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# Technical Note

Date: 8/9/2021

Client: Kingston District Council

Subject: Wyomi Beach – Seawall Versus Managed Retreat Adaptation Pathway

## Executive Summary

**Study Purpose**
The recently completed Kingston Coastal Adaptation Plan (CAP) identified that multiple assets at Wyomi Beach are at risk from coastal erosion now and into the future. The following Technical Note compares managed retreat against a staged seawall (defend) approach to manage erosion risks in the Wyomi Beach area, with a specific focus on the financial implications of these adaptation pathways.

**Pathways considered**
Several adaptation pathways have been considered, including staged seawalls (with and without nourishment), managed retreat and a hybrid option (maintain a seawall in the center of the Wyomi Beach area with retreat to the north and south). The adaptation pathways are grouped under two streams, those that:

1. *Result in loss of beaches*, including seawall without nourishment and the hybrid option.
2. *Maintain beaches*, including managed retreat and seawall with nourishment.

**Key findings**
Pathways resulting in significant loss of beaches:

- The seawall adaptation pathway is the lowest cost option at -$4.6M NPV. Per lineal meter of coastline, it is generally cheaper to protect assets with a seawall than by purchasing properties and retreating.
- The hybrid pathway is approximately $2.6M more expensive (-$7.2M NPV) when compared to the seawall pathway.

Pathways that maintain beaches:

- The managed retreat adaptation pathway is the lowest cost option at approximately -$15M NPV.
- Given the severity of erosion at the site and anticipated future climate change impacts, maintaining a beach in front of a seawall is significantly more expensive than managed retreat, at a cost of approximately -$30M NPV.

**Recommendations**
It is recommended that:

- The results of this study are incorporated into the Coastal Adaptation Plan, so that these financial outcomes are considered alongside factors such as environmental impact and community/social acceptability.
- The benefits and costs of the adaptation pathways should be discussed with the community to determine the level of community acceptability, with a particular focus on the potential loss of beaches vs the retreat of properties and other assets.

# 1 Introduction

## 1.1. Background

In March 2021, Wavelength Consulting Pty Ltd (Wavelength) completed the Kingston Coastal Adaptation Plan (CAP) for the coastline from Cape Jaffa to Blackford Drain (Figure 1). The CAP recommends specific priority adaptation pathways considering economic, environmental and community factors (Wavelength, 2021a).

A key recommendation of the CAP was to further assess the viability of a managed retreat pathway against a staged seawall (defend) approach to manage erosion risks in Section 4, Wyomi Beach (Figure 1).

Kingston District Council (KDC) engaged Wavelength to undertake the investigations into the retreat versus seawall pathways, which have been summarised in this Technical Note.

## 1.2. Objectives

The key objective of the study is to develop adaptation pathways for the retreat and the seawall (defend) options, including Order of Magnitude (OOM) costs for input to the over-arching CAP Multi Criteria Assessment (MCA).

## 1.3. Approach

The intent is for this Technical Note to be attached to the Kingston CAP report, with the CAP MCA updated for community consultation purposes.

This Technical Note is structured as follows:

1. Section 2- Identification of coastal structures, key infrastructure and assets that are expected to be impacted by coastal erosion in the Wyomi area.

2. Section 3- Staging and long-term costs for adaptation pathways, including:

    - **Seawall pathway,** including consideration of on-going costs for repairs and upgrades to accommodate future Sea Level Rise (SLR).
    - **Retreat pathway**, including consideration of removal, relocation and property access.
    - **Hybrid pathway**, a combination of the above approaches

3. Section 4 – Assessment of beach nourishment costs to maintain beaches for amenity purposes.

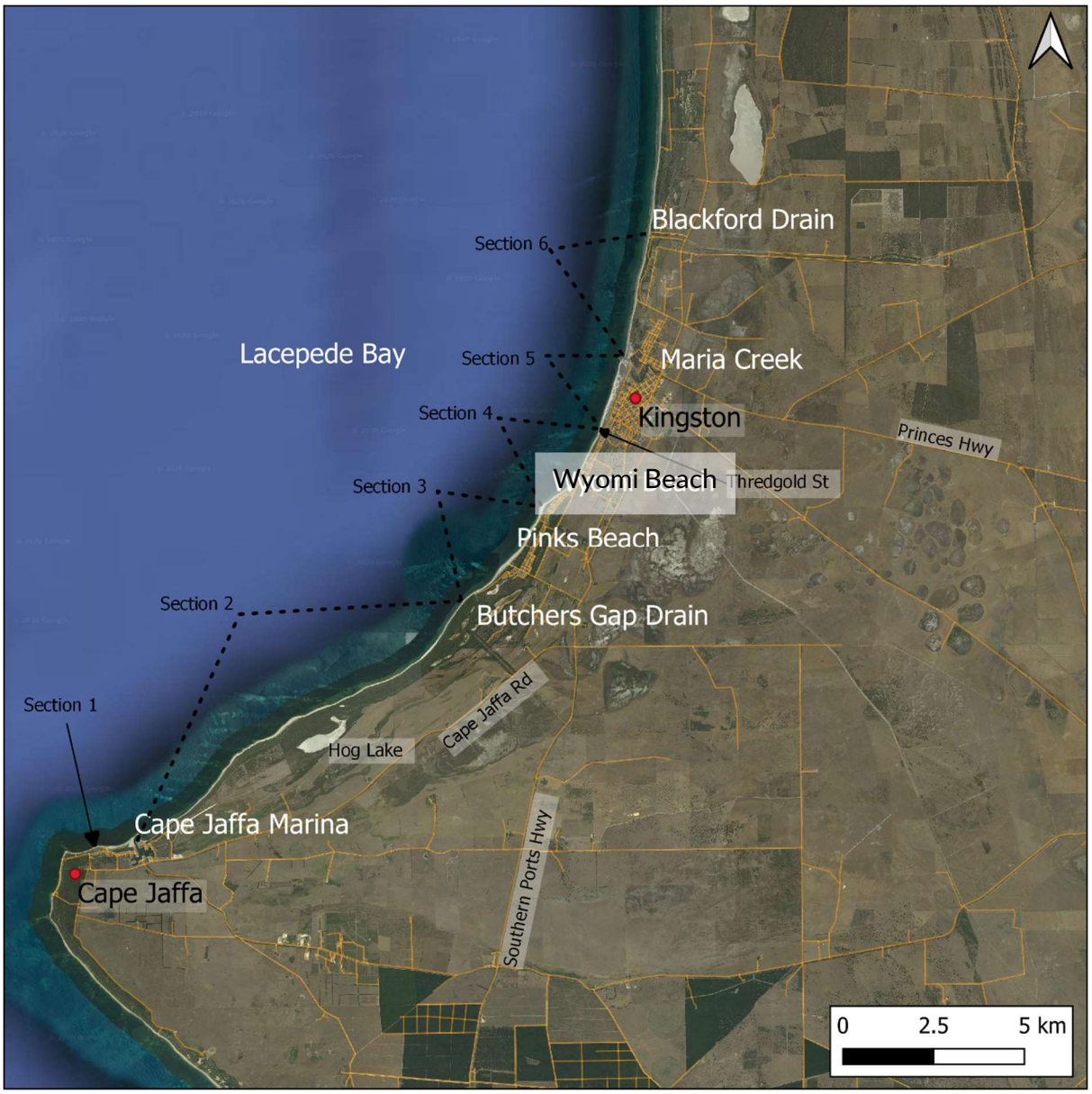


**Figure 1: Kingston CAP Extent**

# 2 Site Setting and Assets at Risk

## 2.1. Site Setting

Wyomi Beach is located approximately 2.5km south-west of the Kingston township (Section 4 on Figure 1). Over the last two decades ongoing erosion has resulted in the loss of approximately 10 to 15m of dune width, damaging paths and threatening Marine Parade.

Previous work by Wavelength and others suggest that Wyomi Beach is particularly sensitive to storm erosion, as outlined below:

- Sand moves from south to north along the coast in this area, with an estimated transport rate of 30,000 to 50,000 $m^3$ per year (Wavelength, 2020a), as shown in Figure 2. From March 2016 to October 2018, it was estimated that a total volume of approximately 100,000 $m^3$ was lost from the Wyomi beach area, which is approximately 40,000 $m^3$ per year (Wavelength, 2020a).
- Analysis of the DEW beach profile 715008 (shown in Figure 2), shows the largest erosion recorded since 2005 was between March-2016 and May-2017, with approximately 10 to 15m of dune width lost (Wavelength, 2020b). Most of this erosion is likely to have occurred during a large storm event between 10$^{th}$ and 13$^{th}$ July 2016.
- Further analysis of the DEW profile suggests sand is lost at a rate of **approximately 15 $m^3$/m** in a year with relatively few storms and **up to 45 $m^3$/m** in a year with several large storms, such as 2016 (Wavelength, 2021b).
- Recent analysis of the Wyomi nourishment area by Flinders University (Coote et al, 2019) suggests that the longshore transport rate can increase by a factor of 27 during storm conditions. Therefore, 2 days of storm conditions may contribute up to 15% of the annual transport (Coote et al, 2019).

## 2.2. Existing Coastal Management

In recent years, KDC has constructed several seawall structures to protect assets at Wyomi Beach, including two temporary Geotextile Sand Container (GSC) seawalls and one rock seawall (refer Figure 2).

The rock seawall design drawings are presented in Appendix A, which show that the seawall has a design armour size of 1.1t granite rock.

Whilst longer term adaptation pathways were being developed, nourishment was selected by KDC as the preferred short-term management approach at Wyomi Beach. Two nourishment campaigns have been completed in recent years:

- In May/June 2020, KDC placed 13,000 $m^3$ nourishment to the north and south of the rock seawall.
- In May 2021, KDC placed approximately 9,000 $m^3$, with an additional 2,000 $m^3$ planned for July 2021.

Further discussion on the effectiveness of this nourishment is presented in Section 4.


**Figure 2: Section 4 extent with coastal protection structures and nourishment**

**Table 1: Existing coastal protection structure details**

| Location | Structure Description | Date constructed | Approximate Length (m) |
|---|---|---|---|
| **North** | North 2.5m$^3$ GSC seawall | April 2019 | 72 |
| | North ad hoc rock seawall | Mid 2018 | 22 |
| **Centre** | Centre rock seawall | April – May 2018 | 395 |
| **South** | South 0.75m$^3$ GSC seawall | April 2019[1] | 28 |
| | South 2.5m$^3$ GSC seawall | April 2019 | 72 |

Notes: 1. Original 0.75m$^3$ GSC seawall constructed post July-2016 and upgraded with a top row of 2.5m$^3$ GSCs in April 2019.

## 2.3. Assets at Risk of Erosion

The *Kingston CAP Erosion and Inundation Mapping Technical Note* (Wavelength, 2021c) outlines the key inputs to development of the erosion hazard lines, identifying assets at risk for the following planning horizons:

- Present day
- 2050
- 2100

An intermediate 2070 erosion scenario has also been included in this technical note to allow better definition of the adaptation pathways.

The erosion allowances to develop the erosion hazard lines are summarised below:

- **S1 erosion allowance** – A present day storm erosion allowance of 16m based on SBEACH modelling presented in Wavelength (2021c).
- **S2 erosion allowance** – On-going erosion rate of approximately 1m/yr based on historical shoreline movements (Wavelength, 2021c).
- **S3 erosion allowance -** A bruun factor of 50 (BR50) was calculated based on beach profiles. This was applied to the following Sea Leve Rise (SLR) values.
    - 2050 = 0.3m SLR
    - 2070 = 0.6m SLR
    - 2100 = 1m SLR

These allowances have been combined for the four scenarios, giving the Possible Zone of Recession (ZR) presented in

Table 2. The Possible ZR lines have been presented for the four scenarios in Figure 3. Given retreat is one of the adaptation pathways investigated, the hazard lines have been developed assuming no coastal protection structures or management are in place.

The Possible ZR is not a prediction of the future shoreline recession, instead indicating a risk of erosion that is likely to be intolerable when the asset or property line is seaward of the hazard line.

The hazard lines presented in Figure 3 were used to determine assets at risk, which are presented in Appendix B.

