Department of State Growth

Arthur Highway - Eaglehawk Neck Safety Upgrade Project

Coastal Geomorphology Assessment

July 2021

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1. Introduction

1.1 Background

GHD has been engaged by Department of State Growth (State Growth) to prepare a tender design for the widening of Arthur Highway at Eaglehawk Neck. To protect the highway from the effects of wave impact, a rock revetment has been proposed along the highway between Chainage CH 4130 to CH 4670.

Following the submission of the tender design in June 2020, the approval authority Tasmania Parks and Wildlife Service (Parks and Wildlife) requested State Growth prepare a coastal geomorphology assessment (this report) as a supplement submission to support the development proposal. The report was submitted to Parks and Wildlife on 9 February 2021.

Prior to the start of construction in November 2020, concerns were raised by the Aboriginal community about the impact on cultural heritage in the area and construction was paused. The Department of State Growth has since further consulted the Aboriginal community and regulatory authorities to revise the design. The revised design addresses concerns raised by the Aboriginal community by removing all ground disturbing activities within cultural heritage areas.

This coastal geomorphology assessment report (revision 1) has been updated to reflect the redesign.

1.2 Purpose of this report

The purpose of this document is to provide a desktop review and assessment of the potential coastal impacts of the proposed rock revetment to the western foreshore of Arthur Highway at Eaglehawk Neck using the readily available information.

This report includes the process, assumptions, clarifications, limitations, and results arising from the undertaking of the scope of work described in Section 1.3.

1.3 Scope of work

Constrained by data availability and submission timeframe, GHD was engaged to:

- Undertake a desktop review of long-term shoreline morphology along the eastern and western foreshore of the Eaglehawk Neck using aerial images.
- Develop a beach response model to evaluate short-term variations of the beach profile along the western side of the highway with and without the proposed revetment under the following two design conditions.
  - Ambient condition, being a 5 yr ARI event
  - Extreme condition, being a 50 yr ARI event
- Undertake an evaluation of the outcomes and prepare a summary report

1.4 Clarifications

- No additional site/field investigation was undertaken as part of this study. Geotechnical properties such as particle size distribution and soil stratification considered in the coastal geomorphology assessment were based on the test pits and boreholes BH1, BH3, and BH4 conducted by GHD in January 2020.

- Borehole from the January 2020 field investigation suggests there is no rock layer encountered within 2 m Below Ground Level. As such, the beach response model does not include a non-erodible layer beneath the beach surface.
- The beach response model assumed the beach sediment is homogeneous quartz sand with no cohesion.
- The design condition estimated during the revetment design was based on an uncalibrated numerical model driven by the generic wind speed for Tasmania per AS 1170. No additional model calibration and or verification was conducted in this assessment.
- As requested by State Growth and in line with the design philosophy adopted in the revetment design, no sea level rise was considered in the beach response model.
- The beach response model was aimed to estimate the beach response. Local effects such as revetment toe scouring was not evaluated using the model.

1.5 Disclaimers

This report has been prepared by GHD for Department of State Growth and may only be used and relied on by Department of State Growth for the purpose agreed between GHD and the Department of State Growth as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Department of State Growth arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

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

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

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

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The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Basis of assessment

2.1 Aerial images

The assessment included a desktop review of publicly available aerial images of the coastline of Eaglehawk Neck Bay near the project site. The purpose of reviewing the images was to identify the historical shoreline movements and changes.

The source of images is the historical aerial images archive from the LiST[1], as well as from Google Earth. In total, 17 images spanning 50 years from 1970 to 2019 were reviewed.

2.2 Storm conditions

The nominated storm conditions adopted in the beach response modelling are listed in Table 1. The conditions for the 50 yr ARI event were adopted from the GHD Revetment Design Report (GHD, 2020). The conditions for the 5 yr ARI event was estimated adopting the same methodology as the 50 yr ARI event.

Waves are locally generated seas developed along the waterbody to the west of the revetment. The narrow waterbody is expected to minimise directional spreading, size and period of waves.

Table 1 Nominated st conditions for beach response modelling

ARI	Design water level (m AHD)	Design wave height H_s (m)	Peak wave period (sec)
5 yr	1.17	0.4 to 0.5	2.0 to 3.0
50 yr	1.55	0.6 to 0.7	3.0 to 4.0

In the beach response modelling, a constant peak wave height(s) (as per Table 1) was adopted from the start of the simulation to the end. This is considered a valid assumption for the assessment of beach response in this application, given the fetch and depth limited waves that would be developed under local wind conditions.

2.3 Beach profiles

The beach profiles at CH4200, CH4400, and CH4600[2] took into account the available topography survey, publicly available bathymetry data, and the design profile of the proposed highway widening.

Figure 1 and Figure 2 show the initial profiles at the three chainages with and without the revetment (i.e., present-day condition). In these figures, 0 m in the x-axis is defined as the baseline of the profiles, which is the seaward edge of the revetment crest.

[1] https://www.thelist.tas.gov.au/app/content/the-list/aerialphotoviewer/
[2] Chainages are referring to that adopted in the design of the highway.

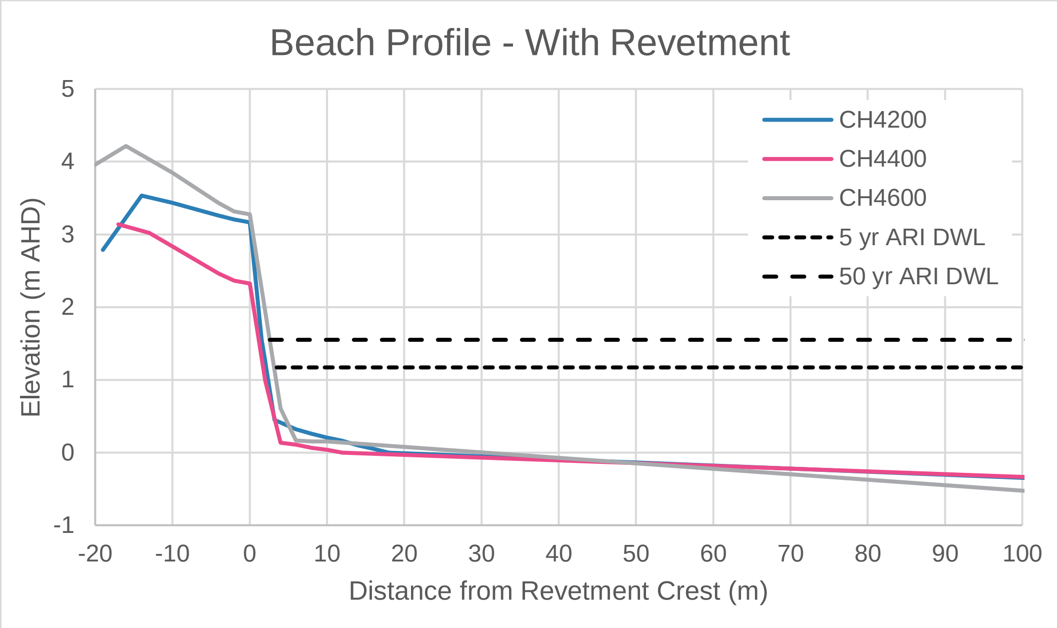


Figure 1 Beach profiles at the three chainages, with the rock revetment

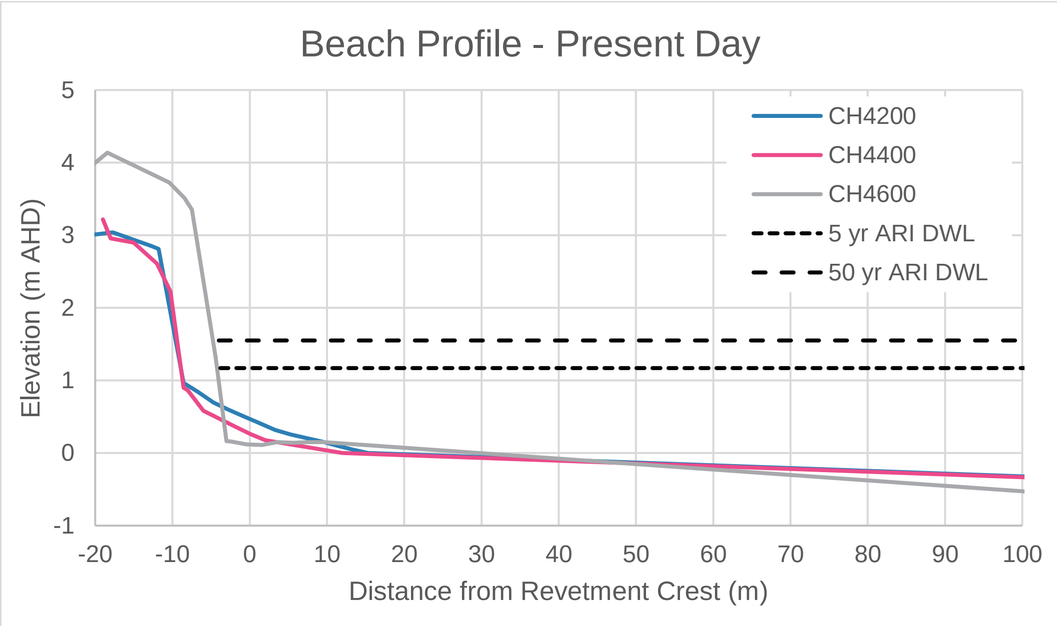


Figure 2 Beach profiles at the three chainages, without the rock revetment (present day)

2.4 Sediment properties

The modelling adopted a typical sediment median diameter of 0.25 mm, representing average beach sand.

Considering the findings of the geotechnical investigation conducted in January 2020 and the scale of the beach profile, no *non-erodible layer* was defined in the model other than the surface slope of the rock revetment.

3. Assessment results

3.1 Review of aerial images

Aerial images collected from the LiSTMap (1970 – 2016) and Google Earth (2016 – 2019) were reviewed in approximately five-year intervals to establish the likely historical movement of the shoreline along the project site.

