Wamberal Terminal Coastal Protection Assessment

Stage 6 – Cost-Benefit Analysis of Wamberal Terminal Coastal Protection Options

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Contact:
Edward Couriel
Director, Manly Hydraulics Laboratory
110b King Street, Manly Vale NSW 2093
T: 02 9949 0200
E: Edward.Couriel@mhl.nsw.gov.au

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			Name	Date
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Foreword

In May 2020 NSW government's professional specialist advisor, Manly Hydraulics Laboratory (MHL) in association with the Water Research Laboratory (WRL) of UNSW Sydney and Balmoral Group Australia (BGA) were commissioned by Central Coast Council to undertake the *Wamberal Terminal Coastal Protection Assessment*. The assessment outcomes are being delivered via a series of reports for the following stages of work:

1. Review of previous studies
2. Coastal protection amenity assessment
3. Seawall concept design options
4. Sand nourishment investigation
5. Provision of coastal monitoring (online webpage)
6. **Cost benefit analysis and distributional analysis of options (this report)**

This report provides the outcomes of Stage 6 of the Wamberal Terminal Coastal Protection Assessment, namely the undertaking of a cost-benefit analysis and distributional analysis for Terminal Protection Options for Wamberal Beach.

The economic analyses have been undertaken by Balmoral Group Australia with reference to the Department of Planning, Industry and Environment Guidelines for using cost-benefit analysis to assess coastal management options (DPIE, Sep 2020), coastal engineering inputs and advice from the MHL and WRL project team, and the other aforementioned project series reports. This approach has identified unresolved methodologies and assumptions within the DPIE cost-benefit Guidelines that have potential to alter the economic feasibility of some options. Sophisticated economic analyses for coastal management is an evolving area of research. The present study has attempted to resolve many of the assumptions and uncertainties, however, coastal economics in NSW would benefit from more detailed and explicit Practice Notes. In the meantime, "*The decision on which option Council should implement is likely to depend on several other considerations which are not addressed in a CBA"* as concluded in the DPIE (2020) Guidelines and this report.

This report is issued as Final and is classified as publicly available.

Executive Summary

Over the past 50 years development along the foredune of Wamberal Beach has had a history of damage and loss due to coastal erosion events. Managing risks to public safety and built assets, pressures on coastal ecosystems and community uses of the coastal zone make up the priority management issues of the certified Gosford Beaches Coastal Zone Management Plan (CZMP, 2017). Undertaking a review of terminal protection design for Wamberal Beach, coupled with the provision of beach nourishment (in accordance with Section 27 of the Coastal Management Act 2016), was a key recommended action of the CZMP (2017).

This report forms part of a broader series of work, the Wamberal Terminal Coastal Protection Assessment, recently undertaken to progress the key recommended management actions for Wamberal Beach from the Gosford Beaches Coastal Zone Management Plan (2017). The Wamberal Terminal Coastal Protection Assessment includes a detailed review of previous studies (Stage 1), amenity assessment of coastal protection options (Stage 2), development of seawall concept design options (Stage 3), sand nourishment investigation (Stage 4), implementation of coastal monitoring initiatives (Stage 5) as well as an updated *cost-benefit analysis and distributional analysis of management options for Wamberal Beach (Stage 6 - this Report)*.

This report has been compiled by Balmoral Group Australia (BGA) in collaboration with Manly Hydraulics Laboratory (MHL) and the Water Research Laboratory (WRL) to provide a cost-benefit analysis (CBA) and distributional analysis of coastal protection options for Wamberal Beach. Cost-benefit analysis provides a monetarised comparative view between options to assist in the decision-making process alongside the need for consideration of several aspects that are not well monetarised and a range of other considerations arising from engineering studies, stakeholder consultation, available funding arrangements, legislation, policy and planning context; all upon which a preferred option is selected.

The CBA quantifies the expected costs and benefits for five concept design protection alternatives (compared to the base case “Status Quo” approach) to consider economic trade-offs for options to manage future coastal hazards at Wamberal Beach. These options include those originally detailed in Council’s certified Gosford Beaches Coastal Zone Management Plan (CZMP) (WorleyParsons, 2017).

The CBA also includes a distributional analysis supported by a socio-economic profile of the local government area. The distributional analysis provides insight into which stakeholders receive the benefits, or incur the impacts and costs associated with each option for the purposes of assisting decisions regarding funding arrangements. The socio-economic profile compares key 2016 ABS census population, housing, employment, and income data of Central Coast LGA, Erina - Green Point, Gosford – Springfield, Terrigal - North Avoca, and Wamberal - Forresters Beach areas. Additionally, socio-economic indices and tourism data were compared across the various regions.

The scope of the analysis for the CBA consists of approximately 1500 m of beach situated between the Terrigal and the Wamberal Lagoon entrances of Wamberal Beach. Based on coastal hazard studies of the study area, without protection, approximately 72 houses are situated on lands subject to immediate coastal hazards that are expected to exacerbate over the next 30 years.

All options are compared relative to a base case scenario of continuing the 'Status Quo'. This involves repeated storm events triggering reactive emergency works that poorly mitigate the present and long-term risk of coastal erosion to private property and public lands at Wamberal Beach. This was recently demonstrated during the July 2020 storm event that resulted in damage to properties, substantial disruption to private and public land and $2.1M of publicly funded emergency works being placed on the beach. Without alternative management intervention, the frequency of such events threatening property at Wamberal Beach will increase with continued underlying recession and sea level rise, noting further that the July 2020 event was only of moderate magnitude compared with historical major coastal storms that can occur at this location.

Five management options were analysed in comparison to the base case as part of this report and are listed below:

Base case: 'Maintain Status Quo'

Option 1: Basalt rock revetment and periodic sand nourishment

Option 2: Sandstone rock revetment and periodic sand nourishment

Option 3: Vertical seawall and periodic sand nourishment

Option 4: Vertical seawall with rock toe and periodic sand nourishment

Option 5: Tiered vertical seawall with promenade and periodic sand nourishment

Seawall concept designs associated with each option are detailed in the *Stage 3 - Seawall Concept Design Options* report. Sand nourishment for each option was evaluated as part of the *Stage 4 Sand Nourishment Investigation*. The Stage 4 works found that substantial sand sources required to offset encroachment impacts of rock revetments (Options 1 and 2) are subject to future viability at the time of the nourishment campaign, as well as potential added complexities around lagoon entrance management depending on design placement. Given the feasibility of larger sand source availability, it was considered more realistic to assess all options in the CBA excluding nourishment to offset encroachment impacts. Instead, the CBA examines marginal benefits and costs between seawall options based on differing degrees of encroachment and available dry beach width amenity. These relative impacts for each option are detailed in the *Stage 2 Coastal Protection Amenity Assessment* and used as input to the CBA. All alternatives to the Base Case in the CBA include periodic sand nourishment (approx. every 10 years) to offset estimated natural beach recession due to underlying losses and sea-level rise (see *Stage 4 Sand Nourishment Investigation* for further detail).

The economic analysis was conducted over 30 years by interpolating between two time periods comprising year one (immediate hazard line) and in 30 years (up to the 2050 hazard line). The body of the report describes how each of the seawall options have been treated in the economic analysis.

All seawall options considered in the *Stage 3 - Seawall Concept Design Options* report will provide protection to beachfront properties and public infrastructure along the beach. However, options vary with regard to the construction costs, ongoing maintenance costs and impacts on beach width fronting the seawalls available to beach users. The economic model considers the costs and benefits of coastal protection options not only for beachfront properties at-risk but also the broader community. The economic effect of beach width encroachment carries significance from not just those owning property near the waterfront, but from a community perspective. The avoided loss value of the at-risk properties in Wamberal has a material impact on the CBA and distribution analysis. The outcome of the analysis is shown in Table A.

Table A: Distribution of Net Benefit/Losses, Net Present Value (NPV) and Benefit-Cost Ratio of Coastal Management Options at Wamberal Beach. Values in $M for 7% discount rate and 30-year horizon.

Stakeholder group		Option 1	Option 2	Option 3	Option 4	Option 5
Funding body(s)		-$29.1	-$27.5	-$37.6	-$38.3	-$53.3
General community & non-beachfront homeowners	**LGA**	-$6.0	-$7.5	$20.4	$20.4	$33.6
Homeowners	**Beachfront**	$65.1	$65.1	$65.1	$65.1	$65.1
Council	**LGA**	$3.2	$3.1	$5.9	$5.9	$5.8
Net Present Value ($M)		**$33.1**	**$33.2**	**$53.7**	**$53.0**	**$51.2**
Benefit-Cost Ratio		**1.94**	**1.95**	**2.43**	**2.39**	**1.96**

In assessing the economic analysis outcomes, a positive NPV indicates that the economic benefits outweigh the costs and is the preferred economic metric for ranking and informing selection of a preferred alternative to the base case. Notwithstanding that, other non-economic factors, such as social, legislative, legal, engineering and environmental criteria, as well as the uncertainties in quantifying benefits and costs (sensitivity analysis) will form part of the final preferred option selection process that will occur with consideration of community and other interested parties' views.

All five options achieve positive NPVs between +$33.1M to +$53.7M over 30-years using a 7% discount rate. Of these alternatives, Option 3 (vertical seawall) is indicated to achieve the highest NPV (+$53.7M). However, the comparative results between options are based on central estimates used as inputs into the CBA and are only marginal, and well within the bounds of natural error and uncertainty. Therefore, the results of sensitivity tests, and qualitative factors are expected to play an instrumental role in identifying a preferred option, particularly where alternatives are closely matched on economic criteria. Careful consideration of aesthetic and other factors difficult to monetarise (such as the significant height of vertical seawalls following major storms) will be required in identifying a preferred option and mitigating any undesirable effects as part of detailed design.

Sensitivity tests carried out on the CBA indicate that Option 5 (tiered seawall with promenade) delivers much greater net benefits, and therefore, achieves a much higher NPV than other alternatives under scenarios where a lower discount rate (3%) is chosen allowing it to accrue greater benefits over time (NPV: +$81.6M), where the base number of visitors to Wamberal beach is higher than estimated (NPV: +$102.1M), and where improved accessibility attracts a greater than forecast number of additional visitors (NPV: +$108.2M). Under these scenarios, Option 5 is a comparatively strong performing option economically relative to the base case. However, community consultation, more robust visitation data, and qualitative factors will play a role in determining what weighting to give these scenarios in decision making.

Table B: Distribution of net benefits across stakeholder groups. Values for 7% discount rate and 30-year horizon.

Stakeholder group		Option 1	Option 2	Option 3	Option 4	Option 5
Council	**LGA**	4.7%	4.6%	6.4%	6.4%	5.5%
General community & non-beachfront homeowners	**LGA**	-	-	22.3%	22.3%	32.2%
Homeowners	**Beachfront**	95.3%	95.4%	71.3%	71.2%	62.3%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**

Table A and Table B summarise the results of the distributional analysis. Table A provides the NPV (total benefits less total costs) relative to the base case flowing to each of the stakeholder groups under each of the seawall options considered. Table B summarises corresponding distribution analysis in terms of the percentage of total net benefits flowing to each stakeholder group under each option.

For all options the majority of benefit flows to the Beachfront Homeowners with the protection of private property at-risk to coastal hazards. Some additional benefit for Options 3-5 flows to Non-Beachfront Homeowners with improved beach width. For all options, beach width is maintained at the post seawall construction level into the future via periodic sand nourishment. Beach widths are compared for each seawall option relative to the encroachment of the present ad-hoc (non-engineered) works (Figure A) which is expected worsen under long-term natural beach recession. Option 5 delivers a larger share of benefits to the General Community in the LGA, via provision of a public promenade improving access along the beach (maintained immediately after storms when the beach is eroded) and attracting some potential additional beach visitation. Benefits which flow to Council under each seawall option include avoided administrative and staff costs and avoided costs of repeat emergency works. Avoided public disruption from all seawall options could not be monetarised in this study but should also be considered in the value proposition of all seawall options.

In all cases the majority of costs will fall on the funding body(s) expected to be based on the identified primary beneficiaries with specific parties yet to be agreed. For Options 1 and 2, a loss of beach width would result in some costs to the broader Non-Beachfront Homeowners. Should these options be pursued this cost could be mitigated by additional beach nourishment to offset impacts of seawall encroachment (see *Stage 4 Sand Nourishment Investigation*).

Planned retreat was not included in the scope of the CBA as there is no present policy or mechanism for property reacquisition under planned retreat. In addition, planned retreat was not a recommended action of the certified Coastal Zone Management Plan for Wamberal Beach, in part because it achieved negative NPVs of -$272M and -$215M in previous studies. Due to ongoing advocacy for some models of planned retreat by some community members, planned retreat is considered in the sensitivity analysis section of this report. None of the planned retreat options considered were economically viable. It is important to note that the prohibitively high cost (and impracticability) of planned retreat through property acquisitions would likely fail to ever complete and impose a long-standing disruption by dividing community and imposing significant financial burden on Council, and by extension, the community of the Central Coast.

Sophisticated economic analyses for coastal management is an evolving area of research and hence "*The decision on which option Council should implement is likely to depend on several other considerations which are not addressed in a CBA*" as concluded in the DPIE (2020) Guidelines and in this report. Coastal economics in NSW would greatly benefit from more detailed and explicit Practice Notes. Notwithstanding that, all seawall options are indicated to have strong net benefit to beachfront homeowners with strong potential to achieve net benefits to all interested parties.

Figure A: Wamberal Beach (Grant Leslie, 2020)

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1 Introduction

1.1 Background

Wamberal Beach is within the traditional boundaries of Darkinjung (Darkinyung) land, which extends from the Hawkesbury River in the south, Lake Macquarie in the north, the McDonald River and Wollombi up to Mt Yengo in the west and the Pacific Ocean in the east.

Wamberal Beach is a sandy ocean coast shoreline, situated within the Wamberal-Terrigal embayment on the NSW Central Coast as shown in Figure 1.1. A more detailed description of the study site including regional wave climate is provided in the Stage 2 Report (in draft). Over the past 50 years development along the foredune of Wamberal Beach has had a history of damage and loss due to coastal erosion events. Managing risks to public safety and built assets, pressures on coastal ecosystems and community uses of the coastal zone make up the priority management issues of the certified Gosford Beaches Coastal Zone Management Plan (CZMP, 2017) with the primary objective:

> *"to protect and preserve the beach environments, beach amenity, public access and social fabric of the Open Coast and Broken Bay beaches while managing coastal hazard risks to people and the environment".*

Major actions recommended for Wamberal Beach from the CZMP (2017) were the following:

- *"TW11 Terminal protection – Council to action review, design and funding of terminal protection structure for Wamberal."*
- *"TW14 Investigate sources of sand and feasibility of beach nourishment for Wamberal Beach."*
- *"TW15 Beach nourishment coupled with a terminal revetment to increase buffer against storm erosion."*

Also relevant to the present cost-benefit analysis is the recommend action:

- *"TW27 Erosion protection works to be allowed for properties"*

In 2020 NSW government's professional specialist advisor, Manly Hydraulics Laboratory (MHL) in association with the Water Research Laboratory (WRL) of UNSW Sydney and Balmoral Group Australia (BGA) were commissioned by Central Coast Council to undertake the *Wamberal Terminal Coastal Protection Assessment*. A key outcome of the study is a series of reports for the following stages of work:

1. Review of previous studies
2. Coastal protection amenity assessment
3. Seawall concept design options
4. Sand nourishment investigation
5. Provision of coastal monitoring (online webpage)
6. **Cost benefit analysis and distributional analysis of options (current report)**

This report provides the outcomes of Stage 6 of the Wamberal Terminal Coastal Protection Assessment, namely the undertaking of a cost-benefit analysis and distributional analysis for Terminal Protection Options for Wamberal Beach. The report and analyses have been undertaken by Balmoral Group Australia.

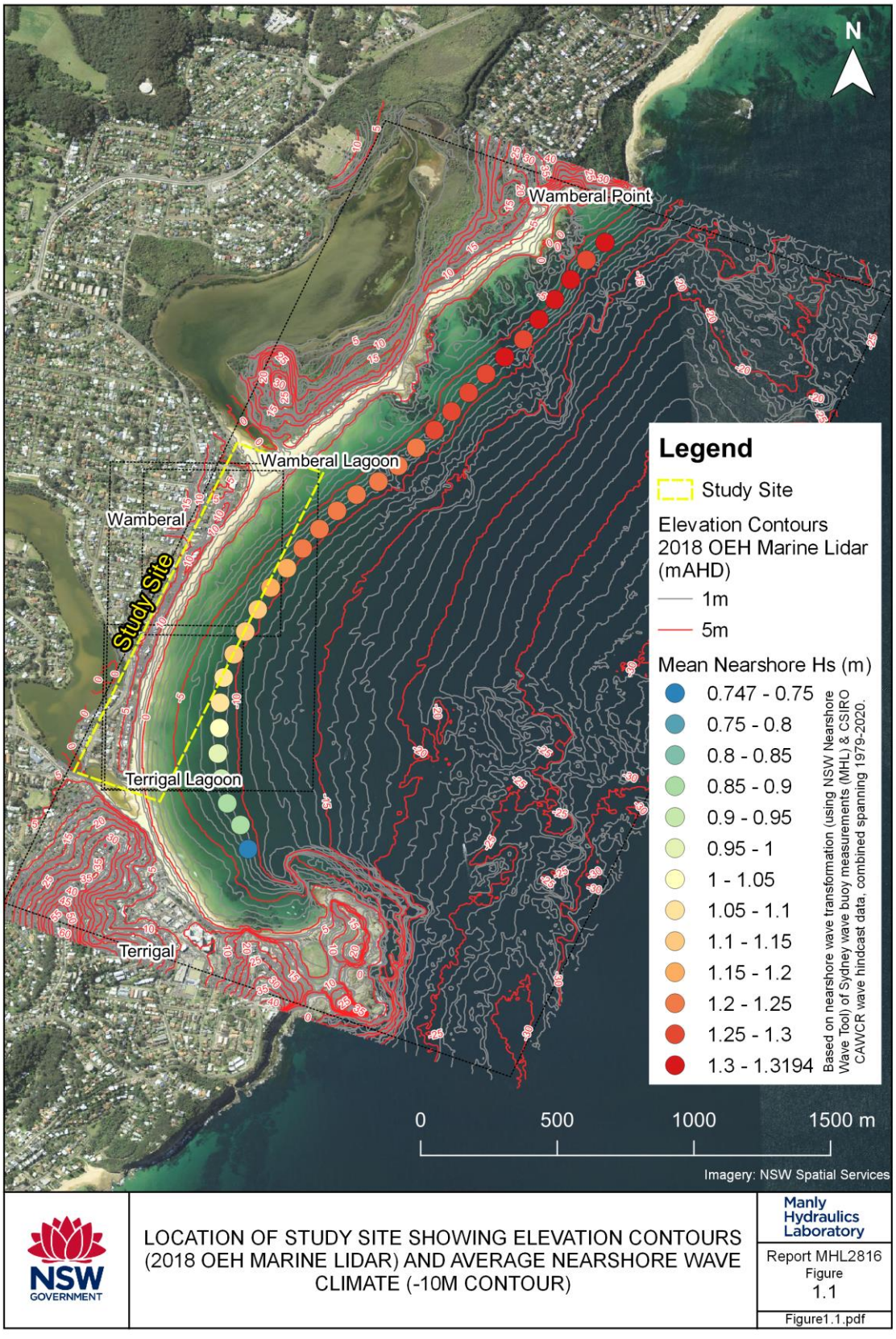

Figure 1.1: Study site location map. From Stage 1 Report.

1.2 Stage 6 objectives

Objectives of Stage 6 of the *Wamberal Coastal Protection* Assessment include:

- summarise the options for protection of Wamberal beach and identify the elements of them of consequence to a CBA.
- detail the underlying assumptions underpinning the quantification of costs and benefits to be included in the CBA.
- report on the total costs, benefits, and net present value of each of the options, as well as sensitives and uncertainties that may have a material impact on the outcome of the CBA.
- provide a distributional analysis, supported by a socio-economic profile, that identified the degree to which relevant stakeholders within the referent group of the CBA incur costs or gain benefits as a result of the proposed interventions.

1.3 Stage 6 overview

The Stage 6 report includes the following:

- A summary of historical events relevant to aiding understanding of the issue (Section 2).
- An outline of the options considered and their features relevant for the quantification of costs and benefits (Section 3).
- A summary of the critical assumptions underpinning the entire CBA (Section 4).
- A Cost Benefit Analysis (Section 5), including:
    - A description of costs and benefits and their economic quantification
    - Results
    - Treatment of relevant uncertainties and sensitivities
    - A distributional analysis.

2 Historical context

New South Wales has several erosion 'hot spot' locations. Wamberal Beach located on the Central Coast of NSW is one of the most exposed beaches in this state, having experienced several severe erosion impacts over the past 50-years[1]. The community of Wamberal beach faces a difficult and challenging situation due to coastal erosion.

