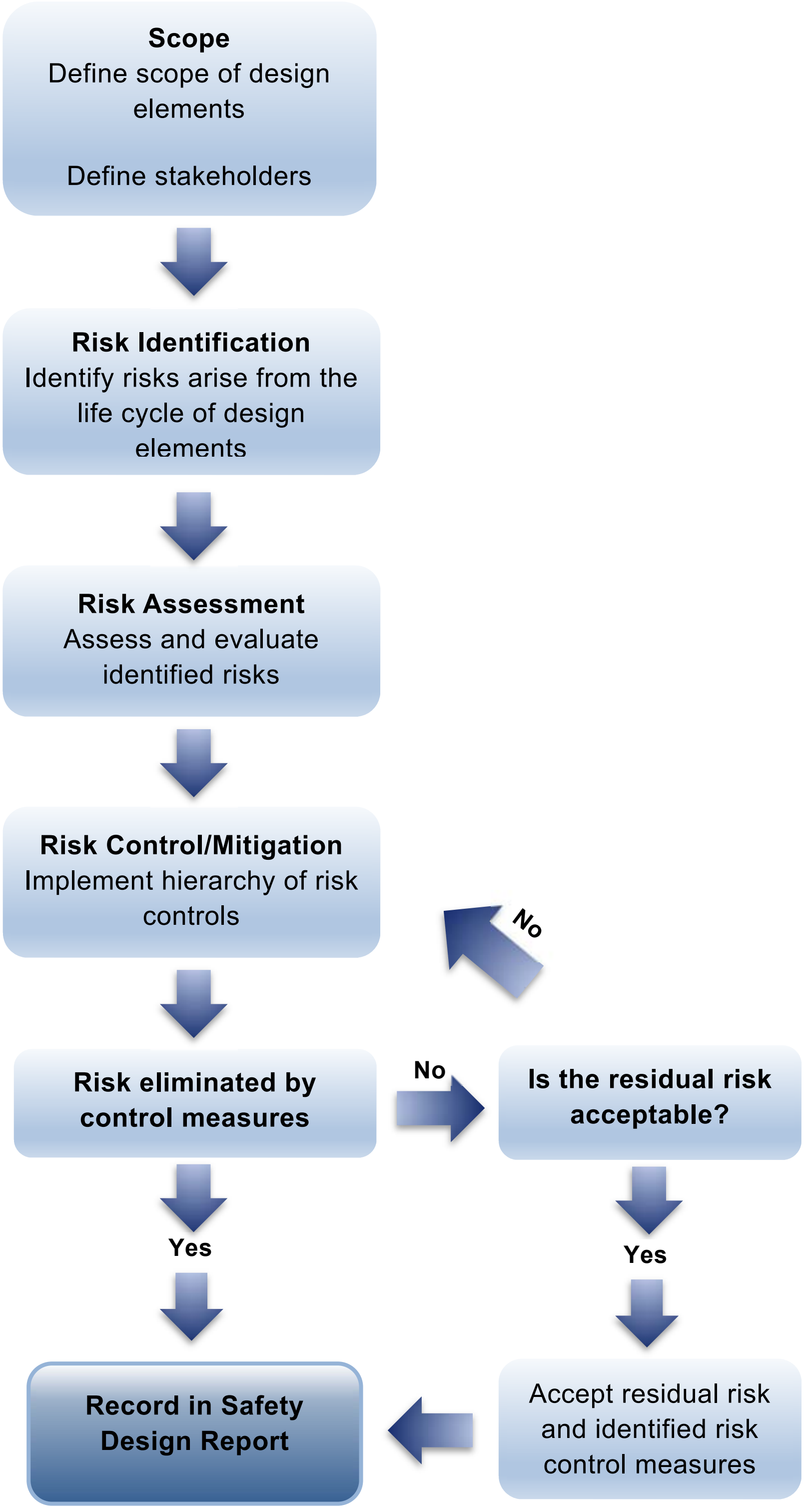

Figure 7.1 Steps in Safety in Design Assessment

The stages of the SID assessment are discussed in the following sections.

7.3.1 Stakeholders

The primary focus of a safe design is the elimination or minimisation of risk to a party that may be influenced by the design. This includes any party that may be involved in the design, construction, operation, maintenance and demolition of the design elements in this project. A list of relevant stakeholders is presented below.

