AGENDA ATTACHMENTS
(Part 1)

Finance, Policy, Operations and Legislation Committee

Wednesday, 10 April 2019, 6.00 pm

City of Fremantle

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FPOL1904-1 METROPOLITAN REGIONAL ROAD GROUP - ROAD IMPROVEMENTS GRANT APPLICATION

ATTACHMENT 1 MRRG Pavement Design

MIBROS
Consulting

J19001

MRRG PAVEMENT DESIGN

FOR

CITY OF FREMANTLE

Revision	Date
0	14/03/19

J19001-Rev0

J19001-Rev 0

1. Introduction

The City of Fremantle requested MIB-ROS Consulting (MIB-ROS) assess the information garnered by the City for each of the roads sections to determine rectification options that could be submitted as a part of the City's MRRG funding submission.

The roads proposed for MRRG funding are:

- Carrington Street form Hugh St to property 188 (in both directions)
- Lefroy Road from York St to McCleery Street (in both directions)
- Ord Street from Ellen Street to James St (north bound carriageway only)
- Queen Street from Phillimore Street to Henderson Street (in both directions)
- South Terrance from Wray St Roundabout to Alma Street (in both directions)
- Winterford from McCombe Avenue to property 114 (east bound carriageway only)

This report presents the findings of the pavement assessment for each of the proposed road sections.

2. Carrington Street – Hughes Street to Property 188

2.1. Summary of Road

Carrington Street is a Distributor A running from Canning Highway, which is Primary Distributor to Hamilton Road. The road has an AADT of 18,450 between South Street and Clarke Street with 6.1% heavy vehicles. The road is Network 1 in Main Roads WA Restricted Access Vehicle (RAV) network south of Clarke St, which this section falls into. Therefore, only as of right vehicles (19m semi-trailers or smaller) may traverse this section. This section of road is also currently part of the 114 bus route.

The Equivalent Standard Axles (ESAs) were determined using a 30 year life and an assumed 3% growth rate. The calculated ESAs were 1.34×10^7.

The section proposed for MRRG funding is between Hughes Street and Property 188 and includes all four lanes.

2.2. Geology and Ground Water

The Fremantle 1:50,000 geological mapping sheet shows that the natural soil in the area being sand derived from Tamala Limestone.

The Department of Water ground water mapping shows the ground water table being at a depth of 49 metres below the existing ground surface. The cores carried out by Aslab Pty Ltd (Aslab) also did not detail any presence of water.

2.3. Pavement Cores

The City of Fremantle engaged Aslab to carry out pavement cores to determine the layer thicknesses of the pavement. Table 1 below shows the depths of each layer.

Table 1. Carrington Street Core tests

Material	Core 1 13m North Hughes Thickness (mm)	Core 2 66m South of Hughes St Thickness (mm)
Asphalt	35	50
Basecourse	35	120
Limestone	270	470+
Sand with Blue Metal	110	
Total Thickness	450	640+
Subgrade	Sand	Refusal

2.4. Dynamic Cone Penetrometer (DCP) Testing

Aslab have carried out Dynamic Cone Penetrometer (DCP) Testing to assess the in-situ subgrade strength. The results of the testing as well as correlated in-situ CBR strengths[1] are outlined in Table 2 below.

Table 2. Carrington Street DCP tests

DCP 1 51m South Hughes St		DCP 2 80m South Hughes St		DCP 3 13m North Hughes St	
mm/5 blows	CBR	mm/5 blows	CBR	mm/5 blows	CBR
60	18	30	39	50	22
60	18	30	39	20	62
70	15	30	39	30	39
160	6	30	39	30	39
120	8	30	39	40	28
160	6	20	62	30	39
		40	28	40	28
		40	28	30	39
				50	22
				40	28

2.5. Falling Weight Deflectometer (FWD)

ARRB have also carried out Falling Weight Deflectometer (FWD) testing on behalf of the City on all four carriageways. An assessment of the FWD results has been carried out for both the Deflection and Curvature as outlined in Austroads Guide to Pavement Technology Part 5 (AGPT5).

[1] Main Roads Western Australia "Engineering Road Note 9" (2013)

The Austroads methodology for assessing the FWD data, to determine the requirements for a structural overlay are as follows:

- deflections and curvatures are adjusted for seasonal moisture variations and adjusted from the measurement temperature to the temperature in-service;
- as deflections and curvatures may be measured by Benkelman Beam, deflectograph or FWD, they need to be standardised using Figure 6.3 and Figure 6.4 of AGPT5;
- the adjusted deflections are then divided into homogeneous sub-sections; and
- characteristic values of deflection and curvature are calculated for each sub-section.

The seasonal moisture variation factor was assumed to be 1 as testing was carried out in December and it is assumed that the subgrade is free draining.

The deflections and curvatures were standardised using AGPT5 Figures 6.3 and 6.4. These factors are outlined in Table 3 below. Correction figures are presented in Appendix A.

Table 3. Correction factors for Carrington Street

	D0	**Curvature**
Temperature Correction	1.05	1.1
Deflection Correction	1.15	1

The characteristic deflection (CD) and curvature (CC) for all test within the section are outlined in the table below.

Table 4. CD and CC for Carrington Street

	CD	**CC**
	0.33	0.07
Coefficient of Variation (CV)	0.299	0.348

The Coefficient of Variation is slightly above what is recommend in Austroads (0.25). This is can be reduced to 0.25 by removing 3 outliers that are in the outer lane for southbound traffic.

The method then assesses the CD against the design deflection to determine if an overlay is required to prevent permanent deformation and assesses the overlay thickness using the CC in order to prevent fatigue failure of the asphalt. These are determined using Figure 6.5 and Figure 6.6 of AGPT5. The MRRG Guidelines for the Submission of Road Rehabilitation Projects presents a slightly different methodology that is based on the 1992 Austroads Pavement Design Guide[2]. The 1992 procedure determines a design deflection and curvature and assesses these against the CD and CC, however the adjustment factors are slightly different. For conservatism the current Austroads factors were applied. Both methods are based off the same foundation and will give a very similar result, albeit using slightly different methodologies.

The design deflection and curvature using the guidelines figures are presented in the table below and are compared to the CD and CC values calculated.

[2] Austroads Technical Basis of Austroads Design Procedures for Flexible Overlays on Flexible Pavements (2008).

Table 5. Comparison of design deflection and curvature against CD and CC for Carrington Street

	CD	CC
Measured	0.33	0.07
Design	**0.88**	**0.105**

As seen the CD and CC are significantly below the design values indicating that the pavement is likely structurally sound.

Upon assessment of each test point it can be seen that there are 3 points that are greater than the design curvature. These points are in the outer lane for the southbound traffic. The image below shows the locations of these 3 tests (red). Significant variations in individual FWD data points should be treated with caution, as there can be false readings. However, in this instance the observed data is consistent with the pavement failures observed on site and the thinner than recommended basecourse encountered in these areas.

Figure 1. Comparison of individual FWD tests Carrington Street

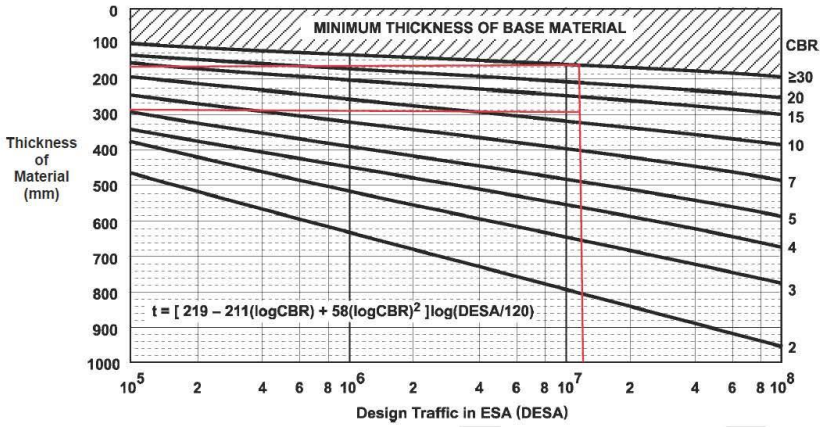
2.6. Assessment of pavement thickness

Based on the correlated DCP results and the geological information a conservative CBR of 12% was used to determine the recommended design pavement using Figure 8.4 of Austroads Guide to Pavement Technology Part 2 (AGPT2).

As seen in the figure below the required thickness of the basecourse material is approximately 170mm and the subbase is 125mm. In both cores the basecourse is too thin and for the core near Hughes Street if the asphalt is excluded the pavement just meets the required thickness. Given the lack of basecourse the stress distribution

through the pavement would be narrower than typical resulting in greater stain at the top of the subgrade, which could lead to permanent deformation sooner.

Figure 2. Carrington Street pavement using Figure 8.4



2.7. Treatment options

The pavement is showing signs of failure north of Hughes Street and some minor structural cracking across the remainder of the section. There is cracking at the joins and the asphalt has also begun to ravel indicating that it is nearing the end of its life. Based on the information above the pavement appears to be relatively sound apart from the Hughes Street intersection north, particularly on the southbound carriageways, however the CD was significantly lower than the design deflection and would indicate that permanent deformation of the subgrade may not be an issue.

Two possible treatment options are:

1. Localised reconstruction of the failing sections around Hughes Street, mill out the asphalt in the remaining section, apply a SAMI seal and replace the asphalt using Dense Graded Asphalt with 14mm maximum aggregate (DG14) (nominally 40mm).
2. Profile out the existing asphalt, apply a SAMI seal and replace the asphalt either using DGA 14 or Stone Mastic Asphalt (SMA) (nominally 40mm).

The SAMI seal would provide some additional flexibility at the base of the asphalt to improve fatigue cracking.

The combination of SAMI and SMA would provide a surfacing that is less susceptible to fatigue cracking. However, SMA overlays are more difficult to construct than typical Dense Graded Asphalt (DGA) and can stay softer for longer, particularly if constructed during hot days in summer. As the works are on a major road and adjacent to a major intersection, if SMA is chosen additional care will be required during construction.

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3. Lefroy Road - McCleery Street to York Street

3.1. Summary of Road

Lefroy Road is a Local Distributor running from Carrington Street to Little Lefroy Lane. The road has an AADT varying from 4565 to 5945 between McCleery Street to York Street and carries between 5.2% to 7.4% heavy vehicles. The road is a Network 1 in Main Roads WA Restricted Access Vehicle (RAV) network, therefore only as of right vehicles should be traversing it. This section of road is also currently part of the 511 and 513 bus routes.

The Equivalent Standard Axles (ESAs) were determined using a 30 year life and an assumed 3% growth rate. The highest number of ESAs were used for the assessment of the entire road section which where $3.78x10^6$.

The section proposed for MRRG funding is between McCleery Street and York Street in both directions.

3.2. Geology and Ground Water

The Fremantle 1:50,000 geological mapping sheet shows that the natural soil in the area is sand derived from Tamala Limestone. The western edge of the section is close to an area mapped as underlain by Tamala Limestone.

The Department of Water ground water mapping shows the ground water table varying between 13.8m below the ground existing surface at Caesar St to 34.6m below the surface at Edmund St. The cores carried out by Aslab also did not detail any presence of water.

3.3. Pavement Cores

The City of Fremantle engaged Aslab to carry out pavement cores to determine the layer thicknesses of the pavement. Table 6 below shows the depths of each layer.

Table 6. Lefroy Street cores

Material	Core 1 105m east of McCleery St Thickness (mm)	Core 2 340m east of McCleery St Thickness (mm)	Core 3 612m east of McCleery St Thickness (mm)	Core 4 906m east of McCleery St Thickness (mm)	Core 5 1117m east of McCleery St Thickness (mm)	Core 6 1340m east of McCleery St Thickness (mm)
Asphalt	40	40	35	50	60	55
Basecourse	170	60	35	100	90	
Subbase (Limestone)		430+	470+	210	220	385
Other	Refusal (Ballast Mix)				110+ (Gravelly Sand)	
Total Thickness	210+	530+	540+	360	480+	440
Subgrade	Refusal	Refusal	Refusal	Sand	Refusal	Sand

3.4. Dynamic Cone Penetrometer (DCP) Testing

Aslab have carried out Dynamic Cone Penetrometer (DCP) Testing to assess the in-situ subgrade strength. The results of the testing as well as correlated in-situ CBR strengths are outlined in Table 7 below.

Table 7. Lefroy Street DCP tests

DCP 1 906m East St of McCleery St		DCP 2 1340m East St of McCleery St	
mm/5 blows	CBR	mm/5 blows	CBR
50	22	50	22
20	62	50	22
		10	134
		10	134

3.5. Falling Weight Deflectometer (FWD)

The City also engaged ARRB to carried out Falling Weight Deflectometer (FWD) testing for the entire section.

The methodology outlined in Section 2.5 was also used for this road.

The seasonal moisture variation factor was assumed to be 1 as testing was carried out in December and it is assumed that the subgrade is free draining.

The deflections and curvatures were standardised using Figures 6.3 and 6.4 of AGPT5. These factors are outlined in Table 8 below and the figures are presented in Appendix A.

Table 8. Lefroy Street FWD correction factors

	D0	Curvature
Temperature Correction	1.02	1.05
Deflection Correction	1.15	1

The characteristic deflection (CD) and curvature (CC) for the entire section is outlined in the table below.

Table 9. Lefroy entire section CD and CC

	CD	CC
	0.636	0.112
Coefficient of Variation (CV)	0.346	0.403

The Coefficient of Variation is significantly above what is recommend in Austroads (0.25), this indicates the section should be divided into sub-sections. Assessing the data, the following sub-sections were determined. The design deflection and curvature are also included in the table below.

Table 10. Lefroy sub-sections CD and CC

Road Section		CD	CC
McCleery Street to Edmund Street		0.547	0.117
	CV	0.176	0.219
Edmund Street to Caesar Street		0.702	0.143
	CV	0.285	0.323
Curedale Street Roundabout		0.385	0.087
	CV	0.173	0.184
Caesar Street to York Street		0.513	0.080
	CV	0.357	0.297
Design		**0.950**	**0.125**

The Curedale Street roundabout has been considered as a separate sub-section as it appears the pavement in this area was reconstructed around 2005/6 as part of the installation of the roundabout. The CV for Caesar to York is higher than desirable, however if 4 points out of the 56 (that are above the mean) are excluded the CV decreases to 0.3 and 0.22 for the deflection and curvature respectively.

The CC for the section between Edmund Street to Caesar Street is above the design curvature indicating that the upper layers are not stiff and would result in increased stain at the bottom of the asphalt layer leading to fatigue cracking. The high curvature could be a result of the asphalt layer containing structural cracking and not acting as a bound layer; also due to the lack of basecourse and possibly poor construction given the layer thicknesses and variability present in this section. The CD for this section is below the design deflection, however it is significantly higher than the other sections.

The image below shows locations where the curvature for the individual tests were above the design curvature. No points had a deflection above the design deflection, again it should be noted that this is not typically how the assessment would be carried out but provides a good representation of the sections outlined above.

3.7. Treatment options

There is structural cracking forming along the length of the section particularly between Edmund Street to Caesar Street. The road has a bicycle lane with traffic lanes only around 3m wide; this would result in substantial channelisation of heavy vehicles, resulting in little wander and causing the stresses to be concentrated in a small area. The CC of the section between Edmund Street to Caesar Street is above the design curvature and indicates that the upper layers of the pavement are not the required strength.

It is recommended that the road be divided into sub-sections as outlined above.

Edmund Street to Caesar Street

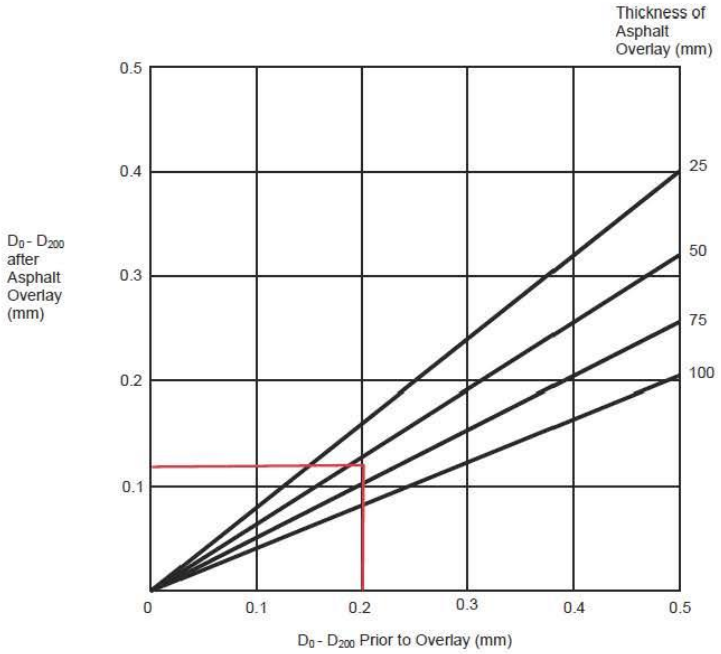
The below treatment options could be considered.

1. Foamed Bitumen Stabilisation (FBS) to a depth of 210mm and surface with 35-40mm DG10.
2. Profile out the existing asphalt nominally 40mm, apply a SAMI seal and install 60mm of Dense Graded Asphalt (DGA).

The analysis for the FBS was carried out using the Austroads pavement design software AustPADS. AustPADS is a finite element method model that assesses pavements using the mechanistic-empirical method. The output sheet from AustPADS for the FBS analysis are included in Appendix B.

The depth of the overlay is determined using the figure in the guidelines shown below, however as the existing surface is to be profiled the CC was increased by 25% per 25mm as outlined in AGPT5. If the surface was not profiled the overlay thickness would be approximately 25mm, however there would be a risk of reflective cracking given the thin layer. An overlay would also likely require modification to sections of kerbing and crossovers.

Figure 5. Structural overlay thickness Lefroy Street



Given the significantly thin layer of basecourse in this section it is possible that fatigue cracking will occur sooner than anticipated as the flexible overlay thickness method was based on the pavement being sound and does not address cracking in the existing asphalt layer. Therefore, the FBS option would provide the City with a lower risk of the road requiring rehabilitation sooner than designed.

Remaining Sections

Based on the FWD information and visual assessment the remaining sections are sounder and an overlay is considered appropriate.

Possible options would be:

1. Profile out the existing asphalt (nominally 35-40 mm), apply a SAMI seal and install 30mm of Dense Graded Asphalt (DG10)
2. Profile out the existing asphalt (nominally 30-35mm) without damaging the underlying seal and install SMA

A DG10 has been proposed for this section to decrease tire noise for the nearby residents. The thickness of the cores indicates a variable existing asphalt thickness, therefore some areas may have a thin layer of asphalt remaining, as such a SAMI or SMA has been proposed to limit any reflective cracking from the existing asphalt into the new asphalt layer. The City may wish to consider installing DG14 75blow/Intersection Mix at the roundabout of Lefroy and Curedale Streets to limit deformation of the asphalt albeit the horizontal loads would not be excessive at this location and therefore may not be required. A SAMI could also be considered with the SMA to provide additional fatigue life.

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4. Ord Street – Ellen Street to James Street

4.1. Summary of Road

Ord Street is a Local Distributor running from High Street to James Street. The road has an AADT of 6674 which includes approximately 10% heavy vehicles. The road is Network 1 in Main Roads WA Restricted Access Vehicle (RAV) network. This section of road is also currently part of a bus route.

The Equivalent Standard Axles (ESAs) were determined using a 30 year life and an assumed 3% growth rate. The ESAs used for the assessment of the road were 8.10×10^6

The section proposed for MRRG funding is between Ellen Street and James Street in the northbound direction only.

4.2. Geology and Ground Water

The Fremantle 1:50,000 geological mapping sheet shows the subsurface conditions being Tamala Limestone.

The Department of Water ground water mapping shows the ground water table being at a depth of 3m below the existing surface. The cores carried out by Aslab did not detail any presence of water.

4.3. Pavement Cores

The City of Fremantle engaged Aslab to carry out pavement cores to determine the layer thicknesses of the pavement. Table 11 below shows the depths of each layer.

Table 11. Ord Street cores

Material	Core 1 115m north of Ellen St Thickness (mm)	Core 2 232m north of Ellen St Thickness (mm)	Core 3 355m north of Ellen St Thickness (mm)
Asphalt	45	40	40
Basecourse	80	55	50
Subbase (Limestone)	225	405	390
Other			Refusal (Sand & Ballast Mix)
Total Thickness	350	500	570+
Subgrade	Sand	Sand	Refusal

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4.4. Dynamic Cone Penetrometer (DCP) Testing

Aslab have carried out Dynamic Cone Penetrometer (DCP) Testing to assess the in-situ subgrade strength. The results of the testing as well as correlated in-situ CBR strengths are outlined in Table 12 below.

Table 12. Ord Street DCP tests

DCP 1 115m south Hughes St		**DCP 2 232m South Hughes St**	
mm/5 blows	CBR	mm/5 blows	CBR
90	11	50	22
110	9	30	39
130	8	20	62
200	5	30	39
80	13	30	39
		30	39
		30	39
		30	39
		30	39
		30	39

4.5. Falling Weight Deflectometer (FWD)

The methodology outlined employed in Section 2.5 was also used for this road.

The seasonal moisture variation factor was assumed to be 1 as testing was carried out in December and it is assumed that the subgrade is free draining.

The deflections and curvatures were standardised using Figures 6.3 and 6.4 of AGPT5. These factors are outlined in Table 13 below. Correction figures are presented in Appendix A.

Table 13. Correction factors for Ord Street

	D0	**Curvature**
Temperature Correction	1.05	1.15
Deflection Correction	1.14	1

The characteristic deflection (CD) and curvature (CC) for the entire section is outlined in the table below. The design deflection and curvature are also included.

Table 14. Comparison of design deflection and curvature against CD and CC for Ord Street

	CD	**CC**
	0.668	0.133
Coefficient of Variation (CV)	0.284	0.252
Design	**0.9**	**0.117**

The Coefficient of Variation is reasonably close to the recommended value in Austroads (0.25).

The CC is greater than the design curvature indicating that the upper layers are not stiff and would result in increased stain at the bottom of the asphalt layer leading to fatigue cracking. The high curvature could be a result of the asphalt layer containing structural cracking and not acting as a bound layer and due to the lack of basecourse and possibly poor construction. The CD is below the design deflection indicating there is unlikely any risk of permanent deformation of the subgrade.

The image below shows the relatively homogenous nature of the pavement as it shows the locations where the curvature for the individual tests were above the design curvature (red). No points had a deflection above the design deflection.

Figure 6. Comparison of individual FWD tests Ord Street

4.6. Assessment of pavement thickness

Based on the correlated DCP results and the geological information a conservative CBR of 12% was used to determine the recommended design pavement using Figure 8.4 of Austroads Guide to Pavement Design Part 2.

As seen in the figure below the required thickness of the basecourse material is approximately 160mm and the subbase is 120mm. No cores demonstrated sufficient basecourse thickness, however they all had the sufficient overall pavement thickness.

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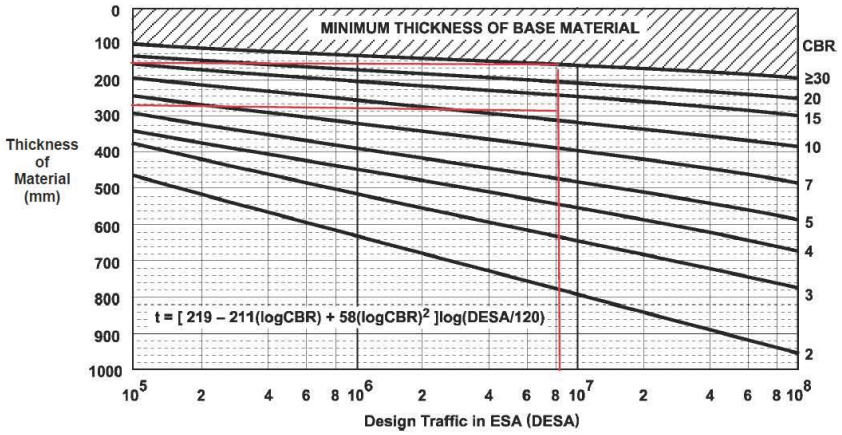
Figure 7. Ord Street pavement thickness using Figure 8.4



4.7. Treatment options

There is structural cracking along the length of the section, some areas are pumping fines to the surface, the asphalt is aged and there is damage from roots from the surrounding trees. The lane width is approximately 3m causing the traffic to be channelised.

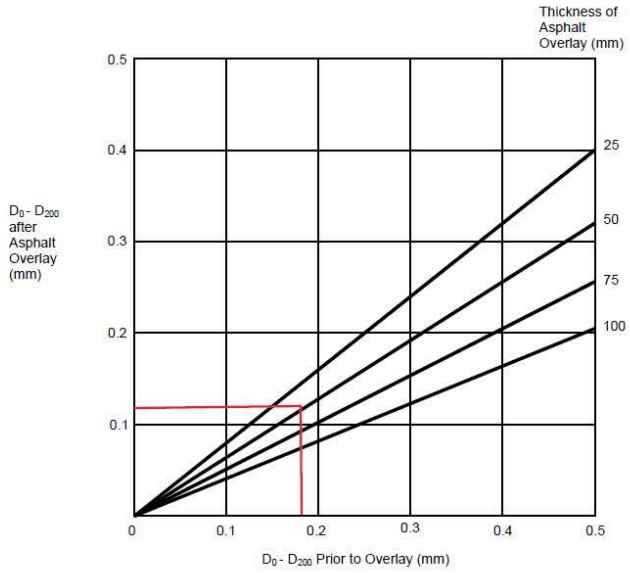
Possible treatment options are:

1. Foamed Bitumen Stabilisation (FBS) to a depth of 220mm and surface with 40mm DG14.
2. Profile out the existing asphalt nominally 40mm, apply a SAMI seal and install 50mm of Dense Graded Asphalt (DG14).

The AustPADS output sheet for the assessment of the FBS depth is included in Appendix B.

The depth of the overlay is determined using the figure in the guidelines shown below, however as the existing surface is to be profiled the CC was increased by 25% per 25mm as outlined in AGPT5. Given the extents of structural cracking it is not considered viable to carry out an overlay without profiling out the existing surface.

Figure 8. Structural overlay thickness Ord Street



Given the significantly thin layer of basecourse in this section it is possible that fatigue cracking will occur sooner than anticipated if option 2 is chosen, as the flexible overlay thickness method was based on the pavement being sound. Therefore, the FBS option would provide the City with a lower risk of the road requiring rehabilitation sooner than designed.

The tree roots appear to be close to the surface of the pavement in many areas, therefore stabilisation could damage the root system and mix roots into the pavement material. This should be further assessed prior to carrying out any works.

5. Queen Street – Phillimore Street to Henderson Street

5.1. Summary of Road

Queen Street is a Local Access running from Phillimore Street/Elder Place to Henderson Street. The road has an AADT that varies between 3132 and 5150 and based on the recent traffic counts has a heavy vehicle percentage between 14.5% to 29.7%. The road is Network 1 in Main Roads WA Restricted Access Vehicle (RAV) network and can only be used by as of right vehicles. This section of road is also currently used by a number of bus services.

The Equivalent Standard Axles (ESAs) were determined using a 30 year life and an assumed 3% growth rate. The ESAs used for the assessment of the road is 1.13×10^7. The entire length of the road is proposed for MRRG funding in both directions.

5.2. Geology and Ground Water

The Fremantle 1:50,000 geological mapping sheet shows the subsurface conditions being sand derived from Tamala Limestone.

The Department of Water ground water mapping shows the ground water table being at a depth of 3m below the existing surface. The cores carried out by Aslab did not detail any presence of water.

5.3. Pavement Cores

The City of Fremantle engaged Aslab to carry out pavement cores to determine the layer thicknesses of the pavement. Table 15 below shows the depths of each layer.

Table 15. Queen Street cores

Material	Core 1 109m east of Elder Place Thickness (mm)	Core 2 60m east of Elder Place Thickness (mm)	Core 3 213m east of Elder Place Thickness (mm)	Core 4 323m east of Elder Place Thickness (mm)	Core 5 402m east of Elder Place Thickness (mm)
Asphalt	40	70	160	100	40
Basecourse	110		310 (Gravelly Sand)		80
Subbase (Limestone)		300			20
Other	170 (Gravelly Sand)			20+ (Ballast Mix)	80+ (gravelly Sandy Ballast mix)
Total Thickness	320	370	370	120+	220+
Subgrade	Sand	Sand	Sand	Refusal	Refusal

Material	Core 6 261m east of Elder Place Thickness (mm)	Core 7 160m east of Elder Place Thickness (mm)	
Asphalt	50	170	
Basecourse			
Subbase (Limestone)		210	
Other	50+ (Ballast Mix)	60 (Gravelly Sand)	
Total Thickness	100+	440	
Subgrade	Refusal	Sand	

5.4. Dynamic Cone Penetrometer (DCP) Testing

Aslab have carried out Dynamic Cone Penetrometer (DCP) Testing to assess the in-situ subgrade strength. The results of the testing as well as correlated in-situ CBR strengths are outlined in Table 16 below.

Table 16. Queen Street DCP tests

DCP 1 109m east of Elder Place	
mm/5 blows	CBR
60	18
20	62
20	62
20	62
10	134

5.5. Falling Weight Deflectometer (FWD)

The methodology outlined employed in Section 2.5 was also used for this road.

The seasonal moisture variation factor was assumed to be 1 as testing was carried out in December and it is assumed that the subgrade is free draining.

The deflections and curvatures were standardised using Figures 6.3 and 6.4 of AGPT5. These factors are outlined in Table 17 below and the figures are presented in Appendix A. As the asphalt thickness was significantly larger between Cantonment Street and Adelaide Street these were given separate correction factors

Table 17. Correction factors for Queen Street

		D0	Curvature
Cantonment Street to Adelaide Street	Temperature Correction	1.1	1.15
	Deflection Correction	1.38	1
Remaining areas	Temperature Correction	1.03	1.26
	Deflection Correction	1.1	1

There is a large variability for the characteristic deflection (CD) and curvature (CC) for the entire section therefore it was divided into subsections based on the FWD results and cores.

Table 18. Comparison of design deflection and curvature against CD and CC for Queen Street

Road Section		CD	CC
Elder Place to Cantonment Street		0.699	0.129
	CV	0.220	0.269
Cantonment Street to Adelaide Street		0.517	0.059
	CV	0.504	0.607
Adelaide Street to High Street		0.483	0.077
	CV	0.171	0.243
High Street to Henderson Street		0.667	0.135
	CV	0.191	0.307
Design		**0.8**	**0.105**

The Coefficient of Variation (CV) is very high for the section between Cantonment Street and Adelaide Street, this is likely due to the small number of test and variability of the pavement. The other sections are relatively close to a CV of 0.25.

The CC is above the design curvature for the sections between Elder Place to Cantonment Street and High Street to Henderson Street. This would indicate that the upper layers do not have the required stiffness. This could be due to cracking of the asphalt that has resulted in the layer not being bound or the lack of high strength basecourse material.

The image below shows the individual tests that were above the design curvature (red). No points had a deflection above the design deflection.

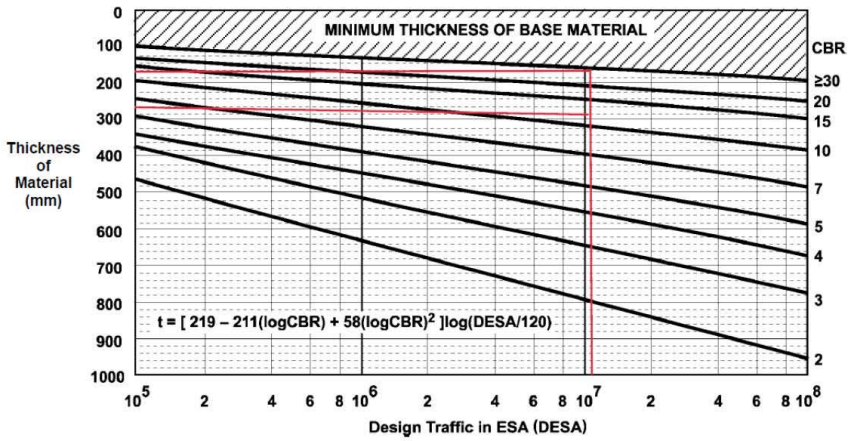
Figure 9. Comparison of individual FWD tests Queen Street

5.6. Assessment of pavement thickness

Based on the correlated DCP results and the geological information a conservative CBR of 12% was used to determine the recommended design pavement using Figure 8.4 of Austroads Guide to Pavement Design Part 2.

As seen in the figure below the required thickness of the basecourse material is approximately 170mm and the subbase is 125mm. No cores demonstrated sufficient basecourse thickness, however Cores 3 and 7 indicated a deep lift asphalt pavement was present between Cantonment Street and Adelaide Street, therefore a limestone sub-base would likely be sufficient.

Figure 10. Queen Street pavement thickness using Figure 8.4



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5.7. Treatment options

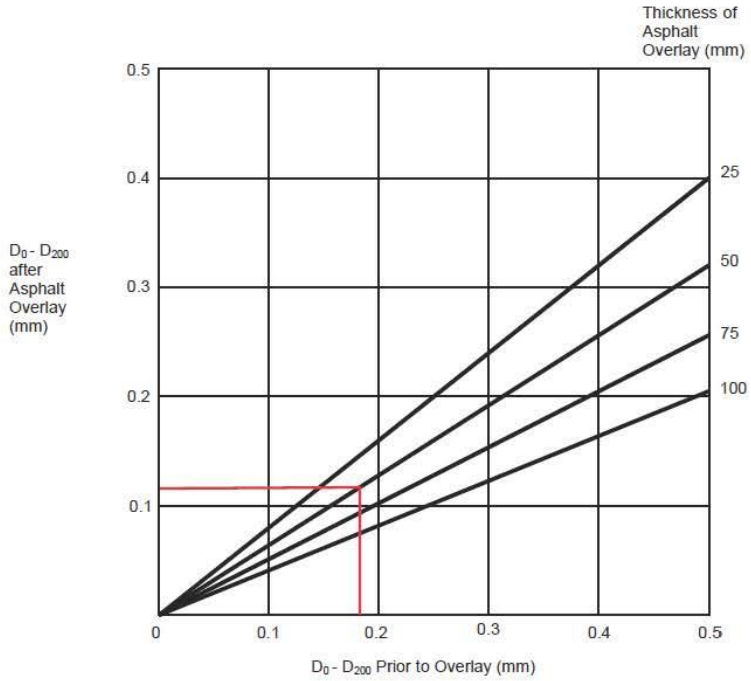
There is severe structural cracking and rutting eastbound between Elder Place and Cantonment Street and the section between High Street and Henderson Street has significant patch work. The remainder of the road has minor structural cracking and occasional patches. Based on the information possible treatments for each section are outlined below. It should be noted that the extents of each section may need to be modified based on local experience and if required additional testing to determine the extents of each type of pavement.

Elder Place to Cantonment Street

1. Foamed Bitumen Stabilisation (FBS) to a depth of 230mm and surface with 40mm DGA.
2. Profile out the existing asphalt nominally 40mm, apply a SAMI seal and install 50mm of Dense Graded Asphalt (DGA).

The AustPADS output sheet for the FBS is included in Appendix B.

Figure 11. Structural overlay thickness Queen Street – Elder Pl to Cantonment St



The depth of the overlay is determined using the figure above, however as the existing surface is to be profiled the CC was increased by 25% per 25mm as outlined in AGPT5. The eastbound lane has significant structural cracking and rutting and the structural overlay design method is based on sound pavements. Therefore, the thickness determined may not resolve the issues that are present, and Foam Stabilisation would be the lower risk option.

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The foam stabilisation thickness is the minimum thickness required to limit fatigue cracking on of the stabilised layer assuming it is placed directly on the sand subgrade. This was done for conservatism and to allow for further assessment by the City to ensure adequate pavement exists for stabilisation across the entire section. It has been assumed that the material logged as Gravelly Sand would be suitable for stabilisation as other cores show thick lift asphalt constructed over it. Through stabilisation the basecourse material would also be mixed through improving the grading of the combined material. It is recommended that the suitability of this material be confirmed prior to stabilisation.

Cantonment Street to Adelaide Street

This section has some minor structural cracking particularly at the intersection. The FWD results indicate that the pavement is relatively sound albeit with the possibility of significant variability in the pavement and cores show asphalt with a depth greater than 160mm even at the intersection of Adelaide Street. As this section appears relatively sound and the majority of the cracking is around the intersection or around services. The cracking could be due to the higher strains at intersections and localised issues around services.

Possible options for this section would be:

1. Profile out nominally 40mm asphalt, apply a seal if required (if granular pavement is exposed) and install nominally 40mm DG14
2. Profile out the existing asphalt (nominally 40mm), apply a seal if required (if granular pavement is exposed) and install 40mm of Stone Mastic Asphalt (SMA)

A Polymer Modified Binder (PMB) such as A15E is recommended particularly at the intersection as the addition of an elastomeric PMB will reduce permanent deformation and increase fatigue life. A SAMI could also be used to limit the possible fatigue cracking of the upper layer. As outlined previously, if SMA is chosen then care would need to be taken during construction. Repairs should also be undertaken to the concrete roundabout to prevent the ingress of water in to the pavement.

Adelaide Street to High Street

The asphalt in this section appears to be older than the above section and has additional patch work, with some environmental and isolated structural cracking. The FWD results are all within the design deflection and curvature. The pavement thickness is not adequate as the asphalt is installed directly over what Aslab have described as a "Ballast Mix" it is unclear what this material is and if it provides any structural support. Given the pavement is not showing significant signs of failure and the FWD results do not show any areas where the CD and CC are below the design, an asphalt overlay may be appropriate.

Possible options for this section would be:

1. Reconstruction with 40mm of asphalt, 170mm of basecourse and 150mm limestone
2. Profile out the nominally 40mm of existing asphalt, apply a SAMI seal and install nominally 40mm of DG14

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3. Profile out the existing asphalt nominally 40mm, apply a seal where required and install 40mm of Stone Mastic Asphalt (SMA)

Again, a PMB could be added and a SAMI could also be used under the SMA to provide some additional life for the pavement.

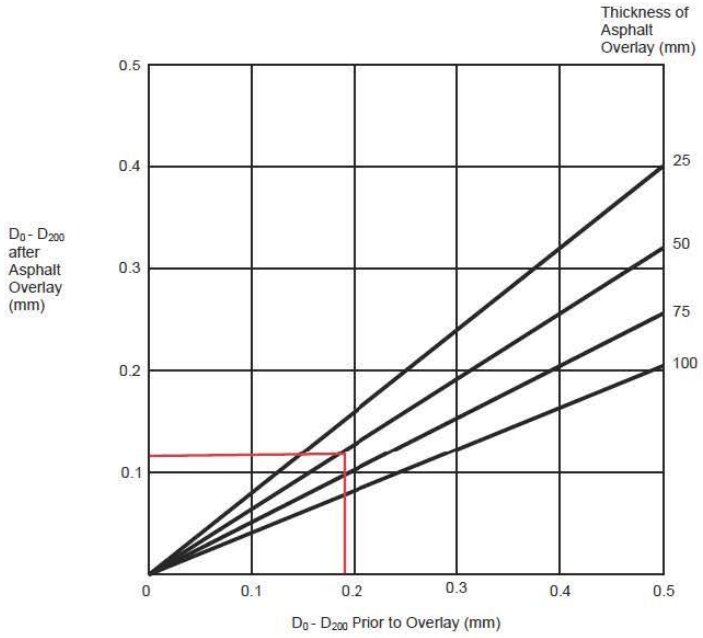
High Street to Henderson Street

There are numerous patches in this section and there is scour around one of the side entry pits. The FWD tests indicate a higher than allowable curvature which indicates that the upper layers do not have the required strength. The core result shows 40mm of asphalt, over 80mm of roadbase, over 20mm of limestone, over a Ballast Mix. The lack of sufficient base material agrees with the FWD results. Again it is unclear what the Ballast Mix consists of and if it provides any structural strength.

Possible options for this section would be:

1. Reconstruction with 40mm of asphalt, 170mm of basecourse and 150mm of subbase
2. Profile out the existing asphalt, apply a SAMI seal and install 55mm of DGA or Stone Mastic Asphalt (SMA)

Figure 12. Structural overlay thickness Queen Street – High St to Henderson St



The depth of the overlay is determined using the figure above, however as the existing surface is to be profiled the CC was increased by 25% per 25mm as outlined in AGPT5. The combination of a SAMI and SMA should provide greater resistance to fatigue cracking. The structural overlay design method is based on sound pavements therefore

the thickness determined may not resolve the issues that are present, and failure could occur prematurely.

The reconstruction would ensure the pavement is adequately constructed and provide a life of 30 years with adequately planned preventative maintenance.

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6. South Terrace & Wray Avenue Roundabout

6.1. Summary of Road

South Terrace is a Local Distributor running from Market Street to South Beech Promenade, Wray Street is also a Local Distributor and runs from South Terrace to South Street. South Terrace has an AADT of 12124 which includes approximately 9.4% heavy vehicles. The road is Network 1 in Main Roads WA Restricted Access Vehicle (RAV) network. The roundabout is also used by numerous bus routes.