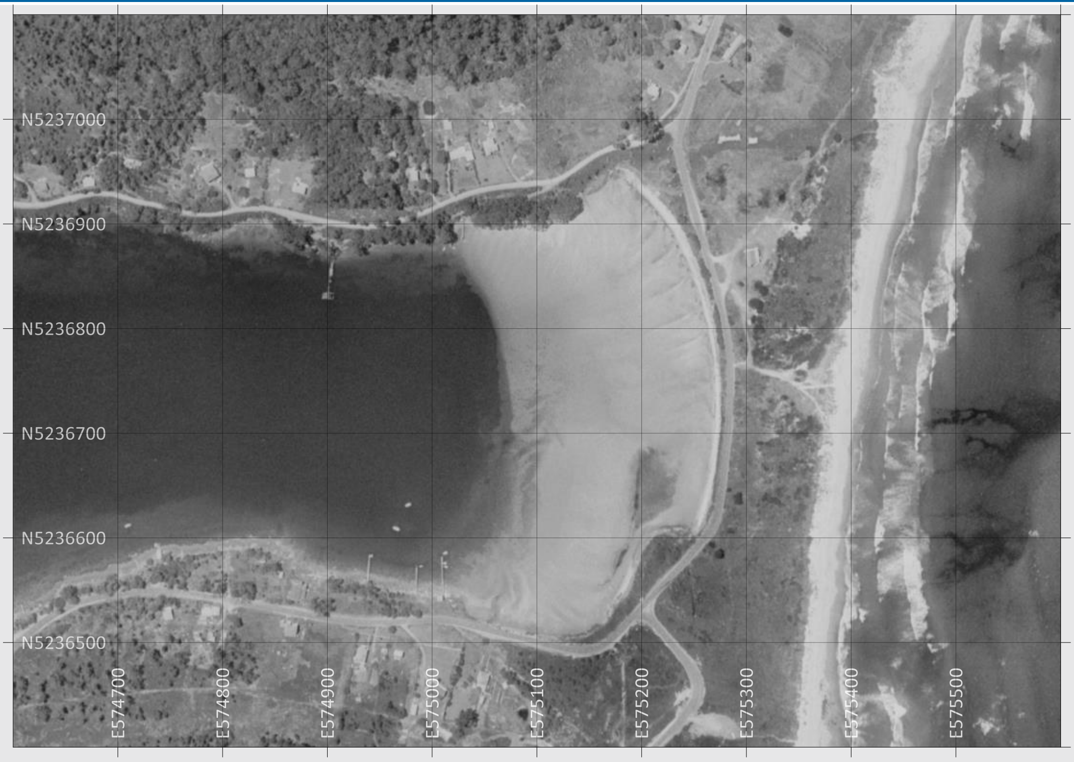
Images were georeferenced using between four to seven visually selected reference points. The coordinates shown in the figures is UTM, Australian AGD 84, Zone 55.

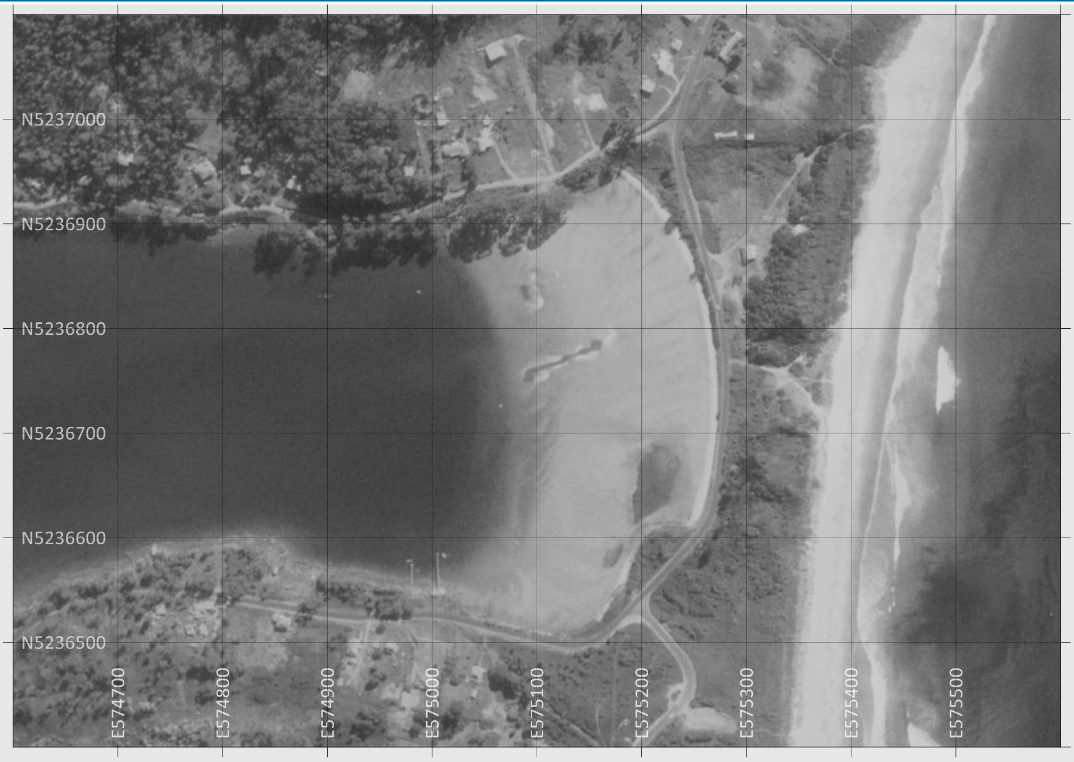
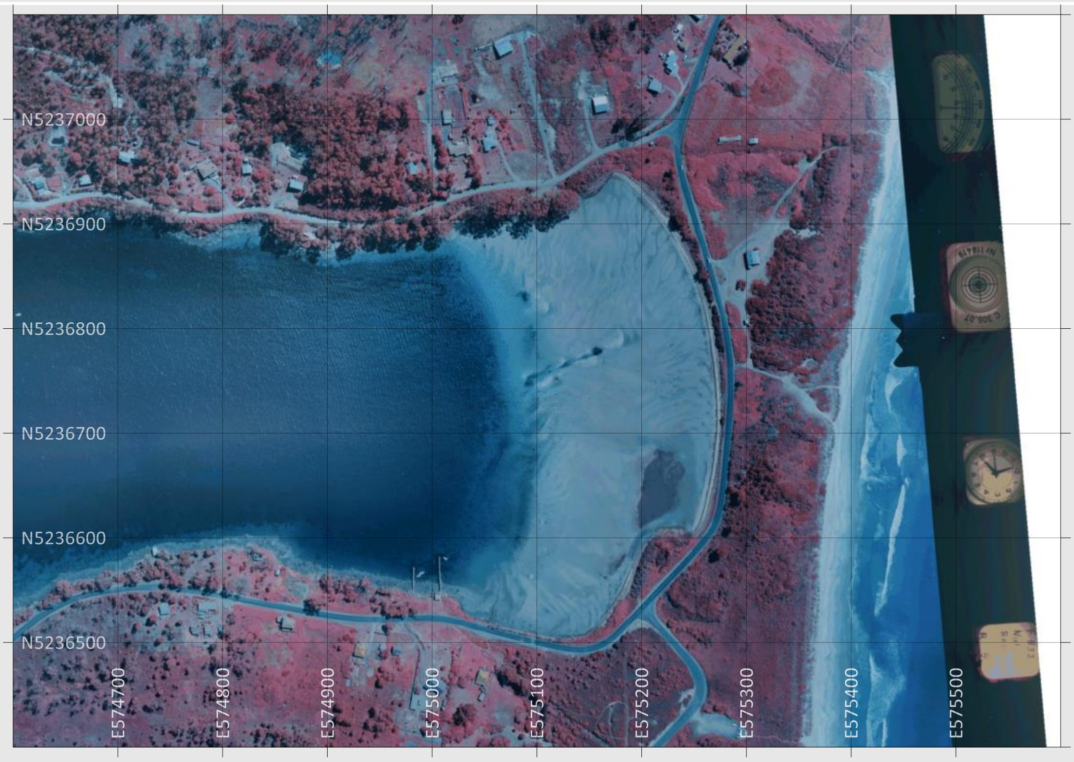
Table 2 summarises the aerial images reviewed. Observations on the images indicate that:

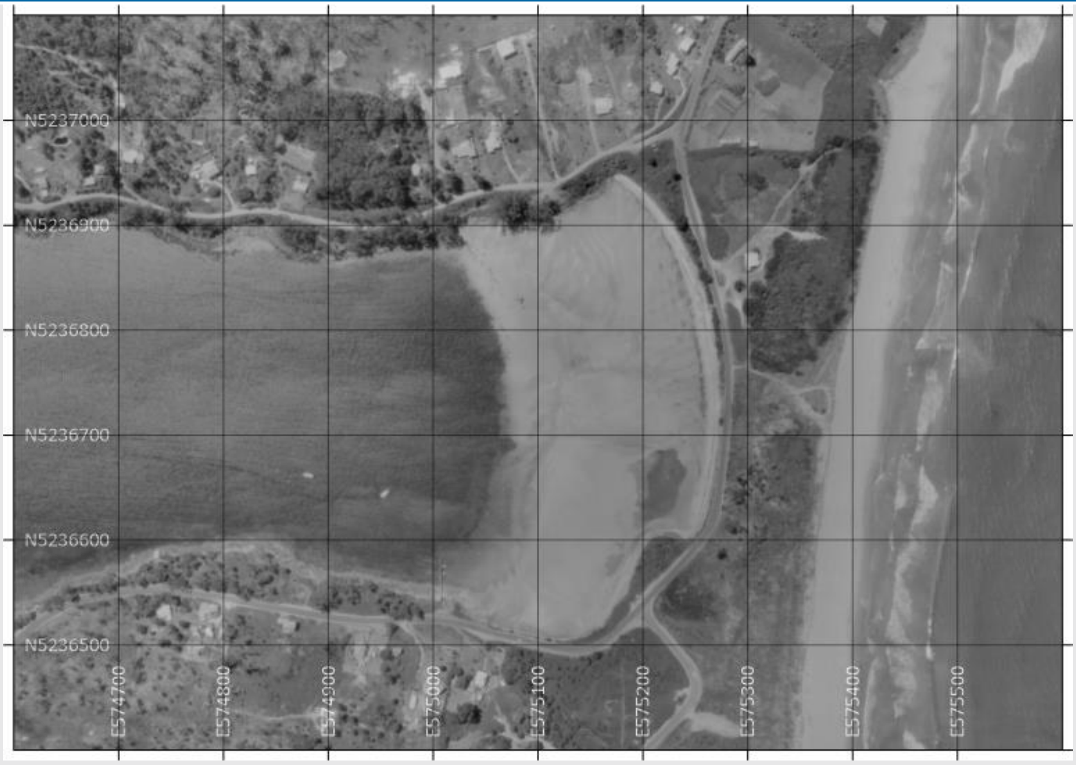
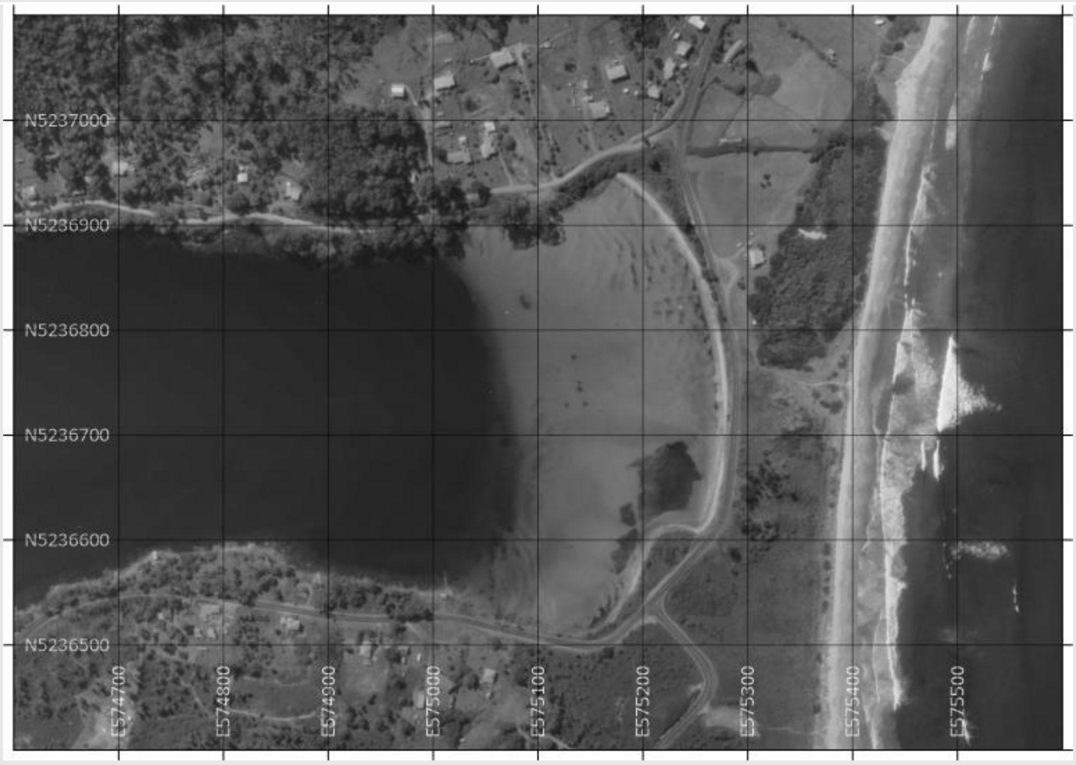
- The vegetation line of the project site has been relatively stable. A recession rate was not estimated given the stability of the shoreline. An estimate of the recession rate would likely be incorrect and any rate obtained, would most likely be from an error associated with georeferencing the images
- The width of visible dry beach varies; however, this is most likely due to variation in water levels when the photos were taken. The changes could also be caused by seasonal changes.
- There is no prominent trend of longshore sediment transport and shoreline movement along the project site and the adjacent shoreline. The sediment transport pattern, if any, appears to be in a cross-shore direction (on/offshore)
- Aeolian transport of sediment (by wind) is still likely to occur, but the volumes would be small as demonstrated by stable sandy beach areas shown on the reviewed aerial images. The construction of the proposed revetment is not expected to alter the natural pattern.
- The more recent photographs show large patches of seagrass offshore of the proposed revetment. These patches were not visible in the earlier images (before 2010). The presence of these patches is not considered a coastal morphologic change and may be studied as part of an evaluation of the benthic habitat. Reasons could include warmer temperatures, nutrient loading (human induced) or other factors. Refer to Appendix A for further discussion on marine ecological impacts.

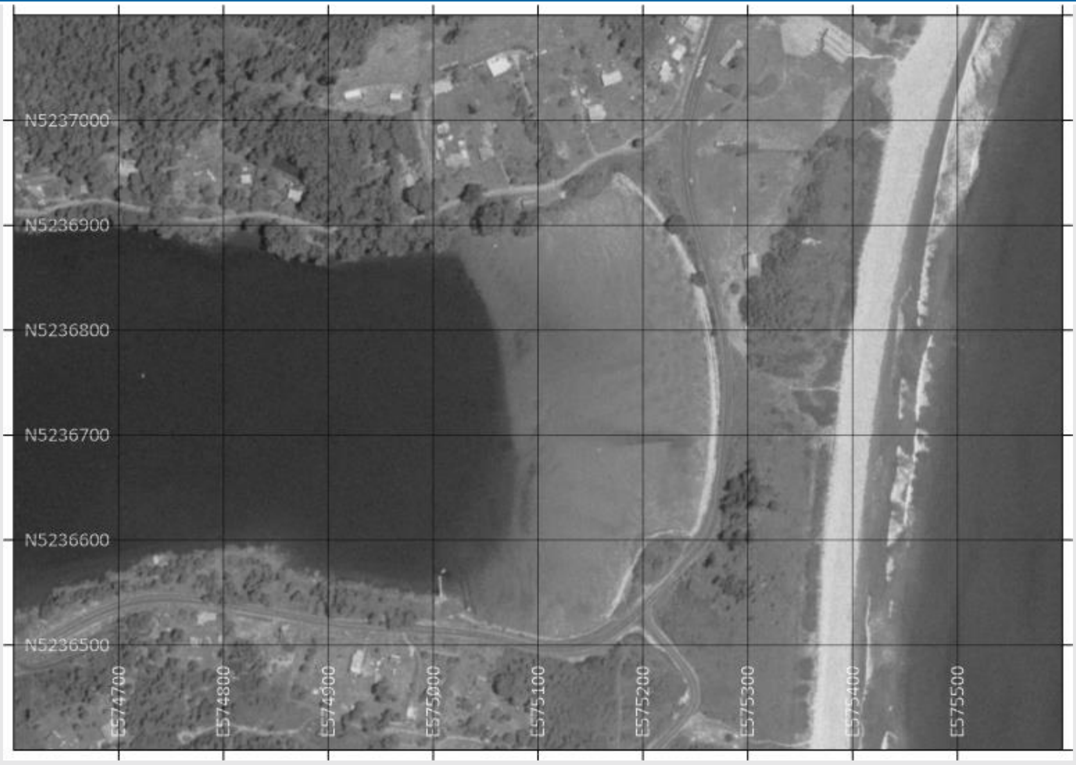
Overall, longshore sediment along the beach is expected to be insignificant and possibly negligible. This is generally deductable from the narrow fetch and uni-directional wave climate but also confirmed through review of aerial images demonstrating that beach width at the northern and southern extremities of the foreshore have been stable over the years.

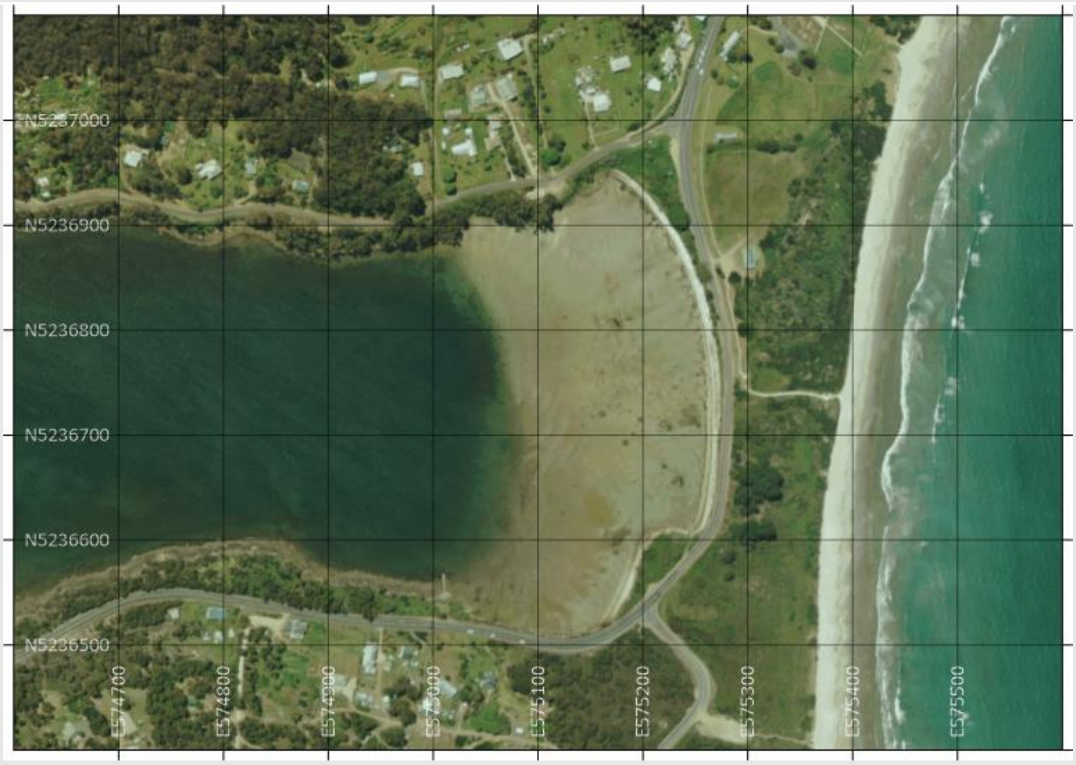
Table 2 Compilation of aerial images from 1970 to 2019

Year	
1970	
1971	

Year	
1975	
1977	

Year	
1980	
1985	

Year	
1993	
2001	

Year	
2006	
2010	

Year	
2016	
2019	

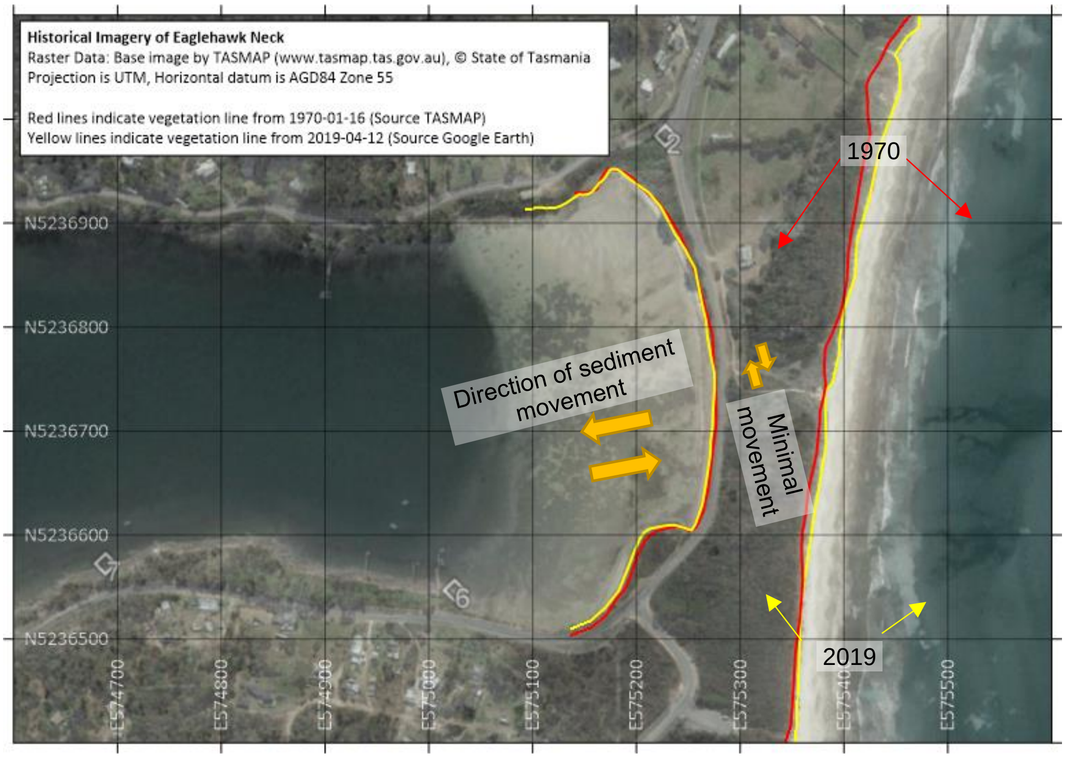


Figure 3 Overlay of 2019 (50% transparency) and 1970 images including shorelines

3.2 Beach response modelling

The SBEACH model (Larson and Kraus, 2002) was used to compute the potential storm erosion before and after the construction of the revetment structures. SBEACH is a widely applied modelling tool in coastal engineering industry to calculate beach dune erosion under storm wave action and to estimate shoreline retreat during storm events.