Wamberal Beach has always experienced storm erosion, although threats to property emerged in the 1960s, and continued since the 1970s. The safety of houses was threatened in 1974, and two houses were lost after the storm in May, 1978 (Coastal Management, 2010). Beach erosion continues to be a major geographic issue with major events in 1991, 1995, and 1996 threatening the beach front and coastal communities. In 2016, another ocean storm event eroded a large portion of the beach (Lord & Macdonald, 2016). A number of reports have been completed to assist stakeholders in understanding the options for the future. Central Coast Council (formerly Gosford City Council) has developed a Coastal Zone Management Plan (CZMP) to help the community plan for and manage future coastal hazards.

1970's: The Central Coast was battered by a stormy period in the 1970s. Land was lost to erosion from severe coastal storms in 1974 and 1978. The major storms of May-June 1974 threatened all beachfront properties at Wamberal and damaged one house. The State Emergency Service and the Australian Army placed rocks, sandbags and other materials in front of the erosion scarp. Beachfront property owners also placed ad hoc protection works on the beach (rock rubble, corrugated iron, concrete walls). In June 1978, land was again lost to the ocean from major storms that occurred. Coastal erosion resulted in two neighbouring houses being washed away by heavy seas.

1990 to 2000's: The early 1990's saw another period of significant sand build up on the beach and dunes. The sandstone block wall was built at Terrigal in 1999. The beach and dunes were mostly steady during the 2000's. Large storms impacted Wamberal-Terrigal Beach in 1995 and 2007.

2015-2016: Beachside development was again threatened by destructive erosion events in April 2015 and June 2016. The 2016 event was caused by a major coastal storm with a more hazardous wave direction and king tides. In addition to the erosion impacts, waves washed through Terrigal Lagoon entrance, causing flooding and damage to lakeside properties. Rock, building rubble and other ad hoc protection materials from the 1970's was exposed in the Wamberal dunes and on the beach. Some houses were left hanging on the edge of the erosion scarp. This storm resulted in the erosion of the vegetated foredune by up to 15 metres in width and erosion scarps 6 metres high, as well as severely damaged public amenity and private property (Lord & Macdonald, 2016).

2020: Several large storms impacted Wamberal-Terrigal Beach in 2020. The most destructive erosion event occurred from a major storm in mid-July which impacted numerous properties. Approximately 54 residents were evacuated for their personal safety. Hazardous rubble and debris were strewn across the beach. A rapid and coordinated erosion emergency response at Wamberal saw the placement of 4,400 tonnes of rock by Council, under emergency orders by the NSW Government appointed Local Emergency Operations Controller. Guided by expert coastal engineers, the emergency rock works ensured that coastal infrastructure was not further damaged by wave action throughout the emergency event. However, these rock works are not a long-term solution to the erosion issue (the 2020 event being well below historical and design storm conditions).

[1] The history of Wamberal erosion is taken from https://info.centralcoast.nsw.gov.au/erosionsurvey

3 Cost-benefit analysis (CBA)

3.1 Objectives of CBA

This CBA describes the evaluation of the various options available with regards to the CZMP (WorleyParsons, 2017). The objective of the analysis is to address two principal objectives:

1. To assess the costs and benefits of options for managing the identified threat posed by coastal erosion to Wamberal; and
2. To understand the social and economic impacts of each option in terms of housing, local tourism, environmental benefits, beach amenity, supporting industries and the long-term viability of Wamberal.

The CBA is also the principal input into the distributional analysis (section 4) which provides insight into the proportion of net benefits ascribed to different stakeholder groups for the purposes of supporting any future funding decisions. For a better understanding of the social and economic impacts of the coastal protection options, or any subsequent funding decisions, a socioeconomic profile (Appendix A) data and analysis is also provided.

3.2 Options considered in CBA

The options considered in this CBA were originally agreed to by Central Coast Council members following the assessment completed by MHL. The following list includes the base case and seawall concept design options to be considered:

Base case: 'maintain status quo'- this is the business as usual 'do-normal' scenario- The base case scenario involves a continuation of current management approaches to coastal processes with no specific intervention program to mitigate the impact of coastal erosion on beach front properties. In this scenario emergency protection works occur as needed for public safety and temporary protection of beachfront houses. Emergency works are by nature undertaken reactively and often in an "ad-hoc" manner. Emergency works are not designed to provide long-term protection against coastal erosion hazards and future sea level rise recession.

Option 1: Basalt rock revetment and periodic sand nourishment – This option consists of a conventional rubble mound rock seawall with basalt rock armour. The revetment would comprise of two layers of graded rock armour overlying a graded rock filter layer and composed of basalt stones in this scenario. The option includes periodic sand nourishment to offset long-term natural beach recession (described below).

Option 2: Sandstone rock revetment and periodic sand nourishment – This scenario also consists of a conventional rubble mound rock seawall with sandstone rock armour. The revetment would comprise of two layers of graded rock armour overlying a graded rock filter layer and composed of sandstone stones in this scenario. The option includes periodic sand nourishment to offset long-term natural beach recession (described below).

Option 3: Vertical seawall and periodic sand nourishment - This scenario consists of piled vertical seawall located at the back of the beach comprising precast concrete panels and a sheet pile toe. The option includes periodic sand nourishment to offset long-term natural beach recession (described below).

Option 4: Vertical seawall with rock toe and periodic sand nourishment – As an alternative option to the sheet pile toe, this scenario consists of piled vertical seawall located at the back of the beach comprising precast concrete panels with a non-rigid rock rubble toe. The option includes periodic sand nourishment to offset long-term natural beach recession (described below).

Option 5: Tiered vertical seawall with promenade and periodic sand nourishment - This option consists of a tiered vertical seawall design including piled footings, a mid-level promenade, split (lower and upper) vertical faces, and a sloping rockfill near the crest. The option includes periodic sand nourishment to offset long-term natural beach recession (described below).

Seawall concept designs associated with each option are detailed in the *Stage 3 - Seawall Concept Design Options* report. Sand nourishment for each option was evaluated as part of the *Stage 4 Sand Nourishment Investigation*. The Stage 4 works found that substantial sand sources required to offset encroachment impacts of rock revetments (Options 1 and 2) are subject to future viability at the time of the nourishment campaign, as well as potential added complexities around lagoon entrance management depending on design placement. Given the feasibility of larger sand source availability, it was considered more realistic to assess all options in the CBA excluding nourishment to offset encroachment impacts. Instead, the CBA examines marginal benefits and costs between seawall options based on differing degrees of encroachment and available dry beach width amenity. These relative impacts for each option are detailed in the *Stage 2 Coastal Protection Amenity Assessment* and used as input to the CBA. All alternatives to the Base Case in the CBA include periodic sand nourishment (approx. every 10 years) to offset estimated natural beach recession due to underlying losses and sea-level rise (see *Stage 4 Sand Nourishment Investigation* for further detail).

3.3 Scope of CBA

3.3.1 Reference groups

The NSW Government *Guidelines for using cost-benefit analysis to assess coastal management options* (OEH 2020) (hereafter, the OEH guidelines) state that the perspective of the CBA should be determined by the purpose of the analysis. Where the CBA is used as a local decision support tool, the reference group should be the local government area (LGA) in order to determine whether the LGA community will be better off. However, where a broader focus is required, the CBA should adopt a wider geographic scope, such as the state-wide reference group prescribed by the *NSW Treasury guide to cost-benefit analysis (TPP17-03)* (hereafter, the NSW Treasury guidelines).

The purpose of this CBA is not only to determine if the local community is better off, but to inform a distributional analysis that will inform a future funding decision by Central Coast Council, including the cost share of any potential management options that may be borne by specific stakeholder groups.

The OEH guidelines indicate that a geographical scope that is strictly limited to the LGA will necessarily exclude homeowners who are not also residents of the local community. It will also exclude tourists who are not residents of the LGA. Adopting this limited geographical scope would

distort the outcomes of the distributional analysis[1].

Therefore, the reference group of this CBA takes a wider scope, including all beachfront properties regardless of ownership. It also does not exclude tourists from outside the LGA, in recognition of the fact that beach-related tourism accounts for significant flow-on benefits to local businesses and households, but that these economic impact effects are substantially more complex to estimate relative to the marginal impact of the beach in question.

3.3.2 Temporal scope

The OEH guidelines indicate that long-term projects should adopt an analysis timeframe of 30 years, in alignment with the NSW Treasury guidelines. However, where the design life of the proposed infrastructure is longer (50 years), such as in the case of seawalls, a longer period may be considered.

In this CBA, analysis is limited by the ability to project potential future erosion risks. The key input into the CBA for understanding potential future erosion likelihood are probabilistic hazard lines which are used to estimate the likelihood of the coastal erosion hazard over time. This study has adopted two sets of hazard lines, those showing the immediate likelihood of coastal erosion, and the exceedance probability of coastal erosion at 2050. A 30-year timeframe for the cost-benefit analysis has been adopted, corresponding to the 2050 projection limit of recently updated probabilistic hazard modelling for Wamberal Beach (DPIE Science, 2020). Former coastal hazard lines for 2100 projections by OEH (2016) were not included in the analysis.

The following section provides greater details on the hazard lines adopted in the CBA.

3.3.2.1 Hazard lines

Hazard lines adopted in the study were provided from DPIE (per comms 10 September 2020) and are detailed in Kinsela et al. (2017). The hazards lines represent an exceedance probability of the coastal erosion hazard at year 2020 and at 2050 and are shown Terrigal-Wamberal beach in Figure 3.1 and Figure 3.2. The hazard lines include the immediate hazard area and incorporate allowances for both the long-term recession of the shoreline due to local sediment imbalance and for measured and projected sea level rise.

The hazard lines are described in OEH (2016) as: *"the range of potential locations of the crest of a hypothetical dune escarpment following erosion into unconsolidated sand and slumping to the angle of repose – i.e. the 'Zone of Slope Adjustment' after Nielsen et al. (1992), assuming $\phi = 30°$."*

And further:

"It should also be noted that, depending on the composition of the dune substrate, there may exist an area of unstable land extending several metres landward of the mapped scarp location, which may threaten structures that have been built on traditional (unpiled) foundations – i.e. the 'Zone of Reduced Foundation Capacity', after Nielsen et al. (1992)."

[1] As a general illustrative proof of concept, take for example a case where beachfront properties protected were worth $20M in total ($10M to local residents, and $10M to absentee landlords), and other public benefits to the wider LGA community were worth $10M. A CBA that excluded absentee landlords would result in a distribution analysis that implied that beachfront property owners received 50% of the benefits, and the wider community received the other 50%. This may bias any subsequent funding decision, since it ignores the fact that, in reality, beachfront property owners receive 67% of the benefits and may be willing to contribute a commensurate amount to the costs of protecting their property.

The hazard lines used in the present CBA to determine potential losses to private property and land avoided with seawall protection correspond with the zone of slope adjustment (ZSA). Further consideration of engineering safety could take into account unpiled buildings situated within the zone of reduced foundation capacity (ZRFC) discussed above, located approximately 10-15 m landward of the adopted ZSA hazard lines. It is estimated that consideration of unpiled houses within the ZRFC would add approximately $30-50M of losses to private building and land avoided with seawall protection at Wamberal Beach in addition to that calculated in the present study.

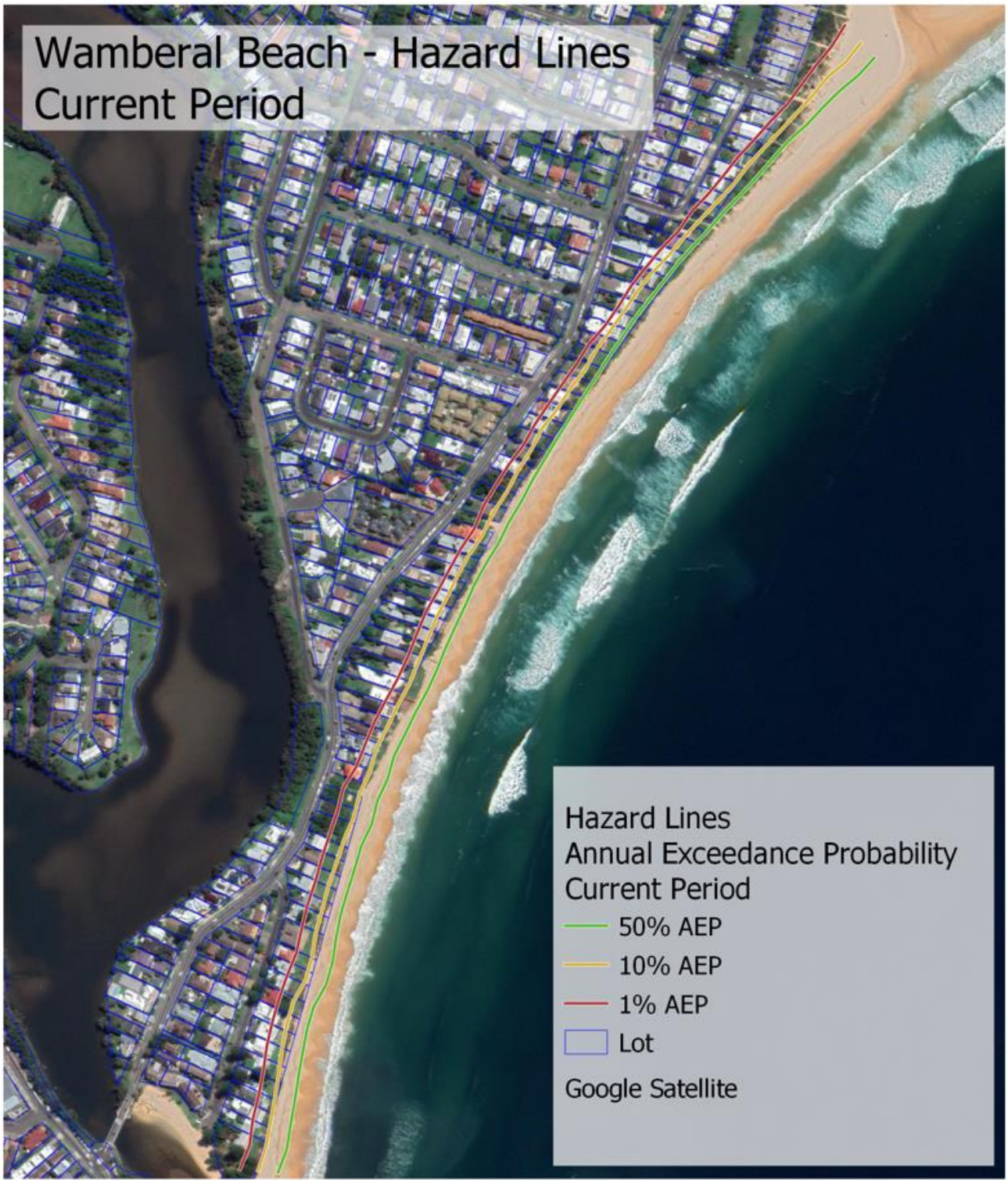

Figure 3.1: Immediate hazard line. Source DPIE (2020).

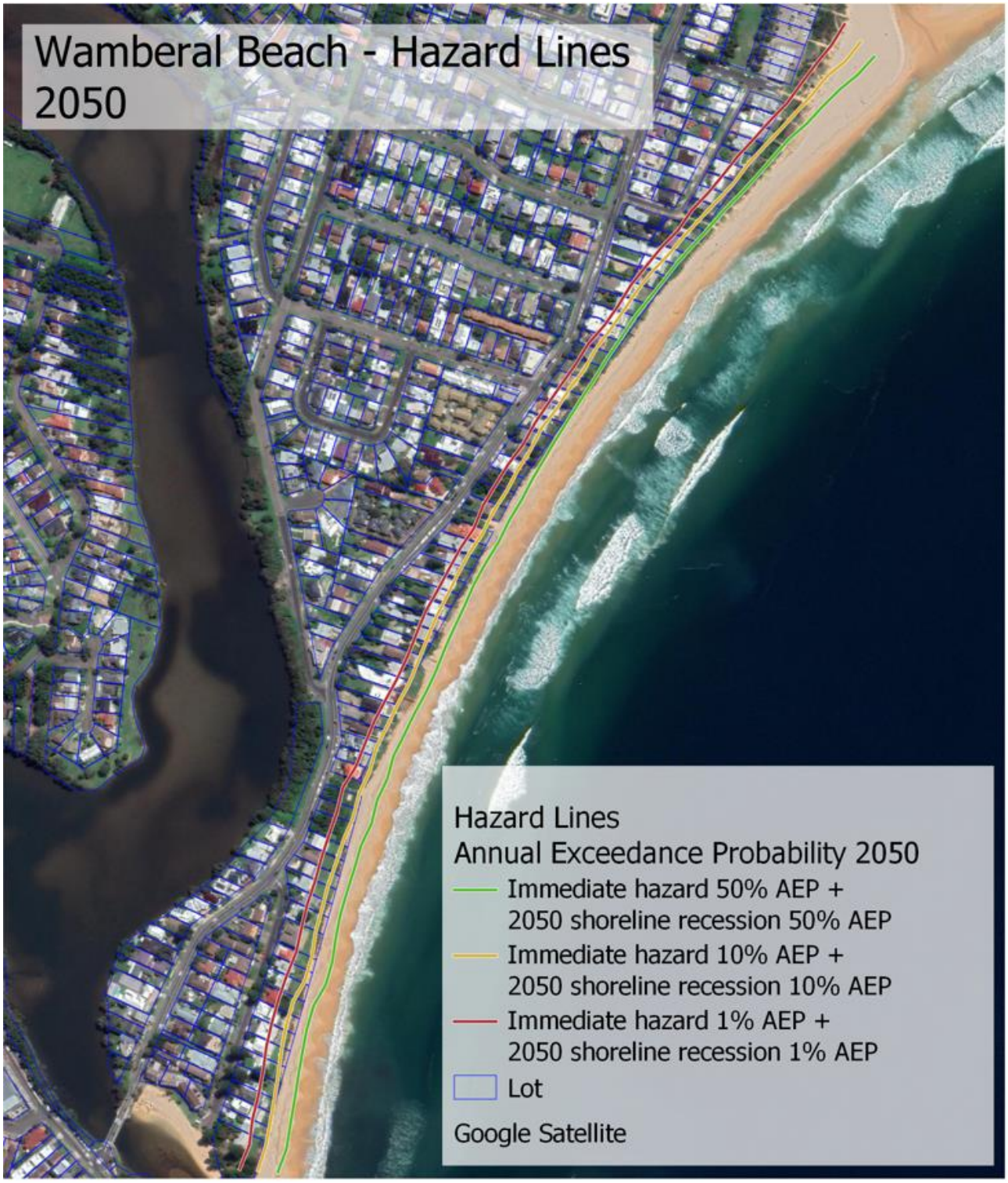

Figure 3.2: 2050 hazard line. Source DPIE (2020).

The key function of the hazard line map in the CBA is to identify at risk properties under different scenarios.

Table 3.1 summarises the cumulative number of lots where dwellings are impacted by coastal erosion at 50%, 10%, and 1% annual exceedance probabilities. These lots where dwellings are impacted are considered lost to their entire real estate value.

Table 3.1: Cumulative number of lots where dwellings are impacted by shoreline erosion/recession

Exceedance probability	2020 – immediate hazard	2050 – 30-year hazard
50%	0	14
10%	22	62
1%	58	72
Total	**58**	**72**

Table 3.2 summarises the cumulative total area (m^2) lost to shoreline erosion/recession for those lots impacted by coastal erosion but where dwellings **are not** impacted. These areas of land that are impacted but where the dwellings are not impacted are considered lost to the value of unimproved land. It is noted that land areas in Table 3.2 are not equivalent to the total area of private land situated seaward of the hazard lines.

Table 3.2: Cumulative area of unimproved land impacted by erosion/recession in lots where buildings are not impacted

Exceedance probability	2020 – immediate hazard	2050 – 30-year hazard
50%	497	2,975
10%	4,806	7,030
1%	6,460	7,664
Total	**6,460**	**7,664**

A detailed description of the methodological reasoning underpinning the quantities outlined in Table 3.1 and Table 3.2 is provided in section 3.4.1.1. A detailed description of the methodology underpinning the application of real estate and unimproved property values to the quantities of property protected under each coastal management option is provided in 3.4.3.

It should be noted that by their nature, hazard lines are only modelled estimates of where the future coastal hazard may be in 2050, and that those models of sea-level rise, erosion, and storm intensity are themselves subject to uncertainty and confidence intervals. While the best available science has been used to conduct the current study, the underlying assumptions, and therefore the conclusions, will be subject to continual updating as time progresses. However, it is considered that the models of coastal erosion are sufficiently well understood, and within confidence intervals that can enable informed decisions to be made regarding the long-term (to 2050) management of Wamberal Beach.

3.4 Costs and benefits considered

The analysis considered three types of costs to the community; direct, indirect and non-market, characterised as follows.

- Direct costs – cash, council staff time or other direct expenditure, as for construction or maintenance.
- Indirect costs – generally, a loss of income or asset value due to loss of some activity, etc.
- Non-market costs – generally, the value of something that the public values and will no longer

have.

Likewise, the analysis considered three types of benefits; community-oriented, recreational, and environmental. The latter categories may include direct expenditures and proxies for value identified by "willingness-to-pay (WTP)."