The Equivalent Standard Axles (ESAs) where determined using a 30 year life and an assumed 3% growth rate. The ESAs used for the assessment of the road where 1.38 $x10^7$.

The section proposed for MRRG funding is the roundabout of South Terrace and Wray Avenue as well as South Terrace to Alma Street.

6.2. Geology and Ground Water

The Fremantle 1:50,000 geological mapping sheet shows the subsurface conditions being Tamala Limestone bordering sand derived from Tamala Limestone.

The Department of Water ground water mapping shows the ground water table being at a depth of 2.8m below the existing surface. The cores carried out by Aslab did not detail any presence of water.

6.3. Pavement Cores

The City of Fremantle engaged Aslab to carry out pavement cores to determine the layer thicknesses of the pavement. Table 19 below shows the depths of each layer.

Table 19. South Terrace cores

Material	Core 1 41m south of Alma St Thickness (mm)	Core 2 79m south of Alma St Thickness (mm)
Asphalt	70	80
Basecourse	130	120
Subbase (Limestone)	130	420+
Other	10+ (Ballast Mix)	
Total Thickness	340+	620+
Subgrade	Refusal	Refusal

6.4. Dynamic Cone Penetrometer (DCP) Testing

No cores reached the subgrade, therefore no DCP testing was carried out.

6.5. Falling Weight Deflectometer (FWD)

The methodology outlined employed in Section 2.5 was also used for this road.

The seasonal moisture variation factor was assumed to be 1 as testing was carried out in December and it is assumed that the subgrade is free draining.

The deflections and curvatures were standardised using Figures 6.3 and 6.4 of AGPT5. These factors are outlined in Table 20 below. Correction figures are presented in Appendix A.

Table 20. Correction factors for South Terrace

	D0	Curvature
Temperature Correction	1.05	1.2
Deflection Correction	1.16	1

There is a large variability for the characteristic deflection (CD) and curvature (CC) for the entire section therefore it was divided into subsections based on the surfacing as it appears the roundabout was constructed around 2010/2011 and the section north of Wary Avenue was resurfaced around 2013. The design deflection and curvature are also included.

Table 21. Comparison of design deflection and curvature against CD and CC for South Terrace

Road Section		CD	CC
Alma Street to Little Howard Street		0.671	0.090
	CV	0.432	0.441
Little Howard Street to End		0.626	0.124
	CV	0.286	0.299
Design		**0.88**	**0.105**

The Coefficient of Variation from Howard Street to the End of the proposed section is very large due to a number of inconsistent points. There is one CD measured as 0.84 (shown in orange in the Figure below), which is close to the design deflection of 0.88, this could either be an inaccurate test or indicate insufficient pavement thickness or strength in this area. There is also test that has a curvature of 0.216, which is adjacent to 0.84 CD point (shown in blue in the figure below).

The image below shows the locations where the curvature for the individual tests were above the design curvature (red). No points had a deflection above the design deflection.

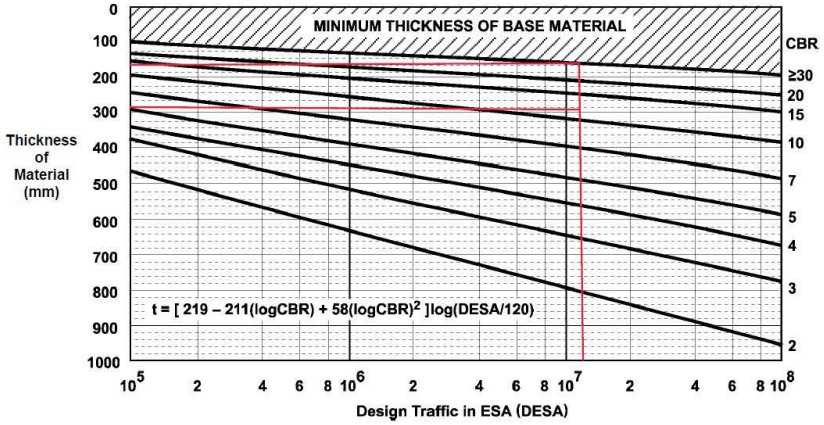
Figure 13. Comparison of individual FWD tests South Terrace

6.6. Assessment of pavement thickness

No DCP tests were carried out due to refusal of the cores, therefore the subgrade CBR was assumed to be 12% based on the geological mapping. This value was then used to determine the recommended design pavement using Figure 8.4 of Austroads Guide to Pavement Design Part 2.

As seen in the figure below the required thickness of the basecourse material is approximately 175mm and the subbase is 125mm. No cores demonstrated sufficient basecourse thickness, however they all had the sufficient overall pavement thickness.

Figure 14. South Terrace pavement using Figure 8.4



6.7. Treatment options

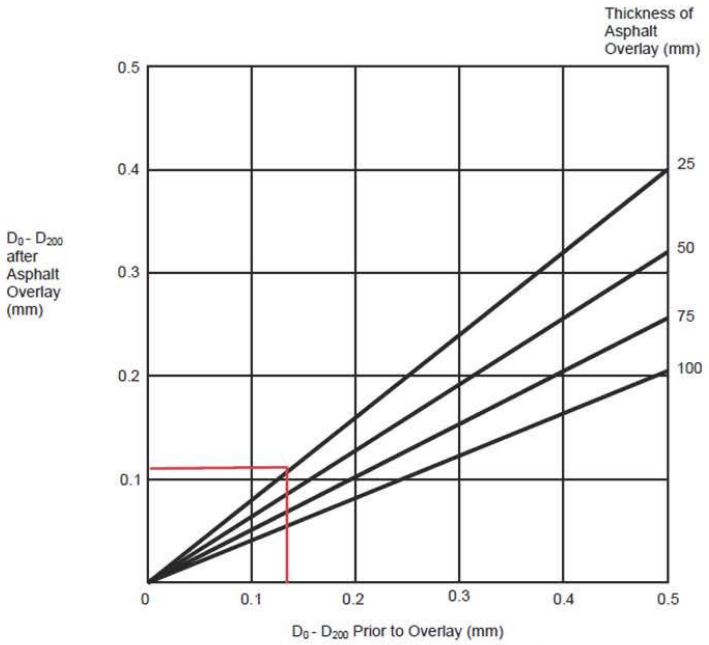
There is structural cracking along the length of the section particularly between Alma Street and Little Howard Street southbound, some areas are pumping fines in the roundabout. Based on aerial imagery the asphalt appears to only be around 8 years old in the roundabout however structural cracking is forming in areas. The asphalt between Alma Street and Little Howard Street appears to only be 6 years old, however red asphalt typically does not have the same life as standard DGA.

Possible treatment options are:

1. Foamed Bitumen Stabilisation (FBS) to a depth of 230mm and surface with 40mm DGA.
2. Reconstruction with 40mm of asphalt, 175mm basecourse and 150mm subbase.
3. Apply a SAMI and overlay 25mm DGA

The AustPADS output sheet for the FBS is included in Appendix B.

Figure 15. Structural overlay thickness South Terrace



The depth of the overlay is determined using the figure above, however given the structural cracking that is forming after relatively few years an asphalt overlay would likely crack again within a few years and is not considered viable. Modifications to the drainage, kerbing and adjoining streets would also be required.

Areas where there are horizontal loads typically fail due to the increased strains that form both at the bottom and top of the asphalt layer and can exhibit both bottom up and top down cracking. Therefore, a PMB is recommended for the wearing course to reduce the fatigue cracking, the seal/interface between the underlying layer and wearing course is also important to prevent slippage failure.

If the FBS option is chosen it is recommended to investigate the pavement thickness around the areas where the higher deflections and curvatures were measured to ensure the required pavement thickness is available.

7. Winterfold Road - McCombe Ave to Property 114

7.1. Summary of Road

Winterfold Road is a Local Distributor running from Carrington Street to North Lake Road. Winterfold Road has an AADT of 8294 east of McCombe Avenue which includes 7.2% heavy vehicles. The road is Network 1 in Main Roads WA Restricted Access Vehicle (RAV) network. This section of road is not used by buses on regular bus routes.

The Equivalent Standard Axles (ESAs) where determined using a 30 year life and an assumed 3% growth rate. The ESAs used for the assessment of the road where 7.35 $x10^6$.

The section proposed for MRRG funding is Winterfold Road from McCombe Avenue to Property 114 east bound only.

7.2. Geology and Ground Water

The Fremantle 1:50,000 geological mapping sheet shows the subsurface conditions being sand derived from Tamala Limestone.

The Department of Water ground water mapping shows the ground water table being at a depth of 39.5m below the existing surface. The cores carried out by Aslab did not detail any presence of water.

7.3. Pavement Cores

The City of Fremantle engaged Aslab to carry out pavement cores to determine the layer thicknesses of the pavement. Table 22 below shows the depths of each layer.

Table 22. Winterfold Road cores

Material	Core 1 41m south of Alma St Thickness (mm)	Core 2 79m south of Alma St Thickness (mm)
Asphalt	45	80
Basecourse		
Subbase (Limestone)	155	265
Other		
Total Thickness	200	310
Subgrade	Sand	Sand

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7.4. Dynamic Cone Penetrometer (DCP) Testing

Aslab have carried out Dynamic Cone Penetrometer (DCP) Testing to assess the in-situ subgrade strength. The results of the testing as well as correlated in-situ CBR strengths are outlined in Table 23 below.

Table 23. Winterfold Road DCP tests

DCP 1 133m east of McCombe Avenue		**DCP 1 327m east of McCombe Avenue**	
mm/5 blows	CBR	mm/5 blows	CBR
40	28	120	8
30	39	150	6
30	39	210	4
20	62	180	5
20	62	60	18
20	62		
30	39		
10	134		
30	39		
20	62		
50	22		

7.5. Falling Weight Deflectometer (FWD)

The methodology outlined employed in Section 2.5 was also used for this road.

The seasonal moisture variation factor was assumed to be 1 as testing was carried out in December and it is assumed that the subgrade is free draining.

The deflections and curvatures were standardised using Figures 6.3 and 6.4 of AGPT5. These factors are outlined in Table 24 below. Correction figures are presented in Appendix A

Table 24. Correction factors for Winterfold Road

	D0	**Curvature**
Temperature Correction	1.01	1.05
Deflection Correction	1.14	1

The characteristic deflection (CD) and curvature (CC) for the entire section is outlined in the table below. The design deflection and curvature are also included.

Table 25. Comparison of design deflection and curvature against CD and CC for Winterfold Road

	CD	**CC**
	0.528	0.102
Coefficient of Variation (CV)	0.152	0.158
Design	0.89	0.11

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The Coefficient of Variation is below 0.25 indicating the section of road is relatively homogeneous.

The image below shows the locations where the curvature for the individual tests were above the design curvature (red), however these points are all within approximately 10% of the design curvature. No points had a deflection above the design deflection.

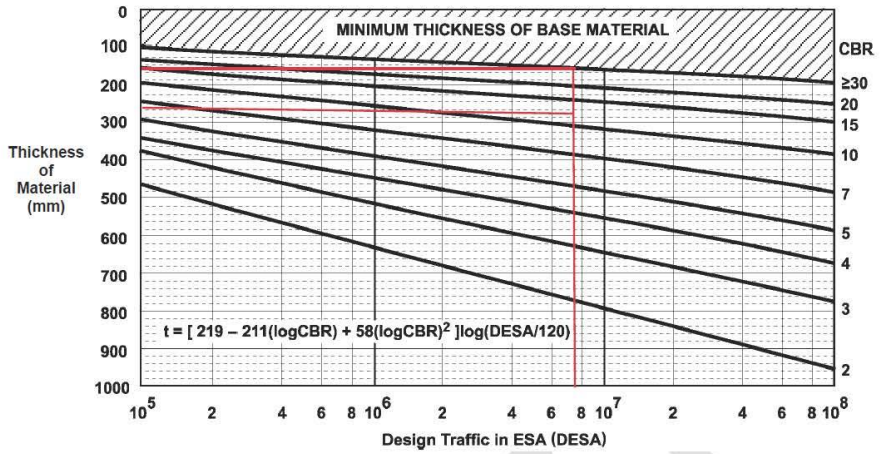
Figure 16. Comparison of individual FWD tests Winterfold Road

7.6. Assessment of pavement thickness

At Core 2 the DCP results indicated a CBR between 4 and 18. Such low CBRs are not typical for sand derived from Tamala limestone and may indicate a localised compaction issue or disturbance during coring therefore were excluded from the analysis. A conservative CBR of 12% was used to determine the recommended design pavement using Figure 8.4 of Austroads Guide to Pavement Design Part 2.

As seen in the figure below the required thickness of the basecourse material is approximately 165mm and the subbase is 120mm. No cores had any basecourse material and were simply asphalt over limestone. Core 1 also did not have sufficient pavement thickness.

Figure 17. Winterfold Road pavement using Figure 8.4



7.7. Treatment options

The existing asphalt surface appears to be nearing the end of its life with significant ravelling, environmental cracking and cracking at the joints. There were minimal signs of structural cracking present and the FWD results indicated that the curvature was only marginally above the allowable curvature at a few points. However, there was no basecourse material and Core 1 did not have sufficient pavement thickness based on Figure 8.4.

Possible treatment options are:

1. Reconstruction with 35-40mm of asphalt, 165mm of basecourse and 150mm of limestone.
2. Apply SAMI seal and 35mm DGA overlay

As there are no signs of structural failure a viable option would be to apply a SAMI seal and a 35mm DGA overlay. There appears to be sufficient kerb height to allow for a straight overlay and number of crossovers have fillets to minimise the level difference between the road and the crossover, this would also be rectified with a straight overlay, however as the asphalt thickness will now be within a thickness zone that induces the highest tensile strain it is considered appropriate to apply a SAMI seal to reduce any chances of reflective cracking from the underlying layer. Localised adjustments would need to be carried out around the side entry pits and some crossovers.

Appendix A – FWD correction chats

Carrington Street

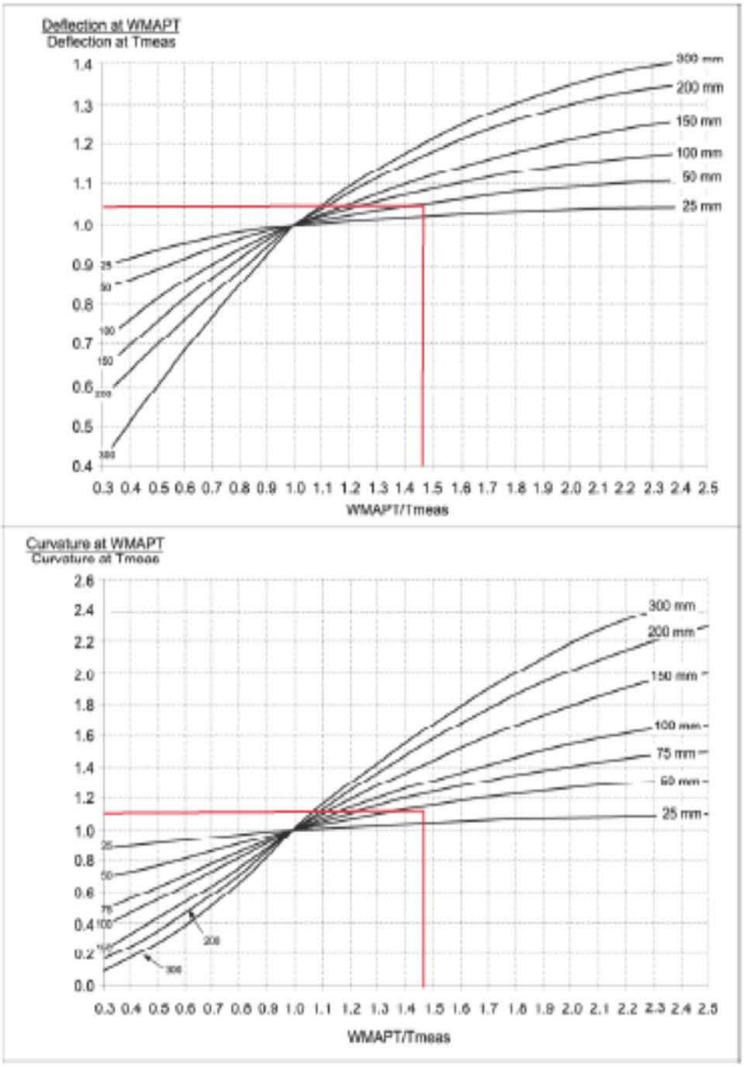


Figure 6.2: Temperature correction of FWD deflections and curvatures for various asphalt thicknesses

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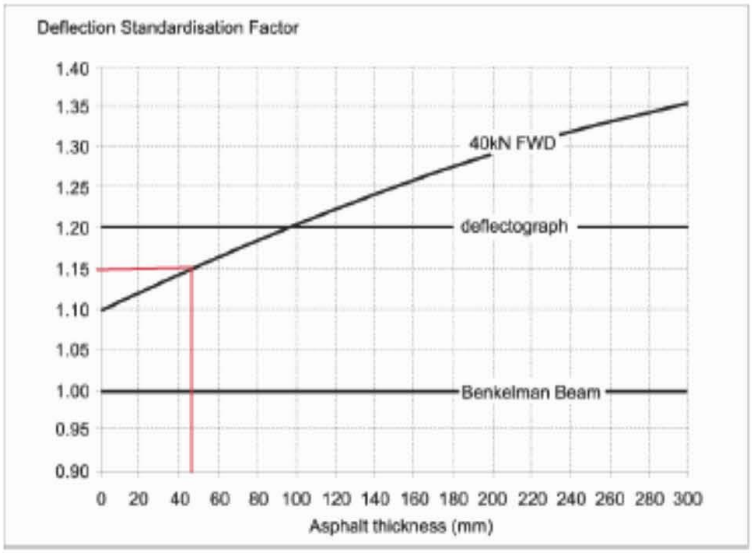

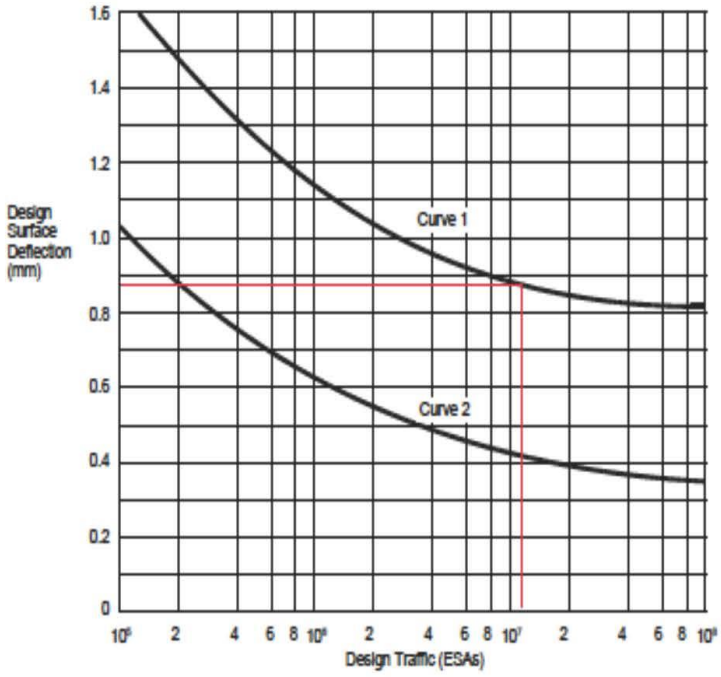

Source: Austroads 1992

Figure 2.1: Design deflection as a function of design traffic

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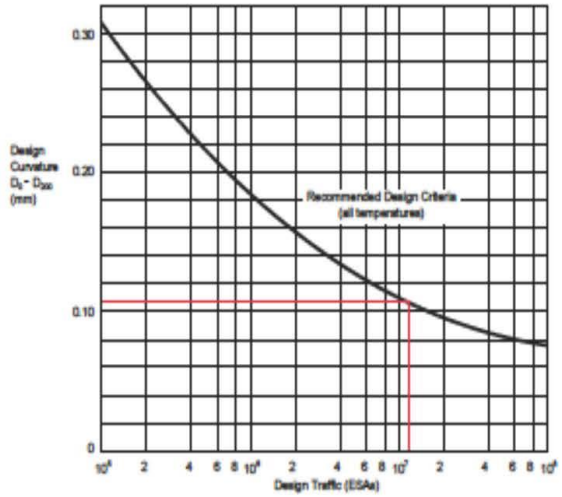
0.30
0.20
0.10
0
Design Curvature $D_0 - D_{200}$ (mm)
Recommended Design Criteria (all temperatures)
10^6 2 4 6 8 10^6 2 4 6 8 10^7 2 4 6 8 10^8
Design Traffic (ESAs)

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Lefroy Street

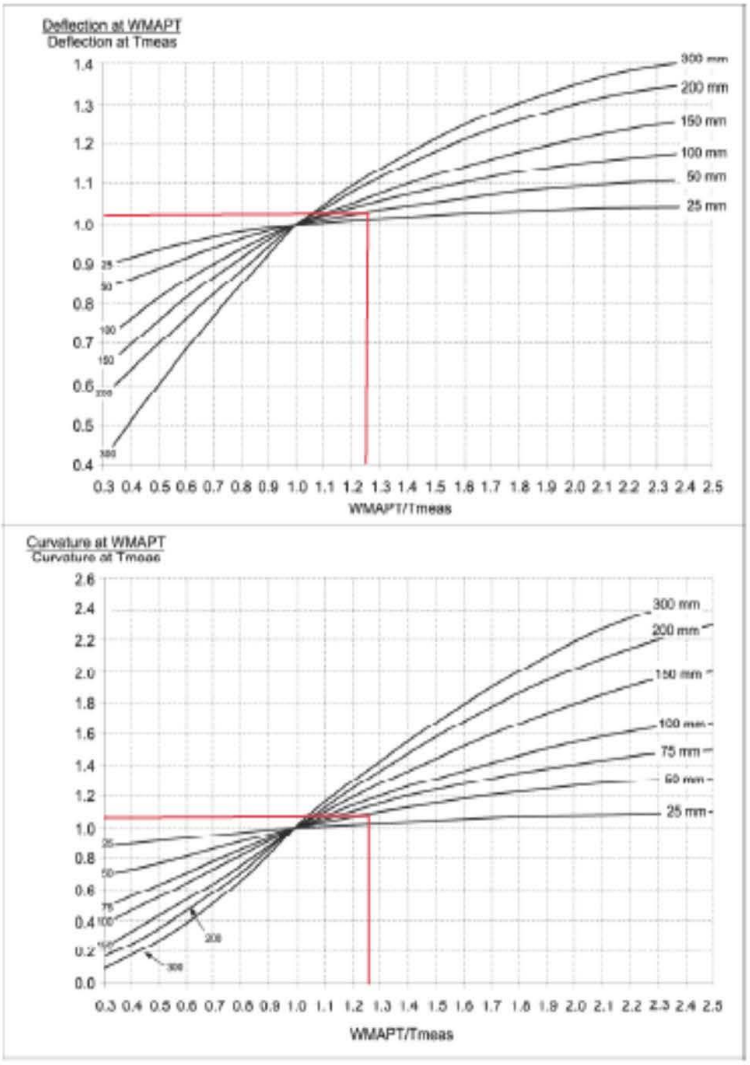

Figure 6.2: Temperature correction of FWD deflections and curvatures for various asphalt thicknesses

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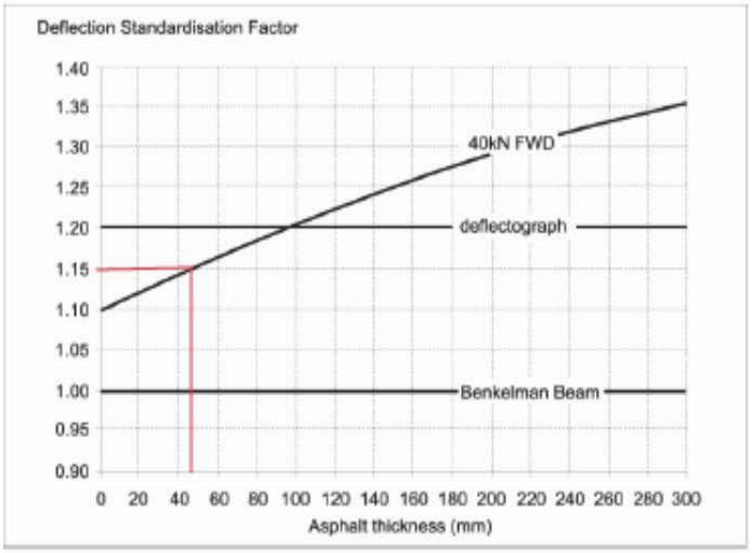
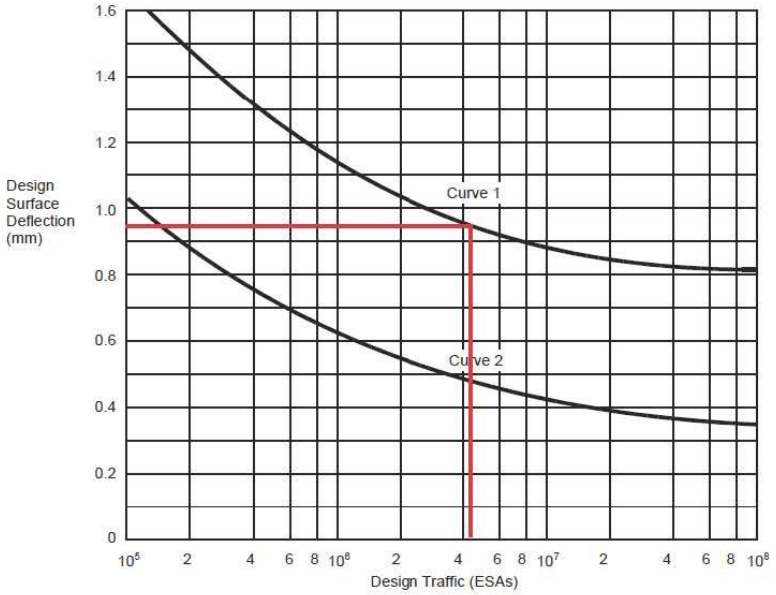

Deflection Standardisation Factor
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
40kN FWD
deflectograph
Benkelman Beam
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Asphalt thickness (mm)


Design Surface Deflection (mm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Curve 1
Curve 2
10^5 2 4 6 8 10^6 2 4 6 8 10^7 2 4 6 8 10^8
Design Traffic (ESAs)

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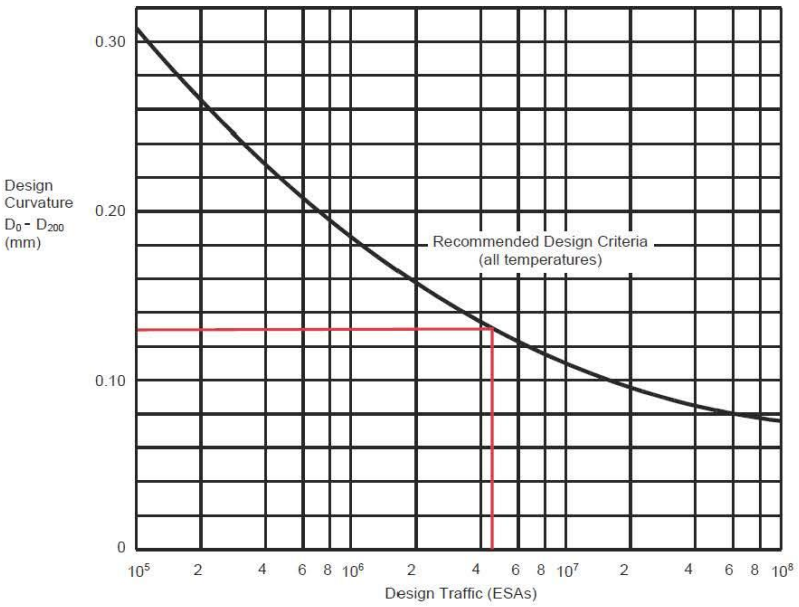

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Ord Street

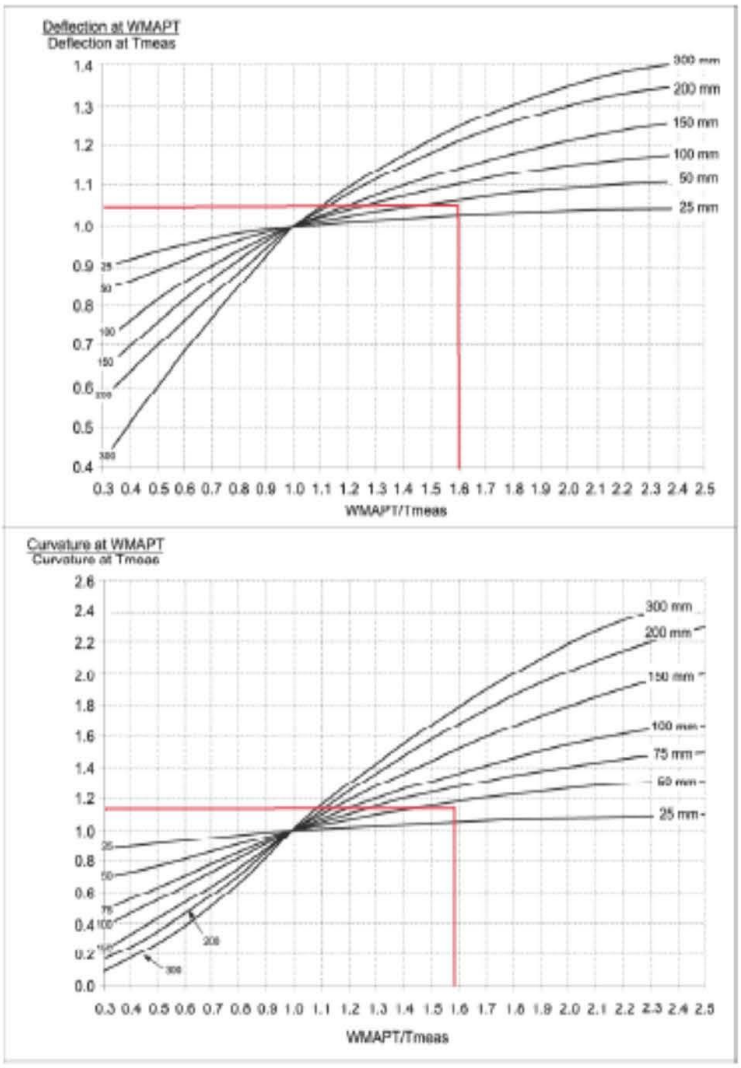

Figure 6.2: Temperature correction of FWD deflections and curvatures for various asphalt thicknesses

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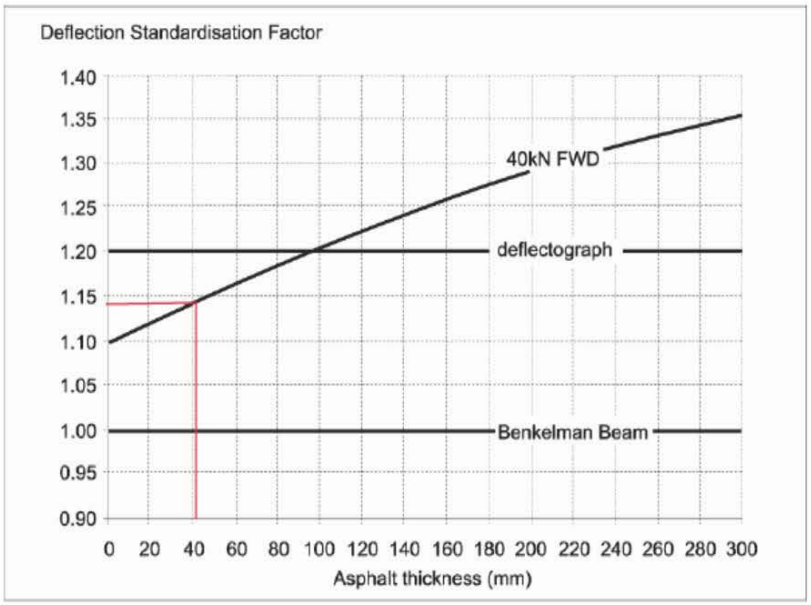
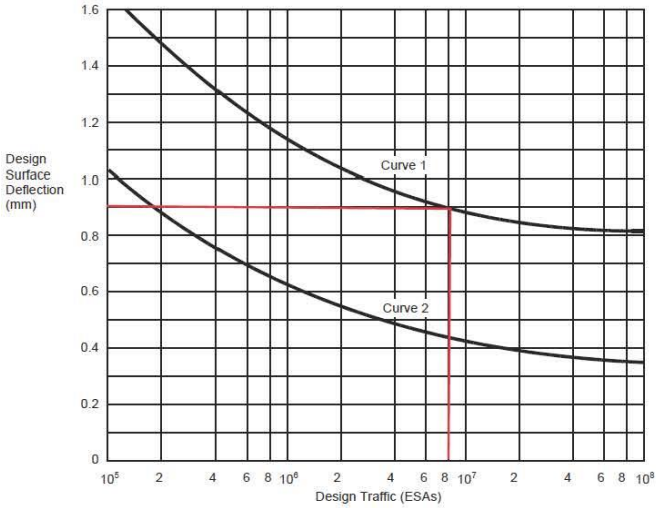


Figure 6.3: Deflection standardisation factors



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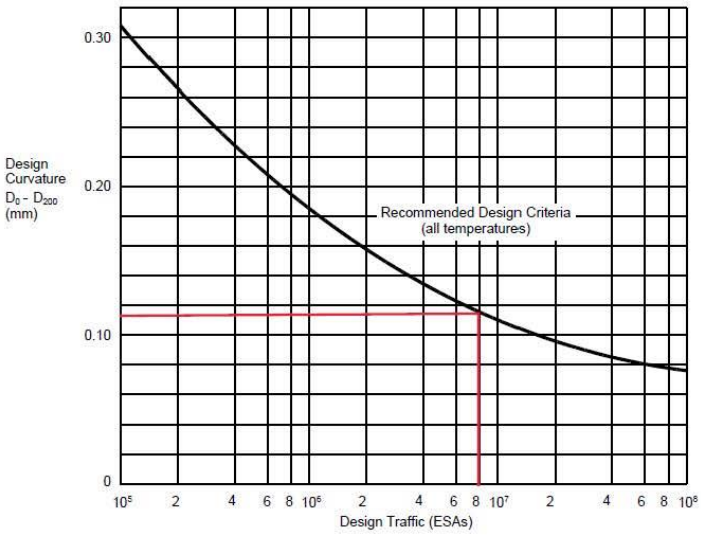
Design Curvature $D_0 - D_{200}$ (mm)
0.30
0.20
0.10
0
Recommended Design Criteria (all temperatures)
10^5 2 4 6 8 10^6 2 4 6 8 10^7 2 4 6 8 10^8
Design Traffic (ESAs)

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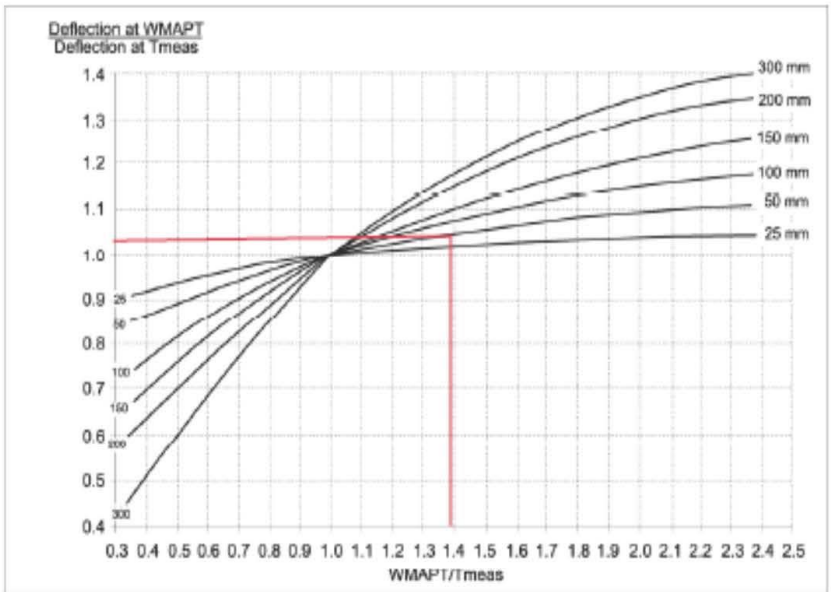
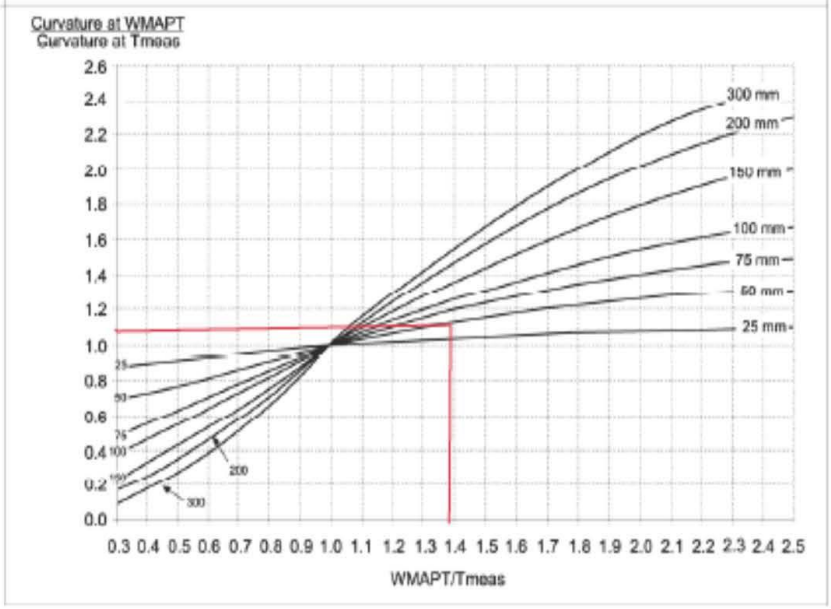
Queen Street





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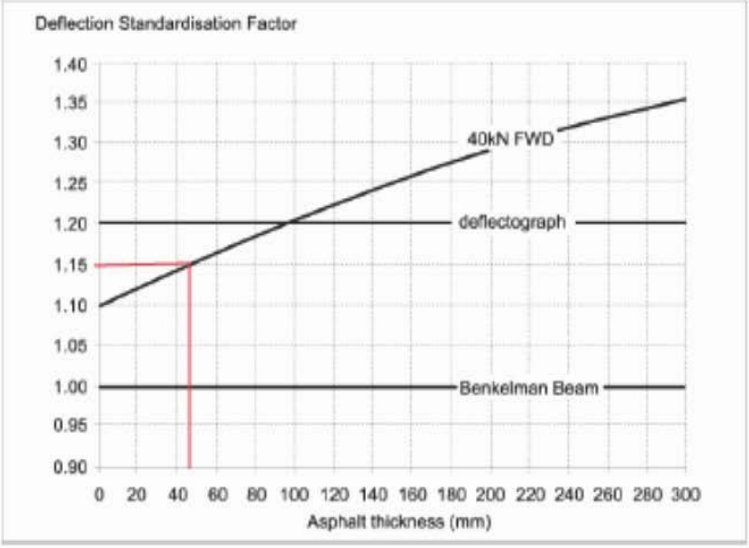
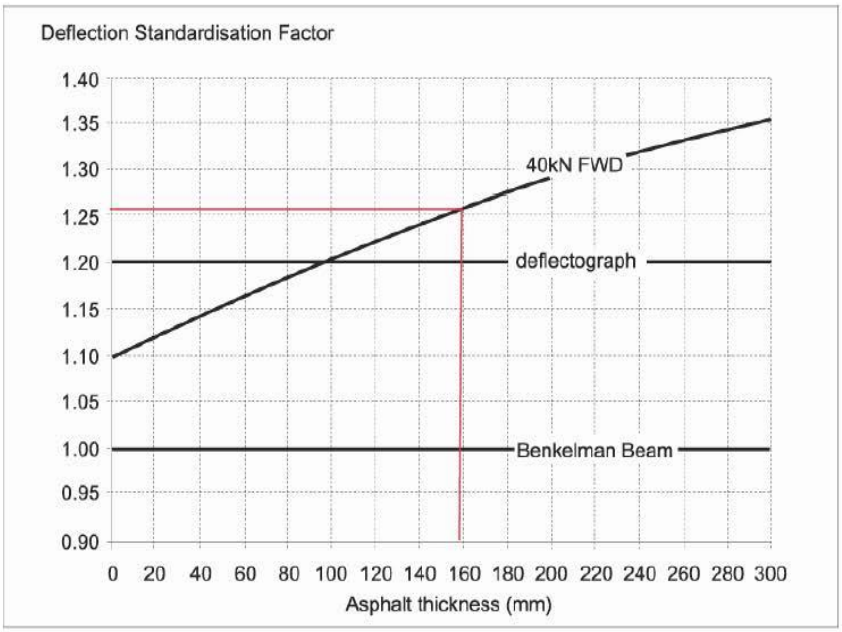

Deflection Standardisation Factor
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
40kN FWD
deflectograph
Benkelman Beam
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Asphalt thickness (mm)


Deflection Standardisation Factor
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
40kN FWD
deflectograph
Benkelman Beam
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Asphalt thickness (mm)