The estimated beach response at the three nominated chainages due to the presence of the revetment is shown in Table 3, Table 4, and Table 5. The results show:

- During the 5 yr ARI event, the model estimated recession of the present-day highway batter slope above the design water level, with the sediment being deposited below the design water level. This erosion is expected as the wave impacts the batter slope and mobilises the sediment, where the sediment is then settled underwater[3]. With the construction of the proposed revetment, the erosion at the shoreline is seen to have been reduced and or eliminated.
- During the 50 yr ARI event, the model simulated erosion of present-day highway batter slope in the is predicted to occur. With the revetment in place, the model results show loss of sediment from the area immediately seaward of the revetment (beachfront), resulting in an approximate beach lowering of 0.2 m. The lowering of the beach was estimated to occur from approximately 10 m to 30 m from the revetment toe.
- The sediment mobilised from the lowered foreshore is generally expected to relocate offshore, but as typically occurs in seasonal calm and storm cycles, would return to the beach during the subsequent calm periods.

[3] Note that the effect of existing revetment which is present at some areas is ignored given its present-day condition.

Table 3 Estimated beach profiles for CH4200

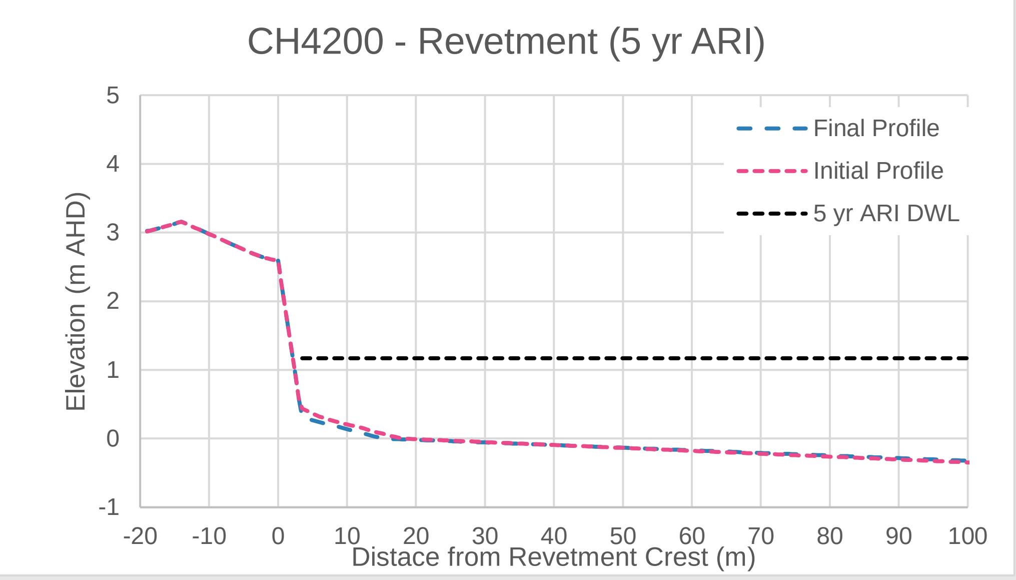
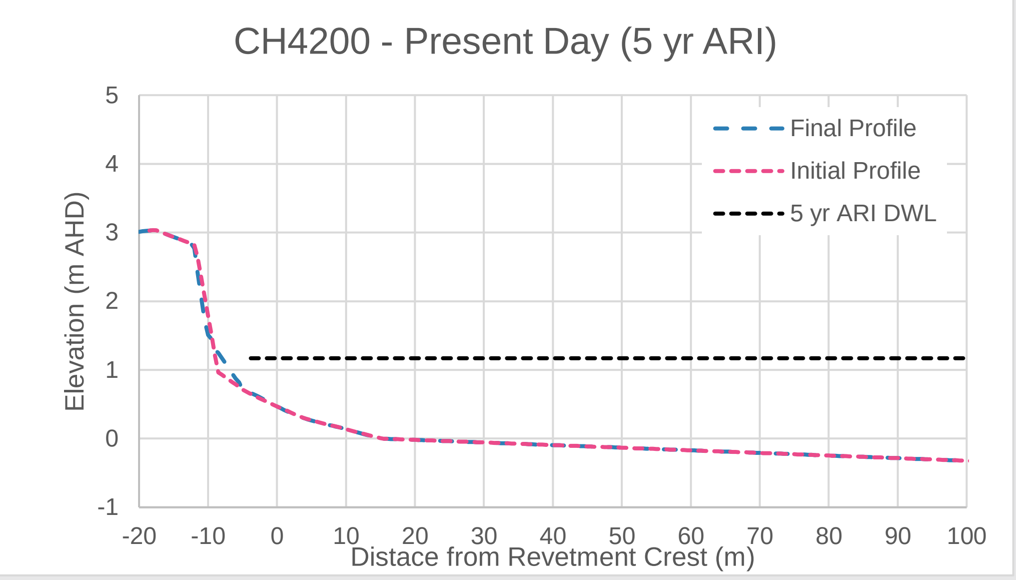
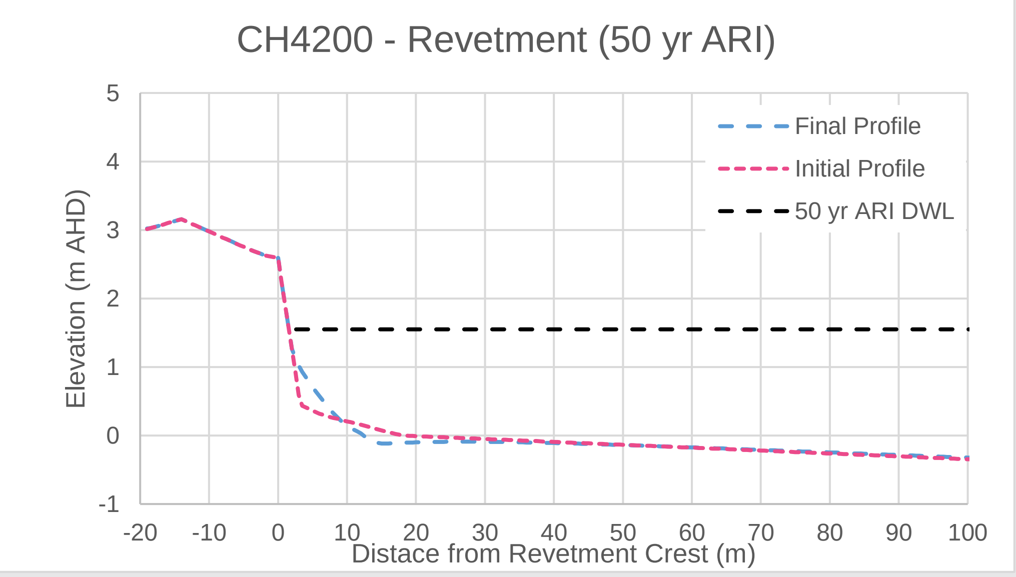
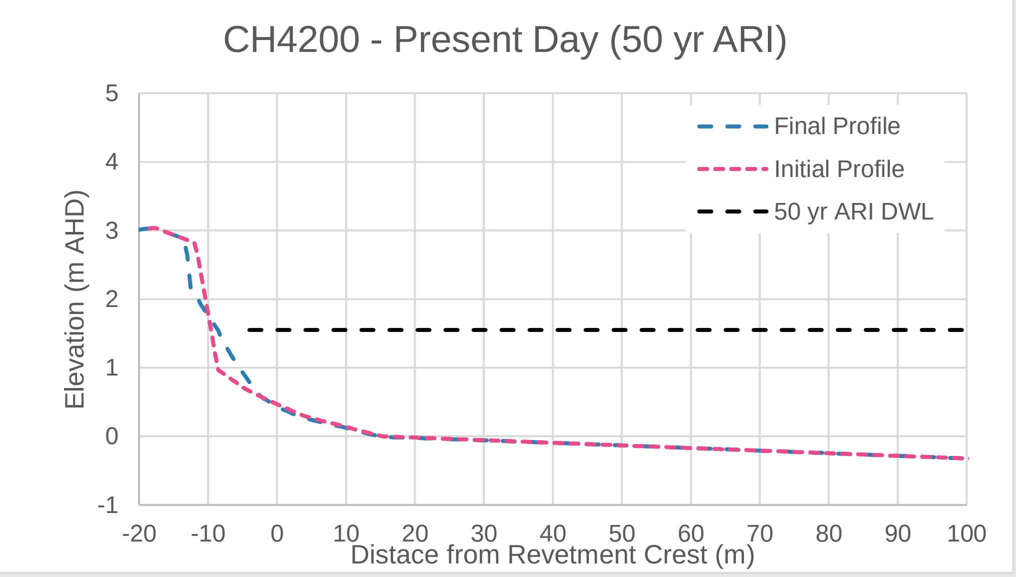
Design return period	Beach response with revetment	Beach response without revetment (present day)
5 yr ARI		
50 yr ARI		