- Community benefits are broad, commerce-based benefits that accrue to the community in general, not to a specific party, in addition to the value of protected property.
- Recreational benefits such as walking, swimming or surfing by residents and visitors.
- Environmental benefits are published willingness-to-pay values for various ecological assets.

The net of the total costs and benefits therefore provide an indication of the extent to which producers and consumers are worse off verses whether producers and consumers are better off.

The value of each cost or benefit was assigned and estimated independently for each option. In some cases, values were derived directly from the relevant engineering reports. In other cases, published literature or government statistics were used to quantify impacts. Values for recreational and environmental benefits were derived from a review of relevant publications and calibrated to local visitor counts, household numbers and demographics. Table 3.3 provides a brief description of costs and benefits has been used in the analysis.

Table 3.3: Brief description of costs and benefits

Category Costs	Brief Description
Construction costs	Capital construction works costs for seawall concept design options including preliminary estimates for removal of ad-hoc emergency works present on beach. Please refer to *Stage 3 Seawall Concept Design Options* for further detail. Construction costs in the CBA were discounted over the construction period.
Property related costs	Value of properties or land lost to erosion, or conversely, not lost under each of the management options. Also includes acquisition of land for seawall with promenade or the upkeep of the buildings. Note: Whether compensation occurs, or the property owner bears the cost, costs are incurred.
Repair and Maintenance costs	Structure maintenance costs for each seawall option; may also apply to the costs after a significant recession event of capping pipes, maintaining public safety, etc. For the beach front properties: For the upkeep of the buildings. Structure maintenance costs are compared relative to ad-hoc emergency costs for the base case
Administrative/staff costs	To manage public inquiries and oversee orderly transition and the Council staff time/salary. Erosion emergency response by Council for emergency response in case of storm events.
Periodic nourishment cost	Cost of replacing sand lost due to underlying recession and sea level rise on a periodic basis (approx. every 10 years) as per *Stage 4 Sand Nourishment Investigation.* Due to future uncertainty in timing of works, periodic nourishment costs in the CBA are annualised over study period (excluding the duration of the construction period).

Category Benefits	Brief Description
Value of private property– building impacted by erosion	The entire real estate value of a beachfront property (land and building) is retained by protecting the beach. The total value of at-risk properties is based on the average value for beachfront properties in Wamberal, calculated with a hedonic model.
Value of private property– unimproved area impacted by erosion	Area and value of land lost to erosion is only calculated for those lots where there is no erosion impact to the building but there is still the likelihood that land will be lost. This is not equivalent to the total area of private land situated seaward of the hazard lines.
Additional property premium associated with beach quality	Homeowners pay a premium for nearshore properties protected by nature or by humans while shoreline changes affects the premium as well (Jin et al. 2015; Parsonz et al. 2013). Wide beach has positive impact on property value however the impact would be marginal after a certain point depends on the long-term beach width in each coastal area over the last decades. In this study the impact of shoreline changes, as measured by beach width, within 500m of Wamberal beach has taken into account.
Residual value	The remaining value of the protection infrastructure at the end of the analysis prior, for the 30-year analysis only.
WTP for beach use values (generic beach use such as walking, swimming, dog walking, enjoy nature)	Values the public either pays (direct expenses by visitors) or is willing to pay for recreational opportunities or ecological amenities. To avoid double-counting, the number of surfers (who are already accounted for in the WTP for surfing) was subtracted from total visitors to obtain the WTP for beach amenity.
Environmental WTP- beach and sandy seabed value	The value that households are willing to pay to preserve the beach, sandy seabed and the dune in the region.
WTP for surfing	The value that surfers are willing to pay to continue surfing in the Wamberal beach.
WTP to increase beach access	The value that beach users are willing to pay for improved beach accessibility.

3.4.1 Methodological notes on specific cost and benefit items

3.4.1.1 Property related costs – value of properties lost to erosion

The OEH guidelines published July 2018[1] provide a suggested treatment for identifying the lost value to a property that has been affected by coastal erosion:

- If coastal erosion impacts affect the dwelling, then the entire real estate (market) value of the property is considered lost.
- If coastal erosion impacts on land but not the dwelling, then the land area lost should be valued at the latest NSW Valuer General's value for unimproved land.

However, the OEH Guidelines published September 2020 provides slightly different advice that:

- Unimproved land may only be considered lost if it falls below the minimum lot size of the land, and
- Land is valued at the base rate, without the additional premium associated with being a beachfront property, in order to account for changes in welfare associated with lots behind drawing closer to the coastline, and
- Damage to dwellings does not immediately cause a lot be considered condemned, as owners

[1] Appendix A Table A.2

may repair and rebuild in different parts of their property in response to damage.

There are a number of reasons why the approach suggested by the OEH 2020 Guidelines are not adopted in favour of the OEH 2018 Guidelines. These are due primarily to the atypical characteristics of lots along the Wamberal coastline, including that,

- Most are much larger than the minimum lot size (420 m^2). The average lot size is 835 m^2 with many larger than 1,000 m^2. The smallest beachfront size block is 455 m^2. It is considered unlikely that property owners could incur loss to half or more of their land before economic damage could be attributed to them. And,
- Most have dwellings close to or directly abutting the seaward boundary of the lots. In addition, planning controls apply such that rebuilding the property in the event that it becomes compromised is prohibitively expensive for most owners, who are required to install deep concrete piles for any new structures. Over time, two houses along Wamberal beach have been lost to erosion events. And,
- Most are very elongated, with many lots longer than 70 m. Since most dwellings will be impacted near the seaward side of the lot, within the first 15 m of erosion, it would take significantly more erosion and time after the initial damage to property can been incurred, likely longer than the analysis period of the CBA allows, for the dwellings behind to gain the same hedonic premium that those lots that are currently beachfront properties enjoy[1].

The CBA therefore adopts the approach recommended by OEH in the 2018 Guidelines.

3.4.1.2 WTP for generic beach use values, and increased beach access

The OEH guidelines specify that impacts can be easily double counted, especially where benefits are inherently reflected in the pricing of other benefits, such as property values. In the case of this CBA, three value streams reflecting distinct but related beach values are accounted for. However, these are incorporated to measure the impacts of changes to the beach, and its use, as a result of transforming two distinct beach characteristics: beach quality (width), and beach accessibility.

An increase in **beach quality** will likely change both the number of visitors to the beach, as well as the value that each visitor gains from using it. The total impact associated with increased visitation and increased value is captured in the CBA through the increase in property premiums associated with additional beach width. Only the additional, not total, property premium is accounted for in the CBA in order to avoid double counting against the WTP for beach amenity use values.

An increase in **beach access** will also likely change the number of visitors and the value that each visitor gains from using it. Applicable literature values on the hedonic (property value) effect of increasing beach access do not exist to measure this effect, which is distinct from beach width. Therefore, we apply literature estimates for the increased number of visitors to the beach as a result of increased accessibility and apply an additional WTP to increase beach access in order to reflect the total impact on all users – current and induced.

3.4.1.3 Net impact on Council rates

The OEH Guidelines[2] specify that where the reference group is limited to the LGA, rate revenue may

[1] Hedonic modelling of properties at Wamberal beach undertaken to support the CBA indicate that beachfront lots receive a premium of approximately $2.02M due to their proximity to the beach. The premium declines rapidly to only $0.50M for properties between 100-250 m of the beach.
[2] Appendix A, Table A.2

be considered a cost to Council and subsequently the wider community if homeowners are forced to vacate their property due to coastal erosion and leave the LGA. However, this loss of revenue will be counteracted to some degree by reduced costs of council services provision. The guidelines therefore suggest that the net impact to any given Council facing a loss of beachfront properties to be marginal.

While the OEH guidelines suggest that measurement of the value of the services provided to individual households is likely to be a data intensive task, we have adopted a simplified methodology. We assume that, on average, the cost to council for providing services is equal to the average ordinary rates received from each household. The Central Coast Council Operational Plan 2019/20 indicates that the typical ordinary rates payable in the Gosford area is $972 per year. Therefore, if a beachfront property is lost due to erosion, Council may lose rate revenue, but will also not have to provide some $972 worth of services.

The avoided costs of services of $972 per year is also likely to be an overestimate on two counts:

- Some portion of those services represent the 'fixed costs' of managing a local government and will therefore vary at a less than 1:1 rate with the number of households.
- Wealthier households are less likely to require Council services than the average or lower income households, who may rely on services such as the local library if they do not have access to their own books or internet.

The likely overestimate of the costs to Council of service provision per household therefore makes the calculation of the net impact to Council revenue a more conservative one for the purposes of the calculation of the net benefits in the CBA. As outlined in section 3.4.3 (Table 3.4), the net impact to Council revenues, and subsequently the remaining population of ratepayers, is considered to be substantial and non-trivial for the purposes of the CBA.

In addition, as outlined in section 3.4.1.1, the loss in the value of private property and real estate as a result of coastal erosion is unlikely to be offset, at least over the analysis period, by a corresponding increase in wealth accruing to households subsequently made closer to the coastline. Therefore, it is considered likely that the increase in rate burden falling to other households in the LGA or area will represent a real economic financial impact to those property owners.

3.4.2 Specific exclusions from costs and benefits

3.4.2.1 Household income

The OEH Guidelines[1] specify that loss of income may be included in a CBA as it is assumed that residents who are impacted by coastal erosion will leave the LGA.

In the current analysis it is considered potentially likely that housing stock would be made available elsewhere in the LGA or else brought forward in response to a decline in the housing stock in one part of the LGA (i.e. the beachfront). Therefore, no assumptions can be made about the movement of household incomes from the LGA, and this potential cost is excluded from the analysis. Notwithstanding, it is not considered likely that any assumption about the proportion of homeowners who may leave the LGA as a result of any coastal management option will change the outcomes of any of the other allocative assumptions made in this section.

[1] Section 7.1.2

3.4.3 Costs and benefits under each option

3.4.3.1 Base case

The base case scenario involves a continuation of current management approaches to coastal processes with no specific intervention program to mitigate the impact of coastal erosion on beach front properties. We assume that primarily Wamberal residents on the beach front and shoreline neighbourhood are impacted (663 households). Existing development controls and the State Government's emergency management framework are assumed to continue as they currently exist over the analysis period.

In this scenario emergency protection works occur as needed for public safety and temporary protection of beachfront houses, for example as occurred in July 2020 under the *State Emergency and Rescue Management Act 1989.* The nature of these works will are limited in the prevention of the risks at-hand and will not address future risks nor provide an engineering level of protection to properties. These works have typically included the placement of temporary (often ad-hoc) rock works and materials on the beach in effort to reduce erosion during storm events. In this option, no substantial mitigation activities are undertaken beyond repair to address hazards and address public safety. This may mean capping pipes, blocking unsafe stairways, and so forth. Further consideration regarding the ability for Council to continue to fund these ongoing works (or the ongoing costs of any of the management options explored here) are expounded on in section 4.

Despite reactive emergency management, losses of property are still projected to occur over the analysis period. Impacts to the community include the expected market value loss of homes consistent with the projected effects of recession over the two planning horizons, and the associated losses of council rates and general economic contribution of household incomes. Economic impacts of property occupation and loss, changes in beach use and related expenditures, and predicted loss of habitat consistent with the projected recession effects are included.

The principal operating assumptions underpinning the analysis of the base case are outlined in Table 3.4.

Table 3.4: Allocation of costs and benefits under the base case.

Category Costs	Allocation method
Construction costs	No costs for new infrastructure under the base case.
Property related costs	A total of 72 properties are at risk of being directly impacted by coastal erosion by 2050 (see Table 3.1 for probabilistic details). A hedonic model undertaken as part of the study estimates that the average market price of a beachfront property is $4,222,466. The entire real-estate value of these properties is considered lost in year 30 of the analysis. The baseline value of properties lost to erosion under the base case is $57.96M. A total of 7,664m^2 of unimproved land is at risk of being directly impacted by coastal erosion by 2050 (see Table 3.2). Valuer General's data for individual lots where available, and a population mean where not available, were used to determine the value of land lost. The average value per m^2 was $2,533. These unimproved land areas are considered lost in year 30 of the analysis. The baseline value of unimproved land lost to erosion under the base case is $7.11M.

Category	Allocation method
Ad-hoc emergency works ($M)	Data provided by Council indicates that the costs for the initial response, emergency protection, and post storm closure amounted to $2.1M for Wamberal Beach during the July 2020 storm event. The peak offshore significant wave height of the July 2020 storm had an average recurrence interval (ARI) of approximately 4 years, with emergency works providing some level of temporary protection typically up to approximately a 10-year ARI erosion event. Given the temporary protection of emergency works and the historical reoccurrence of erosion events at Wamberal Beach over the last 45 years, a frequency of emergency works of every 10 years has been adopted. A conservative estimate of costs to Council for continuing to reactively manage these events is $210,000 per year, which is likely to increase with continued underlying recession and sea level rise. Emergency works costs were annualised over the study period given the uncertainty in the timing of storm events triggering these works.
Administrative/ staff costs	Council administrative and staff costs associated with managing risks of coastal erosion as well as supply for beach clean, disposal of dislodged stair cases/ ad-hoc material were provided by Council. Total associated administrative costs over the last 12-month period area estimated to be $143,880 per year.
Net impact on Council rates	The Central Coast Council Operational Plan 2019/20 indicates that the ad valorem tax rate per dollar of unimproved land value in the former Gosford LGA is 0.29c per dollar. Applied to the properties in the study area, for which the Valuer General's appraisals of land value have been applied, this amounts to an average rateable income from beachside properties of $5,296 per year. As outlined in section 3.4.1.3, the average ordinary rates for households in the same area is $972 per year, which is taken as a proxy for the value of services Council provides per household. The net impact to Council rates per property lost to coastal erosion is the difference between the rates received and the costs of services supplied, that is, $5,296-$972 = $4,324. The total annual value, incorporating the properties lost to erosion as outlined in section 3.3.2.1, is $54,859 per year.
Periodic nourishment cost	No costs for beach nourishment under the base case.
Value of private property– building impacted by erosion	A building is condemned if erosion reaches the footprint of the building. In this case, the entire real estate value of the property (land and building) is considered lost. The total value of properties lost is based on the average value for beachfront properties in Wamberal, calculated with a hedonic model. Year 1 losses plus incremental probabilistic totals thereafter (discounted for future years) provide the total values for properties lost on an annual basis, weighted by their annual probability exceedance under different hazard lines. Based on this approach, a total of 21 private properties will have their buildings impacted by erosion, equivalent to a NPV of $57,962,399 over the 30-year horizon at a 7% discount rate. This approach results in higher upfront losses initially over the study period. This is not unrealistic considering the erosion damage and hazard experienced over recent times (storm events April 2015, June 2016, July 2020).
Value of private property– unimproved area impacted by erosion	The total area and value of land lost to erosion is only calculated for those lots where there is no erosion impact to the building but there is still the likelihood that land will be lost. Year 1 losses plus incremental probabilistic totals thereafter (discounted for future years) provide the total values for unimproved area lost on an annual basis, weighted by their annual probability exceedance under different hazard lines. Under the base case (status quo) total area lost to erosion would be about 7,664 m^2 over the 30-year period with the value of $7,115,930. The land value associated with the unimproved areas is based on NSW Government Valuer General.

Category Benefits	Allocation method
Additional property premium associated with beach quality	The premium associated with properties within 500m of Wamberal beach was estimated using a hedonic model of properties in the area. Total property counts, and average premiums associated with lots within 100m-250m (217 properties, average premium $496,025), and 250m-500m (372 properties, average premium $279,510) zones were calculated. The associated premium per m^2 of beach was derived from the hedonic model within each zone. Average beach width over the 30-year analysis period was estimated for each option considering underlying and future design recession (Stage 3 works), degree of seawall encroachment (Stage 2 works) and periodic sand nourishment (Stage 4 works). Under the base case (with no nourishment) the average beach width decreases from 20m to 2.4m by 2050, with an average beach width of 11.2m over the 30-year period. The baseline premium associated with beach width under the base case is $10.7M.
Residual value	No residual value for new infrastructure under the base case.
WTP for beach use values (generic beach use such as walking, swimming, dog walking, enjoy nature)	Data from the Wamberal Life Saving Club between 2017-2020 indicates that there are 54,611 non-surfer visitors to Wamberal beach per year. Pascoe and Doshi (CSIRO, 2018) found that use value for the average generic beach visit by primary and secondary reasons (Swimming, Walking, Fishing, Surfing, Enjoying Nature is $32.20 per trip for both Sydney and non-Sydney residents). The baseline WTP for beach use under the base case is $1.8M.
Environmental WTP- beach and sandy seabed value	Estimated beach areas were calculated based on the Beach Width Amenity Impact Assessment in Stage 2 works. The total area of Wamberal beach is estimated to decrease from 3ha to 0.4ha by 2050, with an average of 1.68ha over the next 30 years. Pascoe and Doshi (CSIRO, 2018) estimated coastal values and found a WTP per household per year $5 for non-Sydney residents. The WTP value is applied to residents of the suburb of Wamberal (2,135 households). The baseline WTP for environmental beach values (non-use) is $18,474 per year.
WTP for surfing	Data from the Wamberal Life Saving Club indicates that there are 6,725 surfer visitors to Wamberal beach per year. Lazarow (2009) estimates a WTP for surfers per session between $18.67 and $30.36. The lower bound estimate of $23 (current prices) is used for surfers. The baseline WTP for surfers' use of Wamberal beach is $155,255 per year.
WTP to increase beach access	Under the base case access to Wamberal beach remains poor. No additional WTP value is applied to generic beach visits.

3.4.3.2 Options 1 and 2 – Basalt/sandstone rock revetment

The two Rock Revetment options (Option 1 and 2) provide concept designs for basalt and sandstone. The options provide a conventional rock armoured revetment, also referred to as rubble mound seawall, comprising two layers of graded rock armour overlying a graded rock filter layer. Rock revetment options have the largest footprint compared to other concept designs and will likely impede more frequently on alongshore beach access following storms and encroach further into the active beach profile (see Stage 2 results). Both options are identical on cost and benefit line items except for total capital cost and the maintenance costs per year.

The principal operating assumptions underpinning the analysis of Rock Revetments are outlined in Table 3.5.

Table 3.5: Allocation of costs and benefits under Options 1 and 2.

Category	Allocation method
Costs	
Construction costs	The construction costs of seawall options are detailed in *Stage 3 Seawall Concept Design Options* The total construction costs for Option 1: Basalt rock revetment are $26,540,000. The total construction costs for Option 2: Sandstone rock revetment are $24,990,000. Costs were discounted over the construction period. Construction costs are inclusive of a 20% contingency.
Property related costs	No property impacts, or land acquisitions are forecast under either Option 1 or Option 2. The property related costs outlined in Table 3.4 are considered avoided under Options 1 and 2.
Repair and maintenance costs of public infrastructure	Maintenance costs were provided by MHL (see Stage 3 report). The maintenance costs for Option 1: Basalt rock revetment are expected to be $265,400 per year. The maintenance costs for Option 2: Sandstone rock revetment are expected to be $249,900 per year.
Administrative/staff costs	No costs for Council administration and management of coastal erosion events at Wamberal beach under Option 1 or 2. The administrative and staff costs outlined in Table 3.4 are considered avoided under Options 1 and 2.
Net impact on Council rates.	The net impact on Council rates outlined in Table 3.4 are considered avoided under Options 1 and 2.
Periodic nourishment cost	Periodic nourishment costs are assumed to incur every 10 years to offset underlying recession and future recession associated with future sea level rise. Periodic nourishment costs have been annualised in the CBA. The cost of periodic nourishment under Option 1 and 2 is $333,300 per year. Further sand nourishment details are provided in Stage 4 works.
Benefits	
Value of private property– building impacted by erosion	Avoided loss of the entire real estate value of the at-risk properties (land and building) is considered a benefit under options 1 and 2. The total value of saved properties is based on the average value for beachfront properties in Wamberal, calculated with a hedonic model. Under the options 1 and 2, at risk private properties will be saved over 30-year period at the value of $57,962,399.
Value of private property–unimproved area impacted by erosion	The total area and value of land lost to erosion is only calculated for those lots where there is no erosion impact to the building but there is still the likelihood that land will be lost. Under the options 1 and 2 the total avoided loss of unimproved land area to erosion would be about 7,664 m^2 over the 30-year period with the value of $7,115,930. The land value associated with the unimproved areas is based on NSW Government Valuer General.
Additional property premium associated with beach quality	The premium associated with properties within 500m of Wamberal beach is estimated using the same methodology described in Table 3.4. Under Option 1 (including periodic sand nourishment) the average beach width over the 30 year analysis period is estimated at 7.5m, less than the base case (no nourishment) at 11.2m. Under Option 2 the average beach width is estimated at 6.6m and again less than the base case. The additional property premium for Option 1, relative to the base case over 30 years, is $-5.9M. The additional property premium for Option 2, relative to the base case over 30 years, is $-7.4M.