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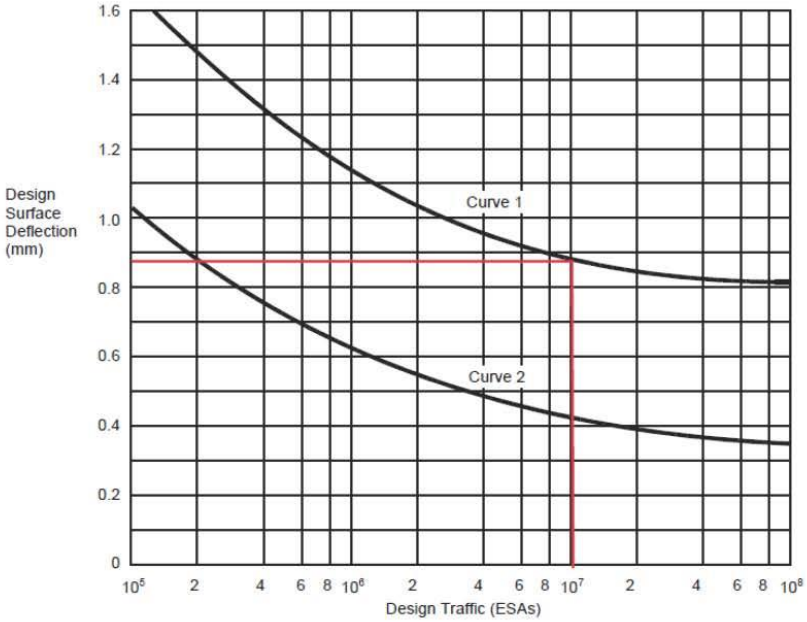
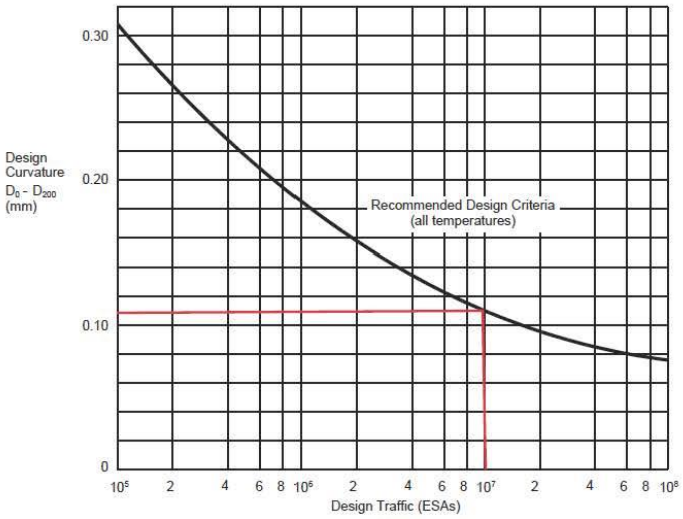

Design Surface Deflection (mm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Curve 1
Curve 2
10^5 2 4 6 8 10^6 2 4 6 8 10^7 2 4 6 8 10^8
Design Traffic (ESAs)


Design Curvature $D_0 - D_{200}$ (mm)
0.30
0.20
0.10
0
Recommended Design Criteria (all temperatures)
10^5 2 4 6 8 10^6 2 4 6 8 10^7 2 4 6 8 10^8
Design Traffic (ESAs)

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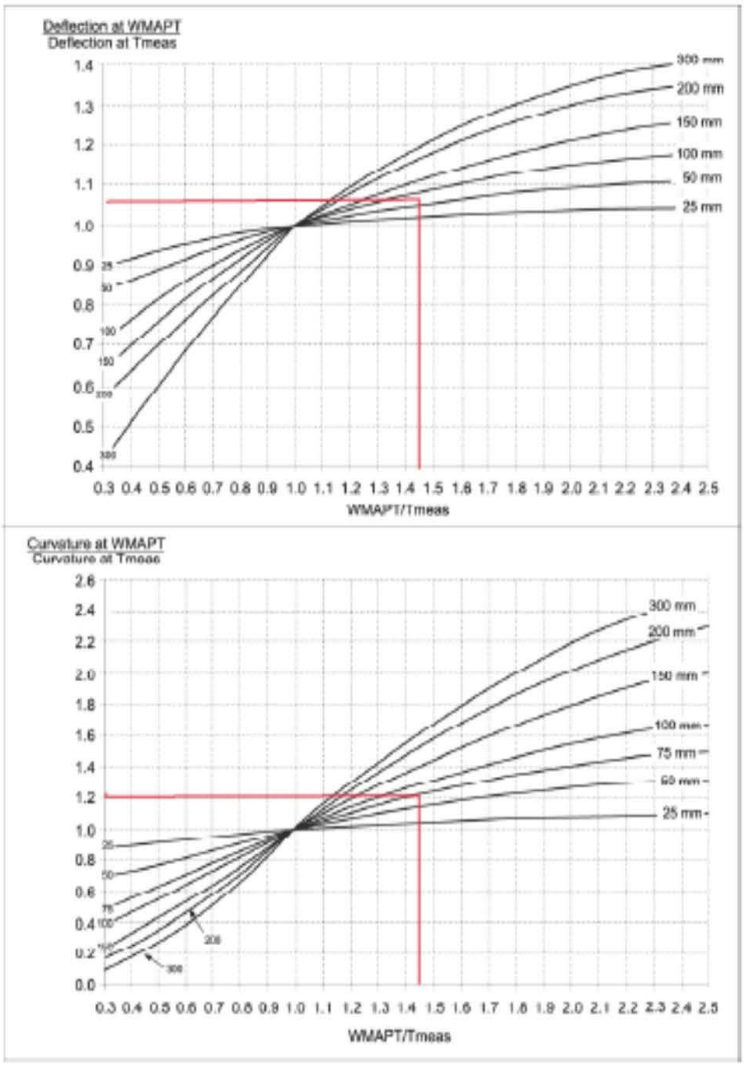
South Terrace



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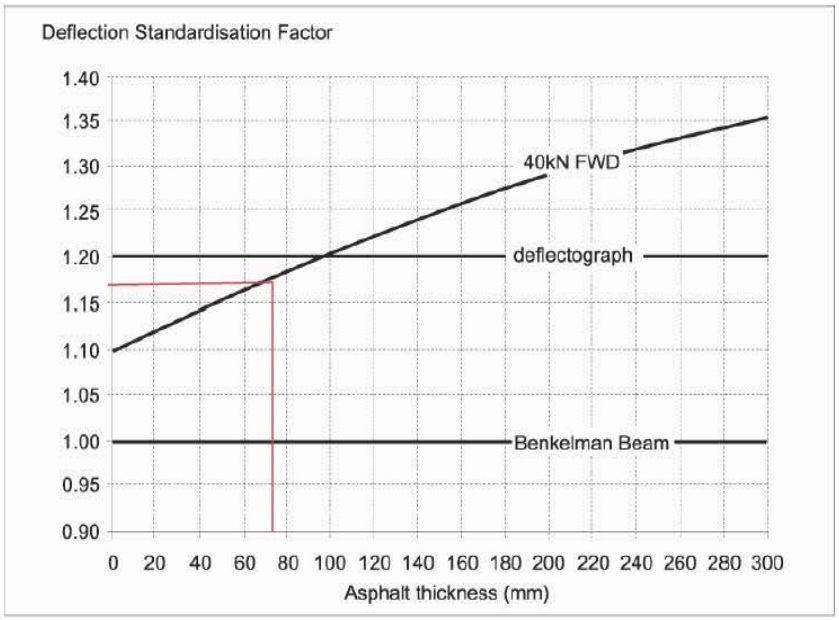
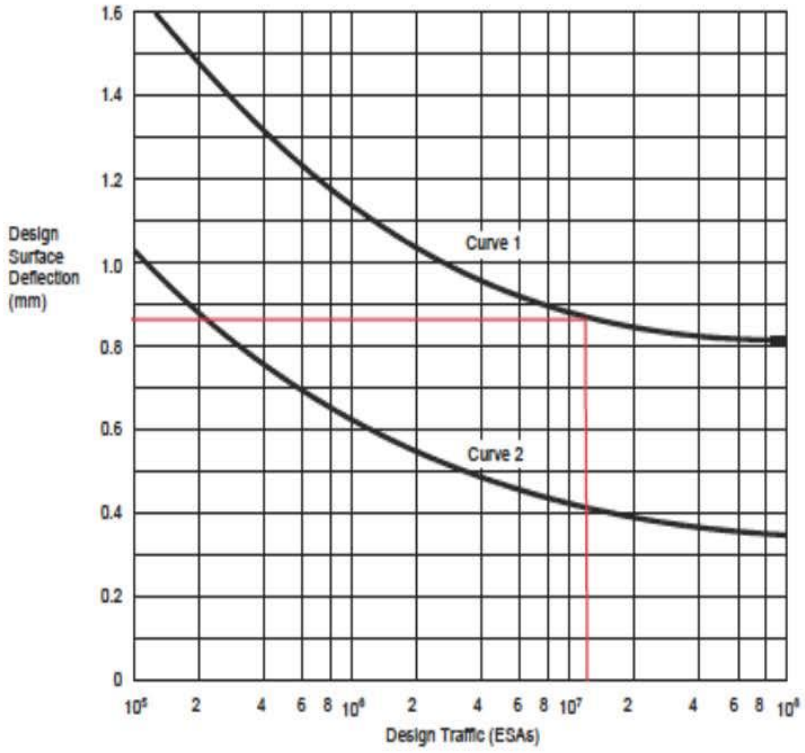

Deflection Standardisation Factor
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
40kN FWD
deflectograph
Benkelman Beam
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Asphalt thickness (mm)


Design Surface Deflection (mm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Curve 1
Curve 2
10⁵ 2 4 6 8 10⁶ 2 4 6 8 10⁷ 2 4 6 8 10⁸
Design Traffic (ESAs)

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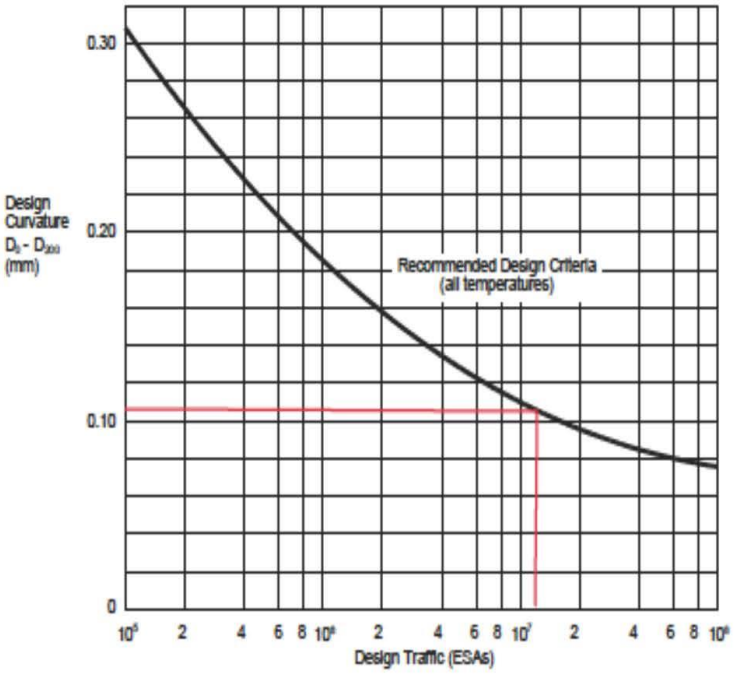
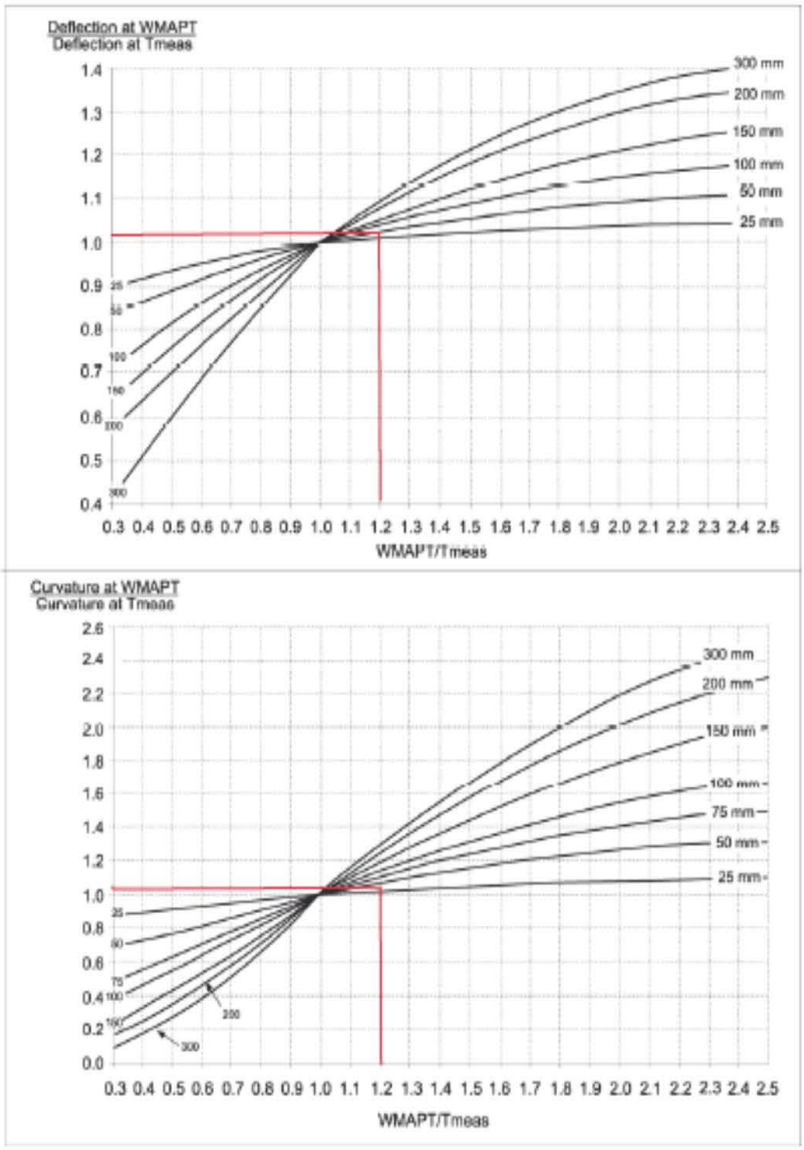

0.30
0.20
0.10
0
Design Curvature
$D_0 - D_{200}$
(mm)
Recommended Design Criteria
(all temperatures)
10^5 2 4 6 8 10^6 2 4 6 8 10^7 2 4 6 8 10^8
Design Traffic (ESAs)

J19001-Rev 0

Winterfold Road



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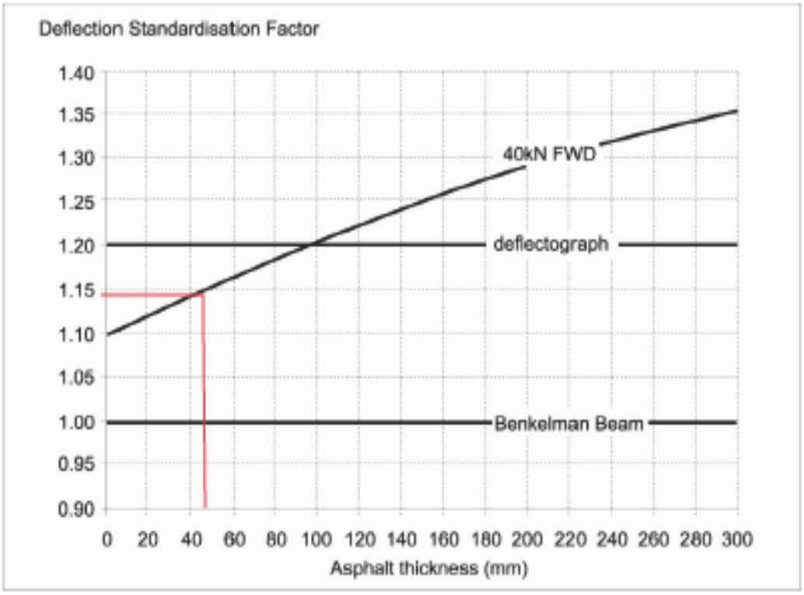
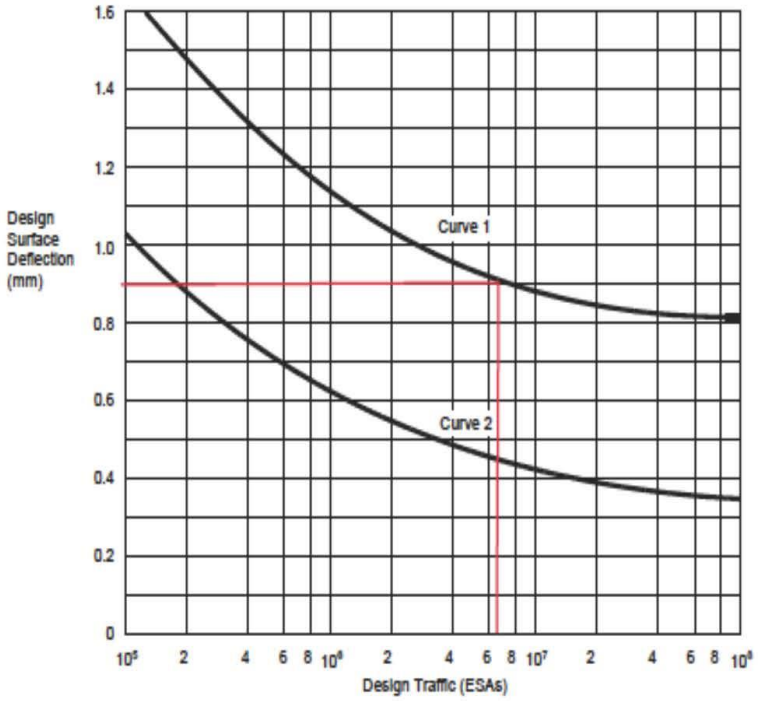

Deflection Standardisation Factor
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
40kN FWD
deflectograph
Benkelman Beam
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Asphalt thickness (mm)


Design Surface Deflection (mm)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Curve 1
Curve 2
10⁵ 2 4 6 8 10⁶ 2 4 6 8 10⁷ 2 4 6 8 10⁸
Design Traffic (ESAs)

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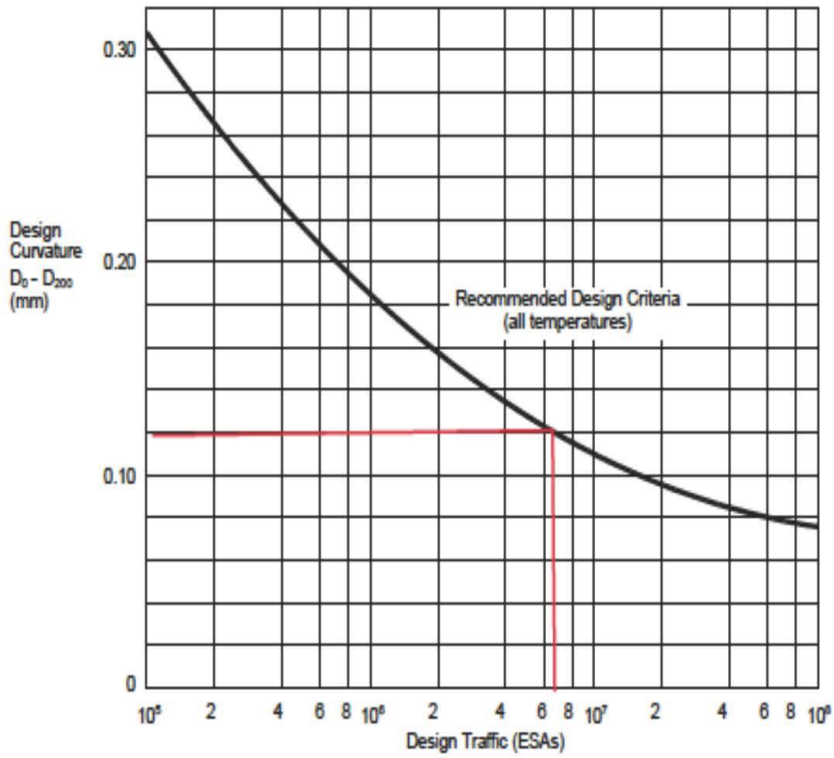
Design Curvature $D_0 - D_{200}$ (mm)
0.30
0.20
0.10
0
Recommended Design Criteria (all temperatures)
10^5 2 4 6 8 10^6 2 4 6 8 10^7 2 4 6 8 10^8
Design Traffic (ESAs)

J19001-Rev0

Appendix B – AustPADS outputs

Lefroy Street

Project Details

This sheet contains the top level information for the current project.

Project Name:	Lefroy
Location Name:	
Report Generated:	2019-03-06 05:28:14 AM
Completed On:	2019-03-05 11:47:22 PM
Design Date:	05/03/2019
AustPads version:	v3.1
APADS version:	1.0a
Chainage:	
Comments:	
Designer:	Steven Middleton
WMAPT (°C):	29
Design Speed (km/h):	40
Cemented Material Fatigue Reliability Factor:	1.00
Asphalt Fatigue Reliability Factor:	6.00
Pavement Layers:	3
Load Type: [TLD]	Collector with buses

Load Summary

Design Traffic (HVAGs):	3.012E+06
Design Traffic (ESAs):	4.41E+06
ESA/HVAG:	1.464

Pavement Details

Layer Type	LayerChar	Thickness [mm]	Modulus [MPa]	Poisson's Ratio
Asphalt	10mm 40km/h	35	2300.00	0.40
Asphalt	FBS 40km/h	210	2250.00	0.40
Subgrade	CBR 12	0	120	0.45

Pavement Performance

Layer Type	Layer Name	Critical Strain SAST-53	Critical Strain SADT-80	Damage
Asphalt	10mm 40km/h		4	2.772E-010
Asphalt	FBS 40km/h	129	150	8.189E-001
Subgrade	CBR 12	320	328	3.354E-004

J19001-Rev 0

Layer Material Information

Asphalt:

Name:	10mm 40km/h
Thickness[mm]:	35
Vertical Modulus[MPa]:	2300.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	11.00
K:	4474.89
Bulk Density[t/m3]:	2.40
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Asphalt:

Name:	FBS 40km/h
Thickness[mm]:	210
Vertical Modulus[MPa]:	2250.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	7.00
K:	3039.04
Bulk Density[t/m3]:	2.00
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Subgrade:

Name:	CBR 12
Thickness[mm]:	0
Vertical Modulus[MPa]:	120
Ev/Eh:	2.00
Poisson's Ratio:	0.45
Volume of Binder[%]:	
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

J19001-Rev0

TLD Table

LoadValue	SAST	SADT	TAST	TADT	TRDT	QADT
24	0.0000000000	0.0379999680	0.0000000000	0.0000000000	0.0000000000	0.0000000000
34	0.0669999900	0.0000000000	0.0289998800	0.0000000000	0.0000000000	0.0000000000
39	0.1390001250	0.0379999680	0.0479999000	0.0000000000	0.0000000000	0.0000000000
44	0.0579999150	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
49	0.0480000900	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
52	0.0140002200	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
53	0.1099999350	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
54	0.0000000000	0.0379999680	0.0000000000	0.0000000000	0.0000000000	0.0000000000
64	0.0290001900	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
69	0.0000000000	0.0479999450	0.0000000000	0.0000000000	0.0000000000	0.0000000000
76	0.0000000000	0.0140001340	0.0000000000	0.0000000000	0.0000000000	0.0000000000
83	0.0000000000	0.1010000170	0.0000000000	0.0000000000	0.0000000000	0.0000000000
93	0.0000000000	0.0000000000	0.0580000200	0.0000000000	0.0000000000	0.0000000000
147	0.0000000000	0.0000000000	0.1249999400	0.0000000000	0.0000000000	0.0000000000

J19001-Rev 0

Ord Street

Project Details

This sheet contains the top level information for the current project.

Project Name:	Ord
Location Name:	
Report Generated:	2019-03-06 05:34:57 AM
Completed On:	2019-03-05 11:52:28 PM
Design Date:	05/03/2019
AustPads version:	v3.1
APADS version:	1.0a
Chainage:	
Comments:	
Designer:	Steven Middleton
WMAPT (°C):	29
Design Speed (km/h):	40
Cemented Material Fatigue Reliability Factor:	1.00
Asphalt Fatigue Reliability Factor:	6.00
Pavement Layers:	8
Load Type: [TLD]	Collector with buses

Load Summary

Design Traffic (HVAGs):	5.53E+06
Design Traffic (ESAs):	8.096E+06
ESA/HVAG:	1.464

Pavement Details

Layer Type	LayerChar	Thickness [mm]	Modulus [MPa]	Poisson's Ratio
Asphalt	14mm, 40km/h	40	2500.00	0.40
Asphalt	FBS 40km/h	220	2250.00	0.40
Granular	Limestone	18	150	0.35
Granular	Limestone	18	143	0.35
Granular	Limestone	18	137	0.35
Granular	Limestone	18	131	0.35
Granular	Limestone	18	125	0.35
Subgrade	CBR 12	0	120.00	0.45

Pavement Performance

Layer Type	Layer Name	Critical Strain SAST-53	Critical Strain SADT-80	Damage
Asphalt	14mm, 40km/h	11	19	2.369E-006
Asphalt	FBS 40km/h	112	133	7.560E-001
Granular	Limestone			N/A
Granular	Limestone			N/A
Granular	Limestone			N/A
Granular	Limestone			N/A
Granular	Limestone			N/A
Subgrade	CBR 12	211	236	6.148E-005

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Layer Material Information

Asphalt:

Name:	14mm, 40km/h
Thickness[mm]:	40
Vertical Modulus[MPa]:	2500.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	11.00
K:	4342.56
Bulk Density[t/m3]:	2.45
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Asphalt:

Name:	FBS 40km/h
Thickness[mm]:	220
Vertical Modulus[MPa]:	2250.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	7.00
K:	3039.04
Bulk Density[t/m3]:	2.00
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Granular:

Name:	Limestone
Thickness[mm]:	18
Vertical Modulus[MPa]:	150
Ev/Eh:	2.00
Poisson's Ratio:	0.35
Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Granular:

Name:	Limestone

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Thickness[mm]:	18
Vertical Modulus[MPa]:	143
Ev/Eh:	2.00
Poisson's Ratio:	0.35
Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Granular:

Name:	Limestone
Thickness[mm]:	18
Vertical Modulus[MPa]:	137
Ev/Eh:	2.00
Poisson's Ratio:	0.35
Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Granular:

Name:	Limestone
Thickness[mm]:	18
Vertical Modulus[MPa]:	131
Ev/Eh:	2.00
Poisson's Ratio:	0.35
Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Granular:

Name:	Limestone
Thickness[mm]:	18
Vertical Modulus[MPa]:	125
Ev/Eh:	2.00
Poisson's Ratio:	0.35

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Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Subgrade:

Name:	CBR 12
Thickness[mm]:	0
Vertical Modulus[MPa]:	120.00
Ev/Eh:	1.00
Poisson's Ratio:	0.45
Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

TLD Table

LoadValue	SAST	SADT	TAST	TADT	TRDT	QADT
24	0.0000000000	0.0379999680	0.0000000000	0.0000000000	0.0000000000	0.0000000000
34	0.0669999900	0.0000000000	0.0289998800	0.0000000000	0.0000000000	0.0000000000
39	0.1390001250	0.0379999680	0.0479999000	0.0000000000	0.0000000000	0.0000000000
44	0.0579999150	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
49	0.0480000900	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
52	0.0140002200	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
53	0.1099999350	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
54	0.0000000000	0.0379999680	0.0000000000	0.0000000000	0.0000000000	0.0000000000
64	0.0290001900	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
69	0.0000000000	0.0479999450	0.0000000000	0.0000000000	0.0000000000	0.0000000000
76	0.0000000000	0.0140001340	0.0000000000	0.0000000000	0.0000000000	0.0000000000
83	0.0000000000	0.1010000170	0.0000000000	0.0000000000	0.0000000000	0.0000000000
93	0.0000000000	0.0000000000	0.058000C200	0.0000000000	0.0000000000	0.0000000000
147	0.0000000000	0.0000000000	0.1249999400	0.0000000000	0.0000000000	0.0000000000

J19001-Rev 0

Queen Street

Project Details

This sheet contains the top level information for the current project.

Project Name:	Queen FBS
Location Name:	
Report Generated:	2019-03-10 01:27:57 AM
Completed On:	2019-03-09 07:42:04 PM
Design Date:	09/03/2019
AustPads version:	v3.1
APADS version:	1.0a
Chainage:	
Comments:	
Designer:	Steven Middleton
WMAPT (°C):	29
Design Speed (km/h):	40
Cemented Material Fatigue Reliability Factor:	1.00
Asphalt Fatigue Reliability Factor:	6.00
Pavement Layers:	3
Load Type: [TLD]	Collector with buses

Load Summary

Design Traffic (HVAGs):	6.61E+06
Design Traffic (ESAs):	9.677E+06
ESA/HVAG:	1.464

Pavement Details

Layer Type	LayerChar	Thickness [mm]	Modulus [MPa]	Poisson's Ratio
Asphalt	14mm, 40km/h	40	2500.00	0.40
Asphalt	FBS 40km/h	230	2250.00	0.40
Subgrade	CBR 12	0	120.00	0.45

Pavement Performance

Layer Type	Layer Name	Critical Strain SAST-53	Critical Strain SADT-80	Damage
Asphalt	14mm, 40km/h	13	20	4.797E-006
Asphalt	FBS 40km/h	106	128	6.976E-001
Subgrade	CBR 12	247	245	9.549E-005

J19001-Rev0

Layer Material Information

Asphalt:

Name:	14mm, 40km/h
Thickness[mm]:	40
Vertical Modulus[MPa]:	2500.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	11.00
K:	4342.56
Bulk Density[t/m3]:	2.45
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Asphalt:

Name:	FBS 40km/h
Thickness[mm]:	230
Vertical Modulus[MPa]:	2250.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	7.00
K:	3039.04
Bulk Density[t/m3]:	2.00
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Subgrade:

Name:	CBR 12
Thickness[mm]:	0
Vertical Modulus[MPa]:	120.00
Ev/Eh:	1.00
Poisson's Ratio:	0.45
Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

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TLD Table						
LoadValue	SAST	SADT	TAST	TADT	TRDT	QADT
24	0.0000000000	0.0379999680	0.0000000000	0.0000000000	0.0000000000	0.0000000000
34	0.0669999900	0.0000000000	0.0289998800	0.0000000000	0.0000000000	0.0000000000
39	0.1390001250	0.0379999680	0.0479999000	0.0000000000	0.0000000000	0.0000000000
44	0.0579999150	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
49	0.0480000900	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
52	0.0140002200	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
53	0.1099999350	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
54	0.0000000000	0.0379999680	0.0000000000	0.0000000000	0.0000000000	0.0000000000
64	0.0290001900	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
69	0.0000000000	0.0479999450	0.0000000000	0.0000000000	0.0000000000	0.0000000000
76	0.0000000000	0.0140001340	0.0000000000	0.0000000000	0.0000000000	0.0000000000
83	0.0000000000	0.1010000170	0.0000000000	0.0000000000	0.0000000000	0.0000000000
93	0.0000000000	0.0000000000	0.0580000200	0.0000000000	0.0000000000	0.0000000000
147	0.0000000000	0.0000000000	0.1249999400	0.0000000000	0.0000000000	0.0000000000

J19001-Rev0

South Terrace

Project Details

This sheet contains the top level information for the current project.

Project Name:	South Terrace
Location Name:	
Report Generated:	2019-03-06 06:57:09 AM
Completed On:	2019-03-06 01:15:07 AM
Design Date:	05/03/2019
AustPads version:	v3.1
APADS version:	1.0a
Chainage:	
Comments:	
Designer:	Steven Middleton
WMAPT (°C):	29
Design Speed (km/h):	40
Cemented Material Fatigue Reliability Factor:	1.00
Asphalt Fatigue Reliability Factor:	6.00
Pavement Layers:	3
Load Type: [TLD]	Collector with buses

Load Summary

Design Traffic (HVAGs):	9.426E+06
Design Traffic (ESAs):	1.38E+07
ESA/HVAG:	1.464

Pavement Details

Layer Type	LayerChar	Thickness [mm]	Modulus [MPa]	Poisson's Ratio
Asphalt	14mm, 40km/h	40	2500.00	0.40
Asphalt	FBS 40km/h	230	2250.00	0.40
Subgrade	CBR 12	0	120.00	0.45

Pavement Performance

Layer Type	Layer Name	Critical Strain SAST-53	Critical Strain SADT-80	Damage
Asphalt	14mm, 40km/h	13	20	6.841E-006
Asphalt	FBS 40km/h	106	128	9.947E-001
Subgrade	CBR 12	247	245	1.362E-004

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Layer Material Information

Asphalt:

Name:	14mm, 40km/h
Thickness[mm]:	40
Vertical Modulus[MPa]:	2500.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	11.00
K:	4342.56
Bulk Density[t/m3]:	2.45
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Asphalt:

Name:	FBS 40km/h
Thickness[mm]:	230
Vertical Modulus[MPa]:	2250.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	7.00
K:	3039.04
Bulk Density[t/m3]:	2.00
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Subgrade:

Name:	CBR 12
Thickness[mm]:	0
Vertical Modulus[MPa]:	120.00
Ev/Eh:	1.00
Poisson's Ratio:	0.45
Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

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TLD Table						
LoadValue	SAST	SADT	TAST	TADT	TRDT	QADT
24	0.0000000000	0.0379999680	0.0000000000	0.0000000000	0.0000000000	0.0000000000
34	0.0669999900	0.0000000000	0.0289998800	0.0000000000	0.0000000000	0.0000000000
39	0.1390001250	0.0379999680	0.0479999000	0.0000000000	0.0000000000	0.0000000000
44	0.0579999150	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
49	0.0480000900	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
52	0.0140002200	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
53	0.1099999350	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
54	0.0000000000	0.0379999680	0.0000000000	0.0000000000	0.0000000000	0.0000000000
64	0.0290001900	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
69	0.0000000000	0.0479999450	0.0000000000	0.0000000000	0.0000000000	0.0000000000
76	0.0000000000	0.0140001340	0.0000000000	0.0000000000	0.0000000000	0.0000000000
83	0.0000000000	0.1010000170	0.0000000000	0.0000000000	0.0000000000	0.0000000000
93	0.0000000000	0.0000000000	0.0580000200	0.0000000000	0.0000000000	0.0000000000
147	0.0000000000	0.0000000000	0.1249998400	0.0000000000	0.0000000000	0.0000000000

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Winterfold Road

Project Details

This sheet contains the top level information for the current project.

Project Name:	Winterfold
Location Name:	
Report Generated:	2019-03-10 08:48:19 PM
Completed On:	2019-03-10 02:13:19 PM
Design Date:	05/03/2019
AustPads version:	v3.1
APADS version:	1.0a
Chainage:	
Comments:	
Designer:	Steven Middleton
WMAPT (°C):	29
Design Speed (km/h):	40
Cemented Material Fatigue Reliability Factor:	1.00
Asphalt Fatigue Reliability Factor:	6.00
Pavement Layers:	3
Load Type: [TLD]	Collector no buses

Load Summary

Design Traffic (HVAGs):	4.95E+06
Design Traffic (ESAs):	7.346E+06
ESA/HVAG:	1.484

Pavement Details

Layer Type	LayerChar	Thickness [mm]	Modulus [MPa]	Poisson's Ratio
Asphalt	10mm 40km/h	35	2300.00	0.40
Asphalt	FBS 40km/h	165	2250.00	0.40
Subgrade	CBR 12	0	120.00	0.45

Pavement Performance

Layer Type	Layer Name	Critical Strain SAST-53	Critical Strain SADT-80	Damage
Asphalt	10mm 40km/h			N/A
Asphalt	FBS 40km/h	176	189	6.088E+000
Subgrade	CBR 12	416	387	1.779E-003

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Layer Material Information

Asphalt:

Name:	10mm 40km/h
Thickness[mm]:	35
Vertical Modulus[MPa]:	2300.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	11.00
K:	4474.89
Bulk Density[t/m3]:	2.40
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Asphalt:

Name:	FBS 40km/h
Thickness[mm]:	165
Vertical Modulus[MPa]:	2250.00
Ev/Eh:	1.00
Poisson's Ratio:	0.40
Volume of Binder[%]:	7.00
K:	3039.04
Bulk Density[t/m3]:	2.00
Shift Factor:	6.00
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

Subgrade:

Name:	CBR 12
Thickness[mm]:	0
Vertical Modulus[MPa]:	120.00
Ev/Eh:	1.00
Poisson's Ratio:	0.45
Volume of Binder[%]:	0.00
K:	
Bulk Density[t/m3]:	2.00
Shift Factor:	
Nonlinear Flag:	Linear
K1[MPa]:	
K2[-]:	
K3[-]:	
Emin[MPa]:	
Emax[MPa]:	
Residual Compaction Stress[kPa]:	

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TLD Table

LoadValue	SAST	SADT	TAST	TADT	TRDT	QADT
24	0.0000000000	0.0429999640	0.0000000000	0.0000000000	0.0000000000	0.0000000000
34	0.0740000800	0.0000000000	0.0319999260	0.0000000000	0.0000000000	0.0000000000
39	0.1380001370	0.0429999640	0.0530000030	0.0000000000	0.0000000000	0.0000000000
44	0.0640000570	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
49	0.0530001670	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
53	0.1220000100	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
54	0.0000000000	0.0429999640	0.0000000000	0.0000000000	0.0000000000	0.0000000000
69	0.0000000000	0.0529999800	0.0000000000	0.0000000000	0.0000000000	0.0000000000
83	0.0000000000	0.0800001280	0.0000000000	0.0000000000	0.0000000000	0.0000000000
93	0.0000000000	0.0000000000	0.0640001390	0.0000000000	0.0000000000	0.0000000000
147	0.0000000000	0.0000000000	0.1379999320	0.0000000000	0.0000000000	0.0000000000

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Appendix C - Limitations

This report has been prepared for the particular purpose outlined in MIBROS's proposal and no responsibility is accepted for the use of this report in other contexts or for any other reason.

MIBROS did not undertake a complete assessment of all possible conditions or circumstances that exist at the site referenced in this report. Conditions may exist that were undetectable given the nature of the works undertaken.

The opinions by MIBROS in this document were provided based on the conditions at the time, it should be recognised that the passage of time affects the information and assessment outlined in this report.

Where data has been supplied by the client or other external sources it has been assumed that the information contained in these documents is correct unless otherwise stated. No responsibility is accepted by MIBROS for incomplete or inaccurate data supplied by others.

This report is provided for sole use by the Client, no responsibility for the contents of this report will be accepted to any other person than the Client.

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FPOL1904-2 WET AND DRY HIRE OF PLANT AND ROAD CONSTRUCTION MACHINERY (FCC531/18) - TENDER REPORT

ATTACHMENT 1 Pricing Matrix for Tender FCC533/18 Wet and Dry Hire Of Plant and Road Construction Machinery

Confidential attachment (under separate cover)

FPOL1904-3 STRATEGIC COMMUNITY PLAN REVIEW - DRAFT REVISION
ATTACHMENT 1 – DRAFT STRATEGIC COMMUNITY PLAN 2015-2025 (REVISED 2019)

Strategic Community Plan 2015-2025

Revised 2019

Contents

Acknowledgement of People and Country

The City of Fremantle acknowledges the Wadjuk people as the traditional owners of the Greater Fremantle area (Walyalup). It acknowledges the wisdom of the Elders both past and present and pays respect to Aboriginal communities of today.

Introduction

Our proud history

Fremantle's most important assets are its heritage and its people of diverse backgrounds and cultures. Its irresistible character is inviting and rich in history. Fremantle is an important place for Aboriginal people and lies within the Aboriginal cultural region of Beeliar. Its Nyoongar name is Walyalup (the place of walyo) and its local people are known as the Whadjuk people. To the local Whadjuk people, whose heritage dates back tens of thousands of years, Fremantle is a place of ceremonies, significant cultural practices and trading. Walyalup has several significant sites and features in many traditional stories.

Fremantle was established 1829 at the time of European colonization. The city's early economy was driven by trade in wheat, meat and wool. By 1900 Fremantle had grown to include many of the landmarks we know today including the Fremantle Harbour, Fremantle Hospital, Fremantle Markets and the railway between the harbour and Perth.

At this time the Western Australian gold rush period had begun and Fremantle served as a gateway to people heading to the goldfields. In the lead up to World War II the main industries in Fremantle were shipbuilding, soap boiling, saw milling, smelting, iron founding, furniture making, flour milling, brewing and animal skin tanning.

In the post war period, Fremantle's suburban areas grew and the city underwent a period of consolidation. As a result of technology advancements within the shipping industry, an ever progressive Fremantle moved to diversify its economy and evolve to create more diverse population-driven industries. In 1987 Fremantle was thrust into the global spotlight when the city hosted the America's Cup defence event, held in Gage Roads offshore from Fremantle harbour. The event saw a large public and private investment in the city and subsequent growth in retail and tourism sectors, leading to the vibrant and culturally rich Fremantle we know today.