**Table 2: Summary of setback allowances and assets at risk**

| Scenarios | Possible Zone of Recession (m) | | | |
|---|---|---|---|---|
| | **S1** | **S2** | **S3** | **Total** |
| **Present Day** | 16 | - | | **16** |
| **2050** | | 30 | 15 | **61** |
| **2070** | | 50 | 30 | **96** |
| **2100** | | 80 | 50 | **146** |

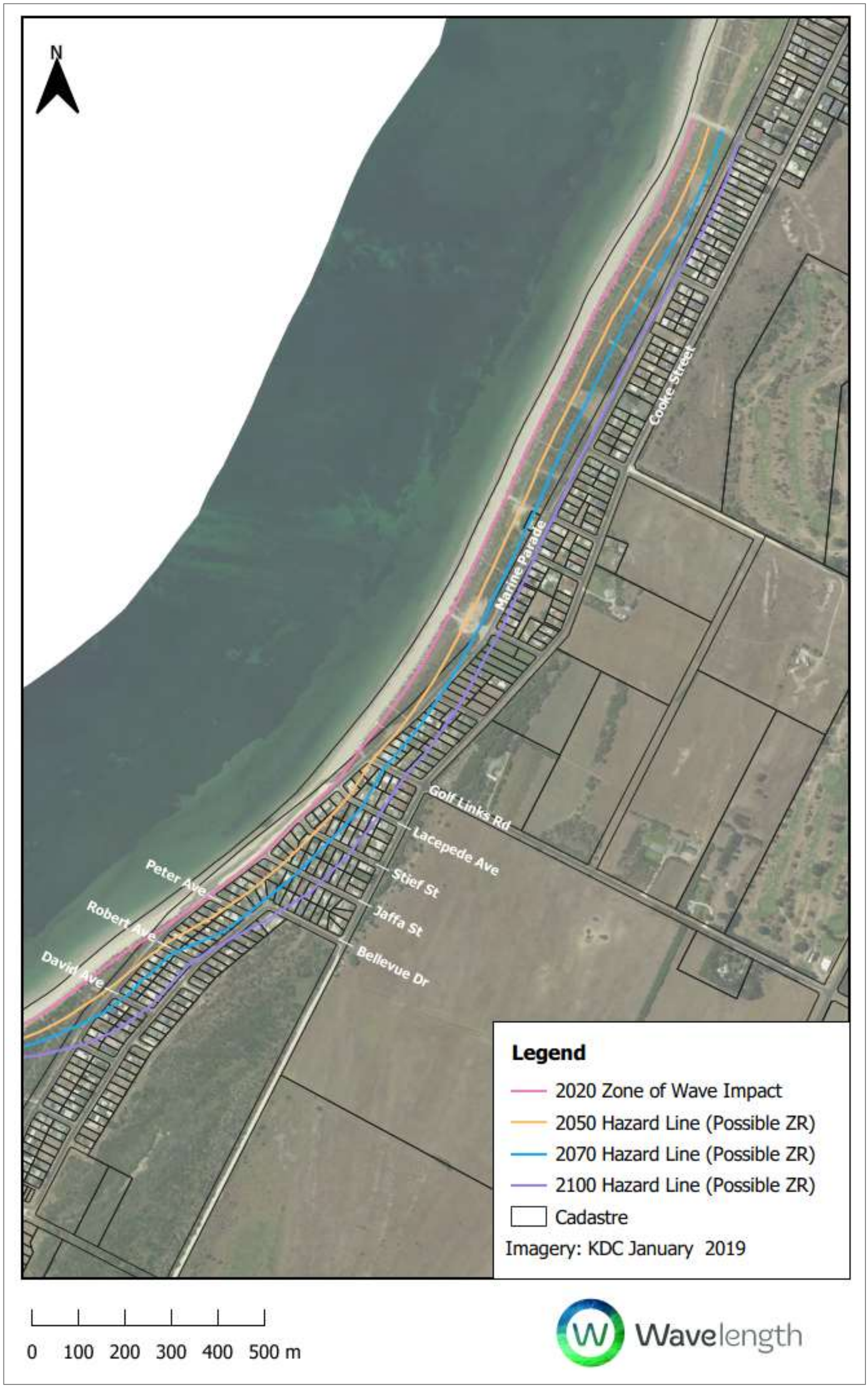


**Figure 3: Section 4 Erosion Hazard Lines**

# 3 Adaptation Pathways

## 3.1. Objective

The primary objective of the two adaptation pathways, as defined in the SA Local Government Association (LGA) *Coastal Adaptation Guidelines* (SA LGA 2020), are below:

- **Defend (Seawall)** - Install protection or defense infrastructure that reduces the impact of coastal hazards, especially during extreme events such as storm surge; and
- **Managed Retreat** – Progressively move assets or services away from areas that could be impacted by coastal hazards now or in the future.

## 3.2. Approach

The adaptation pathways have been investigated as below:

1. Development of staging plans and pathways.
2. Calculation of Order of Magnitude capital and on-going costs.

Further detail on these steps is provided below, with findings presented in Sections 3.3.

**Staging Plans**

In conjunction with the erosion hazard lines (Figure 3) to guide the timing of implementation, the following general guidelines have been used to develop staging plans:

- **Seawall** (presented in Appendix C):
    - Rock seawalls are extended along the coast to protect assets before risk becomes intolerable.
    - The seawall alignment sits as landward as possible to reduce impacts on coastal processes and to defer/delay construction as much as possible.
    - Smaller assets or assets at the end of their design life that can be readily relocated behind the seawall alignment, such as the footpath and Sailing Club, are assumed to be relocated (rather than the seawall protecting their current location).
    - The armour size and crest level for the new seawall stages increase over time to accommodate SLR.
    - Existing seawall armour size and crest levels are upgraded to account for SLR over time.
- **Managed Retreat** (presented in Appendix D):
    - The existing rock seawall and GSC seawalls are removed to allow the natural coastal processes to continue unimpeded.
    - Affected private properties are acquired/purchased and demolished, with the land remediated to allow natural erosive processes to continue.
    - The following assets are removed and relocated:
        - Pathways to allow continued foreshore access.
        - Telstra Cable.
        - Sailing Club (assumed demolished and moved at the end of its useful life).
        - Sewer along Marine Parade.
    - Affected roads are removed, while maintaining continued access to properties where possible. Where alternative access can't be provided to a property, the property is acquired/purchased at the time the road is removed.
- **Hybrid** (presented in Appendix E):

- A hybrid pathway combining key elements of the seawall and managed retreat pathways has also been investigated.
- Under this option, a group of assets (those likely to be at most risk by 2050) are protected by the seawall pathway:
    - The existing rock seawall is maintained and upgraded as required.
    - The existing seawall is extended to the north and south to protect the most at-risk properties, optimising for seawall length.
    - Seawall returns are built to the north and south of the seawall to prevent end scour and erosion behind the seawall.
- Other assets outside the protection of this seawall are managed under the retreat pathway guidelines, outlined above.

**Net Present Value Calculations**
Order of magnitude capital and recurrent maintenance cost estimates for the adaptation pathways have been estimated. These costs are then taken as inputs to a Net Present Value (NPV) analysis. NPV analysis provides an indication of the relative costs of the pathways over time, considering capital and on-going costs.

Importantly in NPV analyses, costs that are incurred later, have a reduced value in present day dollars. Therefore, the above staging plans have attempted to optimise the NPV of each pathway, deferring costs until required.

The cost estimates presented are to be used as a guide only, detailed costings should be developed following selection of an option for detailed design and implementation. Key assumptions related to each pathway are summarised in Section 3.4, with the full NPV cost breakdowns presented in Appendices F to H.

## 3.3. Key findings

NPV results are presented in Table 3 and Figure 4, with the key findings summarised below:

- Per lineal meter of coastline, it is generally cheaper to manage erosion risks with a seawall than by retreat.
- The seawall pathway has the lowest overall cost at -$4.6M NPV.
- The hybrid pathway has the lowest cost to 2030. However, by 2050 it is equal to the seawall pathway (~-$3.9M NPV) and by 2100 is more expensive by approximately $0.7M (-$5.3M NPV).
- The managed retreat pathway is the most expensive pathway, at -$12M NPV to 2030 and -$15.1M NPV to 2100.
- Importantly, managed retreat is the only pathway that maintains a beach along the full length of the Wyomi coastline, with the beach width lost for the other options (refer Section 4 for more details on maintaining beaches).

**Table 3: Adaptation Pathway NPV Results**

| | Adaptation Pathway | | |
|---|---|---|---|
| | **Seawall** | **Managed Retreat** | **Hybrid** |
| **2030** | -$2,350,000 | -$11,840,000 | -$4,400,000 |
| **2050** | -$3,940,000 | -$13,240,000 | -$5,920,000 |
| **2070** | -$4,190,000 | -$14,320,000 | -$6,630,000 |
| **2100** | -$4,590,000 | -$15,060,000 | -$7,240,000 |

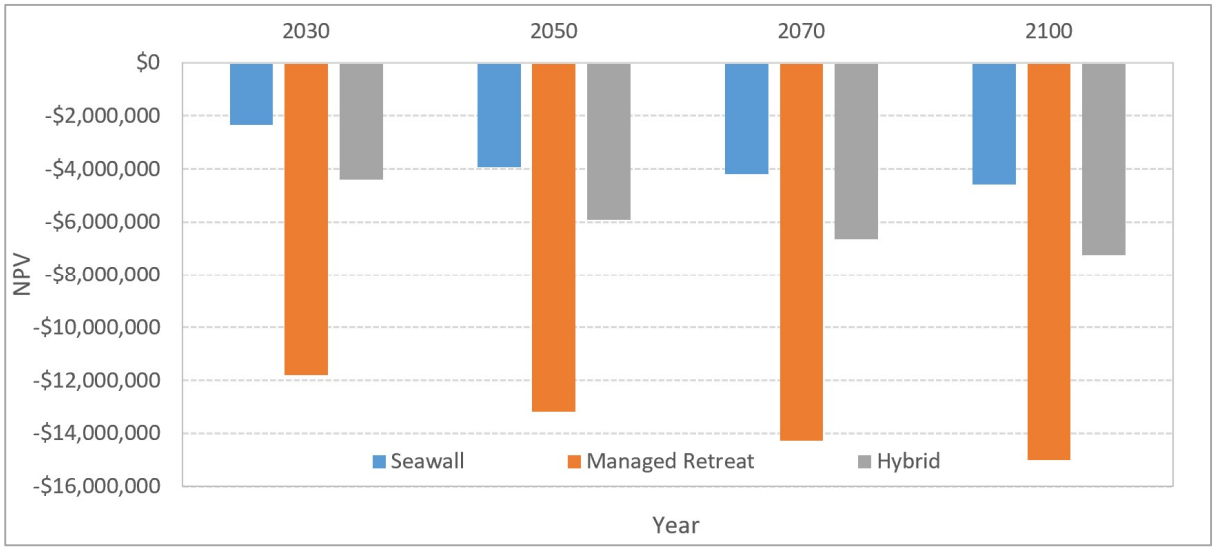


**Figure 4: Adaptation Pathway NPV Results**

## 3.4. Staging and NPV Assumptions

**NPV analysis:**

- A discount rate of 5% was used in the NPV calculations.
- NPV calculations were prepared over the full 80 years to the end of the 2100 scenario. This provides an indication of the relative costs of the pathways over the longer term.

Costings are based on 2021 value and costs. These costings are reflective of a point in time and given the timeframes for implementation are unknown, costings will need to be revised prior to commencing works.

**Seawall Staging:**

- The timing and description of the new seawall staging works, upgrades and repairs are presented in Table 4.
- The seawall staging plans are presented in Appendix C, with the full seawall staging NPV analysis results presented in Appendix F.
- **Seawall armour size and crest levels (next page):**

- With 0.3m SLR to 2050, wave conditions are expected to cause the existing 1.1t armour on the existing seawall to fail (CRESS, 2018), requiring 4t armour to remain stable in the 1% Annual Exceedance Probability (AEP) storm event.
- Overtopping is anticipated to become critical by 2070, requiring the crest height to be increased by 1.1m to +4.8 mAHD.

- **Seawall repairs:**
  - Seawall repairs are required approximately every 20 years and are assumed to involve replacing ~5% and repositioning ~20% of the armour rocks.
- **Seawall rates:**
  - Seawall construction costs, including upgrades and repairs, are based on recent supply and placement rates from a local contractor (pers comm. John Clarke ). This contractor has recent local knowledge of the seawall construction costs, having recently constructed the existing rock seawall in 2018.