Category	Allocation method
Residual value	The residual value of Option 1 and 2 is the remaining value of the constructed works remaining after 30 years, calculated using a straight-line depreciation method. The analysis assumed that both structures have a design life of 50 years. Therefore, 40% of the initial capital construction costs are allocated as a benefit in the final year of the analysis. The nominal residual value for Option 1 is $10.2M. The nominal residual value for Option 2 is $9.6M.
WTP for beach use values (generic beach use such as walking, swimming, dog walking, enjoy nature)	The WTP for beach use values is estimated using the same methodology described in Table 3.4. Under Options 1 and 2 there is no forecast change in beach visitation relative to the base case. Therefore, there is no increase in the use value of the beach under Option 1 or 2, relative to the base case.
Environmental WTP-beach and sandy seabed value	The WTP for beach use values is estimated using the same methodology described in Table 3.4. Estimated beach areas were calculated based on the Beach Width Amenity Impact Assessment in Stage 2 works. Under Option 1 (including periodic sand nourishment) the total area of Wamberal Beach between lagoon entrances is estimated to be on average 1.13ha over the next 30 years and less than the base case. The WTP for environmental beach values therefore decreases by -$6103 per year relative to the base case. Under Option 2 (including periodic sand nourishment) the total area of Wamberal Beach between lagoon entrances is estimated to be on average 0.99ha over the next 30 years and less than the base case. The WTP for environmental values therefore decreases -$7587 per year relative to the base case.
WTP for surfing	The WTP for beach use values associated with surfing is estimated using the same methodology described in Table 3.4. Under Options 1 and 2 there is no forecast change in beach visitation associated with surfing relative to the base case. Therefore, there is no increase in the use value of the beach under Option 1 or 2, relative to the base case.
WTP to increase beach access	Under the Options 1 and 2 access to Wamberal beach remains poor. No additional WTP value is applied to generic beach visits relative to the base case.

3.4.3.3 Options 3 and 4 – Vertical seawall with/without rock toe

The Stage 3 report provides concept designs for a vertical seawall with a sheet pile toe (Option 3), and a vertical seawall with a non-rigid rock toe (Option 4). The concept design incorporated a piled vertical seawall comprised of precast concrete panels supporting H-columns. Option 4 provides an alternative non-rigid scour protection at the toe of the structure in comparison to the rigid sheet pile toe protection for Option 3.

The principal operating assumptions underpinning the analysis of Options 3 and 4 are outlined in Table 3.6

Table 3.6: Allocation of costs and benefits under Options 3 and 4.

Category	Allocation method
Costs	
Construction costs	The construction costs of seawall options are detailed in *Stage 3 Seawall Concept Design Options* The total construction costs for Option 3: Vertical seawall are $34,010,000. The total construction costs for Option 4: vertical seawall with rock toe is $34,660,000. Costs were discounted over the construction period. Construction costs are inclusive of a 20% contingency.
Property related costs	No property impacts, or land acquisitions are forecast under either Option 3 or Option 4. The property related costs outlined in Table 3.4 are considered avoided under Options 3 and 4.
Repair and maintenance costs of public infrastructure	Maintenance costs were provided by MHL (see Stage 3 report). The maintenance costs for Option 3: Vertical seawall are expected to be $34,000 per year. The maintenance costs for Option 4: Vertical seawall with rock toe are expected to be $34,700 per year.
Administrative/staff costs	No costs for Council administration and management of coastal erosion events at Wamberal beach under Option 3 or 4. The administrative and staff costs outlined in Table 3.4 are considered avoided under Options 3 and 4.
Net impact on Council rates	The net impact on Council rates outlined in Table 3.4 are considered avoided under Options 3 and 4.
Periodic nourishment cost	Periodic nourishment costs are incurred every 10 years to offset underlying recession and future recession associated with future sea level rise. Periodic nourishment costs have been annualised in the CBA. The cost of periodic nourishment under Option 3 and 4 is $316,650 per year.
Benefits	
Value of private property– building impacted by erosion	Avoided loss of the entire real estate value of the at-risk properties (land and building) is considered a benefit under options 3 and 4. The total value of saved properties is based on the average value for beachfront properties in Wamberal, calculated with a hedonic model. Under the options 3 and 4, at risk private properties will be saved over 30-year period at the value of $57,962,399.
Value of private property–unimproved area impacted by erosion	The total area and value of land lost to erosion is only calculated for those lots where there is no erosion impact to the building but there is still the likelihood that land will be lost. Under the options 3 and 4, the total avoided loss of unimproved land area to erosion would be about 7,664 m^2 over the 30-year period with the value of $7,115,930. The land value associated with the unimproved areas is based on NSW Government Valuer General.
Additional property premium associated with beach quality	The premium associated with properties within 500m of Wamberal beach is estimated using the same methodology described in Table 3.4. Under Options 3 and 4 (including periodic nourishment) the average beach width is estimated at 23.7 m over the 30 year analysis period and wider than the base case at 11.2 m. The additional property premium for Option 3 and 4, relative to the base case, is $20.1M.
Residual value	The residual value of Option 3 and 4 is the remaining value of the constructed works remaining after 30 years, calculated using a straight-line depreciation method. The analysis assumed that both structures have a design life of 50 years. Therefore, 40% of the initial capital construction costs are allocated as a benefit in the final year of the analysis. The nominal residual value for Option 3 is $13.6M. The nominal residual value for Option 4 is $13.9M.

Category	Allocation method
WTP for beach use values (generic beach use such as walking, swimming, dog walking, enjoy nature)	The WTP for beach use values is estimated using the same methodology described in Table 3.4. Under Options 3 and 4 there is no forecast change in beach visitation relative to the base case. Therefore, there is no increase in the use value of the beach under Option 3 or 4, relative to the base case.
Environmental WTP-beach and sandy seabed value	The WTP for beach use values is estimated using the same methodology described in Table 3.4. Estimated beach areas were calculated based on beach widths provided by MHL. Under Options 3 and 4 (including periodic nourishment) the average beach area of Wamberal beach was estimated as 3.56ha and greater than the base case. The WTP for environmental beach values therefore increases by $20,61M per year relative to the base case.
WTP for surfing	The WTP for beach use values associated with surfing is estimated using the same methodology described in Table 3.4. Under Options 3 and 4 there is no forecast change in beach visitation associated with surfing relative to the base case. Therefore, there is no increase in the use value of the beach under Option 3 or 4.
WTP to increase beach access	Under Options 3 and 4 access to Wamberal Beach is assumed to remain the same as the base case scenario.

3.4.3.4 Option 5 – Tiered vertical seawall with promenade

Option 5 is comprised of a piled vertical seawall with a tiered configuration and mid-level promenade to enhance beach access and foreshore amenity. The vertical components of the design are similar to Options 3 and 4, including precast columns and H-columns with a piled toe.

The principal operating assumptions underpinning the analysis of Option 5 are outlined in Table 3.7

Table 3.7: Allocation of costs and benefits under Options 5.

Category Costs	Allocation method
Construction costs	The construction costs of seawall options are detailed in *Stage 3 Seawall Concept Design Options* The total construction costs for Option 5: Tiered vertical seawall with promenade is $40,100,000. Costs were discounted over the construction period. Construction costs are inclusive of a 20% contingency.
Property related costs	Under Option 5, 3,990m^2 of private property will need to be acquired in order to allow for the construction of the wider structure. The Value per m^2 was derived from the NSW Valuer General for individual lots. The total land acquisition costs under Option 5 are $11,336,231. The property related costs outlined in Table 3.4 are considered avoided under Options 5.
Repair and maintenance costs of public infrastructure	Maintenance costs were provided by MHL (see Stage 3 report). The maintenance costs for Option 5 are expected to be $60,100 per year.
Administrative/staff costs	No costs for Council administration and management of coastal erosion events at Wamberal beach under Option 5. The administrative and staff costs outlined in Table 3.4 are considered avoided under Options 5.

Category	Allocation method
Net impact on Council rates	The net impact on Council rates outlined in Table 3.4 are considered avoided under Option 5.
Periodic nourishment cost	Periodic nourishment costs are incurred every 10 years to offset underlying recession and future recession associated with future sea level rise. Periodic nourishment costs have been annualised in the CBA. The cost of periodic nourishment under Option 5 is $316,650 per year.
Benefits	
Value of private property– building impacted by erosion	Avoided loss of the entire real estate value of the at-risk properties (land and building) is considered a benefit under option 5. The total value of saved properties is based on the average value for beachfront properties in Wamberal, calculated with a hedonic model. Under the option 5, at risk private properties will be saved over 30-year period at the value of $57,962,399.
Value of private property–unimproved area impacted by erosion	The total area and value of land lost to erosion is only calculated for those lots where there is no erosion impact to the building but there is still the likelihood that land will be lost. Under the option 5, the total avoided loss of unimproved land area to erosion would be about 7,664 m^2 over the 30-year period with the value of $7,115,930. The land value associated with the unimproved areas is based on NSW Government Valuer General.
Additional property premium associated with beach quality	The premium associated with properties within 500m of Wamberal beach is estimated using the same methodology described in Table 3.4. Under Option 5 (including periodic nourishment) the average beach width over the 30-year analysis period is estimated at 17.8m and wider than the base case at 11.2m. The additional property premium for Option 5, relative to the base case, is $10.6M.
Residual value	The residual value of Option 5 is the remaining value of the constructed works remaining after 30 years, calculated using a straight-line depreciation method. The analysis assumed that the structure has a design life of 50 years. Therefore, 40% of the initial capital construction costs are allocated as a benefit in the final year of the analysis. The nominal residual value for Option 5 is $15.3M.
WTP for beach use values (generic beach use such as walking, swimming, dog walking, enjoy nature)	The WTP for beach use values is estimated using the same methodology described in Table 3.4. Under Options 5 there is a forecast increase in beach visitation, relative to the base case, of an additional 30,317 visitors per year. It is predicted that by building a promenade, the number of visitors would increase due to a proper walking area for residents, families with young kids (pram) and people with disabilities. The estimated number of visitors was imputed from research by Raybould et al. (2013), assuming that the beach access score increases from 1 (poor) to 5 (very good) with the construction of the promenade. Therefore, under option 5, the use value for generic beach visits increases by $991,394, relative to the base case.
Environmental WTP-beach and sandy seabed value	The WTP for beach use values is estimated using the same methodology described in Table 3.4. Estimated beach areas were calculated based on the Beach Width Amenity Impact Assessment in Stage 2 works. Under Option 5 (including periodic nourishment) the average beach area of Wamberal beach was estimated as 3.56ha and greater than the base case. The WTP for environmental beach values therefore increases by $10,886 per year relative to the base case.

Category	Allocation method
WTP for surfing	The WTP for beach use values associated with surfing is estimated using the same methodology described in Table 3.4. Under Options 5 there is no forecast change in beach visitation associated with surfing relative to the base case. Therefore, there is no increase in the use value of the beach under Option 5.
WTP to increase beach access	As outlined above, the number of visitors to Wamberal beach is forecast to increase under option 5 by 30,317 per year due to an increase in beach accessibility. As well as attracting more visitors, the increased accessibility also provides an increased WTP for beach visits. Research by Dixon et al. (2012) and Oh et al. (2008) provide a range of values for increased WTP for beach access, over and above the generic WTP for a beach visit. A midpoint of values of $10.8 per visit is chosen to represent a best estimate for benefit transfer to Wamberal Beach. Under Option 5, the WTP for beach access provides a benefit stream of $919,529 per year, relative to the base case.

3.5 Results of CBA

3.5.1 Summary results

Table 3.8 summarises the results of the CBA for each option at a 7% discount rate, and 30-year analysis period. The total costs, total benefits, and net benefits are provided in Net Present Value (NPV) terms (discounted over 30-years) and calculated relative to the base case – that is, incremental to the costs and benefits outlined in Table 3.4. Where costs that accrue under the base case are avoided under each of the management options, for example the avoided damage costs to public or private property, these are accounted for as benefits under each of the options.

The results indicate that under the central estimates, only Options 3, 4, and 5 achieve positive NPVs, and a BCR greater than 1.0. Where options for coastal management are mutually exclusive, ranking options based on highest positive NPV is the recommended approach to choosing a preferred alternative to the base case (Morris et al., 2021). Ranking based on BCR has a number of pitfalls, since equally valid methods of calculating them may yield substantially different results, and the option with the highest BCR will not necessarily be the option with the highest NPV. Therefore, for the purpose of reporting the results of the CBA and comparing them to the results of other previous studies (section 3.5.3.5), emphasis is placed on NPV here.

Table 3.8: Summary results of CBA under 7% discount rate and 30-year analysis period

Option	Total Costs (PV $M)	Total Benefits (PV $M)	Net Present Value (NPV $M)	Benefit-Cost Ratio (BCR)[1]
Option 1 – Basalt rock revetment + periodic nourishment	$35.17	$68.26	$33.09	1.94
Option 2 – Sandstone rock revetment + periodic nourishment	$34.99	$68.18	$33.20	1.95
Option 3 – Vertical seawall + periodic nourishment	$37.64	$91.32	$53.67	2.43
Option 4 – Vertical seawall with rock toe + periodic nourishment	$38.29	$91.34	$53.05	2.39
Option 5 – Tiered vertical seawall with promenade + periodic nourishment	$53.33	$104.50	$51.17	1.96

[1] BCR is calculated on the basis of total benefits divided by total costs. Therefore, it does not represent benefit achieved per $1 of capital investment.

Of the options that achieve a positive NPV, Option 3 achieves the greatest positive net benefits of $53.7M (BCR: 2.43), although the extent to which it is the most favourable option is extremely marginal compared to other options, and well within the bounds of error and uncertainty. Overall, no preferred option can be definitively identified from the central CBA results alone, and careful attention should be paid to the sensitivity tests outlined in section 3.5.3, which test various scenarios to identify which options are exposed to greater risks in the uncertainties, or are clearly preferred under certain conditions. Qualitative factors and community preferences may also play a role in selecting a preferred alternative, particularly where options are closely matched on economic criteria. Other non-economic factors as well as the uncertainties in quantifying benefits and costs (sensitivity analysis) will form part of the final preferred option selection process that will occur with involvement of community and other interested parties.

Careful consideration of aesthetic and other factors difficult to monetarise (such as the significant height of vertical seawalls following major storms) will be required in identifying a preferred option and mitigating any undesirable effects as part of detailed design.

Figure 3.3: Wamberal beach, Grant Leslie (2020)

3.5.2 Detailed results

Table 3.9 summarises the results of the CBA for each of the options considered, relative to the base case, by individual costs and benefits.

Table 3.9: Detailed costs and benefits of options for coastal protection at Wamberal beach

Line Item	Option 1	Option 2	Option 3	Option 4	Option 5
Costs					
7% discount rate relative to the base case	$M	$M	$M	$M	$M
Construction costs of protection works ($M)	25.39[a]	23.91[a]	34.01[a]	34.66[a]	38.37[a]
Maintenance cost relative to ad-hoc emergency works ($M)	0.21	0.04	-	-	-
Periodic nourishment costs ($M)	3.53[b]	3.53[b]	3.63[b]	3.63[b]	3.63[b]
Land acquisition costs ($M)	-	-	-	-	11.34
Environmental WTP – decrease in beach and sandy seabed ($M)	0.06	0.08	-	-	-
Reduced property premium – beach width	5.9	7.4			
Total Costs ($M)	**35.17**	**34.99**	**37.64**	**38.29**	**53.33**
Benefits					
Avoided maintenance cost relative to ad-hoc emergency works ($M)	-	-	2.22	2.21	1.92
Avoided administrative and staff costs	1.79	1.79	1.79	1.79	1.79
Net impact to Council rate revenues	0.06	0.06	0.06	0.06	0.06
Avoided loss of private property– building impacted by erosion	57.9	57.9	57.9	57.9	57.9
Avoided loss of private property – unimproved area impacted by erosion	7.1	7.1	7.1	7.1	7.1
Additional property premium – beach width	-	-	20.16	20.16	10.64
Residual value	1.335	1.26	1.79	1.82	2.02
Environmental WTP – increase in beach and sandy seabed	-	-	0.21	0.21	0.11
WTP for beach amenity – generic beach visit	-	-	-	-	11.46
WTP to increase beach access	-	-	-	-	11.41
Total Benefits	**68.26**	**68.18**	**91.32**	**91.34**	**104.50**
Net Present Value (NPV)	**33.09**	**33.20**	**53.67**	**53.05**	**51.17**
BCR	**1.94**	**1.95**	**2.43**	**2.39**	**1.96**

[a] Construction costs discounted over the construction period

[b] Periodic nourishment costs annualised over study period excluding construction period

The results shown in Table 3.9 are presented 'relative to the base case', that is, the costs and benefits under each Option, and each line item are net of the corresponding costs and benefits that would have accrued otherwise under the base case. For example, costs of maintaining public infrastructure under the base case are avoided, although there are increased costs of maintenance associated with any new beach protection infrastructure, and only the net cost (or benefit) is shown.

The detailed results indicate that the most instrumental benefit to the proposed works is the avoided loss of properties adjacent to the beach, attributed to households in Wamberal within 100 m from the beach. The second material benefit under options 3, 4 and 5 is the increased real estate value, or premium, attributed to households in Wamberal further than 100 m from the beach as a result of increased beach width. Beach width is impacted by a number of factors, including natural variability, beach nourishment as well as the encroachment and impacts of coastal protection works on the public beach use area.

With regards to Option 5, the results of the CBA for that option compare to options 1 and 2, are heavily dependent on both the forecast increase in beach visitation, and the increase amenity as a result of improved beach accessibility. While it achieves net benefits comparable to Options 3 and 4, relatively minor differences in the assumptions made to beach visitation rates and values could have a significant impact in favour, or against, Option 5.

3.5.3 Sensitivity tests

3.5.3.1 Discount rates

The discount rate used in the CBA can affect the results. A 7% discount rate was used in this analysis as per NSW Treasury guidelines. The CBA was also assessed using discount rates of 3% and 10% to assess whether the NPV is sensitive to changes in the discount rate. A lower discount rate indicates a preference to value future costs and benefits with more weight, a higher discount rate indicates a preference to value future costs and benefits with less weight.

Table 3.10 summarises the NPV, and BCR associated with discount rates of 3%, 7% and 10%.

Table 3.10: Sensitivity analysis- NPV and BCRs of options at varying Discount Rates

Option	3%	7%	10%
Relative to the base case **30- year analysis**	$M BCRs in italic	$M BCRs in italic	$M BCRs in italic
Option 1 – Basalt rock revetment	$47.15 *2.24*	$33.09 *1.94*	$27.77 *1.82*
Option 2 – Sandstone rock revetment	$47.18 *2.25*	$33.19 *1.95*	$27.88 *1.82*
Option 3 – Vertical seawall	$70.62 *2.77*	$53.67 *2.43*	$47.31 *2.29*
Option 4 – Vertical seawall with rock toe	$70.06 *2.73*	$53.04 *2.39*	$46.67 *2.25*
Option 5 – Tiered vertical seawall with promenade	$81.61 *2.47*	$51.16 *1.96*	$39.29 *1.75*

The results of the sensitivity test on discount rates indicate that the weight placed on the time value of money is likely to be very impactful to the expected flow of benefits and costs for Options 1, 2 and 5. Under a low discount rate of 3%, Option 5 accrues more recreational benefits over time due to the increased visitation, and therefore becomes the stronger performing option economically. However, under a high discount rate of 10% the additional recreational benefits that occur in the future fail to grow large enough to counterweigh the large upfront construction costs of the project.

3.5.3.2 Beach nourishment costs

Future sources and availability of sand for periodic nourishment to offset underlying recession and sea level rise are subject to future viability (*Stage 4 Sand Nourishment Investigation*). In addition, our analysis provides a linear, annualised estimate of sand needs. In reality, sand needs are likely to occur over more concentrated intervals (determined by beach monitoring) and may increase in demand with time due to sea level rise. The benefits assumed herein are predicated on the ongoing nourishment costs, which itself may be an uncertain event. If sand were not available when required to offset future recession, the amenity values associated with the accordant benefits could be zeroed out, negating the benefits of nourishment.

Due to the uncertainty around future costs associated with sand for beach nourishment, sensitivity testing was carried out. Based on findings of Stage 4 works upper, central and lower bound costs were estimated for beach nourishment, utilising unit cost rates of \$50/m^3, \$30/m^3 and \$10/m^3 respectively. Total costs for beach nourishment under the upper, central and lower bounds are provided in Table 3.11. More detailed description of unit cost rates in relation to potential sand sources is provided in the Stage 4 Sand Nourishment Investigation.

The results of varying the cost of periodic beach nourishment are outlined in Table 3.12. The results indicate that all Options retain positive net benefits even under substantially higher nourishment costs.

Reduced beach width available to users is expected for rock revetments (Options 1 and 2) without additional large-scale nourishment to offset encroachment impacts (*Stage 2 Coastal Protection Amenity Assessment*). Additional nourishment requirements to offset encroachment impacts for Options 1 and 2 are detailed in Stage 4 works. Suitable sand sources are subject to future viability at the time of the nourishment campaign, as well as potential added complexities around lagoon entrance management depending on design placement.