Our city today

Fremantle, which is approximately 18 kilometres southwest of the Perth CBD, is home to 30,868 people (ABS 2018) and includes the suburbs of Beaconsfield, Fremantle, Hilton, North Fremantle, O'Connor, Samson, South Fremantle and White Gum Valley. The City of Fremantle employs more than 400 people and services more than 30 000 residents over a land area of 19 square kilometres.

Bounded by the Swan River and Indian Ocean, Fremantle is widely regarded as Perth's second city and is still home to the state's busiest and most important cargo port. The port, which has grown from the humble trading post to handling 30 million tonnes of cargo per year, is the beating heart of Western Australia's economy.

Fremantle's unique character is captured by its landscape, heritage architecture, music, arts, culture, festivals, retail stores, markets, cafés and restaurants, which all contribute to its village-style atmosphere.

Fremantle has developed a reputation for being gritty, eclectic and quirky as well as creative, musical and artistic. It is a place to discover a wide range of hidden treasures and experience laid-back adventures. This experience is reflected in the City's four aspirational brand pillars: eclectic and quirky, culturally significant, vibrant: and welcoming and inclusive.

According to Tourism Western Australia, Fremantle is often ranked as the state's most visited tourist destination outside of the Perth CBD, attracting over 1.2 million* national and international tourists each year.

In October 2015, Lonely Planet voted Fremantle as one of the top 10 cities to visit in the world for 2016.

As Perth's second city, Fremantle offers a diverse range of housing options, exceptional access to public transport and a dynamic economy, creating jobs and opportunities that enable Fremantle residents to live, work and play. Its character is embodied through stunning heritage buildings that house important cultural and artistic institutions including the Fremantle Arts Centre and the Shipwreck Galleries, as well as tributes to Fremantle's iconic past including the Duyfken replica.

Freo's desirable Mediterranean climate offers ideal opportunities for relaxing with family and friends, recreating and enjoying the Swan River and Indian Ocean.

Fremantle's rich cultural history has created a city with numerous dining options, a vibrant café and bar scene, and a range of entertainment options. The arts are strikingly represented within the city, and numerous food, arts and music festivals take place in Fremantle each year.

Our exciting future

A key council focus over the last few years has been to sustainably revitalise the city centre. The strategies implemented, including innovative planning scheme amendments across key non-heritage inner-city areas, have led to a significant increase in investor confidence in Fremantle.

As a result there is currently unprecedented investment and renewal underway with the combined level of public and private investment exceeding $1.3 billion including several civic, commercial, residential and retail developments. As part of this the City of Fremantle has set ambitious targets for the development of new dwellings, commercial office and retail floor space within the city's central area to be achieved over the next decade.

The development pipeline will see the delivery of a mix of civic, commercial and retail projects spanning over the next 5-10 years. A boutique hotel was recently completed and construction has commenced on Sirona's redevelopment of the Myer, the new council administration and Kings Square public realm, and the refurbishment of the Manning Building.

With levels of development and investment not seen since the America's Cup, Fremantle is on the cusp of a major period of revitalisation that will reinforce its position as a place of great significance to Western Australia, being home to modern facilities and high quality infrastructure.

As Western Australia works to diversify its economy amid a softening resources sector; it continues to investigate strong opportunities in agriculture, service industries and tourism. As the most visited destination in Western Australia outside of Perth CBD, and the host of WA's busiest port, Fremantle is well placed to thrive and grow as the Western Australian economy continues to diversify.

Mayor's message

To be inserted

About the plan

The City of Fremantle 2015-25 Strategic Community Plan is the overarching document that sets out the vision, outcomes and objectives of the local community for the next 10 years.

The state government has legislated a new integrated planning and reporting framework for local government. This framework requires all local governments to consult with their communities to develop a vision for the future in a number of integrated plans. It expects all local governments to examine the demographic, social, environmental and economic trends shaping the future of their area and align their activities and resources to the community's needs and aspirations.

The framework also requires local governments to manage their financial, infrastructure and human resources effectively and efficiently to ensure the sustainable delivery of high-quality services into the future.

The City has developed a corporate planning framework (right) which contains a number of key strategic documents to guide its planning, development and service delivery into the future.

While the Strategic Community Plan identifies 'what' the City is seeking to achieve, the City's Corporate Business Plan outlines 'how' it will achieve this. At an operational level, the business plans are a direct link to the City's annual budget process.

Community input

As a way of guiding the new strategic plan the City embarked on an extensive community visioning initiative aimed at getting to the core of community visions and values for Fremantle, now and into the future.

The Fremantle 2029: Community Visioning Project was an innovative, professional and interactive community engagement exercise which involved a wide range of Fremantle people including those who are not normally engaged in the future of Fremantle.

Close to 1 000 people attended five major workshops and three stakeholder forums during 2013-14. The visioning made the most of Fremantle's extraordinary local talent and knowledge among the presenters and the participants to reach a diverse group of stakeholders in the community. The interactive workshops enabled participants to have their say on key Fremantle issues and to be informed about the long-term strategic issues facing Fremantle.

The issues most frequently mentioned by participants included:

- slowing traffic and making the city better for pedestrians, cyclists and improving public transport
- supporting independent small business and the creative sector
- protecting and enhancing the natural environment, green spaces and heritage features of the city
- improving the connectivity around Fremantle, especially to the waterfront.

The following six key themes were distilled from the various discussions, ideas and priority issues identified by participants throughout the visioning process.

Fremantle 2029 Community Visioning Themes

1. **People:** A welcoming place for all
2. **Plan:** A liveable city that serves its residents needs and values heritage
3. **Prosper:** A diverse and unique local economy and a recognised centre of excellence
4. **Green:** A city that values its environment
5. **Create:** A dynamic innovative city with a strong knowledge economy and arts sector
6. **Decide:** A collaborative and connected community with a shared vision and good governance

The themes and actions that emerged from this visioning process have been used to inform the council's long term strategic planning and priority projects.

Vision for the Future

Fremantle: a destination city:
A city that is clever and creative, inspiring and inclusive.
A city that welcomes and celebrates all people and cultures.
A city that encourages innovation, prosperity and achievement.
A compassionate city that cares for the wellbeing of people and the environment we share.
A city that thrives on diversity and dares to be different.

Strategic Focus Areas

The six themes provided through the community visioning process were considered by council when identifying the following strategic focus areas of the 2015-25 strategic community plan.

Economic development
Diversify and strengthen Fremantle's economic capacity.
Environmental responsibility
Work with the community to develop environmentally sustainable solutions for the benefit of current and future generations.
Transport and connectivity
Enhance the connectivity throughout the City of Fremantle and other strategic economic hubs and population centres.
Character, culture and heritage
Sustain and grow arts and culture and preserve and promote the importance of our social capital, built heritage and history (both pre- and post european settlement).
Places for people
Create great spaces for people through innovative urban and suburban design.
Health and happiness
Creating a physical and social environment where it is easy for people to lead safe, happy and healthy lives.
Capability
An innovative, responsive, influential local government which leads the way in delivering services and projects through good governance, effective communication, responsible management and excellence in delivery.

The Strategic Community Plan was reviewed and updated in 2018-2019.

Economic development

Economic Development 'Diversify and strengthen Fremantle's economic capacity'		1
Outcome	**More people live in, work in and visit Fremantle**	1.1
Objective		1.1.1
	Greater opportunity for businesses to attract customers	1.1.1.1
	Improve the number and range of employment opportunities available in Fremantle	1.1.1.2
	Improve the resilience of the weekday economy and maintain a strong weekend economy	1.1.1.3
Measure of Success		1.1.2
	Increase the number of people living in Fremantle (up to 10% by 2020)	1.1.2.1
	Increase the number of people working in Fremantle (up to 7% by 2020)	1.1.2.2
	Increase the number of visitors to Fremantle (average of 3 million per year)	1.1.2.3
	Increase commercial and retail development within 800 metres of Fremantle train station	1.1.2.4
Outcome	**Fremantle welcomes investment and is an attractive destination for high-quality development**	1.2
Objective		1.2.1
	Improve investment confidence and support private sector investment in Fremantle	1.2.1.1
	Increase the number of sustainable, intensive and higher value land uses and developments	1.2.1.2
Measure of Success		1.2.2
	Growth in the total value of development investment (based on building approvals)	1.2.2.1
	Increase the net lettable area of A-grade and B-grade office space by at least 70,000m^2 by 2020	1.2.2.2
	Increase the net lettable area of retail space by at least 20,000m^2 by 2020	1.2.2.3
	Decrease in number of times a development application is assessed by the design advisory committee	1.2.2.4
Outcome	**A shared vision with the business community for a thriving and diverse local economy which embraces new trends and innovation whilst building on Fremantle's points of difference and strengths in education, health and tourism**	1.3
Objective		1.3.1
	A more resilient, self-sufficient and sustainable economy	1.3.1.1
	Increase in variety of businesses and economic diversity	1.3.1.2
	Greater collaboration for more effective problem solving	1.3.1.3

	Maintenance and evolution of traditional service centres	
Measure of Success		1.3.2
	Maintain current Economic Development Strategy and business liaison group/s	1.3.2.1
	Increase the number of desirable population-driven businesses opening in Fremantle	1.3.2.2
	Growth in local knowledge-based industries above 2015 level	1.3.2.3
	Improve customer satisfaction survey result for business sentiment to exceed the industry average	1.3.2.4
	Increase in the range and availability of retail product / merchandise mix	1.3.2.5
Outcome	**Fremantle is recognized as WA's premier port gateway and Perth's second city**	**1.4**
Objective		1.4.1
	Recognition of Fremantle as Perth's second city by private and government sectors	1.4.1.1
	Investment in Fremantle reflective of its role and confidence in its future	1.4.1.2
Measure of Success		1.4.2
	Increase in the value of state and federal investment in Fremantle	1.4.2.1
	Retention of priority port functions in Westport plan	1.4.2.2

Environmental responsibility

Environmental responsibility **'Develop environmentally sustainable solutions modelled on the principles of the One Planet Fremantle Strategy for the benefit of current and future generations'**		**2**
Outcome	**Embedded consideration of environmental (as well as social and economic) sustainability in decision-making**	**2.1**
Objective		2.1.1
	Embedded consideration of sustainability in Council decision-making	2.1.1.1
	Increase community awareness of and support for environmentally sustainable lifestyle and investment decisions	2.1.1.2
	Stay abreast of technological innovation to maximize benefits of early uptake	2.1.1.3
Measure of success		2.1.2
	Application of sustainability criteria in tender allocation for majority of tendered expenditure	2.1.2.1
	Increased participation in sustainable living courses	2.1.2.2
	Increased priority placed on sustainability in Community Perceptions Survey	2.1.2.3
Outcome	**All City controlled buildings, activities and public places will be more energy and water efficient and energy will increasingly be delivered by renewable technology**	**2.2**
Objective		2.2.1
	Continue carbon neutral status with less reliance on offsets	2.2.1.1
	Promote building energy efficiency and deliver energy with renewable technologies	2.2.1.2
	Manage water usage through minimization and reuse strategies	2.2.1.3
Measure of success		2.2.2
	All buildings, structures (including street lighting and stationary energy sources) and activities within the operational control of the City of Fremantle will be 'net zero carbon' by 2025 with a substantially reduced reliance on off-sets	2.2.2.1
	Implementation of 'fit for purpose' water supply options for the City's green spaces	2.2.2.2
	Measured improvements in water use at City of Fremantle facilities by 2020	2.2.2.3
Outcome	**The City, working with the community, will reduce waste (ultimately to zero) and reuse wherever possible.**	**2.3**
Objective		2.3.1
	Develop and implement a strategic waste management plan to reduce and reuse waste effectively that includes a waste transfer station and a three bin system	2.3.1.1

	Support development of the circular economy	2.3.1.2
Measure of success		2.3.2
	At least 80% of the City of Fremantle residential waste will be recycled or reused by 2020	2.3.2.1
	A waste transfer station will be operational by 2020	2.3.2.2
	A three bin system will be implemented for domestic waste	2.3.2.3
Outcome	**Better quality natural habitat with space for endemic biodiversity**	**2.4**
Objective		2.4.1
	Protect and enhance the city's natural landscapes and biodiversity	2.4.1.1
Measure of success		2.4.2
	Maintain and upscale 1,000 new trees per year program	2.4.2.1
	A 10% increase year on year of native verge gardens	2.4.2.2
	Protect existing significant trees and increase overall tree canopy by 20% by 2020	2.4.2.3
	Management plans prepared for environmentally significant terrestrial areas including our coastal and river foreshores	2.4.2.4

Transport and connectivity

Transport and connectivity: 'Enhance the connectivity between all areas of Fremantle, the city centre and other strategic economic hubs and population centres'		3
Outcome	**Fremantle is recognised as a pedestrian and cycle friendly city**	3.1
Objective		3.1.1
	Support design, investment and programs which enhance walking and cycling in Fremantle	3.1.1.1
	Improve the quality and connectivity of the pedestrian and cycling environments (with a particular focus on activity centres)	3.1.1.2
	Improve way-finding throughout the city	3.1.1.3
	Create shared streets and pedestrian friendly zones in key activity areas in the CBD and local centres	3.1.1.4
	Plan and provide improved 'end of trip' facilities	3.1.1.5
Measure of success		3.1.2
	Improve community satisfaction for footpaths and cycleways to exceed the industry average	3.1.2.1
	Increase in pedestrian counts in CBD and on recreational paths	3.1.2.2
	Achieve a walkability score over 90	3.1.2.3
	Increase mode share for walking and cycling within Fremantle	3.1.2.4
Outcome	**Public and active transport are preferred methods of transport**	3.2
Objective		3.2.1
	Improve public transport options (including the pursuit of high frequency fixed route public transport corridors), facilities and amenities for the efficient movement of people so there is less reliance on private transport and better connections to suburbs and activity centres	3.2.1.1
	Design streets, spaces and places for access by multiple transport modes based on a clear hierarchy	3.2.1.2
Measure of success		3.2.2
	Rezone land to support the development of public transport routes	3.2.2.1
	Develop preferred routes and case for high frequency fixed route public transport corridors	3.2.2.2
	Increase the share of journeys to work undertaken using public transport	3.2.2.3
Outcome	**An economically efficient, environmentally and socially sustainable freight network that supports continued container functions of the port**	3.3
Objective		3.3.1
	Achieve a port and freight network that suits Fremantle and the greater metropolitan area	3.3.1.1
Measure of success		3.3.2

	Advocate for effective and sustainable freight links with the port	3.3.2.1
	Advocate for a sustainable, viable and active port and investment in the right context-responsive infrastructure to support this	3.3.2.2
Outcome	**A city that provides a range of parking options that support community and visitor needs in balance with other land use and transport requirements**	**3.4**
Objective		3.4.1
	Improve parking options on the periphery of the city centre and appropriately focused parking options in the CBD	3.4.1.1
Measure of success		3.4.2
	Improve community satisfaction on parking within the city centre	3.4.2.1
	Majority of off-street parking (excluding on-street bays) on the periphery of the city centre	3.4.2.2

Character, culture & heritage

Character, culture and heritage **Sustain and grow arts and culture and preserve and promote the importance of our social capital, built heritage and history (both pre and post European settlement).**		**4**
Outcome	**Recognise and celebrate aboriginal heritage and culture**	**4.1**
Objective		4.1.1.
	Strengthen sense of place, history and heritage	4.1.1.1
	To be recognised as a city with a holistic understanding of its heritage and an emphasis on reconciliation, interpretation and inclusive design	4.1.1.2
Measure of success		4.1.2
	Develop plan for aboriginal cultural centre	4.1.2.1
	Improve community satisfaction with and awareness of local history and heritage	4.1.2.2
Outcome	**Fremantle celebrates its history and built heritage through active renewal and adaption**	**4.2**
Objective		4.2.1.
	Strengthen sense of place, history and heritage	4.2.1.1
	To be recognised as a city with an emphasis on strong heritage interpretation and design excellence	4.2.1.2
	Facilitate and promote investment in heritage	4.2.1.3
Measure of success		4.2.2
	Achieve state heritage registration for the West End area	4.2.2.1
	Improve community satisfaction with local history and heritage	4.2.2.2
	Strong investment in heritage buildings (BPs), programs and infrastructure	4.2.2.3
Outcome	**Fremantle provides a cultural, economic and physical environment that supports arts and culture**	**4.3**
Objective		4.3.1.
	Attract and retain diverse quality arts organisations and artists	4.3.1.1
	Develop and support curated quality arts events and cultural experiences	4.3.1.2
	Incubate, support and develop a vibrant arts community	4.3.1.3
	Support innovative housing, work and exhibition options for artists	4.3.1.4
Measure of success		4.3.2
	Arts organisations operating in Fremantle report increased support, development and sustainability	4.3.2.1
	Fremantle is recognised as a hub for arts and culture	4.3.2.2
	Increase the number of City of Fremantle curated, external performing arts, visual arts and cultural events	4.3.2.3
	Increase the number of artists and arts organisations successfully	4.3.2.4

	accessing funding from all levels of government	
	Fremantle offers mentoring and a support role for leveraging funding	4.3.2.5
	The economic benefits of arts and culture to Fremantle is measured	4.3.2.6
Outcome	**Fremantle is recognised locally, nationally and internationally for its festivals and street life**	**4.4**
Objective		4.4.1.
	Promote Fremantle as a leading edge destination to attract vibrant festivals and street life	4.4.1.1
Measure of success		4.4.2
	Increase the number of businesses taking an active role in festivals	4.4.2.1
	Increase the number of external festival events held in Fremantle	4.4.2.2
	Increase in visitor and participant numbers	4.4.2.3

Places for people

Places for People 'Create great spaces for people through innovative urban and suburban design'		5
Outcome	**Fremantle provides more diverse and affordable living opportunities**	5.1
Objective		5.1.1
	Increase in diversity of dwellings (including adaptive, accessible and affordable housing)	5.1.1.1
Measure of success		5.1.2
	Provide for and incentivize more adaptive, accessible and affordable housing	5.1.2.1
	Increase the diversity of residential dwellings in the City of Fremantle	5.1.2.1
Outcome	**Fremantle has high quality urban and suburban environments for everyone to enjoy**	5.2
Objective		5.2.1
	Places and spaces (including recreation nodes) are designed using innovative and sustainable approaches to be actively used throughout the day and night by everyone	5.2.1.1
Measure of success		5.2.2
	Invest in ways to deliver high quality public spaces for multiple uses	5.2.2.1
Outcome	**Activate urban spaces through increased numbers of people within Fremantle**	5.3
Objective		5.3.1
	Create interesting and diverse activities to encourage people to stay longer in Fremantle	5.3.1.1
	Improved density in urban centres, transit corridors and redevelopment areas	5.3.1.2
	Redeveloped urban density to be achieved with improvements to green spaces	5.3.1.3
Measure of success		5.3.2
	An increase in the number of programmed events and activities in public spaces	5.3.2.1
	Increase the number of dwellings provided in the city centre	5.3.2.2
	Improved urban / suburban amenity with green spaces	5.3.2.3

Health and happiness

Health and Happiness **'Creating a physical and social environment where it is easy for people to lead safe, happy and healthy lives'**		6
Outcome	**Fremantle is a welcoming, safe and caring place that celebrates and actively supports diversity**	6.1
Objective		6.1.1
	Create an environment where people feel welcome and safe	6.1.1.1
	Create public spaces which encourage people to linger and interact (to facilitate social connectivity)	6.1.1.2
	Improve community inclusiveness and participation	6.2.1.1
Measure of success		6.1.2
	Improve community satisfaction of community safety to exceed the industry average	6.1.2.1
	Reduce the number of anti-social related incidents in CBD	6.1.2.2
	Actively involve and engage with aged, youth, people with a disability, aboriginal people and people from all cultural backgrounds	6.1.2.3
	Conduct accessible events which celebrate diversity.	6.1.2.4
Outcome	**Partner with the community to build capacity for social inclusion and capital**	6.2
Objective		6.2.1
	Improve community inclusiveness and participation	6.2.1.1
	Facilitate a sense of community and meaningful social connection	6.2.1.2
Measure of success		6.2.2
	Increased participation in community life for all	6.2.2.1
	Increased awareness regarding the range of social groups and activities available	6.2.2.2
Outcome	**Environments that promote healthier lifestyles and community enjoyment**	6.3
Objective		6.3.1
	Enhance the health and wellbeing of people who live, work and visit Fremantle	6.3.1.1
	Support formal and informal sporting activities and sustainable clubs	6.3.1.2
Measure of success		6.3.2
	Improve community satisfaction of sporting and recreational facilities provided by the City of Fremantle to exceed industry standard	6.3.2.1
	Parks and open spaces are within walking distance for all residents	6.3.2.2
	There is a diverse range of parks and open spaces provided	6.3.2.3

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	Maintain connectivity and active transport infrastructure	
Outcome	**The City will have walkable access to green spaces for recreation**	6.4
Objective		6.4.1
	Pursue open space strategy which removes gaps in the open space network	6.4.1.1
	Ensure best practice open space design is applied in an integrated way for existing and new public open space	6.4.1.2
Measure of success		6.4.2
	Improve resident and worker access to functional public open space within a walkable catchment by 2020	6.4.2.1

Capability

Capability 'An innovative, responsive, influential local government which leads the way in delivering services and projects through good governance, effective communication, responsible management and excellence in delivery'		7
Outcome	**A transparent and responsive organisation working in partnership with the community**	7.1
Objective		7.1.1
	Provide greater opportunities for the community to participate in decision-making processes	7.1.1.1
	Improve the quality of community engagement	7.1.1.2
	Improve community access to information to ensure people are well informed of council activities	7.1.1.3
	Maintain a high standard of corporate governance	7.1.1.4
	Encourage active civic participation through precinct groups, online engagement tools, events and other means	7.1.1.5
Measures of success		7.1.2
	Community satisfaction survey reports to exceed industry average	7.1.2.1
	Increase the number of interactions and participants by using the 'My Say Freo' online engagement tool and other engagements methods	7.1.2.2
	Active precinct groups in each ward or suburb	7.1.2.3
Outcome	**Effective leadership where people are responsible for outcomes, and are empowered, structured and resourced to act effectively and efficiently within a clear framework**	7.2
Objective		7.2.1
	Effectively communicate and build understanding and support for the City's vision and position on strategic matters and projects both internally and externally	7.2.1.1
	Build understanding and support for the vision	7.2.1.2
	Demonstrate clear connections between the city's its strategic direction and its services and activities	7.2.1.3
	Strengthen the City's organisational capacity and financial resilience	7.3.1.4
	Create an organisational culture of performance, innovation and excellence	7.3.1.5
Measure of success		7.2.2
	Improve community satisfaction survey results to exceed industry average	7.2.2.1
	Aligned Strategic Community Plan and Corporate Business Plan	7.2.2.2
	Improve employee engagement results to exceed the industry benchmark	7.2.2.3
	Implemented appropriate reporting measures for financial	7.2.2.4

	resilience	
Outcome	**An influential and collaborative thought leader in local government**	7.4
Objective		7.4.1
	Improve local, regional, state and national political relationships	7.4.1.1
	Build on Fremantle's reputation as an innovative leader	7.4.1.2
Measure of success		7.4.2
	Increase participation in state and regional forums	7.4.2.1
	Significant and appropriate investment from federal and state government	7.4.2.2
	Operational advocacy agenda	7.4.2..3
Outcome	**A city that maintains its assets and operates in a financially sustainable manner to meet the needs of its community**	7.5
Objective		7.5.1
	Maintain robust long term financial plan	7.5.1.1
	Improve the City's asset management practices	7.5.1.2
	Strengthen the City's financial resilience	7.5.1.3
Measure of success		7.5.2
	Implemented appropriate reporting measures for financial resilience	7.5.2.1
	Implement asset management plan	7.5.2.2
	Meet or exceed financial ratios for each of the nine asset classes	7.5.2.3

Major Strategic Projects

Advocacy

1. *Develop and pursue key advocacy positions in accordance with the advocacy policy.*

Policy & Planning

1. *One Planet Strategy*
2. *Economic Development Strategy*
3. *Westport and planning for the future of Fremantle as a port*
4. *Freo 2029: Transformational Moves including:*
    a. *Station Precinct redevelopment*
    b. *Fremantle Oval Precinct redevelopment*
    c. *Northern Gateway*
    d. *Victoria Quay*
    e. *Fishing Boat Harbour*
    f. *Light rail / priority high frequency fixed route public transport corridors*
5. *Integrated Transport Strategy including:*
    a. *Integrated Road Hierarchy*
    b. *Greater Fremantle Parking Plan*
    c. *Walking and Pedestrian Plan*
6. *Urban renewal projects including:*
    a. *Heart of Beaconsfield*
    b. *Fremantle Oval precinct*
    c. *Leisure Centre precinct*
7. *Leisure and Recreation Plan*

Capital & Delivery

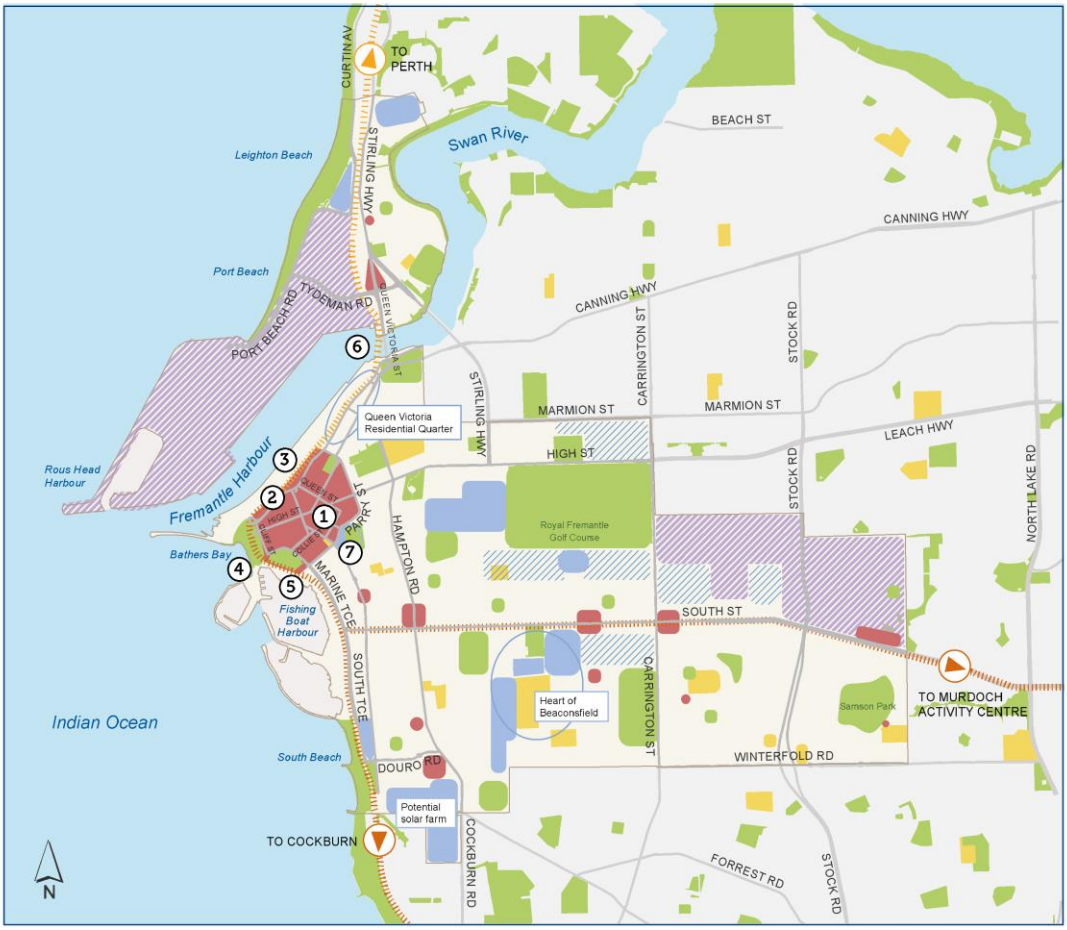
1. *Kings Square Civic Centre Project*
2. *Greening Fremantle Strategy and Urban Forest Plan*
3. *Corporate Energy Plan and Water Conservation Strategy*
4. *Strategic Waste Management Plan*
5. *Asset Renewal*
6. *Destination Marketing*

Subsidiary documents

- Advocacy Policy
- One Planet Strategy
- Fremantle 2029: Transformational Moves
- Economic Development Strategy
- Destination Marketing Plan
- Integrated Transport Strategy
- Bike Plan
- Greening Fremantle Strategy 2020
- Urban Forest Plan
- Corporate Energy Plan
- Water Conservation Strategy

ATTACHMENT 2 – DRAFT STRATEGIC COMMUNITY PLAN COMPANION PLAN

STRATEGIC COMMUNITY PLAN: SPATIAL COMPANION PLAN



Indicative plan only. Refer to detailed and statutory plans for further information.

LEGEND

- Activity centre
- Open space
- Education
- Special precincts and development areas
- Freo Alternative small infill housing precinct (approximate)
- Industry / Employment
- Fremantle–Perth passenger rail (existing)
- Future priority public transport corridor (subject to further investigation)

FREO 2029 PROJECT AREAS

1. Kings Square
2. Fremantle Station Forecourt
3. Victoria Quay
4. Bathers Beach
5. Fishing Boat Harbour
6. Northern Gateway
7. Fremantle Oval

City of Fremantle

FPOL1904-4 ADVERTISING OF THE PROPOSED DIFFERENTIAL RATE FOR THE 2019/2020 FINANCIAL YEAR

ATTACHMENT 1 Objects and Reasons for Differential Rates 2019-2020

OBJECTS AND REASONS FOR DIFFERENTIAL RATES

Published: May 2019
For the: 2019/2020 financial year.

OBJECTS AND REASONS FOR DIFFERENTIAL RATES

The following Objects and Reasons are provided in accordance with Sections 6.33 and 6.36 of the Local Government Act 1995 and the Council's "Notice of Intention to Levy Differential Rates" for the 2019-2020 financial year on various categories of properties within the City. This paper details the Objects and Reasons for those proposals.

Rates are a primary source of revenue for the City of Fremantle and are levied each financial year on all ratepayers in a manner that is deemed to be fair and equitable so as to meet the City's annual budget commitments.

Rates are levied on all rateable properties within the boundaries of the City of Fremantle Municipality in accordance with the Local Government Act 1995. The overall objective of the proposed rates and charges in the 2019-2020 Budget is to provide for the net (i.e. after taking into account all other forms of revenue) funding requirements of the City's services, activities, financing costs and the current and future capital requirements of the City as outlined in the City's Strategic Community, Corporate Business and Long Term Financial Plans.

The rates in the dollar will be applied on the general valuation as supplied by the Valuer General (VG) in respect of gross rental values (GRVs) effective from 1 July 2017 and as amended by any interim valuations received subsequent to that date.

If land is undeveloped, a statutory valuation of three per cent of the unimproved value is applied to residential properties and five per cent for commercial and industrial properties.

Differential Rate Categories

The Local Government Act 1995 states in Section 6.32. Rates and service charges that:

(1) When adopting the annual budget, a local government —
  (a) in order to make up the budget deficiency, is to impose*a general rate on rateable land within its district, which rate may be imposed either —
    (i) uniformly; or
    (ii) differentially;

The City intends to retain the following differential rate categories:

- Residential Improved
- Commercial and Industrial General
- Vacant Commercial and Industrial
- City Centre Commercial
- Nightclubs
- Vacant Residential Land
- Short Stay Accommodation

Section 6.33 of the Local Government Act sets out the basis on which differential general rates may be based:

(1) A local government may impose differential general rates according to any, or a combination, of the following characteristics —
(a) the purpose for which the land is zoned, whether or not under a local planning scheme or improvement scheme in force under the *Planning and Development Act 2005;* or
(b) a purpose for which the land is held or used as determined by the local government; or
(c) whether or not the land is vacant land; or
(d) any other characteristic or combination of characteristics prescribed.

(2) Regulations may —
(a) specify the characteristics under subsection (1) which a local government is to use; or
(b) limit the characteristics under subsection (1) which a local government is permitted to use.

(3) In imposing a differential general rate a local government is not to, without the approval of the Minister, impose a differential general rate which is more than twice the lowest differential general rate imposed by it.

(4) If during a financial year, the characteristics of any land which form the basis for the imposition of a differential general rate have changed, the local government is not to, on account of that change, amend the assessment of rates payable on that land in respect of that financial year but this subsection does not apply in any case where section 6.40(1) (a) applies.

(5) A differential general rate that a local government purported to impose under this Act before the Local Government Amendment Act 2009 section 39(1) (a) came into operation is to be taken to have been as valid as if the amendment made by that paragraph had been made before the purported imposition of that rate.

Minimum Payment
The Local Government Act 1995, Section 6.35, sets out the basis on which Minimum Rates may be levied.

(1) Subject to this section, a local government may impose on any rateable land in its district a minimum payment which is greater than the general rate which would otherwise be payable on that land.

(2) A minimum payment is to be a general minimum but, subject to subsection (3), a lesser minimum may be imposed in respect of any portion of the district.

(3) In applying subsection (2) the local government is to ensure the general minimum is imposed on not less than —
(a) 50% of the total number of separately rated properties in the district; or
(b) 50% of the number of properties in each category referred to in subsection (6), on which a minimum payment is imposed.

(4) A minimum payment is not to be imposed on more than the prescribed percentage of —
(a) the number of separately rated properties in the district; or
(b) the number of properties in each category referred to in subsection (6), unless the general minimum does not exceed the prescribed amount.

(5) If a local government imposes a differential general rate on any land on the basis that the land is vacant land it may, with the approval of the Minister, impose a minimum payment in a manner that does not comply with subsections (2), (3) and (4) for that land.

(6) For the purposes of this section a minimum payment is to be applied separately, in accordance with the principles set forth in subsections (2), (3) and (4) in respect of each of the following categories —

(a) to land rated on gross rental value;
(b) to land rated on unimproved value; and
(c) to each differential rating category where a differential general rate is imposed.

Being cognisant of the City's strategic community, corporate business and long term financial plans, it is proposed** to increase the rate in the dollar and minimum payment on all differential rating categories by an average 1.50% for the 2019-2020 financial year.

The proposed rate in the dollar and minimum payment for each differential rating category are:

Differential Rate Category	Proposed Minimum Payment	Proposed Rate in the Dollar ($)
Residential Improved	$1,340	0.073110
Commercial and Industrial General	$1,340	0.081355
Vacant Commercial and Industrial	$1,340	0.146219
City Centre Commercial	$1,340	0.086031
Nightclubs	$1,340	0.146220
Vacant Residential Land	$1,298	0.117018
Residential Short Stay Accommodation	$1,340	0.081345

(NOTE: The proposed rate in the dollar and minimum payment amounts may be varied by Council when adopting the annual budget.)**

Following are the objects and reasons for each of the differential rates:-

1. Residential Improved

Characteristics
The residential improved differential general rate applies to land valued on a Gross Rental Value basis (GRV) that is used for residential purposes under the Local Planning Scheme No. 4 however may be located in any zone.

Objects and Reasons
The object of this rate is to apply a base differential general rate to land zoned and used for residential purposes and to act as the City's benchmark differential rate by which all other GRV rates properties are assessed. The purpose of which is to ensure that all ratepayers make a reasonable contribution towards the ongoing maintenance and provision of works, services and facilities throughout the City of Fremantle. It is also lower than vacant land as the City endeavours to encourage landowners to develop vacant land.

The proposed rate in the dollar of GRV value for this rate category is 0.073110¢ with a minimum payment amount of $1,340. This will apply to 13578 properties or 83.23% of the City's rateable properties.

2. Commercial and Industrial Differential Rate

Characteristics
The commercial and industrial differential general rate applies to all commercial and industrial properties that are zoned under the Local Planning Scheme No. 4 for commercial and industrial purposes and which are not specifically covered by any other differential rate and is valued on a Gross Rental Value basis (GRV).

Objects and Reasons
The object of this rate is to apply a differential rate to land zoned and used for commercial and industrial purposes to ensure that a reasonable contribution is made towards the higher costs of ongoing maintenance and provision of works, services and facilities located in these zones. These costs include the additional costs associated with economic development initiatives, marketing and transport links.

The proposed rate in the dollar of GRV value for this rate category is 0.081355¢ with a minimum payment amount of $1,340. This will apply to 1742 Properties or 10.68%of the City's rateable properties.

3. Vacant Commercial and Industrial Land Differential Rate

Characteristics
The vacant commercial and industrial land differential general rate applies to vacant land that is zoned under the Local Planning Scheme No. 4 for commercial and industrial purposes.

Under the Valuation of Land Act 1978 (VLA), land for which no active rental market exists is required to be valued on a prescribed percentage of capital value. Landgate Property and Valuation Services prescribe a rate of 5% on vacant commercial and industrial land.

Objects and Reasons
The city considers the development of vacant commercial and industrial rateable land in the best interests of the community therefore has set a differential higher than that which applies to developed commercial and industrial properties

The proposed rate in the dollar of GRV value for this rate category is 0.146219¢ with a minimum payment amount of $1,340. This will apply to 57 Properties or 0.35% of the City's rateable properties.

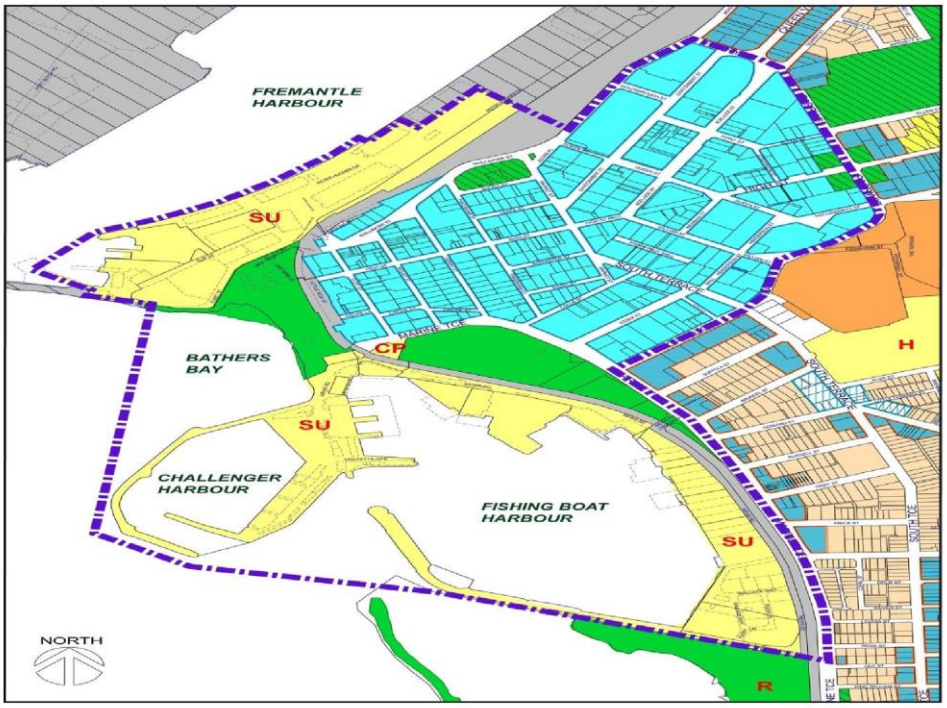
4. City Centre Commercial Differential Rate

Characteristics
The City Centre Commercial differential general rate applies to all properties other than residential located within the boundaries of the City Centre zone and the abutting Metropolitan Regional reserves (refer map below) being areas bounded by Parry Street, Norfolk Street and including those properties located in Fremantle Fishing Boat and Challenger Harbours and on Victoria Quay.

Objects and Reasons
The object of this rate is to apply a differential rate to land zoned and used for commercial purposes to ensure that a reasonable contribution is made towards the higher costs of ongoing maintenance and provision of works, services and facilities located in these zones. The rate in the dollar is higher than that of the Commercial and Industrial differential rate.

Additional funds raised are to be allocated to the City's destination marketing activities in line with the endorsed Destination Marketing Strategic Plan 2018-2022 which aims to support all consumer facing industries in Fremantle including retail, hospitality, tourism and professional services. This includes costs associated with facilitating Fremantle as regional centre.

The proposed rate in the dollar of GRV value for this rate category is 0.086031¢ with a minimum payment amount of $1,340. This will apply to 435 Properties or 2.67% of the City's rateable properties.



5. Nightclubs Differential Rate

Characteristics
The Nightclubs differential general rate applies to any venues that are used for entertainment with or without eating facilities that open from the evening until early morning, having facilities such as a bar and disco or other entertainment and are licensed under the Liquor Control Act 1988. These premises are also subject to the City of Fremantle Late Night Entertainment policy.

Objects and Reasons
Nightclubs that operate outside usual business hours, frequently impact the community and present additional challenges for the City requiring a higher level of resourcing to maintain and remediate surrounding amenities due to anti-social behaviour that often occurs.

The nightclubs differential rate applies to venues that operate beyond 2:00am to recover the increased resourcing costs directly and indirectly linked to the operation of these venues. Resourcing to address noise complaints, vandalism, increased street sweeping and cleaning costs, unsociable behaviour, facilitating safe access to public transport and taxis for all visitors to the city including nightclub patrons and CCTV surveillance.