Table 4 Estimated beach profiles for CH4400

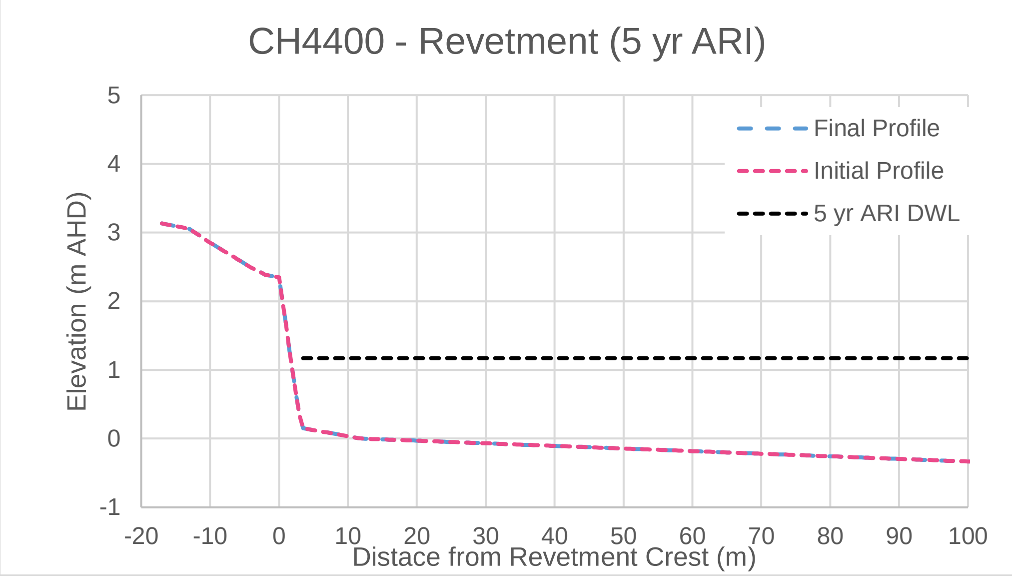
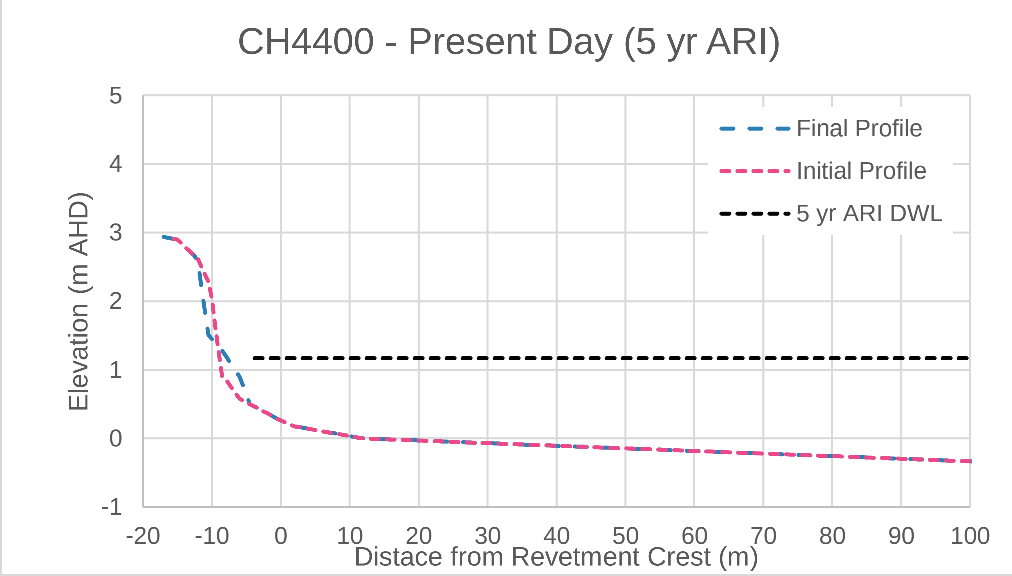
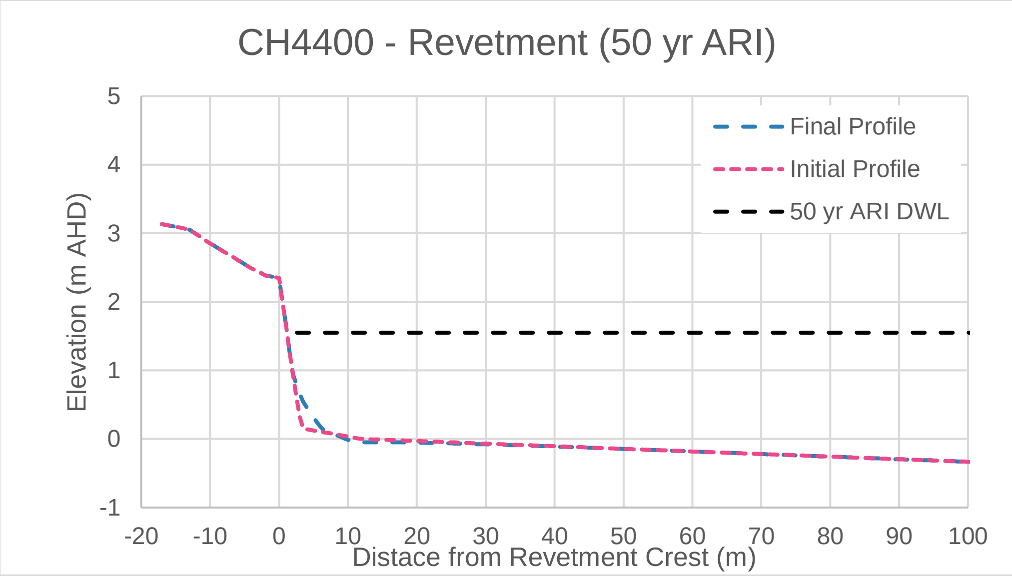
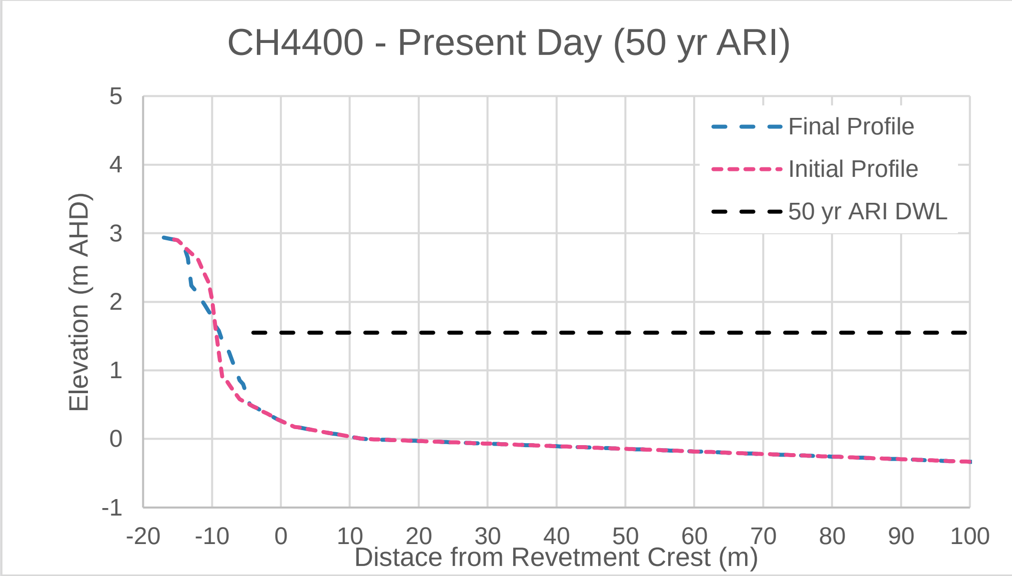
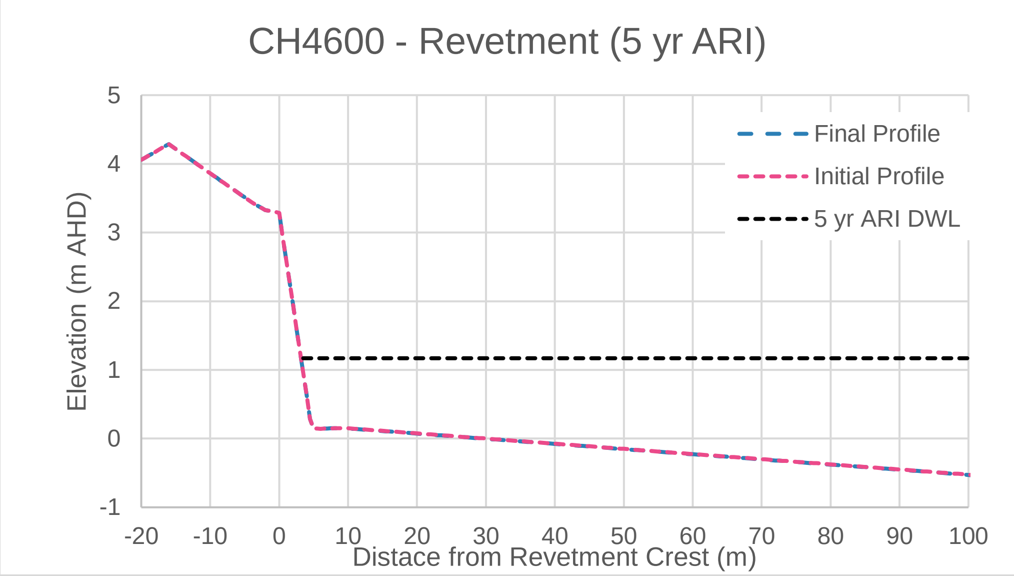
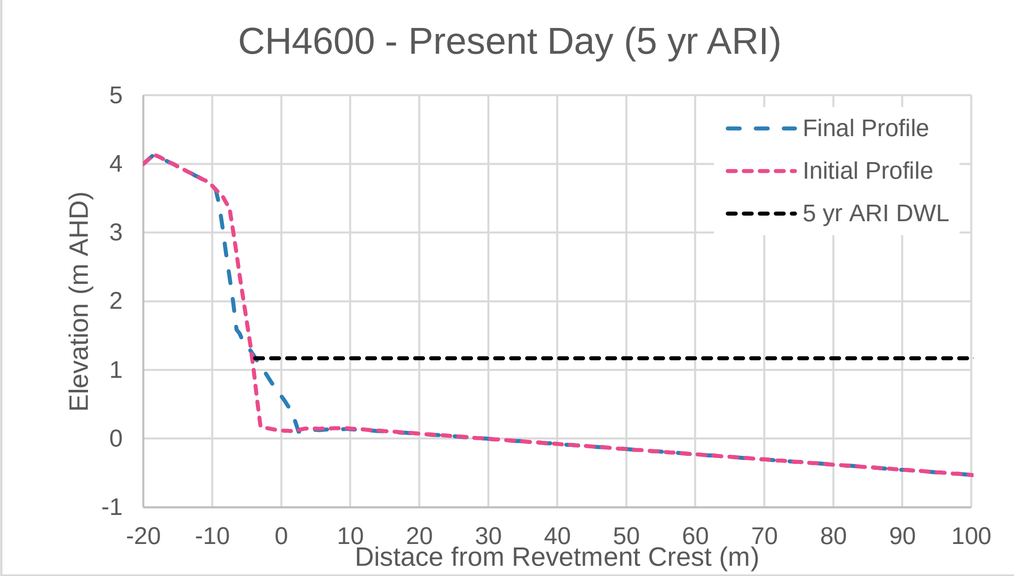
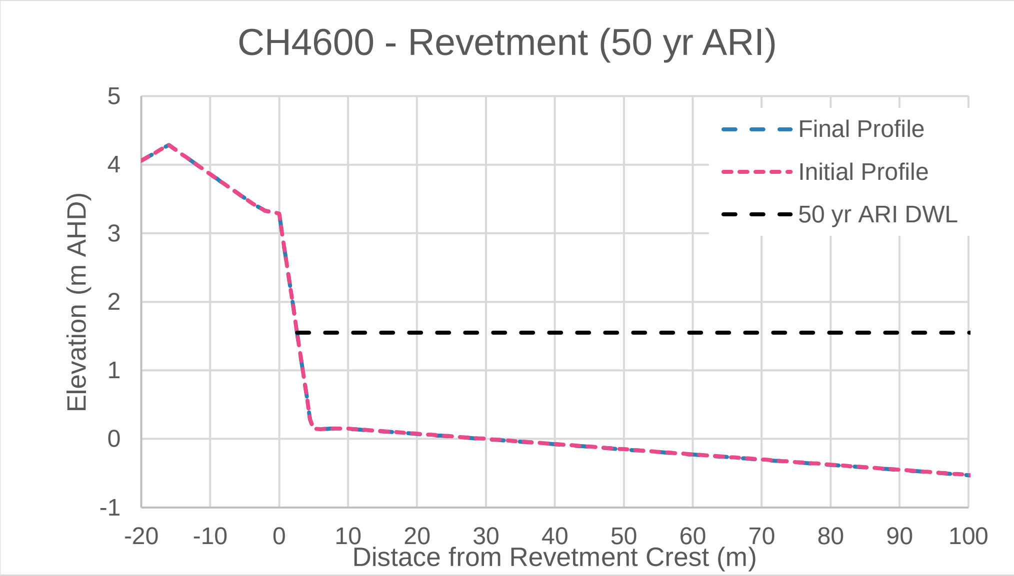
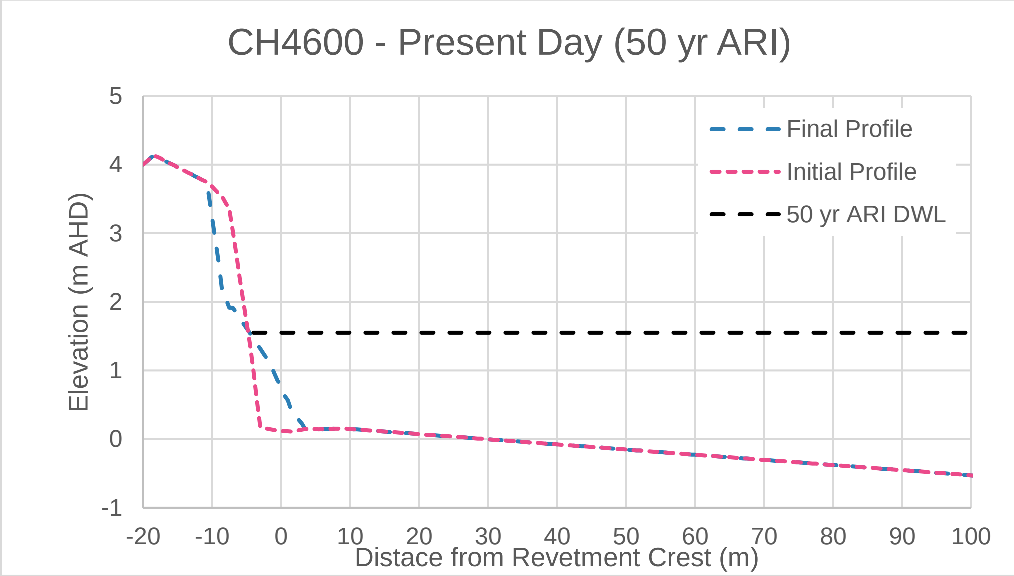
Design return period	Beach response with revetment	Beach response without revetment (present day)
5 yr ARI		
50 yr ARI		