- City of Mandurah (Client).
- MRA.
- Contractor.
- The Public.
- Marine based State Agencies such as DoT, DWER, etc.

7.3.2 Risk Identification

The risk identification involves identifying design related risks / hazards associated with the life cycle of the project. In particular, the risk identification stage should aim to identify risks / hazards that may affect the stakeholders during the design, construction, operation, maintenance and demolition stage of the Facility. The life cycle of the design elements for this project is presented in Figure 7.2.

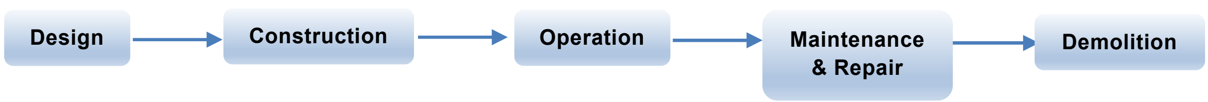

Figure 7.2 Life Cycle of the Design Elements

The risk identification was completed using the following procedures to identify risks over the whole lifecycle of this project.

- Examining design records and experience from past similar types of projects.
- Consulting relevant Australian Standards, codes and guidance materials.
- Examining available data on particular construction technique.
- Constructability review with special emphasis on occupational safety and health issues.
- Considering any particular issues associated with the intended use of the project, and including any foreseeable misuse.
- Examining available maintenance records from past similar types of projects and considering required maintenance.
- Examining records and data on demolition of past similar projects and considering required demolition.

7.3.3 Risk Assessment

To quantify the impact (eg injury and harm) of the risks identified and assess the effectiveness of risk control measures, the identified risks were evaluated, and an initial risk rating was provided for each risk event. The risk evaluation process was repeated after risk control measures were adopted.

The risk evaluation involves assessment of the likelihood of risk occurrence, and the consequences should the risks occur. A likelihood rating as presented in Table 7.3 was assigned to each risk event. Subsequently a consequence rating presented in Table 7.4 was then assessed and assigned to each risk event. Based on the likelihood and consequence rating, the overall risk rating for each risk event was determined using the risk matrix presented in Table 7.5.

Table 7.3 Likelihood Rating

Likelihood	Description	Indicative Return Period	Indicative Probability (over the timeframe)
5 – Almost Certain	Common/frequent occurrence. Expected to occur on an annual basis.	Every year or more	> 0.9
4 – Likely	Is known to occur or has happened regularly. The event has occurred a number of times in the last decade.	Every three years	> 0.3, < 0.9
3 – Possible	Could occur, or known to occur based on anecdotal evidence. The event might occur once per decade.	Every ten years	> 0.1, < 0.3
2 – Unlikely	Not likely to occur very often, but does occur from time to time.	Every thirty years	> 0.03, < 0.1
1 – Rare	Conceivable but only in exceptional circumstances.	Every 100 years	> 0.03

Table 7.4 Consequence Rating

Consequence	Description
5 – Substantial	Results in fatality or permanent widespread environmental damage.
4 – Major	Results in permanent injury or significant environmental damage.
3 – Moderate	Results in injury and illness or major but recoverable environmental damage.
2 – Minor	Results in medical treatment or recoverable interim environmental damage.
1 – Negligible	Results in first aid treatment or short term environmental damage.

Table 7.5 Risk Matrix

	Consequence					
		Negligible (1)	**Minor (2)**	**Moderate (3)**	**Major (4)**	**Substantial (5)**
Probability (Likelihood)	**Almost Certain (5)**	Medium (8)	High (16)	High (18)	Extreme (22)	Extreme (25)
	Likely (4)	Low (4)	Medium (10)	High (17)	Extreme (21)	Extreme (24)
	Possible (3)	Low (3)	Medium (9)	Medium (12)	High (19)	Extreme (23)
	Unlikely (2)	Low (2)	Low (6)	Medium (11)	Medium (14)	High (20)
	Rare (1)	Low (1)	Low (5)	Low (7)	Medium (13)	Medium (15)

The design response to the resultant risk levels is outlined in the following table.