The proposed rate in the dollar of GRV value for this rate category is 0.146220¢ with a minimum payment amount of $1,340. This will apply to 3 Properties or 0.20% of the City's rateable properties.

6. Vacant Residential Land Differential Rate

Characteristics
The vacant residential land differential general rate applies to vacant land that is zoned under the Local Planning Scheme No. 4 for residential purposes.

Objects and Reasons
The City considers the development of all vacant rateable land to be in the best interests of the community as it will improve increase the vibrancy of the City and neighbourhood centres.

The proposed rate in the dollar of GRV value for this rate category is 0.117018¢ with a minimum payment amount of $1,298. This will apply to 320 Properties or 1.96% of the City's rateable properties.

7. Residential Short Stay Accommodation

Characteristics
The residential short stay accommodation differential general rate applies to to land zoned residential where a purpose for which the land is held or used is to offer home short stay lodging primarily for tourism experiences and includes the following dwellings in accordance with the Short Stay Accommodation Local Law or otherwise approved under LPS 4 for short stay accommodation.

a) One bedroom dwelling used primarily for short stay accommodation

b) Dwellings with two or more bedrooms used for short stay accommodation

Objects and Reasons
The object of this differential general rate is to ensure the owners of residential land wholly or partly used for the commercial purpose of short stay accommodation contribute to the provision of services and facilities that may be associated with such commercial use.

The proposed rate in the dollar of GRV value for this rate category is 0.081345¢ with a minimum payment amount of $1,340. This will apply to 178 Properties or 1.09% of the City's rateable properties.

FPOL1904-7 NORTHBANK FORESHORE STABILISATION PLAN 2018
ATTACHMENT 1 NORTHBANK FORESHORE STABILISATION PLAN 2018

City Of Fremantle

Northbank Foreshore Stabilisation Plan

September 2018

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

Executive summary

The City of Fremantle is undertaking the Northbank Foreshore Stabilisation project to develop and assess concept options, determine issues related to foreshore stabilisation from community and stakeholders, recommend the most appropriate and cost-effective option to minimise future erosion damage, and improve amenity for the section of foreshore between the Fremantle Traffic Bridge abutment and the existing Northbank river-wall.

Historical foreshore reclamation (riverbank realignment) between 1953 and 1965 altered the shape of northern foreshore between the Fremantle Traffic Bridge and the Stirling Highway Bridges. The reclamation reduced the cross sectional area of the river and constrained river flows in an already very narrow area. The impact to the study site is that it is prone to erosion because the river is trying to establish a new cross sectional profile and foreshore alignment, and because the opposite banks of the river are controlled by hard protection. Erosion has resulted from a combination of river, coastal and human induced processes including boat wakes, wind generated waves, storm surges and tidal and river flood currents.

The Northbank residential development by Monteath Properties Pty Ltd was conditionally approved by the Western Australian Planning Commission (WAPC) in May 1995 with the requirement that a Foreshore Management Plan was prepared as part of the development application. The Northbank Foreshore Management Plan (1997) recommended the construction of a hard-edged foreshore to extend from the Fremantle Traffic Bridge abutment across the western portion of the development area. The contractor however went into receivership in 2001 and the foreshore management plan was not fully implemented including the construction of the foreshore edge treatments.

In 2004 the City of Fremantle with financial contributions from the WAPC undertook foreshore landscaping and the construction of the block retaining foreshore wall in front of developed land at that time. The 'Rivershores' apartment building was the last building constructed within the Northbank Development Area which was completed in 2012.

The project site is bound by the existing limestone retaining wall to the east and the Fremantle Traffic Bridge abutment retaining wall to the west. The site is impacted by tidal currents, residual swell waves penetrating through the Fremantle Harbour, wind generated waves, and boat wakes from ferries and other recreational and commercial vessels. The site also has potential acidity and contamination issues which have been reviewed from past documentation, but should be investigated at the detailed design phase or prior to construction to prevent risks to the environment and the public.

Stakeholder consultation was undertaken with Department of Biodiversity Conservation and Attractions (DBCA), Department of Planning Lands and Heritage, Fremantle Port and City of Fremantle and Main Roads WA through a facilitated session and phone and email communication. Opportunities and constraints identified from stakeholder consultation identified opportunities to align the foreshore restoration with the MRWA maintenance of the Fremantle Traffic Bridge Abutment; and opportunities for future foreshore improvements, such as transport linkages, during the future proposed Fremantle Traffic Bridge replication project. DBCA are joint funding partners for this project and opportunities for Riverbank funding may be available for the detailed design and construction phases of the project.

There were two phases of community consultation undertaken for the project. The purpose of the first session was to hear what the local community had to say regarding this area, provide an overview of the project scope (what is in and out of scope) and provide an overview of the development of the project. The second phase of consultation was in the form of a community

information session to assist the community to provide feedback on the concept options through the City of Fremantle's MySay website. The community information session was held on Thursday 31 May 2018 and included a presentation providing details on the concept options and an opportunity for the community to ask questions from GHD, the City and DBCA.

The options identified and developed to concept level were:

- Option 1 – Block wall – Riverward alignment
- Option 2 – Block wall – Landward alignment
- Option 3 – Sand bag wall with rock groynes

Two variations to Option 1 and Option 2 were investigated considering construction with, or without a rock toe for beach stabilisation:

- A – Without rock toe for beach stabilisation
- B – With rock toe for beach stabilisation

In all, five different concept options were investigated.

The two alignments considered for the block walls were:

- Riverward alignment - to minimise excavation and disposal volumes of soil from construction. This alignment requires a net import of fill material.
- Landward alignment - To provide an alignment similar to that proposed in the Building Licences' site plan drawings by Hassel in 2010. This option minimises introduction of fill material on site but requires more excavation and disposal of displaced materials.

There are also a number of features not considered in the concept options such as the presence and location of stairs or access ramps for kayaks and small vessels that can be considered in detailed design stage of the project.

A Multi Criteria Analysis (MCA) was undertaken to assist identifying the preferred foreshore stabilisation option or options. An MCA is a decision-making tool used to assist in the comparison of options. An MCA evaluates the benefits and impacts of options based on the relative importance of several criteria.

The criteria used in foreshore stabilisation MCA are summarised Table 1-1.

Table 1-1 Summary of MCA Criterion

Criterion Groups	Criterion Weighting	Criterion
Community	0.10	Community Preference
Amenity	0.09	Land Area
		Beach Area
		Access to and from water
Environment	0.18	Soil treatment
		Structural Footprint
Feasibility	0.27	Beach Stability
		Design Life
Cost	0.36	Implementation cost (higher)
		Beach Maintenance Cost

The MCA provides a strong indication that Option 1A, a block retaining wall along the riverward alignment is the recommended option to be taken forward to detailed design on both raw sum and weighted sum. This indicates that regardless of the weightings applied, the ranking for this option is not very sensitive to changes in the weightings applied.

Before detailed design is undertaken, it is recommended that detailed investigations into acid sulphate soils and site contaminants is undertaken to provide increased certainty into the cost of implementation for the City of Fremantle and to inform development of the construction management plans in relation to these aspects.

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1. General

1.1 Purpose of this Report

This report was prepared by GHD Ltd Pty (GHD) for the City of Fremantle (CoF) to document the investigation and development of the foreshore stabilisation plan for the area between the Fremantle Traffic Bridge abutment and the existing Northbank river-wall (the project site).

This project is joint funded by the City of Fremantle and the Department of Biodiversity Conservation and Attractions '(DBCA) Rivers and Estuaries Division by Riverbank funding. The steering committee for this project includes both members of the City of Fremantle and DBCA.

1.2 Background

The project site is a section of the Swan River Estuary foreshore, within the City of Fremantle's parks and recreation reserve. The study area extends from the riverwall of the Fremantle Traffic Bridge abutment in the west, to the block retaining riverwall that stops at the boundary between the Rivershores Apartments and "the Brighton" as shown in Figure 1-1. Upstream of the study area is the Northbank Jetty, and downstream is the Fremantle Traffic Bridge and Fremantle Port. This area of foreshore has been maintained by sand replenishment predominantly from the maintenance dredging of the berths at the adjacent Northbank Jetty.

Historical foreshore reclamation (riverbank realignment) between 1953 and 1965 altered the shape of northern foreshore between the Fremantle Traffic Bridge and the Stirling Highway Bridges. The reclamation reduced the cross sectional area of the river and constrained river flows in an already very narrow area. The impact to the study site is that it is prone to erosion because the river is trying to establish a new cross sectional profile and foreshore alignment, and because the opposite banks of the river are controlled by hard protection.

The Northbank residential development by Monteath Properties Pty Ltd was conditionally approved by the Western Australian Planning Commission (WAPC) in May 1995 with the requirement that a Foreshore Management Plan was prepared as part of the development application. The Northbank Foreshore Management Plan (1997) recommended the construction of a hard-edged foreshore to extend from the Fremantle Traffic Bridge abutment across the western portion of the development area. The contractor however went into receivership in 2001 and the foreshore management plan was not fully implemented including the construction of the foreshore edge treatments.

In 2004 the City of Fremantle with financial contributions from the WAPC undertook foreshore landscaping and the construction of the block retaining foreshore wall in front of developed land at that time. The 'Rivershores' apartment building was the last building constructed within the Northbank Development Area which was completed in 2012.

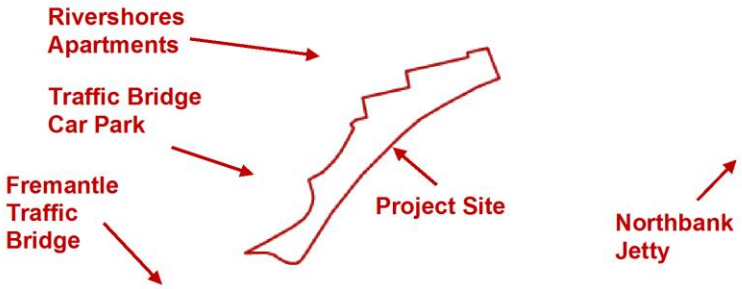


Figure 1-1 Study area and adjacent infrastructure.

The beach of the project site has experienced erosion from river and coastal process as well as stormwater drainage damage as a result of overflow from the Rivershores apartment's infiltration tanks in recent years. The river erosion and inundation are resultant from a combination of boat wake, wind generated waves, storm surges and tidal currents. Storm water damage during large rainfall events has occurred as a result of water overflowing from the 'Rivershores' apartments drainage infiltration cells and resulted in damage to the grassed foreshore and loss of sand from the beach area into the river.

1.3 Purpose of this Project

The City of Fremantle is undertaking the Northbank Foreshore Stabilisation project to develop and assess concept options to stabilise the riverbank of the parks and recreation reserve between the Fremantle Traffic Bridge abutment and the existing Northbank river-wall (the project site). The project will identify issues related to foreshore stabilisation from the community and key stakeholders, undertake an assessment of the concept options recommend the most appropriate and cost-effective options to minimise future erosion damage with the goal to improve amenity of the foreshore within the study site.

1.4 Scope

GHD's scope for this study is to prepare a foreshore stabilisation plan to address current and future threats to both public and private assets adjacent the project site through:

- Stakeholder Consultation
- Site desktop assessment and review to inform the concept design including:
  - Met ocean conditions
  - Morphology of the beach and nearshore areas
  - Presence and likelihood of contamination and Acid Sulfate Soils.
- Identification of opportunities and constraints
- Provision of a suite of potential management actions
  - Concept options (x 5)
  - Advantages and disadvantages of the proposed options
  - Preliminary cost estimates
- Recommendations for preferred treatment

- Identification of the preferred treatment based on economic, social and environmental criteria
- Prioritisation of actions
- Future management of site

The scope of this document is to capture the findings of the:

- Site desktop assessment and review
- Identification of opportunities and constraints
- Management options including concept designs
- Options comparison including details on multi criteria assessment and preferred option

1.5 Disclaimer

This report: has been prepared by GHD for City Of Fremantle and may only be used and relied on by City Of Fremantle for the purpose agreed between GHD and the City Of Fremantle as set out in section 1.4 of this report.

GHD otherwise disclaims responsibility to any person other than City Of Fremantle arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by City Of Fremantle and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Climate change and seal level rise by nature are dynamic and ongoing process. The sea level rise estimates used in the concept design are based on publicly available information and advice provided by the Western Australian Department of Transport in:

- *Bicknell (2010). Sea Level Change in Western Australia: Application to Coastal Planning, prepared by the Department of Transport, Fremantle, WA.*

GHD has prepared preliminary cost estimates for the concept options set out in section 5.10 of this report ("Preliminary Construction Cost Estimate") using information reasonably available to GHD employees who prepared this report and information from cost estimations undertaken by RBB (Northbank Foreshore, Fremantle, Foreshore Restoration Works Cost Plan No. 1, Preliminary Concept Estimate Rev 1 and based on assumptions and judgments made by GHD in regards to required construction materials and quantities.

The Preliminary Construction Cost Estimate has been prepared for the purpose of preliminary understanding of the cost implications and to assist in comparing the options and is to be

considered a comparative costing, not an absolute costing and must not be used for any other purpose.

The Preliminary Construction Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Preliminary Construction Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the [works/project] can or will be undertaken at a cost which is the same or less than the Preliminary Construction Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

2. Site Analysis

2.1 Literature Review

2.1.1 Northbank Foreshore Management Plan (1997)

The 1997 Northbank Foreshore Management Plan (NFMP) produced by a team of firms led by Monteath Properties reviewed the physical, biological, and cultural environment, as well as access to foreshore, recreation, management, and management strategies of the Fremantle Northbank. A concept development plan with budgeting, staging, responsibility delegation also formed part of the Management Plan.

The primary focus of the Concept Plan developed was on the area between the Fremantle Traffic Bridge and the Stirling Highway Traffic Bridge. With regards to the foreshore, the concept plan included staged development of soft edged landscaping, foreshore stabilisation, promenades, boardwalk and town wharf along the foreshore and three jetties, refer to Figure 2-1 and Figure 2-3.

Two types of retaining walls were referenced as appropriate foreshore retaining structures:

- Rock armour walls only to be used underneath boardwalk or wharf structures which are not visible from the land, and
- Limestone block retaining walls.

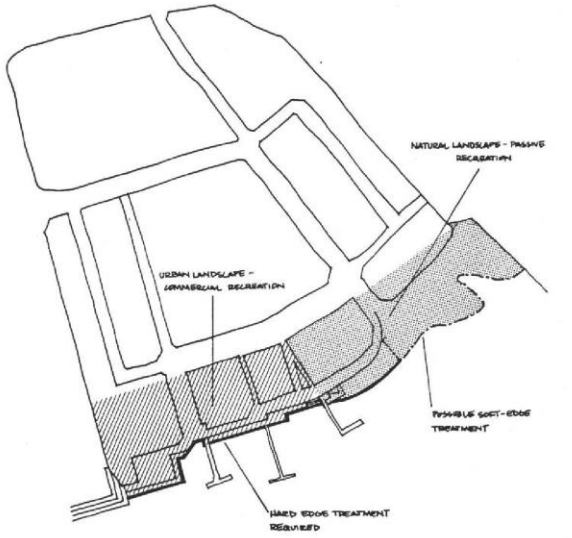


Figure 2-1 Foreshore areas and edge treatments.

Management issues relating to the hydrodynamic conditions of the area from strong tidal and stream flow conditions were identified and an assessment of survey transects of the nearshore area was undertaken. The study identified that while the eastern portion of the site (near Stirling Bridge) was stable over the 6 year survey period between 1989 and 1995, some erosion was experienced in the central portion (up to 0.5 m) and accumulation of material was recorded at the western end of the foreshore, although the source and nature of accumulation was not clear, refer to Figure 2-2.

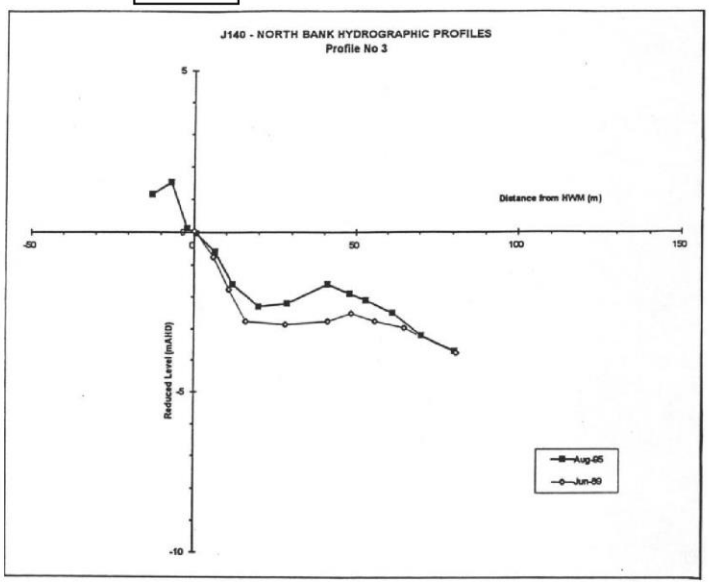


Figure 2-2 Beach profiles in the vicinity of the old slipway, in the vicinity of the project site.

Site ground conditions inferred from historical published data and a geotechnical investigation undertaken by Coffey Partners International Pty Ltd (1995, referenced in Monteath 1997) identified three soil units within the investigation area. These consisted of fill material comprising medium grained sand with traces of shell fragments up to 1.5 m, likely originating from dredge spoil placed during the 1960s. This was underlain by assumed natural material up 0.6 m in thickness (typically 0.3 m) comprising medium grain black sand with some organic fines and organic fibre. Black medium grained sand interfingered with bands of organic fibre, (possibly seaweed) was encountered up to the investigation termination depth of 2.5 m below ground level. It should be noted that GHD was not privy to the Coffey Partners International Pty Ltd (1995) report at the time of this report preparation and therefore the actual site investigation locations (i.e. landward or foreshore) are unknown. Refer to sections 2.5.11 and 2.5.12 for further details on overcoming ASS and contamination data gaps.

The report indicated that the area has previously been zoned as 'Industry', 'Public Purposes' and 'Parks and Recreation', land uses prior to the current residential development land use. Historically the site was utilised as productive farms, market gardens and primarily light industrial activities, including wool scouring, steam laundering, boat repairs and slipway. The former land uses which included the storage of fuels, oils and other chemicals may have resulted in some pollution and contamination. Industrial activities were reported to cease between 1994 and 1996 and remediation measures within identified contaminated areas were reported to subsequently be undertaken between 1995 and 1996.

2.1.2 Northbank Dredging Management Plan (2003)

Bowman Bishaw Gorham prepared a dredging management plan for the Northbank Jetties (No.1) in 2003. The dredge area is approximately 100 m upstream from the project site and may provide some relevance to the project area.

The investigation encountered riverbed sediments consisting of black, medium grained sand to an investigation termination depth (1.5 m) with particle sizes typically less than 75 um. These riverbed sediments were investigated at 30 locations (44 field samples) to inform the dredge management plan and identify potential contaminates of concern. The results indicated all samples were below the Screening Level specified by the Environment Australia: National Ocean Disposal Guidelines for Dredged Material (2002). Additionally, the dredged material was deemed suitable to be used as fill material based on the fact that the 95% Upper Confidence Limits of the mean concentrations of contaminants in the samples were below the Environmental Investigation Guidelines specified in the ANZECC/NHMRC: Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (1992).

It is important to note that emerging contaminants of concern, screening levels and criteria outlined within the Northbank Dredging Management Plan are likely to have been amended since its preparation in 2003.

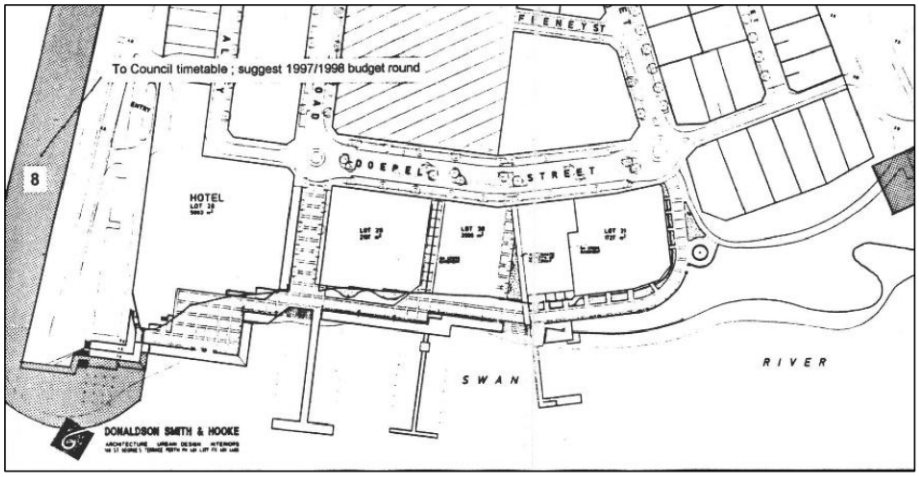


Figure 2-3 Extract from NFMP indicating foreshore treatments and infrastructure completed by stage 8/9 of the Concept Design.

2.1.3 North Fremantle Foreshore Management Plan (2013)

The 2013 Management Plan was prepared by the landscape designer UDLA. The Management Plan reviewed the condition of the North Fremantle Foreshore, and highlighted areas for improvement, such as revegetation, better connectivity between footpaths, replacement of public information signs, etcetera. Of relevance to this project, the following values, recommendations and actions have been identified:

- The importance of areas for passive and active recreation including a swimming beach in front of the Rivershores apartment ,
- Shoreline and edge treatments including hard edge treatments for the study site, refer to Figure 2-5
- The importance of access and connectivity through the area was highlighted with the recommendation to upgrade and maintain the track connecting the Fremantle Railway Bridge carpark to the project site.
- The project site was not identified as requiring management and maintenance of landscapes, however adjacent foreshore areas have been identified as requiring high maintenance due to the manicured formal garden beds and lawn.

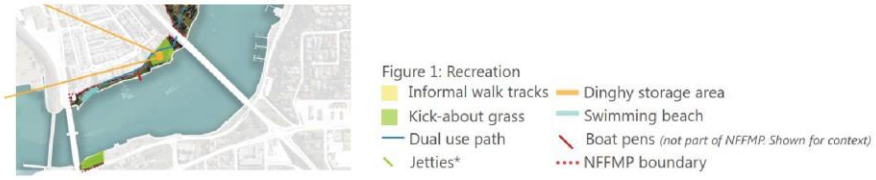


Figure 2-4 Recreation areas.

Figure 2-5 Shoreline and edge treatments.

2.1.4 North Fremantle Foreshore Study (2015)

In 2015 Damara WA and Oceanica Consulting examined the impact of water level rise to a 250 m section of North Fremantle foreshore between Johannah Street and Stirling Highway and developed options for erosion management.

The study comprehensively reviewed the development history of this section of shoreline, traced back as early as European settlement. The study determined a number of key characteristics of the North Fremantle Foreshore using information from site measurements for wave / wind / current.

Based on the assumption of vessels passing the site within 100 m from shore and at a speed of 5 kts, Damara WA and Oceanica Consulting calculated a sequence of 20 passing vessels per hour would generate an estimated boat wake height of 0.40 m and a wake period of 2.5 s. This wake height was inclusive of the recommended 50% increase of wave height for the design of

shore protection structures, as suggested by CIRIA *et al*.: *The Rock Manual (2007)*, and is similar to that of 10-year ARI wind-generated wave (Damara WA and Oceanica Consulting, 2015).

2.2 Historical Imagery Analysis – Shoreline Erosion

To assess foreshore changes at the site including identification of erosion and changes in the shoreline position, analysis of historical aerial imagery provided by City of Fremantle via Landgate's Slip Portal was undertaken. The aerial images range from 1947 to 2016 and capture the study area and adjacent infrastructure. An approximate outline of the shoreline position was obtained for all images (see Figure 2-6) to visually compare the changes in shoreline throughout the years. The base aerial image is from 2016. An enlarged image is included in Appendix A.

Figure 2-6: Shoreline Position (1947 to 2012).

In this assessment of foreshore movement, the vegetation line cannot be traced (as might be undertaken for assessing coastal erosion of a dune line) hence water level was used to indicate shoreline position. In this highly modified environment, it is not possible to calculate erosion rates from natural processes using aerial imagery analysis. Further, human activity has caused many of the changes to the shoreline through planting of lawn, construction of river walls, land reclamation and other activities.

Figure 2-6 shows that the position of the shoreline changed significantly between 1947 and 1965. The land reclamation resulted in a significant modification to the cross section of the river in this region. In response to this change, it is likely that river processes are trying to return to a state of equilibrium and therefore flows are eroding this section of the foreshore as the opposing banks are all hard.

Between 1965 and 2016 there have been no large changes in the shoreline position. However, it is difficult to determine the exact shoreline shape using the water level. This is due to the tidal range and difficulty in tracing the waterline precisely.

2.3 Impacts from Existing Infrastructures

During the site visit, GHD observed minimum infrastructures exists around the project site, except the following:

- A concrete retaining wall in front of the apartments (painted white)
- A rock retaining wall holding the formation of the carpark and the foundation of the Railway Bridge (Main Roads WA asset).

- Further to the east (upstream the Swan River) an engineered scour protection adjacent to the boat pens (refer to Figure 2-8) was constructed in accordance with designs by MP Rogers and Associates in 2015.

Figure 2-7 Panorama view of the project site, with the concrete retaining wall and rock retaining wall indicated.

Figure 2-8 Boat pens and scour protection rock wall east to the project site.

2.3.1 Northbank Jetty

The Northbank Jetty is privately owned and operated by the Northbank Jetties (no. 1) Pty Ltd. The Jetty licence is managed by the Department of Transport and the riverbed lease through the Department of Biodiversity Conservation and Attractions (DBCA) under the *Swan and Canning Rivers Management Act 2006*. The river bed lease area for the jetty is shown in Figure 2-9. A requirement on the lease of the privately owned jetty is to maintain two public berths (closest to the land) including a public foreshore platform for use at all times. In order to maintain access to the public berths dredging maintenance is undertaken by the Jetty operator and the sand disposed of along the beach in the project site.

Construction of a rock scour wall between the boat pens and foreshore retaining wall was undertaken around 2005 and maintenance and upgrades completed in 2015. This has allowed an intertidal sandy terrace to be formed between the block retaining walls and the boat pens. The assumed purpose of the structure is to minimise the impact of maintenance dredging on the retaining wall stability.

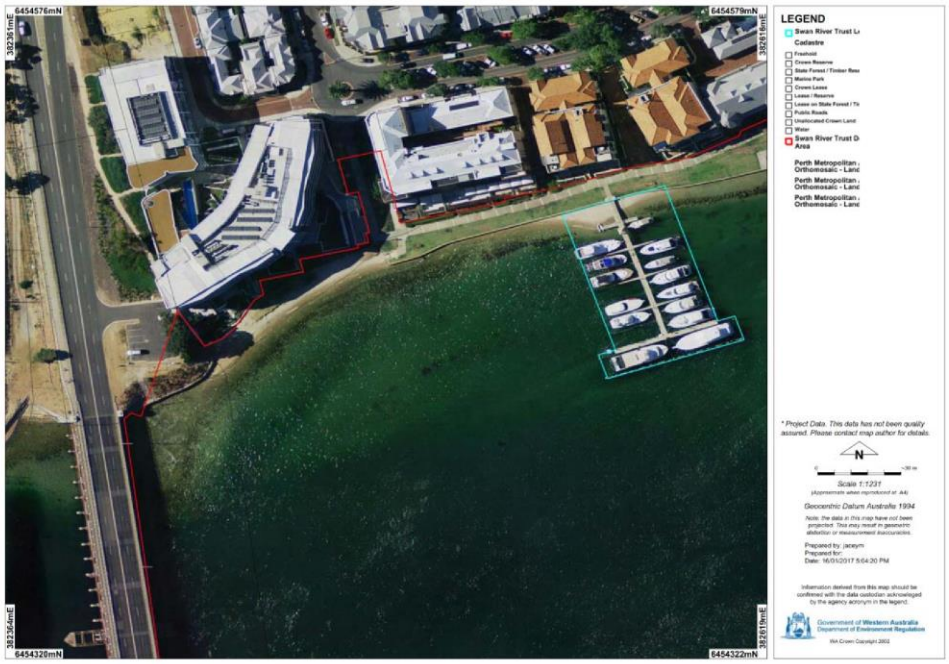


Figure 2-9 Northbank Jetty Lease Area.

2.3.2 Site Access

There are three main access routes to the study area:

- To the east from the adjacent parks and recreation reserve (concrete footpath)
- From the laneway between "the Brighton" and the Rivershores apartments and
- From the Queen Victoria Street carpark at the top of the Fremantle Traffic Bridge abutment.

In the North Fremantle Foreshore Management Plan (2013), the access to the project site from the Queen Victoria Street carpark has been identified as requiring upgrade and maintenance. Aged wooden steps lead down from the carpark, which finish at the top of the bridge abutment

retaining wall. There is no formal path from here to the beach, with the only access via the narrow top of the degraded limestone retaining wall which is no wider than 0.8 m, and stands approximately 1.2 m above ground level, which potentially is a safety risk, refer to Figure 2-10

The only alternative access down from the carpark to the beach of the project site is an informal goat track. This goat track also connects the Queen Victoria Street carpark to the project site, however on a milder gradient and at a safer way, as shown in Figure 2-11

Figure 2-10 Existing concrete step.

Figure 2-11 Exposed foot trail on traffic bridge abutment and carpark embankment.

2.4 Proposed Rivershores Seawall

A review of the Rivershores Design plan drawings, which were 'Issued for Building Licence', identified that the design was inclusive of a ramp and a 'proposed retaining wall as seawall' which was intended to extend across the majority of the site from the middle of the retaining wall to the Rivershores boat storage in the west to the existing staircase and retaining wall at the eastern end of the project site. No further details or design documentation of the retaining wall have been identified.

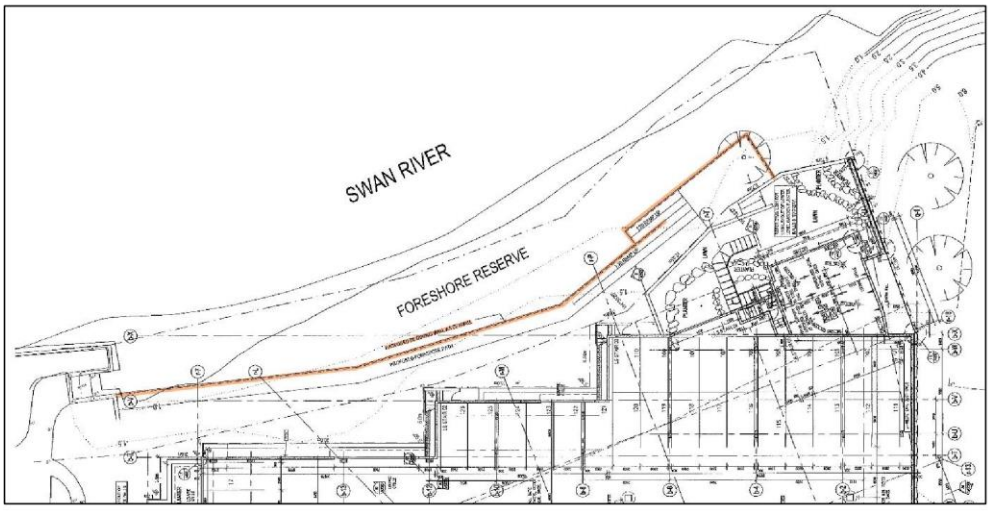


Figure 2-12 Extract from Issued for Building Licence' site plan drawing prepared by Hassel (2010) indicating proposed seawall highlighted in orange.

2.5 Basis of Design

GHD has developed the following basis of design using information from the literature review and public information.

2.5.1 Design life

The typical design life for foreshore stabilisation structures in the river is 25-50 years. Typically concrete or limestone block retaining walls are designed for a 50 year design life, whereas the design life of geotextile sand container structures is limited to the potential design life of the materials, which based on current projects, typically they last up to 25 years.

2.5.2 Bathymetry Feature

Based on the Department of Transport's hydrographic survey data, a shallow subtidal terrace with elevation ranging from -1.8 to +0.8 m Chart Datum (CD) is located in front of the project site. The subtidal terrace extends approximately 45 m from the shoreline in to the river. The bed elevation deepens rapidly once the bathymetry passes the -1.8 m CD contour, reaching -4.0 m CD in only 12 m at the steepest section. The bathymetry further deepens until the centre of the Swan River where the bed elevation is approximately -6.3 m CD.

On a larger scale, the Site is adjacent to the end of the Fremantle Port harbour basin. The basin is constantly maintained at -14.7 m CD and has a water depth of 16.1 m during Highest Astronomical Tide (HAT). The water depth reduces to 7.4 m approximately 11 m at the end of the basin (near the Fremantle Railway Bridge) and marries with the bathymetry feature described above.

The bearing perpendicular to the foreshore at the project site is south-south easterly (150°N).

2.5.3 Beach Morphology

On the 12th of January 2018 GHD undertook a visual inspection of the beach in front of the foreshore. The subtidal terrace described in Section 2.5.2 can be observed from the beach. The beach sediment is medium grained, with pebble to rock sized debris located in the intertidal zone.

The beach face is steeply sloping, resulting in a narrow strip of beach, with an elevation change of about 2 m between the nearshore subtidal terrace and the grassed terrace behind the beach, refer to Figure 2-13.

Figure 2-13 Beach profile looking west towards the Fremantle Traffic Bridge.

2.5.4 Tides

Tidal level in Fremantle is small in amplitude and are diurnal (one high tide and one low tide in 24 hrs), with typical tidal range being 0.3 m (neaps) to 0.5 m (springs). Table 2-1 lists the tidal levels derived from Fremantle Submergence Curve.

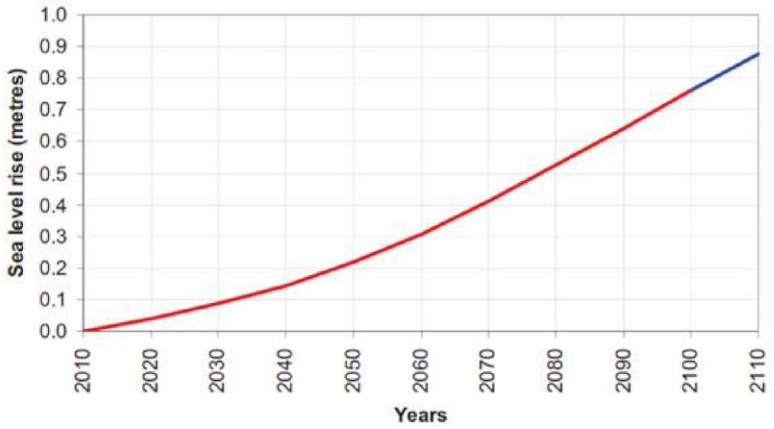
Table 2-1 Tidal levels at Fremantle (DoT 2016)

Tidal Level*	CD (m)	AHD (m)
Highest Astronomical Tide (HAT)	1.40	0.63
Mean Highest High Water (MHHW)	1.15	0.38
Mean Sea Level (MSL)	0.81	0.04
Mean Lowest Low Water (MLLW)	0.47	-0.30
Lowest Astronomical Tide (LAT)	0.26	-0.51
Chart Datum (CD)**	0.00	-0.77

* derived from 1615-13-02 Fremantle Fishing Boat Harbour submergence curve, ** CD is the Fremantle Low Water Mark 1949.

2.5.5 Sea Level Rise

Sea level rise allowance for concept options considers the design life of the construction and is in line with the Department of Transports recommendations on Sea Level Change in Western Australia (DoT 2010), refer to Figure 2-14. For a design life of 25 and 50 years, sea level rise allowances of a 0.15 m and 0.4 m respectively are recommended.



Recommended allowance for sea level rise in coastal planning for WA (red line SRES scenario A1FI 95th percentile after Hunter (2009), normalised to 2010, blue line continuation of scenario to 2010)

Figure 2-14 Sea level change curve for future planning periods (DoT 2010).

2.5.6 Currents

The project site is located just upstream of the mouth of the river at the Fremantle Port. The Swan River in the vicinity of the project site is approximately 200 m wide which is relatively narrow in comparison to other areas of the Swan River Estuary and as a result tidal currents up to 1.0 m/s have been reported (Bowman Bishaw Gorham, 2003). Combined with winter rainfall runoff, ebbing currents can reach up to 1.5 m/s in the central river channel near the project site. The 1997 Foreshore Management Plan (Monteath Pty Ltd.) suggested an estimated peak current flow of 2.0 m/s due to river discharge be considered.

In situ measurement is available at the Fremantle Railway Bridge from 2004 to 2006, for which the current speed recorded is adopted for the development of this foreshore stabilisation plan. The record indicates that most of the current speeds are in the range of 0.0~0.4 m/s for flooding and 0.0~0.6 m/s for ebbing (Damara WA and Oceanica Consulting, 2015).

Table 2-2 Flooding and ebbing speed occurrence (reproduced after Damara 2015)

Flooding		Ebbing	
U_{AVG} (m/s)	Occurrence	U_{AVG} (m/s)	Occurrence
> 0.6	0.01	> 0.8	0.04%
0.5 – 0.6	0.72%	0.7 – 0.8	0.46%
0.4 – 0.5	3.72%	0.6 – 0.7	1.49%
0.3 – 0.4	8.61%	0.5 – 0.6	3.37%
0.2 – 0.3	12.93%	0.4 – 0.5	5.51%
0.1 – 0.2	12.79%	0.3 – 0.4	6.98%
0 – 0.1	13.92%	0.2 – 0.3	8.22%
-	-	0.1 – 0.2	9.54%
-	-	0 – 0.1	11.64%

2.5.7 Extreme Flood Levels and Scour Velocities

The Northbank site location can be considered to be similar to the location for SW2 as reported in URS (2013). Based on this assumption, the extreme flood level for the Northbank site under a 100 year ARI event at present is approximately 1.3 m AHD and approximately 1.1 m AHD under a 10 year ARI event.

Table 2-3 River Flood Levels

	Present (mAHD)	2070*(mAHD)
10 ARI	1.1	1.5
100 ARI	1.3	1.7

- Water levels for 2070 have been assumed to be the inundation level from present plus a 40 cm allowance for sea level rise

In terms of scour velocities, previous reports focused on the area have indicated that both the 10 year ARI events and the 100 year ARI events will both have an approximate near shore current velocity of 0.5 m/s at the Northbank site location (refer Figure 2-15 and Figure 2-16 below).

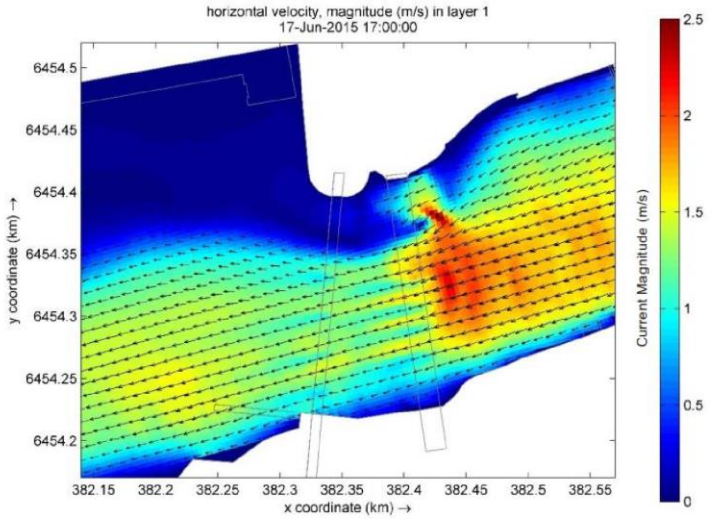


Figure 2-15 Flood Current Velocities - 10 Year ARI Event (MPR, 2017).

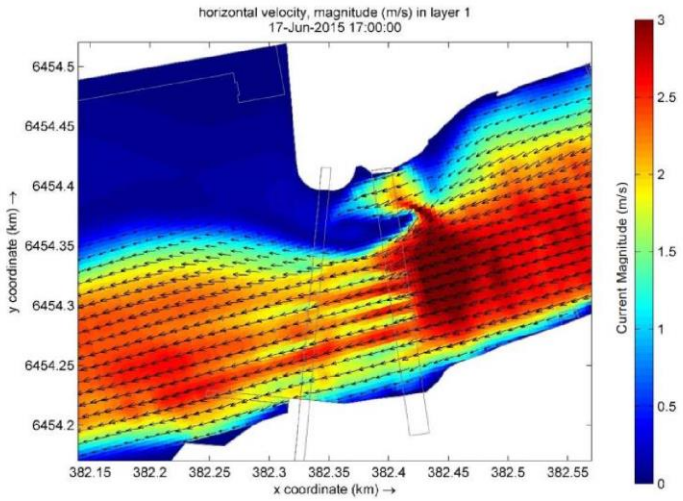


Figure 2-16 Flood Current Velocities - 100 Year ARI Event (MPR, 2017).

2.5.8 Wind

Figure 2-17 shows the wind record derived from the Swanbourne Automatic Weather Station (AWS) (station 9215). The Swanbourne AWS is located north of the project site, and is the closest AWS with recent records. GHD has therefore adopted the record from the Swanbourne AWS for this Project.

The Swanbourne AWS records suggest bi-directional pattern of wind direction, corresponding to the land and sea breeze patterns (Damara WA and Oceanica Consulting, 2015).