Table 3.11: Sensitivity analysis- Periodic maintenance nourishment costs

Option	Beach nourishment maintenance cost Lower bound ($/m)	Beach nourishment maintenance cost Upper bound ($/m)
7% discount rate 30- year analysis		
Option 1 – Basalt rock revetment	\$741	\$3,704
Option 2 – Sandstone rock revetment	\$741	\$3,704
Option 3 – Vertical seawall	\$704	\$3,519
Option 4 – Vertical seawall with rock toe	\$704	\$3,519
Option 5 – Tiered vertical seawall with promenade	\$704	\$3,519

Table 3.12: Sensitivity analysis- Periodic maintenance nourishment

Option	Lower bound nourishment costs	Central nourishment costs	Upper bound nourishment costs
7% discount rate 30- year analysis	$M BCRs in italic	$M BCRs in italic	$M BCRs in italic
Option 1 – Basalt rock revetment	$35.44 *2.08*	$33.09 *1.94*	$30.73 *1.82*
Option 2 – Sandstone rock revetment	$35.55 *2.09*	$33.19 *1.95*	$30.83 *1.83*
Option 3 – Vertical seawall	$56.09 *2.59*	$53.67 *2.43*	$51.24 *2.28*
Option 4 – Vertical seawall with rock toe	$55.47 *2.55*	$53.04 *2.39*	$50.62 *2.24*
Option 5 – Tiered vertical seawall with promenade	$53.58 *2.05*	$51.16 *1.96*	$48.74 *1.87*

3.5.3.3 Number of generic beach visitors

The numbers of visitors at Wamberal Beach was estimated based on data from the Wamberal Surf Life Saving Club. The Club recorded the number of visitors to the beach on the weekends during the period 2017 – 2020. The average yearly weekend beach visitation number was doubled to account for weekday visitation to obtain an estimate for annual visitation estimates. However, other estimates for beach visitation at Wamberal beach were carried out by WorleyParsons on April 2015. The report 'Open Coast and Broken Bay Beaches Coastal Zone Management Study' by WorleyParsons estimates there are 125,632 visitors to Wamberal Beach in 2014-15 which potentially does not include after hours and non-patrol months. A revised input would be to upscale the Worley Parsons estimate by 20% to account for after hours and winter beach visitors = 125,632 X 1.2 = approx. 151,000. This number is in better agreement with annual visitor estimates at other beaches (eg Flynn's Beach 150,000).

Beach visitation estimates by the Surf Life Saving Club were used in CBA, as the data is likely to be more accurate and up to date and is a lower bound estimate for beach visitation. Table 3.13 outlines the impact on the CBA if a base estimate of 151,000 visitors is substituted for Surf Lifesaving Club data.

An increase in the base rate of beach visitation only affects the outcomes of the CBA for Option 5, as Option 5 is the only option which benefits from an additional WTP for increased beach access, accruing to all visitors. Under this assumption, Option 5 becomes stronger performing option economically, with net benefits of $64.11 (BCR: 2.20) relative to the base case.

Table 3.13: Sensitivity analysis- Beach visitation rates

Option	Base visitation rate of 54,611 per year	Base visitation rate of 151,100 per year
7% discount rate 30- year analysis	$M BCRs in italic	$M BCRs in italic
Option 1 – Basalt rock revetment	$33.09 *1.94*	$33.09 *1.94*
Option 2 – Sandstone rock revetment	$33.19 *1.95*	$33.19 *1.95*
Option 3 – Vertical seawall	$53.67 *2.43*	$53.67 *2.43*
Option 4 – Vertical seawall with rock toe	$53.04 *2.39*	$53.04 *2.39*
Option 5 – Tiered vertical seawall with promenade	$51.16 *1.96*	$64.11 *2.20*

Also relevant to the outcomes of the CBA are the number of additional visitors that may be induced to use Wamberal beach as a result of the increased access due to the provision of the promenade. We have applied an estimate derived from comparable Australian beaches with varying levels of accessibility infrastructure from Raybould et al. (2013), illustrating that a beach with an access infrastructure score of 5 (very good) compared to an access infrastructure score of 1 (very poor) had on average 30,317 more visitors per year. However, the strength of the reported correlations is subject to considerable variation. Therefore, we also test the outcomes of the CBA with respect to Option 5 under varying levels of additional visitor attraction, as shown in Table 3.14.

Table 3.14: Sensitivity analysis of Option 5- Additional beach attraction

Adjustment in additional visitors to Option 5	-25% 22,738	-10% 27,825	Central est. 30,317	+10% 33,348	+25% 37,896
7% discount rate 30- year analysis	$M BCRs in italic	$M BCRs in italic	$M BCRs in italic	$M BCRs in italic	$M BCRs in italic
Option 5 – Tiered vertical seawall with promenade	$47.28 *1.89*	$59.89 *1.94*	$51.16 *1.96*	$52.72 *1.99*	$55.05 *2.03*

The results indicate that if the proposed promenade in option 5 is more than 75% as effective as anticipated in attracting additional visitors to Wamberal beach, then Option 5 could still achieve positive net benefits, although the benefits may be very marginal. However, if Option 5 is able to attract between 10-25% more visitors than anticipated, then the net benefits it accrues may be close to Options 3 or 4, and lead it to be a relatively strong performing option economically compared to options 1 and 2.

3.5.3.4 Number of surfers

Wamberal beach is popular with surfers, attracting approximately 6,725 surfing visits per year (Surf Life Saving Club data collection, 2020). Surfers are noted in the literature for having a much higher Willingness to Pay per beach visit compared to the average visitor (Lazarow, N., 2009), therefore, impacts to surfers were estimated separately to other visitors.

Some of the coastal protection works may impact the attractiveness of Wamberal beach, for example, by replacing dune with a rocky or walled escarpment that could impact accessibility and visual amenity. Alternatively, some options, notably Option 5 may attract a greater number of new surfers to the beach.

Table 3.15 summarises the impact of increasing or decreasing the number of surfers who visit Wamberal beach as a result of the proposed works.

Table 3.15: Sensitivity analysis- Levels of surfer visitation

Adjustment in number of surfers	-25% 5,044	-10% 6,053	Central est. 6,725	+10% 7,398	+25% 8,407
7% discount rate 30- year analysis	$M BCRs in italic	$M BCRs in italic	$M BCRs in italic	$M BCRs in italic	$M BCRs in italic
Option 1 – Basalt rock revetment	$32.61 *1.91*	$32.90 *1.93*	$33.09 *1.94*	$33.28 *1.95*	$33.57 *1.95*
Option 2 – Sandstone rock revetment	$32.71 *1.92*	$33.00 *1.94*	$33.19 *1.95*	$33.38 *1.95*	$33.67 *1.96*
Option 3 – Vertical seawall	$53.19 *2.40*	$53.48 *2.41*	$53.67 *2.43*	$53.86 *2.43*	$54.15 *2.44*
Option 4 – Vertical seawall with rock toe	$52.56 *2.36*	$52.85 *2.37*	$53.04 *2.39*	$53.24 *2.39*	$53.53 *2.40*
Option 5 – Tiered vertical seawall with promenade	$50.91 *1.95*	$51.06 *1.95*	$51.16 *1.96*	$51.26 *1.96*	$51.42 *1.97*

3.5.3.5 Planned retreat: voluntary acquisition

Although retreat could be undertaken through various mechanisms, Council does not have a planned retreat policy adopted as many of mechanisms may not be permissible or achievable within the prevailing legislative regime and/or geographic setting of a given area facing the risk of coastal erosion. The Coastal Zone Management Study (WorleyParsons, 2015) assessed broadly two types of managed retreat options for Wamberal Beach:

- **Planned retreat from this area, through voluntary purchase of properties where buildings are seaward of 2050 Zone of Slope Adjustment.** Capital cost $304 million, Costs PV $319 million, Benefits PV Up to $47.5 million, BCR 0.15. There is additional cost of demolishing/taking to landfill and dune remediation which makes this option even less viable.
- **Voluntary purchase of properties where buildings are seaward of Immediate Zone of Slope Adjustment (i.e. 61 properties).** Capital cost $244 million, Costs PV $259 million, Benefits PV Up to $44 million, BCR 0.17. There is additional cost of

demolishing/taking to landfill and dune remediation which makes this option even less viable.

Marsden Jacob Associates (2017) undertook a cost-benefit analysis of coastal management options for Wamberal Beach to estimate the direct and indirect costs and benefits that may accrue to a range of critical stakeholders (refer to Stage 1 Review of Previous Studies for more detailed summary). As part of the study a planned retreat option was analysed and described as "managing the duration, type and intensity of future development within the plan area" through the use of a rolling development-free buffer along the foreshore. This planned retreat option was calculated with a low NPV of $1.2m[1] for the entirety of Wamberal, making it economically marginal.

Allowing for property acquisition over time allows costs to be staggered in such a way that only properties deemed at a substantial and immediate risk of coastal erosion are voluntarily acquired, minimising the number of properties that are acquired in the short-term. This may give Council time to adequately budget and consider the discounting of future costs. It is important to note, however, that in either case, the requirements for Council to provide current and future infrastructure and services would be significantly impacted. Furthermore, as time progresses, costs that are discounted into the future may become a greater burden on Council as they approach. While a financial analysis is beyond the scope of this report, if this option is to be further pursued, a significant commitment to expenditure on this scale should be considered within the context of Council's ability to raise revenue and provide other services which are potentially as much, or more essential, to the community of the Central Coast.

All of the likely caveats and legal issues outlined in the Coastal Zone Management Study (WorleyParsons, 2015) with regard to the practical execution of any attempt to apply voluntary purchase as a meaningful coastal management strategy apply here. However, in brief these issues encompass:

- High capital costs, with low prospect of State Government funding for this option. Costs are likely to be borne by the broader community and also by property owners due to loss of property value.
- Acquisition is predicated on the voluntary nature of the scheme, which property owners may not take up.
    - While Councils do have the power to compulsorily acquire land under the Local Government Act, the purposes under which it may do so are defined under the Act and relate primarily for infrastructure. The Council would require the consent of the Minister to allow for compulsory acquisition outside the scope of the Act.
- Social and economic impacts on the locality as a result of urban degradation and impacts on investor confidence.
- Loss of rateable income for Council.
- Risk to remaining properties still exists, and road access to/along Wamberal Beach could be lost along Ocean View Drive if a breakthrough into Terrigal Lagoon occurs under future

[1] Despite achieving only low NPV, the option also achieved a BCR of 5.03. This illustrates why BCR **cannot** be used a criteria for ranking alternatives to government intervention except under specific circumstances, and only when calculated a specific way.
See: The Australian guide to nature-based methods for reducing risk from coastal hazards, Earth Systems and Climate Change Hub (2021).

coastal hazards.

A planned retreat scenario would require the above issues to be dealt with satisfactorily to provide a reasonable assurance of completion, which is considered unlikely.

For the purposes of completeness, planned retreat through voluntary acquisition was considered for sensitivity analysis in the present report. The results of the sensitivity analysis indicate that, similar to the analysis undertaken in the CZMP, the immediate (upfront) purchase of properties under a planned retreat option has a large negative net cost to the community, at NPV: -$294M (BCR: 0.04). Staggering the acquisition of properties as they become exposed to serious risk over 30 years may reduce the upfront costs, but planned retreat remains economically unviable. The analysis did not consider any uplift in property values over the projected buyback period nor future risk to public infrastructure and roads that would eventuate under this scenario with estimated long-term natural beach recession. Without a policy for implementing planned retreat, these options have not been further considered.

4 Distributional analysis

The distribution of the cost-burden and the benefits enjoyed is an important consideration when evaluating the options available to Council. Those who gain benefits or bear costs are discussed under three main stakeholders, divided into four geographic levels. The stakeholder groups included in the distributional analysis include:

- Central Coast Council (government)
- General community
- Homeowners

The four geographic boundaries included in the distributional analysis include:

- Beachfront lots, incorporating those residential lots that are physically impacted by coastal erosion.
- Non-beachfront lots, incorporating those residential lots whose values are directly impacted by beach width. Only includes lots for which Wamberal beach is the closest beach.
- Wamberal suburb, representing the general neighbourhood of Wamberal beach
- Central Coast LGA, representing the general community of the LGA, and the Council.

Figure 4.1 illustrates the physical geographical boundaries of the distribution analysis.

The costs and benefits identified in section 3.4 under the five management options are allocated to each of the stakeholder-geographic groups in order to assist Council to understand the implications of different management options on impacted parties and inform potential funding options. Table 4.1 outlines the distribution protocols used in the analysis.

It is important to note that the distribution analysis only considers first-round economic effects. For example, before any potential co-contributions to the capital or maintenance costs of the options are implemented, or flow-on impacts to household income, expenditure, or wealth are considered.

Costs associated with seawall construction, maintenance, periodic nourishment and potential land acquisition are expected to be borne by the parties who most benefit from the investment and hence have been rolled up into a single category identified as the Funding Body(s) which may comprise of several different interested parties. Details of the funding arrangements between the different interested parties (likely to comprise private beachfront homeowners, Council, State government and possibly also the Australian government) are yet to be agreed.

The distribution analysis is supported by a socioeconomic profile (Appendix A). The purpose of the socioeconomic profile is to provide insight into the equity considerations regarding certain management options or subsequent funding decisions that may arise from the distribution analysis. For example, while a specific stakeholder group may benefit significantly from a given coastal management strategy and may be considered eligible to contribute to the cost of those works via a special rate variation under S495 of the Local Government Act, IPART requires an assessment of ratepayers' ability and willingness to pay, and an understanding of socioeconomic factors will form part of the consideration. However, it must be emphasised that the socioeconomic analysis provided here is only preliminary and is not a substitute for careful and sensitive stakeholder consultation with the community by Council.

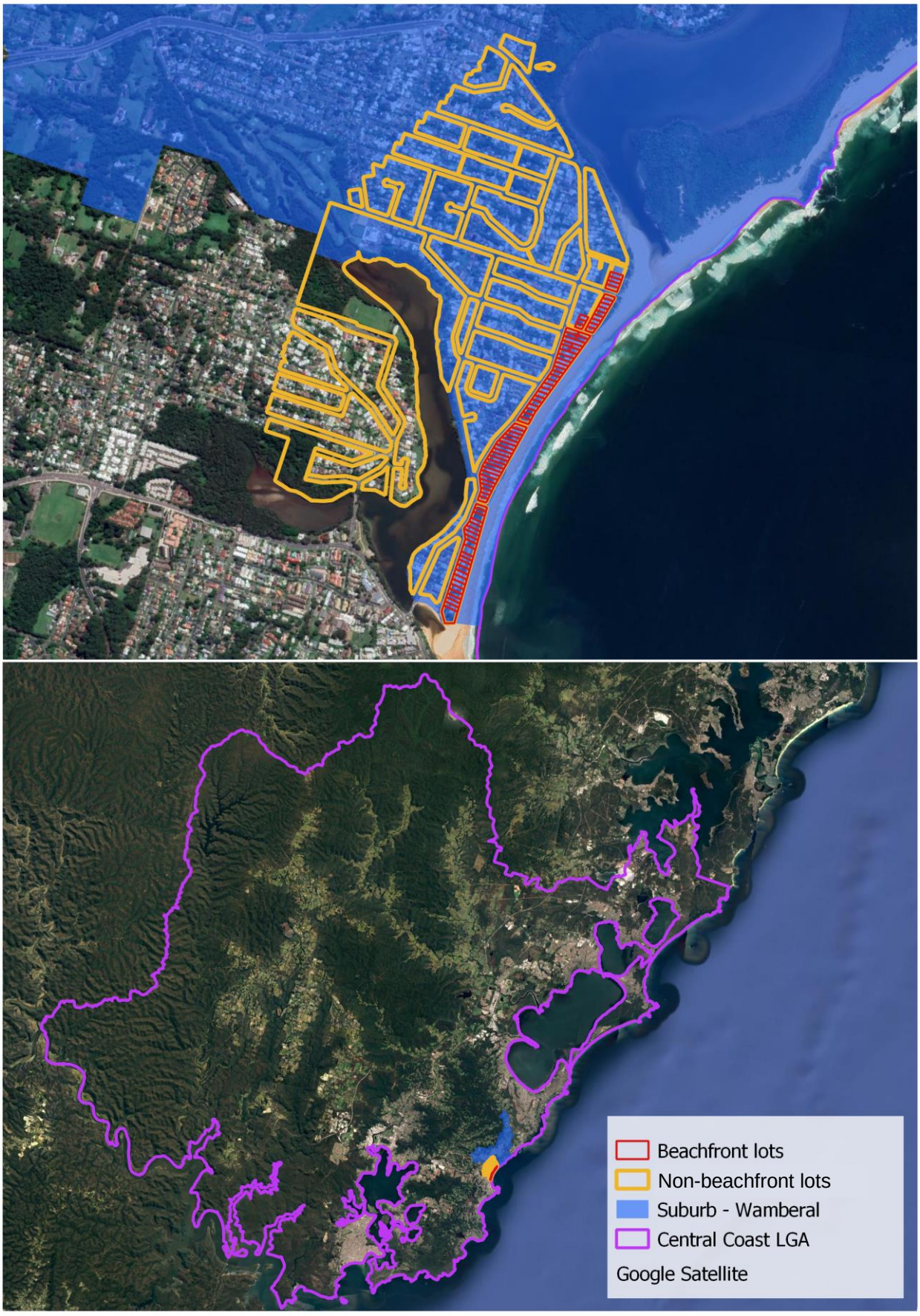

Figure 4.1: Geographic boundaries of relevance to distributional analysis.

Table 4.1: Summary of allocation protocol of cost and benefit line items

Line Item	Stakeholder group	Geography
Construction costs of protection works	Funding body(s)	LGA
Maintenance of public infrastructure – increase/decrease in costs	Funding body(s)	LGA
Land acquisition costs	Funding body(s)	LGA
Periodic nourishment costs	Funding body(s)	LGA
Avoided administrative and staff costs	Council	LGA
Net impact to Council rate revenues	Council	LGA
Residual value	Council	LGA
Additional property premium – beach width	Homeowners	Non-beachfront lots
Avoided loss of private property	Homeowners	Beachfront lots
WTP for beach amenity – generic beach visit	General community	LGA
WTP to increase beach access	General community	LGA
Environmental WTP – increase/decrease in beach and sandy seabed	General community	Wamberal suburb

Furthermore, the type of benefit or cost flowing to (or from if it is a cost) stakeholders is characterised by the type of good, service, or resource it represents. There are four types of goods and services that outlines how such costs should be levied or recovered, including:

- Private: is a product that must be purchased to be consumed, and consumption by one individual prevents another individual from consuming it, for example private properties
- Club: costs borne by the specific group of people who benefit such as property owned by a collective and include strata properties, surf clubs, swimming pools and libraries.
- Public: refers to a good or service that is made available to all members of a society such as access to clean air
- Common-pool: is a good that is shared and available to everyone but also scare, with a finite supply such as estuarine habitats and lagoons

Doing so informs the range of possible cost recovery strategies that may be possible. Table 4.2 outlines an example of how these factors may be incorporated into any future funding decisions: The examples provided are purely theoretical and only serve to illustrate the range of possible factors involved.

It is important to note that any of the cost recovery strategies that may be implemented by Council will incorporate *transaction costs*[1] which have not been incorporated in the CBA but should be considered carefully by Council to ensure that the costs of raising revenue for any given strategy do not outweigh the potential benefits. For example, while we have identified that the avoided administrative and staff costs associated with managing coastal erosion events is a benefit to most strategies in the CBA, these may be outweighed by new costs associated with inefficient or cumbersome methods of raising revenue.

[1] Transaction costs are costs that arise as a result of any economic exchange, such as the raising of revenue by a government. They include costs associated with the measurement of the appropriate charges, administration costs, as well as the costs of enforcement, and avoidance by payers.

Table 4.2: The effect of CBA goods or services in distributional considerations (examples).

Example benefit / cost	Stakeholder - geography distribution groups	Type of good / service or resource	Possible cost recovery strategy
Prevents private property from being lost to erosion.	Individual Households (Homeowners – Beachfront)	Private	Fund via Coastal Protection Service Charge under S496B of Local Government Act Fund via Special Rate Variation applied to specific subset of ratepayers under S495 of the Local Government Act.
Prevents property owned by a collective, such as a strata, being lost to erosion.	Strata Body Corporates (Homeowners – Beachfront)	Club	
Prevents public parkland and beaches being lost to erosion.	Local Area (General Community – LGA)	Public	Impossible to implement an entry charge on users of public goods. Fund via Special Rate Variation applied to all ratepayers under S495 of the Local Government Act. Install parking meters at popular recreation sites.
Loss of rate revenue	Council (Government – LGA)	Common-pool	Fund via redistribution of rates to other households or defer other public expenditure.
Prevent habitat, such as lagoons, that supports commercial fishing being lost to erosion.	Fishing businesses (Business – LGA)	Common-pool	Fund via a voluntary cost-sharing agreement with local business association.

4.1 Summary results of distribution analysis

Figure 4.2 and Table 4.3 summarise the distribution of the net benefits (or net costs) accruing to different stakeholder groups considered in the CBA, relative to base case at 7% discount rate, and at 30-year analysis period. Table 4.4 summarises the NPV of net benefits (total benefits less total costs) relative to the base case flowing to each of the stakeholder groups under each of the options considered.