Table 7.6 Design Response to Risks

Risk Level	Actions to be Taken
Extreme	Immediate action required to reduce risk. Engineering input required to reduce risk.
High	Immediate action required to reduce risk. Engineering input required to reduce risk.
Medium	Action required to reduce risk. Engineering input required to reduce risk.
Low	May require localised control measures – business as usual.

In general, the extreme and high risk items are considered intolerable and require input to reduce the risk. Low risk items are considered tolerable. Risk controls are outlined further below.

7.3.4 Risk Control

Risk control is the implementation of risk mitigation measures to reduce or eliminate the risks identified. The Code of Practice – Safe Design of Buildings and Structures (Commission for Occupational Safety and Health, 2008) outlined a 'hierarchy of control' model. This model was used to determine the most appropriate risk control measures for each risk event and it is summarised in the following table.

Table 7.7 Hierarchy of Control

Type of Control	Description
Elimination	Remove hazard from the structure or site through design.
Substitution	Substituting or replacing hazard or hazard component through redesign or design modification.
Isolation	Isolate or separate hazard from the people involved.
Engineering Controls	If the hazard cannot be eliminated, substituted or isolated, design or install elements to counteract the hazard (eg guard or barrier).
Administrative Controls	This involves noting in the design the use of safe work practices to reduce risks (eg work procedures, signage).
Personal Protective Equipment (PPE)	Use of PPE near potential risks / hazard.

Risk control measures higher up the hierarchy (such as elimination, substitution and isolation) were adopted to control the identified risks where possible, as these control measures are generally more passive and do not rely on the actions of people. In the case where the risk cannot be eliminated or reduced so far as is reasonably practicable, administrative controls which include providing information on remaining or residual risks, and further control measures were adopted.

It is noted that a single risk control measure may be used to treat many risks, and that multiple control measures may be required to control a single risk.

A summary of the results from the SID assessment is presented in the Risk Register in Appendix A. Included in the register are the ratings associated with the identified risk and the proposed mitigation measures to reduce the risks.

7.4 Residual Risks

The residual risk is the level of risk that remains and is transferred after all risk control measures are successfully implemented at the completion of the design. It is noted that the majority of the risks identified in the SID assessment have been treated with control measures that either eliminated or reduced the risks to an acceptable level. However, there are still some residual risks that have a high risk rating, and will require on-going monitoring and management. This may be achieved by applying administrative controls and the use of PPE. The higher residual risks for this project and the corresponding control measures required are presented in the following table. It should be noted that there are a number of other medium risks which also require consideration and these are outlined in the Risk Register in Appendix A.

Table 7.8 High Residual Risks & Corresponding Control Measures

Phase of Works	Residual Risk	Residual Risk Owner	Control Measures
Design	Fall due to slip hazard.	City	Boat ramp constructed with anti-slip module finish. City to manage risk with appropriate signage. Boat ramp maintenance to be completed as appropriate.
Design	Vehicle sliding due to slip hazard.	City	Boat ramp constructed with anti-slip module finish and to recommended gradients. City to manage risk with appropriate signage. Boat ramp maintenance to be completed as appropriate.
Construction	Public interference with site. Conflicts between pedestrians, and the works.	Contractor & Public	Contractor's management plans as well as Pedestrian, and Traffic Management Plan to be reviewed. Appropriate signage, fencing.
Construction	Conflicts between workers and machinery.	Contractor	Contractor's management plans and construction methodology. OHS practices, training, PPE.

From the Safety in Design assessment, there were a number of maintenance and management items that the Client will need to consider. These include:

- Notification or management during unsafe conditions and flood events.
- General monitoring and maintenance of the structure, including but not limited to cleaning, maintenance, monitoring, etc.

Other measures are outlined in the Risk Register provided in Appendix A.

These residual risks and management measures are to be communicated by the Client to any parties involved in the future construction, management and maintenance or demolition of any structures.

It is noted that the SID assessment should be maintained throughout the project. Risk measures implemented should be monitored and reviewed regularly to ensure they have eliminated the risk or reduced it to an acceptable level.

8. Summary

The City has engaged MRA to complete the design of an upgraded Boat Ramp facility located at the end of Birchley Road on the Serpentine River. The proposed design consists of retaining the existing car park and access roads, while replacing the Boat Ramp, installing a Floating Jetty for universal access and upgrading the riverine protection adjacent to the structure.

The following are the key components of this work.