A review of the 17 years of the Swanbourne wind recordings at 9am and 3pm indicated that the strongest winds are from the north west to the south west. The prevailing 9am winds are from the east and the prevailing 3pm winds are recorded from the south west (local sea breeze).

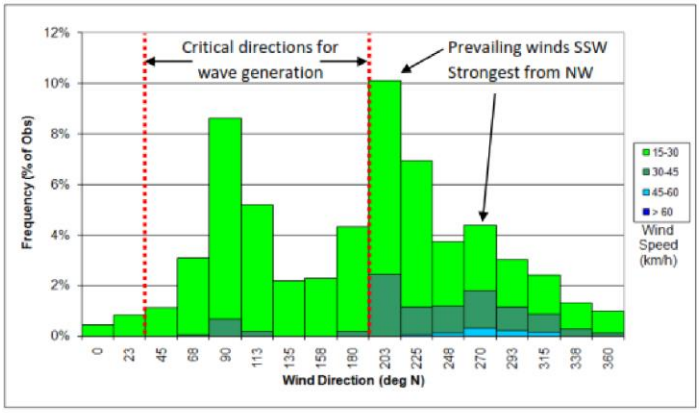


Figure 2-17 Wind distribution at Swanbourne analysed for Prawn Bay (source: Damara 2015)

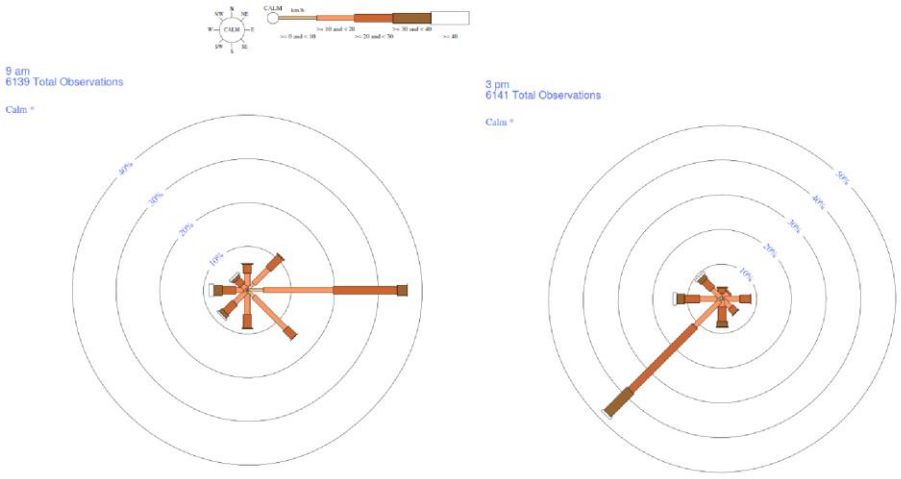


Figure 2-18 Annual Wind Roses at 9am and 3pm for Swanbourne AWS 9215 from September 1993 to Sep 2010 (BOM 2016).

2.5.9 Wave

Due to the limited fetch of the waters surrounding the site, the critical wave action experienced by the Northbank foreshore is driven by boat wake. The most severe of these wakes was reported to be the wake form the Rottnest ferry services that produced a wave height of 0.8 m with a period of 7 s as reported within MPR (2017).

2.5.10 Stormwater Drainage

Stormwater drainage overflows during significant rainfall events from the adjacent 'Rivershores' Apartments has resulted in repeated erosion damage to a section of foreshore shoreward of the infiltration cells on the south eastern corner of the property. The causes of the overflow were investigated by GHD as part of a separate project to assist the City.

GHD visited the site on the 13 February 2018 to review the damage which occurred after a 50 ARI rainfall event on the evening of 9 February 2018, refer to Figure 2-19 Figure 2-20 shows the erosion of grassed foreshore and the formation a small depositional feature on the beach.

Current Status

In July 2008 on behalf of Watersun Properties Pty Ltd, Pritchard Francis Consulting Engineers developed a design for stormwater disposal scheme for the Rivershores apartments. The consultant had designed the system which collected storm water runoff into a storage tank and infiltrated storm water without overflow in events up to and including the 1 in 100 year average recurrence interval, 20 minute duration event. Atlantis cells units were implemented to facilitate disposal of storm water via infiltration.

The issue found was related to higher overflow than designed flow rate (7.5 l/sec) from the pumps and this was rectified in May 2017 by their maintenance unit. Based upon the review of video survey and the observation from the council officers, it was revealed that the storage tank and over flow systems failed to meet the design criteria and damaged the landscaping adjacent to the footpath (including riverbank and grassed areas) and the scour also damaged adjacent to the board walk viewing platform.

At a meeting on 15 August 2017, an option to convey system overflow to the City's drainage system was discussed and it was agreed that Paul Symington of Pritchard Francis would need to evaluate and provide a design solution to Strata Management and the City with the cost for implementation of overflow to the city's drainage system by Strata Management.

This option was considered during the site meeting with the Paul Symington on November 2017 and supported by the City. The City have not received an update or decision on the alternative design option which was presented to the City by Paul Symington of Pritchard Francis since the meeting was held on November 2017.

Figure 2-19 Foreshore erosion after rainfall event on the 9 February 2017.

Figure 2-20 Photo taken on the 10/02/2017 provided by a resident of the Rivershores Apartments.

2.5.11 Acid Sulfate Soil Desktop Assessment

A review of the Acid Sulfate Soil Risk Map, Swan Coastal Plain (DWER-055) which was available through Government of Australia, National Map (2018) portal was undertaken in April 2018. The risk map identifies that the immediate foreshore is located within a designated Class 1 ASS risk area and the remainder of the site is within an area un-classified or Class 3 ASS risk classification area. The risk classifications are described below:

- Class 1: *High to moderate risk of ASS occurring within 3 m of natural soil surface.*
- Class 2: *Moderate to low risk of ASS occurring within 3 m of natural soil surface, but high to moderate risk of ASS beyond 3 m of natural soil surface.*
- Class 3: *Low to nil risk of ASS occurring within 3 m of natural surface that could be disturbed by most land development activities (ASS not known to occur below 3 m).*

The ASS risk map data has been determined from topographical maps, survey and Global Positioning Systems (GPS). The mapped ASS disturbance risk and accuracy has been largely determined by geology unit mapping and Department of Agriculture 1:50 000 Swan Coastal Plain soil-landscape mapping. This is also supported by field soil survey and interpretation of high resolution aerial photography. Boundaries of high risk areas with any other risk categories identified by on-ground mapping are known to be accurate to +/-50 m, whereas accuracy of boundaries between moderate to low and low to nil map units are estimated to be at least +/-100 m. On this basis, care should be taken when interpreting data solely from this data source.

Additionally, historical information (refer to Section 2.1) indicates that dredged spoil from the Swan River was placed on the landward side of the site up to 1.5 m thick, typically around the 1960s. The fill material comprised black, medium grained sand (BBG, 2003) and is considered a potential source of sedimentary sulfides including pyrites, metal complexes and potentially acid volatile sulfides. However, the site walkover presented no evidence of the filling material and the exposed face of the subtidal terrace and the foreshore indicated a fine to coarse grained sand

with carbonate material present such as shells and remnant shell debris as indicated in Figure 2-13.

A review of the concept designs indicate a relatively minor volume of material (maximum 500 m^3) potentially excavated during construction, this will however be dependent on the construction methodology and the finalised design.

The desktop assessment and site walkover indicate a low risk of ASS occurrence at the subtidal terrace and the immediate foreshore area with carbonaceous sands observed at the surface. However, it would be prudent to undertake preliminary site investigation works to confirm the shallow soil surface once a concept design has been finalised. A preliminary investigation may consist of manual excavation at 50 m intervals and limited ASS laboratory analysis, if ground conditions vary from the surface carbonaceous sands.

Potential treatment or disposal options

In the event that ASS is present and anticipated to be disturbed during the construction of the concept options, it is recommended that a simplistic management plan reflective of the volume of excavation is prepared for the site.

Excavated ASS could be treated (neutralised) on-site and reused during backfill or re-instatement operations. Alternatively, ASS may be disposed off-site to landfill processing facility, although this is considered the least sustainable option and likely most expensive outcome.

Treatment rates for ASS is likely to be within the range of $25 to $35 per m^3 for on-site treatment.

2.5.12 Site Contamination Desktop Assessment

Historical photograph review

The historical aerial photographs of the site, retrieved from the Landgate on-line mapping service, were reviewed in order to assess past activities and land uses at the site or within the immediate vicinity of the site. The historical photographs assist in the identification of potential areas of concern, which have the potential to result in soil contamination, such as land filling, demolition of buildings or earthworks.

A summary of visual observations and findings from the review of aerial photography is presented below. The review is only applicable to the foreshore area and immediate vicinity of the site, it is also noted that photographed tidal fluctuations may impede the assessment of the foreshore area.

Table 2-4 Summary of aerial photograph review

Aerial photograph	Comments
12 December 1947	First publically available photograph. The photograph is black and white and of poor quality. The foreshore area appears to be undeveloped and vacant. Queen Victoria Street and the Fremantle Traffic Bridge are evident. Industrial buildings and assumed discharge outlet is evident to the east of the foreshore area.
27 November 1953	No significant changes to the foreshore area appear evident. Further industrial development appears evident surrounding the site.
11 March 1965	The foreshore area appears to have been infilled.

Aerial photograph	Comments
	Railway line appears evident beyond Queen Victoria Street to the west.
6 September 1974 to 29 September 1979	Docking facilities on the river and boat slipway appear evident on the foreshore.
30 August 1981	Further infilling between Queen Victoria Street and the foreshore area appears evident.
14 June 1983 to 6 February 1995	No significant changes to the foreshore area appear evident.
17 March 1999	Pontoon construction appears evident at the foreshore. Stockpiles of material are present at the future Rivershores apartment site.
24 February 2000	Pontoon construction has been removed.
26 January 2001 to 26 January 2006	No significant changes to the foreshore area appear evident. Retaining wall associated with the adjoining apartment building to the east appears to have been constructed in the 2001 aerial image.
21 December 2003	No significant changes to the foreshore area appear evident. The Northbank Jetty appears to be under construction to the east of the foreshore area. Material for the jetty appears to be tracked from the Rivershores apartment building site to the construction area (along the foreshore).
22 February 2004 to 12 December 2004	Northbank Jetty construction is not evident.
16 March 2006	Northbank Jetty appears evident to east of foreshore.
7 May 2006 to 6 July 2008	No significant changes to the foreshore area appear evident.
17 December 2008 to 7 February 2009	A linear structure is located on the Rivershores apartment site.
1 March 2010	Rivershores apartment site has been cleared and is fenced.
2 November 2010 to 23 March 2011	Rivershores apartment building is under construction.
29 August 2011	Rivershores apartment building appears to be complete.
7 April 2012 to 23 November 2017	No significant changes to the site or immediate surrounding area.

Contaminated sites database

A review of the DWER contaminated sites database was undertaken on 6 April 2018, accessed through Government of Australia, National Map (2018). The site was not registered or evident during the review of the database, it is important to note that the database holds information on confirmed contaminated sites only. The site may be awaiting classification or the information is not currently publically available.

Registered contaminated sites including the Fremantle Port is located approximately 165 m west of the site. The Fremantle Port has been classified as remediated for restricted use given previous soil (asbestos and hydrocarbon) and groundwater (hydrocarbon) contamination.

Potential contaminants of concern

Historical evidence and reports indicate that the landward side of the foreshore area was developed and utilised for market gardens and light industrial activities including wool scouring, steam laundering and boat repairs and slipway. Industrial activities ceased between 1994 and 1996 and remediation of the foreshore land was undertaken between 1995 and 1996 (BBG, 2003). Details of the remediation undertaken was not available at the time of writing the Northbank Foreshore Stabilisation Plan, however this information is not expected to be critical to the progression or outcomes of the project if our recommendations below in regards to sampling and Construction Environment Management Plans are followed.

With reference to '*Assessment and management of contaminated sites'* (DER 2014), the following contaminants of potential concern (COPC) are generally associated with the above mentioned historical land uses. The COPC listed below are not considered an exhaustive list and additional contaminants may be identified.

- **Wool scouring:** nutrients, total dissolved solids, oil and grease, detergents, pesticides and bleaching agents.
- **Steam laundering** (dry cleaning establishments): solvents, volatile organic compounds (VOC).
- **Boat repairs and slipway** (boat building and maintenance): metals such as copper, chromium, lead, mercury and zinc and antifouling paints (organotin, tributylin).
- **Market gardens:** metals such as aluminium, arsenic, cadmium, copper, lead, mercury, magnesium and iron, organochlorine and organophosphorous pesticides (OCP and OPP), carbamates, total recoverable hydrocarbons (TRH) and benzene, toluene, ethyl benzene, xylenes and naphthalene (BTEXN).

Asbestos containing materials (ACM) and asbestos products should also be considered.

Historical investigation data

The riverbed and foreshore area applicable to the redevelopment area are not known to have been historically investigated or recorded to have been subject to remediation activities. However, in 2003, a total of 44 field samples were collected from 30 locations in the riverbed sediments for the Northbank Jetty site located approximately 50 m from the redevelopment area (as shown in Figure 2-20). The samples were analysed for total petroleum hydrocarbons and metals to assist in the preparation of a dredging management plan (BBG, 2003).

Figure 2-21 Figure 2 22 Riverbed sediment sampling location (dredged area).

The analytical data and with reference to current human health and ecological criteria for public open spaces (HIL-C, EIL-public open spaces) from '*National Environment Protection (Assessment of Site Contamination) Measure: Schedule B1: Guideline on Investigation Levels for Soil and Groundwater*' (NEPM, 2013) has been reviewed and is presented below.

- Total petroleum hydrocarbons C_9-C_{32} concentrations ranged between <1 mg/kg and 270 mg/kg, however, no current Department of Water and Environment Regulation (DWER) endorsed human health or ecological criteria is available to compare this data.
- Concentrations of arsenic (ranging between <0.5 mg/kg and 5.5 mg/kg), cadmium (<0.1 mg/kg to 1.0 mg/kg), chromium (4.2 mg/kg to 18 mg/kg), lead (<1 mg/kg to 95 mg/kg), mercury (0.02 mg/kg to 0.30 mg/kg) and nickel (<0.5 mg/kg to 3.6 mg/kg) were all reported below the adopted current human health and ecological criteria for public open spaces.
- Copper concentrations, ranging 2.2 mg/kg to 120 mg/kg, were below the human health criteria, however, exceeded the adopted ecological criteria for public open spaces (95 mg/kg) for two out of 44 samples.
- Zinc concentrations, ranging 1.7 mg/kg to 300 mg/kg, were below the human health criteria, however, exceeded the adopted ecological criteria for public open spaces (70 mg/kg) for five out of 44 samples.

It is pertinent to note that sampling and analysis of the river sediments was undertaken within areas of continuous deposition and erosion almost 15 years ago. It is unlikely that the above results reflect the current sediment quality of the dredged area. Additionally, sediment deposition in the Swan River has been recorded up to 1 m over a six-year period (BBG, 2003) further supporting the assumption that sediment quality and composition may vary since the investigation data was obtained.

Recommendations

Disturbance of the ground surface associated with the three concept designs indicate that excavations are likely to be approximately 1 m below ground level and typically within the subtidal terrace. Excavations are estimated to disturb approximately 500 to 1000 m^3 during

construction and to date no sampling and analysis has been undertaken at the redevelopment area.

In light of the above, it is recommended to undertake soil sampling and analysis at the site in locations where there is proposed ground disturbance and spoil will be generated, which is likely to require off-site disposal.

Generic waste disposal classification criteria includes the following parameters. Additional parameters may be required depending on the disposal facility.

- Metals/metalloids including aluminium, arsenic, cadmium, copper, chromium, lead, mercury, magnesium, iron and zinc.
- Cyanide (amenable and total).
- Total Recoverable Hydrocarbons (TRH) and BTEXN.

It is also recommend that an unexpected finds procedure in regards to contamination and asbestos is prepared for the site prior to commencing construction. This should be detailed in the relevant documents including but not unlimited to:

- Construction Environmental Management Plan (or similar).
- Incorporation of an Asbestos Containing Materials (ACM) risk analysis into the construction contractors Health & Safety Plan (Job Safety and Environmental Analysis (JSEA), Safety& Health and Environment Work Method Statement (SHEWMS) or similar).
- If materials suspected of containing asbestos are encountered during the civil and reuse works, it is recommended that appropriate management and confirmatory laboratory analysis (where required) is undertaken. A competent person (as defined in NOHSC 2005) or, an appropriately licenced contractor should be engaged, if the removal involves friable asbestos or volumes of bonded (non-friable) asbestos is in excess of 10 m^2.

Potential disposal options

Disposal options and rates will be dependent on the waste classification assessment. However a guide to waste disposal costs are provided below and will be subject to cartage to an appropriate landfill facility.

Table 2-5 Landfill Disposal Information

Landfill Class	Landfill Disposal (excluding cartage)
Landfill Class I	$120 per tonne (includes state government landfill levy)
Landfill Class III	$154 per tonne (includes state government landfill levy)
Landfill Class IV	$239 per tonne (includes state government landfill levy)

3. Community and Stakeholder Consultation

The process of stakeholder and community engagement is fundamental to any project and formed a key component of this project.

3.1 Overarching Consultation Strategy

A Community Engagement Plan (CEP) was prepared to guide the consultation and engagement throughout the project.

The CEP provided:

- the overarching rationale for why engagement was being undertaken;
- the engagement outcomes for the project;
- a situational assessment to determine the project complexity, impact and sensitivity;
- a list of identified stakeholders and their level of interest, impact and engagement;
- the process for engagement and the associated plan;
- communication and media plans; and
- the indicative timeframe.

For this project, the International Association of Public Participation (IAP2) spectrum (Figure 3-1) is used as a framework to identify, in consultation with City of Fremantle, the appropriate level of participation and engagement with stakeholders and the community throughout the project.

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problems, alternatives and/or solutions.	To obtain public feedback on analysis, alternatives and/or decision.	To work directly with the public throughout the process to ensure that public issues and concerns are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and issues are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advise and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
EXAMPLE TOOLS	• Fact sheets • Websites • Open houses	• Public comment • Focus groups • Surveys • Public meetings	• Workshops • Deliberate polling	• Citizen Advisory committees • Consensus-building • Participatory decision-making	• Citizen juries • Ballots • Delegated decisions

Figure 3-1 IAP2 Spectrum.

Consultation was divided into two phases. Phase one was to establish an understanding of the local issues which may impact on stabilisation options. The second phase was to seek feedback on the stabilisation options.

During the first phase, consultation was undertaken with government agency stakeholders, particularly those who have assets adjacent to the project area or those that could have influence during the decision making process. The stakeholder agency consultation was undertaken in the form of a workshop. The first phase also included a community information session, where community members were able to obtain an overview of the project and provide comments relating to the stabilisation issues in the project area.

The second phase of consultation was in the form of a community information session to assist the community to provide feedback on the concept options through the City of Fremantle's MySay website. The community information session was held on Thursday 31 May 2018 and included a presentation providing details on the concept options and an opportunity for the community to ask questions from GHD, the City and DBCA.

3.2 Stakeholder Consultation

Two stakeholder sessions were held. The first was a facilitated stakeholder session with the Department of Biodiversity and Conservation and Attractions (DBCA) Rivers and Estuaries Division, Department of Planning, Fremantle Port and City of Fremantle held at GHD. The second session was an individual session with Main Roads WA (MRWA) who were unable to attend the first facilitated session.

The purpose of this session was to share intelligence and exchange information on the project area with key stakeholders. It was also designed to allow the project team to understand the future planning for this area and identify any issues and or elements that may impact on the stabilisation options for the area.

3.2.1 Facilitated Stakeholder Session

The key outcomes of this session were:

- A number of assets were identified in the area including public and privately owned/managed.
- The area is predominantly used by the local residents
- The purpose of the area is not clearly defined.
- The space should be accessible to everyone, used for passive recreation, be sympathetic to development and the environment and provide protection for infrastructure.
- The opportunities identified included:
  - Connection to old traffic bridge
  - Safe access
  - Improve amenity
  - Natural enhancement
  - Improved passive uses – benches, visual amenity, shade
  - Increasing accessibility - along and up to bridge
  - Soft-scaping, improved health/enviro values
- The identified negative impacts included:
  - Currently – too private. Close to Port, rail and traffic
  - Community resistance – reducing the private use and enjoyment by surrounding residents

- Increased use pressures on existing facilities (parking)
- Increased access without improved and safe access -may increase likelihood of safety hazards
- Perceptions of safety and crime
- Impact of port activities – complaints
- Renourishment impacting jetty infrastructure
- Costs of maintaining
- Access to maintain (machinery)
- Investment is not consistent with MR/States future plans
- Might be inconsistent with DoT/DBCA Aquatic Use Framework.

DBCA are joint funding partners for this project and opportunities for Riverbank funding may be available for the detailed design and construction phases of the project.

3.2.2 MRWA Stakeholder Session

Separate to the joint stakeholder session (which MRWA was unable to attend), a separate teleconference was arranged with MRWA as well as email communication. The key outcomes of this consultation process were:

- Identification of potential future opportunities to connect the Northbank Foreshore Stabilisation with adjacent foreshore and ground improvement works for the Fremantle Traffic Bridge Duplication Project if or when the project goes ahead. This project is not on the current MRWA works list and is therefore guaranteed not to be delivered within the next 4 years (from May 2017);
- MRWA expressed an interest in working together with CoF to improve this section of foreshore and indicated they would engage DBCA's Rivers and Estuaries division and the City as required for future planning of foreshore works in this area;
- GHD highlighted the condition and degradation of MRWA assets in the area including the staircase and riverwall to the Fremantle Traffic Bridge abutment;

No confirmation of maintenance or repair works schedules was provided, however MRWA confirmed that this section of the river wall would be included as part of the design report and risk assessment for the next stage of works proposed at the Bridge (May 2017).

3.3 Community Consultation

There were two phases of community consultation undertaken for the project. The purpose of the first session was to hear what the local community have to say regarding this area, provide an overview of the project scope (what is in and out of scope) and an overview of the development of the project.

3.3.1 Phase One – Community Consultation

The first phase of consultation was undertaken in the form of a semi-formal community information session. Community members could drop in at any time during the evening session and speak to members of the project team. In addition to this, three short presentations were held throughout the evening providing an overview of the project as well as allowing time for questions and answer. All three presentations covered the same content.

The session was attended by 24 community members and two Council Members. A summary of the key issues raised are outlined below.

Use and preference for future

- Varying preferences for beach and seawall in the area (some residents strongly preferred a seawall whereas one was opposed to solutions that would modify nearshore flows).
- Comments noting the range of activities taking place in the area including swimming, kayaking and fishing.
- Access from Rivershores Kayak/dinghy storage to river.
- Comments regarding swimming ban for this portion of foreshore. It was requested that Council minutes documenting the discussion be provided to GHD for consideration.

Amenity

- Comments relating to rubbish build up, its source and how will it be managed.
- Council and City of Fremantle efforts to address the removal of rubbish

Stability of the area

- Comments regarding evidence of erosion for this portion of foreshore and what it is actually caused by – comments around natural tidal processes vs. boat wake.
- Vessel speed limits and implications of 8 knot limit on boat wake generation.
- Queries regarding what options are available for the foreshore and how they would be evaluated and assessed.
- Issues related to flooding and the "One in 100 year flood" how this would impact the site (including Rivershores) and how the protection may or may not address this.
- Comments relating to the stability of the foreshore being along the whole foreshore and queries why the project is limited to this area.
- Comments relating to what sort of options would be investigated and how they would be evaluated and assessed.
- Comments relating to who is responsible for foreshore stabilisation.
- Comments relating to current flanking erosion being experienced in the vicinity of the stairs at the western end of the existing seawall

Consultation and project program

- Queries regarding the cost of the options and who will be responsible for paying for the works.
- Concerns raised that this project would not progress
- Comments that previous consultation had already been undertaken in this area so why is it being done again.
- Community information session notification.
- Overall project staging was and whether the community was going to be consulted on the options.

Areas adjacent to project area

- Comments relating to the importance of the project taking into consideration the protection of the Rivershores apartment building.
- Safety concerns around the stairs and retaining wall at the Fremantle traffic bridge.

- Potential impacts of the Fremantle traffic bridge realignment (duplication) and potential rail bridge duplication.
- Comments relating to jetty operations from the jetty owner – regarding maintenance of public berths.
- Impacts of the river flow from the bridge abutments
- Current flanking erosion being experienced in the vicinity of the stairs at the western end of the existing seawall.
- Comments relating to the presence of an adequate beach at Sorell Park – "great for wading/dog walking/swimming".
- Comments relating to the heritage value of Fremantle traffic bridge pilings.

Community members were also encouraged to complete a short survey to understand where the attendees were from and seek feedback on the session. The survey was only complete by one attendee.

The opportunity to provide feedback online was also made available for those community members who were unable to attend the information session. Two responses were received. A summary of the verbatim comments is provided below.

Question: Do you have any comments about the Northbank foreshore now?

- *Yes. We need to build a bank like the one in front of the Brighton Building.*
- *Thanks for consulting.*
- *Should be a landscape driven solution and not engineering alone.*
- *Connectivity to Bridge by foot and bike if grade allows.*
- *Lack of P/Toilets in the parks at Nth Freo, could be considered for car park to north west to also allow food truck capability i.e. power/water outlet. Touristic benefits lost in North Fremantle as no loop pedestrian track along rive[r].*
- *SUP launching ramp could be considered into any reversal.*
- *Lighting important.*

Question: Do you have any comments or concerns if this area were to change?

- *No. It needs to change.*
- *No.*

Both respondents had a preference for online information and survey for the next phase of consultation.

Following the session, the City of Fremantle followed up with those attendees of the workshop who requested additional information. This included a community member who requested empirical evidence of erosion.

Overall the information session was considered successful and there were a number of good discussions and feedback received in relation to the area.

3.3.2 Phase Two – Community Consultation

The purpose of the second phase of consultation was to seek feedback on the community's preferences for the different stabilisation concept options and in particular to assess the importance and likely impacts upon beach amenity and land amenity.

A community information session was held for the Community to provide an overview of the concept options developed. The purpose of the information session was to inform the community about the results of desktop investigations and the advantages and disadvantages of the concept options developed to assist them to provide feedback to the City of Fremantle on their preferences for the stabilisation of the parks and recreation reserve of the study area.

The information session was held at the North Fremantle Community Hall on Thursday 31 May 2018. The session commenced at 5.30pm and concluded at 7.30pm. A 20 minute presentation was given and at the completion of the presentation there was time for the community to ask questions and the City, GHD and DBCA to respond. In general the comments were focussed on individual implications of specific options and current uses and less focussed on general public uses and what would be best for the greater community. The perception from the community was that cost should not be a factor or concern when implementing a solution here. The City, GHD and DBCA provided answer to questions where required but a large number of members raised comments and voiced opinions instead of asking direct questions.

The MySay Fremantle survey was open from the Friday the 18th May to the 6th of June.

In total 76 submissions were received and the results indicated that:

- The key priorities by the community are having a sandy beach and having a visually pleasing area.
- Interestingly easy access between the land and water was not highlighted as a key importance which strongly contrasts some of the opinions stated at the information session.
- Weighting of the key criteria by the community indicate that amenity and beach stability are most important. Environment and cost are the least important, with land stability being considered in the middle.
- By far the most preferred option was Option 3 with 67% of people identifying this as a preferred option followed by Option 1A with 18% of people identifying this as a preferred option (respondents were allowed to select up to two responses).
- Key community concerns from comments highlighted importance of an area for launching and landing of kayaks and the current impacts of sediment transport on the operability of adjacent jetty public berths and how specific options may assist to increase operability.

A more detailed summary of the Consultation Activities and Outcomes for Phase 1 and Phase 2 can be found in Appendix B.

4. Opportunities and Constraints

This section of the report provides context for the opportunities and constraints of developing concept options at the site. Before undertaking the concept design phase, any additional constraints and opportunities will be identified through a community and stakeholder engagement and updated at the completion of the initial stages.

4.1 Physical Opportunities

Based on outcome of the site visit and literature review, GHD has identified the following physical opportunities of the project site:

- The project site is sheltered from the incident SWS wind wave by the Fremantle Railway Bridge abutment
- The foreshore stabilisation measure may be tied-in with the bridge abutment to form a continuous stretch of protection work
- Minimum public facilities in the vicinity of the project site, reducing the potential interfacing issue with other agency
- The width of the beach at the project site is narrow, however it is considered adequate to incorporate foreshore stabilisation modifications

4.2 Physical Constraints

In addition to opportunities, GHD has identified the following physical constraints of the project site:

- Adjacent to important infrastructure:
  - Fremantle traffic bridge duplication;
  - Fremantle traffic bridge abutment riverwall;
  - Riverwall and stair case at eastern end of site; and
  - Northbank No 1 Jetty – including consideration of access for machinery to undertake maintenance dredging via the foreshore.
- Overland drainage from the Rivershores Apartment's urban stormwater drainage system, which has resulted in the scour of the beach during intense rainfall events and could compromise the stability of foreshore stabilisation measures implemented if they remain unresolved. Rivershores Apartments are required to resolve their stormwater drainage issues and so the drainage issue should not present as a physical constraint to the next stage of the project.
- ASS and soil contamination may impact the cost for treatment/disposal of excavated materials during construction. An investigation into the presence and levels of ASS and contamination at the site is recommended during the detailed design stage.

4.3 Opportunities/Constraints from Stakeholder Consultation

- Opportunities to align the foreshore restoration with the MRWA maintenance of the Fremantle Traffic Bridge Abutment; and
- Opportunities for future foreshore improvements, such as linkages, during the future proposed Fremantle Traffic Bridge replication project.

5. Development of Concept Options

This section details the development of five concept options for the Northbank foreshore study area. The options investigated were selected based on advice and discussions between GHD, DBCA and the City of Fremantle. The options identified and developed to concept level were:

- Option 1 – Block wall – Riverward alignment
- Option 2 – Block wall – Landward alignment
- Option 3 – Sand bag wall with rock groynes

Two variations to Option 1 and Option 2 were investigated considering construction with, or without a rock toe for beach stabilisation:

- A – Without rock toe for beach stabilisation
- B – With rock toe for beach stabilisation

In all, five different concept options were investigated.

The two alignments considered for the block walls were:

- Riverward alignment - to minimise excavation and disposal volumes of soil from construction. This alignment requires a net import of fill material.
- Landward alignment - To provide an alignment similar to that proposed in the Building Licences' site plan drawings by Hassel in 2010. This option minimises introduction of fill material on site but requires more excavation and disposal of displaced materials.

- There are also a number of features not considered in the concept options such as the presence and location of stairs or access ramps for kayaks and small vessels that will be considered in detailed design stage of the project.

5.1 Objectives

The City of Fremantle and DBCA's key objectives for the foreshore stabilisation options are

- Reduce the risks of erosion and inundation to public infrastructure through stabilisation of the shoreline and adjacent public land.
- Improvement in site amenity through the provision of a healthy and well maintained foreshore area.

5.2 General Considerations

The following general considerations are relevant to all concept options presented below:

- The height of all of the structures was limited to +1.50 m AHD to tie into the existing river wall structure immediately east of the Northbank location as the purpose of the foreshore stabilisation options are to stabilise the foreshore and not to prevent inundation of assets behind the structure;
- Whilst stepped geotextile sand containers are able to be utilised by users as a pedestrian beach access between levels, blockwork retaining wall structures typically have a shear vertical face and an allowance will need to be made to facilitate continual beach access/egress between the levels; and
- GHD understands the potential for ASS and contamination of soil are present and that it may be more cost effective to construct any retaining wall structure closer to the water to reduce the amount of excavation and disturbance required of the existing foreshore.

- Two alignments of the riverwall have been considered in the assessment. One that minimises soil disturbance, but requires a net import of soil material to the site. The second alignment has a higher volume of soil disturbed, but it minimises the need to import fill material. Each alignment has different pros and cons considering the uncertainty around soil conditions.

5.3 Artists Perspectives

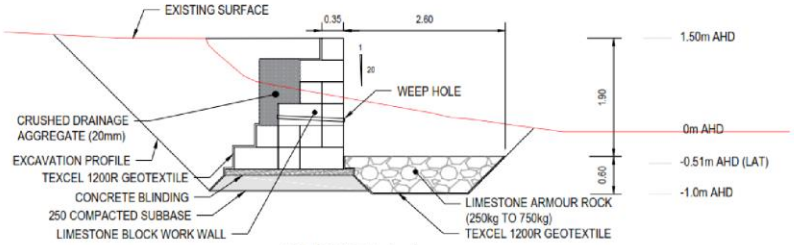
Artists perspectives of each of the concept options have been prepared to assist the community and decision makers to consider what the foreshore may look like after an option has been implemented. These perspectives are the artists interpretation of the engineering concept designs and do not reflect how the foreshore would necessarily look after implementation as there are likely to be revisions to the designs and components between now (the concept design phase) and preparation of issued for construction drawings during the detailed design phase. Artist's perspectives for each of the options are included in Appendix C along with concept options sketches.

5.4 Block Retaining Wall Construction Types

Two types of block wall construction were considered in the investigation including a limestone blockwork wall and a coloured concrete block and geogrid retaining wall. Details on each of the construction types is provided below in sections 5.4.1 and 5.4.2. The appearance of the both types of construction will be very similar once constructed and both options are expected to perform in a similar manner with regards to their durability and effect on coastal processes. There are pros and cons to both construction types as summarised in Table 5-1

5.4.1 Limestone Blockwork Retaining Wall

A limestone blockwork retaining wall us a mass retaining wall structure involves the use of a traditional mass limestone blockwork retaining wall to be installed along the toe line of the existing grassed area. The retaining wall would require a compacted foundation and concrete blinding layer to ensure that the wall is well seated and that any settlement of the structure is minimised. The seaward toe of the structure includes a limestone armour rock apron to prevent erosion at the toe of the wall from wave and current induced scour. A typical cross section of a limestone blockwork retaining wall is shown in Figure 5-1



SECTION A-A
OPTION 1A - LIMESTONE BLOCKWORK WALL

Figure 5-1 Typical Limestone Blockwork Wall Cross Section.

5.4.2 Concrete Block and Geogrid Retaining Wall

A concrete block and geogrid retaining wall involves the use of modular concrete blocks to form a retaining wall structure and relies on geogrid ties to anchor the wall in place as opposed to a mass limestone block wall. The geogrid is tied back into the soil landward of the wall during

construction to provide the horizontal load capacity for the wall to retain soil and any surcharges applied. Similarly to the limestone blockwork retaining wall, the geogrid wall would also require a limestone rock armour apron to prevent erosion at the toe of the wall from wave and current induced scour.

The required length and number of geogrid anchors would need to be addressed during detailed design to ensure the wall is appropriately supported from horizontal earth and surcharge pressures. This consideration would affect the exact excavation profiles required. The length of these ties has been assumed to be 3.3 m.

A typical cross section of a concrete block and geogrid retaining wall is shown in Figure 5-2

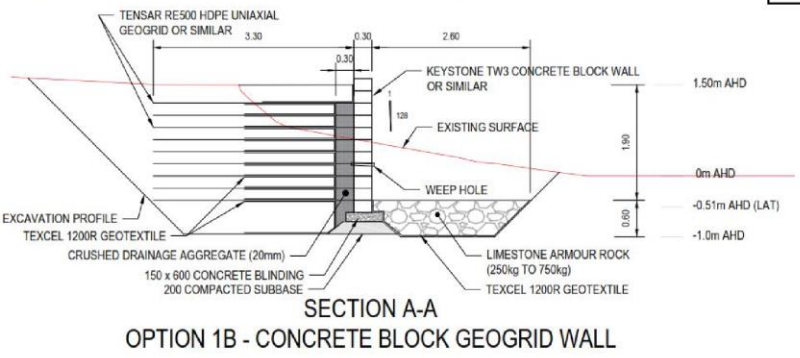


Figure 5-2 Typical Geogrid Concrete Block Wall Cross Section.

5.4.3 Comparison of Block Retaining Wall Construction Types

Table 5-1 provides a summary of the pros and cons of the two types of block wall construction but does not consider the absolute differences of a particular wall alignment. The feasibility of implementing the different types of block retaining walls is dependent on specific site factors that will be determined in the detailed design investigation phase.

Table 5-1 Comparison of Block wall construction types.

	Limestone Blockwork Retaining Wall	Concrete Block and Geogrid Retaining Wall
Aesthetic Impact	The aesthetic appearance of the limestone block work wall will match the existing limestone wall to the east of the site.	Blockwork for this type is concrete and the blocks are slightly smaller than the limestone blocks. Colouring of the concrete should enable the appearance to be similar to adjacent limestone wall.
Constructability	Requires larger machinery and access may be restrictive at this site. Inclusion of services landside of retaining wall is easier.	Smaller concrete blocks are easier to construct with, little to no lifting machinery required Inclusion of services landside of retaining wall is more difficult.
Dewatering	Required to enable construction of the foundations in the initial stages of the works.	Required to enable construction of foundations in the initial stages, plus is likely to be required to enable compaction of soil between lower geogrid layers.
Excavation	Requires less excavation	Requires more excavation
Design Life	50 years	50 years

	Limestone Blockwork Retaining Wall	Concrete Block and Geogrid Retaining Wall
Surplus material	More surplus material	Less surplus material
Environment	Planting behind limestone wall to soften appearance of concrete blocks and to reduce area of grass.	Planting behind concrete blocks will be limited to grasses and very shallow rooted plants as the geo-grid and geotextile layers and compacted soils will inhibit root growth.
Scour Protection	The seaward toe of the structure includes a limestone armour rock apron to prevent erosion at the toe of the wall from wave and current induced scour.	The seaward toe of the structure includes a limestone armour rock apron to prevent erosion at the toe of the wall from wave and current induced scour.
Costs	The costs for implementing limestone block work vs concrete block and geogrid retaining walls is similar. Concept level cost estimates undertaken by RBB indicate that the difference in pricing between the options is within the order of accuracy of the pricing.	

5.5 Option 1A – Block Wall – River Alignment

Option 1A is a block retaining river wall. The key features of this option are that it provides increased land area for land based amenity, a durable solution with a 50 year design life and its appearance will match the adjacent limestone block retaining wall, see Figure 5-3 for the artist's perspective and Figure 5-4 for the engineering plan sketch.

The retaining wall in this option provides a clear separation between the landside and water is closer to the water's edge, retaining more land and also minimising the amount of soil disturbed in the foreshore area during construction. Table 5-2 provides a comparison of this option against key criteria.

Figure 5-3 Artist perspective of Option 1A.

Figure 5-4 Option 1A - Plan View.

Table 5-2 Option 1A – Advantages and Disadvantages

Criterion		Advantages	Disadvantages
Amenity	Beach/ land Amenity	Provides the greatest area for land based amenity (Approximately 500 m^2).	Provides no guarantee of beach amenity. A small beach may be present at low tide levels. (Approximately 0 m^2)
	Access		Ease of access from the land to water is restricted.
Environment	Excavation & Surplus Quantity	This option has the least disturbance of soils. This option also has the least generation of surplus excavation materials (approximately 0 m^3) which will reduce costs but also does not provide as great an opportunity to undertake remediation of soils compared with other options.	
	Structural Footprint	Once constructed this option has the least surface area of exposed built structure compared to the other options. (28 m^2)	
	River Processes	This option will have minimal interruption to alongshore sediment transport and flood conveyance.	
Feasibility	Beach Stability	This option does not provide for a beach area.	
	Design Life	50 years	
Cost	Implementation Cost Estimate	$530,000 to $600,000 dependent upon levels of ASS and contamination identified. Please refer to section 5.10 for full details of costing assumptions.	
	Operation/ Maintenance Cost Estimate	$0. Please refer to section 5.11 for full details of costing assumptions.	

5.6 Option 1B – Block Wall – River Alignment – With Beach Scour Protection

Option 1B is a block retaining wall the same as Option 1A, but this option includes sand nourishment to maintain a beach area and a rock toe to minimise erosion or scour of the beach area. The key features, similar to Option 1A are that it provides increased land area for land based amenity, a durable solution with a 50 year design life and its appearance will match the adjacent limestone block retaining wall plus it provides the added benefit of increased beach amenity from the stability provided by the rock toe. See Figure 5-5 for the artist's perspective and Figure 5-6 for the engineering plan sketch.

The retaining wall in this option provides a clear separation between the landside and water is closer to the water's edge, retaining more land and also minimising the amount of soil disturbed in the foreshore area during construction. Table 5-3 provides a comparison of this option against key criteria.

Figure 5-5 Artist perspective of Option 1B.

Figure 5-6 Option 1B - Plan View.