**Managed Retreat Staging:**

- The managed retreat pathway plans are presented in Appendix D, with the full NPV analysis results presented in Appendix G.
- **Property Rates:**
  - The Improved Value of private properties (i.e. combined land and house value) and the Sailing Club have been provided by KDC and adopted as the acquisition/purchase price for the private properties in the retreat NPV analysis.
  - The retreat of properties with houses includes demolition and site remediation cost of $12,000 per house based on online demolition quotes (Oneflare, 2021).
- **Pathways and roads:**
  - Pathway and road removal and reconstruction rates have been based on recent Town Centre works provided by KDC:
    - Pathway removal at a cost of $78 per lineal m, assuming a 2m wide and 0.2m thick path.
    - Pathway reconstruction of $80 per lineal m.
    - Road removal at a cost of $630 per lineal m, assuming an 8m wide and 0.5m thick asphalt road, sub-base and sub-grade.
- **Services:**
  - KDC did not have any recent rates for relocation of services. The following were assumed in this estimate:
    - Telstra cable relocation cost of $200,000. This would need to be confirmed if the retreat pathway was preferred.
    - The sewer and pump station along the road are assumed to require replacement in the coming 30 to 50 years, at which stage they should be relocated away from the coast. As such, the cost of replacing these services has not been included in the NPV.

**Hybrid Staging:**

- The timing and description of the new seawall staging works, upgrades and repairs are presented in Table 5.
- The hybrid pathway plans are presented in Appendix E, with the full NPV analysis results presented in Appendix H.
- The hybrid pathway uses the seawall construction and retreat rates outlined in the previous sections.

**Table 4: Seawall Staging Summary**

| Indicative Timeframe | Description of Seawall Works | | |
|---|---|---|---|
| | **New Seawall Stage** | **Upgrade** | **Repairs** |
| **2023** | Remove existing GSC seawalls and ad-hoc rock seawall & Construct **Stage 2 Seawall** (North 110m, South 160m)<br>1.1t armour | - | - |
| **2030** | Construct **Stage 3 Seawall** (north 120m, south 100m)<br>1.1t armour | - | Repair Stages 1 & 2<br>665m |
| **2050** | Construct **Stage 4 Seawall** (north 140m, south 180m)<br>4t armour | Upgrade armour to 4t Stages 1 to 3<br>885m | Repair Stages 1 to 3<br>885m |
| **2070** | - | Upgrade crest Stages 1 to 4 to +4.8 mAHD<br>1,205m | Repair Stages 1 to 4<br>1,205m |
| **2090** | Construct **Stage 5 Seawall** (north 460m +560m)<br>4t armour and +4.8mAHD crest | - | Repair Stages 1 to 5<br>1,820m |

**Table 5: Hybrid Staging Summary**

| Indicative Timeframe | Description of Seawall Works | | |
|---|---|---|---|
| | **New Seawall Stage** | **Upgrade** | **Repairs** |
| **2023** | Remove existing GSC seawalls and ad-hoc rock seawall & Construct **Stage 2 Seawall** (North 110m, South 220m)<br>1.1t armour | - | - |
| **2030** | - | - | Repair Stages 1 & 2<br>725m |
| **2050** | Construct seawall returns (North 25m and South 25m)<br>4t armour | Upgrade armour to 4t Stages 1 to 2<br>725m | Repair Stages 1 to 3<br>725m |
| **2070** | Construct seawall returns (North 35m and South 35m)<br>4t armour | Upgrade crest Stages 1 to 2 to +4.8 mAHD<br>845m | Repair Stages 1 to 4<br>775m |
| **2085** | Construct 4t and 4.8 mAHD crest seawall returns (north and south) | - | Repair Stages 1 to 5<br>845m |

# 4 Beach Amenity and Nourishment

## 4.1. Objective

Consultation with Kingston community members has revealed that the beach is highly valued for its amenity value, including:

- Beach access and swimming
- Boat launching
- Walking and driving along an uninterrupted stretch of beach

A key difference between the two primary adaptation pathways (seawall and retreat) is the resultant impact on the coastal processes and beach widths following their implementation:

- **Seawalls** - on an eroding coastline, beaches in front and downdrift from seawalls will tend to narrow and disappear over time.
- **Managed Retreat** – the retreat pathway has less impact on coastal processes, allowing the beach and dune to continue to erode naturally, maintaining a beach over time.

A beach may be maintained in front of the seawall through beach nourishment; however nourishment can be expensive and is often required to be maintained on a regular basis. Given the importance of beach amenity, the following section investigates the beach nourishment costs to maintain a beach in front of the seawall for input to the CAP MCA for Section 4.

## 4.2. Approach

The following steps were undertaken to assess the potential beach nourishment volumes at Wyomi:

1. Review of previous beach nourishment effectiveness.
2. Assessment of future beach nourishment volumes.

**Previous Nourishment Campaigns**

In May 2020 approximately 13,000 $m^3$ of beach nourishment was sourced adjacent to the Kingston Jetty and placed to the north and south of the existing rock seawall. A review of the 2020 nourishment effectiveness and 2021 nourishment design is presented in Wavelength (2021b). Overall, the 2020 nourishment campaign achieved the overarching objectives of the campaign:

1. Assets and dunes to the north and south of the existing rock seawall were protected over the winter period.
2. Beach widths in front of the rock seawall were maintained, improving beach amenity and access.
3. No additional erosion beyond previous extents.

Nourishment loss rates were at the upper end of predictions, in the order of **35 $m^3$ per m**, more than twice the longer-term erosion rate of 15 $m^3$ per m.

Limited information is available on the storminess of the 2020 winter season and the sand was placed adjacent to the seawalls (to protect assets) rather than in front of the seawalls.

**Future Nourishment Campaigns**

Predicting future beach nourishment volumes can be difficult, as it is dependent on several factors, including:

- The severity of storms experienced, affecting longshore and cross-shore transport of beach nourishment.

- The size of the nourishment sand grain size, with a smaller sediment size being lost faster than coarser material.
- The length of seawall constructed and end scour at the end of the seawall.
- Future SLR, including:
    - a general increase in mean sea level will result in a narrowing of beach widths directly from inundation, requiring a significant amount of sand to maintain beach levels.
    - an increase in wave energy, resulting in increased transport potential
    - potential changes in wave directions, which may lead to increased erosion from longshore transport.

These factors were considered in the development of future nourishment volumes and were input to the NPV analysis (full analysis presented in Appendix I), with key assumptions outlined further in Section 4.4. This allows comparison of the seawall pathway with nourishment, against the pathways discussed in Section 3 (managed retreat, seawall without nourishment and the hybrid option).

### 4.3. Key findings

NPV results are presented in Table 6 and Figure 5, with the key findings summarised below:

- Managed retreat is the cheaper pathway for maintaining beach widths at Wyomi compared to a seawall with nourishment.
- By 2100, approximately 200,000 $m^3$ of sand nourishment could be required to maintain beach widths at Wyomi. The seawall with nourishment cost to 2100 is approximately -$30M NPV, which is twice the amount of the managed retreat pathway (-$15M NPV).

**Table 6: Beach Nourishment NPV Results**

| | **Adaptation Pathway** | | |
|---|---|---|---|
| | **Nourished Seawall** | | **Managed Retreat** |
| | **Nourishment Volumes ($m^3$ per year)** | **NPV** | **NPV** |
| **2021** | 21,000 | -$330,000 | - |
| **2030** | 57,000 | -$6,900,000 | -$11,840,000 |
| **2050** | 128,000 | -$17,700,000 | -$13,240,000 |
| **2070** | 155,000 | -$24,920,000 | -$14,320,000 |
| **2100** | 197,000 | -$29,280,000 | -$15,060,000 |

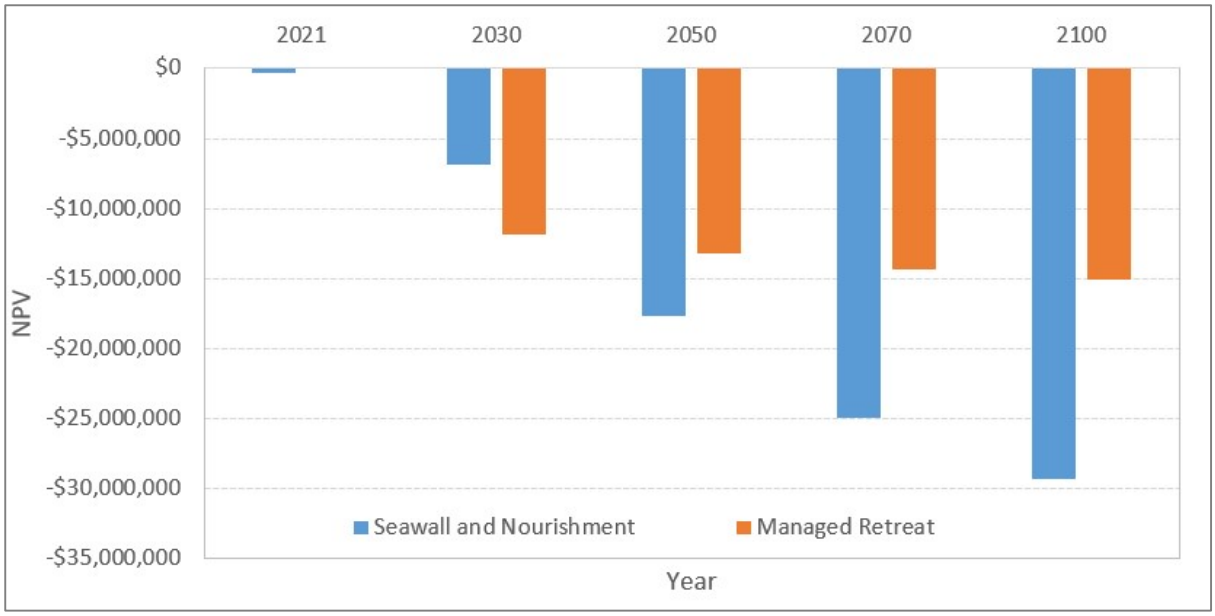


**Figure 5: Beach Nourishment NPV Results**

The nourishment volumes should be considered order of magnitude only, to be used as a guide for planning purposes. Detailed shoreline evolution modelling would be worth considering should the increased confidence of future nourishment volumes be required.

## 4.4. NPV Assumptions

NPV calculation inputs are summarised in Section 3.4.

**Nourishment Volumes**

The following was assumed in the development of the nourishment volumes:

- From 2021, a minimum 35 $m^3$ per lineal m is placed in front of the seawall and extending 200m to the north of the seawall (i.e. end scour location).
- Sand is sourced from the jetty area, with a similar grain size to the 2020 campaign.
- Once every 20 years, a significant storm event occurs, such as the 2016 event, requiring placement of an additional 55 $m^3$ per m (=(2x 45) - 35) to account for a significant loss of sand.
- The base nourishment volume increases by a factor of 4 from 35 to 140 $m^3$ per m due to 1m SLR to 2100, as below:
    - SLR Inundation - Volume estimates suggest an additional 70 $m^3$ per m needs to be placed to maintain beach widths at the same level with 1m SLR.
    - Increase in wave energy and potential longshore transport of an additional 35 $m^3$ per m.

**Nourishment Rates**

- A nourishment rate of $16 per $m^3$ has been used based on 2020 and 2021 contract rates. This assumes sand is continued to be sourced and backpassed from the Kingston Jetty area.

**Seawall**

- Maintaining a beach in front of the seawall is likely to maintain the same design wave conditions into the future (i.e. the nourishment will counter SLR). Therefore, the existing armour size of 1.1t is assumed for future seawall stages.
- A +4.8 mAHD crest is still required by 2070 with nourishment.

  It is assumed that the Stage 5 seawall (2090) is still required, however on-going nourishment in the earlier part of the century may reduce erosion rates in this northern area.

# 5 Key Findings and Recommendation

Wyomi Beach has experienced significant coastal erosion, which is expected to continue with multiple assets at risk of erosion to 2100.

Several adaptation pathways have been considered, including staged seawalls (with and without nourishment), managed retreat and a hybrid option (maintain a seawall in the center of the Wyomi Beach area with retreat to the north and south). The adaptation pathways are grouped under two streams, those that:

- *Result in loss of beaches*, including seawall without nourishment and the hybrid option.
- *Maintain beaches*, including managed retreat and seawall with nourishment.