- The site extends is on the western bank of the Serpentine River, at the end of Birchley Road and approximately 2.9 km upstream from the confluence of the Peel Inlet.
- The navigable waters surrounding the site are restricted to 5 knots to motorised vessels.
- The critical design considerations for the site are vessel generated waves and riverine influences (water levels and current speeds).
- The new single lane Boat Ramp is designed to accommodate a vessel length and displacement of up to 8 m and 5 t respectively.
- Detailed design has been undertaken for the site and includes the design of a single lane Boat Ramp, Floating Jetty and Concrete Abutment, and Rock Revetment. The design has considered all relevant standards, publications and guidelines.
- The Birchley Road Boat Ramp Upgrade is estimated to cost $995,109.00, including a 20% contingency to allow for uncertainties associated with the Works.
- A Safety in Design assessment was completed for the design. A number of items were considered to still have high risk ratings after the implementation of control measures. These items will require ongoing monitoring and management.

9. References

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Water Authority of Western Australia 1990. *Revised Lower Serpentine Flood Study, Report No. S20R1.* Prepared by Water Authority of Western Australia.

10. Appendices

Appendix A – Risk Register

Appendix A – Risk Register

Work Break Down Structure	Risk Identification			Risk Rating Before Treatment				Residual Risk Assessment			Residual Risk Allocation
Phase DE=Design C=Construction O=Operation M=Maintenance D=Demolition	Hazard	Causes	Potential Consequences	Likelihood	Consequence	Rating	Mitigation Plan - Elimination Measure, Design Initiative or Control	Likelihood	Consequence	Rating	Residual Risk Owner (Contractor, Public & City)
Design											
General											
DE	Fall due to slip hazard.	Slippery surfaces due to water and marine growth on structures.	Injury or death.	3	5	23	Boat ramp constructed with anti-slip module finish. City to manage risk with appropriate signage. Boat ramp maintenance to be completed as appropriate.	2	5	20	City
DE	Vehicle sliding due to slip hazard.	Slippery surfaces due to water and marine growth on structures.	Injury or death.	3	5	23	Boat ramp constructed with anti-slip module finish and to recommended gradients. City to manage risk with appropriate signage. Boat ramp maintenance to be completed as appropriate.	2	5	20	City
DE	Poor access.	Steep gradients at high or low water.	Injury.	3	3	12	MRA designed structures to provide universal access in accordance with appropriate standards.	1	3	7	City
DE	Flooding/inundation of structures.	Storm events with high wind speeds and water levels.	Injury or death.	2	5	20	MRA designed structures to remain in place during storm or flood events. City to manage inundation and potential use of facility in floods.	1	5	15	City
DE	Exposure to waves.	Waves reaching ramp in storm conditions. Poor design leading to movement of revetment armour. Damage to jetty.	Overloading or movement of structures.	2	4	14	Facilities designed to accommodate wave conditions. Revetment armour designed for conditions.	1	4	13	City
DE	Settlement/movement of structures.	Poor construction, damage during storm events.	Damage to structures, repair/replacement required. Possible injury as a result of damaged structures.	4	3	17	MRA designed structures with appropriate rock sizes to withstand severe storm conditions. Testing of piles and foundation required during construction.	3	3	12	City
DE	Damage to structure from degradation of materials in marine environment.	Use of non-durable materials not suited to marine environment.	Personal injury, collapse of structure.	4	3	17	Durable materials chosen in design. Quality Assurance testing undertaken during construction works to ensure sufficient durability of construction materials.	1	3	7	City
DE	Design inadequate for purpose.	Design not completed in accordance with Standards or inexperienced designer.	Personal injury, collapse of structure.	3	3	12	Design completed by coastal engineer to the required standards. Chartered Engineer with Engineers Australia reviewed the design. Completed in accordance with MRA third party certified QMS.	1	3	7	City
DE	Poor materials create hazards - sharp edges, trip hazards	Poor material degrade over time.	Injury.	3	2	9	Facilities designed with durable materials.	1	2	5	City
DE	Damage to trees and existing vegetation,	Poor design or construction.	Environmental damage.	3	3	12	Tree survey completed and considered in design, tree protection required by specification.	1	2	5	City, Contractor
