TECHNICAL REPORT

MOUNT HENRY SPIT
RESTORATION PLAN

SEPTEMBER 2014

FOR
CITY OF SOUTH PERTH

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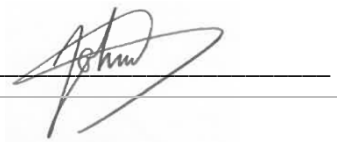
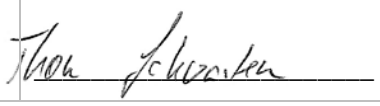
Author: AJ		**Reviewer**: TS	
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1.0 PROJECT BACKGROUND

The Mount Henry Spit (the Site) is a 4.03 hectare (ha) section of the Mount Henry Peninsula, which has the largest area of remnant bushland still persisting within the City of South Perth (the City) Local Government Area.

The Spit itself is considered to be conservation significant because it supports floristic assemblage that is not well represented within the immediate proximity to Canning River and in the wider Perth Metropolitan area. As such, the Site has been recognised as regionally significant and forms a part of Bush Forever Site No. 277 (Department of Environmental Protection 2000).

The Spit is characterised by an estuarine foreshore and low sandy slopes which have been subject to a variety of disturbances resulting in continuous habitat degradation impacting negatively on the ecological function and values of the Site. Of primary concern is the rate at which the foreshore particularly the spit end is being affected by erosion. The low topography of the Site makes it highly susceptible to rising water levels and storm surge events. In addition, informal access throughout the Site and the long history of disturbance has provided an avenue for further erosion, degradation of vegetation and the introduction of invasive weeds.

Given the biodiversity, conservation and amenity values of the area and the threatening processes to those assets, the Swan River Trust (the Trust) has classified the Mount Henry Spit as the area of high management priority – “Priority 1” in its Swan and *Canning Rivers Foreshore Assessment and Management Strategy* (2008) publication. Following the recommendations given in that document, a funding agreement was formed between the Trust and the City to commission the preparation of a Restoration Plan for the Site.

This Restoration Plan provides background information for the Site, defines the restoration intent and outlines works necessary to achieve restoration objectives. The Plan also takes into account the possible impacts of climate change at the Mount Henry Spit which include average sea level rise, increased storm surge events and a drying climate.

1.1 PROJECT OBJECTIVES AND OUTCOMES

This Plan provides an operational and practical guide that will allow the City to:

- Set priorities and achievable restoration goals;
- Implement appropriate works to facilitate the most ecologically appropriate and economically feasible approach for foreshore restoration;
- Allow effective allocation of resources; and
- Seek funding opportunities.

The Plan includes:

- An outline of works designed to reduce erosion and to retain and enhance the biodiversity values of the area, based on the physical site investigations and consideration of the existing information; and
- Indicative costs and timelines for implementation and maintenance works.

1.2 SCOPE OF WORKS

The scope of works undertaken to prepare this Plan included the following:

- A desktop study of historical, land use, environmental and other relevant background documentation;
- Field assessments of the Site including, foreshore assessment, bushland condition, and floristic composition;
- Wave velocity study and assessment;
- Development of specific management actions based on particular environmental issues including: erosion, climate change, vegetation composition and condition, presence of weed species, access, maintenance and monitoring; and
- Indicative timelines and a detailed cost estimates for implementation.

PART 2: SITE CONTEXT

2.0 LOCATION AND ENVIRONMENT

This section of the report provides details of the existing environmental aspects of Mount Henry Spit that form the basis for the development of this Restoration Plan.

2.1 LOCATION

The Mt Henry Spit is located within the City of South Perth and is part of the Canning River catchment close to the confluence with the Swan River estuary system. Together with the Mount Henry Bushland to the east, the vegetation of the Spit forms part of Bush Forever Site No. 227.

This restoration plan covers the area of approximately 4.03 ha which includes 900 linear metres (Lm) of foreshore and encompasses the dryland area up to the Kwinana Freeway road reserve (Figure 1).

Figure 1 Site location within the Perth Metropolitan Area (Imagery: Landgate, 2006)

2.2 CLIMATE

The project area has a Mediterranean climate which is characterised by wet, mild winters and dry, hot summers.

The mean minimum and maximum winter temperatures are 7.6°C and 18.4°C respectively, with the mean minimum and maximum summer temperatures being 18.3°C and 31.6°C respectively. The mean total annual rainfall for Perth is 728.8 mm (Bureau of Meteorology 2013 for Perth Metro Station 009225 1994-2013).

The winds on site are typically dry easterlies in the morning and then cooling moderate to strong south-westerlies in the afternoon, (Bureau of Meteorology 2013). The exposed position of the Mt Henry Spit means that it is often influenced by winds from many directions.

2.3 TOPOGRAPHY

The dominant topographical feature in the vicinity of the Site is Mount Henry which rises to 15 m above sea level (Water and Rivers Commision 1997). The Site lies to the western side of Mount Henry where the landscape changes from low undulating dunes to sandy beaches at the Spit. The Mt Henry Spit is topographically low and is approximately 1-2 m above the ground water level (Department of Water 2013). As a consequence Mt Henry Spit is subject to inundation during high water levels (Water and Rivers Commision 1997).

2.4 GEOLOGICAL SETTING AND SOILS

Mt Henry Spit is part of the eastern most dune of the Spearwood Dune System, bordering on the Bassendean Dune System. Over time the calcareous sands have formed into limestone that can be observed on the exposed sections of cliff on the southern end of the Mount Henry Spit (Ecoscape 2004). The soils present on site were described by Brooker *et al.*, (1993) as being characteristic of Cottesloe soils (sands) with limestone present very close to surface. The sands are white to pale grey, sub-angular to sub-rounded, medium to course-grained quartz sand with shell fragments of alluvial origin. The sands associated with the limestone located adjacent to the freeway are light yellowish brown, fine to course-grained, sub-angular to well rounded, quartz (Gozzard 1983).

At the western-most end of the Spit where remnant Swamp Sheoaks (*Casuarina obesa*) are present, small areas of exposed Swan River Alluvium of silty clay, soft, grey to black with some organic fines are found.

2.5 HYDROLOGY

The Site experiences a high level of hydrological activity and understanding the hydrology is crucial to determining an appropriate restoration approach as the vegetation communities found on site rely on these processes.

2.5.1 Surface water

The most prominent surface water feature adjacent to the Site is the Canning River as it surrounds the Spit from the north, west and south. There are no significant surface water features within the Site boundary with the exception of swales which occur across the lower slopes where winter water table is close to the surface. Any surface water runoff due to rainfall would be discharged directly into the Canning River; however, it is expected that most of the rainfall would infiltrate on Site.

Any inundation of the Site is primarily due to seasonal fluctuations in the river level particularly during winter high tides and storm events. The inundation negatively impacts on vegetation health of the foreshore and dryland areas. This in particular increases the erosion potential in foreshore areas that are not vegetated and increases salinity levels in areas where vegetation is not tolerant to such change (e.g. dryland vegetation).

2.5.2 Groundwater

The Mt Henry Spit is on the edge of the Cloverdale groundwater mound, the smallest of the three mounds in the Perth Metropolitan Area (Ecoscape 2004, Water and Rivers Commision 1997). The Site is positioned approximately 1-2 m above the ground water (Department of Water 2013). In addition, a small groundwater mound exists under the Mount Henry Peninsula. This mound dries up during summer and is recharged from infiltrating winter rains (Ecoscape 2004).

2.5.3 Tidal Influence

The section of the Canning River surrounding the Site is classified as estuarine with tidal influences experienced past the Site to the Kent Street Weir. Based on a review of readily available information, no tidal observations have been conducted directly at the Spit. Given this, for the purposes of this document it has been assumed that tidal influences will approximate those experienced at the Barrack Street Jetty with average daily tidal range of 0.4m (Department of Water 2013, Water and Rivers Commision 1997).

2.6 FLORA AND VEGETATION

Historically the vegetation on site was described as that of the Bassendean Complex. This complex is highly variable and incorporates woodlands of Jarrah *(Eucalyptus marginata*), Sheoak (*Allocasuarina fraseriana*) and Banksia species (*Banksia* spp.) to sedge lands and herblands in the moist depressions / swales.

The foreshore vegetation of the Spit consists of a mosaic of *Juncus kraussii* sedgelands with *Sarcocornia quinqueflora*, *Suaeda australis* and *Sporobolus virginicus* (Marine couch) and a canopy of *Melaleuca cuticularis* and *Casuarina obesa* (Ecoscape 2004).

The dryland sandy slopes of Mount Henry Spit are covered with a low woodland community dominated by Christmas tree (*Nuytsia floribunda*), Sheoak (*Allocasuarina fraseriana*) and grey stinkwood (*Jacksonia furcellata*). The understorey supports low shrubs and herbs such *Leschenaultia floribunda*, *Dasypogon bromeliifolius* and *Phlebocarya ciliata* (Ecoscape, 2004). The dryland community once supported Jarrah (*Eucalyptus marginata*); however, this has been selectively logged historically and no Jarrah trees are currently present on site (Water and Rivers Commission 1997).

Due to a long history of disturbance, the vegetation condition on site is largely degraded (Ecoscape, 2004). The loss of vegetation cover has resulted in high level of erosion at the western face of the Spit and introduction and establishment of the several environmental weed species such as **Ehrharta calycina* (Veldt grass).

No specific records exist for significant flora on Mount Henry Spit. *Dodonaea hackettiana* which is a Priority 3 species is listed for the Bush Forever Site No. 227 *(*Department of Environmental Protection, 2000)*;* however, it is unlikely that this species remains on Site as the only habitat that would have supported this species on Site was disturbed by the building of the Mount Henry Bridge.

Whilst it is unlikely that Threatened or Priority flora might be present due to a long history of disturbance, species such as *Phlebocarya ciliata* which persisted on site would be considered as locally significant due to their poor representation (or representation at a lower abundance) in the nearby bushland communities.

2.6.1 Introduced Flora

The introduction and spread of the weeds on site has been facilitated through long-term poor land management practices associated with land use, particularly clearing, trampling, and compaction. Some species such as Geraldton Wax (*Chamelaucium uncinatum*) and Peppermint (*Agonis flexuosa*) have been introduced as part of freeway verge and Dual Use Pathway (DUP) revegetation works, further compromising the integrity of the remnant (natural) bushland.

Veldtgrass (**Ehrharta calycina*) is the most prolific weed on site with Kikuyu (**Cenchrus clandestinum*) and Couch (**Cynodon dactylon*) also being abundant (Ecologia, 2004, NAC, 2012). These species have resulted in replacement of native understorey species, particularly in remnant fringing paperbark communities (Ecoscape, 2004).

A comprehensive weed survey was conducted in 2012 by Natural Area Consulting (NAC, 2012). Data obtained during this survey has been used to assist in developing the Weed Management Plan (which forms a component of this report).

2.7 TERRESTRIAL FAUNA

Remnant vegetation in urban areas can act as important habitats for a number of fauna species. Birds, reptiles and amphibians in particular can thrive in relatively small remnant areas provided suitable habitat persists. However, the importance of these areas in the maintenance of fauna populations is largely related to the condition of the vegetation and the connection to other remnant areas. Much of the vegetation communities present at the Mount Henry Spit are currently considered degraded or in a completely degraded condition (approximately 65% of the Site) and the Spit is heavily impacted by invasive plant species and introduced fauna. Control of these invasive species and the rehabilitation of the Site to a state representative of its origins (i.e. replanted with locally appropriate native species) will facilitate the maintenance of existing fauna populations and may enable nearby populations of fauna to expand into the area.

2.7.1 Native fauna

Surveys encompassing the full suite of fauna at the spit have been limited in recent years. A search on NatureMap (DEC, 2013) and a literature database has identified that comprehensive surveys were conducted in 1964 and 1994 (How and Dell 2000) and reptiles were surveyed in the early 1990's (DEC 2007-2013 NatureMap accessed February 2013, How and Dell 1994). These surveys identified a range of relatively common reptiles and amphibians, in and around the vicinity of the Mount Henry Spit. A Priority 3 (Department of Environment and Conservation 2013) reptile, *Lerista lineata* (Perth slider or lined skink) was noted in How and Dell's (2000) survey, however Syrinx could find no confirmation of any records since that date, nor confirm if the record was from the Spit or another part of the Peninsula. A single record of a Priority 5 mammal, the quenda or southern brown bandicoot (*Isoodon obesulus* subsp. *fusciventer*) was made in the 1964 (Western Australian Museum Mammal Database – accessed through NatureMap February 2013) in the area (no exact location is provided), although none were reported in the 1994 survey (How and Dell 2000) and no detail could be found to determine if other future surveys have targeted this species. Anecdotal evidence suggest the species may still be present at the Site, however the degraded nature of the majority of the habitat and the large numbers of feral predators

including cats and foxes noted at the Site (Ecoscape 2004) would suggest if the quenda is still present numbers are likely to be limited.

The area was surveyed for birds most recently in 1999, 2000 and 2001. A number of the birds recorded during these surveys are considered of international importance as they are protected under a variety of international migratory bird agreements. The species of birds of migratory significance include the common sandpiper (*Actitis hypoleucos*), sharp-tailed sandpiper (*Calidris acuminata*), bat-tailed godwit (*Limosa laponica*) and the rainbow bee-eater (*Merops ornatus*). The area is also frequented by a number of bushland birds including a variety of honeyeaters (DEC 2007-2013). The Directory of Bush Forever Sites, indicates the area may be suitable as a feeding area for Carnaby's Cockatoo (Department of Environmental Protection 2000), which is currently listed as endangered and is also protected pursuant to the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The DEC mapping of the Carnaby's Black Cockatoo habitat indicates that the Spit is within the known Carnaby's Black Cockatoo roost area buffer. Whilst the *Casuarina obesa* and *Allocasuarina fraseriana* on the Spit may contribute to the feeding habitat of this endangered species, it is unlikely that the birds would roost on the Spit.

Several invertebrate fauna are likely to occupy the range of habitats on site some of which may be rare or endangered; however, no certified records for invertebrate conservation taxa exist for the Mount Henry Spit.

An incidental observation by the City's Natural Areas Maintenance team has recorded a trapdoor spider nest on site in October 2013. Whilst the spider was not located, the nest was in good condition indicating that it had likely been recently maintained by the spider. Several photographs (see Figure 2) were sent to the WA Museum for confirmation and the first indications are that the nest might be that of the *Idiosoma hirsutum* a rare species which is known to occur at Salter Point and few other locations in the Perth Metropolitan area.

Although unconfirmed, it is important that prior to any restoration works detailed inspections are made to ensure no disturbance to trapdoor spider nests or other native fauna occur. If found the locations of the nests should be clearly marked to avoid their disturbance. The City and the Contractor should consult with the expert fauna specialists to identify the species and seek the best strategy for its protection. For this reason it is prudent to complete detailed site inspections well in advance of restoration works (i.e. at a minimum of 2-3 weeks prior to start of works).

Figure 2 Trapdoor spider nest at Mount Henry Spit October 2013 (Source: City of South Perth)

2.7.2 Introduced fauna

How and Dell (2000) recorded the presence of the introduced house mouse (*Mus musculus*) in the area and it is likely that the black rat (*Rattus rattus*) occurs at the Site. Ecoscape (2004) suggested that foxes, cats and dogs frequent the area and rabbits have been recorded at the Site. According to Ecoscape (2004) rabbit control had been successful however, it was unclear if control of this pest continued beyond the reporting date.

2.8 EROSION

It is inferred that a natural rate of erosion would have occurred at the Site prior to European settlement, particularly along the foreshore with seasonal shifts in sand accretion (beach formation). Some level of vegetation loss would have been expected during severe storm events; however, it is likely that the vegetation would be able to recover during periods of stable and mild weather.

The examination of the historical aerial photographs available through Landgate (2013) has indicated that, since 1953 the erosion of the Spit has been relatively rapid at an average rate of approximately 800 mm per year (Figure 3). Ecoscape (2004) stipulates that just within one decade (1988 – 1997) the Spit had retreated about 5 - 10 metres. The causes of the erosion were listed as likely due to:

- Boat wash causing bank slumping;
- Storm waves at high water levels causing a similar slumping effect; and
- Southerly and northerly winds causing waves and moving sediment to the flanks of the Spit (Ecoscape, 2004).

The construction of the freeway and Mount Henry Bridge as well as loss of foreshore vegetation through trampling would have also significantly contributed to the rapid Spit erosion.

The dryland areas on site appear to be stable; however, there is a potential for a significant amount of soil to be lost during high storm events should native vegetation cover not be established along the foreshore. As the Site was used as a lay down area during construction of the freeway, some compaction of the ground may be present causing surface water flow to be diverted straight to the Canning River increasing sheet or rill erosion.

Figure 3 Traces of foreshore erosion from 1953 – 2014 (Source: Historical photographs from Landgate, 2013)

Note: traces of the vegetated areas were taken as opposed to the beach extent to avoid errors due to different water levels.

The beaches on the flanks of the spit have increased since 1953 with records from 1985 showing early signs of sedimentation in these areas. During construction of the Mount Henry bridge, dredge material resulting from installation of bridge foundations and piers had contributed to the increase in southern beach size. This may have had an adverse effect on the natural sediment movement and wave pattern to the south west of the spit point which shows first signs of erosion in 1981 and which has eroded by approximately 44m metres

since 1977 as opposed to the north west end of the spit which has eroded by 32m during the same time.

Approximately 13 – 15 m of shore are lost per decade since bridge construction. The erosion and sand accumulation / movement at the spit in the last decade (between 2004 and 2014) is shown in Figure 4.

Figure 4 Rate of erosion at the spit end between January 2004 and January 2014 (Image source: Landgate Map Viewer: https://www.landgate.wa.gov.au/bmvf/app/mapviewer/)

★Red star is used as a reference marker to show the extent of erosion.

Without a more detailed study of the wave impact and overall sediment transport on site it is difficult to predict the extent of future erosion / sedimentation patterns, suffice to say that it is likely that the erosion will continue in a similar manner, at least in the short term (i.e. next 5 – 10 years).

3.0 SOCIAL CONTEXT

In order to establish a restoration plan and evaluate the success of its implementation, the historical, cultural, and economic trends that shaped the ecosystem of Mount Henry Spit need to be understood. The events and/ or trends that have led to degradation of natural environment at the Mount Henry Spit, the current social context, and the potential impacts of restoration on the use of the Spit are presented in this section.

3.1 LAND USE HISTORY

Prior to European settlement, the Mount Henry Spit and Peninsula was a Nyungar hunting and fishing ground (Brooker *et al*., (1993) cited in Ecoscape, 2004). It is likely that the area formed a part of the river trail network that Nyungar people used to access hunting and food gathering grounds and to move from camp to camp.

There are no registered Indigenous Heritage sites within the Mt Henry Spit study area. However, the Swan and Canning River and their tributaries are registered as sacred sites (DIA, 2002) and are of high spiritual significance to Nyungar people.

Since European settlement, the Mt Henry Spit has undertaken many changes predominantly associated with the clearing of vegetation and the building of the Mt Henry Bridge.

In the 1920's, the foreshore area was commonly used for weekend camping, with up to 8000 people camping in the area on summer weekends (Ecoscape 2004). This caused concern for the health inspectors at the time due to sharp increases in pollution throughout the area. Later, during the depression of the late 1920's and 1930's, families took shelter in the bushland of the Mt Henry foreshore out of necessity, having been evicted from their homes around Perth. In 1936 the Mount Henry Peninsula was acquired by Christian Brothers as part of the Aquinas College (Ecoscape 2004).

During the late 1970's and early 1980's the Site was impacted by the construction of the Kwinana Freeway and the Mount Henry Bridge (opened in 1982). Between 2004 and 2006, the Mount Henry Bridge was widened and strengthened to accommodate the tracks of the Perth Southern Suburbs Railway. Currently the Site is under the care of the City of South Perth and experiences relatively light recreational use from walkers, cyclists, fishermen and boaters.

3.2 FACILITIES AND AMENITIES

The Site is accessible by a DUP along the eastern boundary adjacent to the Kwinana Freeway and contains a number of limestone walking tracks within the dryland areas of the Site. A small information board can be found at the entry gate to the northern end of the Spit.

Boat ramps are located at nearby Cloisters and Deep Water Point which service the majority of the area's boating activity.

3.3 CURRENT USE OF THE SITE

The Mount Henry Spit area is used recreationally for both on and off-shore activities. Walkers, runners and cyclists use the DUP. Cyclist activity is high along the path with commuters travelling between Perth and suburbs surrounding the Mitchell Freeway. Usage can be up to 300 cyclists per hour during peak times (City of South Perth 2011). The northern half of the reserve appears to be most impacted by cyclists, especially in the areas where the foreshore is very close to the DUP. Walkers frequent the area and currently use both formal and informal pathways to walk their dogs, for recreational walking as well as commuting to Aquinas College.

A formal beach access path is also present enabling access from the DUP to the foreshore from the south-eastern corner of the path closest to the Mount Henry Bridge. The public currently use the foreshore area for fishing, prawning, skiing, rowing, swimming, picnicking, etc. (Water and Rivers Commision 1997). Aquinas College also uses the Spit area periodically for interactive learning classes such as biology (Ecoscape 2004).

3.3.1 Boating and water skiing

The Canning River area adjacent to the Spit forms part of the Mount Pleasant water skiing area, which extends from the Canning Bridge, past the reserve to Aquinas Bay. This section of the river has a speed limit of 5 knots except between the hours of 9 am and sunset when boaters within the Mount Pleasant water skiing area can travel to speeds of up to 8 knots or more (Department of Transport 2013). Boat access to the area is not limited to the Cloisters launching site as many boats launch from nearby sites including the Narrows, Deepwater Point and Mt Pleasant to avoid launching congestion (City of South Perth 2011).

Field observations show that the area of river opposite the spit end is a popular spot to turn boatsaround as no turning within 100 metres of Mount Henry Bridge is permitted (The Mount Pleasant water ski area is also an official rowing course according to the Swan Canning River Boating Guide (Department of Transport 2013).

Aquinas College also use the area for rowing, canoeing and power boating (Ecoscape 2004).

4.0 FUTURE CONSIDERATIONS

4.1 CLIMATE CHANGE AND COASTAL FLOODING

The potential impact of future climate change on the Swan River area is important to consider for land management practices. There are three major processes linked to climate change that may adversely impact the Swan River. These include a rise in sea level, an increase in the magnitude and intensity of storm surges and a drying climate. Projections based on various CO_2 emission scenarios have predicted an increase in sea level and storm surge activity, as well as a reduction in rainfall in the future for the southwest of Western Australia (Swan River Trust Technical Advisory Panel 2007).

4.1.1 Sea level rise

Thermal expansion of the ocean or a rise in sea levels is predicted as a consequence of climate change. There is still uncertainty as to the size of the impact; however, current records from Fremantle show that the mean sea level of the Swan River rose at rate of 1.54 mm per annum between 1897 and 2007 (SRT 2007). Climate prediction models have indicated that rises in the sea level from the 1980-1999 levels may be between 0.18 m and 1 m by 2100 (Swan River Advisory panel, 2007, URS, 2013) or more than 3 m by 2300 (CSIRO, 2014) . A consequence of any sea level rise is that inundation levels at the Mount Henry Spit will increase.

The Department of Water (DoW) recently assessed the Swan and Canning River tidal and storm surge levels (URS, 2013) in order to incorporate the predicted sea level rise due to climate change and produce the new 100 year ARI flood levels.

The list below shows 100 year ARI water levels for the Site based on modelling results provided by URS (2013). These levels include the maximum water level for that site including the wind set up. The wind set up refers to the effect of the wind on tide levels during storm surges (i.e. elevation in the direction towards which the wind is blowing).

100 year ARI “Present Day” (2010)	1.44 mAHD
100 year ARI Future (2110)	2.23 mAHD

The flood levels above show that by year 2110 the entire site will be subject to flooding particularly during storm surge events.

The DoW has mapped the 100 year floodway and the flood fringe boundaries for the Swan Canning River System. The section relevant to Mount Henry Spit is shown in Figure 5 and

indicates that large areas of foreshore (~30% of the site) are subject to flooding under current 100 year ARI (DoW, 2013a).

Figure 5 100 year ARI Floodway and Flood Fringe Line (Source: Landgate , 2014 with dataset by DoW (2013a)

A rise in sea level and the associated increase in inundation and salinity are likely to negatively impact the vegetation communities at the Spit. Increased inundation may alter vegetation complexes, elevation (in relation to distance from shoreline) and existing species composition and distribution. This will likely promote the invasion of weed species and alter the density of native vegetation in the riparian zone (Swan River Trust Technical Advisory Panel 2007).

A rise in average water levels combined with increase intensity and frequency of storm surges (see Section 4.1.2) will alter current riparian vegetation leading to reduced bank stability and increase bank erosion. Foreshore deposition will also be affected due to a change in the sediment supply regime.