In all cases the majority of costs will fall on the funding body(s) with parties yet to be agreed. For Options 1 and 2, a loss of beach width results in some costs to the broader Non-Beachfront Homeowners. Should these options be pursued this cost could be mitigated by additional beach nourishment to offset impacts of seawall encroachment (see *Stage 4 Sand Nourishment Investigation*).

All seawall options achieve a positive NPV, such that benefits outweigh costs. For all options the majority of benefit falls to the Beachfront Homeowners with the protection provided to private property at-risk to coastal hazards. Some additional benefit for Options 3-5 flows to Non-Beachfront Homeowners with improved beach width relative to the encroachment of present ad-hoc rock works. Option 5 delivers a larger share of benefits to the General Community in the LGA, in addition to the benefits flowing to Beachfront and Non-beachfront Homeowners. The distribution of benefits and costs between different stakeholder groups is discussed in greater detail in the following sections.

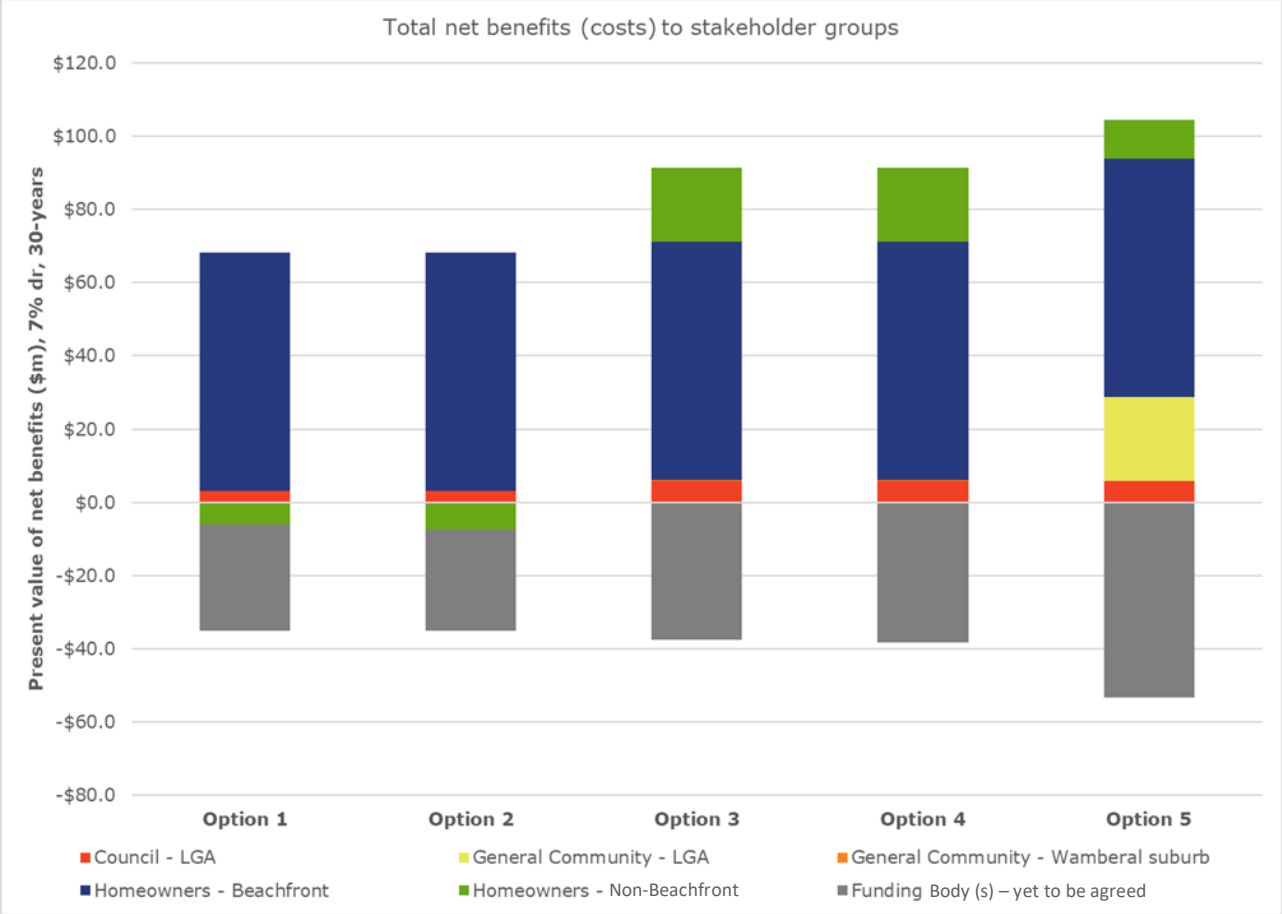

Figure 4.2: Net benefits per stakeholder groups under different options.

Table 4.3: Net benefits/costs to individual stakeholder groups under different options.

Stakeholder group		Option 1	Option 2	Option 3	Option 4	Option 5
7% discount rate 30-year analysis period		$M	$M	$M	$M	$M
Funding body(s)		**-29.13**	**-27.49**	**-37.64**	**-38.29**	**-53.33**
Council	**LGA**	**3.18**	**3.11**	**5.85**	**5.88**	**5.78**
General community	**LGA**	**-**	**-**	**-**	**-**	**22.88**
General community	**Wamberal suburb**	**-0.06**	**-0.08**	**0.22**	**0.22**	**0.12**
Homeowners	**Non-Beachfront**	**-5.97**	**-7.42**	**20.17**	**20.17**	**10.65**
Homeowners	**Beachfront**	**65.08**	**65.08**	**65.08**	**65.08**	**65.08**
Net Benefit		**33.1**	**33.2**	**53.7**	**53.0**	**51.2**

Table 4.4: Distribution of net benefits across stakeholder groups in the CBA.

Stakeholder group		Option 1	Option 2	Option 3	Option 4	Option 5
Council	**LGA**	4.7%	4.6%	6.4%	6.4%	5.5%
General community	**LGA**	0.0%	0.0%	0.0%	0.0%	21.9%
General community	**Wamberal suburb**	0.0%	0.0%	0.2%	0.2%	0.1%
Homeowners	**Non-beachfront**	0.0%	0.0%	22.1%	22.1%	10.2%
Homeowners	**Beachfront**	95.3%	95.4%	71.3%	71.2%	62.3%
Total		**100%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

4.1.1 Distribution of net benefits

Table 4.4 summarises the results of the distribution analysis in terms of the percentage of total net benefits flowing to each stakeholder group under each option. 0% means that the stakeholder group accrued more costs than benefits, or break-even, with costs and benefits cancelling out.

It is emphasised that the Beachfront Homeowners, which benefits directly from expected avoided damage to property (i.e., adjusted for the probability of coastal erosion), is comprised of only 72 properties. Whereas the Non-Beachfront Homeowners which benefit from improved beach width (relative the present ad-hoc emergency works) under Options 3-5 is comprised of a broader number properties. Although the benefits to the former are larger per property, they apply only once at the end of the analysis period, whereas there are more properties in the latter group who benefit from improved beach area. The improvements to beach width are maintained into the future via periodic sand nourishment. Discounting procedures therefore play an integral role in the apportioning of Net Present Values.

The results indicate that for all Options, most of the net benefits flow to homeowners of the beachfront community, with a minority of benefits flowing to the non-beachfront neighbourhood and to the general community of the Wamberal suburb. A relatively small proportion of benefits flows for each option to Council in avoided administrative and staff costs, avoided costs of repeat emergency works and avoided loss of Council rate revenues. It is important that avoided disruptions from future storms offered by all seawall options could not be monetarised and hence should be considered as an added albeit unquantified benefit.

Option 5 delivers a larger share of benefits to the General Community in the LGA via provision of a public promenade improving access along the beach (maintained after storms when the beach is eroded) and attracting some additional beach visitation.

The detailed results of the distribution analysis (section 4.2) indicate that the net benefits flowing to homeowners are private benefits, and they largely accrue to benefits associated with increased or maintained property values, or the value of properties outright protected from coastal erosion. The benefits flowing to the general community however are largely associated with public benefits associated with greater beach accessibility.

The socio-economic profile indicates that within the SA2 of Wamberal-Forrester's beach at the time of the 2016 Census, approximately 35% of residents own their own home outright, 43% own their home with a mortgage, and 17% rent. Compared to the LGA as a whole, this indicates that there are significantly more people who own property with a mortgage than rent. This may indicate that the area is a desirable place to live long-term, and owners may therefore care deeply about maintaining property values. Residents in the Wamberal-Forrester's beach SA2 also had higher median equivalised total household incomes, at $1,020 per week, compared to the LGA as a whole, which was $774 per week. It also has a higher proportion of people in income brackets over $1,000 per week compared to other SA2s. The Wamberal-Forrester's beach SA2 also had fewer residents on the aged pension or Newstart allowance than other SA2s. The Wamberal-Forrester's beach SA2 ranks in the 90th percentile in the SEIFA Index of Relative Socio-economic Advantage and Disadvantage, compared to the LGA as a whole, which only ranked much lower, in the 70% percentile.

The flow of benefits to private homeowners, and the general community has implications for the options help inform any potential future funding model. In addition, the Council may also wish to consider the relative socio-economic indicators of the area, compared to the general population of the CBA when considering relative cost shares, although it should be emphasised that statistics derived from the Census are not necessarily reflective of individual household's circumstances, or willingness or ability to pay.

4.2 Detailed results of distribution analysis

Table 4.5 (next page) provides a detailed breakdown of the flows of benefits and costs to each of the stakeholder groups under each of the proposed management options considered in the CBA. The data supports the analysis provided in Section 3.5.

Table 4.5: Net benefits/costs flowing to stakeholder groups under five options.

	Geography	Cost / Benefit	CBA line item	Type of Good / Service	Option 1	Option 2	Option 3	Option 4	Option 5
					$M, 7% Discount Rate, 30-year horizon				
Funding body(s)		Cost	Construction costs of protection works	Common-pool	25.39	23.91	34.01	34.66	38.37
			Land acquisition costs	Common-pool	0.00	0.00	0.00	0.00	11.34
			Periodic nourishment costs	Common-pool	3.53	3.53	3.63	3.63	3.63
			Maintenance of public infrastructure	Common-pool	0.21	0.04	0.00	0.00	0.00
Funding body(s) Net Benefit/ Loss					**-29.13**	**-27.49**	**-37.64**	**-38.29**	**-53.33**
Council	**LGA**	Benefit	Avoided administrative and staff costs	Common-pool	1.79	1.79	1.79	1.79	1.79
			Avoided maintenance costs of public infrastructure	Common-pool	0.00	0.00	2.22	2.21	1.92
			Net impact to Council rate revenues	Common-pool	0.06	0.06	0.06	0.06	0.06
			Residual Value	Common-pool	1.33	1.26	1.79	1.82	2.02
Council Net Benefit/ Loss					**3.18**	**3.11**	**5.85**	**5.88**	**5.78**
General community	**LGA**	Benefit	WTP for beach amenity – generic beach visit	Public	0.00	0.00	0.00	0.00	11.47
			WTP to increase beach access	Public	0.00	0.00	0.00	0.00	11.41
	Wamberal suburb	Benefit	Environmental WTP – increase in beach and sandy seabed	Public	0.00	0.00	0.22	0.22	0.12
		Cost	Environmental WTP – decrease in beach and sandy seabed	Public	0.06	0.08	0.00	0.00	0.00
Homeowners	**Non-beachfront**	Benefit	Additional property premium - beach width	Private	-	-	20.17	20.17	10.65
		Cost	Reduced property premium – beach width	Private	5.97	7.42	0.00	0.00	0.00
General community & non-beachfront homeowners Net Benefit/ Loss					**-6.03**	**-7.50**	**20.39**	**20.39**	**33.64**
Homeowners	**Beachfront**	Benefit	Avoided loss of private property – unimproved area impacted by erosion	Private	7.12	7.12	7.12	7.12	7.12
			Avoided loss of private property– building impacted by erosion.	Private	57.96	57.96	57.96	57.96	57.96
Homeowners Net Benefit/ Loss					**65.08**	**65.08**	**65.08**	**65.08**	**65.08**

4.2.1 Land acquisition costs vs donation costs

Option 5 may require, the purchase of an area of land in order to construct a vertical seawall with a promenade, effectively converting private residential land into a public walkway. Under most circumstances, it would be considered fair to compensate landowners for their loss of private property.

However, Option 5 would also provide landowners significant protection from the threat of coastal erosion to their remaining property. Therefore, there is room to consider an economic exchange whereby landowners 'donate' part of their property in exchange for some measure of protection from coastal erosion, and Council is able to provide both this private service, as well as a positive externality associated with the public good of the shared community walkway along a beach. Under this scenario, the use of the word 'donation' is somewhat of a misnomer, as it is occurring in the context of a voluntary exchange of services in which both parties, landowners and Council, pay either in the form of land or cash, in order to receive some benefit.

Whether or not landowners choose to enter into this exchange does not impact the outcomes of the CBA. Regardless of whether Council pays the fair value of the land in compensation, or landowners willingly forego the use of their land in exchange for the service of coastal protection, somebody pays for the use of the land. However, it does raise the prospect of a change in the distribution of costs and benefits.

As illustrated in Table 4.5 (previous page), under Option 5, over 30 years Beachfront Homeowners are projected to benefit from coastal protection to the sum of approximately $65.1M dollars. Of course, this is only a probabilistic 'expected' value, and avoided damages may be significantly more or less than that amount.

A final note must be made with regard to the potential risks of the 'free rider' problem associated with the provision of non-excludable goods. A non-excludable good or service refers to those that cannot be withheld from those who choose not to pay for it. The free rider problem is a common class of market failure, usually associated with public or communally provisioned goods or services.

In the case of coastal protection, some landowners may choose to donate their land, but others may choose not to. However, both groups will still receive the same benefit associated with coastal protection, regardless of whether or not they chose to pay for it or not. Those who choose not to donate would then be effectively free-riding off the coastal protection paid for by those that did. Therefore, any consideration of voluntary payments (whether via donation of land or cash) for coastal protection works would likely need to be considered in conjunction with non-voluntary payments that take into account who has or has not already contributed, and the fair value of that contribution, in order to avoid perverse outcomes.

Figure 4.3: Wamberal beach, Grant Leslie (2020)

5 Conclusion

Cost-benefit analysis (CBA) provides a monetarised comparative view between options to assist in the decision-making process alongside the need for consideration of several aspects that are not well monetarised and a range of other considerations arising from engineering studies, stakeholder consultation, available funding arrangements, legislation, policy and planning context; all upon which a preferred option is selected.

The CBA quantifies the expected costs and benefits for five concept design protection alternatives (compared to the base case "Status Quo" approach) to consider economic trade-offs for options to manage future coastal hazards at Wamberal Beach. These options include those originally detailed in Council's certified Gosford Beaches Coastal Zone Management Plan (CZMP) (WorleyParsons, 2017).

The CBA also includes a distributional analysis supported by a socio-economic profile of the local government area. The distributional analysis provides insight into which stakeholders receive the benefits, or incur the impacts and costs associated with each option for the purposes of assisting decisions regarding funding arrangements. The socio-economic profile compares key 2016 ABS census population, housing, employment, and income data of Central Coast LGA, Erina - Green Point, Gosford – Springfield, Terrigal - North Avoca, and Wamberal - Forresters Beach areas. Additionally, socio-economic indices and tourism data were compared across the various regions.

The scope of the analysis for the CBA consists of approximately 1500 m of beach situated between the Terrigal and the Wamberal Lagoon entrances of Wamberal Beach. Based on coastal hazard studies of the study area, without protection, approximately 72 houses are situated on lands subject to immediate coastal hazards that are expected to exacerbate over the next 30 years.

All options are compared relative to a base case scenario of continuing the 'Status Quo'. This involves repeated storm events triggering reactive emergency works that poorly mitigate the present and long-term risk of coastal erosion to private property and public lands at Wamberal Beach. This was recently demonstrated during the July 2020 storm event that resulted in damage to properties, substantial disruption to private and public land and $2.1M of publicly funded emergency works being placed on the beach. Without alternative management intervention, the frequency of such events threatening property at Wamberal Beach will increase with continued underlying recession and sea level rise, noting further that the July 2020 event was only of moderate magnitude compared with historical major coastal storms that can occur at this location.

Five management options were analysed in comparison to the base case as part of this report and are listed below:

Base case: 'Maintain Status Quo'

Option 1: Basalt rock revetment and periodic sand nourishment

Option 2: Sandstone rock revetment and periodic sand nourishment

Option 3: Vertical seawall and periodic sand nourishment

Option 4: Vertical seawall with rock toe and periodic sand nourishment

Option 5: Tiered vertical seawall with promenade and periodic sand nourishment

Seawall concept designs associated with each option are detailed in the *Stage 3 - Seawall Concept Design Options* report. Sand nourishment for each option was evaluated as part of the *Stage 4 Sand Nourishment Investigation*. The Stage 4 works found that substantial sand sources required to offset encroachment impacts of rock revetments (Options 1 and 2) are subject to future viability at the time of the nourishment campaign, as well as potential added complexities around lagoon entrance management depending on design placement. Given the feasibility of larger sand source availability, it was considered more realistic to assess all options in the CBA excluding nourishment to offset encroachment impacts. Instead, the CBA examines marginal benefits and costs between seawall options based on differing degrees of encroachment and available dry beach width amenity. These relative impacts for each option are detailed in the *Stage 2 Coastal Protection Amenity Assessment* and used as input to the CBA. All alternatives to the Base Case in the CBA include periodic sand nourishment (approx. every 10 years) to offset estimated natural beach recession due to underlying losses and sea-level rise (see *Stage 4 Sand Nourishment Investigation* for further detail).

The economic analysis was conducted over 30 years by interpolating between two time periods comprising year one (immediate hazard line) and in 30 years (up to the 2050 hazard line). The body of the report describes how each of the seawall options have been treated in the economic analysis.

All seawall options considered in the *Stage 3 - Seawall Concept Design Options* report will provide protection to beachfront properties and public infrastructure along the beach. However, options vary with regard to the construction costs, ongoing maintenance costs and impacts on beach width fronting the seawalls available to beach users. The economic model considers the costs and benefits of coastal protection options not only for beachfront properties at-risk but also the broader community. The economic effect of beach width encroachment carries significance from not just those owning property near the waterfront, but from a community perspective. The avoided loss value of the at-risk properties in Wamberal has a material impact on the CBA and distribution analysis. The outcome of the analysis is shown in Table 5.1.

In assessing the economic analysis outcomes, a positive NPV indicates that the economic benefits outweigh the costs and is the preferred economic metric for ranking and informing selection of a preferred alternative to the base case. Notwithstanding that, other non-economic factors, such as social, legislative, legal, engineering and environmental criteria, as well as the uncertainties in quantifying benefits and costs (sensitivity analysis) will form part of the final preferred option selection process that will occur with consideration of community and other interested parties' views.

Table 5.1: Distribution of Net Benefit/Losses, Net Present Value (NPV) and Benefit-Cost Ratio of Coastal Management Options at Wamberal Beach. Values in $M for 7% discount rate and 30-year horizon.

Stakeholder group		Option 1	Option 2	Option 3	Option 4	Option 5
Funding body(s)		-$29.1	-$27.5	-$37.6	-$38.3	-$53.3
General community & non-beachfront homeowners	**LGA**	-$6.0	-$7.5	$20.4	$20.4	$33.6
Homeowners	**Beachfront**	$65.1	$65.1	$65.1	$65.1	$65.1
Council	**LGA**	$3.2	$3.1	$5.9	$5.9	$5.8
Net Present Value ($M)		**$33.1**	**$33.2**	**$53.7**	**$53.0**	**$51.2**
Benefit-Cost Ratio		**1.94**	**1.95**	**2.43**	**2.39**	**1.96**

All five options achieve positive NPVs between +$33.1M to +$53.7M over 30-years using a 7% discount rate. Of these alternatives, Option 3 (vertical seawall) is indicated to achieve the highest NPV (+$53.7M). However, the comparative results between options are based on central estimates used as inputs into the CBA and are only marginal, and well within the bounds of natural error and uncertainty. Therefore, the results of sensitivity tests, and qualitative factors are expected to play an instrumental role in identifying a preferred option, particularly where alternatives are closely matched on economic criteria. Careful consideration of aesthetic and other factors difficult to monetarise (such as the significant height of vertical seawalls following major storms) will be required in identifying a preferred option and mitigating any undesirable effects as part of detailed design.

Sensitivity tests carried out on the CBA indicate that Option 5 (tiered seawall with promenade) delivers much greater net benefits, and therefore, achieves a much higher NPV than other alternatives under scenarios where a lower discount rate (3%) is chosen allowing it to accrue greater benefits over time (NPV: +$81.6M), where the base number of visitors to Wamberal beach is higher than estimated (NPV: +$102.1M), and where improved accessibility attracts a greater than forecast number of additional visitors (NPV: +$108.2M). Under these scenarios, Option 5 is a comparatively strong performing option economically relative to the base case. However, community consultation, more robust visitation data, and qualitative factors will play a role in determining what weighting to give these scenarios in decision making.