DE	Site contamination	Contamination in soils for excavation.	Environmental damage.	3	4	19	ASS maps and contamination register reviewed, self assessment completed. ASS management required.	1	3	7	City
DE	Failure of piled structures due to poor geotechnical conditions	Unexpected geotechnical conditions.	Injury or death.	3	5	23	Pile capacity testing to be undertaken as part of Design and Construct component of the structure.	1	5	15	City, Contractor
DE	Navigation.	Poor design which does not include navigational lighting.	Collision with structure. Injury or death.	2	5	20	Solar bollard lighting to be included on structure. Navigation markers and lighting to be installed to DoT recommendations.	1	5	15	City
DE	Collision of boat draught on riverbed.	Water depth insufficient for design vessel.	Damage to vessel.	3	4	19	Boat drought considered as part of the design.	2	4	14	City, Public
DE	Unsafe access for disabled persons.	Poor design.	Injury. People with a disability unable to use the	3	4	19	Structure designed to meet AS3962 requirements.	1	4	13	City
Construction											
Site Establishment & Traffic Management											
C	Public interference with site. Conflicts between pedestrians and works.	Poor site management and/or insufficient fence, signage.	Injury or death.	3	5	23	Contractor's management plans to be reviewed. Appropriate signage and fencing.	2	5	20	Contractor, Public
C	Conflicts between workers and machinery.	Poor access.	Injury or death.	3	5	23	Contractor's management plans and construction methodology. OHS practices, training, PPE.	2	5	20	Contractor
General Construction Hazards											
C	Falls	Inadequate barriers to areas where people could fall from a partially constructed structure.	Injury or death.	3	5	23	Contractor's management plans and construction methodology. OHS practices, training, PPE.	1	5	15	Contractor
C	Machinery and tools	Kick back from saws, improper use of tools.	Injury or death.	3	5	23	Contractor's management plans and construction methodology. OHS practices, training, PPE. Use appropriate tools for the works. Use of tagged, tested and maintained tools, RCDs.	1	5	15	Contractor
C	Workers hit by moving plants on construction site.	Working in close proximity to plant and machinery.	Injury or death.	3	5	23	Contractor's management plans and construction methodology. OHS practices, training, PPE. Spotters to be used for moving plant.	1	5	15	Contractor
C	Dangerous chemicals	Poor control of hazardous substances. Fumes.	Injury or death.	2	5	20	Contractor's management plans and construction methodology. OHS practices, training, PPE. MSDS to be located on site.	1	5	15	Contractor
C	Electrocution	Faulty equipment. Power equipment falling into the water.	Injury or death.	2	5	20	Contractor's management plans and construction methodology. OHS practices, training, PPE. Use of tagged, tested and maintained tools, RCDs.	1	4	13	Contractor
C	Fire	Cigarette buts, welding, grinding, hot metal work.	Injury. Death. Environmental damage.	3	5	23	Contractor's management plans and construction methodology. OHS practices, training, PPE. Fire extinguisher on site. No smoking on site. Hot works permit.	1	4	13	Contractor
C	Contaminants, fuel spills and environmental damage.	Construction works. Filling of handheld equipment, machinery, plant, etc. Acid sulphate soils	Injury. Environmental damage.	3	4	19	Contractor's management plans and construction methodology. OHS practices, training, PPE. Spill kit available on site.	1	4	13	Contractor
C	Injury from manual tasks.	Lifting and manual labour	Injury.	4	3	17	Contractor's management plans and construction methodology. OHS practices, training, PPE. Appropriate lifting techniques. Machine or Two person lifts where required.	2	3	11	Contractor
C	Trip hazards	Untidy site. Material and equipment left in the way.	Injury.	4	3	17	Contractor's management plans and construction methodology. OHS practices, training, PPE.	2	3	11	Contractor
Marine Construction Hazards											
C	Working over water	Construction works. Materials and machinery falling into the water.	Drowning. Environmental damage.	2	5	20	Contractor's management plans and construction methodology. OHS practices, training, PPE.	1	5	15	Contractor
C	Coastal hazards - severe events, waves, inundation and erosion.	Nature.	Damage to partially completed works leading to collapse or injury.	3	4	19	Contractor's management plans and construction methodology. OHS practices, training, PPE.	2	4	14	Contractor