4.1.2 Storm surge activity

Storm surge is a rise above the normal water level along a shore resulting from strong onshore winds, reduced atmospheric pressure or flooding events. Low-lying areas are most

vulnerable to flooding from storm surge activity. Storm surges in the Swan River can be due to local weather systems or cyclonic activity along the Northwest Shelf of Western Australia.

A report from the Swan River Trust (2007) identified that the frequency and magnitude of storm surges in the Swan River had increased since 1990. In 1988 the maximum water level in the River was 1.85m but by 2006 the maximum water level was 1.98 m (metres Chart Datum) (Swan River Trust Technical Advisory Panel 2007). Water level data from the Barrack Street tide gauge between 1930 and 1978 shows that a high water level of 1.70 m was expected to occur every 10 year; however, in the period from 1988 to 2001 this level was reached every 5 years. Similarly, water levels of 1.65 m occurred at a frequency of every 7 – 8 years from 1930 to 1978, but by 2007 the frequency was recorded to be every 2 years (Swan River Trust Technical Advisory Panel 2007). The increase in maximum water levels in the Canning River particularly the lower reaches are also attributed to the increased mean sea level in addition to the storm surges. Currently the site is subject to flooding between 1 to 1.2 m AHD during storm surges (Figure 6).

Figure 6 Extent of flooding due to current storm surge events and the normal tidal activity including DoW 100 year ARI flood levels

Higher intensity and more frequent storm surges will increase the likelihood of vegetation degradation which may facilitate the invasion of transitional and weed species particularly between the current water level and 1m AHD. Some species which depend on presence of groundwater close to the ground surface may be affected by salinity particularly if the rainfall and the groundwater levels on site are lowered. Most affected species with regards to saline conditions are the species growing at the spit end such as *Phlebocarya ciliata, Dasypogon bromeliifolius and Nuytsia floribunda*.

In addition, the predicted increased magnitude of flooding events will likely destabilise river banks and in turn increase bank erosion which will effect riparian vegetation negatively. Sediment supply regimes will be affected by flooding events, in the Swan River area, influencing depositional character and stability of foreshores (Swan River Trust Technical Advisory Panel 2007).

It is important to note that the modelling for flood levels as presented by (URS, 2013) does not consider site specific conditions; therefore, the extent of flooding might be different to that predicted in the future. Nonetheless, the revegetation efforts in the predicted flood zones should be focused on riparian species which are able to cope with the changing water levels.

Deposition of sand on the flanks of the spit may decrease likelihood of flooding to the north and south of the site in short term and the elevated topography of the spit end keep vegetation above the flood line.

4.1.3 Drying climate

Western Australia is undergoing a change towards a drying and warming climate. Annual average surface temperatures in the south-west have increased by approximately 0.6°C from 1900 to 1990. The latest predictions have indicated that these temperatures may increase from between 1.6°C to 3.6°C by 2100 (Swan River Trust Technical Advisory Panel 2007) and this in turn will likely affect river water temperatures. Higher river temperatures will reduce the amount of oxygen available in the water column, which may facilitate an increase in the extent, frequency and severity of algal blooms. (Swan River Trust Technical Advisory Panel 2007). A subsequent increase of algae levels may increase the occurrence of algae being washed up on the shore, creating a smothering effect on the intertidal vegetation.

Coupled with the current rises in surface temperature in the south-west of WA, there has been a steep decline in autumn and winter rainfall since the 1970's that has significantly decreased regional river flow. This, in combination with rises in sea levels, has enabled marine water to move further upstream during summer and autumn causing an increase in saline conditions further upstream than previously recorded. Future predictions indicate that winter rainfall in the south-west will decrease from the 1925 - 1975 averages by between 17

and 40% by 2100 (Swan River Trust Technical Advisory Panel 2007), increasing the potential for the salt wedge to move further upstream.

The most influential aspect of a drying climate on vegetation structure and health in the near-shore environment is an alteration to surface and groundwater. Research on the hydrology and ecology of the near-shore environment by CSIRO has demonstrated that changes to river flows and sea level rises will result in increased seasonal inundation and displacement of the near-shore zone groundwater by saline waters (Linderfelt and Turner 2001). This will alter the composition and complexity of vegetation communities, particularly those which support groundwater dependent species and alter the aquatic fauna able to persist in the area. Less rainfall will result in a reduction in runoff which will potentially alter the nutrient and sediment loads to the Canning River, as well as altering the salinity of both the River and near-shore groundwater.

Species found on site that are associated with damplands (seasonally waterlogged sites) such as herbs *Dasypogon bromeliifolius* and *Phlebocarya ciliata* and shrubs like *Hypocalymma angustifolium* will be most at risk from losses due to reduced rainfall and lowering of the groundwater levels. Incursion of salt into groundwater column will have detrimental effect on most dryland flora and therefore careful monitoring of groundwater and plant health may be required to strategically plan revegetation activities in the future.

Sediment availability and transport are also influenced by drying climate with less sediment transport occurring from the catchment (e.g. Bull Creek and the Canning River).

PART 3: FIELD ASSESSMENTS

5.0 ASSESSMENT METHODOLOGY AND RESULTS

5.1 FORESHORE ASSESSMENT

A foreshore assessment was undertaken along the entire length of the Mount Henry Spit foreshore on the 24th January 2013. The project area was traversed on foot and nine foreshore profile cross-sections were established to represent the entirety of the foreshore condition. The locations of these profiles were selected as a comprehensive representation of the varying condition of the foreshore and were based on their distinct characteristics. A laser level was utilised to ensure the accuracy of ground and water levels and to detect subtle changes in micro-topography.

The following attributes were evaluated during the foreshore assessment:

- Evidence of erosion and degradation of the foreshore;
- Foreshore profiles including relative levels and estimated high and low water levels;
- Vegetation composition and position in relation to relative levels;
- Ground cover e.g. presence of litter, bare sand etc.; and
- Formal and informal access to foreshore areas.

The results of this assessment of each section are presented in Appendix 1.

5.2 SOIL PROFILE ASSESSMENT

A total of three (3) soil profiles were recorded across the Site to a depth of 1 m using a hand auger (see Figure 7) in order to understand the characteristics of the soil in relation to the different vegetation communities. The profiles were characterised according to the substrate, its variation with depth, soil moisture and ground water levels.

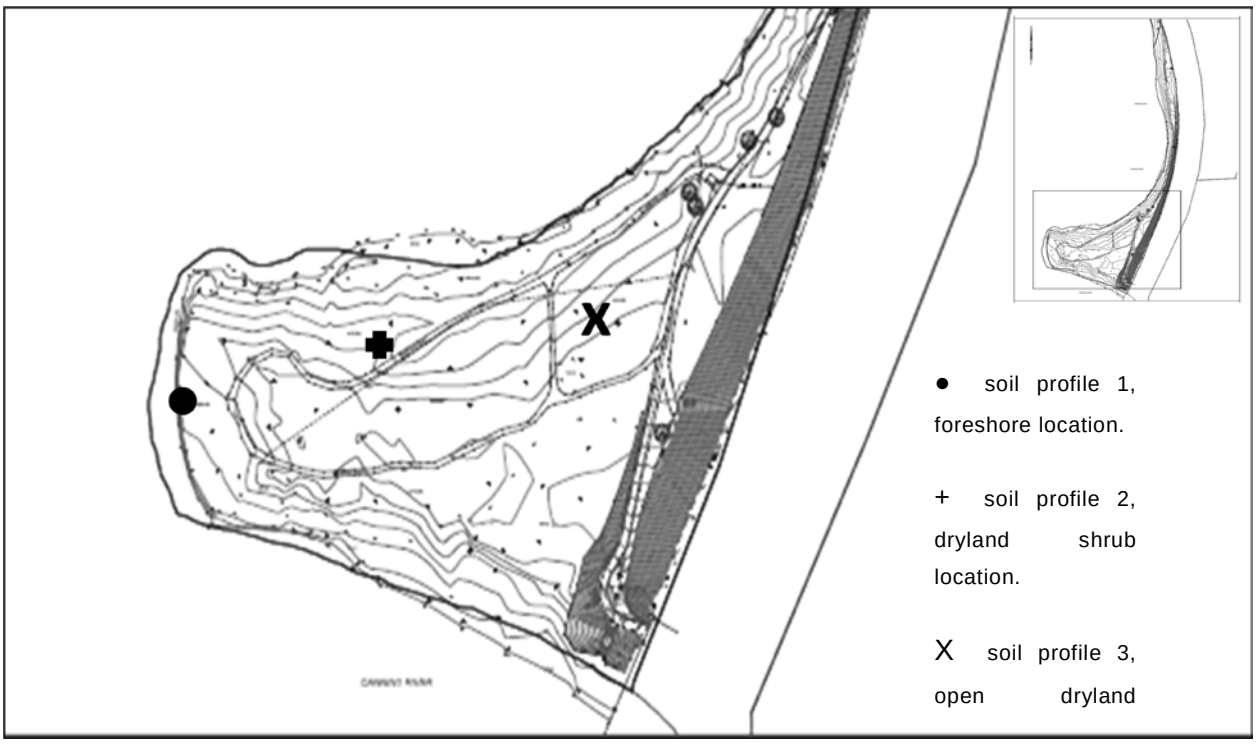


Figure 7 The locations of Mount Henry Spit soil profile assessments

Soil profile 1 was composed entirely of sand with some organic matter noted at 400 mm below the surface (Figure 8). Below 400 mm there was a decreasing percentage of organic matter in the soil. Groundwater was noted at 700 mm below the surface. Soil profiles for sites 2 and 3 had a similar composition with sand dominating the soil profile and an increase in soil moisture at 800 mm below the surface level (Figure 8).

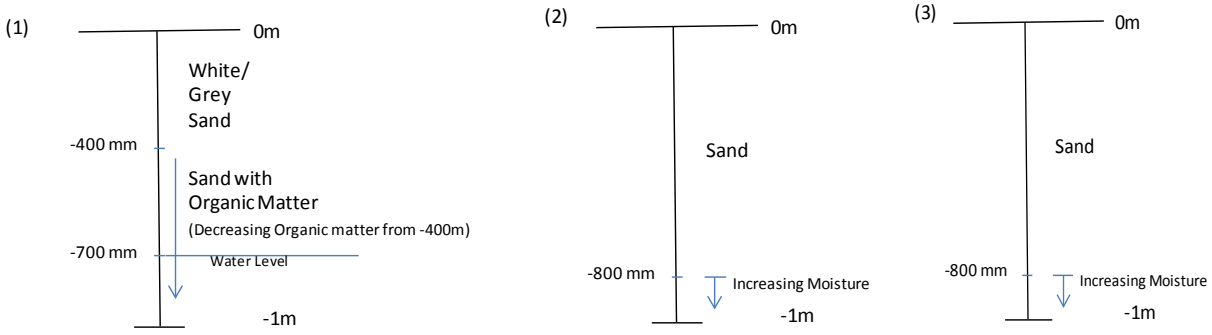


Figure 8 Soil profiles taken at Mount Henry Spit outlining soil composition and moisture levels

5.3 WAVE VELOCITY ASSESSMENT

The purpose of the wave velocity assessment for the Mount Henry Spit was to provide some indication as to the effect of boat wash on the shoreline and assist in determining the most appropriate restoration techniques able to withstand onshore wave impacts.

Two Starflow Ultrasonic Doppler flow meters were used to estimate the velocity of waves impacting on the foreshore at two locations on site (see Appendix 2). The wave velocity data is inferred to be an indicator of the intensity of wave impact on the shoreline.

The wave velocity measurements at the two locations (on the southerly facing foreshore (bridge end) and the westerly facing foreshore (spit end) show higher mean average wave velocities at the southern foreshore resulting in the bank undercutting and loss of *Casuarina obesa* and *Melaleuca cuticularis* trees. Overall, the wave impact assessment suggests the wave velocity is influenced by wind driven wave impact particularly from the predominant south to south - westerly winds as well as the boat wake. The observational data recorded indicate that the north-facing beach of the Spit is also impacted; however, the key driver for the erosion at this Site appears to be the boat wake.

The wave velocity assessment for the Mount Henry Spit area suggests that the foreshore restoration should adopt techniques that would protect the shore from boat wake and south westerly winds particularly at high tide. This can be achieved through the use of brushwalling technique in combination with a rock toe, erosion fabric and planting of indigenous flora species such as sedges and trees. The orientation of the brushwalling should be such that it is perpendicular to wave movement therefore reducing the wave impact.

Aerial image of the site from 22nd January 2014 shown on the next page (Figure 9) is used to demonstrate the effect that the boat wake has on the wave pattern which is congruent with the accelerated erosion at the south west end of the spit and sand movement along the flanks of the spit.

Wind waves also have an effect on erosion particularly the northerly and north westerly winds during winter storms and surge events. These winds have a large fetch and pass over deeper water thus generating larger waves. However, the frequency and duration of winds blowing from the northerly – north westerly direction is low compared to the overall wind directions being north easterly – easterly in the mornings and south to south westerly in the afternoon. Whilst the south westerly winds also cause erosion of the spit end, the fetch is relatively small and the water relatively shallow particularly closer to shore. This would suggest that under normal conditions, waves generated by boat wake have a greater influence on erosion than wind waves in isolation, but this cannot be confirmed without further testing of both variables in isolation.

The storm surges are likely to greatly accelerate erosion on site because the shoreline has already been destabilised via undercuts (formed most likely as a result of boat turning in close proximity to the spit point and wind waves) and has no protective vegetation layer.

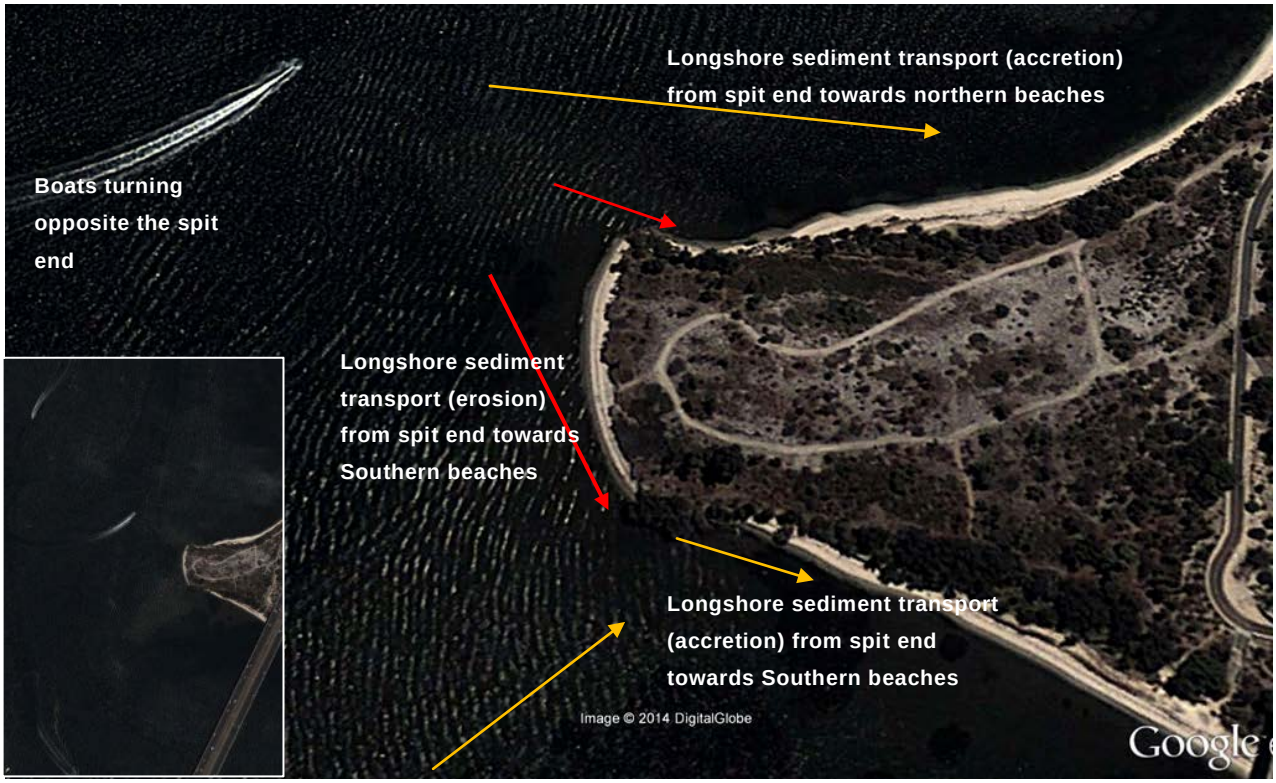


Figure 9 Wave pattern generated by boat wake indicating erosion of the spit end and deposition of sediments along the spit flanks (Imagery: Google Earth, 2014)

5.4 FLORA AND VEGETATION ASSESSMENT

A flora and vegetation assessment of the Spit was conducted on the 5th February 2013. Flora diversity, vegetation composition, structure and condition were assessed using traverses of the Site.

All native and introduced flora species noted during the Site inspection were recorded using the relevé approach. Relevé (French for 'survey') is a fast method of recording species within a given vegetation community based on species abundance and cover. This is done by traversing a particular vegetation community or ecotone (ecotone is the area of transition between two communities) and recording all dominant species and estimating their foliar cover (qualitative assessment). This method is also useful in recording species within degraded communities where species richness is poor and the area of assessment smaller than 100m^2 (i.e. standard plot size for flora assessments on the Swan Coastal Plain).

In this study relevé approach was used as it was considered to be the most efficient and thorough way to record specific vegetation community zones and species which would be

suitable for revegetation. The species list from Mt Henry Peninsula Foreshore Management Plan 2004 (Ecoscape 2004) as well as the list of all weed species recorded on site more recently (NAC, 2012) have been compared with the results from this study to help with the development of the revegetation species list.

5.4.1 Vegetation Description

The vegetation community descriptions were based on the height and estimated cover of dominant species using Aplin's (1979) modification of the vegetation classification of Specht (1970) for the remnant bushland. The methodology is congruent with that described in Keighery (1994).

Table 1 Vegetation Structural Classes based on Muir (1977), and Aplin's (1979) modification of the vegetation classification system of Specht (1970)

Stratum	Canopy cover				
	70-100 %	30-70%	10-30%	2-10%	<2%
Trees over 30 m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland	Scattered tall trees
Trees 10-30 m	Closed forest	Open forest	Woodland	Open woodland	Scattered trees
Trees under 10 m	Low closed forest	Low open forest	Low woodland	Low open woodland	Scattered low trees
Shrubs over 2 m	Tall closed scrub	Tall open scrub	Tall shrubland	Tall open shrubland	Scattered tall shrubs
Shrubs 1-2 m	Closed heath	Open heath	Shrubland	Open shrubland	Scattered shrubs
Shrubs under 1 m	Low closed heath	Low open heath	Low shrubland	Low open shrubland	Scattered low shrubs
Hummock grasses	Closed hummock grassland	Hummock grassland	Open hummock grassland	Very open hummock grassland	Scattered hummock grasses
Grasses, Sedges, Herbs	Closed tussock grassland / bunch grassland / sedgeland / herbland	Tussock grassland / bunch grassland / sedgeland / herbland	Open tussock grassland / bunch grassland / sedgeland / herbland	Very open tussock grassland / bunch grassland / sedgeland / herbland	Scattered tussock grasses / bunch grasses / sedges / herbs

5.4.2 Vegetation Condition Assessment

Condition of vegetation within the Site was assessed in accordance with the vegetation condition scale outlined in Keighery (1994) (see Table 2).

Table 2 Vegetation Condition Scale from Keighery (1994).

Vegetation Condition	Description
(1) Pristine	Pristine or nearly so, no obvious signs of disturbance
(2) Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
(3) Very Good	Vegetation structure altered with obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
(4) Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
(5) Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing
(6) Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

5.5 VEGETATION ASSESSMENT RESULTS

Overall the Site has two vegetation associations and six communities. The vegetation associations for the Site are:

1. **Foreshore**

   Low Open Forest of *Casuarina obesa* and *Melaleuca cuticularis* with **Scattered shrubs** of *Rhagodia baccata* over **Sedgeland** of *Juncus kraussii*, *Schoenus subfascicularis* and *Gahnia trifida* over **Open Grassland** of *Sporobolus virginicus* and **Cynodon dactylon* with **Scattered Herbs** of *Suaeda australis, Sarcocornia quinqueflora* and **Chenopodium album;* and

2. **Dryland**

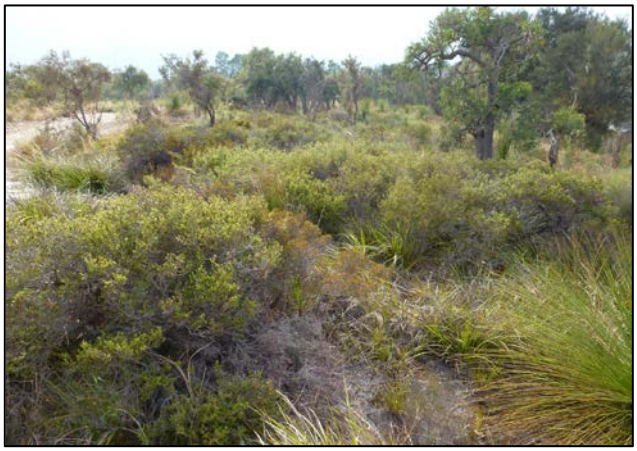
   Low Open Woodland of *Allocasuarina fraseriana, Nuytsia floribunda* and *Corymbia calophylla* over **Open Shrubland** of *Jacksonia furcellata*, *Adenanthos cygnorum*, *Allocasuarina humilis* and *Xanthorrhoea preissii* over **Scattered Low Shrubs** of *Hibbertia hypericoides, Eremaea pauciflora*, *Lechenaultia floribunda, Hypocalymma angustifolium* and *Acacia stenoptera* over **Closed Sedgeland** of *Lyginia barbata*, *Alexgeorgea nitens, Hypolaena exsulca* and *Schoenus subfascicularis* with **Very Open Herbland** of *Phlebocarya ciliata, Dasypogon bromeliifolius, Conostylis aculeate and Patersonia occidentalis*.

Note: Species with ***** in front of their name are introduced (weed) species

A total of six vegetation communities were described for the Site based on the species composition and abundance. The photographs of each community together with the community description based on the dominant flora are presented below. The map showing the distribution of each community is presented in Figure 10.