Table 5-3 Option 1B – Advantages and Disadvantages

Criterion		Advantages	Disadvantages
Amenity	Beach/ land Amenity	Provides the greatest area for land based amenity (Approximately 500 m^2). A moderate area of beach (Approximately 300 m^2).	
	Access		Ease of access from the land to water is restricted. Scour protection may inhibit access to the water.
Environment	Excavation & Surplus Quantity	This option has the least disturbance of soils compared to other options. This option also has a moderate generation of surplus excavation materials (Approximately 640 m^2) which will provide an opportunity to undertake some remediation of soils in the foreshore.	
	Structural Footprint	Once constructed this option has a lesser surface area of exposed built structure compared to the other options. (330 m^2)	
	River Processes	This option will have a moderate interruption to alongshore sediment transport and flood conveyance due to the presence of the rock toe.	
Feasibility	Beach Stability	This option provides increased beach stability.	
	Design Life	50 years	
Cost	Estimate Implementation Costs		$850,000 to $1,200,000 dependent upon levels of ASS and contamination identified. Please refer to section 5.10 for full details of costing assumptions.
	Operation/ Maintenance Cost Estimate		$200,000. Please refer to section 5.11 for full details of costing assumptions.

5.7 Option 2A – Block Wall – Land Alignment

Option 2A is a block retaining river wall, similar to Option 1A, but the alignment of the wall is closer towards the land and matches closely to the proposed alignment as per Hassel's 'Issued for Building Licence' drawings. The key features of this option are that it provides a balanced between land and beach based amenity, is a durable solution with a 50 year design life and its appearance will match the adjacent limestone block retaining wall. See Figure 5-7 for the artist's perspective and Figure 5-8 for the engineering plan sketch.

The retaining wall in this option provides a clear separation between the landside and water is closer to the land. The excavation required to implement this option will be greater than Option 1A because the wall is closer to more elevated land. This will result in increased soil disturbance and higher surplus soil volumes in the foreshore area during construction. Table 5-4 provides a comparison of this option against key criteria.

Figure 5-7 Artist perspective of Option 2A.

Figure 5-8 Option 2A - Plan View.

Table 5-4 Option 2A – Advantages and Disadvantages

Criterion		Advantages	Disadvantages
Amenity	Beach/ land Amenity	Provides a moderate area for land based amenity (Approximately 300 m^2).	A lower area of beach. (Approximately 200 m^2)
	Access		Ease of access from the land to water is restricted.
Environment	Excavation & Surplus Quantity	This option has a moderate disturbance of soils than other options. This option also has the least generation of surplus excavation materials (approximately 370 m^2) which will reduce costs but also does not provide as great an opportunity to undertake remediation of soils compared with other options.	
	Structural Footprint	Once constructed this option has the least surface area of exposed built structure compared to the other options. (25 m^2)	
	River Processes	This option will have minimal interruption to alongshore sediment transport and flood conveyance.	
Feasibility	Beach Stability	This option has the lowest beach stability.	
	Design Life	50 years	
Cost	Estimate Implementation Costs	$550,000 to $750,000 dependent upon levels of ASS and contamination identified. Please refer to section 5.10 for full details of costing assumptions.	
	Operation/ Maintenance Cost Estimate		$200,000. Please refer to section 5.11 for full details of costing assumptions.

5.8 Option 2B – Block Wall – Land Alignment – With Beach Scour Protection

Option 2B is a block retaining wall the same as Option 2A, but this option includes a rock toe to minimise erosion or scour of the beach area. The key features, similar to Option 2A are that it provides a balance between land and beach based amenity, is a durable solution with a 50 year design life and its appearance will match the adjacent limestone block retaining wall plus it provides the added benefit of increased beach amenity from the stability provided by the rock toe. See Figure 5-9 for the artist's perspective and Figure 5-10 for the engineering plan sketch.

The retaining wall in this option provides a clear separation between the landside and water is closer to the land. The excavation required to implement this option will be greater than Option 1B because the wall is closer to more elevated land. This will result in increased soil disturbance and higher surplus soil volumes in the foreshore area during construction. Table 5-5 provides a comparison of this option against key criteria.

Figure 5-9 Artist perspective of Option 2B.

Figure 5-10 Option 2B - Plan View.

Table 5-5 Option 2B – Advantages and Disadvantages

Criterion		Advantages	Disadvantages
Amenity	Beach/ land Amenity	Provides a moderate area for land based amenity (Approximately 300 m^2).	The highest area of beach. (Approximately 545 m^2)
	Access		Ease of access from the land to water is restricted. Scour protection may inhibit access to the water.
Environment	Excavation & Surplus Quantity	This option has the greatest disturbance of soils compared to other options. This option also has a higher generation of surplus excavation materials (Approximately 1000 m^2) which will provide an opportunity to undertake some remediation of soils in the foreshore.	
	Structural Footprint	Once constructed this option has a lesser surface area of exposed built structure compared to the other options. (330 m^2)	
	River Processes	This option will have a moderate interruption to alongshore sediment transport and flood conveyance due to the presence of the rock toe.	
Feasibility	Beach Stability	This option provides increased beach stability.	
	Design Life	50 years	
Cost	Estimate Implementation Costs		$850,000 to $1,400,000 dependent upon levels of ASS and contamination identified. Please refer to section 5.10 for full details of costing assumptions.
	Operation/ Maintenance Cost Estimate	$100,000. Please refer to section 5.11 for full details of costing assumptions.	

5.9 Option 3 – Groynes & Geotextile Sand Container Wall

Option 3 involves the use of a Geotextile Sand Container (GSC) wall in conjunction with three (3) limestone rock groynes (one located at each end of the beach and the third located centrally within the existing beach). GSCs are large engineered sandbags, designed to act as building blocks made of a synthetic non-woven, vandal deterrent fabric.

Considering the potential for overtopping and scour behind the GSC wall during storm surge events, a two container-wide wall (in cross section) was proposed. The two container-wide system is more robust than a single container wide system and has the benefits of mitigating the risk of wall failure and reducing the maintenance requirements of the GSC structure.

Detailed design of this option would need to consider the longshore sediment transport processes in this area to determine the coastal effects the three groynes in terms of sediment trapping and the potential to cause downdrift erosion.

Variations of this option that could be considered include the use of alternate materials such as GSC groynes instead of rock groynes or a rock revetment instead of the GSC wall. The main differentiating factor is that rock has a longer design life than GSCs, while GSCs may be easier to remove and are generally considered to have better amenity. There are also construction cost efficiencies for the use of only one material type, removing the need for two types of equipment to install the two materials. The cost estimate and pros and cons table below applies to rock groynes with a GSC wall.

The key features of Option 3 are that it provides a balance between land and beach based amenity, it provides improved beach stability and it provides better access from the land to the beach and water than the other options, but along shore access and sediment transport will be interrupted by the rock groynes. Construction of rock groynes and a GSC wall will likely require larger plant than the block retaining wall options. The excavation required to implement this option will be greater than all of the other options, but this also provides a remediation benefit. Table 5-6 provides a comparison of this option against key criteria.

The finished appearance will not tie into the adjacent foreshore treatments as effectively as the other options. GSCs also have the potential to become discoloured with marine growth, but this is not represented in the artist's perspectives. See Figure 5-11 for the artist's perspective and Figure 5-12, Figure 5-13 and Figure 5-14 for the engineering plan and section sketches.

Figure 5-11 Artist perspective of Option 3.

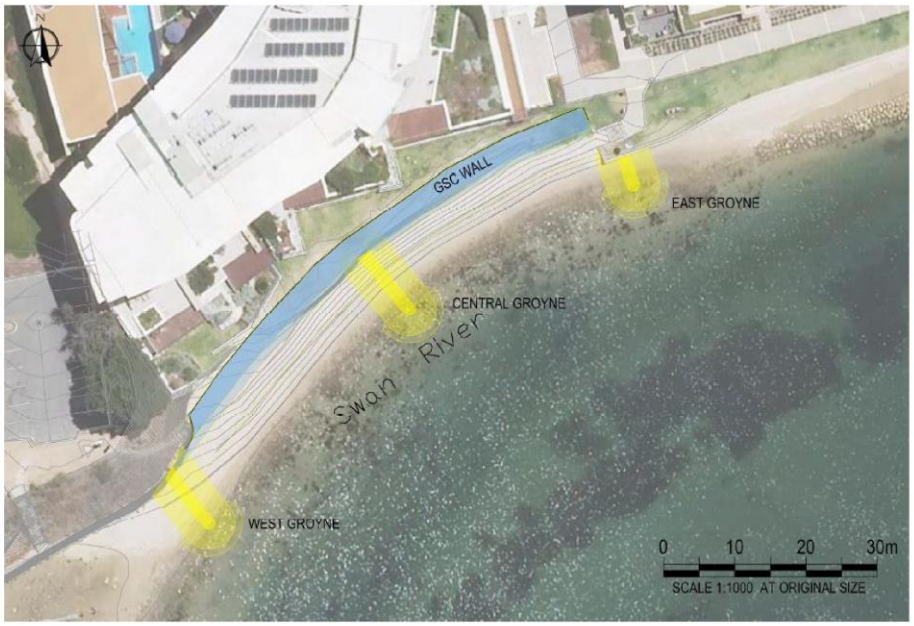


Figure 5-12 Option 3 – Plan form.

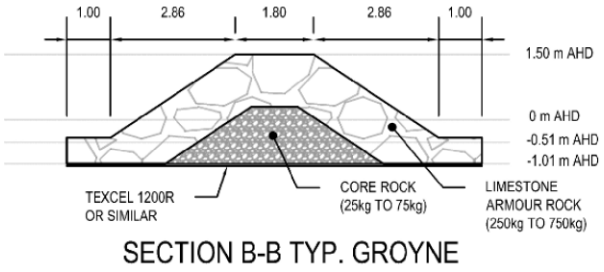


Figure 5-13 Typical Groyne Section.

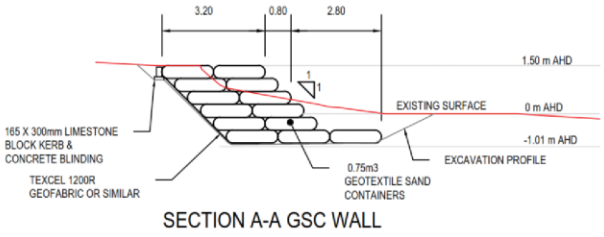


Figure 5-14 Typical GSC Wall Section.

Table 5-6 Option 3 – Advantages and Disadvantages

Criterion		Advantages	Disadvantages
Amenity	Beach/ land Amenity	A higher area of beach (approximately 400 m^2). The GSC wall provides perception of greater beach area.	Provides a lower area for land based amenity (Approximately 150 m^2) however the GSCs provide a surface for people to sit on or walk over.
	Access	Better access to the water from the land	Access along the foreshore is restricted by the rock groynes and may make access to maintain public berths of jetty difficult.
Environment	Excavation & Surplus Quantity	This option has the greatest disturbance of soils compared to other options. This option also has the greatest generation of surplus excavation materials (Approximately 1100 m^2) which will provide an opportunity to undertake some remediation of soils in the foreshore.	
	Structural Footprint	Once constructed this option has the highest surface area of exposed built structure compared to the other options. (560 m^2)	
	River Processes	This option will have the highest interruption to alongshore sediment transport and flood conveyance due to the presence of the rock groynes.	
Feasibility	Beach Stability	This option provides increased beach stability.	
	Design Life		25 years due to the design life of the GSC bags.
Cost	Estimated Implementation Costs		$800,000 to $1,400,000 dependent upon levels of ASS and contamination identified. Please refer to section 5.10 for full details of costing assumptions.
	Operation/ Maintenance Cost Estimate	$100,000. Please refer to section 5.11 for full details of costing assumptions.	

5.10 Preliminary Construction Cost Estimate

A preliminary concept cost estimate has been prepared by RBB for Option 2A and 2B considering both block wall construction types and for Option 3 which is provided in Appendix D. The development of Options 1A and 1B was undertaken after RBB prepared the cost estimate and so GHD has prepared the cost estimate for these options on the basis of the rates provided by RBB and the assumptions as detailed in Appendix D and provided below after Table 5-7. Option cost estimates have been provided purely for comparative purposes to assist in the decision making process and are not to be used for any other purpose.

GHD has considered that there is the potential for significant variation in the costs of implementing the options depending on the ASS treatment and soil disposal costs associated with each option. The costs for ASS treatment and soil disposal are dependent upon the outcomes of acid sulfate soil and soil contamination investigations recommended to be undertaken prior to the detailed design. The least conservative costs assume that no ASS treatment and no costs to specific landfill treatment facilities are provided for. The more conservative costs assumes that ASS treatment of all excavated materials and disposal of excess material to a Class 3 Landfill facility. These costs are based on these assumptions and if levels of contamination or ASS do not meet these assumptions costs could be higher.

Cost estimates are presented in Table 5-7 and further assumptions are detailed below. Note: cost estimates provided for Option 3 do not consider that at the end of the 25 year design life significant upgrades are likely to be required.

Table 5-7 Preliminary Cost Estimates (inclusive of GST) rounded to the nearest $10,000

Option	Estimated costs assuming no acid sulfate soil treatment and surplus material suitable for re-use.	Estimated costs assuming acid sulfate soil treatment to disturbed soil and disposal of surplus to Class 3 Landfill facility.
1A – Block wall – River Alignment	$530,000	$600,000
1B – Block wall – River Alignment – with Rock Beach Stabilisation	$850,000	$1,200,000
2A– Block wall – Land Alignment	$550,000	$750,000
2B– Block wall – Land Alignment – with Rock Beach Stabilisation	$850,000	$1,400,000
3 – Rock Groynes & Geotextile Sand Container Wall	$800,000	$1,400,000

Assumptions:

The following assumptions have been incorporated into the cost estimates:

1. All costing has been prepared on the basis of the concept options presented above;

2. All prices are inclusive of GST;
3. Quantities are based on the extrapolation of typical cross sectional areas applied along the full design length of the various structures;
4. A 15% contingency was applied to the estimated volumes produced by GHD to allow for uncertainty within the concept level designs;
5. RBB has allowed for separate contingencies which predominantly relate to changes between the concept designs and final detailed design (20%) as well as construction contingencies (10%);
6. The works are assumed to be competitively tendered, locally sourced and are based on present day pricing;
7. It is assumed that all works can be undertaken using land-based plant;
8. Works are limited to those described in the detailed cost breakdown;
9. Optional items, including steps at the western end of river wall or small boat launching ramp, have been excluded;
10. Figures are based on a typical cross-section taken midway along the existing beach and based on the latest survey provided to GHD by the City of Fremantle;
11. It is assumed that excavated beach material will be suitable for use a general fill placed landward of the retaining wall.
12. It is assumed that clean imported beach sand will be used to restore the beach profile to the original levels seaward of the retaining wall;
13. Limestone density assumed to be 1.8 t/m^3;
14. It is assumed that the surplus material to be disposed of has a mean density of 2,000 kg/m^3, on the grounds that it is wet, sandy material and has undergone some natural compression;
15. The estimated costs in the first row of Table 5-7 assume that no treatment is required for ASS for excavated materials. It also assumes that excess excavated material can be transported for use elsewhere and does not require disposal.
16. The estimated costs in the second row of Table 5-7 assumes that only excavated materials used on site will require treatment for ASS and has taken the conservative assumption that 100% of excess cut material will require disposal to a facility that accepts Class 3 Landfill.
17. It should be noted that the likelihood of soil requiring treatment for ASS is low based on past experience of similar projects in the river; and
18. Note: Capital costs for Option 3 do not consider that at the end of the 25 year design life significant upgrades are likely to be required.

Exclusions:

The following items have been specifically excluded from the cost estimates:

1. No allowance was made for client costs, contingency, financing or escalation;
2. No allowance was made for client costs, contingency, financing or escalation;
3. No allowance was made for the provision of additional drainage works associated with the overflow from infiltration tank; and
4. Balustrades along the edge of the river wall have not been allowed for and the requirement for them will be considered during the detailed design stage.

5.11 Maintenance Costs

In addition to capital costs each options structural variation will have different expected maintenance costs. The costs for maintaining block walls is typically much lower than that for a geotextile sand container wall. GSC walls area likely to require bag replacement if bags become damaged or removed. The costs for maintaining a beach area are dependent upon the level of protection the option provides to the beach, the volume of replenishment required and the potential frequency of replenishment.

Predicting sand replenishment volumes/costs is difficult due to low accuracies associated with estimating sediment transport rates. At the project site there is a lack of historical beach profiles or sand nourishment volumes that could be used to estimate sediment transport rates which makes calculation of rates or calibration of sediment transport modelling difficult. Therefore costs are indicative only and based on engineering judgement of the relative difference in the frequency of nourishment required. Costs have been estimated base on the anticipated maintenance costs over the design life.

In determining these costs the following assumptions have been made:

- It has been assumed that no beach area is provided or required to be maintained in Option 1A.
- Option 1B will be under higher erosion pressure than Option 2B as the beach is narrower and the wall is closer to the water so reflection of wave energy is expected to be higher. Option 1B - replenishment assumed to be required approximately every 2.5 years.
- Option 2A has a wider beach and no beach stabilisation measures so is most vulnerable to erosion. Option 2A - replenishment assumed to be required approximately every 2.5 years.
- Option 2B - has a wider beach but reflection of wave energy is expected to be lower than option 1B. Option 2B - replenishment assumed to be required approximately every 5 years.
- Option 3 is protected against alongshore sediment transport, but cross shore action and the short length of groynes may allow sediment to be eroded beyond the zone of the groynes capture. Access to nourish sections of this beach may also be more difficult. Option 3 - replenishment assumed to be required approximately every 2.5 years plus GSC bag maintenance is expected to be much higher than block wall options.

A summary of indicative maintenance costs considering the above factors is provided below in Table 5-8

Table 5-8 Indicative Maintenance Costs

Option	Indicative Maintenance Costs
1A – Block wall – River Alignment	$0
1B – Block wall – River Alignment – with Rock Beach Stabilisation	$200,000
2A– Block wall – Land Alignment	$200,000
2B– Block wall – Land Alignment – with Rock Beach Stabilisation	$100,000
3 – Rock Groynes & Geotextile Sand Container Wall	$250,000

6. Recommended Foreshore Stabilisation Plan

The following section provides the methodology undertaken and results of the assessment used to identify the preferred concept option to be developed in the Detailed Investigation and Detailed Design stage of the project.

Additional aspects of the preferred option to be developed during the detailed design stage of the project should include landscaping levels and sloping behind the riverwall, width and shape of stairway access at western end of foreshore, inclusion of specific beach access features within the walls or between the existing Fremantle traffic bridge abutment riverwall, and inclusion of landscaping elements.

6.1 Multi Criteria Analysis

A Multi Criteria Analysis (MCA) was undertaken to assist identifying the preferred foreshore stabilisation option or options. An MCA is a decision-making tool used to assist in the comparison of options. An MCA evaluates the benefits and impacts of options based on the relative importance of several criteria. An MCA however is not a tool to identify fatal flaws. The MCA outcomes provide a ranking of options against a set of criteria.

The criteria used in the MCA should not double count similar aspects to prevent bias towards or against an option. For example, the ease of construction is usually factored by a contractor in the construction cost. Therefore either ease of construction or construction cost but not both should be used as criteria. More criteria are not necessarily better as this dilutes the weighting likely to be assigned and will make it harder to differentiate between the options. The criteria should reflect the values and the feasibility factors that are important in decision making. Where possible the criteria scores for each option should be quantitative inputs over qualitative. E.g. instead of saying one option is better on a scale of 1 to 5 than another because one offers the opportunity to remediate more soil, use the potential volume of soil to be remediated in each of the options instead. Options scores are normalised to allow a combined raw score to be calculated.

The MCA process scores each option against the criteria. Each criteria is weighted or assigned a different percentage, based on its relative importance. This weighting should be considered in isolation. Options are then ranked based on their weighted scores.

6.2 Criteria Scoring and Weighting

The criteria used in this analysis, how they were scored and the weightings assigned are summarised below in Table 6-1. The weightings to the options were discussed and assigned by CoF and DBCA in a steering committee meeting facilitated by GHD.

Table 6-1 Criteria and weighting used in the MCA.

Decision Criteria		Units	Criteria Weight	
Community	Community Preference	%	0.1	0.1
Amenity	Land Area	m2	0.023	0.09
	Beach Area	m2	0.023	
	Access to and from water	0 or 1 (1 is better access)	0.045	
Environment	Soil treatment	Excess Cut Material (m3)	0.135	0.18
	Structural Footprint	m2	0.05	
Feasibility	Beach Stability	0 or 1 (1 is more stable beach)	0.135	0.27
	Design Life	years	0.135	
Cost	Implementation cost (higher)	$100k	0.18	0.36
	Indicative Maintenance Cost	$100k	0.18	

Community preference was based on the result of the MySay survey. Land and beach areas were measured from the engineering plan sketches. Structural footprint considered the visible plan surface area of constructed material after construction is completed. Access to water and Beach stability were considered on a scale of 0 or 1 with 0 being bad and 1 being good based on engineering judgement. Soil treatment is considered by the volume of contaminated soil to potentially be removed from the site. The removal of contaminated soil from within the foreshore reserve to a managed land fill site is considered a benefit for the local environment at the site. Costs used were taken from sections 5.10 and 5.11, implementation costs considered the higher cost figures for each option, assuming acid sulfate soil treatment to disturbed soil and disposal of surplus to Class 3 Landfill facility. Indicative maintenance costs were based on the results from Table 5-8 and is a reflection of the beach stability and design element maintenance costs likely to be incurred over the design life.

6.3 Results

Table 6-2 compares the various concept options over a series of criteria and assigns each option a rank based on assessment of these options against key criteria. Full details of the scoring results against the criteria can be found in Appendix E.

Table 6-2 Concept Options MCA Results

	1A – Block wall – River Alignment	1B – Block wall – River Alignment – with Rock Beach Stabilisation	2A– Block wall – Land Alignment	2B– Block wall – Land Alignment – with Rock Beach Stabilisation	3 – Rock Groynes & Geotextile Sand Container Wall
Raw Sum	624.1	501.6	534.8	544.7	473.4
Weighted Sum	58.7	41.6	44.6	49.2	43.2
Rank	**1**	**5**	**3**	**2**	**4**

The results of the MCA indicate that on both raw sum and weighted sum (624.1 and 58.7 respectively), the best scoring option is Option 1A. This also indicates that regardless of the weightings applied, the ranking for this option is not very sensitive to the weightings applied. This nearest ranked option, Option 2B was over 10 points lower on weighted score. Rankings 2 to 5 all scored within 8 weighted points of each other between 41.6 and 49.2.

6.4 Conclusions and Recommendations

The MCA provides a strong indication that Option 1A is the recommended option to be taken forward to detailed design. Before detailed design is undertaken, it is recommended that detailed investigations into ASS and site contaminants is undertaken to provide increased certainty into the cost of implementation for the City of Fremantle and to assist to inform and require construction management plans in relation to these aspects.

7. References

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Appendices

Appendix A – Shoreline Change Mapping


1965
1974
1981
2001
2010

Appendix B – Community Consultation Memos

Memorandum

12 July 2017

To	City Of Fremantle		
Copy to			
From	Rachel Marie	Tel	+61 8 6222 8525
Subject	Phase 1 Community Consultation Outcomes	Job no.	6135392

A community information session was held for the Northbank Foreshore Stabilisation Project. The purpose of the information session was to inform the community about the project and invite comment on current and future issues or elements they believed should be considered when assessing the stabilisation options.

Community information session details

The information session was held at the North Fremantle Community Hall on Thursday 6 July 2017. The session commenced at 5.00pm and concluded at 7.00pm.

The format of the session was semi-formal, where community members could drop in at any time between 5.00-7.00pm and speak to members of the project team. In addition three short presentations were held throughout the evening at 5.15 pm, 5.45 pm and 6.15 pm providing an overview of the project as well as allowing time for questions and answer. All three presentations covered the same content. The- layout and venue set up is shown in the attachment below.

The community information session was attended by three GHD project team members and one representative from the City of Fremantle.

The workshop materials and display information included:

- Welcome desk with survey, attendance details slips and project business cards;
- Posters with project information and historical aerial imagery;
- Presentation space including projector, screen, laptop and approximately 20 chairs; and
- Refreshments table with tea, coffee and biscuits.

A total of 24 community members attended the session and two Council Members.

The majority of the information session attendees attended the first and second information sessions (15 people at session one, six people at session two excluding Councillors). There were only two attendees at the final presentation of the evening. Due to the larger volume of attendees at the first session, the question and answer period was much longer, resulting in a delay of the scheduled commencement time of the second and third presentations.

Attendees were encouraged to leave their contact details in order to receive updates on the project. These were collected by the City at the end of the session.

Memorandum

Summary of key issues raised

Generally the queries and comments raised where of a more technical manner as attendees wanted to understand the rationale for the project, the options for stabilisation and the causes of the erosion.

The following provides an overview of the key issues raised during the question and answer period of the presentation, as well as in the one-on-one discussion with project team members.

Use and preference for future

- Varying preferences for beach and seawall in the area (some residents strongly preferred a seawall whereas one was opposed to solutions that would modify nearshore flows).
- Comments noting the range of activities taking place in the area including swimming, kayaking and fishing.
- Access from Rivershores Kayak/dinghy storage to river.
- Comments regarding swimming ban for this portion of foreshore. It was requested that Council minutes documenting the discussion be provided to GHD for consideration.

Amenity

- Comments relating to rubbish build up, its source and how will it be managed.
- Council and City of Fremantle efforts to address the removal of rubbish

Stability of the area

- Comments regarding evidence of erosion for this portion of foreshore and what it is actually caused by – comments around natural tidal processes vs. boat wake.
- Vessel speed limits and implications of 8 knot limit on boat wake generation.
- Queries regarding what options are available for the foreshore and how would they be evaluated and assessed.
- Issues related to flooding and the "One in 100 year flood" how this would impact the site (including Rivershores) and how the protection may or may not address this.
- Comments relating to the stability of the foreshore being along the whole foreshore and queries why the project is limited to this area.
- Comments relating to what sort of options would be investigated and how they would be evaluated and assessed.
- Comments relating to who is responsible for foreshore stabilisation.
- Comments relating to current flanking erosion being experienced in the vicinity of the stairs at the western end of the existing seawall

Consultation and project program

- Queries regarding the cost of the options and who will be responsible for paying for the works.
- Concerns raised that this project would not progress

GHD

Memorandum

- Comments that previous consultation had already been undertaken in this area so why is it being done again.
- Community information session notification.
- Overall project staging was and whether the community was going to be consulted on the options.

Areas adjacent to project area

- Comments relating to the importance of the project taking into consideration the protection of the Rivershores apartment building.
- Safety concerns around the stairs and retaining wall at the Fremantle traffic bridge.
- Potential impacts of the Fremantle traffic bridge realignment (duplication) and potential rail bridge duplication.
- Comments relating to jetty operations from the jetty owner – regarding maintenance of public berths.
- Impacts of the river flow from the bridge abutments
- Current flanking erosion being experienced in the vicinity of the stairs at the western end of the existing seawall.
- Comments relating to the presence of an adequate beach at Sorell Park – "great for wading/dog walking/swimming".
- Comments relating to the heritage value of Fremantle traffic bridge pilings.

Survey results

A survey was made available to attendees to complete on their departure. The intention of the survey was to understand where the attendees were from and to seek feedback on the session. The survey was only completed by one attendee.

The respondent was a landowner of the Rivershores apartment. They attended the session to obtain more information about the project. They found the session somewhat useful and would prefer an online information and survey consultation for the next phase.

'MySay' Online feedback

Some residents indicated they were not able to attend the session but wished to still provide feedback. Comments could be submitted online through the City's 'MySay' website. Two responses were received. A summary of the verbatim comments is provided below.

Question: Do you have any comments about the Northbank foreshore now?

- *Yes. We need to build a bank like the one in front of the Brighton Building.*

GHD

Memorandum

- *Thanks for consulting.*
- *Should be a landscape driven solution and not engineering alone.*
- *Connectivity to Bridge by foot and bike if grade allows.*
- *Lack of P/Toilets in the parks at Nth Freo, could be considered for car park to north west to also allow food truck capability i,e power/water outlet. Touristic benefits lost in North Fremantle as no loop pedestrian track along rive[r].*
- *SUP launching ramp could be considered into any reversal.*
- *Lighting important.*

Question: Do you have any comments or concerns if this area were to change?

- *No. It needs to change.*
- *No.*

Both respondents had a preference for online information and survey for the next phase of consultation.

Lessons Learned

The information session was successful[1] however in order to improve the consultation undertaken in the next phase, the following should be taken into consideration.

- Consultation invitations should be provided earlier to allow attendees sufficient notice of the event.
- Greater consideration should be given in relation to information session/consultation notifications and who is being sent an individual notice and who is not. It is noted that the session was open to all community members to attend, however individual notices were only provided to the Rivershores apartment. Comments were made that some people were not aware of the session and found out through non-City of Fremantle sources.
- If multiple presentations are to be provided, consider a reduced number of presentations to allow greater question and answer time. This will avoid subsequent sessions commencing late and reduce excess noise from previous attendees staying at the venue to continue discussion. eg It was difficult for attendees to hear the information being presented during the second presentation due to the close proximity of the display and entrance areas. Alternatively, alter the venue and/or set up to accommodate the number of sessions.
- There was a positive response to the posters – they were of assistance when clarifying the project and provided a point of discussion, particularly the historical aerials. Attendees were also able to view information whilst waiting for the presentation.

[1] Based on the interest and extended question time at the conclusion of each presentation and the number of people who stayed after each presentation to interact and ask questions of the project team.

Memorandum

- Attendees who were late, appreciated that the information presented was the same and that the presentations still took place despite there being less people in the audience. (ie. we delivered the session as advertised which assisted in building rapport and trust in the process).
- Only one survey was complete. Consideration should be given to a shortened survey that people can complete on their arrival. Consider the purpose of the survey and whether it is beneficial to the consultation.
- Additional City representatives to assist in general discussion with attendees. Due to the format of the session, it was difficult for GHD staff to undertake multiple one-on-one discussion as presentations were commencing.
- The impression from the team was that people thought it would be more of a visioning exercise or that there would be options to look at, rather than seeking general feedback. Provide additional information in the invitation regarding the sorts of inputs we would be seeking during the session.
- Additional background in the presentation and on the posters – ie. how does this project fit in with the broader foreshore management. There were comments raised in relation to this being 'just another study that wouldn't go anywhere' as they had previously attended consultation in the area.

Additional Information

Following the session, the City of Fremantle followed up with those attendees of the workshop who requested additional information. This included a community member who requested empirical evidence of erosion.

Matters to be actioned

- City to provide GHD with Council minutes regarding swimming ban for this portion of foreshore.

Conclusion

Overall the information session was considered successful and there were a number of good discussions and feedback received in relation to the area. Based on the comments received, we believe that the community is expecting the opportunity to have a discussion in the next phase of consultation, therefore an in-person consultation format is recommended. This can be further supplemented by online materials. Some attendees appeared to be disheartened with the City and concerned that this would be just another study that does not progress. Therefore consultation moving forward should be carefully considered to ensure the approach and format is appropriate and that the project continues to progress.

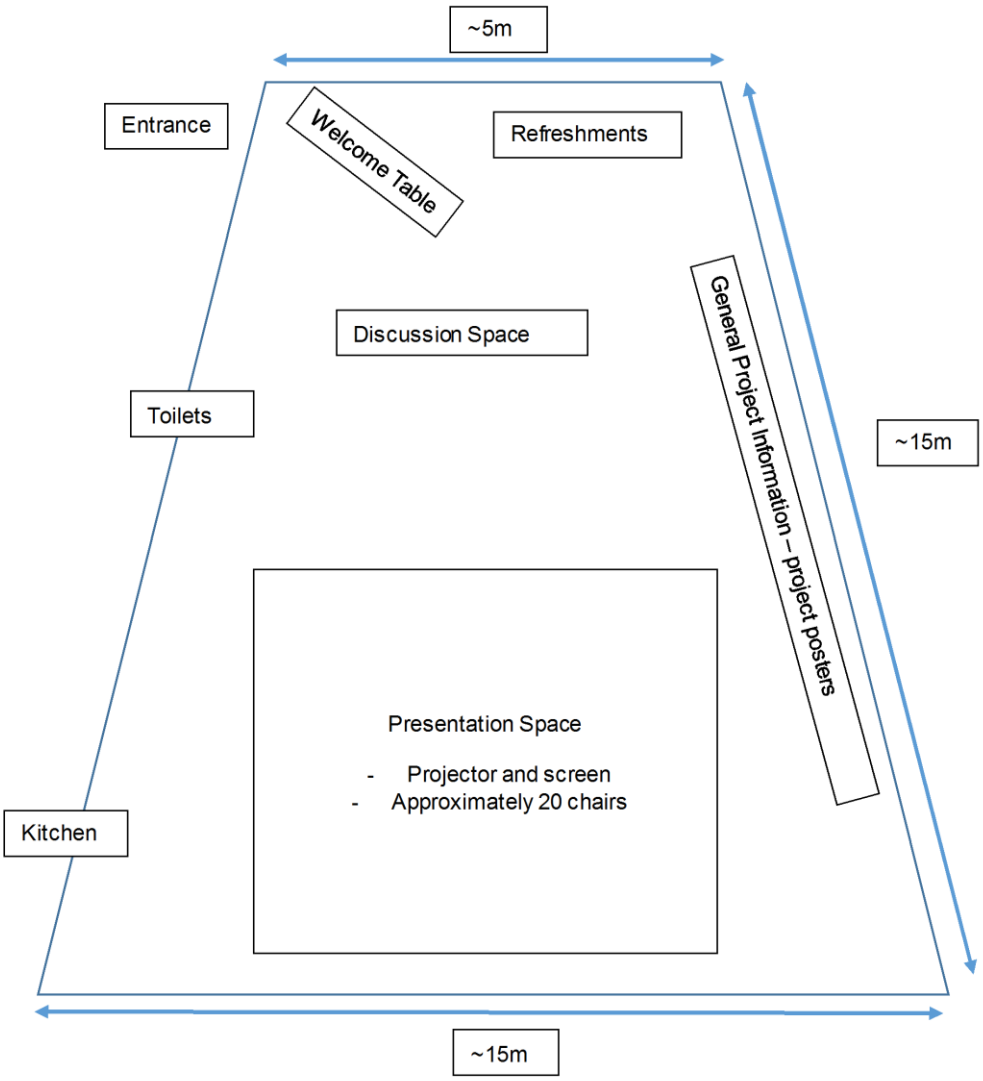
Regards

Memorandum

Rachel Marie
Senior Planner

Memorandum

North Fremantle Community Hall – Community information session layout



Memorandum

15 August 2018

To	City Of Fremantle		
Copy to			
From	Gemma Bertrand	Tel	+61 8 6222 8525
Subject	Community Consultation Outcomes	Job no.	6135392

A community information session was held for the Northbank Foreshore Stabilisation Project to provide an overview of the concept options developed. The purpose of the information session was to inform the community about the results of desktop investigations and the advantages and disadvantages of the concept options developed in order for the community to provide feedback to the City of Fremantle on their preferences for the stabilisation of the parks and recreation reserve in the study area.

Community information session details

The information session was held at the North Fremantle Community Hall on Thursday 31 May 2018. The session commenced at 5.30pm and concluded at 7.30pm.

The format of the session was semi-formal, with two presentations followed by Q&A session planned for 5.45pm and a second for 6.45 pm. The 5:45pm session was undertaken as planned. The 6:45 pm session did not go ahead as planned as no community members were in attendance

The twenty minute presentation provided an overview of the results of desktop assessment and causes for erosion at the site, and, presented artists perspectives of the concept options alongside advantages and disadvantages of the options against key criteria. At the completion of the presentation there was time for the community to ask questions and the City, GHD and DBCA to respond. There was approximately twenty minutes of Q&A's from the community. Before and after the presentation, informal one-on-one or small group discussions were held. The- layout and venue set up is shown in the attachment below.

The community information session was attended by three GHD project team members and one representative from the City of Fremantle.

The workshop materials and display information included:

- Welcome desk with attendance register and copy of MySay surveys;
- Posters of site analysis findings, historical aerial imagery, artists perspectives with advantages and disadvantages of concept options;
- Presentation space including projector, screen, laptop and approximately 25 chairs; and
- Refreshments table with tea, coffee and light refreshments.

A total of approximately 25 community members attended the session. (23 members signed. 2 attendees declined to register). The attendance register indicated that a high proportion of attendees were local residents from immediate buildings adjacent to the study area.

As previously stated, all community members attended the first session, and no additional community members arrived after this session, so a second presentation did not proceed. The project team remained at the venue until the proposed end time at 7.30pm in case additional community members did arrive.

Attendees were encouraged to participate in the MySay Survey (either online or with hard copies provided at the welcome table) after the presentation or in their own time. The paper copies were collected by the City at the end of the session along with other paper copies submitted by the community and combined with the online survey results before being analysed.

Summary of key issues raised

In general the comments were focussed on individual implications of specific options and current uses and less focussed on general public uses and what would be best for the greater community. The perception from the community was that cost should not be a factor or concern when implementing a medium to long-term solution for the site area. The City, GHD and DBCA provided answers to questions where required however, a large number of members raised comments and voiced opinions instead of asking direct questions.

The following provides an overview of the key issues raised during the question and answer period of the presentation, as well as in the one-on-one discussion with project team members.

Access

- Stair /ramp access requested for kayaks and canoes etc
- Concerns were raised on how the scour rock toe will impact access to the water
- Unhappy about the current state of access to the site from the Fremantle Traffic Bridge carpark as it is unsafe and informal.

Rock Groynes

- Sand builds up under jetty impacting public berths. River currents take sediment up and down the river. Only groynes can assist.

GSC Wall

- Instead of a stepped GSC wall it should be a stepped limestone block wall to improve access
- Kids like beach access – GSC walls allow for easy access
- Both positive and negative feedback on the visual impacts of GSC's in East Fremantle near Zephyr Café.
    - GSC groyne walls turning green – looks ugly, looks natural
    - Liked the appearance
    - Causes mosquitoes

Beach & Environment

- Based on local experience – contamination of sediments is probably worse further into the river
- Adjacent foreshore was full of old tyres, timbers etc. While machinery is available on site get volunteers to pull rubbish out. Health of marine environment has since improved. Seagrass and fish now

- Would like to see how water/river flows are influenced by structures.
- Where would sand fill come from? Does it need to come from the area?

Use and preference for future

- Conflicting stories on use of the area:
- "No-one uses the beach to swim. Only to fish. Need access to the water not sure why there is so much emphasis on the beach"
- Some people do use the beach. Grand kids love it.
- Unsafe to swim near the bridge due to currents.

Cost

- CoF need to increase potential spending and might need to look at more funding options.

Project program

- Query was raised about the likely timeframe of implementation of an option.

Project Steering Committee

- Query about representatives on the Steering Committee (SC) and why local representatives from Rivershores, the Brighton and York weren't a part of the SC? Need other people's ideas on the steering committee.

Areas adjacent to project area

- Construction of rocks (underwater rock mound at Fremantle Port to protect the Traffic Bridge) has resulted in sediment accreting in the lee. Sand could be reused at the site.