**Key findings**

- Pathways resulting in significant loss of beaches:
    - The seawall adaptation pathway is the lowest cost option at -$4.6M NPV. Per lineal meter of coastline, it is generally cheaper to protect assets with a seawall than by purchasing properties and retreating.
    - The hybrid pathway is approximately $2.6M more expensive (-$7.2M NPV) when compared to the seawall pathway.
- Pathways that maintain beaches:
    - The managed retreat adaptation pathway is the lowest cost option at approximately -$15M NPV.
    - Given the severity of erosion at the site and anticipated future climate change impacts, maintaining a beach in front of a seawall is significantly more expensive than managed retreat, at a cost of approximately -$30M NPV.

It is recommended that:

- The results of this study are incorporated into the Coastal Adaptation Plan, so that these financial outcomes are considered alongside factors such as environmental impact and community/social acceptability.
- The benefits and costs of the adaptation pathways should be discussed with the community to determine the level of community acceptability, with a particular focus on the potential loss of beaches vs the retreat of properties and other assets.

# 6 References

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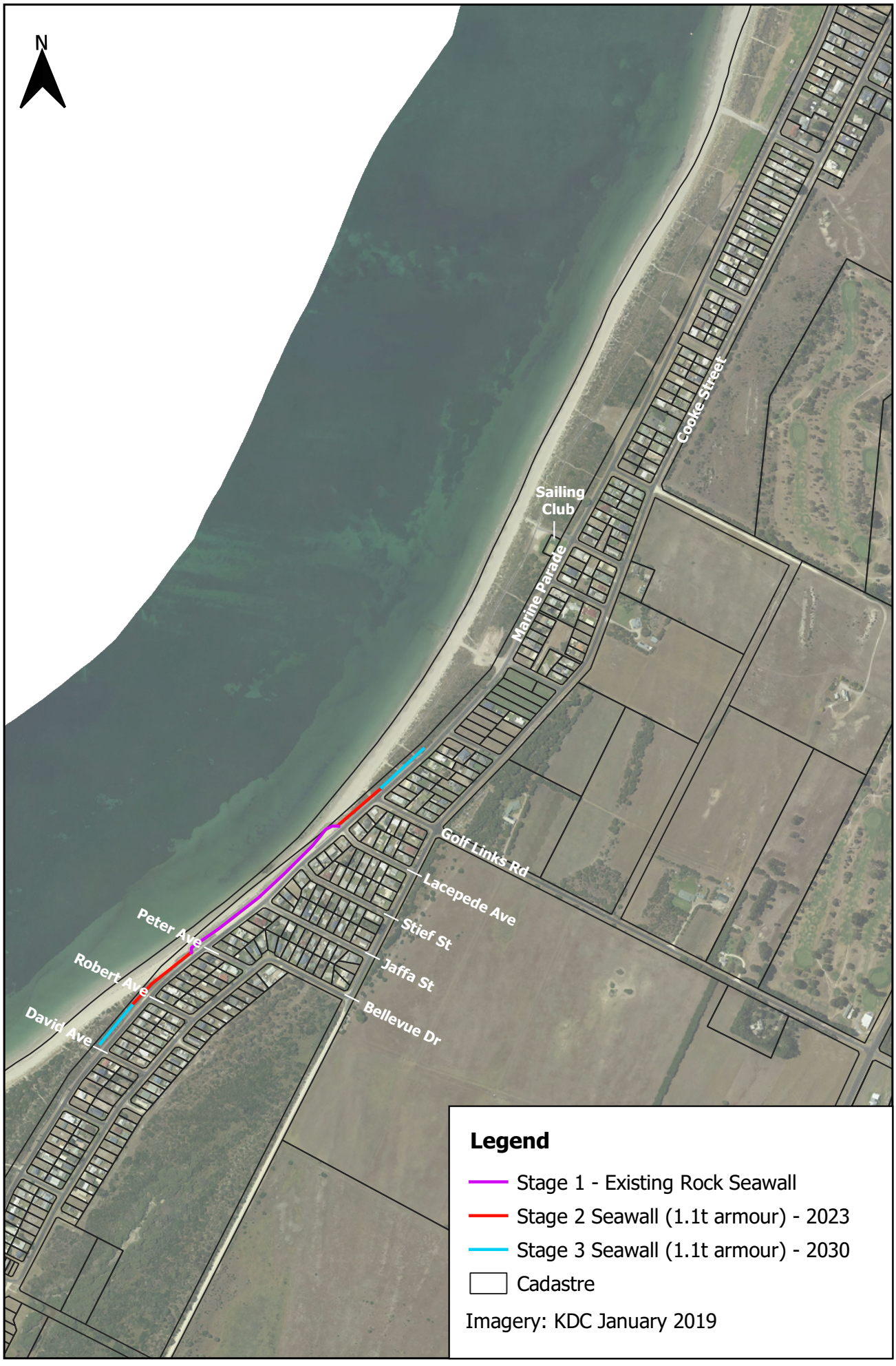
Wavelength, 2021c. Kingston Coastal Adaptation Plan – erosion and inundation mapping calculations Technical Note, prepared for Kingston District Council.

# Appendix A Existing Rock Seawall Design Drawings

## Appendix B Section 4 Coastal erosion risk profiles (assuming no coastal protection)

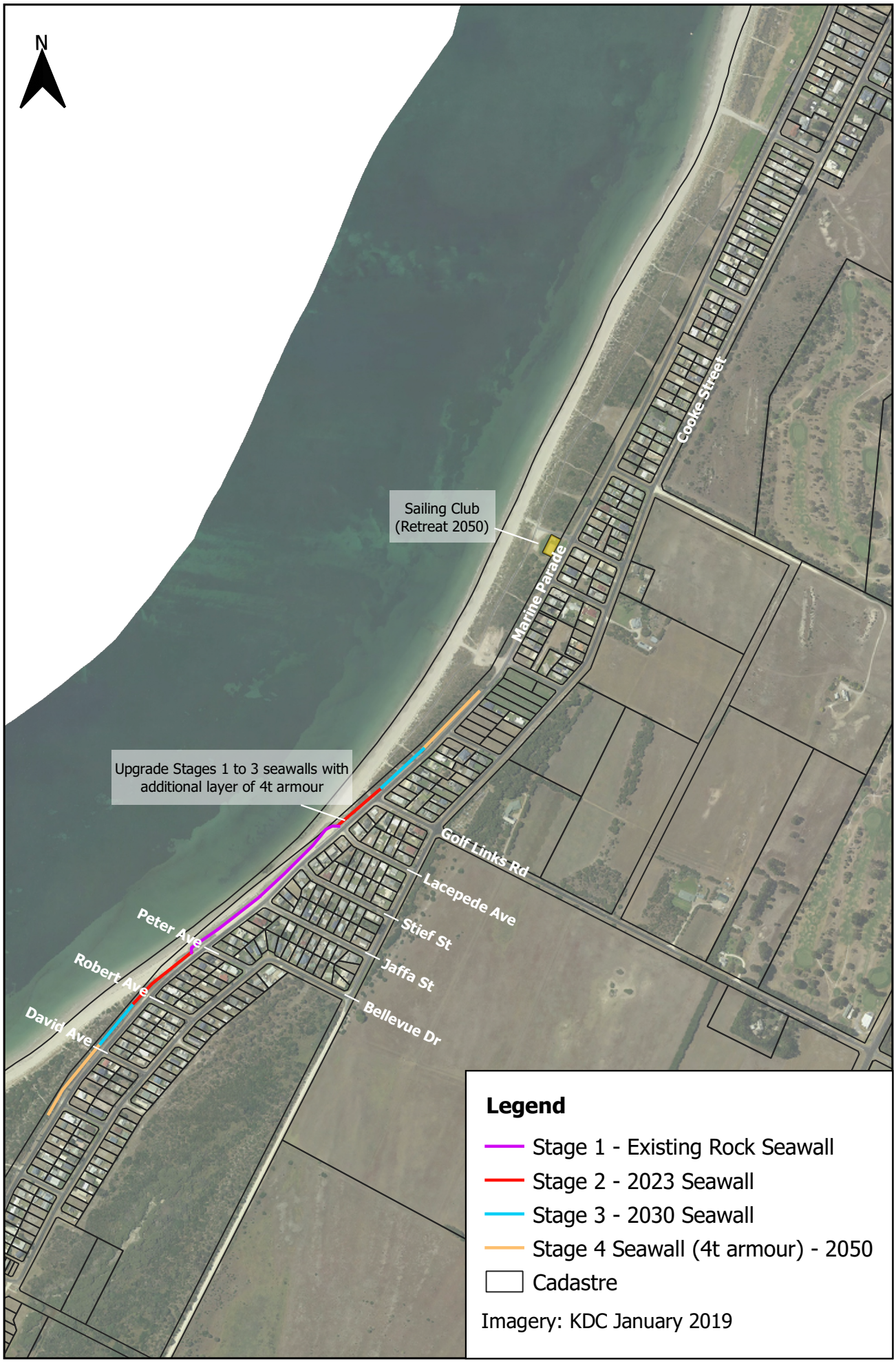
| Ownership | Asset | 2020 | 2050 | 2070 | 2100 |
|---|---|---|---|---|---|
| Privately Owned Assets | Properties along Marine Parade | No | VERY HIGH | VERY HIGH | VERY HIGH |
| | Properties along Jaffa St | No | No | VERY HIGH | VERY HIGH |
| | Properties along Stief St | No | No | VERY HIGH | VERY HIGH |
| | Properties along Lacepede Ave | No | No | VERY HIGH | VERY HIGH |
| | Properties along Golf Links Rd | No | No | VERY HIGH | VERY HIGH |
| | Properties along Bellevue Drive | No | No | VERY HIGH | VERY HIGH |
| State and Council Owned Assets | Shared Path (sealed) | VERY HIGH | VERY HIGH | VERY HIGH | VERY HIGH |
| | Telstra Cable (behind existing seawall) | VERY HIGH | VERY HIGH | VERY HIGH | VERY HIGH |
| | Marine Parade | VERY HIGH | VERY HIGH | VERY HIGH | VERY HIGH |
| | 94 Marine Parade (Buildings, Sailing Club) | No | No | MEDIUM | VERY HIGH |
| | Thredgold St Playground | No | No | VERY HIGH | VERY HIGH |
| | Huntingdale Rd | No | No | VERY HIGH | VERY HIGH |
| | Johnson Ave | No | No | VERY HIGH | VERY HIGH |
| | Goode Ave | No | No | VERY HIGH | VERY HIGH |
| | Scown Ave | No | No | VERY HIGH | VERY HIGH |
| | Sewer along Marine Parade | No | No | No | VERY HIGH |
| | David Ave | No | No | VERY HIGH | VERY HIGH |
| | Stanley Ave | No | No | VERY HIGH | VERY HIGH |