Table 5 Estimated beach profiles for CH4600

Design return period	Beach response with revetment	Beach response without revetment (present day)
5 yr ARI		
50 yr ARI		

3.3 Toe scour

Toe scour is a local effect associated with erosion of erodible material near hard structures or features such as rock revetment during high water level and wave action events. Depth of scour is generally a factor of the size of the structure and, size of wave height and or magnitude of currents.

It is generally expected that scouring in the order of 1.5 times the size of wave height at the structure toe would occur or until the bedrock is reached, should the bedrock be shallower than 1.5 times wave height. In the GHD design, the effect of scouring is countered by the provision of a falling rock toe or a buried toe arrangement.

Scouring is a localised effect and not typically considered a geomorphological impact. The proposed revetment design allows for the likelihood of scouring. Impacts due to scouring at the toe were not further evaluated in this coastal geomorphological assessment report.

3.1 Transient response of beach to construction

In addition to the effects of storms, experience gained from previous revetment/seawall construction projects suggests that in the short term and following the completion of revetment construction, fluctuation in the beach elevation within the excavation zone should be expected. This is partly resulting from the loosened sediment in the excavated trench but also reflects the overall adjustment of the beach to the presence of the revetement

Once the sediment within the excavation zone is stabilised and hydraulically compacted under tidal action and in time, this transient erosion trend will cease and likely reverse.

4. Conclusions and recommendations

4.1 Conclusions

From the desktop coastal geomorphology assessment, the following can be concluded:

- Based on the review of aerial images at the project site spanning 50 years, there appear to have been very limited cross-shore and minimal longshore transport along the foreshore, which contributed to negligible shoreline movements or variation.
- Without the protection of a rock revetment, the highway batter slope and the surrounding shoreline will likely experience erosion under the future storm events considered in the design.
- Construction of the revetement will effectively minimise the likelihood of erosion at the highway batter slope. The model results indicate that some lowering of beach levels is likely to occur following large storm events, primarily as the wave heights reflect from the new revetement. The movement mainly consists of lowering of the foreshore by approximately 0.2 m, at about 10 to 30 m in front of the revetment. It is not expected that the sediment loss will be permanent, however. Given the closed morphological environment of Eaglehawk Neck Bay, the sediment will likely return and beach level re-establish.
- The beach response model mainly considered macro-scale shoreline movements. It should be expected that, within the short term and following the construction of the revetment, sediment movement at the toe of the revetment will occur. The movement would mainly be caused by the excavation and backfilling of foreshore to construct the revetment toe. From experience gained at other project sites, this effect is temporary and over time, the disturbed sediment will be compacted hydraulically and stabilised.
- Local scouring (micro-scale) along the toe of the revetment is likely to occur following storm events, with the sediment redistributed back to the foreshore in calmer wave condition.
- Overall, given the closed-loop nature of Eaglehawk Neck Bay, the sediment taken by waves and currents should stay within the system and will be deposited back to the foreshore by seasonality.

4.2 Recommendation

Given the low likelihood of adverse impacts from a revetment structure at this location and considering the importance of the structure in protecting the highway, we recommend that the revetment is developed as proposed in the design. If the revetment is not established, the highway batter slope and the surrounding shoreline will experience erosion under future storm events considered in the design.

As it is generally recommended for any new coastal development or where there is likelihood of erosion, a foreshore monitoring and management plan may be established and implemented by the asset owner or the appointed delegate.

4.3 Foreshore management plan

The objective of the management plan is to document the risks and triggers for intervention in response to potential foreshore erosion. The triggers should usually be determined in consultation with relevant stakeholders and should allow for natural variations of foreshore elevations due to seasonality to take place.

The management plan should also include regular visual inspection, monitoring, and collection of photos of foreshore to establish a chronological archive of documentation. Additional inspection can be carried out after the occurrence of storm events.

We recommend that post-construction survey of the beach is conducted annually for a period of five years. The post-construction survey is meant to monitor the variation of foreshore with the existence of the revetment. After the initial five-year period where the sediment within the influence zone of the revetment construction would have been stabilised, the regular inspection can be extended to every three to five years, or after the occurrence of major storm events, whichever takes place first.

Appendices

Appendix A – Intertidal Marine Natural Values Assessment

INTERTIDAL MARINE NATURAL VALUES ASSESSMENT: EAGLEHAWK BAY

Prepared by Aquenal Pty Ltd

Marine, Estuarine and Coastal Analysts

AQUENAL

AQUATIC ENVIRONMENT ANALYSTS

FOR

GHD

July 2021

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OPERATIONAL SUMMARY

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FIELD WORK: 1 December 2020

TO BE CITED AS: Aquenal (2021) Intertidal Marine Natural Values: Eaglehawk Bay, Report for GHD, July 2021, 23 pp.

Executive Summary

The Department of State Growth is planning road upgrade works along the Arthur Highway at Eaglehawk Neck on the Tasman Peninsula. The proposed works include widening the existing road and inclusion of a walking track on the eastern side of the road. This includes construction of a rock wall revetment adjacent to Eaglehawk Bay, requiring up to 3.4 meters of backfill perpendicular to the shoreline. Aquenal was engaged by GHD to design and implement a suitable intertidal marine values assessment for the proposed works. The intertidal marine natural values assessment comprised two main components – (1) a desktop survey and risk assessment; and (2) an intertidal field survey.

No threatened or listed intertidal species were identified in desktop searches of the Tasmanian Natural Values Atlas (NVA) within 500 m of the proposed works. Some marine mammals and subtidal species were identified in the NVA search. In a subsequent risk assessment, the lowest risk rating (negligible risk) was assigned to all species identified in the NVA search. The likelihood of marine mammals and/or subtidal species identified in the NVA search occurring in the study area was considered remote. Similarly, the consequence of impact for all species was considered minor, since the works are undertaken in the intertidal zone, with no expected impacts on adjacent subtidal areas.