Community 1 Low Open Forest of *Casuarina obesa* and *Melaleuca cuticularis* with Scattered shrubs of *Rhagodia baccata* over Sedgeland of *Juncus kraussii, Schoenus subfascicularis* and *Gahnia trifida* over Open Grassland of *Sporobolus virginicus* and **Cynodon dactylon* with Scattered Herbs of *Suaeda australis, Sarcocornia quinqueflora* and **Chenopodium album*

Community 2 Low Open Woodland of *Allocasuarina fraseriana* and *Nuytsia floribunda* over Open Shrubland of *Jacksonia furcellata* and *Xanthorrhoea preissii* over Scattered Low Shrubs of *Hibbertia hypericoides*, *Hypocalymma angustifolium* and *Acacia stenoptera* over Closed Sedgeland of *Hypolaena exsulca* and *Schoenus subfascicularis* with Very Open Herbland of *Phlebocarya ciliata* and *Dasypogon bromeliifolius*



Community 3 Scattered Trees of *Nuytsia floribunda* and *Corymbia calophylla* over Shrubland of *Eremaea pauciflora*, *Hibbertia hypericoides, Lechenaultia floribunda* and *Xanthorrhoea preissii* over Very Open Herbland of *Phlebocarya ciliata* and *Patersonia occidentalis*

Community 4 Low Open Woodland of *Nuytsia floribunda* and *Allocasuarina fraseriana* over Tall Shrubland of *Jacksonia furcellata* and *Adenanthos cygnorum* over Low Open Shrubland of *Lechenaultia floribunda* and *Allocasuarina humilis* over Very Open Herbland of *Dasypogon bromeliifolius, Phlebocarya ciliata* and *Corynotheca micrantha* over Very Open Sedgeland of *Lyginia barbata* and *Alexgeorgea nitens with* Very Open grassland of **Ehrharta calycina*

Community 5 Low Open Woodland of *Nuytsia floribunda* and *Corymbia calophylla* over Tall Shrubland of *Kunzea glabrescens* and *Jacksonia furcellata* over Low Open Shrubland of *Lechenaultia floribunda, Acacia stenoptera* and *Xanthorrhoea preissii* over Sedgeland of *Schoenus subfascicularis* over Very Open Herbland of *Phlebocarya ciliata* and *Corynotheca micrantha* with *Pteridium esculentum*

Community 6 Mixed Exotics: Tall Shrubland of *Acacia saligna, Chamelaucium uncinatum* and *Acacia cyclops* over Open Shrubland of *Kunzea glabrescens*, *Melaleuca huegelii* and *Hakea prostrata* over Very Open Grassland of **Ehrharta calycina* and **Avena barbata*

Figure 10 Vegetation communities of the Mount Henry Spit

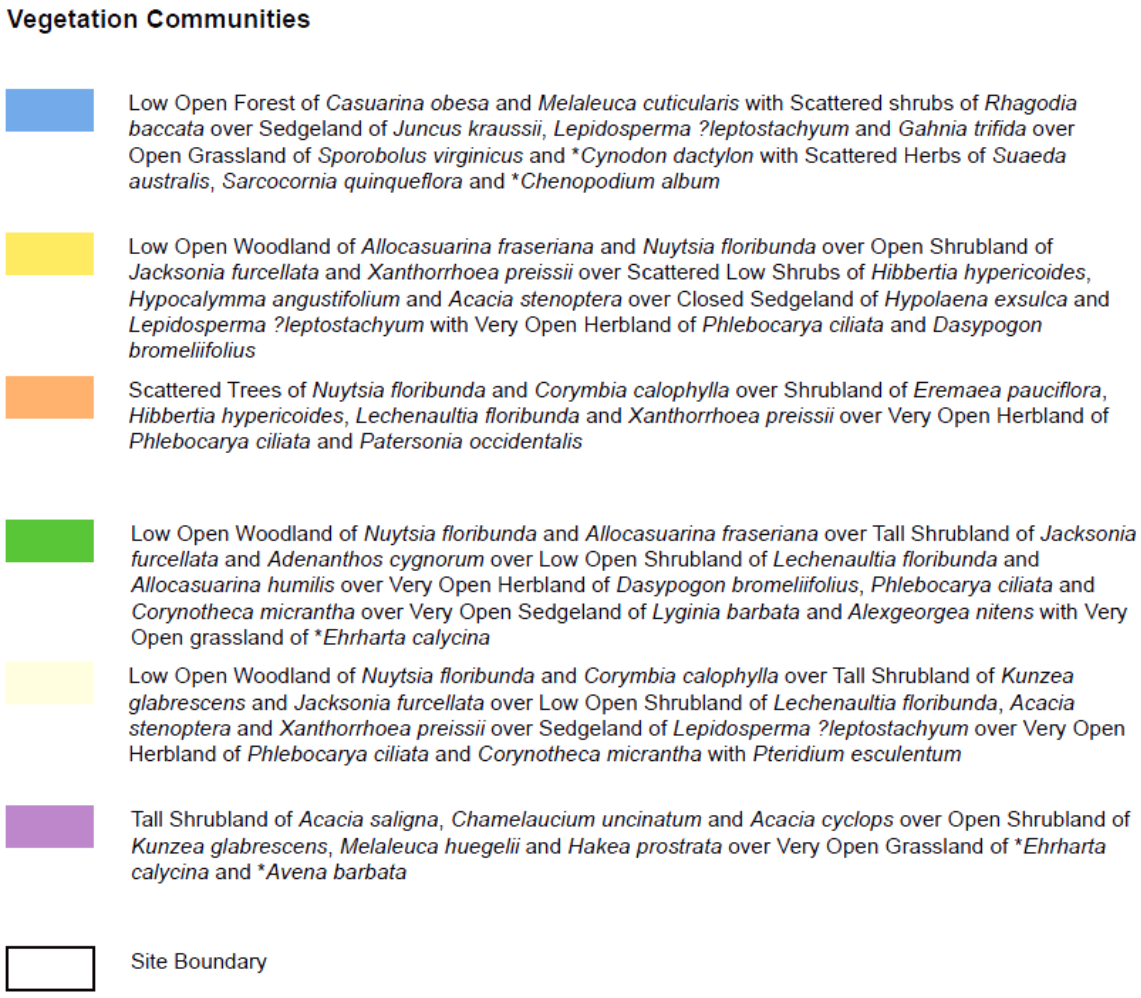


Figure 11 Legend for vegetation communities of the Mount Henry Spit

5.5.1 Vegetation Condition

The condition of vegetation on site ranged from Completely Degraded to Very Good, based on the condition scale adapted from Keighery (1994) (see Table 2). However, the majority of the Site (64.5%) is considered to be Degraded to Completely Degraded, largely because of clearing and trampling of native vegetation and the presence of exotic flora species such as grasses and planted non-native species (e.g. flora such as that along the freeway embankment) (see Figure 12).

Species composition of vegetation communities found in areas that were considered of Good (7.5%) and Very Good (28%) condition were used to form a list of species required to restore the degraded areas, to a pre-disturbance condition.

Figure 12 Vegetation condition of the Mount Henry Spit

5.5.2 Flora and Vegetation of Conservation significance

No Priority or Threatened flora were identified on site and they are unlikely to occur due to the high level of vegetation disturbance / degradation. No records of Priority or Threatened flora were found for the Mount Henry Spit after searches of Naturebase (DEC, 2013) and Protected Matters Search Tool (Department of Sustainability Environment Water Population and Communities (DSEWPAC) 2012) databases. The searches conducted for the Site and the 1 km buffer have revealed *Dodonaea hackettiana* (P3) as a possible species to occur on site. The habitats found at Mt Henry Spit are not suitable for growth of this species with exception of the limestone embankment at the south east corner of the Site which has been completely altered during Mount Henry Bridge construction. However, this species habitat is found in the adjacent Mount Henry Bushland site to the east.

The database searches and the field investigation have not found any Threatened or Priority Vegetation communities to be present on site and none are directly adjacent to the Site. However, the Mount Henry Spit is a part of Bush Forever Site No. 227 and has a riparian (riverine) vegetation along its boundary. As such, the Site is classed as an Environmentally Sensitive Area (ESA) and has high environmental value not only on a local but also a regional level. Presence of dense *Phlebocarya ciliata* herbland of Very Good condition indicative of Damplands (seasonally waterlogged wetlands) and found in small depressions or swales on site can be considered as locally significant as such habitats do not exist in the nearby bushland areas.

PART 4: RESTORATION APPROACH

6.0 VISION

The Mount Henry Spit is a unique site in the Perth Metropolitan Region due to its close proximity to the centre of the City and the value of its remnant vegetation as part of the Bush Forever Site No. 227. The Spit's relative isolation and distinctive ecological characteristics make it an ideal site for comprehensive restoration efforts. The benefits of restoring this site will ensure its long-term sustainability in the face of adverse effects such as erosion of the Spit's western shore. It is envisaged that the implementation of this Restoration Plan will significantly contribute to the protection and enhancement of the biodiversity and aesthetic values of not only the Spit but the entire Bush Forever Site No. 227.

7.0 RESTORATION OBJECTIVES

The objectives for the restoration of Mount Henry Spit are:

- Mitigate further erosion of foreshore areas within the project site through protection of existing vegetation and the re-establishment of native riparian vegetation;
- Improve the condition of dryland vegetation through the staged revegetation of key areas and by reducing the invasive weed community to a manageable level with the possible eradication of some highly invasive species;
- Restore natural vegetation communities of Mount Henry Spit by the re-introduction of flora species that have been heavily affected by human activities at the Site;
- Manage public access to the Site to protect restoration works and facilitate more functional recreational use of the area; and
- Implement a long-term management strategy at the Site including on-going maintenance and monitoring programs.

8.0 PRELIMINARY CONSIDERATIONS

There are a number of preliminary items to consider prior to implementing a comprehensive restoration project and these are outlined below. In order to ensure effective and efficient implementation, logistical coordination is a key task and should be given utmost importance prior to the commencement of any restoration works and continue to be a priority during all phases of works. A designated project manager should be assigned to coordinate the project and ensure sufficient communication with the project team and stakeholders.

8.1 PERMITS AND AUTHORISATION

Prior to any on-ground works commencing, all permits and authorisation from relevant authorities will be required. Sufficient time must be allocated for the approval process to progress and any delays in approvals must be accommodated in the plan. Failure to seek appropriate approvals can slow down work progress causing costly delays.

In addition, a dial-before-you-dig enquiry will be required to ensure no underground services will be affected during implementation works as this service has limited validity.

8.2 SITE ACCESS AND STORAGE

Adequate site access and storage is essential for the efficient implementation of works. Due to the limitations on vehicle access to the Site, any implementation works will require sufficient traffic management along the adjacent DUP. Authorisation will also need to be sought from Main Roads Western Australia and the City of South Perth for any significant vehicle movement along the DUP.

The two most appropriate means of access would be either via accessing the Site directly from the Kwinana Freeway through a Main Roads access gate or from the boat ramp carpark approximately 1.5 km north of the Site and travel along the DUP. Significant logistical input is required to ensure the safety of the public and personnel when transporting staff, materials and equipment.

Storage of materials on site will be required at certain periods of implementation. Most materials can be stored within the Site; however, if more secure options are required, small transportable containers may be utilised to prevent theft or vandalism.

9.0 RESTORATION PLAN

To facilitate effective management of the restoration activities on site, the plan has been divided into the following items:

- Foreshore erosion control works;
- Foreshore and Dryland Revegetation;
- Weed management;
- Access management; and
- Monitoring and maintenance.

9.1 FORESHORE EROSION CONTROL

Based on the results obtained during the field assessment (Appendix 1), the foreshore of the Mount Henry Spit has been categorised into 3 distinct foreshore treatments based on the condition of the foreshore and the level of disturbance that has affected these areas (Figure 13).

Figure 13 Treatment of foreshore areas for restoration

This prioritisation framework has been established to provide a practical guide for allocating resources to areas in most need of restoration works. It is intended that restoration works be implemented in the highest priority zone (Foreshore treatment 1) first, with subsequent implementation efforts being performed in the subsequent priority areas (Foreshore treatment 2 and 3).

9.1.1 Foreshore treatment 1

The area classified as Foreshore treatment 1 (Figure 13) has been identified as having the highest degree of erosion, and as such, has been given the highest priority for restoration. Due to the extent of erosion, this area will require most input in terms of erosion mitigation works. The primary objective will be to reintroduce fringing riparian vegetation, currently completely absent from this section of the foreshore. The vegetation will act as a buffer to wave and tidal action and will significantly reduce the current rate of erosion in this area and thus protect the existing vegetation communities.

Figure 14 Foreshore treatment 1 area at the westernmost end of the Mount Henry Spit

Bioengineering works will be comprised of the construction of a brushwall along the intertidal area of foreshore. The structure will be constructed at a height that substantially exceeds maximum water levels and extend approximately 2 to 3 m from the existing bank to allow sufficient width for the establishment of foreshore vegetation. The vegetation planted in this area should be comprised of species native to the intertidal zone of the river, with an

emphasis on species with known erosion protection attributes. Brushwalling is a bioengineering technique utilised to treat an undercut or steep bank where site conditions do not allow for significant bank re-profiling. The technique is used near to the base of the bank, where the wave action undercuts the foreshore edge, creating a stable structure of natural brush material that dissipates wave energy whilst forming a semi-permeable barrier, allowing water movement but retaining any soil. The structure will protect establishing vegetation for up to 10 years, if maintained, slowly breaking down and allowing the riparian vegetation to assume the main protective function. This technique has been selected due to its high durability and its relatively low input cost compared to other techniques such as log brushmattressing. An example of successful brushwall implementation is shown in Figure 10.

Limestone spalls along the toe of the brushwall on the river side need to be installed to provide protection to the structure and to ensure the erosion fabric installed underneath the brushwall remains in place. This small rock toe only needs to extend approximately 1 m from the base of the brushwall.

Figure 15 Brushwall examples prior to and after plant establishment and during high tide (Source: Syrinx, 2013)

9.1.2 Foreshore treatment 2

The areas defined as Foreshore treatment 2 (Figure 16 and Figure 17) have experienced some erosion and vegetation loss; however, this is not as severe as the Foreshore treatment 1 area and therefore does not require as high restoration input or the same urgency. The particular areas along the Mount Henry Spit foreshore that have been identified as Foreshore treatment 2 have varying degrees of erosion and will require a combination of different techniques.

Figure 16 Foreshore treatment 2 restoration area – northern foreshore

Figure 17 Foreshore treatment 2 restoration area – south western foreshore

The northern foreshore area has experienced minor erosion; however, a distinct lack of foreshore vegetation and its close proximity to the DUP dictate its inclusion as part of Foreshore treatment 2. In addition, it would be advantageous to reduce the canopy cover of existing *Casuarina obesa* to facilitate understory vegetation (i.e. sedges) establishment through minor pruning of the canopy. These techniques have been implemented at a site directly north of the Mount Henry Spit and have been successful in aiding the establishment of the undestorey and in reducing further foreshore degradation.

The south-western foreshore has a number of undercut Casuarinas and it is recommended that these are left to fall into the river as part of a managed retreat approach. Similar techniques to other Priority 2 areas can be implemented directly behind the Casuarinas once they have fallen.

To restore these areas, a combination of various low-impact bioengineering techniques will need to be implemented. This will entail a combination of the following:

- Erosion fabrics;
- Coir nodes;
- Woody debris;
- Limestone rocks; and
- Foreshore planting.

9.1.3 Foreshore treatment 3

The areas identified as Foreshore treatment 3 (Figure 18) have been deemed to be exposed to the lowest level of disturbance and therefore require the least input. Works required in these sections are limited to weed control outlined in section 9.3 of the plan and some minor supplementary planting in areas that may require some further vegetation cover.

It is recommended that these areas be monitored for signs of further erosion and degradation to ensure they do not become a higher priority and require further restoration input. This will particularly be necessary after implementing Priority 1 and 2 foreshore treatments.

Figure 18 Foreshore treatment 3 restoration area, southern foreshore

9.2 FORESHORE AND DRYLAND REVEGETATION

One of the most critical aspects of the Restoration Plan is the revegetation of the Site with suitable native flora, particularly in highly disturbed areas such as the Mount Henry Spit.

9.2.1 Priority areas for revegetation

The same prioritisation system as applied to the erosion control works was applied to the selection of priority areas for revegetation and these are congruent with each other. The prioritisation process was based on the most impacted areas where vegetation cover is low (or non – existent), areas of high erosion and where such cover would improve ecosystem function in such a way that it would ensure long term survival of vegetation communities on the Mount Henry Spit. The priority areas for both foreshore and dryland are outlined in Figure 19. Whilst the highest need for restoration works is within the Priority 1 area, other areas may be addressed at the same time (with consideration of available funds/ budget). Priority 4 areas do not need additional planting as they have dense strands of healthy native flora. However, they require monitoring and maintenance particularly weed control, in order to be sustainable in the long term.

Figure 19 Priority areas for revegetation including foreshore and dryland

9.2.2 Species selection

The species selection for revegetation was based on the existing indigenous flora and vegetation on site. Careful delineation in vegetation communities was made with respect to topography and the surface water flows across the Site, with the aim to replicate the historical condition and vegetation communities on site. The figure showing the proposed extent of each vegetation community boundary is presented in Figure 20. These boundaries

may change due to climate change impacts; however, in the short term (e.g. next 5-10 years) they are considered accurate. The corresponding planting species selection for each community is presented in Table 3 the selection incorporates species that were recorded on site previously by Ecoscape (2004).

Figure 20 Planting zones congruent with the existing vegetation communities on site

Table 3 Planting mix selection for the Mount Henry Spit Revegetation Plan

Species name	Common name	Max.Height (m)	Planting Mix 1	Planting Mix 2	Planting Mix 3	Planting Mix 4	Planting Mix 5	Planting Mix 6
TREES under 10m								
Allocasuarina fraseriana	Sheoak	15		■		■		■
Casuarina obesa	Swamp Sheoak	10	■					
Melaleuca cuticularis	Saltwater Paperbark	7	■					
TREES over 10m								
Corymbia calophylla	Marri	40		■	■	■		
Eucalyptus gomphocephala	Tuart	40						■
SHRUBS over 2 m								
Acacia cyclops	Coastal Wattle	4						■
Adenanthos cygnorum	Common Woollybush	4				■		■
Melaleuca huegelii	Chenille Honeymyrtle	5						■
SHRUBS 1-2 m								
Acacia lasiocarpa	Panjang	1.5						■
Acacia pulchella	Prickly Moses	1.5				■		
Allocasuarina humilis	Dwarf Sheoak	2				■		■
Billardiera heterophylla	Australian Bluebell	1.5		■				
Eremaea pauciflora		2		■	■	■		
Hypocalymma angustifolium	White Myrtle	1.5		■				
Philotheca spicata	Pepper and Salt	1.2				■		■
Phyllanthus calycinus	False Boronia	1.2						■
Templetonia retusa	Cockies Tongues	2						■
SHRUBS under 1 m								
Acacia stenoptera	Narrow Winged Wattle	0.7		■			■	
Astroloma macrocalyx	Swan Berry	0.8				■		
Bossiaea eriocarpa	Common Brown Pea	0.5			■	■		
Conostephium preissii		0.5					■	
Gastrolobium capitatum		1		■				
Gompholobium tomentosum	Hairy Yellow Pea	0.5		■	■	■	■	■
Hibbertia hypericoides	Yellow Buttercups	1		■	■	■		
Hibbertia racemosa	Stalked Guinea Flower	0.8				■		
Hovea trisperma	Common Hovea	0.7				■		
Hypocalymma robustum	Swan River Myrtle	1						■
Lechenaultia floribunda	Free-flowering Leschenaultia	1		■	■	■	■	■
Leucopogon conostephioides		0.5				■		
Petrophile linearis	Pixie Mops	1				■		■
Rhagodia baccata	Berry Saltbush	0.5	■					
Scholtzia involucrata	Spiked Scholtzia	0.7				■		
Synaphea spinulosa		0.5				■		
CYCADS								
Macrozamia riedlei	Zamia	3			■	■	■	■
HERBS								
Anigozanthos humilis	Catspaw	0.3				■		
Anigozanthos manglesii	Mangles Kangaroo Paw	1				■		
Burchardia congesta		0.8		■				
Conostylis aculeata	Prickly Conostylis	0.4				■		
Corynotheca micrantha	Sand Lily	1				■	■	
Dampiera linearis	Common Dampiera	0.3				■		
Dasypogon bromeliifolius	Pineapple Bush	0.8		■	■	■	■	
Dianella revoluta	Blueberry Lily	0.8					■	
Haemodorum spicatum	Mardja	1.5		■				
Hybanthus calycinus	Wild Violet	0.5				■		
Kennedia prostrata	Scarlet Runner	0.2						■
Laxmannia squarrosa		0.1				■		
Lomandra hermaphrodita		0.2				■		
Patersonia occidentalis	Purple Flag	0.8		■	■			
Phlebocarya ciliata		0.6		■	■	■	■	
Ptilotus polystachyus	Prince of Wales Feather	1				■		
Suaeda australis	Seablite	0.6	■					
Thysanotus patersonii		0.5				■		
Tricoryne elatior	Yellow Autumn Lily	0.5					■	
Xanthorrhoea preissii	Grass tree	2		■	■	■	■	
RUSHES AND SEDGES								
Alexgeorgea nitens		0.2		■	■	■	■	
Desmocladus flexuosus		0.3		■				
Hypolaena exsulca		0.6		■	■			
Juncus kraussii	Sea Rush	1.2	■					
Lyginia barbata		0.8		■	■	■	■	■
Schoenus subfascicularis		0.8	■	■	■		■	
Gahnia trifida	Coast Saw-sedge	1.5	■					
Mesomelaena pseudostygia		0.8				■		■
Schoenus curvifolius		0.4		■				
GRASSES								
Sporobolus virginicus	Marine Couch	0.2	■					

As can be noted from Figure 20, Planting Mix 6 is specified for the area of the freeway embankment which currently has relatively high vegetation cover. However, this cover is predominantly composed of introduced flora or native species that are relatively weedy such as *Acacia saligna*. The proposed planting mix focuses on re-introduction of some native indigenous flora to this section of the Site such as the low shrubs herbs and sedges in particular. The planned numbers for revegetation of this area are low due to the already high vegetation cover in the area.

In addition to planting species identified on site, consideration was given to plants that were more prevalent in the past but now have restricted distribution or are absent in the area (e.g. *Eucalyptus marginata* (Jarrah), *Corymbia calophylla* (Marri) and *Adenanthos cygnorum* (Common woollybush) (Ecoscape, 2004). A spring survey of the good condition vegetation areas recording geophytes and native grasses in particular would be required in order to select further species for revegetation and add to the biodiversity of the area, however this can be done at a later stage.

9.2.3 Sourcing plants for revegetation

Local provenance seed and vegetative material should always be used whenever possible to generate required plants for revegetation. This will ensure that the genetic diversity of the area is protected and ensure better plant establishment in the long term, as local plants have evolved to local conditions. Sourcing of seed and vegetative material should be carefully considered and planned prior to undertaking larger scale restoration works, particularly in the dryland areas. Plants should be ordered at least one year prior to planting to allow adequate growth time.

Whilst sourcing of seed or vegetative material may not be an issue for some species particularly those of the foreshore vegetation as they often produce abundant seed, some of the dryland species that are present in remnant patches of vegetation at high densities are not commonly propagated and often do not produce viable seeds. Such plants are *Hibbertia hypericoides, Phlebocarya ciliata* and *Dasypogon bromeliifolius* and these species would have to be propagated vegetatively which incurs greater cost. When collecting seed and vegetative material on site it is important not to collect more than 20% of seed from any given plant (DEC, 2008) and even less for vegetative material, however this would depend on the species itself. Vegetative material and seeds from the foreshore reserves within the City of South Perth would be considered appropriate.

Vegetative material may include cuttings, rhizomes or roots. For those plants difficult to propagate, such as *Phlebocarya ciliata* or *Lyginia barbata,* a small trial for onsite transplanting (i.e. division of a large clump to smaller clumps) should be conducted in the areas with the degraded vegetation and monitored carefully for growth. If successful after a

year of growth at a minimum, further small patches of these particular species can be planted.

Regardless of propagation success, all efforts must be made to conserve populations persisting on site and a species mix surrounding these areas chosen so that it would support their persistence on site. Factors such as shade or type of commonly found associated plants should be considered.

In the event that after two years of trials the nursery is unable to produce recommended stock, the City should contact a specialist consultant to seek advice on changing planting densities and finding alternative species that would be suited to site and are readily propagated in the nursery.

Planting seedlings rather than direct seeding would be preferable for the Site and essential for the foreshore vegetation establishment. The large quantity of seed required to direct seed areas of dryland as well as the presence of persistent weeds such as Veldt Grass would prove somewhat prohibitive to this practice.

The direct seeding should be investigated in small areas where the results will be comparable to the planted seedling areas to assess if this method would be suitable in the future. Species such as native grasses and herbs may be incorporated in the seeding mix and broadcast at a later stage of the project when most of the upper and mid storey have been established and the weed control has proven to be effective.

It is understood that the City of South Perth nursery will be growing the vegetation stock for this project. It might be necessary to seek assistance form a larger commercial nursery to propagate some of the stock as these will be required in high numbers (e.g. *Juncus kraussii* for example) or are more difficult to propagate and require specifically set up nurseries. However, it is likely that the staged approach to restoration works at Mount Henry Spit may allow for all of the plants to be propagated by the City's nursery.

9.2.4 Planting densities

The planting densities will vary between different areas depending on the vegetation type and the amount and distribution of remnant vegetation that exists in those areas. For the areas of the foreshore where impacts of erosion are greatest and where establishment of the dense sedgeland is of utmost importance in establishing a stable shoreline, the planting densities are higher (4 to 6 plants per m^2) than those of the dryland areas (1 to 4 plants per m^2). Wherever practicable the planting density should replicate the natural bush surroundings and should be determined at the time of planting as existing plant cover may change due to the extended period of restoration works (over the five or more years). The vegetation community descriptions provide a guide to plant density and all staff participating

in revegetation works should be inducted and understand the importance of planting species to replicate natural distribution and densities. Remnant vegetation patches can be used as reference sites for this purpose.

9.2.5 Size of plant stock and hardening off prior to planting

Tube stock (50 x 50 x 125 mm) will be suitable for propagation of most plants; however, it is recommended that a larger stock be used in the foreshore areas to help prevent uprooting of plants through wave action. Larger plants (140 mm pots) would have better chance of survival than small plants given that the plants have well developed root systems and are not root bound.

All foreshore sedge seedlings will require acclimatization to saline or brackish water by watering seedlings with brackish water at least two weeks before transplanting.

9.2.6 Implementation works

The revegetation plan should be implemented by a specialist consultant familiar with restoration work in riverine and dryland environments, in collaboration with the City of South Perth, Swan River Trust and the local community in order to achieve the best environmental outcome. The planting densities and species distribution across the Site is dependent on minor changes in topography and surface water flows and these factors need to be considered in great detail when implementing revegetation in order to achieve the set criteria.