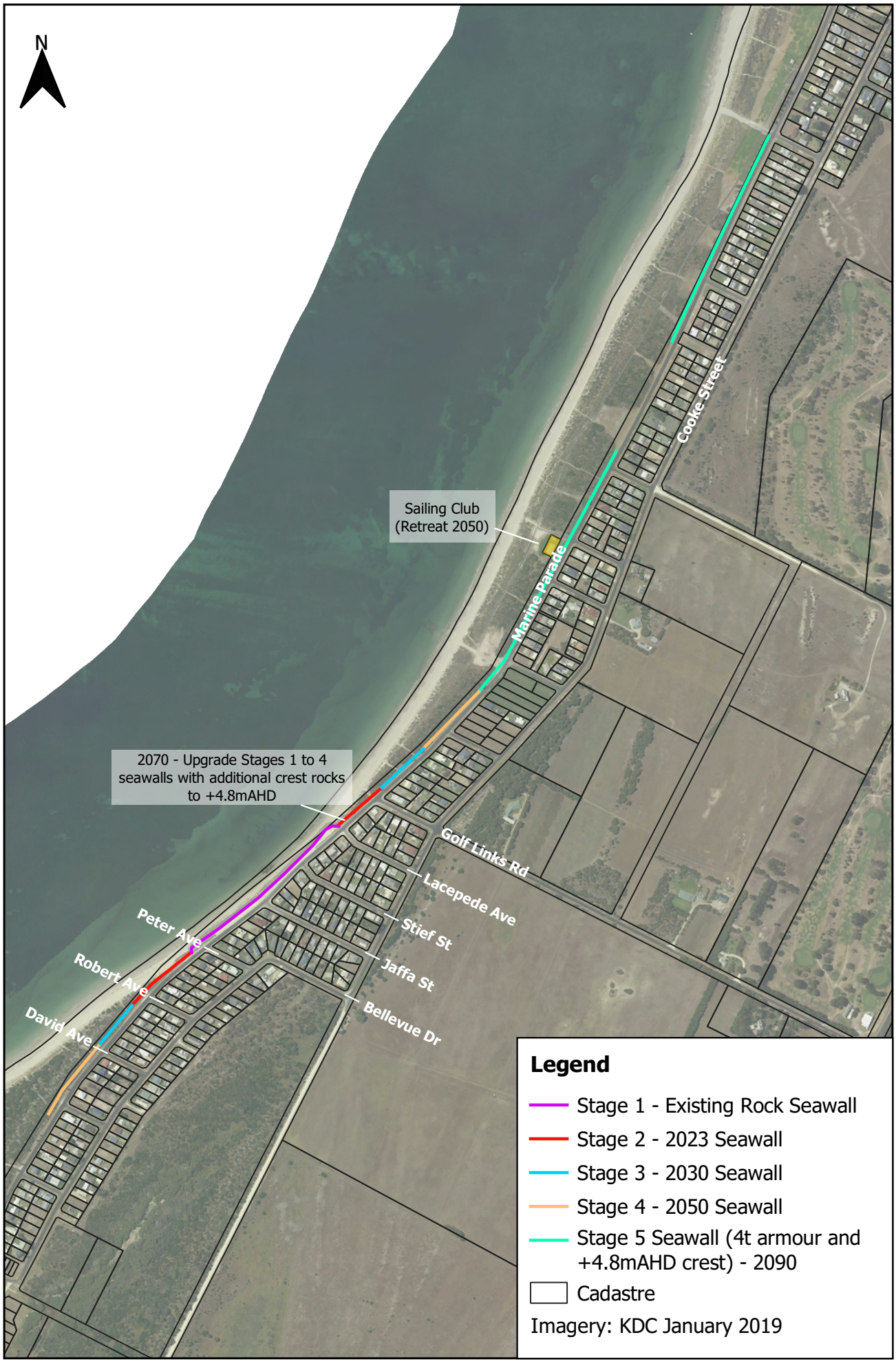
## Appendix C Seawall Staging Plan



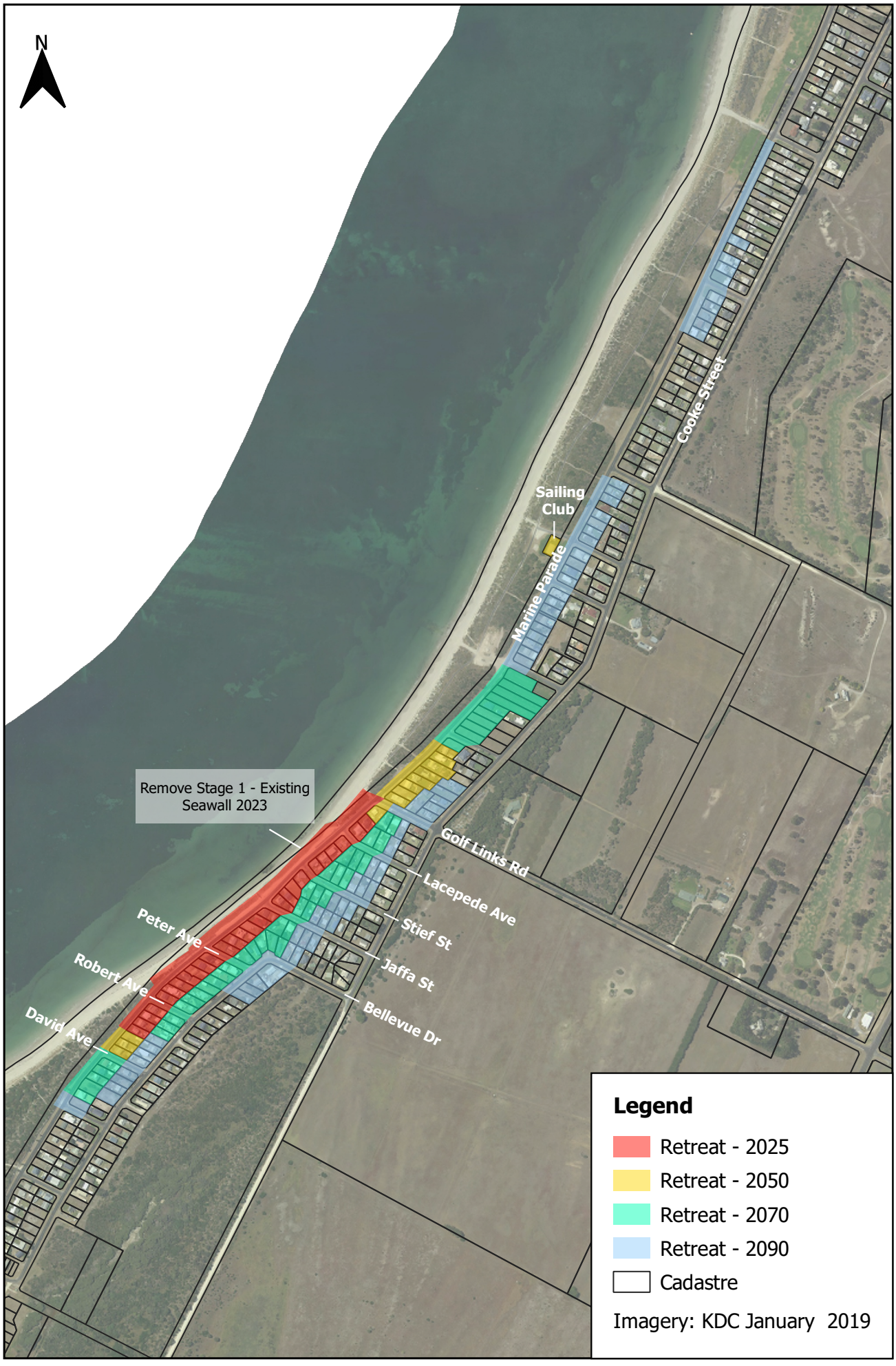

0 100 200 300 400 500 m

Wavelength

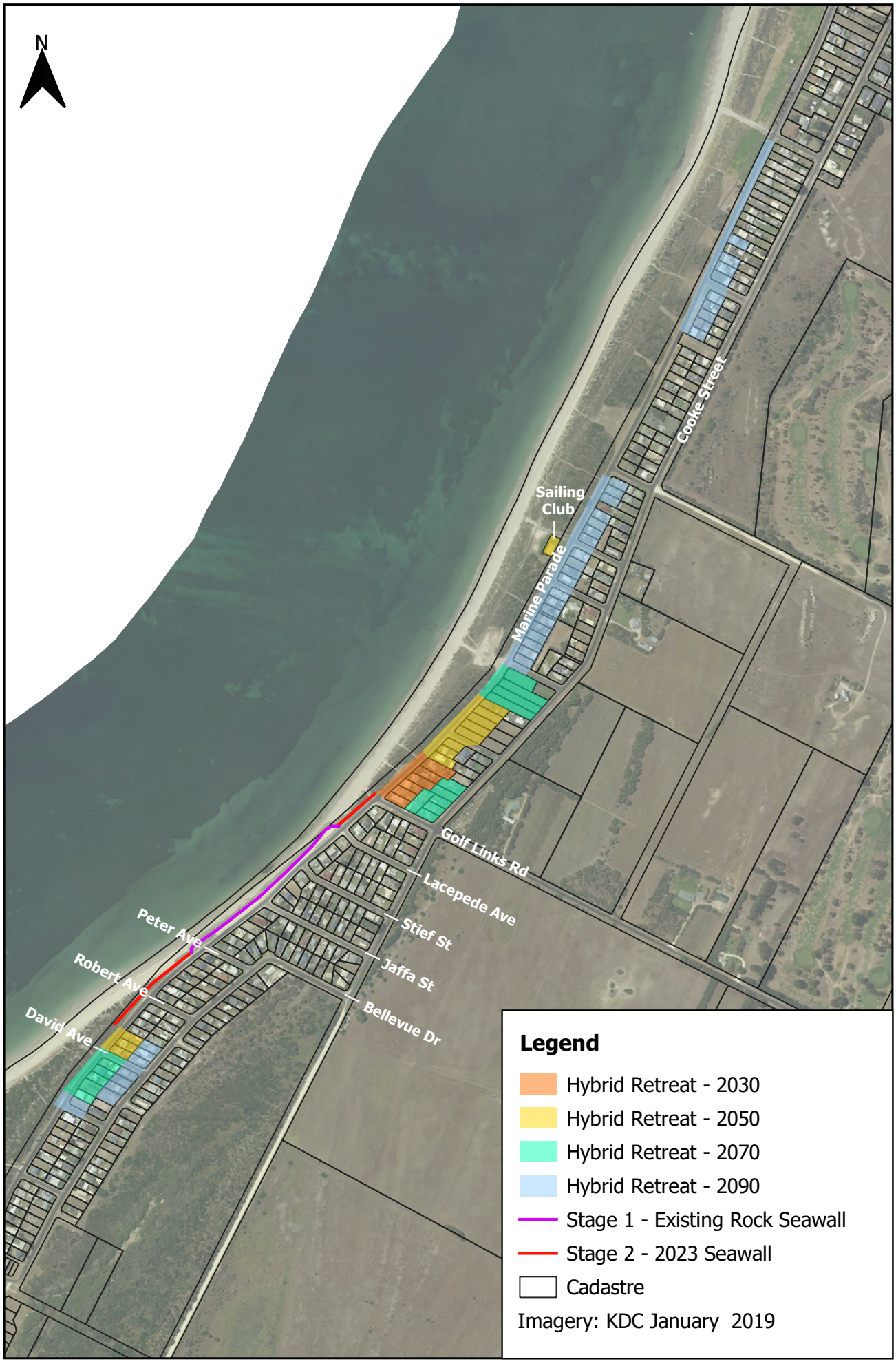

N
Sailing Club
(Retreat 2050)
Upgrade Stages 1 to 3 seawalls with
additional layer of 4t armour
Marine Parade
Cooke Street
Golf Links Rd
Lacepede Ave
Stief St
Jaffa St
Bellevue Dr
Peter Ave
Robert Ave
David Ave
Legend
Stage 1 - Existing Rock Seawall
Stage 2 - 2023 Seawall
Stage 3 - 2030 Seawall
Stage 4 Seawall (4t armour) - 2050
Cadastre
Imagery: KDC January 2019
0 100 200 300 400 500 m
Wavelength


N
Sailing Club
(Retreat 2050)
2070 - Upgrade Stages 1 to 4
seawalls with additional crest rocks
to +4.8mAHD
Cooke Street
Marine Parade
Golf Links Rd
Lacepede Ave
Stief St
Jaffa St
Bellevue Dr
Peter Ave
Robert Ave
David Ave
Legend
Stage 1 - Existing Rock Seawall
Stage 2 - 2023 Seawall
Stage 3 - 2030 Seawall
Stage 4 - 2050 Seawall
Stage 5 Seawall (4t armour and
+4.8mAHD crest) - 2090
Cadastre
Imagery: KDC January 2019
0 100 200 300 400 500 m
Wavelength

## Appendix D Managed Retreat Staging Plan


N
Cooke Street
Sailing Club
Marine Parade
Remove Stage 1 - Existing Seawall 2023
Golf Links Rd
Lacepede Ave
Stief St
Jaffa St
Bellevue Dr
Peter Ave
Robert Ave
David Ave
Legend
Retreat - 2025
Retreat - 2050
Retreat - 2070
Retreat - 2090
Cadastre
Imagery: KDC January 2019
0 100 200 300 400 500 m
Wavelength

## Appendix E Hybrid Staging Plan


N
Sailing Club
Marine Parade
Cooke Street
Golf Links Rd
Lacepede Ave
Stief St
Jaffa St
Bellevue Dr
Peter Ave
Robert Ave
David Ave
Legend
Hybrid Retreat - 2030
Hybrid Retreat - 2050
Hybrid Retreat - 2070
Hybrid Retreat - 2090
Stage 1 - Existing Rock Seawall
Stage 2 - 2023 Seawall
Cadastre
Imagery: KDC January 2019
0 100 200 300 400 500 m
Wavelength