'MySay' Online Information and Survey

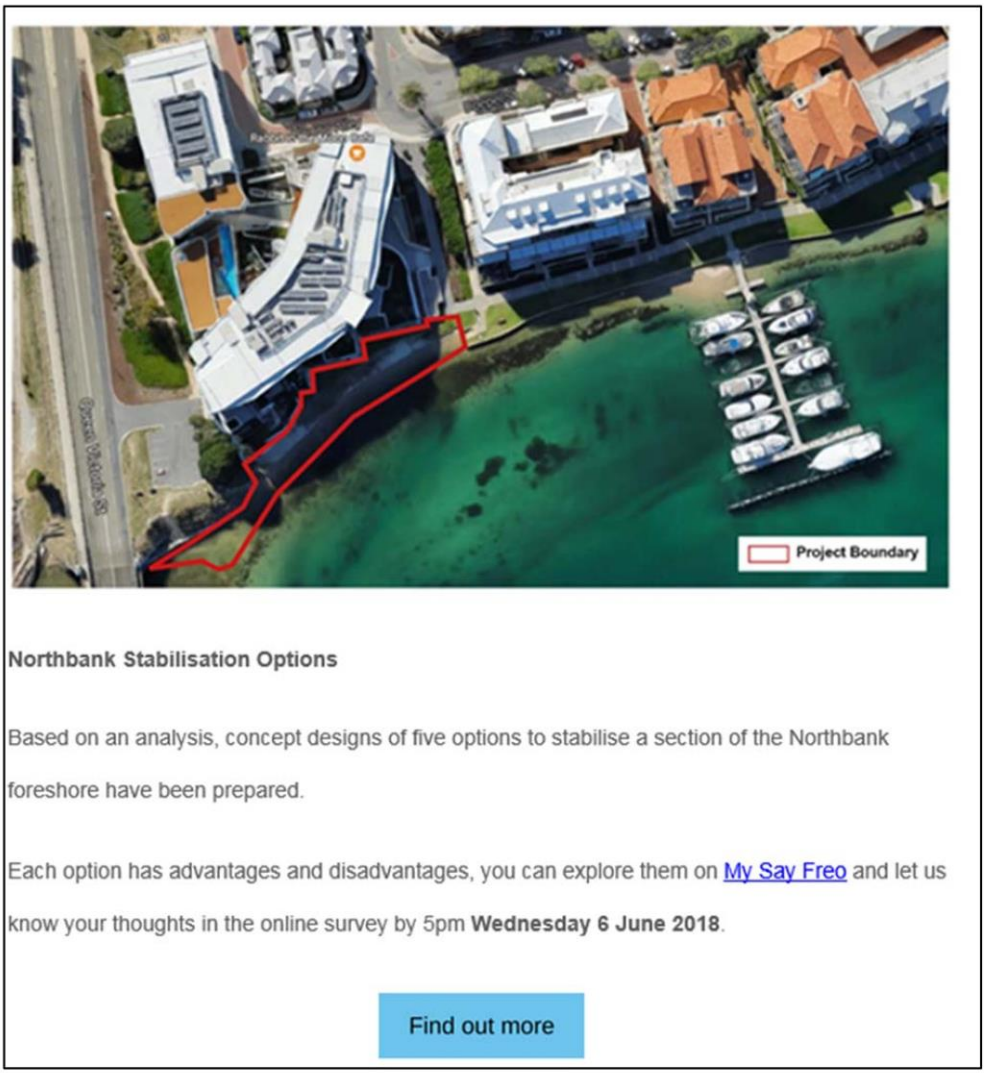
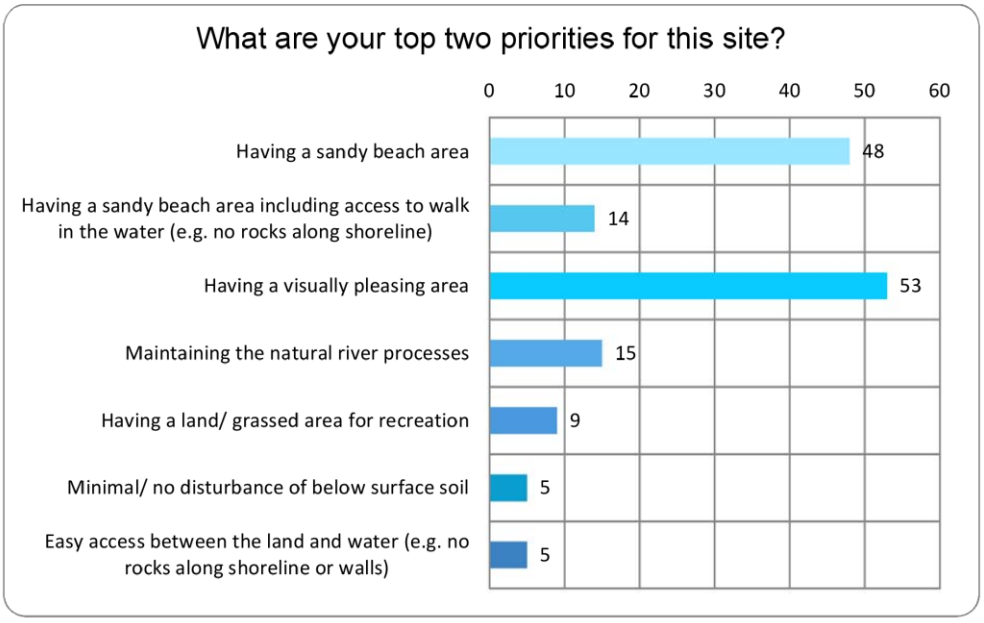


Figure 1 Extract from MySay Fremantle website.

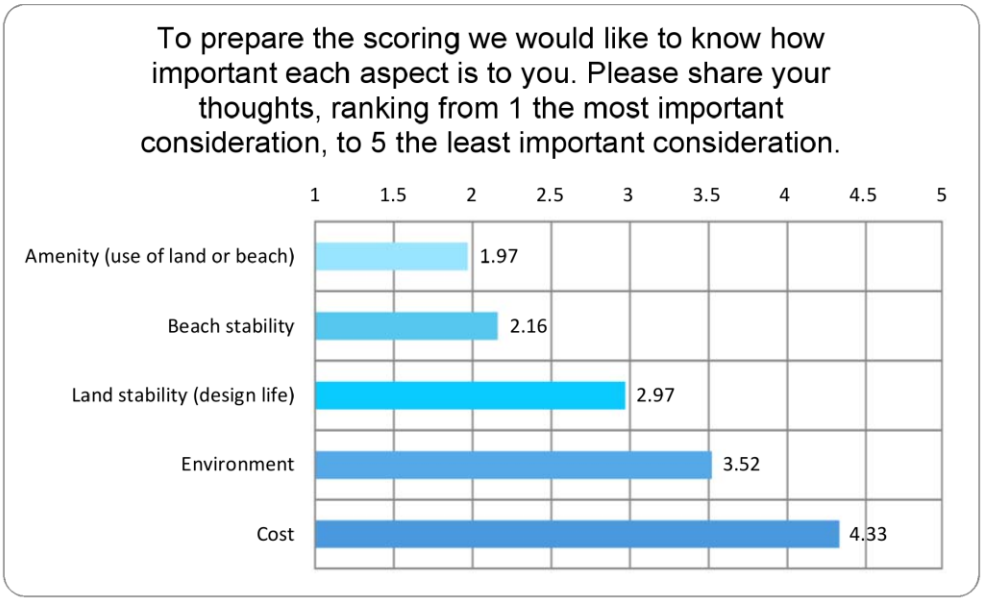
Project information and a short survey were provided on MySay Fremantle website. The site was open from the Friday the 18th May to the 6th of June. A summary of the findings from the MySay Survey is provided below: Full details of the survey questions are included in attachment 1. A total of 76 responses were received, 58 online and 18 hard copy.

Question 1:



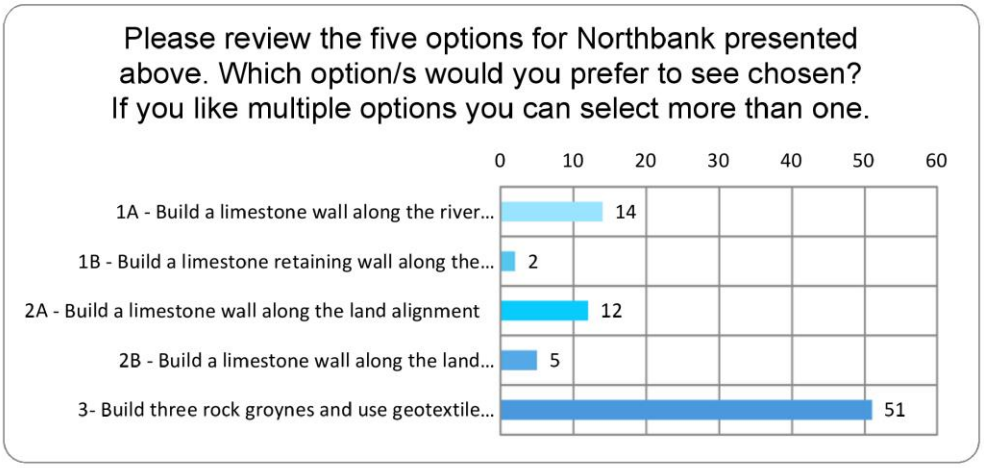
The key priorities as indicated by question 1 are having a sandy beach and having a visually pleasing area. Interestingly easy access between the land and water was not highlighted as a key importance which contrasts some of the opinions stated at the information session.

Question 2:



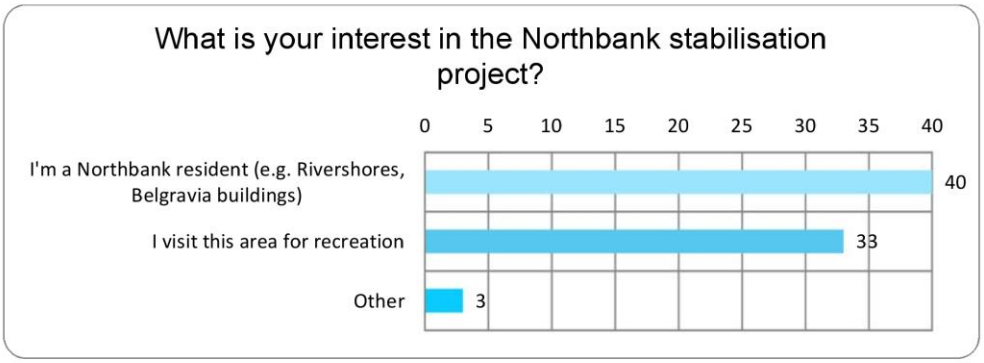
The key priorities to the community indicates are amenity and beach stability are most important. Environment and cost are the least important, with land stability being considered in the middle.

Question 3:



By far the most preferred option was Option 3 with 67% of people identifying this as a preferred option followed by Option 1A with 18% of people identifying this as a preferred option (respondents were allowed to select up to two responses).

Question 5:



Themes raised from review of responses in Questions 4 and 6:

- A large number (33) of responses raised the idea of having limestone block steps instead of GSC's in Option 3.
- A number (5) raised issues of access to sand/water.
- 14 responses mentioned importance of area for kayak launching and landings
- 11 responses mentioned the impacts of different solutions on the adjacent public boat pens and preference for groynes.
- Other comments included themes on access, sandbag visual concerns, queried use of gsc's with rock groynes, siltation impacts and private benefits, concerns about flooding to Northbank and sea level rise.

Lessons Learned

The information session was successful and there was generally a positive response to the presentation [1] however in order to improve effectiveness of future consultation campaigns the following should be taken into consideration.

In presenting options to the community it is important that all the options are presented, but if particular options are considered to have fatal flaws (such as prohibitive costs) consider whether community feedback/preferences be focussed only on the options that are feasible and provide justification of why some options are not considered feasible. This may improve alignment from community feedback with recommended options.

Conclusion

Overall the information session was considered successful and there were a number of good discussions and feedback received on the presentation. Based on the questions asked and statements made by the community there appeared to be a divide between those who preferred river wall solutions and those who preferred the rock groyne and sand bag solutions.

Some concerns were raised about the potential timeframes between now, detailed design phase and the likely implementation phases of this project. Therefore consultation moving forward should be maintained to ensure the community is kept up to date with the future phases including the outcomes from when the Foreshore Stabilisation Plan is presented to Council.

Regards

Gemma Bertrand
Senior Coastal Engineer

Attachments:

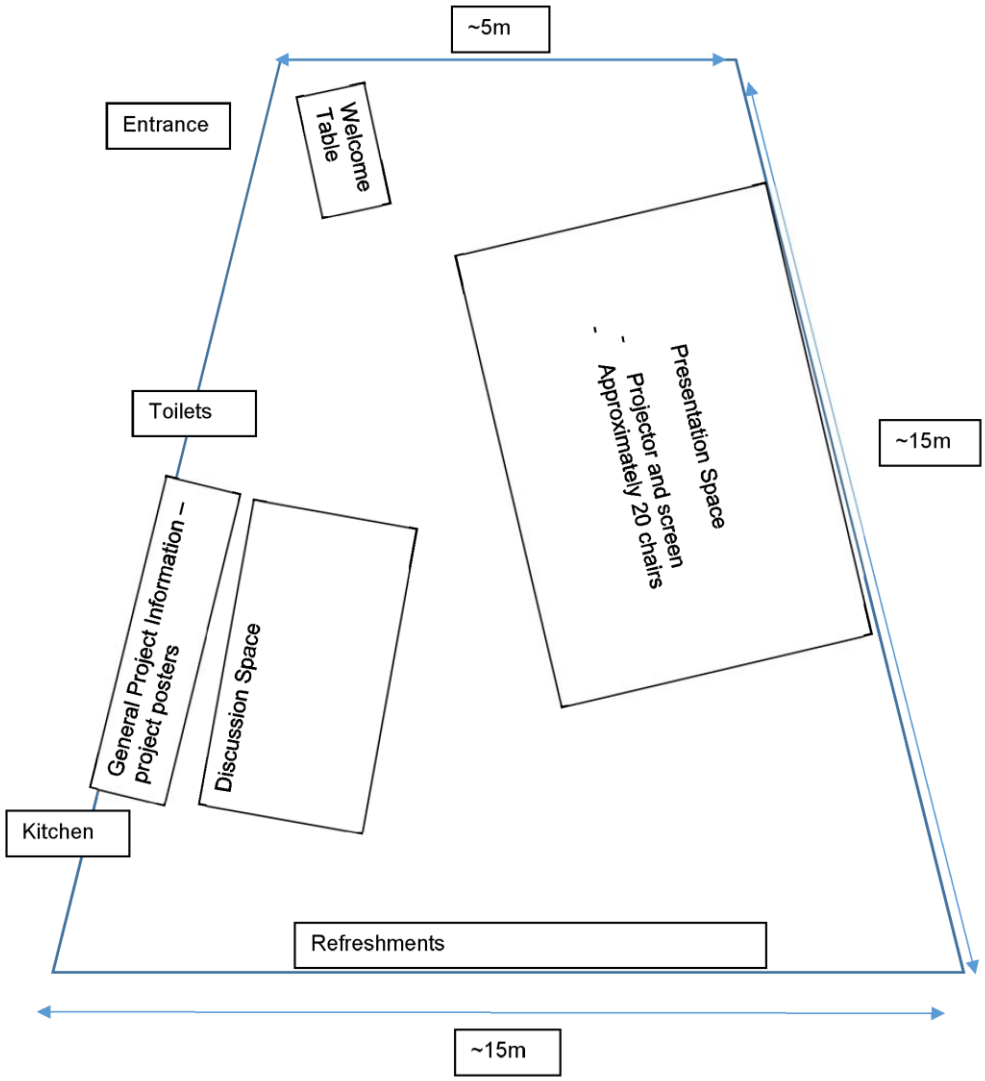
1. MySay Survey Questions
2. North Fremantle Community Hall – Community information session layout

[1] Based on the verbal positive feedback from different community members after the presentation and the interest and extended question time at the conclusion of the presentation.

1 MySay Fremantle - Survey Questions:

1. What are your top two priorities for this site?
    a. Having a visually pleasing area,
    b. Having a land/ grassed area for recreation
    c. Maintaining the natural river processes
    d. Minimal/ no disturbance of below surface soil
    e. Having a sandy beach area including access to walk in the water (e.g. no rocks along shoreline),
    f. Easy access between the land and water (e.g. no rocks along shoreline or walls)
2. The criteria being used to assess the five concepts are: amenity, environment, beach stability, land stability and cost. To prepare the scoring we would like to know how important each aspect is to you. Please share your thoughts, ranking from 1 the most important consideration, to 5 the least important consideration.
    a. Amenity (use of land or beach)
    b. Beach stability
    c. Land stability (design life)
    d. Environment
    e. Cost
3. Please review the five options for Northbank presented above. Which option/s would you prefer to see chosen? If you like multiple options you can select more than one.
    a. 1A - Build a limestone wall along the river alignment
    b. 1B - Build a limestone retaining wall along the river alignment and place rocks along the water edge of shoreline (a 'rock toe')
    c. 2A - Build a limestone wall along the land alignment
    d. 2B - Build a limestone wall along the land alignment and place rocks along the water edge of shoreline (a 'rock toe')
    e. 3- Build three rock groynes and use geotextile sand bags on the bank
4. Please tell us why you prefer this option or options.
5. What is your interest in the Northbank stabilisation project?
    a. I'm a Northbank resident (e.g. Rivershores, Belgravia buildings)
    b. I visit this area for recreation
    c. Other (please specify)
6. Is there anything not addressed in these options that is important to you? Include any concerns or information we need to know.

2 North Fremantle Community Hall – Community information session layout



Appendix C – Artists Perspectives and Concept Option Sketches

Option 1A **Block Wall - River Alignment**

Option 1B **Block Wall - River Alignment - With Rock Toe**

Option 2A **Block Wall - Land Alignment**

Option 2B **Block Wall - Land Alignment - With Rock Toe**

Option 3 **Rock Groynes and Geotextile Sand Container Wall**

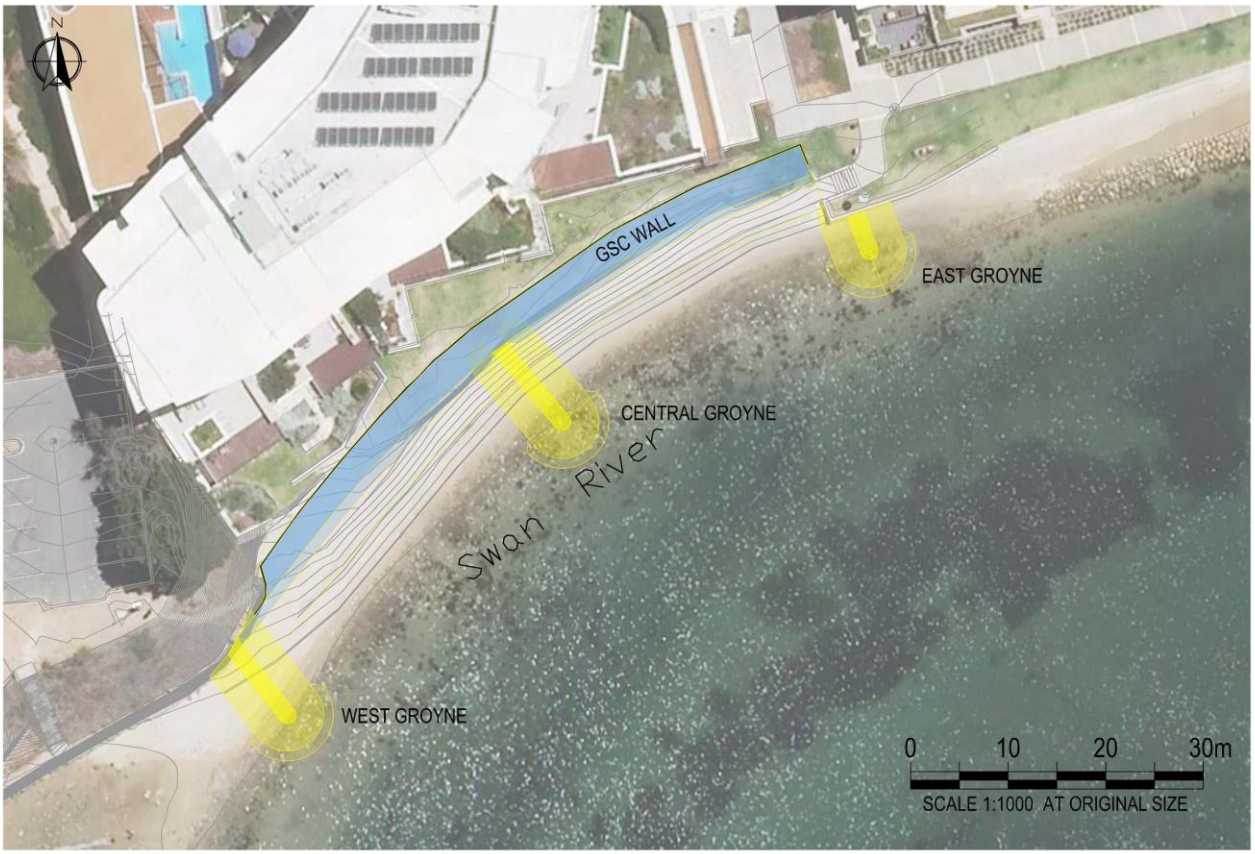
OPTION 1 A- BLOCK WALL - NO BEACH STABILISATION

OPTION 1 B- BLOCK WALL - WITH BEACH STABILISATION

OPTION 2 A - BLOCK WALL - NO BEACH STABILISATION

OPTION 2 B - BLOCK WALL - WITH BEACH STABILISATION

OPTION 3 - GSC WALL & ROCK GROYNE



Appendix D – Preliminary Concept Cost Estimations

Client:	**City of Fremantle**
Project Title:	**Northbank Foreshore Restoration - Concept Options**
Estimate:	**Concept Cost Estimate**
Operating Centre/Job No:	**61-35392**

Northbank Foreshore Stabilisation - Concept Options - SUMMARY

Ref	Scope	1A	1B	2A	2B	3
	Materials and Preliminaries					
1	Preliminaries	$ 45,000	$ 66,000	$ 43,000	$ 65,000	$ 60,000
2	Demolition	N/A	N/A	N/A	N/A	N/A
3	Temporary Works	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000
4	Site Preparation	$ 9,700	$ 9,700	$ 8,250	$ 8,250	$ 5,600
5a	Earth Works (low)	$ 21,750	$ 21,750	$ 30,300	$ 30,300	$ 54,500
5b	Earth Works (high)	$ 66,800	$ 66,800	$ 217,400	$ 217,400	$ 570,500
6	Retaining Walls	$ 195,300	$ 195,300	$ 186,200	$ 186,200	-
7	Rock Armour; Retaining Walls	$ 22,500	$ 22,500	$ 19,900	$ 19,900	-
8a	Beach Scour Protection (low)		$ 145,100		$ 145,100	-
8b	Beach Scour Protection (high)		$ 442,100		$ 442,100	-
9	Geosynthetic Sand Containers	-	-	-	-	$ 184,000
10	Rock Groyne	-	-	-	-	$ 117,700
11	Landscaping	$ 10,000	$ 10,000	$ 6,000	$ 6,000	$ 3,000
12a	**Subtotal (low)**	**$ 339,250**	**$ 505,350**	**$ 328,650**	**$ 495,750**	**$ 519,800**
12b	**Subtotal (high)**	**$ 384,300**	**$ 847,400**	**$ 515,750**	**$ 979,850**	**$ 1,035,800**
	Construction Costs					
13	Design Contingency (20%)	$ 72,000	$ 135,000	$ 84,000	$ 148,000	$ 156,000
14	Construction Contingency (10%)	$ 36,000	$ 67,500	$ 42,000	$ 74,000	$ 78,000
15	Client Contingency	Excluded	Excluded	Excluded	Excluded	Excluded
16	Staging Requirements	Excluded	Excluded	Excluded	Excluded	Excluded
17	Headworks	N/A	N/A	N/A	N/A	N/A
18	Land costs	Excluded	Excluded	Excluded	Excluded	Excluded
19	Profesional fees & disbursements (10%)	$ 36,000	$ 67,500	$ 42,000	$ 74,000	$ 78,000
20	**Subtotal**	**$ 144,000**	**$ 270,000**	**$ 168,000**	**$ 296,000**	**$ 312,000**
	Totals					
21a	**Estimated Total Commitment (excl GST) (low)**	**$ 483,250**	**$ 775,350**	**$ 496,650**	**$ 791,750**	**$ 831,800**
21b	**Estimated Total Commitment (excl GST) (high)**	**$ 528,300**	**$ 1,117,400**	**$ 683,750**	**$ 1,275,850**	**$ 1,347,800**
22a	GST (10%) (lower bound)	$ 48,325	$ 77,535	$ 49,665	$ 79,175	$ 83,180
22b	GST (10%) (upper bound)	$ 52,830	$ 111,740	$ 68,375	$ 127,585	$ 134,780
23a	Estimated Total Commitment (incl GST) (lowe)	$ 531,575	$ 852,885	$ 546,315	$ 870,925	$ 914,980
23b	Estimated Total Commitment (incl GST) (high)	$ 581,130	$ 1,229,140	$ 752,125	$ 1,403,435	$ 1,482,580

OPTIONS

Option 1A	Block Wall - River Alignment
Option 1B	Block Wall - River Alignment - With Rock Toe
Option 2A	Block Wall - Land Alignment
Option 2B	Block Wall - Land Alignment - With Rock Toe
Option 3	Groynes and Geotextile Sand Container Wall

Assumptions & Notes

Optional items including steps at western end of river wall or small boat launching ramp have been excluded.

Figures are based on a typical cross section taken midway along the existing beach and based on the latest survey provided to GHD by the City of Fremantle.

It is assumed that excavated beach material will be suitable for use a general fill placed landward of the retaining wall.

It is assumed that clean imported beach sand will be used to restore the beach profile seaward of the retaining wall to the original levels.

Limestone density assumed at 1.8t/m3

It is assumed that the surplus material to be disposed has a mean density of 2000kg/m3, on the grounds that it is wet sandy material and has undergone some natural compression

The lower bound cost assumes that no treatment is required for ASS for excavated materials. The upper bound assumes that only excavated materials used on site will require treatment for ASS. It should be noted that the likelihood of soil requiring treatment is low.

The low cost for excess excavated material assumes that material can be transported for use else where and does not require disposal. The high has taken the conservative assumption that 100% of excess cut material wll require disposal to a facility that acceps Class 3 Landfill.

NORTHBANK FORESHORE, FREMANTLE

FORESHORE RESTORATION WORKS

COST PLAN No. 1

PRELIMINARY CONCEPT ESTIMATE REV 1

FOR

2-Oct-17

Ralph Beattie Bosworth
Construction Cost Consultants
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NORTHBANK FORESHORE, FREMANTLE
FORESHORE RESTORATION WORKS
COST PLAN No. 1
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QUALITY MANAGEMENT

2-Oct-17

Revision	Prepared By	Checked By	Issue Date	Comments
0	Matthew Buss	Daniel Tang	28-Sep-17	
1	Matthew Buss	Daniel Tang	2-Oct-17	

NORTHBANK FORESHORE, FREMANTLE
FORESHORE RESTORATION WORKS
COST PLAN No. 1
PRELIMINARY CONCEPT ESTIMATE REV 1

SUMMARY

2-Oct-17

REF	SCOPE		OPTION 1A $	OPTION 1B $	OPTION 2 $
1	PRELIMINARIES		62,000.00	63,000.00	58,000.00
2	DEMOLITION		Nil	Nil	Nil
3	TEMPORARY WORKS		35,000.00	35,000.00	35,000.00
4	SITE PREPARTION		8,000.00	9,000.00	6,000.00
5	EARTHWORKS		27,000.00	32,000.00	87,000.00
6	RETAINING WALLS		156,000.00	159,000.00	N/A
7	ROCK ARMOUR; RETAINING WALLS		17,000.00	17,000.00	N/A
8	BEACH SCOUR PROTECTION		162,000.00	162,000.00	N/A
9	GEOSYNTHETIC SAND CONTAINERS		N/A	N/A	137,000.00
10	ROCK GROYNE		N/A	N/A	118,000.00
11	LANDSCAPING		5,000.00	5,000.00	3,000.00
12	SUB-TOTAL		472,000.00	482,000.00	444,000.00
13	Regional Loading - Perth Region	1.00	0.00	0.00	0.00
14	**NET CONSTRUCTION COST**		**472,000.00**	**482,000.00**	**444,000.00**
15	Design Contingency	20%	94,000.00	96,000.00	89,000.00
16	Construction Contingency	10%	47,000.00	48,000.00	44,000.00
17	Client Contingency		Excluded	Excluded	Excluded
18	Staging requirements		Excluded	Excluded	Excluded
19	Headworks		N/A	N/A	N/A
20	Land costs		Excluded	Excluded	Excluded
21	Professional fees & disbursements	10%	47,000.00	48,000.00	44,000.00
22	**GROSS PROJECT COST (At current Prices)**		**660,000.00**	**674,000.00**	**621,000.00**
23	Escalation to Tender		Excluded	Excluded	Excluded
24	**ESTIMATED TOTAL COMMITMENT (excl GST)**		**660,000.00**	**674,000.00**	**621,000.00**
25	GST	10%	66,000.00	67,400.00	62,100.00
26	ESTIMATED TOTAL COMMITMENT (Incl GST)		726,000.00	741,400.00	683,100.00

OPTIONS

27 OPTION 1A - Limestone Block Retaining wall
28 OPTION 1B - Geogrid Keystone Block Retaining Wall
29 OPTION 2 - Groynes and Geotextile Sand Container Wall

NORTHBANK FORESHORE, FREMANTLE
FORESHORE RESTORATION WORKS
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PRELIMINARY CONCEPT ESTIMATE REV 1

RBB

SUMMARY

2-Oct-17

REF	SCOPE	OPTION 1A $	OPTION 1B $	OPTION 2 $

NOTES

30 This estimate is based on the following information from GHD:
Sketch drawings:61-35392-SK001 and SK002
GHD provided quantities (ref (Gemma Bertrand's email dated 17-Sep-17)

31 No allowances have been made for the following:
Removal of hazardous material or waste
Client costs and contingency
Financing costs
Escalation
The drainage swale or bridge over
Balustrade to top of retaining walls (understood from GHD not required)

32 This estimate assumes that the works shall be competitively tendered.

33 This estimate assumes that the works will be sourced locally.

34 The estimate assumes that all works (including the rock groynes) will be undertaken by land based plant and equipment.

35 Refer to the main body of the estimates for works included.

Rev 1 Changes

36 Text corrections as per Iain Robinson's email dated 29-Sep-17

37 All rock armour expressed in tonnes (including associated unit rate), as per GHD BQ, converted back from m3, all as per Iain Robinson's email dated 29-Sep-17

38 Option 2 - 50% of bulk excavation to be removed as class III waste

39 Option 2 - minor review of GSC rates

NORTHBANK FORESHORE, FREMANTLE
FORESHORE RESTORATION WORKS
COST PLAN No. 1
PRELIMINARY CONCEPT ESTIMATE REV 1

OPTION 1A - LIMESTONE BLOCK WALLING

2-Oct-17

REF	SCOPE	UNIT	QTY	RATE	SUB-TOTAL	TOTAL
					$	$
	DEMOLITION AND ALTERNATIONS					
1	No allowances	Note				
	TEMPORARY WORKS					
2	Dewatering; allowance	Item	1	25,000.00	25,000.00	
3	Temporary access and removal; allowance	Item	1	10,000.00	10,000.00	
4	Rounding				0.00	35,000.00
	SITE PREPARATION					
5	Site preparation / devegetation; retaining wall	m2	575	10.00	5,750.00	
6	Miscellaneous works	Item	1	2,500.00	2,500.00	
7	Rounding				-250.00	8,000.00
	EARTHWORKS					
8	Excavate and stockpile; retaining wall	m3	730	15.00	10,950.00	
9	Backfill with selected excavated material; behind retaining wall	m3	350	15.00	5,250.00	
10	Disposal for surplus excavated material; off site	m3	380	14.00	5,320.00	
11	Imported sand; spread and level; beach sand	m3	150	35.00	5,250.00	
12	Rounding				230.00	27,000.00
	RETAINING WALLS					
13	250 thick compacted limestone sub-base; retaining wall and steps	m2	205	15.00	3,075.00	
14	Concrete blinding; 25mpa; retaining wall and steps	m3	20	300.00	6,000.00	
15	Limestone retaining wall; 2100 high x 1750 wide at base	m	75	1,706.00	127,950.00	
16	Limestone steps; 350 x 350 blocks	m	24	170.00	4,080.00	
17	Crushed rock aggregate; backfill behind retaining wall; drainage	m3	40	35.00	1,400.00	
18	Texcel 1200R geotextile membrane	m2	300	15.00	4,500.00	
19	Weephole; 50 dia x 1100 long PVC pipe; built into wall; assume at 1000 centres	No	75	50.00	3,750.00	
20	Balustrade to top of retaining wall				Excluded	
21	Balustrade to stair; allowance	Item	1	5,000.00	5,000.00	
22	Rounding				245.00	156,000.00
	ROCK ARMOUR; RETAINING WALL					
23	Rock armour; 250 to 750kg; limestone; retaining wall	t	140	100.00	14,000.00	
24	Texcel 1200 geotextile membrane	m2	225	15.00	3,375.00	
25	Rounding				-375.00	17,000.00
	BEACH SCOUR PROTECTION					
34	Excavate beach sand; class 3	m3	640	15.00	9,600.00	
35	Disposal of class 3 excavated material; off site	m3	640	110.00	70,400.00	
36	Rock armour; 250 to 750kg; limestone	t	680	100.00	68,000.00	
37	Texcel 1200R geotextile membrane	m2	900	15.00	13,500.00	
38	Rounding				500.00	162,000.00

NORTHBANK FORESHORE, FREMANTLE
FORESHORE RESTORATION WORKS
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OPTION 1A - LIMESTONE BLOCK WALLING

2-Oct-17

REF	SCOPE	UNIT	QTY	RATE	SUB-TOTAL	TOTAL
					$	$
	LANDSCAPING					
38	Revegetation; native plants; at top of retaining wall	m2	250	20.00	5,000.00	
39	Rounding				0.00	5,000.00
40	Sub-Total				$	410,000.00
41	General Preliminaries			15%		62,000.00
42	**TO SUMMARY**				**$**	**472,000.00**

NORTHBANK FORESHORE, FREMANTLE
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PRELIMINARY CONCEPT ESTIMATE REV 1

OPTION 1B - GEOGRID KEYSTONE BLOCK RETAINING WALL

2-Oct-17

REF	SCOPE	UNIT	QTY	RATE	SUB-TOTAL	TOTAL
					$	$
	DEMOLITION AND ALTERNATIONS					
43	No allowances	Note				
	TEMPORARY WORKS					
44	Dewatering; allowance	Item	1	25,000.00	25,000.00	
45	Temporary access and removal; allowance	Item	1	10,000.00	10,000.00	
45	Rounding				0.00	35,000.00
	SITE PREPARATION					
46	Site preparation / devegetation; retaining wall	m2	650	10.00	6,500.00	
47	Miscellaneous works	Item	1	2,500.00	2,500.00	
48	Rounding				0.00	9,000.00
	EARTHWORKS					
49	Excavate and stockpile; retaining wall	m3	900	15.00	13,500.00	
50	Backfill with selected excavated material; behind retaining wall	m3	650	15.00	9,750.00	
51	Disposal for surplus excavated material; off site	m3	250	14.00	3,500.00	
52	Imported sand; spread and level; beach sand	m3	150	35.00	5,250.00	
53	Rounding				0.00	32,000.00
	RETAINING WALLS					
54	200 thick compacted limestone sub-base; retaining wall and steps	m2	100	15.00	1,500.00	
55	Concrete blinding; 25mpa; steps	m3	2	300.00	600.00	
56	Concrete footing; retaining wall	m3	8	350.00	2,800.00	
57	Keystone TW3 retaining wall system	m2	158	350.00	55,300.00	
58	Tensar RE500 geogrid	m2	2,100	25.00	52,500.00	
59	Crushed rock aggregate; backfill behind retaining wall; drainage	m3	50	35.00	1,750.00	
60	Texcel 1200R geotextile membrane	m2	2,250	15.00	33,750.00	
61	Weephole; 50 dia x 400 long PVC pipe; built into wall; assume at 1000 centres	No	75	25.00	1,875.00	
62	Limestone steps; 350 x 350 blocks	m	24	170.00	4,080.00	
63	Balustrade to top of retaining wall				Excluded	
64	Balustrade to stair; allowance	Item	1	5,000.00	5,000.00	
65	Rounding				-155.00	159,000.00
	ROCK ARMOUR; RETAINING WALL					
66	Rock armour; 250 to 750kg; limestone; retaining wall	t	140	100.00	14,000.00	
67	Texcel 1200 geotextile membrane	m2	225	15.00	3,375.00	
68	Rounding				-375.00	17,000.00

NORTHBANK FORESHORE, FREMANTLE
FORESHORE RESTORATION WORKS
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OPTION 1B - GEOGRID KEYSTONE BLOCK RETAINING WALL

2-Oct-17

REF	SCOPE	UNIT	QTY	RATE	SUB-TOTAL	TOTAL
					$	$
	BEACH SCOUR PROTECTION					
77	Excavate beach sand; class 3	m3	640	15.00	9,600.00	
78	Disposal of class 3 excavated material; off site	m3	640	110.00	70,400.00	
79	Rock armour; 250 to 750kg; limestone	t	680	100.00	68,000.00	
80	Texcel 1200R geotextile membrane	m2	900	15.00	13,500.00	
81	Rounding				500.00	162,000.00
	LANDSCAPING					
81	Revegetation; native plants; at top of retaining wall	m2	260	20.00	5,200.00	
82	Rounding				-200.00	5,000.00
83	Sub-Total				$	419,000.00
84	General Preliminaries			15%		63,000.00
85	**TO SUMMARY**				**$**	**482,000.00**

NORTHBANK FORESHORE, FREMANTLE
FORESHORE RESTORATION WORKS
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PRELIMINARY CONCEPT ESTIMATE REV 1

OPTION 2 - GROYNES & GEOTEXTILE SAND CONTAINER WALL

2-Oct-17

REF	SCOPE	UNIT	QTY	RATE	SUB-TOTAL	TOTAL
					$	$
	DEMOLITION AND ALTERNATIONS					
86	No allowances	Note				
	TEMPORARY WORKS					
87	Dewatering; minor allowance	Item	1	25,000.00	25,000.00	
88	Temporary access and removal; allowance	Item	1	10,000.00	10,000.00	
88	Rounding				0.00	35,000.00
	SITE PREPARATION					
89	Site preparation and site strip	m2	310	10.00	3,100.00	
90	Miscellaneous works	Item	1	2,500.00	2,500.00	
91	Rounding				400.00	6,000.00
	EXCAVATION					
92	Excavate and stockpile; GSC wall	m3	1,050	15.00	15,750.00	
93	Backfill with selected excavated material	m3	140	15.00	2,100.00	
94	Disposal for surplus excavated material; off site	m3	455	14.00	6,370.00	
95	Disposal of class 3 excavated material; off site	m3	455	110.00	50,050.00	
96	Imported sand; spread and level; beach sand	m3	130	35.00	4,550.00	
97	Supply sand for GSC	m3	520	15.00	7,800.00	
98	Rounding				380.00	87,000.00
	GEOSYNTHETIC SAND CONTAINERS					
99	Concrete blinding; 25mpa; limestone kerb	m3	3	300.00	900.00	
100	Limestone kerb 165 x 300	m	64	100.00	6,400.00	
101	Hire of filling frames; allowance	Item	1	5,000.00	5,000.00	
102	GSC; 0.75m3; vandal proof	No	582	180.00	104,760.00	
103	GSC with scour flaps; 0.75m3; vandal proof	No	48	215.00	10,320.00	
104	Transportation of GSC; ex Landsdale	Item	1	5,000.00	5,000.00	
105	Texcel 1200R geotextile membrane	m2	250	15.00	3,750.00	
106	Anchoring for geotextile membrane	m	64	15.00	960.00	
107	Rounding				-90.00	137,000.00
	ROCK GROYNE					
108	Site preparation	m2	415	20.00	8,300.00	
109	Rock armour 250 to 750kg; limestone; including carefully placing	t	670	125.00	83,750.00	
110	Rock armour 25 to 75kg; limestone	t	190	100.00	19,000.00	
111	Texcel 1200R geotextile membrane	m2	440	15.00	6,600.00	
112	Rounding				350.00	118,000.00
	LANDSCAPING					
113	Revegetation; native plants; area at top of GSC wall; assume 2m wide strip	m2	128	20.00	2,560.00	
114	Rounding				440.00	3,000.00
115	Sub-Total				$	386,000.00
116	General Preliminaries			15%		58,000.00
117	**TO SUMMARY**				**$**	**444,000.00**

Appendix E - Full MCA Results

Table 7-1 Full Multi Criteria Analysis Results

			Raw Score					Normalised Score							
	Decision Criteria	Units	1A – Block wall – River Alignment	1B – Block wall – River Alignment – with Rock Beach	2A– Block wall – Land Alignment	2B– Block wall – Land Alignment – with Rock Beach Stabilisation	3 – Rock Groynes & Geotextile Sand Container Wall	1A – Block wall – River Alignment	1B – Block wall – River Alignment – with Rock Beach Stabilisation	2A– Block wall – Land Alignment	2B– Block wall – Land Alignment – with Rock Beach Stabilisation	3 – Rock Groynes & Geotextile Sand Container Wall	Criteria Weight		
Community	Community Preference	%	18%	3%	16%	7%	67%	24	0	20	6	100	**0.100**	0.100	Community
	Land Area	m2	500	500	300	300	150	100	100	43	43	0	**0.023**		
	Beach Area	m2	0	300	200	545	400	0	55	37	100	73	**0.023**		
Amenity	Access to and from water	0 or 1 (1 is better access)	0	0	0	0	1	0	0	0	0	100	**0.045**	0.090	Amenity
	Soil treatment	Excess Cut Material (m3)	0	640	370	1010	1100	0	58	34	92	100	**0.135**		
	Structural Footprint	m2	28	330	25	330	560	99	43	100	44	0	**0.045**		
Environment	River Processes	0 to 1 (1 is higher impact)	0	0.5	0	0.5	1	100	50	100	50	0	**0.000**	0.180	Environment
	Beach Stability	0 or 1 (1 is more stable beach)	0	0.5	0	0.5	1	0	50	0	50	100	**0.135**		
Feasibility	Design Life	years	50	50	50	50	25	100	100	100	100	0	**0.135**	0.270	Feasibility
	Implementation cost (upper)	$100k	600	1200	750	1400	1400	100	25	81	0	0	**0.180**		
Cost	Beach Maintenance Cost	$100k	0	200	200	100	250	100	20	20	60	0	**0.180**	0.360	Cost
						Raw Sum		624.1	501.6	534.8	544.7	473.4	**1.00**		
						Weighted SUM		58.7	41.6	44.6	49.2	43.2			
						Rank		**1**	**5**	**3**	**2**	**4**			

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https://projects.ghd.com/oc/WesternAustralia/northbankforeshorest/Delivery/Documents/6135392-REP-2-Foreshore Stabilisation Plan.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	CY Chen G Bertrand	S Hosseini	On file	S Hosseini	On file	
B	S Chapman I Robinson R Walker G Bertrand	C Hart L Cockerton	On file	F Bicker	On file	13/04/2018
0	G Bertrand	S Hosseini	On file	S Hosseini	On file	22/06/2018
1	J Lee	G Bertrand	On file	S Hosseini	On file	16/08/2018
2	C Hart	S Hosseini		S Hosseini		04/09/2018

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