Wherever possible, seedlings from each planting mix should be distributed so that they resemble their natural distribution in the remnant bushland areas on site. For this reason it is best to propagate seedlings in individual pots rather than cell blocks.

For the foreshore planting, particularly in the Priority 1 area, dense strands of *Juncus kraussii* should be incorporated at the water's edge with sparse plantings of *Melaleuca cuticularis*. A *Casuarina obesa* stand should be planted behind the thick band of *Juncus kraussii* interspersed with *Melaleuca cuticularis.* This layer would have sparser *Juncus kraussii* planting (to the high tide mark) with introduction of sparse planting of *Schoenus subfascicularis*, *Rhagodia baccata* and *Suaeda australis*. This form of planting is congruent with the managed retreat approach and would allow for the best possible outcome in terms of erosion control in the long term.

When planting around remnant patches of vegetation it is best to start from the best condition bushland and radiate out towards more degraded areas. This allows the remnant vegetation to be sustained in the long term by provision of a vegetative buffer. Weed control

works will need to be completed prior to planting using a suitable herbicide that will not affect the growth of newly planted seedlings or the remnant native vegetation.

9.2.7 Irrigation

In order to encourage seedling growth particularly in dry years, some watering will need to take place. This is particularly important for difficult to propagate species. To allow for best possible outcome, planting of dryland areas should be conducted in late autumn to early winter, when there is a high probability of adequate rain occurring that would maintain moist conditions on site during establishment.

9.3 WEED MANAGEMENT

Weed species at the Mount Henry Spit are typical of the riparian fringe of the Canning River. Winter and spring emerging plants are the strongest colonisers of the area, e.g. Sow thistle and Veldt grass; however, weed species persist on site all year round.

The Site is susceptible to weed introduction as it is exposed to wind and water transported seeds and has a high degree of public access. Therefore, weed control must be carried out with an emphasis on timing and approach. For example, weeds must be treated with herbicide prior to flowering as herbicides have no effect on viable seeds and may even facilitate their dispersal from the plant.

NAC (2012) has most recently identified and mapped the locations and the extent of infestation for the introduced flora on site. The species recorded in NAC (2012) are congruent with what was found on site by Syrinx in February 2013, although some species were not recorded by Syrinx as they were senescent and or treated by herbicides and hence not observed. Over the past four years, the City has had a major focus on eliminating Veldt and Winter Grass from Mount Henry spit via use of grass selective herbicides and by selective spot spraying. The results indicate the treatments were successful in terms of reducing cover and abundance of the targeted grasses; however the maintenance will have to continue for considerable length of time in order to deplete the weed seed bank.

The recommended management and the timing of weed control works for each of the species recorded on site are given in Table 4. In general, management of weeds at Mount Henry Spit will involve application of low toxicity herbicides such as Glyphosate with lowest concentration necessary to successfully control the weeds while limiting unnecessary exposure to the surrounding environment. Follow up control is required regularly throughout the year in order to control any further emergence. Effective weed control implementation will include:

- Glyphosate application via pressurised spray hoses;

- Direct application of neat glyphosate to cut plants;
- Manual removal of weed biomass and / or seed heads prior to glyphosate treatment; and
- Manual weed removal.

Table 4 Introduced flora and their proposed management at Mount Henry Spit

Botanical name	Common Name	A/P	Summer	Autumn	Winter	Spring
Aira caryophyllea	Silvery hairgrass	A	***	*		*
Arundo donax	Giant Reed	P	****	****	*	***
Avena barbata	Bearded Oat	A			**	*
Brassica tournefortii	Mediterranean Turnip	A			**	*
Briza maxima	Blowfly grass	A			**	*
Bromus diandrus	Great Brome	A			**	*
Carpobrotus edulis	Hottentot Fig	P	*	**	**	**
Cenchrus clandestinus	Kikuyu Grass	P	***	****	***	***
Chenopodium album	Fat hen	A	**	**	**	***
Cynodon dactylon	Couch	P	***	** *		****
Ehrharta calycina	Perennial Veldt Grass	P	***	***	**	**
Ehrharta longifolia	Annual Veldt Grass	A		*	***	***
Euphorbia terracina	Geraldton Carnation Weed	A	***	***		**
Fumaria capreolata	Whiteflower Fumitory	A		**	***	***
Gladiolus caryophyllaceus	Wild Gladiolus	P		**	*	**
Gladiolus undulatus	Wavy Gladiolus	P	**	**	*	
Hedypnois rhagadioloides	Crete weed	A			**	*
Hordeum leporinum	Barley Grass	A			**	*
Hypochaeris glabra	Smooth Catsear	A	*		**	***
Lolium rigidum	Wimmera Ryegrass	A	**		**	*
Oxalis pes-caprae	Soursob	A		**	***	
Pelargonium capitatum	Rose Pelargonium	P	*		**	***
Solanum nigrum	Black Berry Nightshade	P	*	**	**	***
Sonchus asper	Rough Sowthistle	A	*	*	**	***
Sonchus oleraceus	Common Sowthistle	A	**	**	**	***
Stenotaphrum secundatum	Buffalo grass	P	**	*		**
Ursinia anthemoides	Ursinia	A	*		**	***

LEGEND

Species highlighted in **bold** refer to the "invasive weeds" which can suppress the growth of native species and which will be monitored against completion criteria.

Annual	A
Perennial	P
Optimum treatment time	
Germinating/emerging	*
Active growth	*
Reproductive phase	*
Rhizomatous sprawling	*

Manual weed control may be necessary in the areas where weed infestation is low and the established native cover is high, and it would be recommended particularly for the areas

which have been planted with difficult to propagate plants. The manual control is best conducted when the weeds are small (to minimise disturbance to the soil as much as possible) and before they flower and set seed.

9.4 ACCESS MANAGEMENT

Public access within the project site requires some additional management to bolster restoration efforts and to assist with the overall success of restoration. Currently, there are a number of formal and informal access tracks throughout the Site that contribute to overall degradation of the Site. Observations made during field assessments indicate the majority of foot traffic is concentrated along the beach and informal access created to access this area.

It is understood that closing many of these tracks will encourage the creation of new tracks, contributing to further degradation. The best approach therefore will be to restrict access to a few key areas and to formalise access in others. There are three specific areas where initial efforts should be made to regulate access on site as indicated in Figure 21.

Figure 21 Proposed access management areas

Further monitoring following the implementation of these is recommended to gain a better understanding of site access and where improvements can be made. The initial recommendations are as follows:

1. Extend the fence running parallel with the DUP along the western edge of the beach access stairs at the south-east of the project site. This will re-direct foot traffic to the stairs and discourage people from walking down the embankment and through the bushland area;
2. Remove the formal access track that runs from the limestone circle track to the southern foreshore. This will discourage movement through this area and the public are more likely to use the other exiting paths to access the beach area;
3. Formalise the major beach access track that extends from the limestone circle track to the western beach. This will be created using limestone biscuit rocks for the medium term and integrated with the bioengineering works. A more formal and all-inclusive access option may be developed for long term access, such as a board walk ramp, however, this in not included in this plan.

9.5 MAINTENANCE AND MONITORING

A five (5) year maintenance period is highly recommended after completion of all major restoration works to ensure successful restoration of the project area. Monthly site inspections and remediation tasks should be undertaken by an appropriately qualified organisation in order to maintain the functionality of restoration methods.

A schedule of maintenance tasks and monthly progress reports should be provided to City of South Perth and Swan River Trust prior to and following the maintenance tasks in order to follow up on the success of the tasks completed and to develop any contingency measures where necessary. To assess the success of revegetation works, in addition to the monthly qualitative monitoring (survival rate and photo monitoring) a yearly monitoring event is recommended each spring using standard vegetation quadrat technique (10 x 10 m for trees and a 5 x 5 m (located within the 10 x 10 m quadrat) for assessment of shrubs, herbs, sedges/rushes and grasses (see Section 9.5.6 for more detail).

9.5.1 Bioengineering

The maintenance must include, but not be limited to, ensuring all bioengineering work is secured and supplementary foreshore planting conducted where plant losses or further erosion occurs. The primary bioengineering maintenance task is the securing of bioengineering structures through stake placement and wire tension. Erosion control fabrics will also be maintained by ensuring they are properly secured and tears or subsurface erosion are managed. Any further erosion or undercutting following implementation of erosion control works will also be assessed and the appropriate control methods devised to mitigate any soil and or vegetation losses.

9.5.2 Weed Control

Suppression of weeds for an extended period of time has a positive effect on the long term sustainability of the restored areas and should be incorporated as part of the weed control plan. This is important as it promotes an integration of restored vegetation with the adjacent natural areas. The weed control should be regular and focused on priority weeds with the majority of works to occur during the appropriate times of year to reflect active vegetative weed growth.

9.5.3 Vegetation Maintenance

Plant health will be monitored during monthly inspections of the site and supplementary planting will occur if deemed necessary. It is advisable to water revegetated areas during summer in the first year of growth to allow for successful establishment and to minimise plant losses. Liquid fertilisers or slow release fertilisers for native plants applied in small dosages are also advantageous to establishing vegetation. However, it is important not to use any fertilisers near the intertidal zone as this practice can contribute to higher nutrient levels in the river system.

9.5.4 Restoration Monitoring

A well designed monitoring program is important to measure the success of completed restoration works and to identify the most effective restoration approaches for the future works. Monitoring will also aid in determining strategies for combating effects of climate change expressed on site in terms of flooding.

Monitoring in most instances should be conducted annually and be seasonally consistent, preferably in spring when the plants show signs of growth and weeds are easy to observe (e.g. September). The monitoring shall be designed to replicate initial assessments conducted as part of the Restoration Plan. Each year after monitoring is completed; a brief report outlining that year's data in context with the original baseline data should be prepared. It is essential that appropriate photo monitoring points and reference sites are established prior to restoration works which will allow for qualitative and quantitative monitoring of the Site over time.

9.5.5 Erosion Monitoring

To accurately monitor erosion at this Site, it is recommended that established foreshore profiles are measured and compared to the existing baseline data (DSE, 2012). This will be in addition to photo monitoring from a designated photo monitoring point (indicated by a GPS point) and erosion stakes that have been strategically located around the Site. However,

photographic and erosion stake monitoring is considered secondary to profile analysis. Another important aspect of monitoring is taking into account major storm events throughout the year. This would require installation of additional monitoring stakes placed after such events (DSE, 2012). Measurement of erosion at these points would provide perspective on how much of the area is altered by such events and also how the area responds thereafter.

9.5.6 Vegetation Monitoring

Regular vegetation monitoring will provide a tangible measure of the biodiversity throughout the Site and provide insight into how successful the restoration works are in terms of achieving the completion criteria.

The monitoring will involve a regular monthly qualitative assessment of the replanted areas for survival and to obtain a set of photographs from the designated photo monitoring locations which will be determined prior to planting works in consultation with the City and / or specialist consultant.

Additional monitoring should be carried out on a yearly basis in spring to determine the need for supplementary planting the upcoming winter. This way the seedling (and or seed) quantities required for this purpose can be obtained in time for the next planting season.

A yearly assessment of the areas that were revegetated as well as the existing (remnant) vegetation analogous sites within the Planting mix 1 – 4 areas should be conducted to monitor the overall success of the site in terms of species diversity and cover. Planting mix areas 5 and 6 are heavily modified and do not provide good opportunities for monitoring by quadrat technique and as such success of restoration of these areas will be monitored qualitatively using survival rate and general cover of the newly established seedlings as per monthly reports.

For the quadrats, parameters such as survival rate, species diversity and abundance (% cover of species) should be used to compare against previous years monitoring and the baseline (reference quadrat) data.

The monitoring quadrats (10 x 10 m (for trees) and 5 x 5 m for other species such as shrubs, herbs and sedges) can be used to test the established completion criteria. The location of the monitoring quadrats (revegetated sites and remnant vegetation sites (i.e. reference sites) should be assigned at the time of contract award and in collaboration with the City of South Perth Environmental Officers and or their nominated specialist consultant.

The following suggested completion criteria are provided for vegetation monitoring in order to help with the development of contingency plans and project closure:

1. Species richness and tree, shrub and herb density in each ecosystem unit within restoration zones is similar to that of existing remnant vegetation communities. A level of 75 % of plant species diversity and richness or more is considered adequate;

2. The total vegetation cover of the restored foreshore area dominated by *Juncus kraussii* is 95 % after 3 years;

3. The Site is geotechnically stable (i.e. no additional erosion has occurred in the restored areas or the remnant vegetation of Very good condition);

4. A maximum of three invasive weeds (species highlighted bold in Table 4 in Section 9.3) per square metre with a maximum of 5% of weed cover within each revegetation zone;

5. Within each revegetation zone the plants must be in good condition or 'resilient' as evidenced by well-developed root systems and flowers; and

6. Within each revegetation zone shrubs will be well established and in a "young" age class at a minimum (e.g. not comprised of seedlings that may not survive until the following year).

Particular attention should be given to the foreshore monitoring and the increase in water levels noted. Should notable changes arise, contingency plans must be in place to deal with these changes – for example the planting list may change, with Planting Mix 1 occupying wider area of the foreshore.

9.5.7 Weed Monitoring

Weed monitoring should be conducted on a regular basis following commencement of restoration works to measure the effectiveness of weed control efforts. Monitoring will need follow the methods outlined in the DPaW's *Standard Operating Procedures: Techniques for weed mapping distribution and cover in bushland and wetlands*. It is critical that weed survey methodology remains consistent to ensure accuracy of data.

9.5.8 Wave impact studies

It is recommended additional wave impact studies be conducted at other times of the year, such as during storm events and high tides. This information will indicate changes to wave erosive forces and provide information on the potential changes to river processes in the area which will assist in guiding the approach of future restoration works in the project area.

PART 5: SUMMARY AND TIMELINES

Without action, factors such as: erosion, lack of native vegetation cover and weed invasion threaten the long term survival of important riparian and bushland habitats and decrease the amenity value of the Mount Henry Spit. This Restoration Plan presents the existing environmental and social aspects of the Site in order to prioritise and implement restoration efforts required to stop or reduce those threatening processes.

The prioritisation process implemented in this plan considered the severity of erosion, the lack of native vegetation, the extent of flooding for current storm surges and tide levels, low rainfall levels as well as consideration of cost for restoration works and the environmental and social impact to surrounding areas and the Site. On the basis of this, different priority rankings were assigned to the bushland and foreshore areas of the Mount Henry Spit and the plant list developed which would allow for managed retreat approach in the short and long term.

Whilst extending planting of foreshore species higher in the foreshore profile in preparation for the expected flooding due to climate change may work for some species such as trees and shrubs, sedges like *Juncus kraussii* which are crucial in attenuating wave impact will not be able to establish under the current climatic conditions without significant amount of irrigation. Given that the research into the effect of climate change on shorelines such as that at Mt Henry is limited at this time, the best strategy to ensure long term sustainability of plant communities and habitat for fauna is through planting in appropriate hydro zones and continued monitoring and development of new (and improved) ways to combat climate change.

All effort has been taken to assess the site conditions and recommend appropriate bioengineering techniques and the species mixes based on the predicted climate change effects, with managed retreat approach, budgetary constraints and overall aesthetics of the area in mind. However, further assessment of the site by a qualified hydrologist would be beneficial to investigate suitability, efficiency and cost of the chosen bioengineering techniques for long term foreshore stabilisation versus indirect shore stabilisation approaches.

The chosen consultant will need to assess the sediment transport rate and direction to determine the extent of possible erosion in the future if no works were done in the short term versus implementing recommended restoration as indicated in this plan. One possibility of counteracting current erosion at the south western tip of the spit would be by building of geotextile bag groyne, however further calculations would be necessary to determine if this

method would be efficient and sustainable in the future particularly with respect to climate change, increased boat traffic and the proximity of the bridge.

9.6 SCHEDULES, COSTS AND TIMELINES

The area of restoration is relatively large and contains species that are not readily propagated in the nurseries; therefore, to facilitate the best possible environmental outcome and consider the budgetary constraints, a priority schedule for revegetation planting and erosion control works should be staged over a five year period.

The schedule outlined in Table 5 should be referred to for guiding timing of works within any given calendar year. However, the timing of works such as planting for example should be planned in accordance with climatic conditions to ensure plant establishment and survival in the long term. Therefore the schedule given in Table 5 is indicative only.

Table 5 Implementation schedule for restoration works

Activity	Autumn			Winter			Spring			Summer		
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Gathering native plant seed												
Propagate native plant seedlings												
Planting native seedlings												
Weed control – chemical												
Weed control – manual												
Erosion control works												
Monitoring												

The extent of works and the quantities of plants planted each year will depend on the seasonal conditions and the availability of the suitable material for propagation. Therefore, the numbers of plants for each priority area given in Table 6 and the costs (as supplied by the City of South Perth nursery) are indicative only. The costs highlighted in light orange indicate difficult to propagate species and hence a higher cost of propagation has been selected.

The contractor who undertakes the revegetation works will need be cognisant of the best environmental conditions for the growth of any given species in the proposed planting list. The contractor will need to consider remnant patches of vegetation, topography, any surface water flow or ponding, distance from the foreshore and natural distribution and complexity of a particular species within the specific vegetation community in order to achieve successful restoration outcomes.

Table 6 Indicative plant stock supply schedule and costs for restoration of Mount Henry Spit

Year of Works	Priority level	Botanical name	Common name	Growth form	Size	Price	Quantity	Total cost
Year 1	Priority 1	*Casuarina obesa*	Swamp Sheoak	Tree	70mm	$ 2.50	10	$25.00
		Juncus kraussii	Sea Rush	Rush	140mm	$ 4.00	700	$2,800.00
		Juncus kraussii	Sea Rush	Rush	50mm	$ 1.20	1000	$1,200.00
		Melaleuca cuticularis	Saltwater Paperbark	Tree	70mm	$ 2.50	10	$25.00
		Rhagodia baccata	Berry Saltbush	Shrub	50mm	$ 1.20	20	$24.00
		Schoenus subfascicularis		Sedge	50mm	$ 1.20	160	$192.00
		Sporobolus virginicus	Marine Couch	Grass	50mm	$ 1.20	100	$120.00
Total of plants and costs for Year 1							**2000**	**$4,386.00**
Year 2	Priority 1	*Juncus kraussii*	Sea Rush	Rush	140mm	$ 4.00	50	$200.00
		Juncus kraussii	Sea Rush	Rush	50mm	$ 1.20	150	$180.00
					Total plants and costs for Priority Area 1		***200***	***$380.00***
	Priority 2	*Alexgeorgea nitens*		Rush	50mm	$ 1.20	40	$48.00
		Allocasuarina fraseriana	Sheoak	Tree	70mm	$ 2.50	2	$5.00
		Bossiaea eriocarpa	Common Brown Pea	Shrub	50mm	$ 1.20	50	$60.00
		Casuarina obesa	Swamp Sheoak	Tree	70mm	$ 2.50	20	$50.00
		Corymbia calophylla	Marri	Tree	140mm	$ 4.00	9	$36.00
		Dasypogon bromeliifolius	Pineapple Bush	Herb	50mm	$ 2.50	280	$700.00
		Eremaea pauciflora		Shrub	50mm	$ 2.50	120	$300.00
		Gahnia trifida	Coast Saw-sedge	Sedge	50mm	$ 2.50	40	$100.00
		Gastrolobium capitatum		Shrub	50mm	$ 1.20	30	$36.00
		Gompholobium tomentosum	Hairy Yellow Pea	Shrub	50mm	$ 1.20	60	$72.00
		Hibbertia hypericoides	Yellow Buttercups	Shrub	50mm	$ 2.50	90	$225.00
		Hypocalymma angustifolium	White Myrtle	Shrub	50mm	$ 1.20	150	$180.00
		Hypolaena exsulca		Rush	50mm	$ 1.20	120	$144.00
		Juncus kraussii	Sea Rush	Rush	140mm	$ 4.00	300	$1,200.00
		Juncus kraussii	Sea Rush	Rush	50mm	$ 1.20	600	$720.00
		Lechenaultia floribunda	Free-flowering Leschenaultia	Shrub	50mm	$ 1.20	160	$192.00
		Lyginia barbata		Rush	50mm	$ 2.50	80	$200.00
		Macrozamia riedlei	Zamia	Cycad	50mm	$ 2.50	3	$7.50
		Melaleuca cuticularis	Saltwater Paperbark	Tree	70mm	$ 2.50	40	$100.00
		Patersonia occidentalis	Purple Flag	Herb	50mm	$ 1.20	100	$120.00
		Phlebocarya ciliata		Herb	50mm	$ 2.50	858	$2,145.00
		Rhagodia baccata	Berry Saltbush	Shrub	50mm	$ 1.20	40	$48.00
		Schoenus curvifolius		Sedge	50mm	$ 2.50	30	$75.00
		Schoenus subfascicularis		Rush	50mm	$ 1.20	1200	$1,440.00
		Sporobolus virginicus	Marine Couch	Grass	50mm	$ 1.20	500	$600.00
		Suaeda australis		Herb	50mm	$ 1.20	60	$72.00
		Xanthorrhoea preissii	Grass trees	Herb	70mm	$ 2.50	18	$45.00
					Total plants and cost for Priority Area 2		***5000***	***$8,920.50***
	Priority 3	*Acacia pulchella*	Prickly Moses	Shrub	50mm	$ 1.20	200	$240.00
		Acacia stenoptera	Narrow Winged Wattle	Shrub	50mm	$ 1.20	20	$24.00
		Adenanthos cygnorum	Common Woollybush	Shrub	50mm	$ 1.20	40	$48.00
		Alexgeorgea nitens		Rush	50mm	$ 2.50	540	$1,350.00
		Allocasuarina fraseriana	Sheoak	Tree	50mm	$ 1.20	20	$24.00
		Allocasuarina humilis	Dwarf Sheoak	Shrub	50mm	$ 1.20	100	$120.00
		Anigozanthos humilis	Catspaw	Herb	50mm	$ 1.20	80	$96.00
		Anigozanthos manglesii	Menzies Kangaroo-paw	Herb	50mm	$ 1.20	40	$48.00
		Astroloma macrocalyx	Swan Berry	Shrub	50mm	$ 2.50	40	$100.00
		Bossiaea eriocarpa	Common Brown Pea	Shrub	50mm	$ 1.20	130	$156.00
		Conostylis aculeata	Prickly Conostylis	Herb	50mm	$ 1.20	500	$600.00
		Corymbia calophylla	Marri	Tree	50mm	$ 1.20	6	$7.20
		Corynotheca micrantha	Sand Lily	Herb	50mm	$ 2.50	48	$120.00
		Dampiera linearis	Common Dampiera	Herb	50mm	$ 1.20	20	$24.00
		Dasypogon bromeliifolius	Pineapple Bush	Herb	50mm	$ 2.50	200	$500.00
		Dianella revoluta	Blueberry Lily	Herb	50mm	$ 1.20	20	$24.00
		Eremaea pauciflora		Shrub	50mm	$ 2.50	90	$225.00
		Gompholobium tomentosum	Hairy Yellow Pea	Shrub	50mm	$ 1.20	94	$112.80
		Hibbertia hypericoides	Yellow Buttercups	Shrub	50mm	$ 2.50	180	$450.00
		Hibbertia racemosa	Stalked Guinea-flower	Shrub	50mm	$ 1.20	80	$96.00
		Hovea trisperma	Common Hovea	Shrub	50mm	$ 1.20	20	$24.00
		Hybanthus calycinus	Wild Violet	Herb	50mm	$ 2.50	20	$50.00
		Hypolaena exsulca		Rush	50mm	$ 2.50	80	$200.00
		Laxmannia squarrosa		Herb	50mm	$ 2.50	10	$25.00