Field surveys showed the intertidal zone in the survey area to be predominantly soft sediments and patchy seagrass (*Zostera muelleri*), with a narrow band of intertidal reef on the northern and southern edge of the bay. The rocky shores were mainly unvegetated, although occasional patches of green filamentous algae were present. A range of fauna and flora was observed during the survey, mainly comprising molluscs and crustaceans. Bivalve molluscs (e.g. *Katelysia scalarina*) were most prevalent amongst soft sediments, while gastropod molluscs (e.g. *Austrocochlea constricta*) were common amongst seagrass and on rocky substrates. Intertidal assemblages were typical of sheltered environments in south-east Tasmania.

Potential impacts which may occur during earthworks relate to disturbance of soft sediments and seagrass beds within the intertidal zone . A small section of the upper intertidal zone would be covered by rock fill and permanently affected. No marine species of conservation significance were present in this upper intertidal zone based on desktop and field surveys. Localised sediment disturbance impacts in the intertidal zone are likely to be localised and restricted to a short time period associated with construction activities. The field survey recorded relatively coarse sediments in the upper intertidal zone that are likely to settle out rapidly. The site is subject to tide and wave action so any sediment plume should also disperse within a short timeframe.

Potential impacts on seagrass beds may also be associated with altered geomorphological processes linked to the revetment. Modelling of sediment dynamics following large storm events

(i.e. 50 year annual recurrence interval) indicated that some lowering of beach levels may occur, at about 10 to 30 m in front of the revetment. Changes to beach level associated with the new revetment are not expected to have significant impacts on seagrass, since the majority of the observed seagrass was outside the expected area of potential sediment movement (i.e. further than 30 m from the revetment). If localised loss of seagrass occurred on the shallow edge of the beds, recovery would be expected, likely through vegetative growth from nearby unaffected plants. Unlike some other seagrass species, *Zostera muelleri* is known as an opportunistic species with a capacity to adapt to a range of environmental conditions. It is also notable that aerial imagery form 1970 -2016 shows seagrass to be a relatively recent feature of Eaglehawk Bay, with patches appearing after 2010, highlighting the dynamic nature of *Z. muelleri* seagrass beds and their ability to undergo natural fluctuations.

Despite the limited potential impacts, wherever practical, it is recommended that disturbance to intertidal sediments should be minimised during construction activities. Provided that disturbance to intertidal sediments is minimised during construction activities, the proposed development is expected to have minimal impacts on intertidal marine environmental values in the study area.

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The Department of State Growth is planning road upgrade works along the Arthur Highway at Eaglehawk Neck on the Tasman Peninsula (Figure 1). The proposed works include widening the existing road and inclusion of a walking track on the eastern side of the road. This includes construction of a rock wall revetment adjacent to Eaglehawk Bay, requiring up to 3.4 meters of backfill perpendicular to the shoreline.

Aquenal was engaged by GHD to design and implement a suitable intertidal marine values assessment survey. The survey was designed in accordance with the Tasmanian Government's *Guidelines for Natural Values Surveys - Estuarine and Marine Development Proposals* (NCH 2020).

The intertidal marine natural values assessment comprised two main components – (1) a desktop survey and risk assessment; and (2) an intertidal field survey. The risk assessment was based on species identified in the Tasmanian Natural Values Atlas (NVA). The field survey included:

(i) Habitat assessment/site characterisation

(ii) Marine fauna/flora survey in the intertidal zone adjacent to the proposed works

This report provides a summary of desktop and field studies and an assessment of the impact of intended works on the adjacent intertidal marine environment.

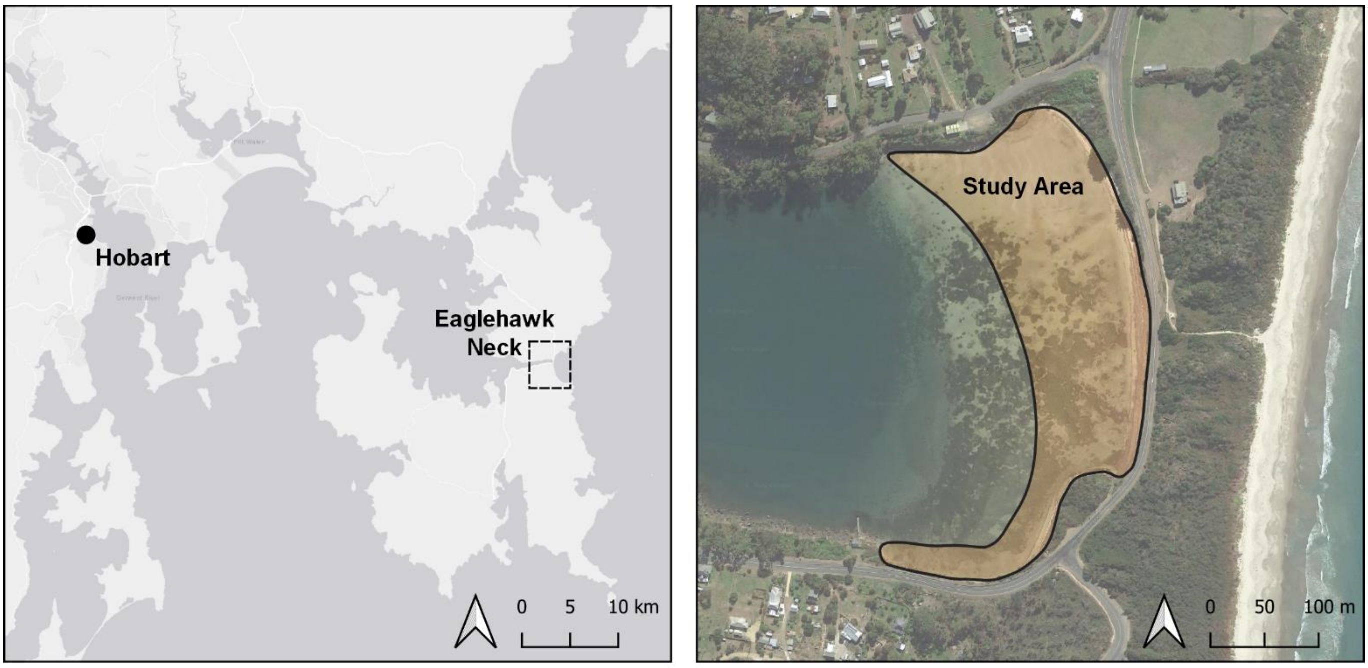


Figure 1 Map showing location of assessment area. Aerial imagery sourced from the LIST[1].

[1] https://www.thelist.tas.gov.au/

2. Methods

2.1 Desktop survey

In accordance with the *Guidelines for Natural Values Surveys - Estuarine and Marine Development Proposals* (NCH 2020), a report using buffers of 500 m and 5000 m around the proposed road upgrade works was generated using the online tool for the Tasmanian Natural Values Atlas (NVA). Observations of threatened species were downloaded from the Natural Values Atlas and used to select threatened species from waters west of Eaglehawk Neck.

For each species listed on the NVA report, a qualitative risk assessment was undertaken as to the likelihood of the species occurring in the local area and being impacted by the proposed development. The risk assessment used a consequence x likelihood matrix (adapted from Fletcher 2014). The outcome of the NVA search and risk assessment was also used to inform the field assessment.

Background information on marine habitats in the vicinity of the development was also investigated using the IMAS Seamap project[2](see Appendix 3) and aerial imagery in the vicinity of the site.

2.2 Field survey

Habitat assessments and marine flora and fauna surveys were undertaken along and adjacent to the proposed development during low tide (0.1 m on 1/12/2020). Habitat assessments were used to ground truth aerial imagery. Flora and fauna surveys focused on five zones within the assessment area.

1. Beach and upper intertidal sandflat
2. Mid-intertidal sandflat
3. Lower-intertidal sandflat
4. Rocky intertidal zone – northern shore
5. Rocky intertidal zone – southern shore

Within each zone, three sites were examined in detail during the field survey (Figure 2). Assessment of intertidal soft sediment habitats involved visual assessment of habitats and surface dwelling biota. Benthic sampling of soft sediments was not undertaken since no benthic fauna of conservation significance were identified in the desktop analysis. Rocky shoreline surveys involved thorough searching of rocky substrates. Rocks were carefully overturned to examine intertidal fauna (e.g. mobile crustaceans, gastropods). Targeted searches for threatened species were not included in the survey design based on the results of the desktop analyses.

[2] http://seamap.imas.utas.edu.au/

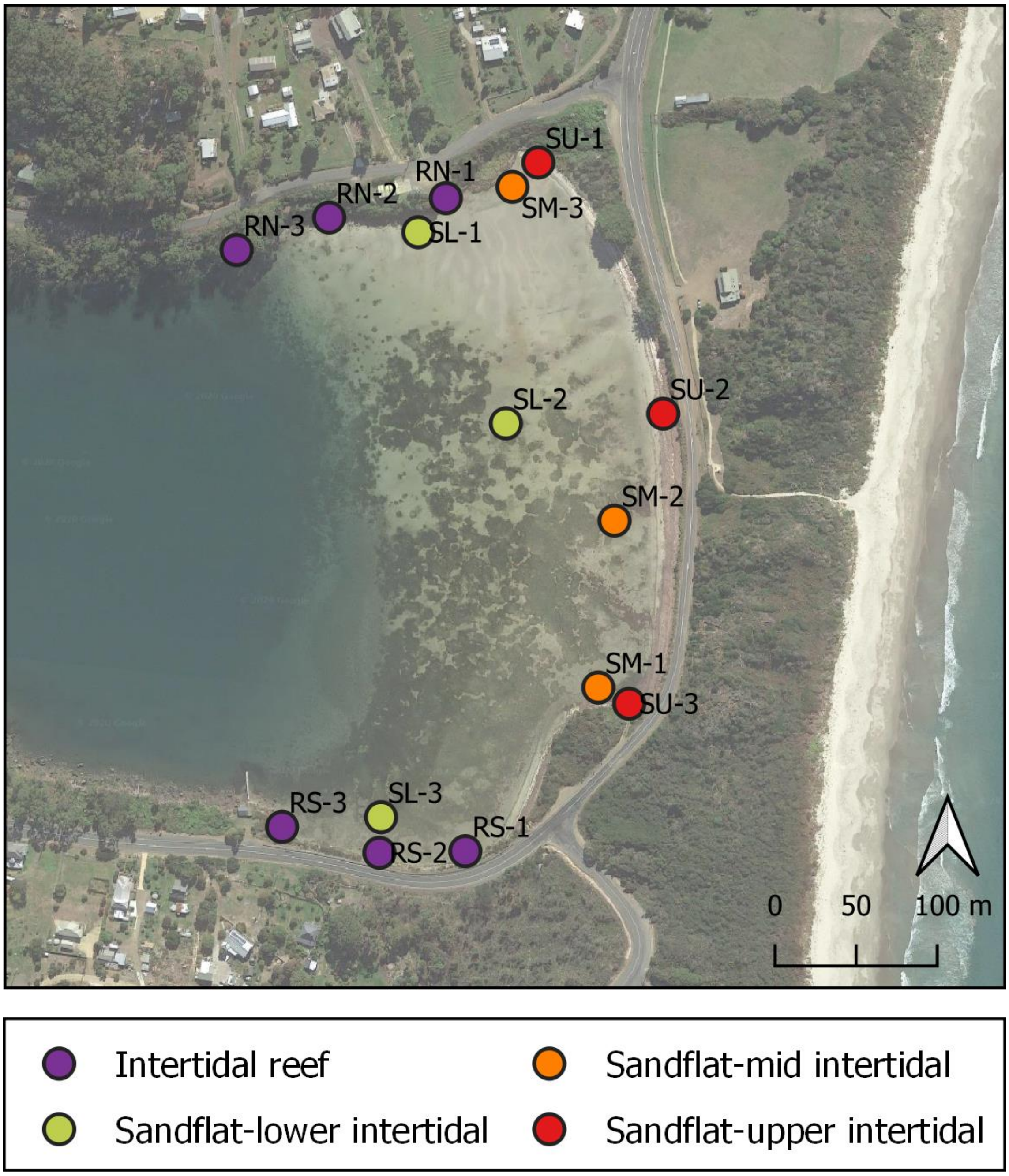


Figure 2 Survey area and location of survey sites. Survey coordinates are included in Appendix 1.