## Appendix F Seawall NPV Results

| Years from Present | Year | Discount Factor | Seawall Stage | Capital Costs | | | Seawall Upgrades | | | Seawall Maintenance | | | Asset Removal & Replacement | | | Net Present Value | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Capital | Upgrades | Mtce | Path removal |
| | 2018 | | 1 | Stage 1 seawall constructed | 395 | | | | | | | | | | | | | | |
| | 2019 | | | | | | | | | | | | | | | | | | |
| | 2020 | | | | | | | | | | | | | | | | | | |
| 0 | 2021 | 1.00000 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 1 | 2022 | 0.95238 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 2 | 2023 | 0.90703 | 2 | Remove existing GSC seawalls and ad-hoc rock seawall & construct Stage 2 Seawall (north 110m, south 160m) - 1.1t armour | 270 | $ 1,531,000 | | | | | | | | | | $ 1,388,662 | $ - | $ - | $ - |
| 3 | 2024 | 0.86384 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 4 | 2025 | 0.82270 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 5 | 2026 | 0.78353 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 6 | 2027 | 0.74622 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 7 | 2028 | 0.71068 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 8 | 2029 | 0.67684 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 9 | 2030 | 0.64461 | 3 | Construct Stage 3 Seawall (north 120m, south 100m) - 1.1t armour | 220 | $ 1,166,000 | | | | Repair Stages 1 & 2 | 665 | $ 332,500 | | | | $ 751,614 | $ - | $ 214,332 | $ - |
| 10 | 2031 | 0.61391 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 11 | 2032 | 0.58468 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 12 | 2033 | 0.55684 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 13 | 2034 | 0.53032 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 14 | 2035 | 0.50507 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 15 | 2036 | 0.48102 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 16 | 2037 | 0.45811 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 17 | 2038 | 0.43630 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 18 | 2039 | 0.41552 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 19 | 2040 | 0.39573 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 20 | 2041 | 0.37689 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 21 | 2042 | 0.35894 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 22 | 2043 | 0.34185 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 23 | 2044 | 0.32557 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 24 | 2045 | 0.31007 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 25 | 2046 | 0.29530 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 26 | 2047 | 0.28124 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 27 | 2048 | 0.26785 | | | | | | | | | | | Sailing Club Removal | | $178,000 | $ - | $ - | $ - | $ 47,677 |
| 28 | 2049 | 0.25509 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 29 | 2050 | 0.24295 | 4 | Construct Stage 4 Seawall (north 140m, south 180m) - 4t armour | 320 | $ 2,720,000 | Upgrade armour to 4t Stages 1 to 3 | 885 | $ 3,097,500 | Repair Stages 1 to 3 | 885 | $ 442,500 | Path removal and replacement | 330 | $ 52,008 | $ 660,814 | $ 752,526 | $ 107,504 | $ 12,635 |
| 30 | 2051 | 0.23138 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 31 | 2052 | 0.22036 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 32 | 2053 | 0.20987 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 33 | 2054 | 0.19987 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 34 | 2055 | 0.19035 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 35 | 2056 | 0.18129 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 36 | 2057 | 0.17266 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 37 | 2058 | 0.16444 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 38 | 2059 | 0.15661 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 39 | 2060 | 0.14915 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 40 | 2061 | 0.14205 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 41 | 2062 | 0.13528 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 42 | 2063 | 0.12884 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 43 | 2064 | 0.12270 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 44 | 2065 | 0.11686 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 45 | 2066 | 0.11130 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 46 | 2067 | 0.10600 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 47 | 2068 | 0.10095 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 48 | 2069 | 0.09614 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 49 | 2070 | 0.09156 | | | | | Upgrade crest Stages 1 to 4 to +4.8 mAHD | 1205 | $ 1,566,500 | Repair Stages 1 to 4 | 1205 | $ 1,205,000 | Path removal and replacement | 330 | $ 52,008 | $ - | $ 143,435 | $ 110,335 | $ 4,762 |
| 50 | 2071 | 0.08720 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 51 | 2072 | 0.08305 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 52 | 2073 | 0.07910 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 53 | 2074 | 0.07533 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 54 | 2075 | 0.07174 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 55 | 2076 | 0.06833 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 56 | 2077 | 0.06507 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 57 | 2078 | 0.06197 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 58 | 2079 | 0.05902 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 59 | 2080 | 0.05621 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 60 | 2081 | 0.05354 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 61 | 2082 | 0.05099 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 62 | 2083 | 0.04856 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 63 | 2084 | 0.04625 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 64 | 2085 | 0.04404 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 65 | 2086 | 0.04195 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 66 | 2087 | 0.03995 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 67 | 2088 | 0.03805 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 68 | 2089 | 0.03623 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 69 | 2090 | 0.03451 | 5 | Construct Stage 5 Seawall (north 460m +560m) -4t armour and +4.8mAHD crest | 1020 | $ 10,200,000 | | | | Repair Stages 1 to 4 | 810 | $ 972,000 | Path removal and replacement | 1110 | $174,936 | $ 351,997 | $ - | $ 33,543 | $ 6,037 |
| 70 | 2091 | 0.03287 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 71 | 2092 | 0.03130 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 72 | 2093 | 0.02981 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 73 | 2094 | 0.02839 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 74 | 2095 | 0.02704 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 75 | 2096 | 0.02575 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 76 | 2097 | 0.02453 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 77 | 2098 | 0.02336 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 78 | 2099 | 0.02225 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 79 | 2100 | 0.02119 | | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| | | | | | | **$ 15,617,000** | | | **$ 4,664,000** | | | **$ 2,952,000** | | | **$456,952** | **$ 3,153,087** | **$ 895,961** | **$ 465,714** | **$ 71,111** |
| | | | | | | | | | | | | | | | | | | | **$ 4,585,873** |

## Appendix G Managed Retreat NPV Results

| Years from Present | Year | Discount Factor | Stage | Path Removal & Replacement Costs | | | Road Removal Costs | | | Miscellaneous removal costs | | | Property Purchase Costs | | Net Present Value | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Nominal Cash Flow | Path Removal | Road Remova | Miscellaneous | Property Purcha |
| | 2018 | | | | | | | | | | | | | | | | | |
| | 2019 | | | | | | | | | | | | | | | | | |
| | 2020 | | | | | | | | | | | | | | | | | |
| 0 | 2021 | 1.00000 | | | | | | | | | | | | | $ - | $ - | $ - | $ - |
| 1 | 2022 | 0.95238 | | | | $ - | | | | | | | | | $ - | $ - | $ 902,857 | $ - |
| 2 | 2023 | 0.90703 | | | | $ - | | | | Remove Seawall | 395 | $ 948,000 | | | $ - | $ - | $ 181,406 | $ - |
| 3 | 2024 | 0.86384 | | | | $ - | | | | Relocate Telstra Cable | | $ 200,000 | | | $ - | $ - | $ - | $ - |
| 4 | 2025 | 0.82270 | | Relocate Path | 1600 | $ 252,160 | Remove road | 900 | $ 568,800 | | | | Private property retreat (inc demolition and remediation of site) | $ 12,253,000 | $ 207,453 | $ 467,953 | $ - | $ 10,080,573 |
| 5 | 2026 | 0.78353 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 6 | 2027 | 0.74622 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 7 | 2028 | 0.71068 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 8 | 2029 | 0.67684 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 9 | 2030 | 0.64461 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 10 | 2031 | 0.61391 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 11 | 2032 | 0.58468 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 12 | 2033 | 0.55684 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 13 | 2034 | 0.53032 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 14 | 2035 | 0.50507 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 15 | 2036 | 0.48102 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 16 | 2037 | 0.45811 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 17 | 2038 | 0.43630 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 18 | 2039 | 0.41552 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 19 | 2040 | 0.39573 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 20 | 2041 | 0.37689 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 21 | 2042 | 0.35894 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 22 | 2043 | 0.34185 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 23 | 2044 | 0.32557 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 24 | 2045 | 0.31007 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 25 | 2046 | 0.29530 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 26 | 2047 | 0.28124 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 27 | 2048 | 0.26785 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 28 | 2049 | 0.25509 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 29 | 2050 | 0.24295 | | Relocate Path | 930 | $ 146,568 | Remove road | 220 | $ 139,040 | | | | Private property and Sailing Club retreat (inc demolition and remediation of site) | $ 5,459,000 | $ 35,608 | $ 33,779 | $ - | $ 1,326,244 |
| 30 | 2051 | 0.23138 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 31 | 2052 | 0.22036 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 32 | 2053 | 0.20987 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 33 | 2054 | 0.19987 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 34 | 2055 | 0.19035 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 35 | 2056 | 0.18129 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 36 | 2057 | 0.17266 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 37 | 2058 | 0.16444 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 38 | 2059 | 0.15661 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 39 | 2060 | 0.14915 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 40 | 2061 | 0.14205 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 41 | 2062 | 0.13528 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 42 | 2063 | 0.12884 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 43 | 2064 | 0.12270 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 44 | 2065 | 0.11686 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 45 | 2066 | 0.11130 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 46 | 2067 | 0.10600 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 47 | 2068 | 0.10095 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 48 | 2069 | 0.09614 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 49 | 2070 | 0.09156 | | Relocate Path | 990 | $ 156,024 | Remove road | 680 | $ 429,760 | | | | Private property retreat (inc demolition and remediation of site) | $ 11,234,000 | $ 14,286 | $ 39,351 | $ - | $ 1,028,629 |
| 50 | 2071 | 0.08720 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 51 | 2072 | 0.08305 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 52 | 2073 | 0.07910 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 53 | 2074 | 0.07533 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 54 | 2075 | 0.07174 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 55 | 2076 | 0.06833 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 56 | 2077 | 0.06507 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 57 | 2078 | 0.06197 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 58 | 2079 | 0.05902 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 59 | 2080 | 0.05621 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 60 | 2081 | 0.05354 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 61 | 2082 | 0.05099 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 62 | 2083 | 0.04856 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 63 | 2084 | 0.04625 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 64 | 2085 | 0.04404 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 65 | 2086 | 0.04195 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 66 | 2087 | 0.03995 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 67 | 2088 | 0.03805 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 68 | 2089 | 0.03623 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 69 | 2090 | 0.03451 | | Relocate Path | 1780 | $ 280,528 | Remove road | 1600 | $ 1,011,200 | | | | Private property retreat (inc demolition and remediation of site) | $ 20,070,000 | $ 9,681 | $ 34,896 | $ - | $ 692,605 |
| 70 | 2091 | 0.03287 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 71 | 2092 | 0.03130 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 72 | 2093 | 0.02981 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 73 | 2094 | 0.02839 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 74 | 2095 | 0.02704 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 75 | 2096 | 0.02575 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 76 | 2097 | 0.02453 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 77 | 2098 | 0.02336 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 78 | 2099 | 0.02225 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| 79 | 2100 | 0.02119 | | | | $ - | | | | | | | | | $ - | $ - | $ - | $ - |
| | | | | | | **$ 835,280** | | | **$ 2,148,800** | | | | | **$ 49,016,000** | **$ 267,028** | **$ 575,979** | **$ 1,084,263** | **$ 13,128,052** |
| | | | | | | | | | | | | | | | **$** | | | **15,055,321** |