Year of Works	Priority level	Botanical name	Common name	Growth form	Size	Price	Quantity	Total cost
Year 2	**Priority 3**	*Lechenaultia floribunda*	Free-flowering Leschenaultia	Shrub	50mm	$ 1.20	140	$168.00
		Leucopogon conostephioides		Shrub	50mm	$ 2.50	20	$50.00
		Lomandra hermaphrodita		Herb	50mm	$ 2.50	20	$50.00
		Lyginia barbata		Rush	50mm	$ 2.50	1080	$2,700.00
		Macrozamia riedlei	Zamia	Cycad	50mm	$ 1.20	20	$24.00
		Mesomelaena pseudostygia		Sedge	50mm	$ 2.50	40	$100.00
		Patersonia occidentalis	Purple Flag	Herb	50mm	$ 1.20	120	$144.00
		Petrophile linearis	Pixie Mops	Shrub	50mm	$ 1.20	80	$96.00
		Philotheca spicata	Pepper and Salt	Shrub	50mm	$ 1.20	20	$24.00
		Phlebocarya ciliata		Herb	50mm	$ 2.50	650	$1,625.00
		Ptilotus polystachyus	Prince of Wales Feather	Herb	50mm	$ 1.20	30	$36.00
		Schoenus subfascicularis		Rush	50mm	$ 1.20	315	$378.00
		Scholtzia involucrata	Spiked Scholtzia	Shrub	50mm	$ 1.20	100	$120.00
		Synaphea spinulosa		Shrub	50mm	$ 1.20	40	$48.00
		Xanthorrhoea preissii	Grass trees	Herb	70mm	$ 2.50	47	$117.50
		Total plants and cost for Priority Area 3					***5300***	***$10,344.50***
Total of plants and costs for Year 2							**10500**	**$19,645.00**
Year 3	**Priority 2**	*Acacia stenoptera*	Narrow Winged Wattle	Shrub	50mm	$ 1.20	10	$12.00
		Alexgeorgea nitens		Rush	70mm	$ 2.50	20	$50.00
		Billardiera heterophylla	Australian Bluebell	Shrub	50mm	$ 1.20	5	$6.00
		Bossiaea eriocarpa	Common Brown Pea	Shrub	50mm	$ 1.20	20	$24.00
		Casuarina obesa		Tree	70mm	$ 2.50	10	$25.00
		Dasypogon bromeliifolius	Pineapple Bush	Herb	50mm	$ 2.50	280	$700.00
		Eremaea pauciflora		Shrub	50mm	$ 2.50	20	$50.00
		Gastrolobium capitatum		Shrub	50mm	$ 1.20	5	$6.00
		Gompholobium tomentosum	Hairy Yellow Pea	Shrub	50mm	$ 1.20	10	$12.00
		Hibbertia hypericoides	Yellow Buttercups	Shrub	50mm	$ 2.50	60	$150.00
		Hypocalymma angustifolium	White Myrtle	Shrub	50mm	$ 1.20	20	$24.00
		Hypolaena exsulca		Rush	50mm	$ 1.20	50	$60.00
		Juncus kraussii	Sea Rush	Rush	50mm	$ 1.20	150	$180.00
		Lechenaultia floribunda	Free-flowering Leschenaultia	Shrub	50mm	$ 1.20	80	$96.00
		Lyginia barbata		Rush	50mm	$ 2.50	50	$125.00
		Melaleuca cuticularis	Saltwater Paperbark	Tree	70mm	$ 2.50	30	$75.00
		Patersonia occidentalis	Purple Flag	Herb	50mm	$ 1.20	260	$312.00
		Phlebocarya ciliata		Herb	50mm	$ 1.20	760	$912.00
		Rhagodia baccata	Berry Saltbush	Shrub	50mm	$ 1.20	10	$12.00
		Schoenus subfascicularis		Rush	50mm	$ 1.20	750	$900.00
		Sporobolus virginicus		Grass	50mm	$ 1.20	400	$480.00
		Total plants and cost for Priority Area 2					***3000***	***$4,211.00***
	Priority 3	*Acacia cyclops*	Coastal Wattle	Shrub	50mm	$ 1.20	20	$24.00
		Acacia lasiocarpa	Panjang	Shrub	50mm	$ 1.20	40	$48.00
		Acacia pulchella	Prickly Moses	Shrub	50mm	$ 1.20	200	$240.00
		Acacia stenoptera	Narrow Winged Wattle	Shrub	50mm	$ 1.20	20	$24.00
		Adenanthos cygnorum	Common Woollybush	Shrub	50mm	$ 1.20	100	$120.00
		Alexgeorgea nitens		Rush	50mm	$ 2.50	1078	$2,695.00
		Allocasuarina fraseriana	Sheoak	Tree	50mm	$ 1.20	5	$6.00
		Allocasuarina humilis	Dwarf Sheoak	Shrub	50mm	$ 1.20	120	$144.00
		Anigozanthos manglesii	Menzies Kangaroo-paw	Herb	50mm	$ 1.20	20	$24.00
		Astroloma macrocalyx	Swan Berry	Shrub	50mm	$ 1.20	40	$48.00
		Bossiaea eriocarpa	Common Brown Pea	Shrub	50mm	$ 1.20	128	$153.60
		Burchardia congesta		Herb	50mm	$ 1.20	15	$18.00
		Conostephium preissii	Pearl Flower	Shrub	50mm	$ 1.20	15	$18.00
		Conostylis aculeata	Prickly Conostylis	Herb	50mm	$ 1.20	500	$600.00
		Corymbia calophylla	Marri	Tree	70mm	$ 2.50	5	$12.50
		Corynotheca micrantha	Sand Lily	Herb	50mm	$ 2.50	100	$250.00
		Dampiera linearis	Common Dampiera	Herb	50mm	$ 1.20	40	$48.00
		Dasypogon bromeliifolius	Pineapple Bush	Herb	50mm	$ 2.50	488	$1,220.00
		Desmocladus flexuosus		Rush	50mm	$ 2.50	10	$25.00
		Eremaea pauciflora		Shrub	50mm	$ 2.50	80	$200.00
		Eucalyptus gomphocephala	Tuart	Tree	50mm	$ 1.20	5	$6.00
		Gastrolobium capitatum		Shrub	50mm	$ 1.20	45	$54.00
		Gompholobium tomentosum	Hairy Yellow Pea	Shrub	50mm	$ 1.20	34	$40.80
		Haemodorum spicatum	Mardja	Herb	50mm	$ 1.20	13	$15.60
		Hibbertia hypericoides	Yellow Buttercups	Shrub	50mm	$ 2.50	370	$925.00

Year of Works	Priority level	Botanical name	Common name	Growth form	Size	Price	Quantity	Total cost
Year 3	**Priority 3**	*Hibbertia racemosa*	Stalked Guinea-flower	Shrub	50mm	$ 1.20	40	$48.00
		Hovea trisperma	Common Hovea	Shrub	50mm	$ 1.20	30	$36.00
		Hybanthus calycinus	Wild Violet	Herb	50mm	$ 2.50	20	$50.00
		Hypocalymma robustum	Swan River Myrtle	Shrub	50mm	$ 1.20	100	$120.00
		Hypocalymma angustifolium	White Myrtle	Shrub	50mm	$ 1.20	80	$96.00
		Hypolaena exsulca		Rush	50mm	$ 2.50	70	$175.00
		Kennedia prostrata	Scarlet Runner	Herb	50mm	$ 1.20	20	$24.00
		Laxmannia squarrosa		Herb	50mm	$ 2.50	20	$50.00
		Lechenaultia floribunda	Free-flowering Leschenaultia	Shrub	50mm	$ 1.20	503	$603.60
		Leucopogon conostephioides		Shrub	50mm	$ 2.50	40	$100.00
		Lomandra hermaphrodita		Herb	50mm	$ 2.50	40	$100.00
		Lyginia barbata		Rush	50mm	$ 2.50	610	$1,525.00
		Macrozamia riedlei	Zamia	Cycad	50mm	$ 1.20	20	$24.00
		Melaleuca huegelii	Chenille Honeymyrtle	Shrub	50mm	$ 1.20	20	$24.00
		Patersonia occidentalis	Purple Flag	Herb	50mm	$ 1.20	260	$312.00
		Petrophile linearis	Pixie Mops	Shrub	50mm	$ 1.20	40	$48.00
		Philotheca spicata	Pepper and Salt	Shrub	50mm	$ 1.20	40	$48.00
		Phlebocarya ciliata		Herb	50mm	$ 2.50	1647	$4,117.50
		Ptilotus polystachyus	Prince of Wales Feather	Herb	50mm	$ 1.20	25	$30.00
		Schoenus subfascicularis		Rush	50mm	$ 1.20	650	$780.00
		Scholtzia involucrata	Spiked Scholtzia	Shrub	50mm	$ 1.20	50	$60.00
		Synaphea spinulosa		Shrub	50mm	$ 1.20	20	$24.00
		Templetonia retusa	Cockies Tongues	Shrub	50mm	$ 1.20	100	$120.00
		Thysanotus patersonii		Herb	50mm	$ 2.50	20	$50.00
		Tricoryne elatior	Yellow Autumn Lily	Herb	50mm	$ 2.50	14	$35.00
		Xanthorrhoea preissii	Grass trees	Herb	50mm	$ 1.20	30	$36.00
		Total plants and cost for Priority Area 3					***8000***	***$15,595.60***
Total of plants and costs for Year 3							**11000**	**$19,806.60**
Year 4	**Priority 2**	*Acacia stenoptera*	Narrow Winged Wattle	Shrub	50mm	$ 1.20	10	$12.00
		Dasypogon bromeliifolius	Pineapple Bush	Herb	50mm	$ 2.50	200	$500.00
		Eremaea pauciflora		Shrub	50mm	$ 2.50	20	$50.00
		Gompholobium tomentosum	Hairy Yellow Pea	Shrub	50mm	$ 1.20	30	$36.00
		Hibbertia hypericoides	Yellow Buttercups	Shrub	50mm	$ 2.50	30	$75.00
		Hypolaena exsulca		Rush	50mm	$ 2.50	40	$100.00
		Lyginia barbata		Rush	50mm	$ 2.50	40	$100.00
		Patersonia occidentalis	Purple Flag	Herb	50mm	$ 1.20	100	$120.00
		Phlebocarya ciliata		Herb	50mm	$ 2.50	980	$2,450.00
		Schoenus subfascicularis		Rush	50mm	$ 1.20	50	$60.00
		Total plants and cost for Priority Area 2					***1500***	***$3,503.00***
	Priority 3	*Acacia cyclops*	Coastal Wattle	Shrub	50mm	$ 1.20	20	$24.00
		Acacia lasiocarpa	Panjang	Shrub	50mm	$ 1.20	40	$48.00
		Acacia pulchella	Prickly Moses	Shrub	50mm	$ 1.20	100	$120.00
		Adenanthos cygnorum	Common Woollybush	Shrub	50mm	$ 1.20	25	$30.00
		Alexgeorgea nitens		Rush	50mm	$ 2.50	2500	$6,250.00
		Allocasuarina humilis	Dwarf Sheoak	Shrub	50mm	$ 1.20	120	$144.00
		Anigozanthos humilis	Catspaw	Herb	50mm	$ 1.20	120	$144.00
		Anigozanthos manglesii	Menzies Kangaroo-paw	Herb	50mm	$ 1.20	20	$24.00
		Bossiaea eriocarpa	Common Brown Pea	Shrub	50mm	$ 1.20	250	$300.00
		Conostylis aculeata	Prickly Conostylis	Herb	50mm	$ 1.20	500	$600.00
		Corynotheca micrantha	Sand Lily	Herb	50mm	$ 2.50	250	$625.00
		Dampiera linearis	Common Dampiera	Herb	50mm	$ 1.20	90	$108.00
		Dasypogon bromeliifolius	Pineapple Bush	Herb	50mm	$ 2.50	700	$1,750.00
		Eremaea pauciflora		Shrub	50mm	$ 2.50	114	$285.00
		Gompholobium tomentosum	Hairy Yellow Pea	Shrub	50mm	$ 1.20	200	$240.00
		Hibbertia hypericoides	Yellow Buttercups	Shrub	50mm	$ 1.20	226	$271.20
		Hibbertia racemosa	Stalked Guinea-flower	Shrub	50mm	$ 1.20	60	$72.00
		Hovea trisperma	Common Hovea	Shrub	50mm	$ 1.20	30	$36.00
		Hypocalymma robustum	Swan River Myrtle	Shrub	50mm	$ 1.20	20	$24.00
		Hypolaena exsulca		Rush	50mm	$ 2.50	40	$100.00
		Kennedia prostrata	Scarlet Runner	Herb	50mm	$ 1.20	40	$48.00
		Laxmannia squarrosa		Herb	50mm	$ 2.50	30	$75.00
		Lechenaultia floribunda	Free-flowering Leschenaultia	Shrub	50mm	$ 1.20	270	$324.00
		Leucopogon conostephioides		Shrub	50mm	$ 2.50	90	$225.00
		Lomandra hermaphrodita		Herb	50mm	$ 2.50	40	$100.00

Year of Works	Priority level	Botanical name	Common name	Growth form	Size	Price	Quantity	Total cost
Year 4	**Priority 3**	*Lyginia barbata*		Rush	50mm	$ 2.50	950	$2,375.00
		Macrozamia riedlei	Zamia	Cycad	50mm	$ 1.20	5	$6.00
		Melaleuca huegelii	Chenille Honeymyrtle	Shrub	50mm	$ 1.20	40	$48.00
		Mesomelaena pseudostygia		Sedge	50mm	$ 2.50	400	$1,000.00
		Patersonia occidentalis	Purple Flag	Herb	50mm	$ 1.20	100	$120.00
		Petrophile linearis	Pixie Mops	Shrub	50mm	$ 1.20	160	$192.00
		Philotheca spicata	Pepper and Salt	Shrub	50mm	$ 1.20	105	$126.00
		Phlebocarya ciliata		Herb	50mm	$ 2.50	970	$2,425.00
		Phyllanthus calycinus	False Boronia	Shrub	50mm	$ 1.20	40	$48.00
		Ptilotus polystachyus	Prince of Wales Feather	Herb	50mm	$ 1.20	25	$30.00
		Schoenus subfascicularis		Rush	50mm	$ 1.20	1050	$1,260.00
		Scholtzia involucrata	Spiked Scholtzia	Shrub	50mm	$ 1.20	300	$360.00
		Synaphea spinulosa		Shrub	50mm	$ 1.20	20	$24.00
		Templetonia retusa	Cockies Tongues	Shrub	50mm	$ 1.20	20	$24.00
		Thysanotus patersonii		Herb	50mm	$ 2.50	40	$100.00
		Total plants and cost for Priority Area 3					***10120***	***$20,105.20***
Total of plants and costs for Year 4							**11620**	**$23,608.20**
Year 5	**Priority 2**	*Dasypogon bromeliifolius*	Pineapple Bush	Herb	50mm	$ 2.50	80	$200.00
		Gompholobium tomentosum	Hairy Yellow Pea	Shrub	50mm	$ 2.50	15	$37.50
		Melaleuca cuticularis		Tree	70mm	$ 2.50	20	$50.00
		Patersonia occidentalis	Purple Flag	Herb	50mm	$ 1.20	20	$24.00
		Phlebocarya ciliata		Herb	50mm	$ 2.50	650	$1,625.00
		Rhagodia baccata		Shrub	50mm	$ 1.20	20	$24.00
		Schoenus subfascicularis		Rush	50mm	$ 1.20	195	$234.00
		Total plants and cost for Priority Area 2					***1000***	***$2,194.50***
	Priority 3	*Adenanthos cygnorum*	Common Woollybush	Shrub	50mm	$ 1.20	25	$30.00
		Alexgeorgea nitens		Rush	50mm	$ 2.50	2500	$6,250.00
		Allocasuarina humilis	Dwarf Sheoak	Shrub	50mm	$ 1.20	50	$60.00
		Anigozanthos humilis	Catspaw	Herb	50mm	$ 1.20	50	$60.00
		Anigozanthos manglesii	Menzies Kangaroo-paw	Herb	50mm	$ 1.20	20	$24.00
		Bossiaea eriocarpa	Common Brown Pea	Shrub	50mm	$ 1.20	100	$120.00
		Corynotheca micrantha	Sand Lily	Herb	50mm	$ 2.50	300	$750.00
		Dampiera linearis	Common Dampiera	Herb	50mm	$ 1.20	50	$60.00
		Dasypogon bromeliifolius	Pineapple Bush	Herb	50mm	$ 2.50	272	$680.00
		Eremaea pauciflora		Shrub	50mm	$ 2.50	20	$50.00
		Gompholobium tomentosum	Hairy Yellow Pea	Shrub	50mm	$ 1.20	113	$135.60
		Hibbertia hypericoides	Yellow Buttercups	Shrub	50mm	$ 2.50	100	$250.00
		Hibbertia racemosa	Stalked Guinea-flower	Shrub	50mm	$ 1.20	20	$24.00
		Kennedia prostrata	Scarlet Runner	Herb	50mm	$ 1.20	20	$24.00
		Laxmannia squarrosa		Herb	50mm	$ 2.50	40	$100.00
		Lechenaultia floribunda	Free-flowering Leschenaultia	Shrub	50mm	$ 1.20	177	$212.40
		Lyginia barbata		Rush	50mm	$ 2.50	500	$1,250.00
		Melaleuca huegelii	Chenille Honeymyrtle	Shrub	50mm	$ 1.20	20	$24.00
		Mesomelaena pseudostygia		Sedge	50mm	$ 2.50	60	$150.00
		Patersonia occidentalis	Purple Flag	Herb	50mm	$ 1.20	40	$48.00
		Philotheca spicata	Pepper and Salt	Shrub	50mm	$ 1.20	65	$78.00
		Phlebocarya ciliata		Herb	50mm	$ 2.50	915	$2,287.50
		Phyllanthus calycinus	False Boronia	Shrub	50mm	$ 1.20	40	$48.00
		Schoenus subfascicularis		Rush	50mm	$ 1.20	923	$1,107.60
		Scholtzia involucrata	Spiked Scholtzia	Shrub	50mm	$ 1.20	100	$120.00
		Thysanotus patersonii		Herb	50mm	$ 1.20	40	$48.00
		Total plants and cost for Priority Area 3					***6560***	***$13,991.10***
Total of plants and costs for Year 5							**7560**	**$16,185.60**
Total quantities and costs within 5 years of project life							**42680**	**$83,631.40**

Difficult to propagate species

The estimated overall cost of bioengineering works, access management works (which include fencing, removal of small limestone paths, formalisation of the beach access, maintenance works (which include repairs to bioengineering works and watering), plant supply, weed control etc are outlined in Table 7. Please note that Priority area 4 is the only area that does not require planting, however, it will require regular weed maintenance throughout the project to maintain its integrity.

Table 7 Indicative cost for materials and labour for restoration of Mount Henry Spit

Year of works	Priority level	Restoration tasks	Approximate contractor costs (ex GST)
Preliminaries			$ 9,000.00
Year 1	Priority 1	Weed control	$ 2,000.00
		Erosion control - foreshore treatment 1	$ 50,000.00
		Plant Supply	$ 4,386.00
		Planting of Priority area 1	$ 6,050.00
		Formalisation of the major beach access track (including removal of bollards and disposal and installation of the formal beach access)	$ 8,000.00
		Maintenance	$ 7,680.00
	Priority 2	Weed control	$ 3,000.00
	Priority 3	Weed control	$ 9,000.00
	Priority 4	Weed control	$ 1,000.00
Monitoring and Reporting - Baseline Report and 12 Monthly reports			$ 15,000.00
Additional Project costs including project management and administration			$ 5,000.00
Year 1 total			**$ 120,116.00**
Preliminaries			$ 9,000.00
Year 2	Priority 1	Weed control	$ 1,500.00
		Plant Supply	$ 380.00
		Supplementary planting	$ 575.00
		Maintenance	$ 4,500.00
	Priority 2	Weed control	$ 1,500.00
		Erosion control - foreshore treatment 2	$ 51,000.00
		Plant Supply	$ 8,920.50
		Planting in Priority Area 2	$ 12,963.50
		Maintenance	$ 5,000.00
	Priority 3	Weed control	$ 7,500.00
		Plant Supply	$ 10,344.50
		Planting in Priority Area 3	$ 13,250.00
		Fencing	$ 3,500.00
		Maintenance	$ 2,500.00
	Priority 4	Weed control	$ 1,500.00
Monitoring and Reporting - Year 1 and 12 Monthly Reports			$ 9,996.00
Additional Project costs including project management and administration			$ 6,000.00
Year 2 total			**$ 149,929.50**
Preliminaries			$ 2,300.00
Year 3	Priority 1	Maintenance	$ 4,000.00
	Priority 2	Weed control	$ 1,500.00
		Plant Supply	$ 4,211.00
		Supplementary planting of Priority area 2	$ 7,500.00
		Maintenance	$ 4,000.00
	Priority 3	Weed control	$ 5,000.00
		Plant Supply	$ 15,595.60
		Planting in Priority Area 3	$ 20,000.00
		Limestone path removal	$ 2,300.00
		Maintenance	$ 2,500.00
	Priority 4	Weed control	$ 1,000.00
Monitoring and Reporting - Year 3 and 12 Monthly Reports			$ 15,000.00
Additional Project costs including project management and administration			$ 4,000.00
Year 3 total			**$ 88,906.60**
Preliminaries			$ 2,300.00
Year 4	Priority 1	Maintenance	$ 3,000.00
	Priority 2	Weed control	$ 1,000.00
		Plant Supply	$ 3,503.00
		Supplementary planting of Priority area 2	$ 3,750.00
		Maintenance	$ 3,000.00
	Priority 3	Weed control	$ 5,000.00
		Plant Supply	$ 20,105.20
		Planting in Priority Area 3	$ 25,300.00
		Maintenance	$ 2,004.00
	Priority 4	Weed control	$ 1,000.00
Monitoring and Reporting - Year 4 and 12 Monthly Reports			$ 15,000.00
Additional Project costs including project management and administration			$ 3,000.00
Year 4 total			**$ 87,962.20**
Preliminaries			$ 2,300.00
Year 5	Priority 1	Maintenance	$ 2,000.00
	Priority 2	Weed control	$ 1,000.00
		Plant Supply	$ 2,194.50
		Supplementary planting of Priority area 2	$ 2,500.00
		Maintenance	$ 2,000.00
	Priority 3	Weed control	$ 5,000.00
		Plant Supply	$ 13,991.10
		Planting in Priority Area 3	$ 16,400.00
		Maintenance	$ 1,520.00
	Priority 4	Weed control	$ 1,000.00
Monitoring and Reporting - Year 4 and 12 Monthly Reports			$ 15,000.00
Additional Project costs including project management and administration			$ 3,000.00
Year 5 total			**$ 67,905.60**
TOTAL PROJECT COST (ex GST)			**$ 514,819.90**

Note: The cost of any transplantation trials for difficult to propagate species as specified in Section 9.2.3 of this report are not included in this table. The Contractor will be required to provide a proposal for a transplantation trial as part of the tender response to conduct restoration works.

The bill of quantities (BOQ) based on the costs presented in Table 7 is given in Appendix 4.

The costs given in Table 7 as well at the BOQ indicate that the overall budget necessary to complete restoration works at Mount Henry Spit will be close to $520,000 over a five year period. Given the large number of restoration projects on the Swan and Canning Rivers, these funds may be difficult to obtain and may be available only in smaller amounts (up to $50,000 per year) over a longer time period (up to 10 years). Therefore, the prioritisation process and the amount of work conducted each year will have to be reviewed each year and may change to what is proposed in this restoration plan.

In the event that the full funds are not available for restoration of Priority 1 area in the first year, other areas of the Site can be restored through winter plantings and weed control. The decision as to the prioritisation of sections of any given planting area can be made based on the information given in this report and the site conditions at that time. A consultation with an experienced environmental consultant may assist in selection of the most appropriate sections and help justify the allocation of funds to those areas.

It is recommended that in short term (1 – 2 years) the City of South Perth:

- Works on obtaining funds for restoration works in the order of magnitude indicated in the cost tables.
- Implements as a minimum Priority 1 restoration works in the short term – (implementing bioengineering works without planting is also possible) if funds are limited;
- Continue weed control for the entire site;
- Monitor performance of the Priority 1 bioengineering works;
- Implements transplantation trials;
- Apply for funding to assist with the implementation of the remainder of the plan. Collaboration with the Swan River Trust will be essential to secure funds for the short and long term restoration works.
- Works with the community groups and schools to investigate opportunities for reducing maintenance and planting costs;
- Employs a qualified hydrologist to confirm if the selected erosion protection methods are sustainable in the short and long term and together with the City and the Swan River Trust investigate and compare if indirect shore stabilisation approaches such as installation of groynes would be more efficacious (in terms of natural plant

establishment) and be more cost effective in long term particularly considering the predicted climate change.

- Consults with a specialist nursery / consultant with regards to growing difficult to propagate species so as to facilitate efficient propagation trials.
- Consults with a specialist consultant with regards to species substitutions after 2 years of trials with recommended dryland species (species indigenous to site).

REFERENCES

Aplin, T.E.H. (1979) Chapter 3: The Flora. In *Environment and Science* (O'Brien, B.J., ed), University of Western Australia Press

Brooker, J., Christie, C., Curry, B., Davis, G., Kennedy, D., McAlpine, K., and Masters, G. (1993) Mount Henry Peninsula Management Plan. Prepared for the City of South Perth

Bureau of Meteorology (2013) Climate Statistics for Australian Locations: Monthly climate statistics for all years of record – Summary statistics Jandakot AERO. Bureau of Meteorology http://www.bom.gov.au/climate/averages/tables/cw_009172.shtml. Accessed on 18th February 2013.

City of South Perth (2011) Open Space Planning Strategy — Part 2.