Table 5.2: Distribution of net benefits across stakeholder groups. Values for 7% discount rate and 30-year horizon.

Stakeholder group		Option 1	Option 2	Option 3	Option 4	Option 5
Council	**LGA**	4.7%	4.6%	6.4%	6.4%	5.5%
General community & non-beachfront homeowners	**LGA**	-	-	22.3%	22.3%	32.2%
Homeowners	**Beachfront**	95.3%	95.4%	71.3%	71.2%	62.3%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**

Table 5.1 and Table 5.2 summarise the results of the distributional analysis. Table 5.1 provides the NPV (total benefits less total costs) relative to the base case flowing to each of the stakeholder groups under each of the seawall options considered. Table 5.2 summarises corresponding distribution analysis in terms of the percentage of total net benefits flowing to each stakeholder group under each option.

For all options the majority of benefit flows to the Beachfront Homeowners with the protection of private property at-risk to coastal hazards. Some additional benefit for Options 3-5 flows to Non-Beachfront Homeowners with improved beach width. For all options, beach width is maintained at the post seawall construction level into the future via periodic sand nourishment. Beach widths are compared for each seawall option relative to the encroachment of the present ad-hoc (non-engineered) works which is expected worsen under long-term natural beach recession. Option 5 delivers a larger share of benefits to the General Community in the LGA, via provision of a public promenade improving access along the beach (maintained immediately after storms when the beach is eroded) and attracting some potential additional beach visitation. Benefits which flow to Council under each seawall option include avoided administrative and staff costs and avoided costs of repeat emergency works. Avoided public disruption from all seawall options could not be monetarised in this study but should also be considered in the value proposition of all seawall options.

In all cases the majority of costs will fall on the funding body(s) expected to be based on the identified primary beneficiaries with specific parties yet to be agreed. For Options 1 and 2, a loss of beach width would result in some costs to the broader Non-Beachfront Homeowners. Should these options be pursued this cost could be mitigated by additional beach nourishment to offset impacts of seawall encroachment (see *Stage 4 Sand Nourishment Investigation*).

Planned retreat was not included in the scope of the CBA as there is no present policy or mechanism for property reacquisition under planned retreat. In addition, planned retreat was not a recommended action of the certified Coastal Zone Management Plan for Wamberal Beach, in part because it achieved negative NPVs of -$272M and -$215M in previous studies. Due to ongoing advocacy for some models of planned retreat by some community members, planned retreat is considered in the sensitivity analysis section of this report. None of the planned retreat options considered were economically viable. It is important to note that the prohibitively high cost (and impracticability) of planned retreat through property acquisitions would likely fail to ever complete and impose a long-standing disruption by dividing community and imposing significant financial burden on Council, and by extension, the community of the Central Coast.

Sophisticated economic analyses for coastal management is an evolving area of research and hence "*The decision on which option Council should implement is likely to depend on several other considerations which are not addressed in a CBA*" as concluded in the DPIE (2020) Guidelines and in this report. Coastal economics in NSW would greatly benefit from more detailed and explicit Practice Notes. Notwithstanding that, all seawall options are indicated to have strong net benefit to beachfront homeowners with strong potential to achieve net benefits to all interested parties.

6 References

Wamberal Terminal Coastal Protection Assessment report references:

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Appendix A - Socio-economic profile

Wamberal beach sits in the Wamberal – Forresters Beach SA2 area and is part of the broader Central Coast Local Government Area (LGA) as shown in Figure A.1. The LGA is the home of the Darkinyung people. Due to the large number of SA2 areas in the Central Coast LGA, the socioeconomic profile will assess a selection of SA2 areas most likely to be impacted by changes to the functionality of Wamberal beach. The SA2 areas assessed included Wamberal - Forresters Beach, Terrigal – North Avoca, Erina – Green Point and Gosford – Springfield. Table A.1 includes a brief description of each SA2 areas assessed.

Socio-economic data for this report is primarily sourced from the Australian Bureau of Statistics (ABS) 1410.0 Data by Region (2019).

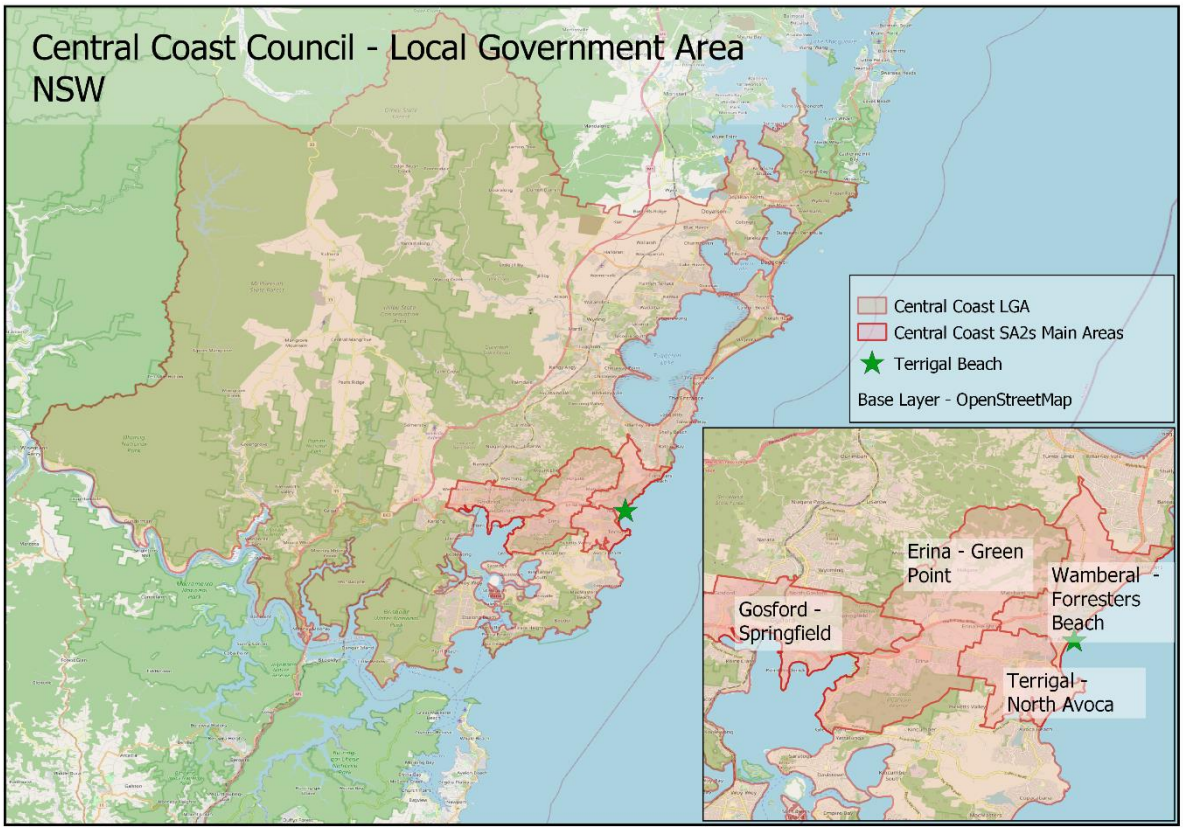

Figure A.1: Location of Wamberal beach, Central Coast LGA, and neighbouring SA2s. Source, Open Street Maps (2020), Australian Bureau of Statistics ASGS (2016).

Table A.1: Description of SA2s and key geographical factors. Source: beachsafe.org, Open Street Maps

SA2	Description
Wamberal - Forresters Beach	The coastal strip in this SA2 area includes Wamberal Lagoon and Nature Reserve and several beaches including North Avoca Beach, Wamberal Beach and Forresters Beach. It also contains the northern end of Terrigal Beach, and the houses adjacent to it, which is the focus of the main report. The Wamberal-Terrigal Beaches are popular holiday destinations with Sydneysiders, with development in the vicinity increasing since the 1960s. The beaches block the entrance to two drowned valleys, now Wamberal and Terrigal Lagoons, which only open during heavy rain. Wamberal Beach tends to pick up more swell, with good breaks, and is popular with surfers.
Terrigal – North Avoca	This SA2 area includes Bouddi National Park and Kincumba Mountain Reserve. The coastline features several beaches including Avoca Beach and Macmasters Beach. It also contains the southern end of Terrigal beach. A shopping centre and large resort backs the southern half of Terrigal Beach. Compared to the strong rips and waves that dominate Wamberal Beach in the north, the southern end of Terrigal Beach offers lower waves and is generally more popular. A southern rock pool also offers a popular swimming spot, as do the two lagoons. Both lagoon mouths, as well as the Terrigal Granny's Rock, are fished for flathead, bream, whiting, tailor, and mulloway.
Erina – Green Point	This SA2 area is one of the key business hubs in the region with several key commercial businesses located on The Entrance Road, Karalta Road and Barralong Road. It is also the home of the main shopping centre in the LGA – Erina Fair Shopping Centre and most of Kincumba Mountain Reserve.
Gosford – Springfield	This SA2 area is the key business hub in the LGA. There are 2 hospitals in this SA2 area – Gosford Hospital and Gosford Private Hospital which services the region.

A.1 Population

In 2016 there were approximately 340,000 people living in the Central Coast LGA with the population expected to rise to approximately 420,000 by 2035 (Figure A.2). Across the Central Coast LGA, 3.8% of the population are of Aboriginal and Torres Strait Islander (ATSI) heritage. The SA2 areas assessed have lower proportions of people with ATSI heritage than the LGA average: Terrigal – North Avoca (1.6%), Wamberal - Forresters Beach (2%), Erina – Green Point (2%) and Gosford – Springfield (2.8%).

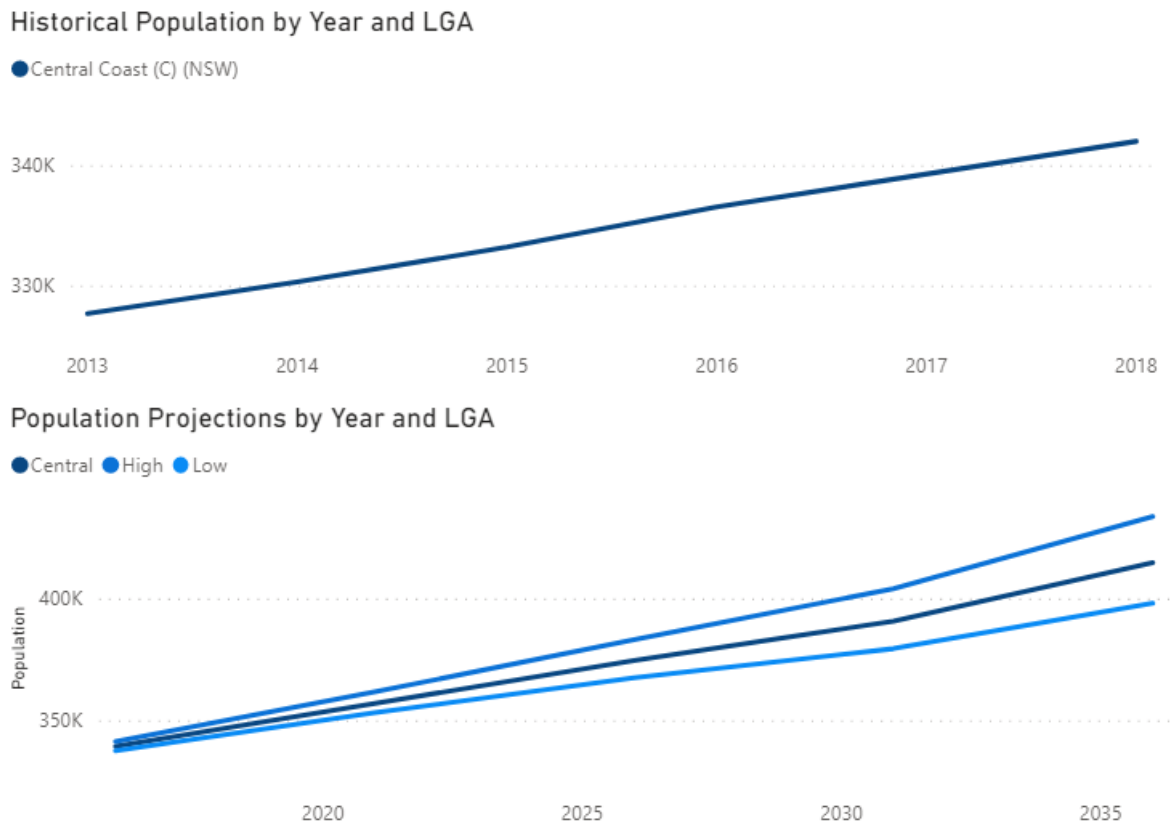

Figure A.2: Historical Population and projections by year for the Central Coast LGA (DPIE, population projections, 2019)

As of 2016 the population of the Wamberal – Forresters Beach SA2 stood at approximately 10,000 people, with a median age of 39.7, and 22.1% of the population over the age of 60. The population pyramid for Wamberal – Forresters Beach SA2 (Figure A.3, top) shows a hollowing out of people aged between 20 – 39 years old who may have moved elsewhere for educational or professional opportunities.

By comparison the Central Coast population pyramid has a more evenly distributed 'bell-shape' with a healthy population of working age people. Compared to Wamberal – Forrester's Beach, the median age of the population is 41.8, with 26.1% of the population over the age of 60. The NSW state has a younger population with median age of 37.6, and only 21.1% of the population over the age of 60 – as illustrated in the shape of the population pyramid

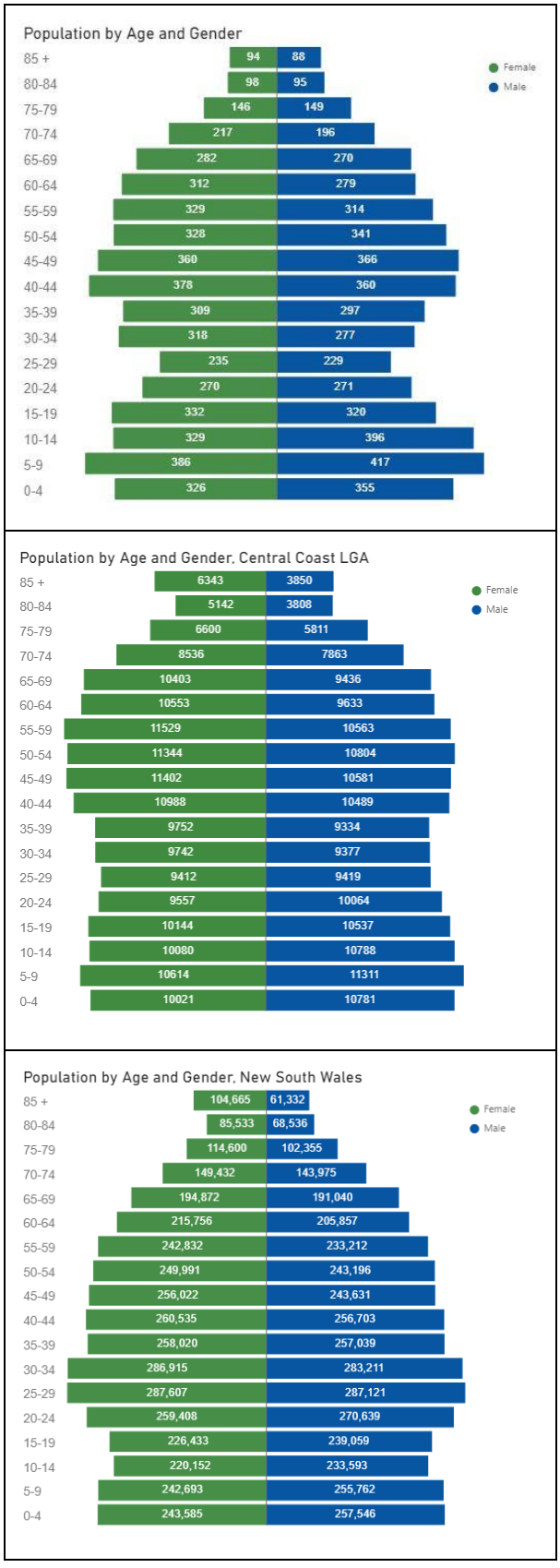

Figure A.3: Population pyramids. Top: Wamberal-Forrester's beach SA2, middle: Central Coast LGA, bottom: New South Wales

A.2 Housing

During 2016 the majority of homes in the Central Coast LGA were owned outright (≈ 35%) with homes owned with a mortgage coming a close second at ≈ 34% (Figure A.4).

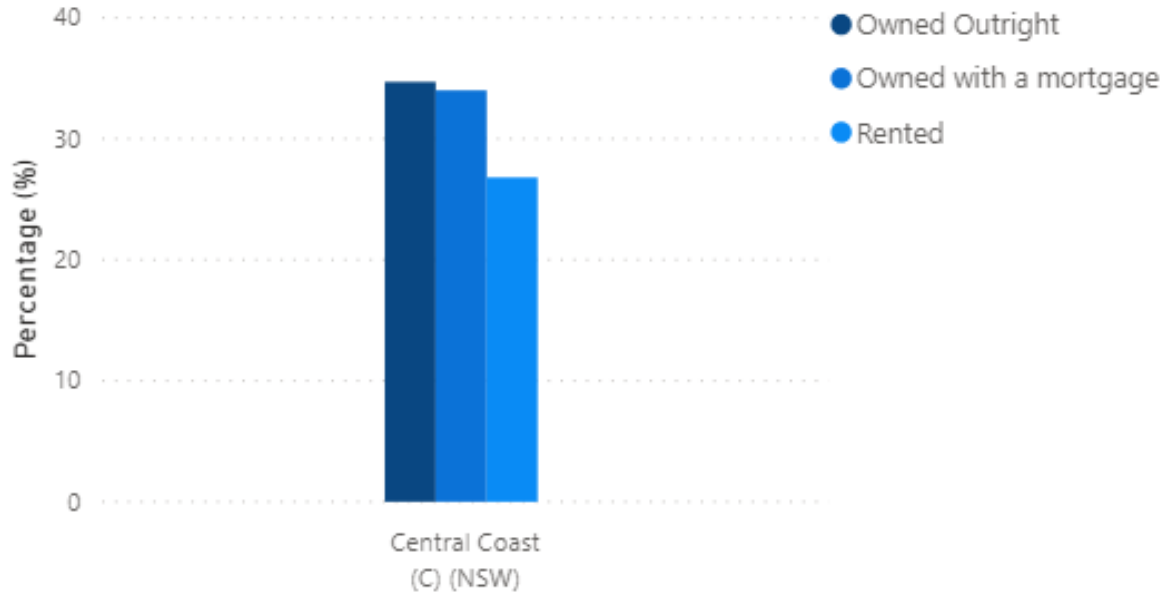

Figure A.4: Tenure Type - Central Coast LGA 2016

Wamberal – Forresters Beach SA2 had similar home ownership rates (≈35%) compared to the LGA whilst the Terrigal – North Avoca SA2 held the highest rate of home ownership at ≈ 38% (Figure A.5). Wamberal - Forresters Beach and Terrigal – North Avoca SA2 areas also have higher proportions of homes owned with a mortgage than the LGA as a whole. High rates of home ownership indicate a high permanent population who may be more invested in the long-term local environmental amenity.

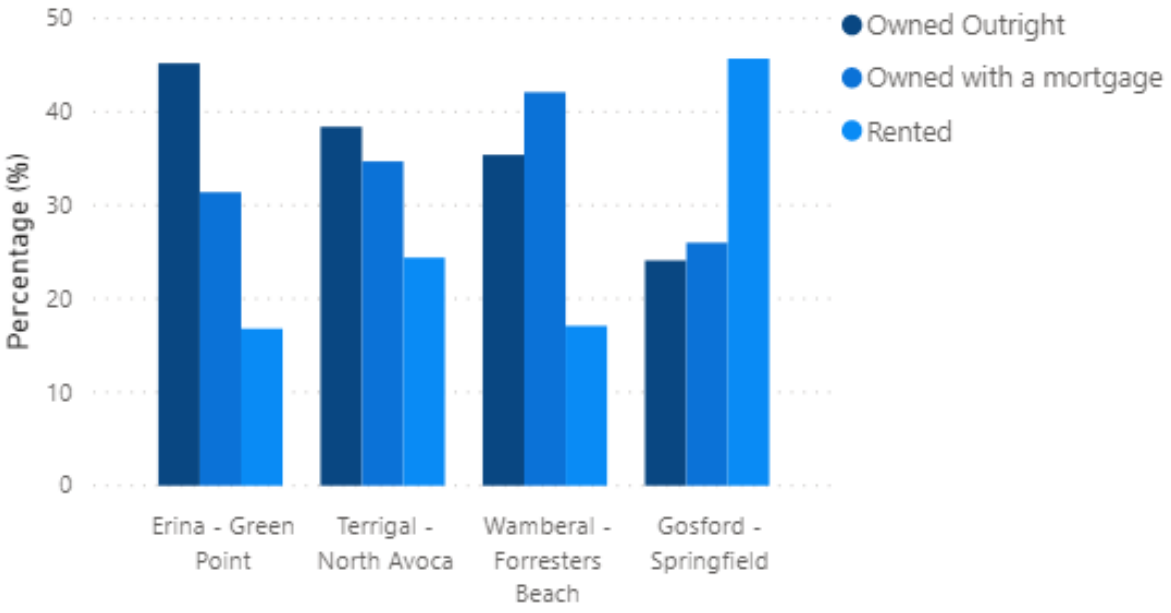

Figure A.5: Tenure Type by SA2 2016

As illustrated in Table A.6.2, nearly $700M worth of residential building was approved in the Central Coast LGA in 2018. Of the SA2 areas surveyed, most of the value of residential buildings were approved in the Gosford-Springfield SA2 -$255M area followed by Terrigal-North Avoca -$93M and Wamberal-Forresters Beach -$32M. The value of residential building approvals is an indicator that there is continued demand for housing in the region.