## Appendix H Hybrid NPV Results

| Years from Present | Year | Discount Factor | Stage | Capital | | | Upgrades | | | Mtce | | | Path Removal & Replacement Costs | | | Road Removal Costs | | | Property Purchase Costs | | Net Present Value | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Nominal Cash Flow | Seawall - Capital | Seawall - Upgrades | Seawall - Mtce | Path Removal | Road Removal | Property Purchase |
| | 2018 | | 1 | Stage 1 seawall constructed | 395 | | | | | | | | | | | | | | | | | | | | | |
| | 2019 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2020 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 2021 | 1.00000 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 1 | 2022 | 0.95238 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 2 | 2023 | 0.90703 | 2 | Remove GSC and ad-hoc seawalls and Construct Stage 2 Seawall (north 110m, south 220m) - 1.1t armour | 330 | $ 1,849,000 | | | | | | | | | | | | | | | $ 1,677,098 | $ - | $ - | $ - | $ - | $ - |
| 3 | 2024 | 0.86384 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 4 | 2025 | 0.82270 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 5 | 2026 | 0.78353 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 6 | 2027 | 0.74622 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 7 | 2028 | 0.71068 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 8 | 2029 | 0.67684 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 9 | 2030 | 0.64461 | | | | | | | | Repair Stages 1 & 2 | 725 | $ 362,500 | | | | Remove road | 150 | $ 94,800 | Property retreat (inc demolition) | $ 3,774,000 | $ - | $ - | $ 233,671 | $ - | $ 61,109 | $ 2,432,754 |
| 10 | 2031 | 0.61391 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 11 | 2032 | 0.58468 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 12 | 2033 | 0.55684 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 13 | 2034 | 0.53032 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 14 | 2035 | 0.50507 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 15 | 2036 | 0.48102 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 16 | 2037 | 0.45811 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 17 | 2038 | 0.43630 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 18 | 2039 | 0.41552 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 19 | 2040 | 0.39573 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 20 | 2041 | 0.37689 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 21 | 2042 | 0.35894 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 22 | 2043 | 0.34185 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 23 | 2044 | 0.32557 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 24 | 2045 | 0.31007 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 25 | 2046 | 0.29530 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 26 | 2047 | 0.28124 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 27 | 2048 | 0.26785 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 28 | 2049 | 0.25509 | | | | | | | | | | | | | | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 29 | 2050 | 0.24295 | | Construct 4t seawall returns (north and south) | 50 | $ 425,000 | Upgrade armour to 4t | 725 | $ 2,537,500 | Repair Stages 1 to 2 | 725 | $ 362,500 | Relocate Path | 870 | $ 137,112 | Remove road | 270 | $ 170,640 | Property retreat (inc demolition) | $ 2,607,000 | $ 103,252 | $ 616,476 | $ 88,068 | $ 33,311 | $ 41,456 | $ 633,361 |
| 30 | 2051 | 0.23138 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 31 | 2052 | 0.22036 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 32 | 2053 | 0.20987 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 33 | 2054 | 0.19987 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 34 | 2055 | 0.19035 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 35 | 2056 | 0.18129 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 36 | 2057 | 0.17266 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 37 | 2058 | 0.16444 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 38 | 2059 | 0.15661 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 39 | 2060 | 0.14915 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 40 | 2061 | 0.14205 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 41 | 2062 | 0.13528 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 42 | 2063 | 0.12884 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 43 | 2064 | 0.12270 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 44 | 2065 | 0.11686 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 45 | 2066 | 0.11130 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 46 | 2067 | 0.10600 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 47 | 2068 | 0.10095 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 48 | 2069 | 0.09614 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 49 | 2070 | 0.09156 | | Construct 4t seawall returns (north and south) | 70 | $ 700,000 | Upgrade crest Stages 1 | 775 | $ 1,007,500 | Repair Stages 1 to 2 | 775 | $ 775,000 | Relocate Path | 330 | $ 52,008 | Remove road | 480 | $ 303,360 | Property retreat (inc demolition) | $ 4,890,000 | $ 64,095 | $ 92,251 | $ 70,962 | $ 4,762 | $ 27,777 | $ 447,748 |
| 50 | 2071 | 0.08720 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 51 | 2072 | 0.08305 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 52 | 2073 | 0.07910 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 53 | 2074 | 0.07533 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 54 | 2075 | 0.07174 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 55 | 2076 | 0.06833 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 56 | 2077 | 0.06507 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 57 | 2078 | 0.06197 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 58 | 2079 | 0.05902 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 59 | 2080 | 0.05621 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 60 | 2081 | 0.05354 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 61 | 2082 | 0.05099 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 62 | 2083 | 0.04856 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 63 | 2084 | 0.04625 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 64 | 2085 | 0.04404 | | Construct 4t and 4.8 mAHD crest seawall returns (north and south) | 90 | $ 900,000 | | | | Repair Stages 1 to 2 | 845 | $ 1,014,000 | Relocate Path | 1110 | $ 174,936 | | | | | | $ 39,639 | $ - | $ 44,660 | $ 7,705 | $ - | $ - |
| 65 | 2086 | 0.04195 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 66 | 2087 | 0.03995 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 67 | 2088 | 0.03805 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 68 | 2089 | 0.03623 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 69 | 2090 | 0.03451 | | | | | | | | | | | | | $ - | | Remove road | 1600 | $ 1,011,200 | Property retreat (inc demolition) | $ 14,130,000 | $ - | $ - | $ - | $ - | $ 34,896 | $ 487,619 |
| 70 | 2091 | 0.03287 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 71 | 2092 | 0.03130 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 72 | 2093 | 0.02981 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 73 | 2094 | 0.02839 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 74 | 2095 | 0.02704 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 75 | 2096 | 0.02575 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 76 | 2097 | 0.02453 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 77 | 2098 | 0.02336 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 78 | 2099 | 0.02225 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| 79 | 2100 | 0.02119 | | | | | | | | | | | | | $ - | | | | | | $ - | $ - | $ - | $ - | $ - | $ - |
| | | | | | | **$ 3,874,000** | | | **$ 3,545,000** | | | **$ 2,514,000** | | | **$ 364,056** | | | **$ 1,580,000** | | **$ 25,401,000** | **$ 1,884,084** | **$ 708,727** | **$ 437,361** | **$ 45,778** | **$ 165,238** | **$ 4,001,482** |
| | | | | | | | | | | | | | | | | | | | | | | | | | **$** | **7,242,669** |