Department of Environment and Conservation (2013) NatureMap: mapping Western Australia's Biodiversity. Department of Environment and Conservation

Department of Environment and Conservation (2013) Threatened and Priority Fauna Rankings – 10 January 2013 (Department of Environment and Conservation, ed), Government of Western Australia.

Department of Environment and Conservation (2011) Techniques for mapping weed distribution and cover in bushland and wetlands SOP No. 22.1 (Department of Environment and Conservation, ed), Government of Western Australia

Department of Environment and Conservation (2008) Seed Notes for Western Australia No. 2: Seed Collection. Website: http://www.dec.wa.gov.au/our-environment/science-and-research/plant-conservation-research/seed-banking-for-biodiversity-conservation/seed-notes-for-wa.html. Date accessed: 30 April 2013.

Department of Environmental Protection (2000) Bush Forever Volume 2: Directory of Bush Forever Sites. (Protection, E., ed), pp. 530, Department of Environmental Protection

Department of Sustainability Environment Water Population and Communities (DSEWPAC) (2012) The Protected Matters Search Tool. Department of Sustainability, Environment, Water, Population and Communities http://www.environment.gov.au/epbc/pmst/index.html Accessed on 16 April 2013.

Department of Transport (2013) Swan and Canning Rivers — A boating guide for the Swan and Canning Rivers. Government of Western Australia

http://www.transport.wa.gov.au/mediaFiles/mar_SwanCanningRiverparkGuideMap.pdf. Accessed on 18 February 2013.

Department of Water (2013) Ground Water Atlas. Government of Western Australia http://www.water.wa.gov.au/idelve/gwa. Accessed on 18 February 2013.

Department of Water (2013a). 100 year ARI Floodway and Flood Fringe Line. WA Atlas https://www2.landgate.wa.gov.au/bmvf/app/waatlas/. Accessed on 20th April 2014

Ecoscape (2004) Mt Henry Peninsula Foreshore Management Plan 2004: Draft for public comment. Prepared by Ecoscape (Australia) PL for the City of South Perth and Aqinas College

Gozzard JR (1983) Fremantle Part Sheet 2033 I and 2033 IV, Environmental Geology Series. Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

How, R.A. and Dell, J. (1994) The zoogeographic significance of urban bushland remnants to reptiles in the perth region, Western Australia. *Pacific Conservation Biology* 6, 198-217

How, R.A. and Dell, J. (2000) Ground vertebrate fauna of perth's vegetation remnants: Impact of 170 years of urbanisation. *Pacific Conservation Biology* 6, 198-217

Keighery, B.J. (1994) Bushland Plant Survey. A Guide to Plant Community Survey for the Community., Wildlife Society of WA (Inc.)

Landgate (2006 – 2014). Map Viewer. Available online: https://www.landgate.wa.gov.au/bmvf/app/mapviewer/ Accessed on 22nd May 2014.

Linderfelt, W.R. and Turner, J.V. (2001) Interaction between shallow groundwater, saline surface water and nutrient discharge in a seasaonl esturary: the Swan-Canning system. *Hydrological Processes* 15, 2631-2653

Muir, B.G. (1977) Biological survey of the Western Australian Wheatbelt. Part II: Vegetation and habitat of Bendering Reserve. *Records of the Western Australian Museum* Suppl. No 3, p142

Natural Area Consulting [NAC] (2012) City of South Perth Mount Henry Spit weed Maps 2012/2013. Unpublished pdf maps for City of South Perth.

Specht, R.L. (1970) Vegetation. In *The Australian Environment* (Leeper, G.W., ed), Melbourne University Press

Swan River Trust (2009) Best Management Practices for Foreshore Stabilisation, Approaches and decision-support framework. Swan River Trust

Swan River Trust (2008) Swan and Canning Rivers Foreshore Assessment and Management Strategy. Swan River Trust

Swan River Trust Technical Advisory Panel (2007) Potential Impacts of Climate Change on the Swan and Canning Rivers. pp. 108, Prepared for the Swan River Trust , Government of Western Australia

URS (2013). Assessment of Swan and Canning River Tidal and Storm Surge Water Levels. DOW2711. Technical Report prepared for Department of Water, 17th January 2013.

Water and Rivers Commision (1997) Pricinct 15: Canning River — Canning River to Freeway at Mount Henry. In *Swan River System: Landscape Description* (Chalmers, L., ed), Report prepared for the Swan River Trust

LIST OF ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in the document include:

- Actual Acid Sulphate Soils (AASS);
- City of South Perth (CoSP);
- Department of Environment and Conservation (DEC);
- Department of Indigenous Affairs (DIA);
- Duel Use Pathway (DUP);
- Environmental Health and Safety (EH&S);
- Environmental Protection Authority (EPA);
- Main Roads Western Australia (MRWA);
- Potential Acid Sulphate Soils (PASS);
- Natural Area Consulting (NAC);
- Swan River Trust (SRT); and
- Western Australia (WA).

DEFINITION OF TERMS

Bioengineering

The use of both engineering and biological techniques in environmental remediation processes. Involves both “hard” and “soft” approaches each with varying levels of non-biological structure involved. Typically involves the use of flora to replace the need for heavier structure.

Brushwall

Erosion control technique that uses a log made from brush (usually *Kunzea glabrescens*) to reduce wave energy upon impact with a shoreline whilst retaining soil and plants. The brush is wired in a log bundle and then anchored to the ground using jarrah stakes. Brushwalls can be stacked up to form multiple levels or in steps forming palisades.

Coir node

An erosion control technique involving the construction of a node out of a coconut fibre (coir) log. The log is anchored to the ground using jarrah stakes and a mesh wrap. Foreshore species such as *Juncus kraussii* are then planted in the soil behind the node.

Duel Use Path

Refers to a path designed for use by both pedestrians and cyclists.

Riparian

Riparian (Latin word meaning river) is the zone of interface between land and river. It contains fringing vegetation of plants that are able to withstand harsh condition such as erosion and saline conditions. Destabilisation of the Riparian zone can cause increased levels of erosion.

APPENDICES

Appendix 1 Foreshore profiles recorded during field assessment

FORESHORE ASSESSMENT – FORESHORE PROFILES

Nine foreshore profiles were surveyed and assessed, identifying the specific topography, indicative tide heights, vegetation and levels of erosion. Their locations are identified in Figure 1. The following figures represent the section profiles as surveyed at each of these locations including a photo at the profile location.

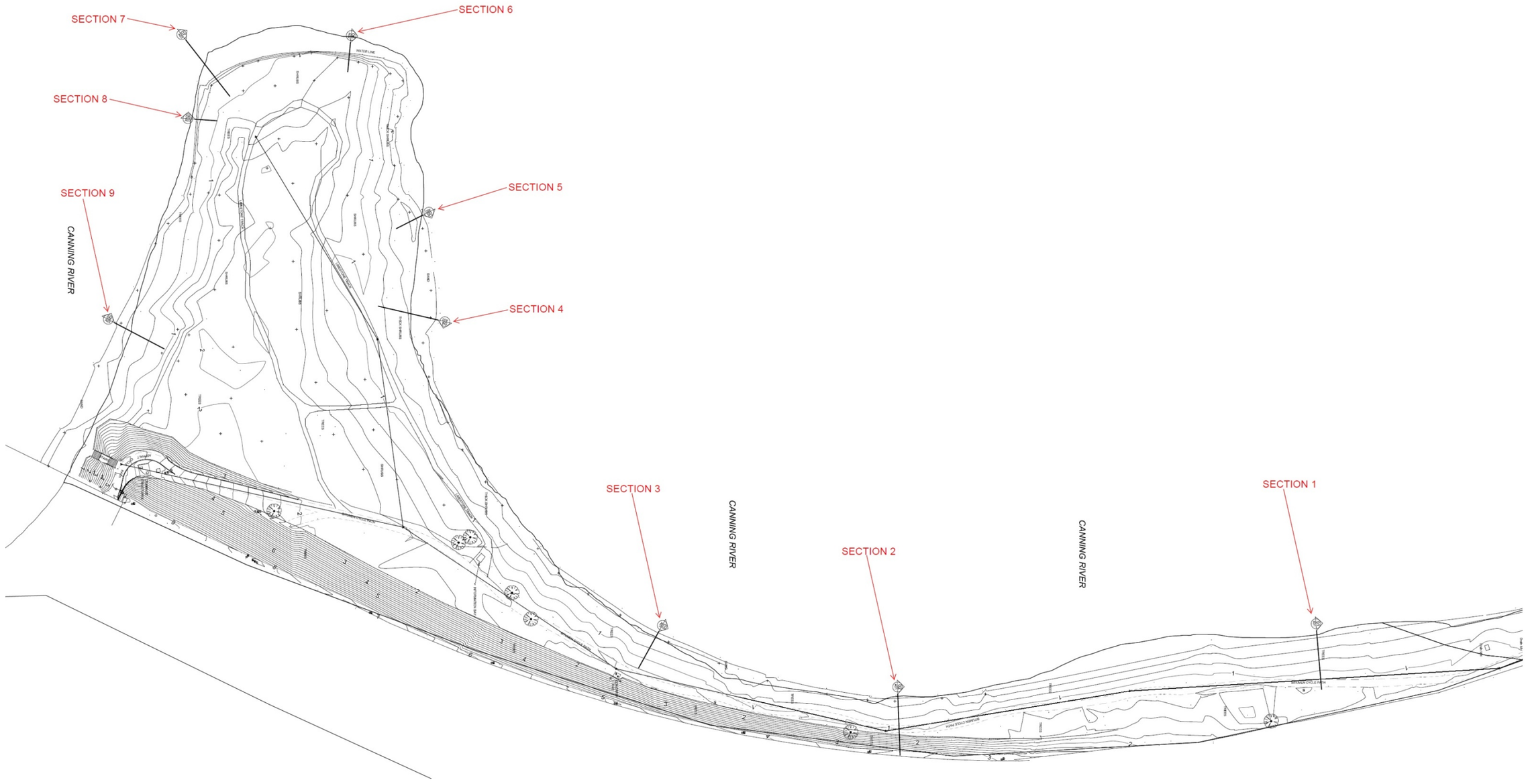


Figure 1. Foreshore profile locations at the Mount Henry Spit

SECTION 1

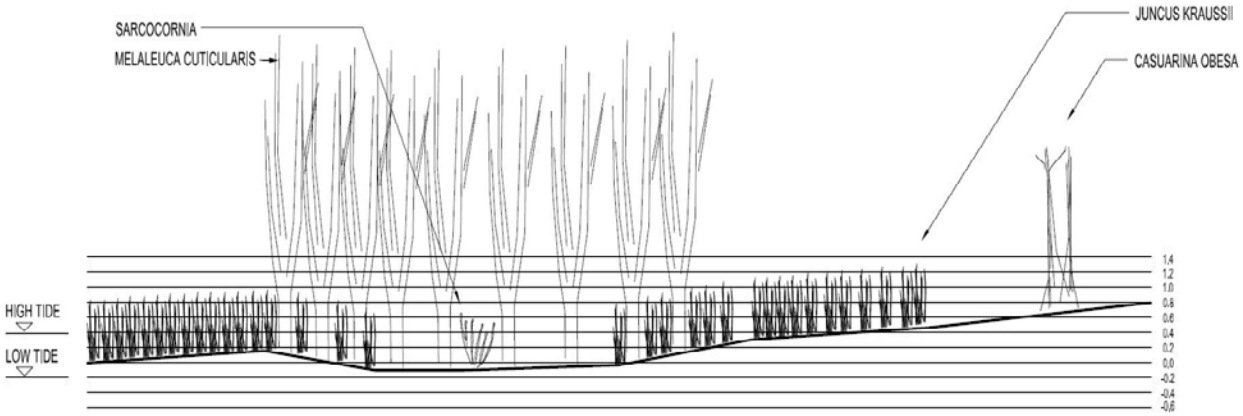


Figure 2. Section 1 foreshore profile

Section 1 (Figure 2) illustrates a high density of healthy *Juncus kraussii* on the lower foreshore. It has to be noted that there is evidence of wave damage to across the front row. Behind this group of *Juncus kraussii* is a slight depression consisting of mainly bare sand, some *Sarcocornia spp.* and *Melaleuca cuticularis*. The depth of this depression indicates water would be present during high tide events. Another healthy group of *Juncus kraussii* is present landward from this depression and continues towards the upper foreshore.

SECTION 2

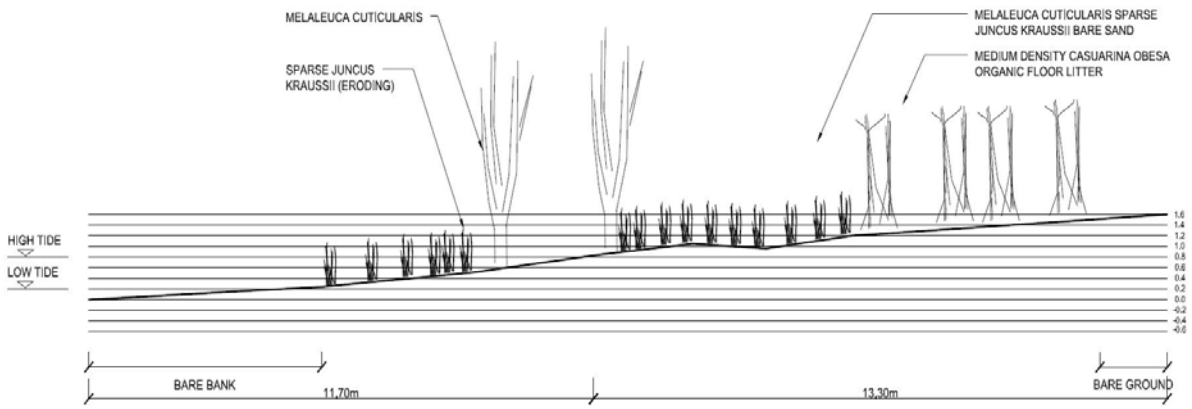


Figure 3. Section 2 foreshore profile

Section 2 (Figure 3) shows a group of *Juncus kraussii* located along the lower foreshore showing evidence of active erosion through their exposed root base. The mid and upper foreshore consists of sparse *Melaleuca cuticularis* and *Juncus kraussii*, together with a good coverage of *Casuarina obesa* closer to the DUP. Informal paths are also present in this area.

SECTION 3

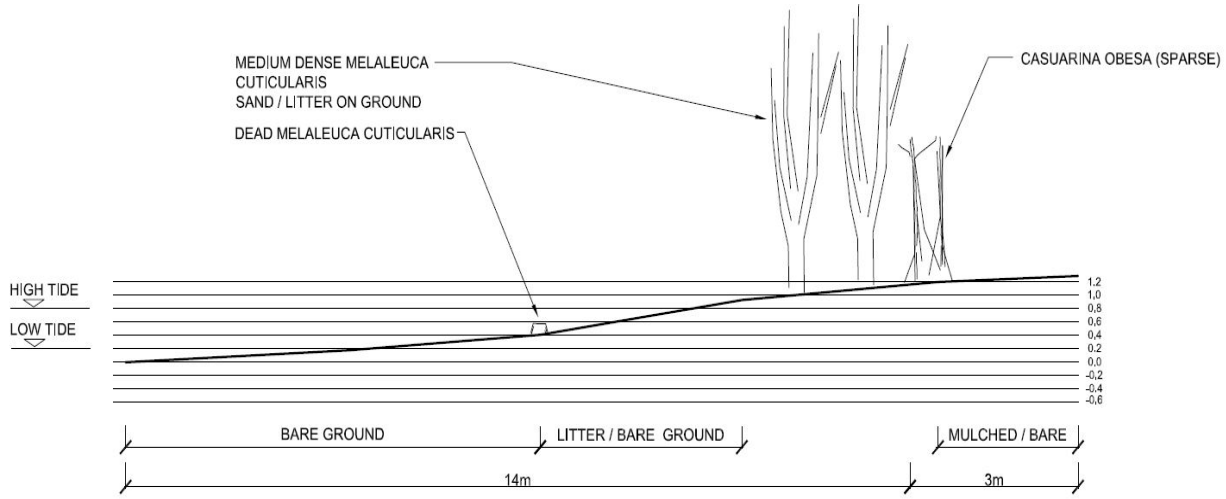


Figure 4. Section 3 foreshore profile

Section 3 (Figure 4) exhibits a shorter distance of only 17m between the shoreline and DUP. *Juncus kraussii* is notably absent from the foreshore and the vegetation is present towards the upper foreshore and consists of low to medium density *Casuarina obesa and Melaleuca cuticularis.*

SECTION 4

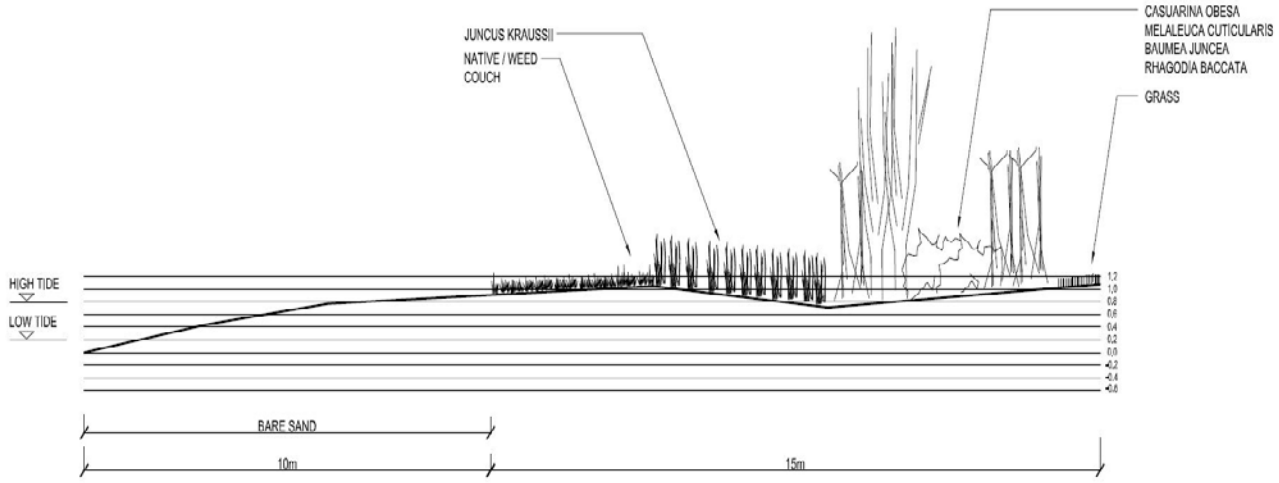


Figure 5. Section 4 foreshore profile

Section 4 (Figure 5) exhibits minimal erosion impact mainly due to the protection offered by the sandbar further down the shoreline. The vegetation within the lower/mid foreshore region include a combination of native and weed couch grass and dense *Juncus kraussii*. The upper foreshore is comprised of a high diversity of species such as *Casuarina obesa, Melaleuca cuticularis, Baumea juncea and Rhagodia baccata.*

SECTION 5

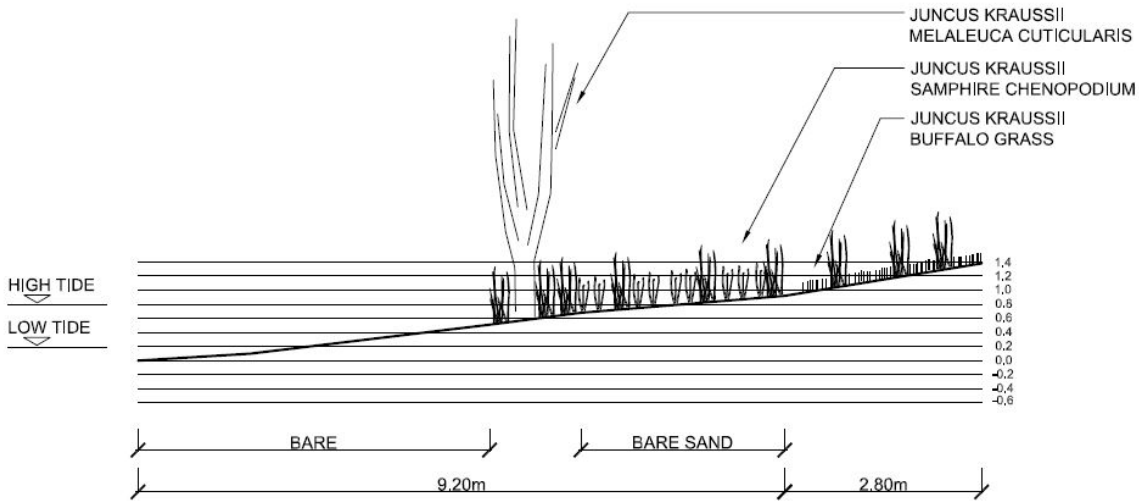


Figure 6. Section 5 foreshore profile

The section 5 (Figure 6) profile highlights a more prominent increase in erosion. This area presents evidence of high traffic due to the number of informal paths scattered between the mid and high foreshore zones. *Juncus kraussii* and various weed species are prominent in this section.

SECTION 6

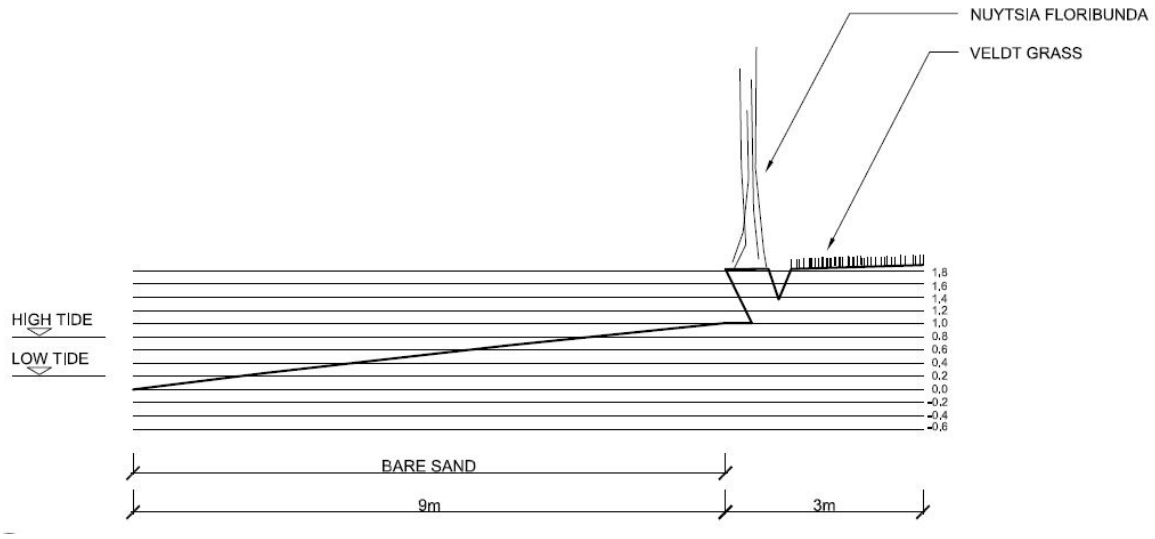


Figure 7. Section 6 foreshore profile

Section 6 (Figure 7) foreshore profile indicates significant signs of erosion. It is highly exposed to the effects of river traffic as well as the wind waves. Beach use is also evident in this area. The eroded embankment height is 0.8m, with undercutting prevalent at the high tide mark. Native herbland, Veldt grass and sparse *Nuytsia floribunda* covers most of the upper embankment.

SECTION 7

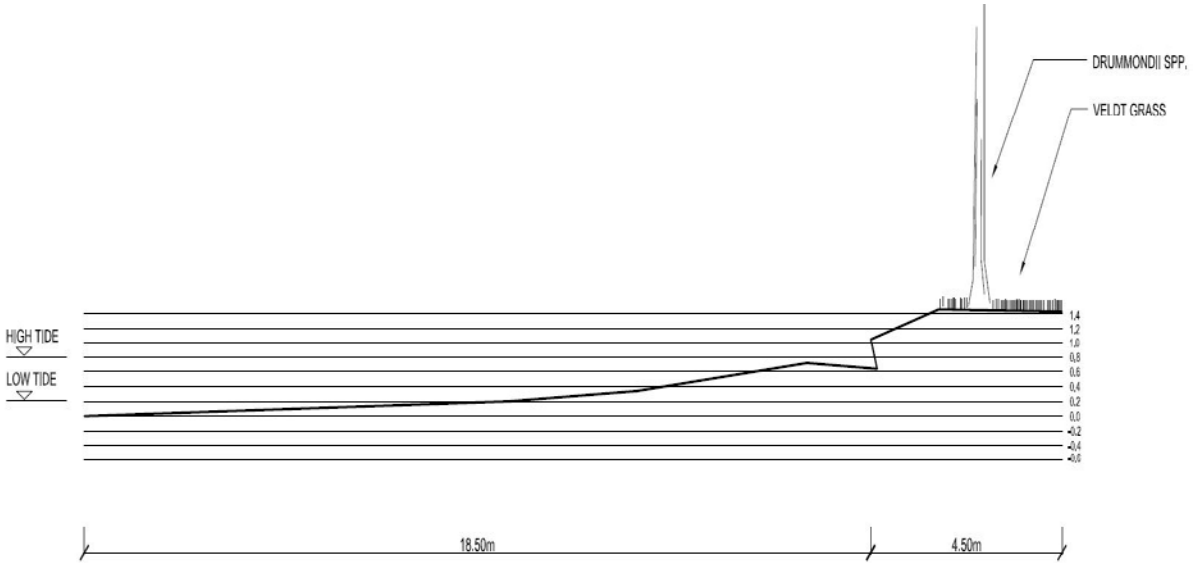


Figure 8. Section 7 foreshore profile

Section 7 (Figure 8) shows a high level of erosion with undercutting clearly visible and a large sand spit exposed during low tide. Multiple informal paths and dense vegetation are present on the upper embankment.