Demolition Works											
D	Structure uncontrolled collapse during demolition.	Poor construction control and insufficient temporary shoring.	Personal injury and damage of equipment.	3	5	23	Contractor's management plans and construction methodology to be reviewed. OHS practices, training, PPE.	2	4	14	Contractor
D	Contamination of soil.	Poor construction control. Contaminants from previous works. Acid sulphate soils	Affect public health, amenity. Damage to environment.	2	4	14	Contractor's management plans and construction methodology to be reviewed. Silt curtain to be installed prior to demolition. ASS management required.	1	4	13	Contractor
D, C	Damage to existing services & infrastructure during demolition.	Poor construction control and planning.	Delays and additional costs to rectify. Personal injury.	3	2	9	Contractor's management plans and construction methodology to be reviewed. Before you Dig, services located & marked.	2	2	6	Contractor
D, C	Damage to trees and existing vegetation.	Poor demarcation of the site and trees requiring protection.	Environmental damage.	4	3	17	Contractor's management plans and construction methodology to be reviewed. Demarcation of site required. Site walk with Contractor and Superintendent to review the site prior to demolition.	1	4	13	Contractor
Piling											
C	Lifting heavy items - piling hammer, piles etc.	Poor piling methodology. Equipment / tools not considered for the works.	Injury or death from falling objects.	2	5	20	Contractor's management plans and construction methodology. OHS practices, training, PPE. Spotters to be used for moving plant. Lead lines to be used when lifting.	1	5	15	Contractor
C	Unstable crane or barge.	Poor piling methodology, sea conditions. Equipment / tools not appropriate for the works.	Injury or death. Crushing hazards.	2	5	20	Contractor's management plans and construction methodology. OHS practices, training, PPE. Equipment should be inspected prior to use.	1	5	15	Contractor
Operation & Maintenance											
Operation											
O	Overloaded deck from people or equipment.	Too much weight on deck of Facilities.	Injury or drowning.	2	5	20	City to provide signage outlining jetty capacity.	1	5	15	City, Public
O	Overloading from large vessels.	Vessel larger than design vessel berthing or mooring against structure.	Injury or drowning.	2	5	20	City to provide signage outlining berthing restriction.	1	5	15	City, Public
O	Overloading from large mooring loads resulting from waves and wind on vessel.	Vessel moored against structure during severe events in excess of conditions allowed for in design.	Injury or drowning.	2	5	20	City to provide signage outlining adverse weather conditions in which the structure should not be used.	1	5	15	City, Public
O	Slippery deck.	Surface of structure not cleaned. Algae or sand build-up.	Injury.	3	4	19	City to implement regular maintenance and cleaning of the structure.	2	4	14	City
O	Collision of boat draught on riverbed.	Water depth insufficient for design vessel.	Damage to vessel.	3	4	19	City to provide signage outlining berthing restriction. City to monitor depth of water.	2	4	14	City, Public
O	Fire on Jetty.	Accident or vandalism.	Injury, burns.	2	4	14	Safety ladders provide access to water. Non-combustible materials used.	1	4	13	City, Public
O	Facilities hard to see at night and encroaches into the river.	Vessel hits the jetty because the structure is not illuminated.	Injury.	2	4	14	Structure to include navigational lighting. City to maintain the lighting.	1	4	13	City
O	Damage from vandalism.	Vandalism.	Injury from sharp edges or tripping hazards.	2	3	11	City to complete regular maintenance and durable materials to be used.	1	3	7	City
Maintenance											
M	Injury during maintenance.	Injury due to routine maintenance to the structure, this could include cleaning, repair works, monitoring, etc.	Injury or death.	2	5	20	Contractor's management plans and construction methodology. OHS practices, training, PPE. MRA designed the structure to a high standard to reduce potential maintenance requirements.	1	5	15	City, Contractor
Decomissioning & Demolition at end of Service Life											
D	Works required to remove structures.	Change in management approach requiring removal of structures	Potential personal injury/death during demolition works.	2	5	20	Contractor's management plans and construction methodology. OHS practices, training, PPE.	1	5	15	Contractor
D	Structures degrade to a point where it requires maintenance.	Increased risk of exposure to storm events beyond the end of the service life	Damage to structure and erosion of dune. Personal injury.	2	5	20	City to continue monitoring condition of structures and to reconstruct/upgrade.	1	3	7	City, Contractor