## Appendix I Nourished Seawall NPV Results

| Years from Present | Year | Discount Factor | Stage | Seawall Capital | | | Seawall Upgrades | | | Seawall Maintenance | | | Nourishment | | | | | | Path Removal & Replacement | | | Net Present Value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Item | SLR Factor | Length (m) | Volume (m3 per m) | Volume | Nominal Cash Flow | Item | Length (m) | Nominal Cash Flow | Capital | Upgrades | Mtce | | Path removal |
| | 2018 | | 1 | Stage 1 seawall constructed | 395 | | | | | | | | | | | | | | | | | | | | | |
| | 2019 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2020 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 2021 | 1.00000 | | | | | | | | | | | | 1 | 595 | 35 | 20825 | $ 333,200 | | | | $ - | $ - | $ - | $ 333,200 | $ - |
| 1 | 2022 | 0.95238 | | | | $ - | | | | | | | | 1.06 | 595 | 37 | 21974 | $ 351,583 | | | | $ - | $ - | $ - | $ 334,841 | $ - |
| 2 | 2023 | 0.90703 | 2 | Stage 2 Seawall (north 110m, south 160m) 1.1t armour | 270 | $ 1,431,000 | | | | | | | | 1.11 | 865 | 39 | 33616 | $ 537,851 | | | | $ 1,297,959 | $ - | $ - | $ 487,847 | $ - |
| 3 | 2024 | 0.86384 | | | | $ - | | | | | | | | 1.17 | 865 | 41 | 35286 | $ 564,577 | | | | $ - | $ - | $ - | $ 487,702 | $ - |
| 4 | 2025 | 0.82270 | | | | $ - | | | | | | | | 1.22 | 865 | 43 | 36956 | $ 591,302 | | | | $ - | $ - | $ - | $ 486,466 | $ - |
| 5 | 2026 | 0.78353 | | | | $ - | | | | | | | | 1.28 | 865 | 45 | 38627 | $ 618,028 | | | | $ - | $ - | $ - | $ 484,241 | $ - |
| 6 | 2027 | 0.74622 | | | | $ - | | | | | | | | 1.33 | 865 | 47 | 40297 | $ 644,753 | | | | $ - | $ - | $ - | $ 481,125 | $ - |
| 7 | 2028 | 0.71068 | | | | $ - | | | | | | | | 1.39 | 865 | 49 | 41967 | $ 671,479 | | | | $ - | $ - | $ - | $ 477,207 | $ - |
| 8 | 2029 | 0.67684 | | | | $ - | | | | | | | | 1.44 | 865 | 50 | 43638 | $ 698,204 | | | | $ - | $ - | $ - | $ 472,572 | $ - |
| 9 | 2030 | 0.64461 | 3 | Stage 3 Seawall (north 120m, south 100m) 1.1t armour | 220 | $ 1,166,000 | | | | Repair Stages 1 & 2 | 665 | $ 332,500 | | 1.50 | 1085 | 52 | 56832 | $ 909,305 | | | | $ 751,614 | $ - | $ 214,332 | $ 586,146 | $ - |
| 10 | 2031 | 0.61391 | | | | $ - | | | | | | | | 1.55 | 1085 | 54 | 58927 | $ 942,828 | | | | $ - | $ - | $ - | $ 578,814 | $ - |
| 11 | 2032 | 0.58468 | | | | $ - | | | | | | | | 1.61 | 1085 | 56 | 61022 | $ 976,350 | | | | $ - | $ - | $ - | $ 570,852 | $ - |
| 12 | 2033 | 0.55684 | | | | $ - | | | | | | | | 1.66 | 1085 | 58 | 63117 | $ 1,009,873 | | | | $ - | $ - | $ - | $ 562,335 | $ - |
| 13 | 2034 | 0.53032 | | | | $ - | | | | | | | | 1.72 | 1085 | 60 | 65212 | $ 1,043,396 | | | | $ - | $ - | $ - | $ 553,335 | $ - |
| 14 | 2035 | 0.50507 | | | | $ - | | | | | | | | 1.77 | 1085 | 62 | 67307 | $ 1,076,919 | | | | $ - | $ - | $ - | $ 543,917 | $ - |
| 15 | 2036 | 0.48102 | | | | $ - | | | | | | | | 1.83 | 1085 | 119 | 129078 | $ 2,065,241 | | | | $ - | $ - | $ - | $ 993,416 | $ - |
| 16 | 2037 | 0.45811 | | | | $ - | | | | | | | | 1.88 | 1085 | 66 | 71498 | $ 1,143,964 | | | | $ - | $ - | $ - | $ 524,063 | $ - |
| 17 | 2038 | 0.43630 | | | | $ - | | | | | | | | 1.94 | 1085 | 68 | 73593 | $ 1,177,487 | | | | $ - | $ - | $ - | $ 513,734 | $ - |
| 18 | 2039 | 0.41552 | | | | $ - | | | | | | | | 1.99 | 1085 | 70 | 75688 | $ 1,211,010 | | | | $ - | $ - | $ - | $ 503,200 | $ - |
| 19 | 2040 | 0.39573 | | | | $ - | | | | | | | | 2.05 | 1085 | 72 | 77783 | $ 1,244,532 | | | | $ - | $ - | $ - | $ 492,504 | $ - |
| 20 | 2041 | 0.37689 | | | | $ - | | | | | | | | 2.10 | 1085 | 74 | 79878 | $ 1,278,055 | | | | $ - | $ - | $ - | $ 481,686 | $ - |
| 21 | 2042 | 0.35894 | | | | $ - | | | | | | | | 2.16 | 1085 | 76 | 81974 | $ 1,311,578 | | | | $ - | $ - | $ - | $ 470,781 | $ - |
| 22 | 2043 | 0.34185 | | | | $ - | | | | | | | | 2.21 | 1085 | 77 | 84069 | $ 1,345,101 | | | | $ - | $ - | $ - | $ 459,822 | $ - |
| 23 | 2044 | 0.32557 | | | | $ - | | | | | | | | 2.27 | 1085 | 79 | 86164 | $ 1,378,623 | | | | $ - | $ - | $ - | $ 448,840 | $ - |
| 24 | 2045 | 0.31007 | | | | $ - | | | | | | | | 2.32 | 1085 | 81 | 88259 | $ 1,412,146 | | | | $ - | $ - | $ - | $ 437,861 | $ - |
| 25 | 2046 | 0.29530 | | | | $ - | | | | | | | | 2.38 | 1085 | 83 | 90354 | $ 1,445,669 | | | | $ - | $ - | $ - | $ 426,910 | $ - |
| 26 | 2047 | 0.28124 | | | | $ - | | | | | | | | 2.43 | 1085 | 85 | 92449 | $ 1,479,192 | | | | $ - | $ - | $ - | $ 416,009 | $ - |
| 27 | 2048 | 0.26785 | | | | $ - | | | | | | | | 2.49 | 1085 | 87 | 94545 | $ 1,512,714 | | | | $ - | $ - | $ - | $ 405,178 | $ - |
| 28 | 2049 | 0.25509 | | | | $ - | | | | | | | | 2.54 | 1085 | 89 | 96640 | $ 1,546,237 | | | | $ - | $ - | $ - | $ 394,435 | $ - |
| 29 | 2050 | 0.24295 | 4 | Stage 4 Seawall (north 140m, south 180m) 1.1t armour | 320 | $ 1,696,000 | | | | Repair Stages 1 to 3 | 885 | $ 442,500 | | 2.6 | 1405 | 91 | 127855 | $ 2,045,680 | Path removal and | 330 | $ 52,008 | $ 412,037 | $ - | $ 107,504 | $ 496,990 | $ 12,635 |
| 30 | 2051 | 0.23138 | | | | $ - | | | | | | | | 2.63 | 1405 | 92 | 129232 | $ 2,067,710 | | | | $ - | $ - | $ - | $ 478,422 | $ - |
| 31 | 2052 | 0.22036 | | | | $ - | | | | | | | | 2.66 | 1405 | 93 | 130609 | $ 2,089,741 | | | | $ - | $ - | $ - | $ 460,494 | $ - |
| 32 | 2053 | 0.20987 | | | | $ - | | | | | | | | 2.68 | 1405 | 94 | 131986 | $ 2,111,771 | | | | $ - | $ - | $ - | $ 443,189 | $ - |
| 33 | 2054 | 0.19987 | | | | $ - | | | | | | | | 2.71 | 1405 | 95 | 133363 | $ 2,133,802 | | | | $ - | $ - | $ - | $ 426,488 | $ - |
| 34 | 2055 | 0.19035 | | | | $ - | | | | | | | | 2.74 | 1405 | 96 | 134740 | $ 2,155,832 | | | | $ - | $ - | $ - | $ 410,373 | $ - |
| 35 | 2056 | 0.18129 | | | | $ - | | | | | | | | 2.77 | 1405 | 152 | 213391 | $ 3,414,262 | | | | $ - | $ - | $ - | $ 618,973 | $ - |
| 36 | 2057 | 0.17266 | | | | $ - | | | | | | | | 2.80 | 1405 | 98 | 137493 | $ 2,199,893 | | | | $ - | $ - | $ - | $ 379,828 | $ - |
| 37 | 2058 | 0.16444 | | | | $ - | | | | | | | | 2.82 | 1405 | 99 | 138870 | $ 2,221,923 | | | | $ - | $ - | $ - | $ 365,363 | $ - |
| 38 | 2059 | 0.15661 | | | | $ - | | | | | | | | 2.85 | 1405 | 100 | 140247 | $ 2,243,954 | | | | $ - | $ - | $ - | $ 351,415 | $ - |
| 39 | 2060 | 0.14915 | | | | $ - | | | | | | | | 2.88 | 1405 | 101 | 141624 | $ 2,265,984 | | | | $ - | $ - | $ - | $ 337,967 | $ - |
| 40 | 2061 | 0.14205 | | | | $ - | | | | | | | | 2.91 | 1405 | 102 | 143001 | $ 2,288,014 | | | | $ - | $ - | $ - | $ 325,003 | $ - |
| 41 | 2062 | 0.13528 | | | | $ - | | | | | | | | 2.94 | 1405 | 103 | 144378 | $ 2,310,045 | | | | $ - | $ - | $ - | $ 312,507 | $ - |
| 42 | 2063 | 0.12884 | | | | $ - | | | | | | | | 2.96 | 1405 | 104 | 145755 | $ 2,332,075 | | | | $ - | $ - | $ - | $ 300,464 | $ - |
| 43 | 2064 | 0.12270 | | | | $ - | | | | | | | | 2.99 | 1405 | 105 | 147132 | $ 2,354,106 | | | | $ - | $ - | $ - | $ 288,859 | $ - |
| 44 | 2065 | 0.11686 | | | | $ - | | | | | | | | 3.02 | 1405 | 106 | 148509 | $ 2,376,136 | | | | $ - | $ - | $ - | $ 277,678 | $ - |
| 45 | 2066 | 0.11130 | | | | $ - | | | | | | | | 3.05 | 1405 | 107 | 149885 | $ 2,398,166 | | | | $ - | $ - | $ - | $ 266,908 | $ - |
| 46 | 2067 | 0.10600 | | | | $ - | | | | | | | | 3.08 | 1405 | 108 | 151262 | $ 2,420,197 | | | | $ - | $ - | $ - | $ 256,533 | $ - |
| 47 | 2068 | 0.10095 | | | | $ - | | | | | | | | 3.10 | 1405 | 109 | 152639 | $ 2,442,227 | | | | $ - | $ - | $ - | $ 246,541 | $ - |
| 48 | 2069 | 0.09614 | | | | $ - | | | | | | | | 3.13 | 1405 | 110 | 154016 | $ 2,464,258 | | | | $ - | $ - | $ - | $ 236,919 | $ - |
| 49 | 2070 | 0.09156 | | | | $ - | Upgrade crest Stages 1 to 4 | 1205 | $ 1,566,500 | Repair Stages 1 to 4 | 1205 | $ 602,500 | | 3.16 | 1405 | 111 | 155393 | $ 2,486,288 | Path removal and | 330 | $ 52,008 | $ - | $ 143,435 | $ 55,167 | $ 227,654 | $ 4,762 |
| 50 | 2071 | 0.08720 | | | | $ - | | | | | | | | 3.19 | 1405 | 112 | 156770 | $ 2,508,318 | | | | $ - | $ - | $ - | $ 218,735 | $ - |
| 51 | 2072 | 0.08305 | | | | $ - | | | | | | | | 3.22 | 1405 | 113 | 158147 | $ 2,530,349 | | | | $ - | $ - | $ - | $ 210,148 | $ - |
| 52 | 2073 | 0.07910 | | | | $ - | | | | | | | | 3.24 | 1405 | 114 | 159524 | $ 2,552,379 | | | | $ - | $ - | $ - | $ 201,884 | $ - |
| 53 | 2074 | 0.07533 | | | | $ - | | | | | | | | 3.27 | 1405 | 115 | 160901 | $ 2,574,410 | | | | $ - | $ - | $ - | $ 193,930 | $ - |
| 54 | 2075 | 0.07174 | | | | $ - | | | | | | | | 3.30 | 1405 | 116 | 162278 | $ 2,596,440 | | | | $ - | $ - | $ - | $ 186,276 | $ - |
| 55 | 2076 | 0.06833 | | | | $ - | | | | | | | | 3.33 | 1405 | 171 | 240929 | $ 3,854,870 | | | | $ - | $ - | $ - | $ 263,389 | $ - |
| 56 | 2077 | 0.06507 | | | | $ - | | | | | | | | 3.36 | 1405 | 117 | 165031 | $ 2,640,501 | | | | $ - | $ - | $ - | $ 171,825 | $ - |
| 57 | 2078 | 0.06197 | | | | $ - | | | | | | | | 3.38 | 1405 | 118 | 166408 | $ 2,662,531 | | | | $ - | $ - | $ - | $ 165,008 | $ - |
| 58 | 2079 | 0.05902 | | | | $ - | | | | | | | | 3.41 | 1405 | 119 | 167785 | $ 2,684,562 | | | | $ - | $ - | $ - | $ 158,451 | $ - |
| 59 | 2080 | 0.05621 | | | | $ - | | | | | | | | 3.44 | 1405 | 120 | 169162 | $ 2,706,592 | | | | $ - | $ - | $ - | $ 152,144 | $ - |
| 60 | 2081 | 0.05354 | | | | $ - | | | | | | | | 3.47 | 1405 | 121 | 170539 | $ 2,728,622 | | | | $ - | $ - | $ - | $ 146,078 | $ - |
| 61 | 2082 | 0.05099 | | | | $ - | | | | | | | | 3.50 | 1405 | 122 | 171916 | $ 2,750,653 | | | | $ - | $ - | $ - | $ 140,245 | $ - |
| 62 | 2083 | 0.04856 | | | | $ - | | | | | | | | 3.52 | 1405 | 123 | 173293 | $ 2,772,683 | | | | $ - | $ - | $ - | $ 134,637 | $ - |
| 63 | 2084 | 0.04625 | | | | $ - | | | | | | | | 3.55 | 1405 | 124 | 174670 | $ 2,794,714 | | | | $ - | $ - | $ - | $ 129,244 | $ - |
| 64 | 2085 | 0.04404 | | | | $ - | | | | Repair Stages 1 to 5 | 1205 | $ 602,500 | | 3.58 | 1405 | 125 | 176047 | $ 2,816,744 | | | | $ - | $ - | $ 26,536 | $ 124,060 | $ - |
| 65 | 2086 | 0.04195 | | | | $ - | | | | | | | | 3.61 | 1405 | 126 | 177423 | $ 2,838,774 | | | | $ - | $ - | $ - | $ 119,077 | $ - |
| 66 | 2087 | 0.03995 | | | | $ - | | | | | | | | 3.64 | 1405 | 127 | 178800 | $ 2,860,805 | | | | $ - | $ - | $ - | $ 114,286 | $ - |
| 67 | 2088 | 0.03805 | | | | $ - | | | | | | | | 3.66 | 1405 | 128 | 180177 | $ 2,882,835 | | | | $ - | $ - | $ - | $ 109,682 | $ - |
| 68 | 2089 | 0.03623 | | | | $ - | | | | | | | | 3.69 | 1405 | 129 | 181554 | $ 2,904,866 | | | | $ - | $ - | $ - | $ 105,258 | $ - |
| 69 | 2090 | 0.03451 | 5 | Construct Stage 5 Seawall (north 460m +560m) - 1.1t armour and +4.8mAHD crest | 1020 | $ 10,200,000 | | | | | | | | 3.72 | 1405 | 130 | 182931 | $ 2,926,896 | | | | $ 351,997 | $ - | $ - | $ 101,006 | $ - |
| 70 | 2091 | 0.03287 | | | | $ - | | | | | | | | 3.75 | 1405 | 131 | 184308 | $ 2,948,926 | | | | $ - | $ - | $ - | $ 96,920 | $ - |
| 71 | 2092 | 0.03130 | | | | $ - | | | | | | | | 3.78 | 1405 | 132 | 185685 | $ 2,970,957 | | | | $ - | $ - | $ - | $ 92,994 | $ - |
| 72 | 2093 | 0.02981 | | | | $ - | | | | | | | | 3.80 | 1405 | 133 | 187062 | $ 2,992,987 | | | | $ - | $ - | $ - | $ 89,223 | $ - |
| 73 | 2094 | 0.02839 | | | | $ - | | | | | | | | 3.83 | 1405 | 134 | 188439 | $ 3,015,018 | | | | $ - | $ - | $ - | $ 85,599 | $ - |
| 74 | 2095 | 0.02704 | | | | $ - | | | | | | | | 3.86 | 1405 | 135 | 189816 | $ 3,037,048 | | | | $ - | $ - | $ - | $ 82,119 | $ - |
| 75 | 2096 | 0.02575 | | | | $ - | | | | | | | | 3.89 | 1405 | 191 | 268467 | $ 4,295,478 | | | | $ - | $ - | $ - | $ 110,615 | $ - |
| 76 | 2097 | 0.02453 | | | | $ - | | | | | | | | 3.92 | 1405 | 137 | 192569 | $ 3,081,109 | | | | $ - | $ - | $ - | $ 75,565 | $ - |
| 77 | 2098 | 0.02336 | | | | $ - | | | | | | | | 3.94 | 1405 | 138 | 193946 | $ 3,103,139 | | | | $ - | $ - | $ - | $ 72,481 | $ - |
| 78 | 2099 | 0.02225 | | | | $ - | | | | | | | | 3.97 | 1405 | 139 | 195323 | $ 3,125,170 | | | | $ - | $ - | $ - | $ 69,520 | $ - |
| 79 | 2100 | 0.02119 | | | | $ - | | | | | | | | 4 | 1405 | 140 | 196700 | $ 3,147,200 | | | | $ - | $ - | $ - | $ 66,676 | $ - |
| | | | | | | **$ 14,493,000** | | | **$ 1,566,500** | | | **$ 1,980,000** | | | | | | $ 166,648,837 | | | **$ 104,016** | **$ 2,813,607** | **$ 143,435** | **$ 403,540** | **$ 25,904,682** | **$ 17,397** |
| | | | | | | | | | | | | | | | | | | | | | | $ | | | | **29,282,661** |