SECTION 8

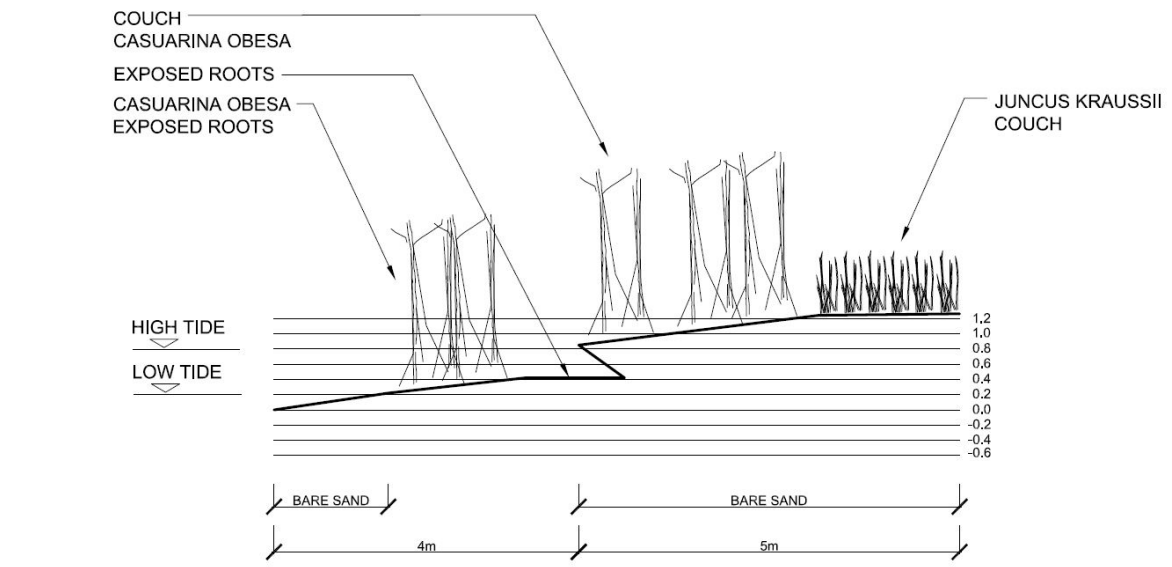


Figure 9. Section 8 foreshore profile

Section 8 (Figure 9) indicates another highly eroded zone. The *Casuarina obesa* located on the lower foreshore are severely undercut. Vegetation behind the *C. obesa* is relatively dense.

SECTION 9

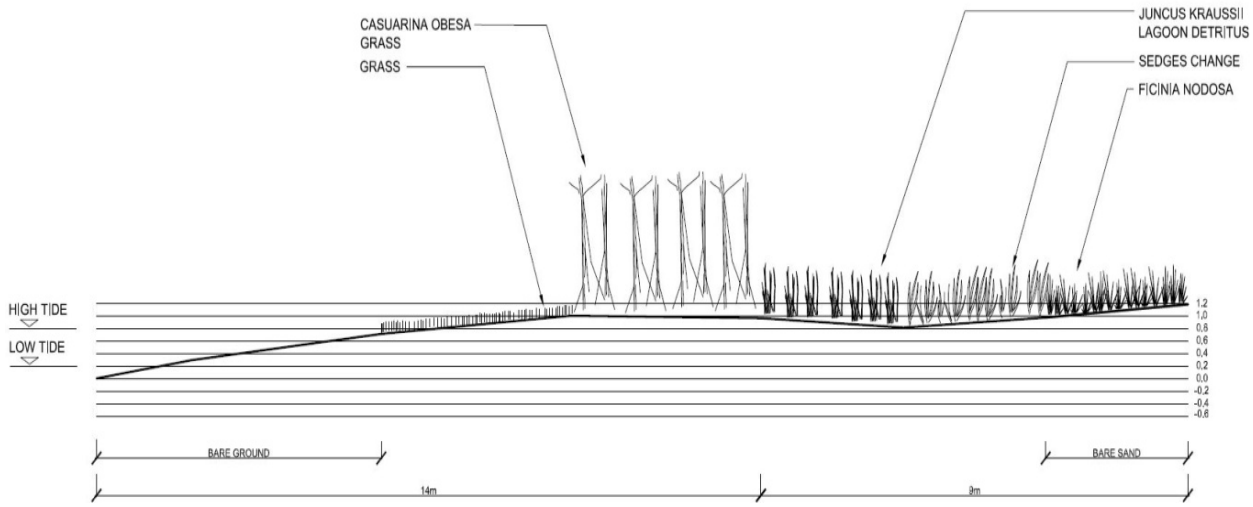


Figure 10. Section 9 foreshore profile

Section 9 (Figure 10) is located on the southern-most end of the Site and shows minimal erosion damage. A slight depression is visible approximately 17m inland from the water's edge. Couch grass is present in patches across the shoreline, with sparse *Casuarina obesa* scattered further inland. *Juncus kraussii* and detritus is present in the depression, which gives way to *Ficinia nodosa* on the upper foreshore.

Appendix 2 Wave Velocity Assessment report

WAVE IMPACT ASSESSMENT FOR MT HENRY SPIT FORESHORE

INTRODUCTION

The Canning River is exposed to intense and frequent wave impact which can vary across discrete areas of foreshore. This variation is dependent on factors such as shoreline orientation in relation to wind direction and boat traffic combined with riverine physiology (i.e. near shore bathymetry) and onshore geomorphology.

A wave impact assessment shows how combined natural and anthropogenic factors affect the shoreline and allows qualitative and quantitative data to be collected and analysed.

The purpose of the wave impact assessment for the Mount Henry Spit was to assist in determining the most effective implementation of restoration techniques able to withstand onshore wave impacts. It is acknowledged that it is not the only factor contributing to erosion and that the storm surges also have an impact. Due to the project timelines it was not practical to wait for a storm surge event to occur and conduct measurements to determine which waves make more impact (i. Boat wake versus storm / wind waves).

Terminology

Following terminology is used in this wave impact assessment report:

- **Wash zone** - the area of foreshore responsible for absorbing, deflecting and reflecting the wave energy associated with water bodies (*Larson* et. al 2004). The term *wash zone* is used in this assessment to describe the area where the waters *upwash* is at maximum level at high tide and *backwash* is at its minimum at low tide.
- **Upwash** - is the reach of water up the foreshore.
- **Backwash** - is the return of water down the foreshore.

METHODOLOGY

Qualitative and quantitative wave impact data was collected on Saturday 20th April 2013, with supporting observations undertaken on Sunday the 7th April, 2013. The weekends were chosen as the boat traffic is likely to be higher than during weekdays.

Two Starflow Ultrasonic Doppler flow meters were used to estimate the velocity of waves impacting on the foreshore. The use of these metres is based on the fact that wave velocity data is inferred to be an indicator of the intensity of wave impact on the shoreline.

Two locations (Location A- “Bridge Side” and Location B- “City Side”) were selected for conducting measurements based on a range of factors including shoreline morphology and the direction of onshore waves. The flow meters were positioned in such a way to ensure the

wave impact was measured at the likely point of maximum velocity. This point was inferred from aerial photograph observations of the landmass loss at the westernmost end of the Spit from 1953 to 2013 and in the field observations of onshore waves.

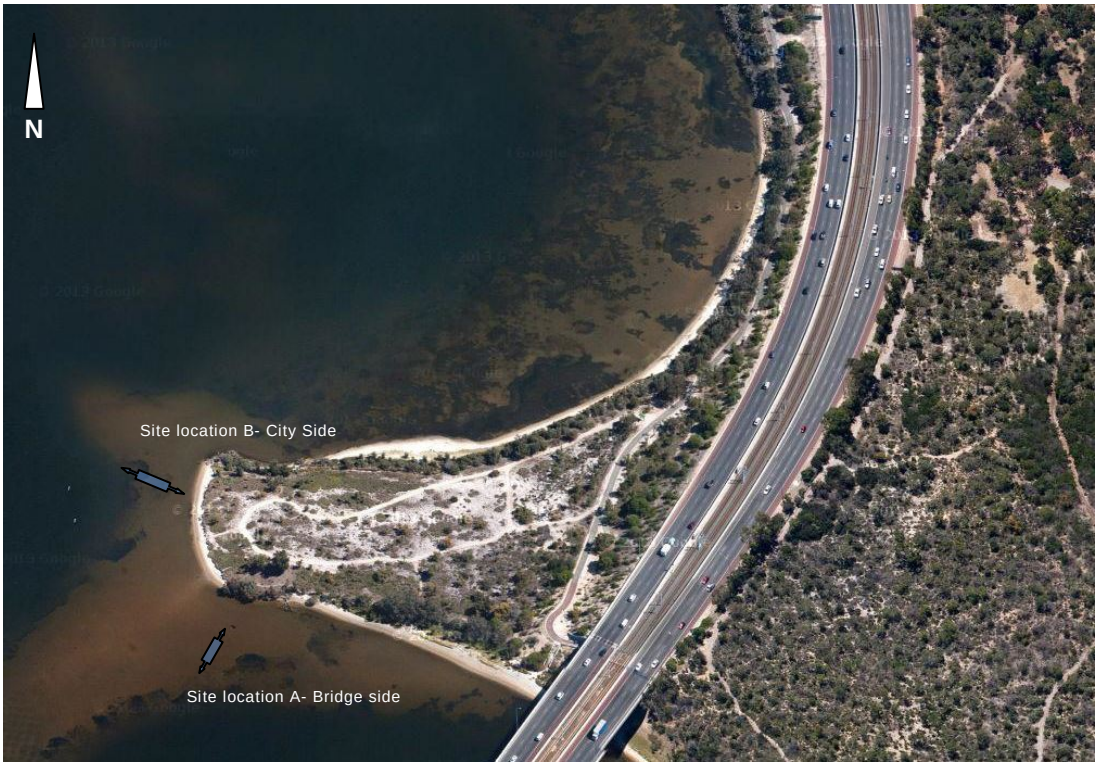


Figure 1 Location of Starflow Ultrasonic Doppler flow meters used to estimate the wave velocity at Mount Henry Spit

The flow meters were positioned in the water for approximately five hours during high to medium tides.

Qualitative data relevant to the boat activity on the river was recorded including:

- Number of boats passing the Site;
- Estimated boat size;
- Direction of travel;
- Approximate distance from shoreline;
- Direction of the boat generated wave impacting on the shoreline; and
- Time of wave impact.

This observational data used for the wave impact assessment to enable the correlation of the above listed parameters with the quantitative wave velocity data recorded by Starflow

meters. The wind direction and the wind speed data for the monitoring period were sourced from the Bureau of Meteorology (BoM, 2013).

Limitations of Wave Velocity Data

Listed below are some of the limitations for the wave velocity assessment methodology:

- Autumn typically provides good boating conditions with little (predominantly easterly) or no wind. The conditions experienced during the monitoring event varied from this general trend and the local environment experienced impact from wind driven wave and minimal boat activities.

- The Starflow Ultrasonic Doppler (Starflow) used to estimate wave velocity and impact and is not intended to provide highly accurate measurements. The Starflow is most applicable where water velocity is measured in closed laminar flow conditions. The movement of water in waves (impacting the shoreline at Mt Henry) is representative of open and turbulent flow. In such conditions, the accuracy of the median water velocity measured by the Starflow is reduced.

Despite the limitations described above, Syrinx is of the view that the data gathered is sufficient to be used as an additional information layer for the purpose of restoration design and implementation.

RESULTS OF WAVE IMPACT ASSESSMENT

The wave impact assessment provided a snapshot of the natural wave action at medium to high tide combined with minimum wake wash from boat activities. Two monitoring events were undertaken: one on 7th of April 2013 and the second on the 20th of April 2013. The former monitoring event collected a series of observational data whilst the latter measured wave velocity in addition to recording the observational data.

Monitoring Event 1

Observations on boat activity and wind conditions for the Mt Henry Spit area were collected from 9:00am to 12:00 pm on the 7th of April 2013. Weather conditions were fine with a temperature of 21.5ºC in the morning with light east to south easterly 15 km/hr winds. Wind gusts occurred throughout the morning with a maximum of 31 km/hr south easterly winds at 10:42 am which coincided with high tide at 10:20 am (BoM 2013).

A relatively low level of boat activity was observed during the monitoring period with three small recreational (2 x ski and 1 x jetski) boats passing the foreshore regularly throughout the course of the morning. Most boats passed the Spit at approximately 150 m distance from the foreshore edge. The on-shore direction of wind generated waves impacting on the wash

zone from south-east in the morning to south- west in the afternoon, and the boat driven waves impacted from the north-west.

Table 1 Table of Observations for Monitoring Event 1

Time	Boat	Winds	Impact on wash zone	Tide	Activity
900	0	ESE	Wind East SE	Medium	Low activity
1000	Ski boat ≈5m	ESE	Wind and Boat W to SW	High 10:20am	passed 7 times
1100	Jetski ≈1.5m	E	N to NW	High -Medium	Passed and pulled in to beach
1200	Boat ≈6m	E	W	Medium-Low	Passed 2 times

Monitoring Event 2

Observations and quantitative data on boat activity, at Location A (Bridge side of Spit), and Location B (City side of Spit) as well as wind conditions was collected from 2:18pm to 7:18pm on the 20th of April 2013. Weather conditions were gusty with a temperature of 20.2ºC in the afternoon with south westerly winds at a mean average of 19km/hr. Wind gusts occurred throughout the afternoon with a maximum of 39 km/h South to south westerly at 13:39 (BoM 2013). The wind direction during the period of monitoring was generally south westerly, with little boat activity due to the dominant gusty winds.

Table 2 Table of Observations for Monitoring Event 2

Time	Boat	Winds	Impact on wash zone	Tide	Activity
1418	canoe	SW	Wind Northwest	Low 1457	recreational
1500	0	SW	Wind	Low medium	-
1600	0	W-SW	Wind	Medium high	-
1700	Boat ≈4m	SW	Wind	High 1736	-
1800	0	SW	Wind	High medium	-
1918	Boat ≈3.5m	SW	Wind	Medium low	fishing boat

The wave velocity measurements at Location A (southerly facing foreshore) and Location B (westerly facing foreshore) show higher mean average wave velocities at Location A, which is consistent with the observations on the day (see Table 2). The prevailing wind direction at Location A was from the south to south west which forced waves into the wash zone at high speeds averaging between 190 -240 mm/sec at low tide and 120 -190 mm/sec at high tide. This indicates that at low tides, wave velocity will be greater and thus create a greater impact on the wash zone of foreshore at this location. This scenario is most noticeable in the resultant undercutting occurring of the bank along the foreshore currently compromising indigenous flora of *Melaleuca cuticularis* and *Casuarina obesa.*

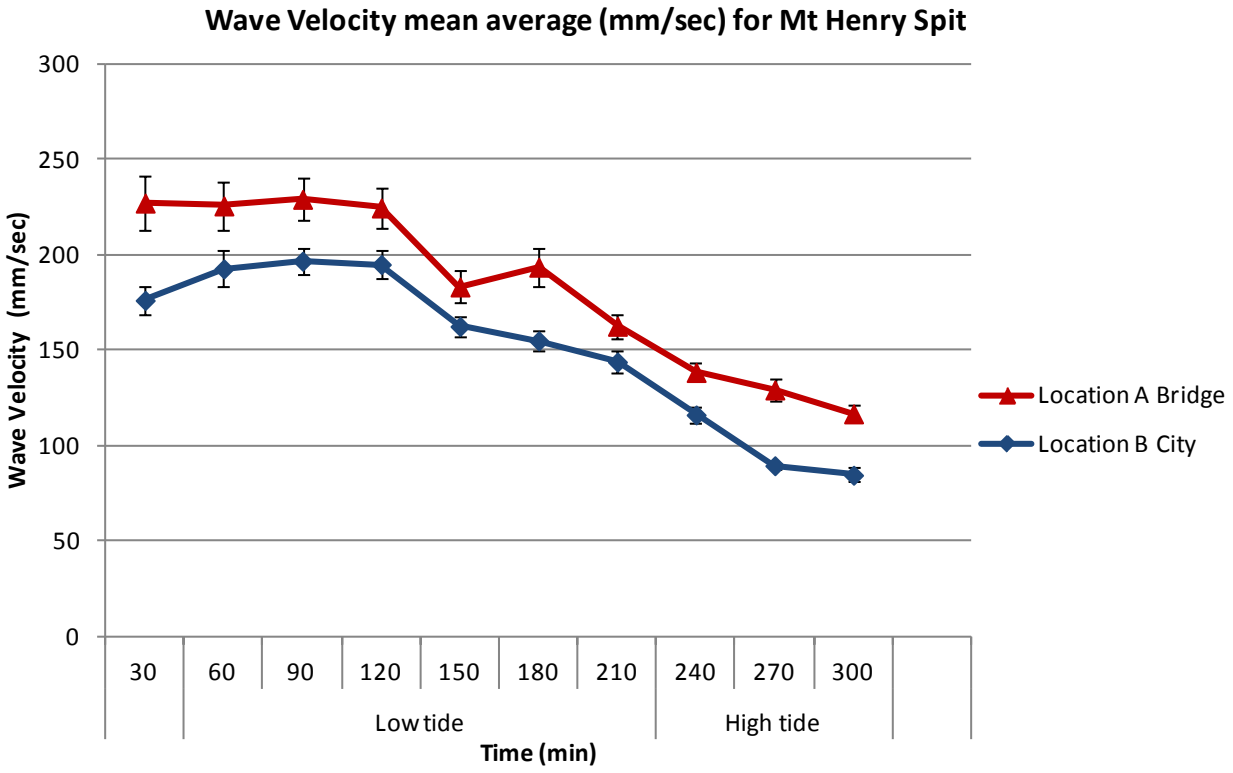


Figure 2 Line Graph of wave velocity data for locations A (Bridge side) and B (City side)

Location B (Westerly facing foreshore) experienced wave velocities generally lower than Location A during the monitoring period. This area of the beach was protected from the direct wave impact as the winds were predominantly southerly and westerly. On days where boat activity is high and with the right onshore directional winds, the wave velocity at this location is likely to be increased.

Figure 3 below shows various wave velocities along the Swan and Canning Rivers and incorporates the current wave velocity measurements at Mount Henry Spit.

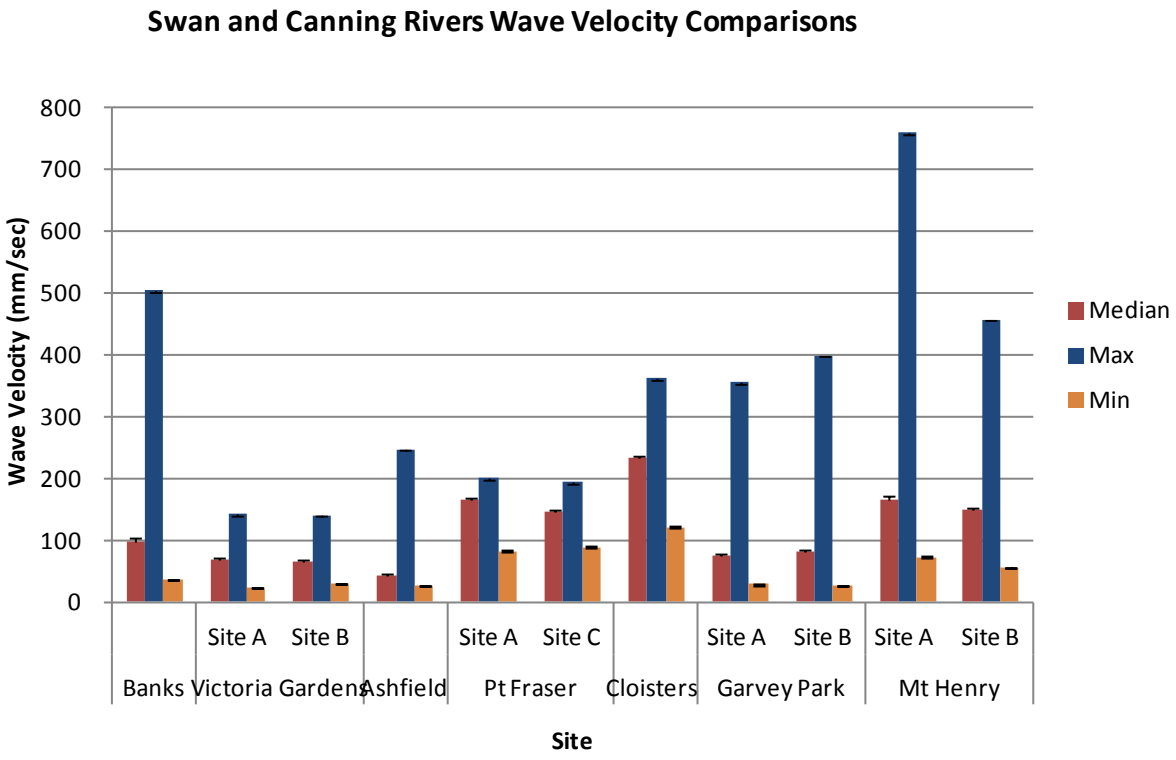


Figure 3 Comparisons of wave velocity at various locations within the Swan and Canning Rivers (Source: Syrinx Environmental PL)

The measurements at Mt Henry Spit show the highest maximum wave velocities recorded by Syrinx at 759 mm/sec at Location A. Location B had high maximum wave velocities at 457 mm/sec with both maximum wave velocities recorded at low tide. The median wave velocities recorded at the Site are comparable with Cloisters foreshore located approximately 1km north of the Mt Henry Spit foreshore. Cloisters foreshore experienced median wave velocities 234 mm/sec compared to 166mm/sec at Mt Henry Spit.

CONCLUSION

Overall, the wave impact assessment suggest the wave velocity is influenced by climate with a high level of wind driven wave impact particularly from the predominant south to south-westerly winds.

On average, the difference in wave velocity measured at the two locations on the Spit (during the same monitoring period) was 28 mm/sec. The wave velocities were consistently higher at Location A (the south facing foreshore) than at Location B (the west facing foreshore).

The observational data recorded indicate that the north-facing beach of the Spit is also impacted; however, the key driver for the erosion at this Site appears to be the boat wake.

The wave velocity assessment for the Mount Henry Spit area suggests that the foreshore restoration should adopt techniques that would protect the shore from south westerly winds

particularly at high tide. This can be achieved through the use of brushwalling technique in combination with a rock toe, erosion fabric and planting indigenous flora species at the high tide mark. The orientation of the brushwalling should be such that it is perpendicular to wave movement therefore reducing the wave impact.

REFERENCES

Larson, M., Kubota, S. Erikson L., (2004). Swash zone sediment transport and foreshore evolution: field experiments and mathematical modelling. *Marine Geology*, **212 :** 61 -79.