Table A.6.2: Value of Buildings approved by Area 2018

Area	Residential building ($M)	Non-Residential building ($M)	Value of total building ($M)
Central Coast (C) (NSW)	682	264	947
Gosford - Springfield	255	73	328
Terrigal - North Avoca	93	2	95
Wamberal - Forresters Beach	32	1	33
Erina - Green Point	18	19	38

The average household size in the Wamberal-Forrester's Beach SA2 in 2016 was 2.8 persons per household, compared to 2.5 in the Central Coast LGA and 2.6 for New South Wales.

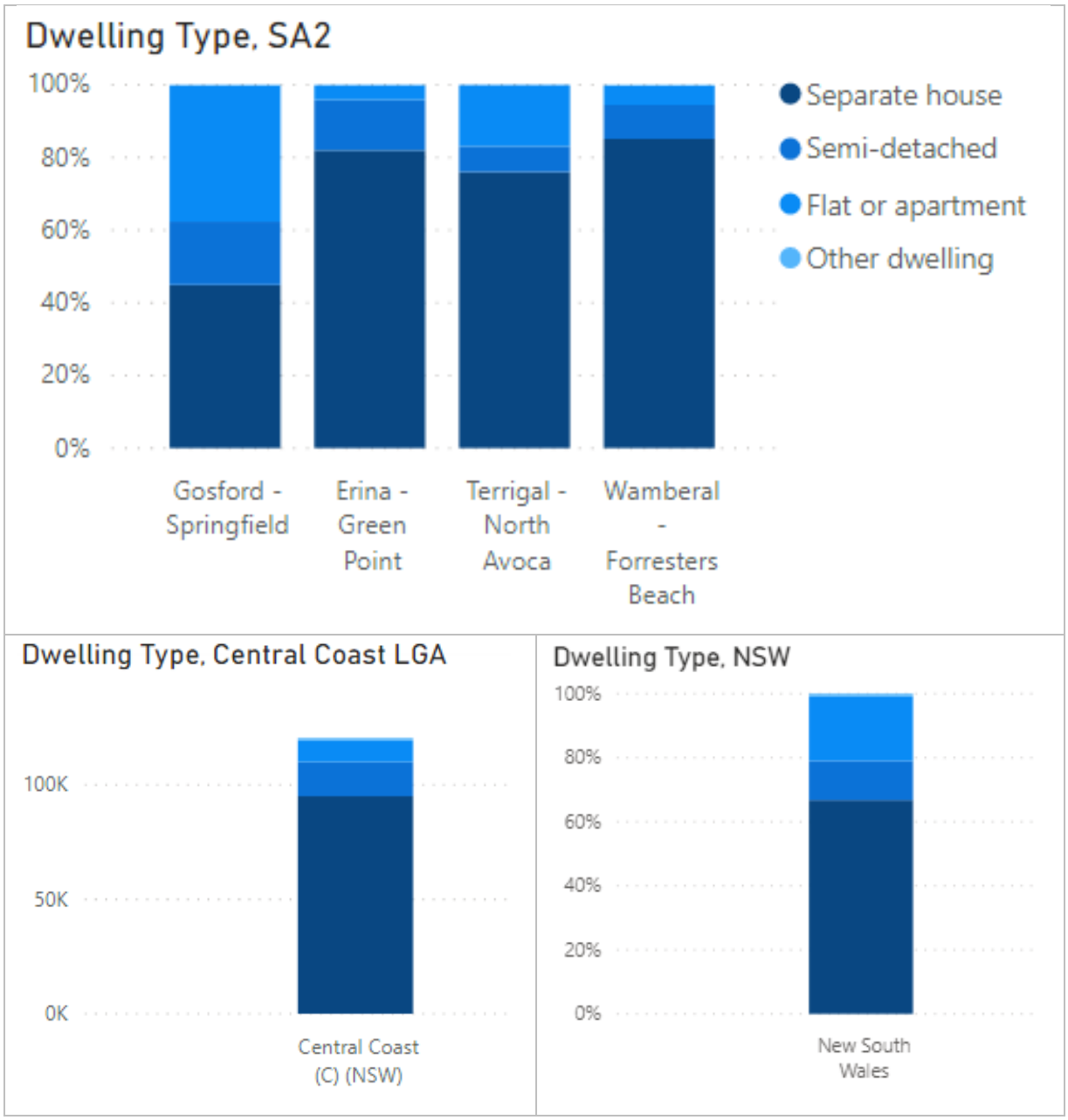

Figure A.6: Composition of dwelling types by SA2, Central Coast LGA, and NSW

A.3 Employment

In 2016 most people in the Central Coast LGA were employed in the Health Care and Social Assistance industry (15%) followed by Construction (11%) and Retail trade (11%) (Figure A.7). The aging population in the region may be the driving factor behind employment in the Health Care and Social Assistance Industry. The large proportion of people employed in the construction industry may indicate that there is continued demand for housing and accommodation in the region. This in turn supports local Retail Trade and Accommodation; and the Food Services industry.

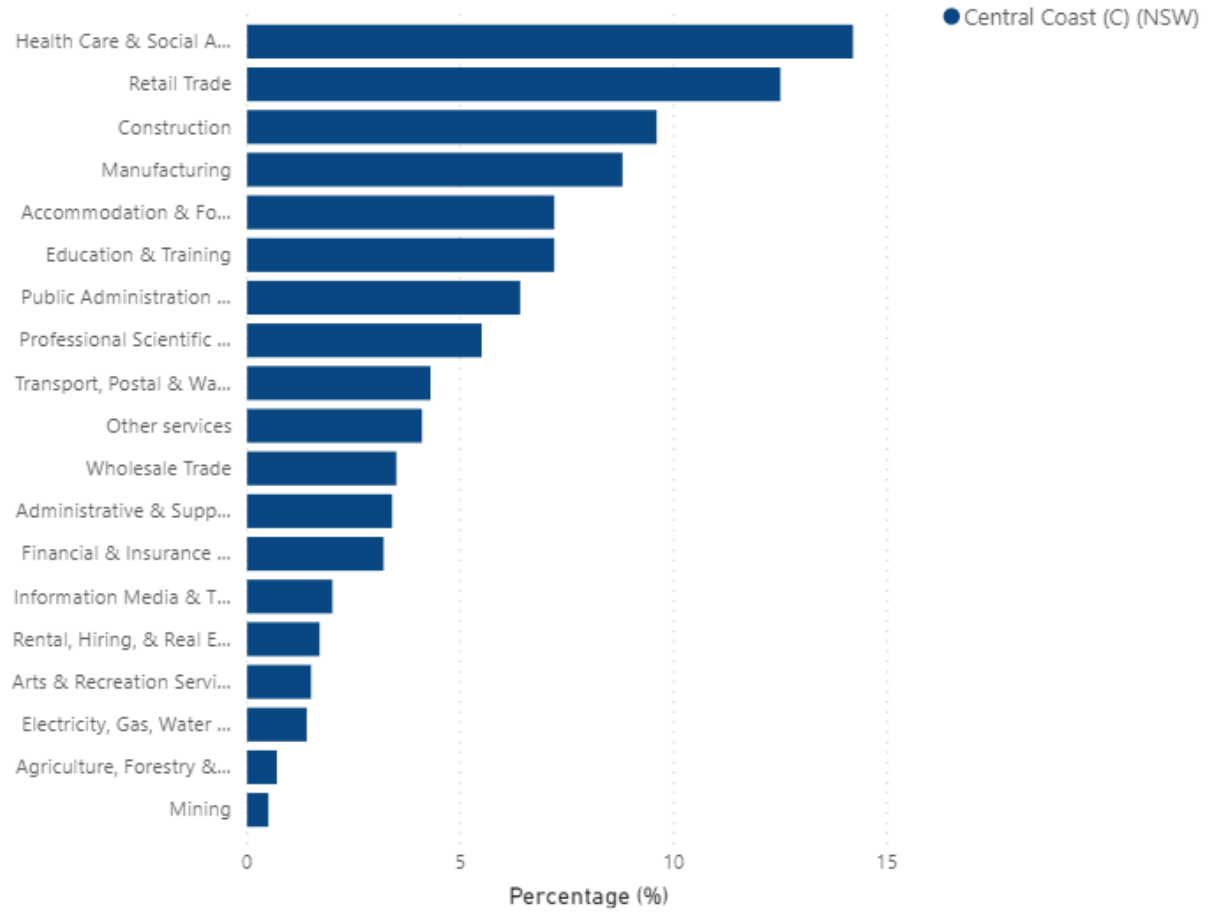

Figure A.7: Employment by Industry - Central Coast LGA

A.4 Income

As shown in Table A.6.3 the median equivalised total household income was highest at $1,020/week for the SA2 areas of Wamberal - Forresters Beach and Terrigal – North Avoca. The local centre of business activity – Gosford – Springfield has a slightly higher median income compared to the LGA as a whole, as did Erina – Green Point.

Table A.6.3: Income by LGA and SA2

Area	Median equivalised total household income ($/weekly)
Central Coast LGA	$774
Erina - Green Point	$808
Gosford - Springfield	$794
Terrigal - North Avoca	$1,020
Wamberal - Forresters Beach	$1,020

The Wamberal – Forresters Beach SA2 was the only SA2 assessed to have the highest proportion of income earners within the $1000 - $1999 range (Figure A.8). Approximately 26% of the Wamberal – Forresters Beach SA2 population earnt income in the $1000 - $1999 range compared to ≈ 20% for the Central Coast LGA.

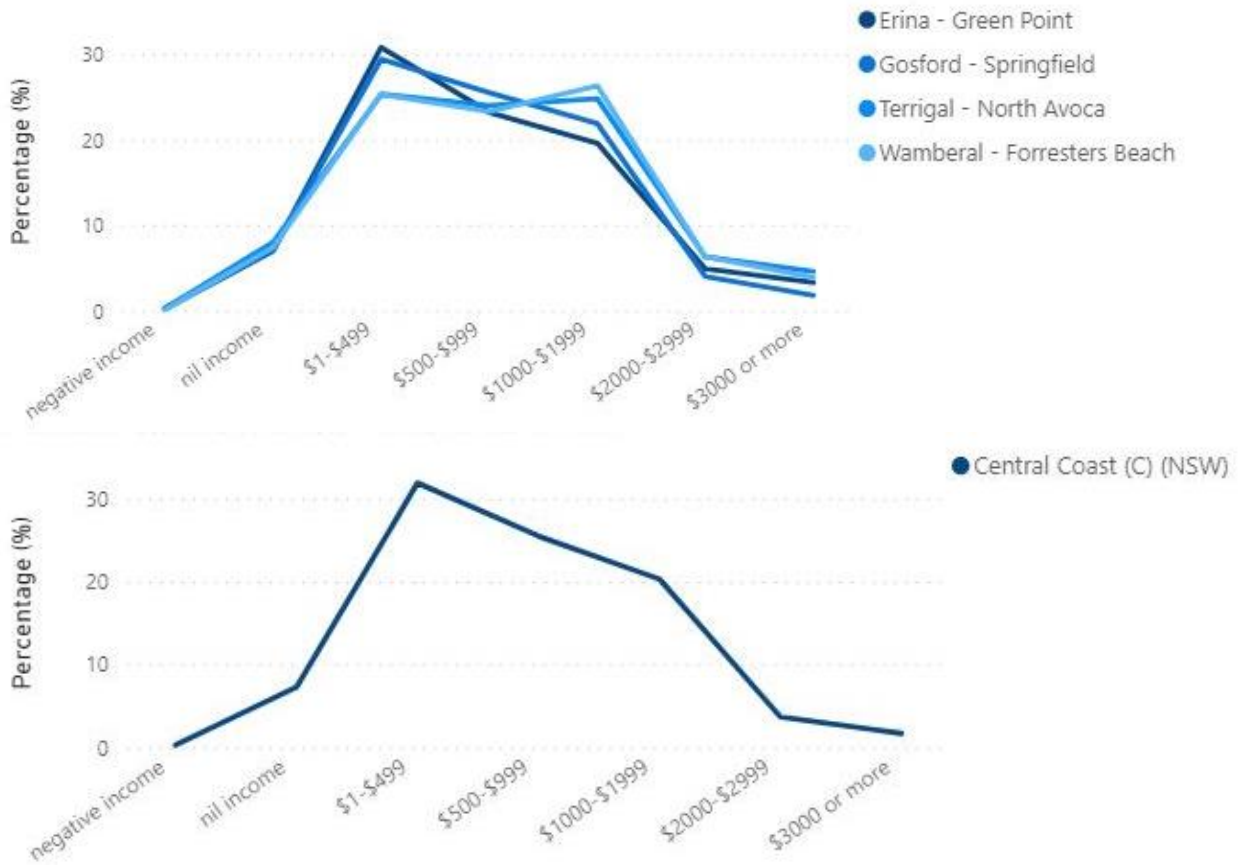

Figure A.8: Personal Weekly income by SA2 compared to the Central Coast LGA

A.5 Social Indicators

The Socio-Economic Indexes for Areas (SEIFA) is a product developed by the ABS that ranks areas in Australia according to relative socio-economic advantage and disadvantage. In 2016 the Wamberal - Forresters Beach and Terrigal – North Avoca SA2 areas had the highest SEIFA index of Relative Socio-economic Advantage and Disadvantage (IRSAD) at 9 compared to the LGA value of 7 (Figure A.9). This indicates that there is a relative lack of disadvantage and greater advantage in general in the Wamberal – Forresters Beach and Terrigal – North Avoca SA2 compared to the LGA as a whole. Of the SA2 areas surveyed, Gosford – Springfield had the lowest SEIFA IRSAD value of 5 and may have less ability to contribute to coastal protection infrastructure compared to Wamberal - Forresters Beach and Terrigal – North Avoca SA2 areas.

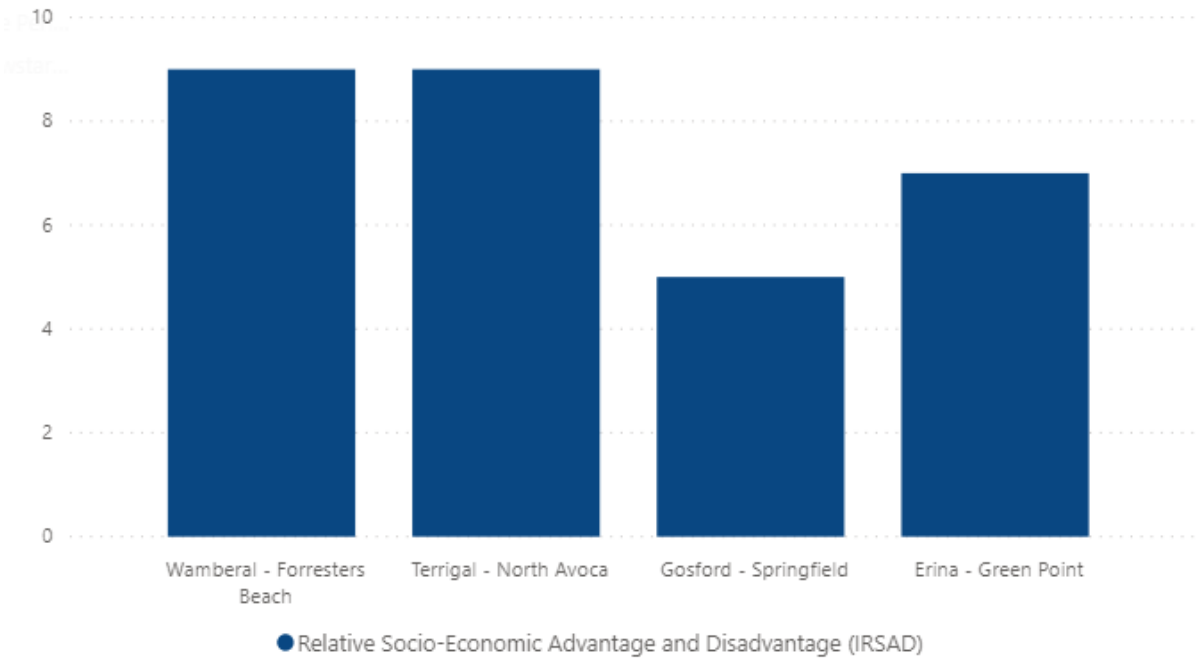

Figure A.9: Index of Relative Socio-Economic Advantage and Disadvantage

In 2016 the Erina – Green Point SA2 area had the largest number of residents receiving the age pension (≈ 3000 people) which reflects the aging population of the SA2 area (Figure A.10). The Gosford - Springfield SA2 area had the second highest number of residents receiving the age pension and the highest number of residents receiving the Newstart Allowance. Of the SA2 areas surveyed, Wamberal – Forresters Beach had the least number of residents receiving the age pension and Newstart Allowance.

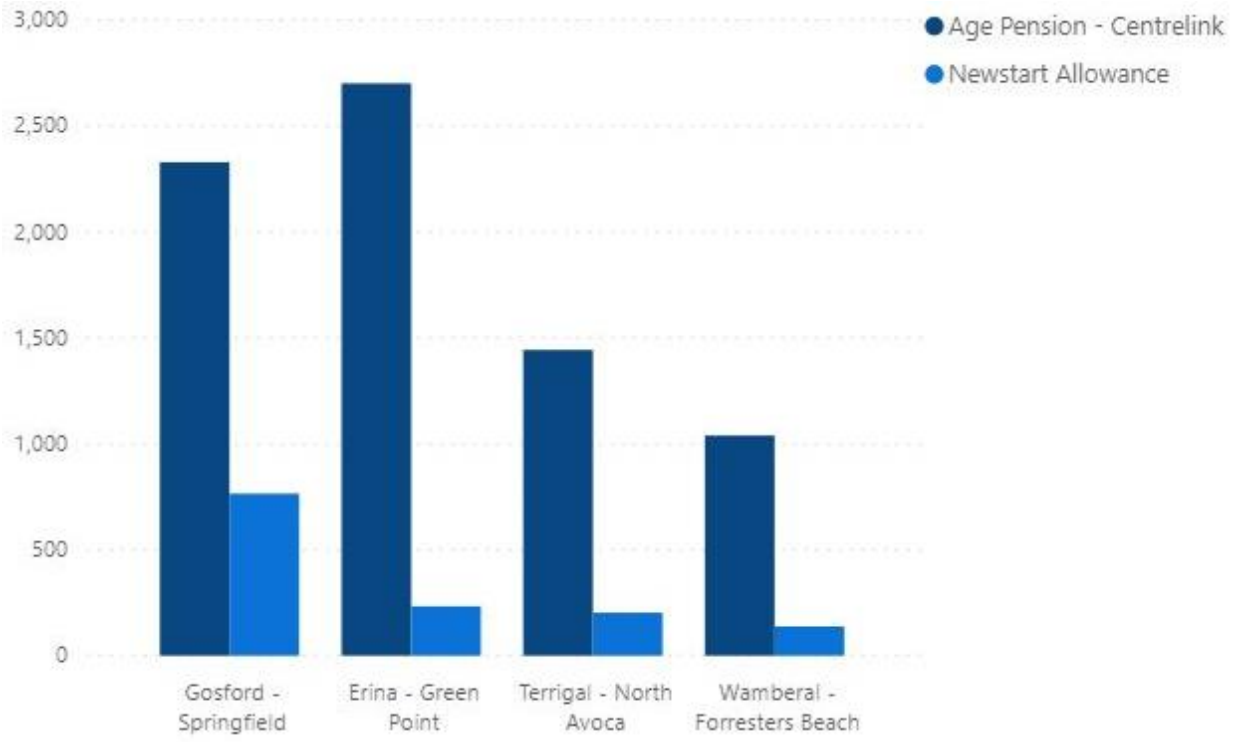

Figure A.10: Number of Government Payments by SA2 in 2018

A.6 Tourism

The beach and its lagoons have long been popular holiday destinations for Sydneysiders, with increasing residential development since 1960s. The community does not have significant beachfront retail or commerce activity other than a surf club.

On average, in the four years to 2018, there were ≈ 4.7 million overnight visitors to the Central Coast LGA. Most visitors to the region came for a holiday (≈ 50%) followed by visits to family and friends (≈ 45%) (Tourism Research Australia, Local Government Area Profiles 2019). Although data for overnight stays by SA2 area do not exist it is likely that beaches in the area such as Wamberal Beach are drawcards for visitors to the region and contributes to the local economy via retail and hospitality and accommodation expenditure.