Bureau of Meteorology, [BOM] (2013). www.bom.gov.au. Website accessed: 20/04/2013

Appendix 3 Species list for the Mount Henry Spit as recorded by Syrinx on 5th February 2013

Family	Full Species Name	Common Name	Growth Form	Perennial/ Annual	Conservation Status
Anarthriaceae	*Lyginia barbata*		Rush	Perennial	
Asparagaceae	*Laxmannia squarrosa*		Herb	Perennial	
	Lomandra hermaphrodita		Herb	Perennial	
	Lomandra sp.		Herb	Perennial	
Asteraceae	*Conyza* sp.		Herb	Annual	Introduced
	Hypochaeris glabra	Smooth Catsear	Herb	Annual	Introduced
	Latuca seriola	Prickly Lettuce	Herb	Annual	Introduced
	Ursinia anthemoides	Ursinia	Herb	Annual	Introduced
Casuarinaceae	*Allocasuarina fraseriana*	Sheoak	Tree	Perennial	
	Allocasuarina humilis	Dwarf Sheoak	Shrub	Perennial	
	Casuarina obesa	Swamp Sheoak	Tree	Perennial	
Chenopodiaceae	*Chenopodium album*	Fat Hen	Herb	Perennial	Introduced
	Rhagodia baccata	Berry Saltbush	Shrub	Perennial	
	Sarcocornia quinqueflora	Beaded Samphire	Herb	Perennial	
	Suaeda australis		Herb	Perennial	
Colchicaceae	*Burchardia congesta*		Herb	Perennial	
Commelinaceae	*Cartonema philydroides*		Herb	Perennial	
Cupressaceae	*Callitris preissii*	Rottnest Island Pine	Shrub	Perennial	
Cyperaceae	*Ficinia nodosa*	Knotted Club Rush	Sedge	Perennial	
	Schoenus subfascicularis		Sedge	Perennial	
	Schoenus curvifolius		Sedge	Perennial	
Dasypogonaceae	*Dasypogon bromeliifolius*	Pineapple Bush	Herb	Perennial	
Dennstaedtiaceae	*Pteridium esculentum*	Bracken	Fern	Perennial	
Dilleniaceae	*Hibbertia hypericoides*	Yellow Buttercups	Shrub	Perennial	
Ericaceae	*Conostephium preissii*		Shrub	Perennial	
Euphorbiaceae	*Euphorbia terracina*	Geraldton Carnation Weed	Herb	Perennial	Introduced
Fabaceae	*Acacia cyclops*	Coastal Wattle	Shrub	Perennial	Not indigenous
	Acacia lasiocarpa	Panjang	Shrub	Perennial	
	Acacia pulchella	Prickly Moses	Shrub	Perennial	
	Acacia saligna	Orange Wattle	Shrub	Perennial	
	Acacia stenoptera	Narrow Winged Wattle	Shrub	Perennial	
	Bossiaea eriocarpa	Common Brown Pea	Shrub	Perennial	
	Gastrolobium capitatum		Shrub	Perennial	
	Gompholobium tomentosum	Hairy Yellow Pea	Shrub	Perennial	
	Jacksonia furcellata	Grey Stinkwood	Shrub	Perennial	
Frankeniaceae	*Frankenia pauciflora*	Seaheath	Herb	Perennial	
Geraniaceae	*Pelargonium capitatum*	Rose Pelargonium	Herb	Perennial	Introduced
Goodeniaceae	*Lechenaultia floribunda*		Shrub	Perennial	

Family	Full Species Name	Common Name	Growth Form	Perennial/ Annual	Conservation Status
Haemodoraceae	*Conostylis candicans*	Grey Cottonhead	Herb	Perennial	Not indigenous
	Conostylis aculeata	Prickly Conostylis	Herb	Perennial	
	Haemodorum spicatum		Herb	Perennial	
	Phlebocarya ciliata		Herb	Perennial	
Hemerocallidaceae	*Corynotheca micrantha*	Sand Lily	Herb	Perennial	
	Dianella revoluta	Blueberry Lily	Herb	Perennial	
	Tricoryne elatior	Yellow Autumn Lily	Herb	Perennial	
Iridaceae	*Gladiolus caryophyllaceus*	Wild Gladiolus	Herb	Perennial	Introduced
	Romulea rosea	Guildford Grass	Herb	Perennial	Introduced
	Patersonia occidentalis	Purple Flag	Herb	Perennial	
Juncaceae	*Juncus kraussii*		Rush	Perennial	
Loranthaceae	*Nuytsia floribunda*	Christmas Tree	Tree	Perennial	
Myrtaceae	*Melaleuca* sp.		Shrub	Perennial	Introduced
	Agonis flexuosa	Peppermint	Tree	Perennial	Not indigenous
	Chamelaucium uncinatum	Geraldton Wax	Shrub	Perennial	Not indigenous
	Corymbia calophylla	Marri	Tree	Perennial	
	Eremaea pauciflora		Shrub	Perennial	
	Eucalyptus gomphocephala	Tuart	Tree	Perennial	
	Eucalyptus rudis	Flooded Gum	Tree	Perennial	
	Kunzea glabrescens	Spearwood	Shrub	Perennial	
	Melaleuca cuticularis	Saltwater Paperbark	Tree	Perennial	
	Melaleuca huegelii	Chenille Honeymyrtle	Shrub	Perennial	
	Melaleuca systena		Shrub	Perennial	
	Scholtzia involucrata	Spiked Scholtzia	Shrub	Perennial	
	Hypocalymma angustifolium	White Myrtle	Shrub	Perennial	
Orchidaceae	*Microtis sp.*		Herb	Perennial	
Pittosporaceae	*Billardiera heterophylla*	Australian Bluebell	Shrub	Perennial	
Poaceae	*Avena barbata*	Bearded Oat	Grass	Annual	Introduced
	Briza maxima	Blowfly Grass	Grass	Annual	Introduced
	Bromus diandrus	Great Brome	Grass	Annual	Introduced
	Cynodon dactylon	Couch	Grass	Perennial	Introduced
	Ehrharta calycina	Perennial Veldt Grass	Grass	Perennial	Introduced
	Eragrostis curvula	African Lovegrass	Grass	Perennial	Introduced
	Sporobolus virginicus	Marine Couch	Grass	Perennial	
Proteaceae	*Adenanthos* sp.		Shrub	Perennial	Introduced
	Banksia attenuata		Tree	Perennial	Not indigenous
	Banksia nivea	Honeypot Dryandra	Shrub	Perennial	Not indigenous
	Adenanthos cygnorum	Common Woolybush	Shrub	Perennial	
	Hakea prostrata	Harsh Hakea	Shrub	Perennial	

Family	Full Species Name	Common Name	Growth Form	Perennial/ Annual	Conservation Status
Restionaceae	*Alexgeorgea nitens*		Rush	Perennial	
	Desmocladus flexuosus		Rush	Perennial	
	Hypolaena exsulca		Rush	Perennial	
Rhamnaceae	*Spyridium globulosum*	Basket Bush	Shrub	Perennial	
Rubiaceae	*Opercularia sp*	Dog Weed	Herb	Perennial	
Xanthorrhoeaceae	*Xanthorrhoea preissii*	Grass Tree	Herb	Perennial	
Zamiaceae	*Macrozamia riedlei*	Zamia	Cycad	Perennial	

Introduced flora is highlighted in grey.

Native flora species recorded by Syrinx and Ecoscape (2004) recorded in each Vegetation Community on Mount Henry Spit and used to develop planting mixes for revegetation

Study Area	Family	Full Species Name	Common Name	Growth Form	Perennial/ Annual	Vegetation Community 1	Vegetation Community 2	Vegetation Community 3	Vegetation Community 4	Vegetation Community 5	Vegetation Community 6
Mt Henry Spit	Fabaceae	*Acacia lasiocarpa*	Panjang	Shrub	Perennial					x	x
Mt Henry Spit	Fabaceae	*Acacia pulchella*	Prickly Moses	Shrub	Perennial				x		
Mt Henry Spit	Fabaceae	*Acacia saligna*	Orange Wattle	Shrub	Perennial	x			x		x
Mt Henry Spit	Fabaceae	*Acacia stenoptera*	Narrow Winged Wattle	Shrub	Perennial		x			x	
Mt Henry Spit	Proteaceae	*Adenanthos cygnorum*	Common Woollybush	Shrub	Perennial						x
Mt Henry Spit	Restionaceae	*Alexgeorgea nitens*		Rush	Perennial		x	x	x	x	
Mt Henry Spit	Casuarinaceae	*Allocasuarina fraseriana*	Sheoak	Tree	Perennial		x		x		x
Mt Henry Spit	Casuarinaceae	*Allocasuarina humilis*	Dwarf Sheoak	Shrub	Perennial				x		
Mt Henry Spit	Pittosporaceae	*Billardiera heterophylla*	Australian Bluebell	Shrub	Perennial		x				
Mt Henry Spit	Fabaceae	*Bossiaea eriocarpa*	Common Brown Pea	Shrub	Perennial			x	x		
Mt Henry Spit	Colchicaceae	*Burchardia congesta*		Herb	Perennial		x				
Mt Henry Spit	Cupressaceae	*Callitris preissii*	Rottnest Island Pine	Shrub	Perennial						x
Mt Henry Spit	Commelinaceae	*Cartonema philydroides*		Herb	Perennial				x		
Mt Henry Spit	Casuarinaceae	*Casuarina obesa*	Swamp Sheoak	Tree	Perennial	x					
Mt Henry Spit	Ericaceae	*Conostephium preissii*		Shrub	Perennial					x	
Mt Henry Spit	Haemodoraceae	*Conostylis aculeata*	Prickly Conostylis	Herb	Perennial				x		
Mt Henry Spit	Myrtaceae	*Corymbia calophylla*	Marri	Tree	Perennial		x	x	x	x	
Mt Henry Spit	Hemerocallidaceae	*Corynotheca micrantha*	Sand Lily	Herb	Perennial				x	x	
Mt Henry Spit	Dasypogonaceae	*Dasypogon bromeliifolius*	Pineapple Bush	Herb	Perennial		x	x	x	x	
Mt Henry Spit	Restionaceae	*Desmocladus flexuosus*		Rush	Perennial		x				
Mt Henry Spit	Hemerocallidaceae	*Dianella revoluta*	Blueberry Lily	Herb	Perennial					x	
Mt Henry Spit	Myrtaceae	*Eremaea pauciflora*		Shrub	Perennial		x	x			
Mt Henry Spit	Myrtaceae	*Eucalyptus gomphocephala*	Tuart	Tree	Perennial						x
Mt Henry Spit	Myrtaceae	*Eucalyptus rudis*	Flooded Gum	Tree	Perennial	x					
Mt Henry Spit	Cyperaceae	*Ficinia nodosa*	Knotted Club Rush	Sedge	Perennial	x					
Mt Henry Spit	Frankeniaceae	*Frankenia pauciflora*	Seaheath	Herb	Perennial	x					
Mt Henry Spit	Fabaceae	*Gastrolobium capitatum*		Shrub	Perennial		x				
Mt Henry Spit	Fabaceae	*Gompholobium tomentosum*	Hairy Yellow Pea	Shrub	Perennial		x	x	x	x	
Mt Henry Spit	Haemodoraceae	*Haemodorum spicatum*		Herb	Perennial		x				
Mt Henry Spit	Proteaceae	*Hakea prostrata*	Harsh Hakea	Shrub	Perennial					x	x
Mt Henry Spit	Dilleniaceae	*Hibbertia hypericoides*	Yellow Buttercups	Shrub	Perennial		x	x	x		
Mt Henry Spit	Myrtaceae	*Hypocalymma angustifolium*	White Myrtle	Shrub	Perennial		x			x	
Mt Henry Spit	Restionaceae	*Hypolaena exsulca*		Rush	Perennial		x	x			
Mt Henry Spit	Fabaceae	*Jacksonia furcellata*	Grey Stinkwood	Shrub	Perennial		x	x	x	x	
Mt Henry Spit	Juncaceae	*Juncus kraussii*	Sea Rush	Rush	Perennial	x					
Mt Henry Spit	Myrtaceae	*Kunzea glabrescens*	Spearwood	Shrub	Perennial					x	x
Mt Henry Spit	Asparagaceae	*Laxmannia squarrosa*		Herb	Perennial				x	x	
Mt Henry Spit	Goodeniaceae	*Lechenaultia floribunda*		Shrub	Perennial		x	x	x	x	
Mt Henry Spit	Asparagaceae	*Lomandra hermaphrodita*		Herb	Perennial				x		
Mt Henry Spit	Anarthriaceae	*Lyginia barbata*		Rush	Perennial		x	x		x	

Study Area	Family	Full Species Name	Common Name	Growth Form	Perennial/ Annual	Vegetation Community 1	Vegetation Community 2	Vegetation Community 3	Vegetation Community 4	Vegetation Community 5	Vegetation Community 6
Mt Henry Spit	Zamiaceae	*Macrozamia riedlei*	Zamia	Cycad	Perennial			x	x	x	
Mt Henry Spit	Myrtaceae	*Melaleuca cuticularis*	Saltwater Paperbark	Tree	Perennial	x					
Mt Henry Spit	Myrtaceae	*Melaleuca huegelii*	Chenille Honeymyrtle	Shrub	Perennial					x	x
Mt Henry Spit	Myrtaceae	*Melaleuca systena*		Shrub	Perennial				x	x	
Mt Henry Spit	Loranthaceae	*Nuytsia floribunda*	Christmas Tree	Tree	Perennial		x	x	x	x	
Mt Henry Spit	Iridaceae	*Patersonia occidentalis*	Purple Flag	Herb	Perennial		x	x			
Mt Henry Spit	Haemodoraceae	*Phlebocarya ciliata*		Herb	Perennial		x	x	x	x	
Mt Henry Spit	Dennstaedtiaceae	*Pteridium esculentum*	Bracken	Fern	Perennial					x	
Mt Henry Spit	Chenopodiaceae	*Rhagodia baccata*	Berry Saltbush	Shrub	Perennial	x					
Mt Henry Spit	Chenopodiaceae	*Sarcocornia quinqueflora*	Beaded Samphire	Herb	Perennial	x					
Mt Henry Spit	Cyperaceae	*Schoenus curvifolius*		Sedge	Perennial		x				
Mt Henry Spit	Cyperaceae	*Schoenus subfascicularis*		Sedge	Perennial	x	x	x		x	
Mt Henry Spit	Myrtaceae	*Scholtzia involucrata*	Spiked Scholtzia	Shrub	Perennial				x		
Mt Henry Spit	Poaceae	*Sporobolus virginicus*	Marine Couch	Grass	Perennial	x					
Mt Henry Spit	Chenopodiaceae	*Suaeda australis*		Herb	Perennial	x					
Mt Henry Spit	Hemerocallidaceae	*Tricoryne elatior*	Yellow Autumn Lily	Herb	Perennial					x	
Mt Henry Spit	Xanthorrhoeaceae	*Xanthorrhoea preissii*	Grass Tree	Herb	Perennial		x	x	x	x	
Mt Henry Peninsula	Fabaceae	*Acacia willdenowiana*	Grass Wattle	Shrub	Perennial		x	x			
Mt Henry Peninsula	Asparagaceae	*Acanthocarpus preissii*		Herb	Perennial				x		
Mt Henry Peninsula	Haemodoraceae	*Anigozanthos humilis*	Catspaw	Herb	Perennial			x	x		
Mt Henry Peninsula	Haemodoraceae	*Anigozanthos manglesii*	Menzies Kangaroo-paw	Herb	Perennial			x	x		
Mt Henry Peninsula	Ericaceae	*Astroloma macrocalyx*	Swan Berry	Shrub	Perennial			x	x		
Mt Henry Peninsula	Haemodoraceae	*Conostylis aculeata*	Prickly Conostylis	Herb	Perennial			x	x		
Mt Henry Peninsula	Haemodoraceae	*Conostylis juncea*		Herb	Perennial			x	x		
Mt Henry Peninsula	Haemodoraceae	*Conostylis setigera*		Herb	Perennial			x	x		
Mt Henry Peninsula	Goodeniaceae	*Dampiera linearis*	Common Dampiera	Herb	Perennial			x	x		
Mt Henry Peninsula	Dilleniaceae	*Hibbertia racemosa*	Stalked Guinea-flower	Shrub	Perennial		x	x			
Mt Henry Peninsula	Fabaceae	*Hovea trisperma*	Common Hovea	Shrub	Perennial			x	x		
Mt Henry Peninsula	Violaceae	*Hybanthus calycinus*	Wild Violet	Herb	Perennial			x	x		
Mt Henry Peninsula	Ericaceae	*Leucopogon conostephioides*		Shrub	Perennial			x	x		
Mt Henry Peninsula	Cyperaceae	*Mesomelaena pseudostygia*		Sedge	Perennial				x		
Mt Henry Peninsula	Proteaceae	*Petrophile linearis*	Pixie Mops	Shrub	Perennial				x		
Mt Henry Peninsula	Rutaceae	*Philotheca spicata*	Pepper and Salt	Shrub	Perennial			x	x		
Mt Henry Peninsula	Primulaceae	*Samolus repens*	Creeping Brookweed	Herb	Perennial	x					
Mt Henry Peninsula	Goodeniaceae	*Scaevola repens* var. *repens*		Shrub	Perennial			x	x		
Mt Henry Peninsula	Asparagaceae	*Sowerbaea laxiflora*		Herb	Perennial		x				
Mt Henry Peninsula	Proteaceae	*Synaphea spinulosa*		Shrub	Perennial			x	x		
Mt Henry Peninsula	Asparagaceae	*Thysanotus patersonii*		Herb	Perennial			x	x		

Species highlighted in blue have been found on Mount Henry Peninsula previously and are suitable for incorporation into the Spit planting mixes in order to increase biodiversity.

Appendix 4 Bill of Quantities (BOQ)

Item	Task	Unit	Quantity	Total quantity	Rate ($)	Total
1.1	**Preliminaries**					
1.1.1	Mobilisation/demobilisation	**item**	1	1	$ 3,000.00	$ 3,000.00
1.1.2	Preparation and meetings	**item**	1	1	$ 1,000.00	$ 1,000.00
1.1.3	Storage and amenities	**item**	1	1	$ 1,500.00	$ 1,500.00
1.1.4	Traffic management plan and execution	**item**	1	1	$ 3,500.00	$ 3,500.00
1.2	**Chemical and manual weed control: 4 treatments in all areas**	**item**	1	4	$ 3,750.00	$ 15,000.00
1.3	**Southern path and bollard removal and disposal**	**item**	1	1	$ 5,000.00	$ 5,000.00
1.3.1	Supply and installation of formal beach access	**m²**	1	10	$ 300.00	$ 3,000.00
1.4	**Foreshore treatment 1**					
1.4.1	Site preparation including minor earthworks	**item**	1	1	$ 3,000.00	$ 3,000.00
1.4.2	Supply and installation of geofabric, coir blanket and starch pins (5/m²)	**m²**	1	500	$ 25.00	$ 12,500.00
1.4.3	Supply and installation of brushwall	**lm**	1	80	$ 300.00	$ 24,000.00
1.4.4	Supply and installation of limestone spalls	**m³**	1	30	$ 350.00	$ 10,500.00
1.5	**1st year plantings**					
1.5.1	Supply of foreshore plants (advanced stock)	**item**	1	700	$ 4.00	$ 2,800.00
1.5.2	Installation of foreshore plants (advanced stock)	**item**	1	700	$ 4.00	$ 2,800.00
1.5.3	Supply of foreshore plants (tubestock)	**item**	1	1300	$ 1.22	$ 1,586.00
1.5.4	Installation of foreshore plants (tubestock)	**item**	1	1300	$ 2.50	$ 3,250.00
1.6	**1st year monthly maintenance inc. all consumables**	**month**	1	12	$ 640.00	$ 7,680.00
1.7	**Monthly monitoring and reporting**	**month**	1	12	$ 1,250.00	$ 15,000.00
1.8	**Additional project costs inc. project management and administration**	**item**	1	1	$ 5,000.00	$ 5,000.00
Year 1 Total						**$ 120,116.00**
2.1	**Preliminaries**					
2.1.1	Mobilisation/demobilisation	**item**	1	1	$ 3,000.00	$ 3,000.00
2.1.2	Preparation and meetings	**item**	1	1	$ 1,000.00	$ 1,000.00
2.1.3	Storage and amenities	**item**	1	1	$ 1,500.00	$ 1,500.00
2.1.4	Traffic management plan and execution	**item**	1	1	$ 3,500.00	$ 3,500.00
2.2	**Chemical and manual weed control: 4 treatments in all areas**	**item**	1	4	$ 3,000.00	$ 12,000.00
2.3	**Foreshore treatment 2**					
2.3.1	Site preparation	**item**	1	1	$ 1,500.00	$ 1,500.00
2.3.2	Supply and installation of geofabric, coir blanket and starch pins (5/m²)	**m²**	1	320	$ 25.00	$ 8,000.00
2.3.3	Supply and install coir nodes	**item**	1	50	$ 250.00	$ 12,500.00
2.3.4	Supply and installation of woody debris	**item**	1	125	$ 120.00	$ 15,000.00
2.3.5	Supply and installation of limestone spalls	**m³**	1	40	$ 350.00	$ 14,000.00
2.4	**2nd year plantings**					
2.4.1	Supply of advanced stock	**item**	1	359	$ 4.00	$ 1,436.00
2.4.2	Installation advanced stock	**item**	1	359	$ 4.00	$ 1,436.00
2.4.3	Supply of tubestock	**item**	1	10141	$ 1.80	$ 18,209.00
2.4.4	Installation of tubestock	**item**	1	10141	$ 2.50	$ 25,352.50
2.5	**Fencing Priority Area 3**	**item**	1	1	$ 3,500.00	$ 3,500.00
2.6	**2nd year monthly maintenance inc. all consumables**	**month**	1	12	$ 1,000.00	$ 12,000.00
2.7	**Monthly monitoring and reporting**	**month**	1	12	$ 833.00	$ 9,996.00
2.8	**Additional project costs inc. project management and administration**	**item**	1	1	$ 6,000.00	$ 6,000.00
Year 2 Total						**$ 149,929.50**
3.1	**Preliminaries**					
3.1.1	Mobilisation/demobilisation	**item**	1	1	$ 1,800.00	$ 1,800.00
3.1.2	Preparation and meetings	**item**	1	1	$ 500.00	$ 500.00
3.2	**Chemical and manual weed control: 4 treatments in Priority Areas 2-4**	**item**	1	4	$ 1,875.00	$ 7,500.00
3.3	**3rd year plantings**					
3.3.1	Supply of tubestock	**item**	1	11000	$ 1.80	$ 19,806.60
3.3.2	Installation of tubestock	**item**	1	11000	$ 2.50	$ 27,500.00
3.5	**Removal of limestone track**	**item**	1	1	$ 2,300.00	$ 2,300.00
3.6	**3rd year monthly maintenance inc. all consumables**	**month**	1	12	$ 1,000.00	$ 10,500.00
3.7	**Monthly monitoring and reporting**	**month**	1	12	$ 1,250.00	$ 15,000.00
3.8	**Additional project costs inc. project management and administration**	**item**	1	1	$ 4,000.00	$ 4,000.00
Year 3 Total						**$ 88,906.60**

Item	Task	Unit	Quantity	Total quantity	Rate ($)	Total
4.1	**Preliminaries**					
4.1.1	Mobilisation/demobilisation	**item**	1	1	$ 1,800.00	$ 1,800.00
4.1.2	Preparation and meetings	**item**	1	1	$ 500.00	$ 500.00
4.2	**Chemical and manual weed control: 4 treatments in Priority Areas 2-4**	**item**	1	4	$ 1,750.00	$ 7,000.00
4.3	**4th year plantings**					
4.3.1	Supply of tubestock	**item**	1	11620	$ 2.03	$ 23,608.20
4.3.2	Installation of tubestock	**item**	1	11620	$ 2.50	$ 29,050.00
4.4	**4th year monthly maintenance inc. all consumables**	**month**	1	12	$ 667.00	$ 8,004.00
4.5	**Monthly monitoring and reporting**	**month**	1	12	$ 1,250.00	$ 15,000.00
4.6	**Additional project costs inc. project management and administration**	**item**	1	1	$ 3,000.00	$ 3,000.00
Year 4 Total						**$ 87,962.20**
5.1	**Preliminaries**					
5.1.1	Mobilisation/demobilisation	**item**	1	1	$ 1,800.00	$ 1,800.00
5.1.2	Preparation and meetings	**item**	1	1	$ 500.00	$ 500.00
5.2	**Chemical and manual weed control: 4 treatments in Priority Areas 2-4**	**item**	1	4	$ 1,750.00	$ 7,000.00
5.3	**5th year plantings**					
5.3.1	Supply of tubestock	**item**	1	7560	$ 2.14	$ 16,185.60
5.3.2	Installation of tubestock	**item**	1	7560	$ 2.50	$ 18,900.00
5.4	**5th year monthly maintenance inc. all consumables**	**month**	1	12	$ 460.00	$ 5,520.00
5.5	**Monthly monitoring and reporting**	**month**	1	12	$ 1,250.00	$ 15,000.00
5.6	**Additional project costs inc. project management and administration**	**item**	1	1	$ 3,000.00	$ 3,000.00
Year 5 Total						**$ 67,905.60**
PROJECT TOTAL (ex. GST)						**$ 514,819.90**

Note: The cost of any transplantation trials for difficult to propagate species as specified in Section 9.2.3 of this report and Section 5.14.3 of the Technical Specifications document are not included in the BOQ. The Contractor will be required to provide a proposal for a transplantation trial as part of the tender response and include their hourly charge out rate for the works.