3. Results

3.1 Desktop Assessment

3.1.1 NVA search and risk assessment

A report using buffers of 500 m and 5000 m around the proposed road upgrade works was generated using the online tool for the Tasmanian Natural Values Atlas (NVA). Observations of threatened species within 5000 m of the development were also downloaded from the NVA website into a GIS. This spatial data was used to refine the online NVA report to include only observations of threatened marine, subtidal and intertidal species in Eaglehawk Bay west of Eaglehawk Neck.

No threatened or listed intertidal species were identified in the NVA searches.

One threatened marine species was identified within 500 m of the proposed works; a single observation of a Southern Elephant Seal (*Mirounga leonine*), recorded on the southern shore of Eaglehawk Bay in 2014 (Table 1; Figure 3). This species is listed as endangered under state TSPA legislation and vulnerable under the federal EPBCA. Three observations (June 2008 and June 2017) of the threatened Humpback Whale (*Megaptera novaengliae*) were recorded within the 5000 m buffer (Table 1; Figure 3).

Three threatened subtidal species may be present in Eaglehawk Bay based on modelled range boundaries in the Natural Values Atlas (Table 2). This include two species of handfish and the Australian Grayling (Table 2). Note that the live-bearing seastar *Parvulastra vivipara* and Ziebells handfish *Brachiopsilus ziebelli* were also listed in the NVA searches, but habitat for these two species occurs on the ocean side of Eaglehawk Neck and they are not relevant to the current assessment.

Table 1 Threatened fauna within 500 m and 5000 m of the proposed road upgrade works based on verified observations in the NVA. See Figure 3 for locations. TSPA = Tasmanian Threatened Species Protection Act 1995; EPBCA = Commonwealth Environment Protection and Biodiversity Conservation Act 1999. TSPA abbreviations: e = endangered; v = vulnerable. EPBCA abbreviations: EN = endangered, VU = vulnerable, CR = critically endangered.

Buffer	Species	Common Name	TSPA	EPBCA	Observation Count	Last Recorded
500 m	*Mirounga leonine*	Southern Elephant Seal	e	VU	1	21/10/2014
5000 m	*Megaptera novaengliae*	Humpback Whale	e	VU	3	16/06/2017

Table 2 Threatened fauna within 500 m and 5000 m of the proposed road upgrade works based on Range Boundaries in the NVA. TSPA = Tasmanian Threatened Species Protection Act 1995; EPBCA = Commonwealth Environment Protection and Biodiversity Conservation Act 1999. TSPA abbreviations: e = endangered; v = vulnerable. EPBCA abbreviations: EN = endangered, VU = vulnerable, CR = critically endangered.

Buffer	Species	Common Name	TSPA	EPBCA
500 m & 5000 m	*Prototroctes maraena*	Australian Grayling	v	VU
500 m & 5000 m	*Brachionichthys hirsutus*	Spotted Handfish	e	CR
500 m & 5000 m	*Thymichthys politus*	Red Handfish	e	CR

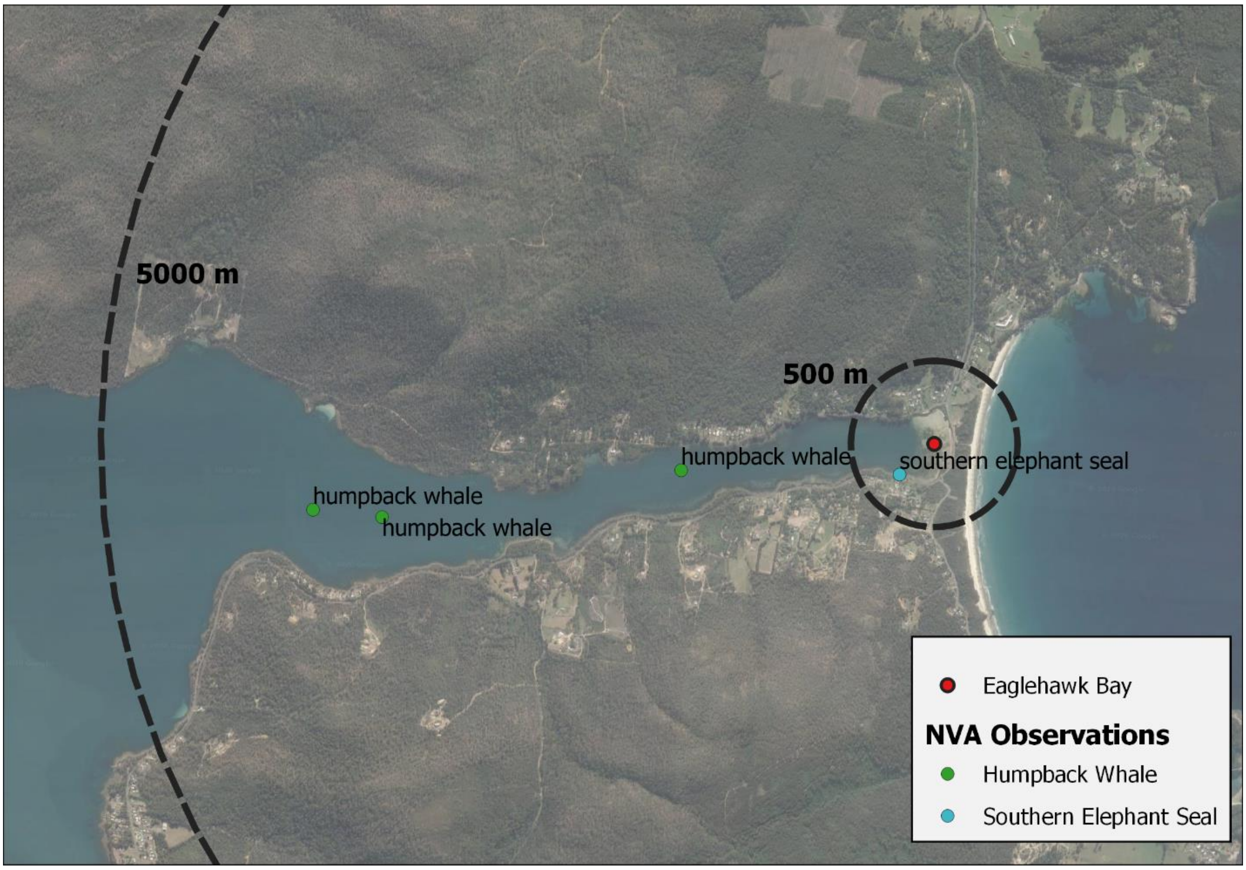


Figure 3 Location of observations of threatened marine species in the Tasmanian Natural Values Atlas within (a) 500 m of Eaglehawk Bay beach and (b) 5000 m of Eaglehawk Bay beach. Only observations of threatened species to the west of Eaglehawk Neck were included.

A risk assessment was conducted for those species identified in the NVA search. The lowest risk rating (negligible risk) was assigned to all species identified in the risk assessment (see Appendix 2 for results and risk assessment framework). The likelihood of marine mammals and subtidal species identified in the NVA search occurring in the study area was considered remote. Similarly, the consequence of impact for all species was considered minor, since the works are undertaken in the intertidal zone, with no expected impacts on adjacent subtidal areas.

3.2 Field surveys

3.2.1 Habitat characterisation

The intertidal zone in the survey area was predominantly soft sediments and patchy seagrass (*Zostera muelleri*), with a narrow band of intertidal reef on the northern and southern edge of the bay (Figure 4). A greater coverage of seagrass was evident on the southern side of Eaglehawk Bay. Epiphytic algae were common amongst the seagrass assemblages.

The rocky shores were mainly unvegetated, although occasional patches of green filamentous algae were present. A summary of habitat observations for each zone is provided in Table 3 below. Representative images for survey zones are shown in Figure 5.

Table 3 Summary of survey site locations.

Zone category	Sites	Habitat observations
Beach and upper intertidal sandflat	SU-1, SU-2, SU-3	Sandy beach and upper intertidal zone predominately coarse sand and wrack. Dead bivalve shells and seagrass most common component of beach wrack.
Mid-intertidal sandflat	SM-1, SM-2, SM-3	Sandflat with patchy seagrass (*Zostera muelleri*). Green algal epiphytes amongst seagrass assemblages. Bivalve molluscs (most common species) and gastropod molluscs commonly observed amongst seagrass and sand.
Lower intertidal sandflat	SL-1, SL-2, SL-3	Sandflat with patchy seagrass (*Z. muelleri*). Green algal epiphytes amongst seagrass assemblages. Bivalve molluscs (most common species) and gastropod molluscs commonly observed amongst seagrass and sand.
Rocky shore - south	RS-1, RS-2, RS-3	Rock wall and sparse boulders overlying sandy habitat. Patches of intertidal seagrass present. Gastropod molluscs common amongst rocky habitats, with *Austrocochlea constricta* relatively abundant. Crabs (*Paragrapsus gaimardii* and *Brachynotus spinosus*) observed beneath boulders and rocks.
Rocky shore - north	RN-1, RN-2, RN-3	Narrow fringe of rocky reef consisting mainly of boulders and rocks overlying sand. Woody debris along shoreline. Intertidal reef becoming more consolidated on the western aspect of the survey area. Gastropod molluscs were common amongst rocky habitats, with *A. constricta* relatively abundant. The most common crustaceans were porcelain crabs (*Petrolisthes elongatus*), with *P. gaimardii* and *B. spinosus* also observed.

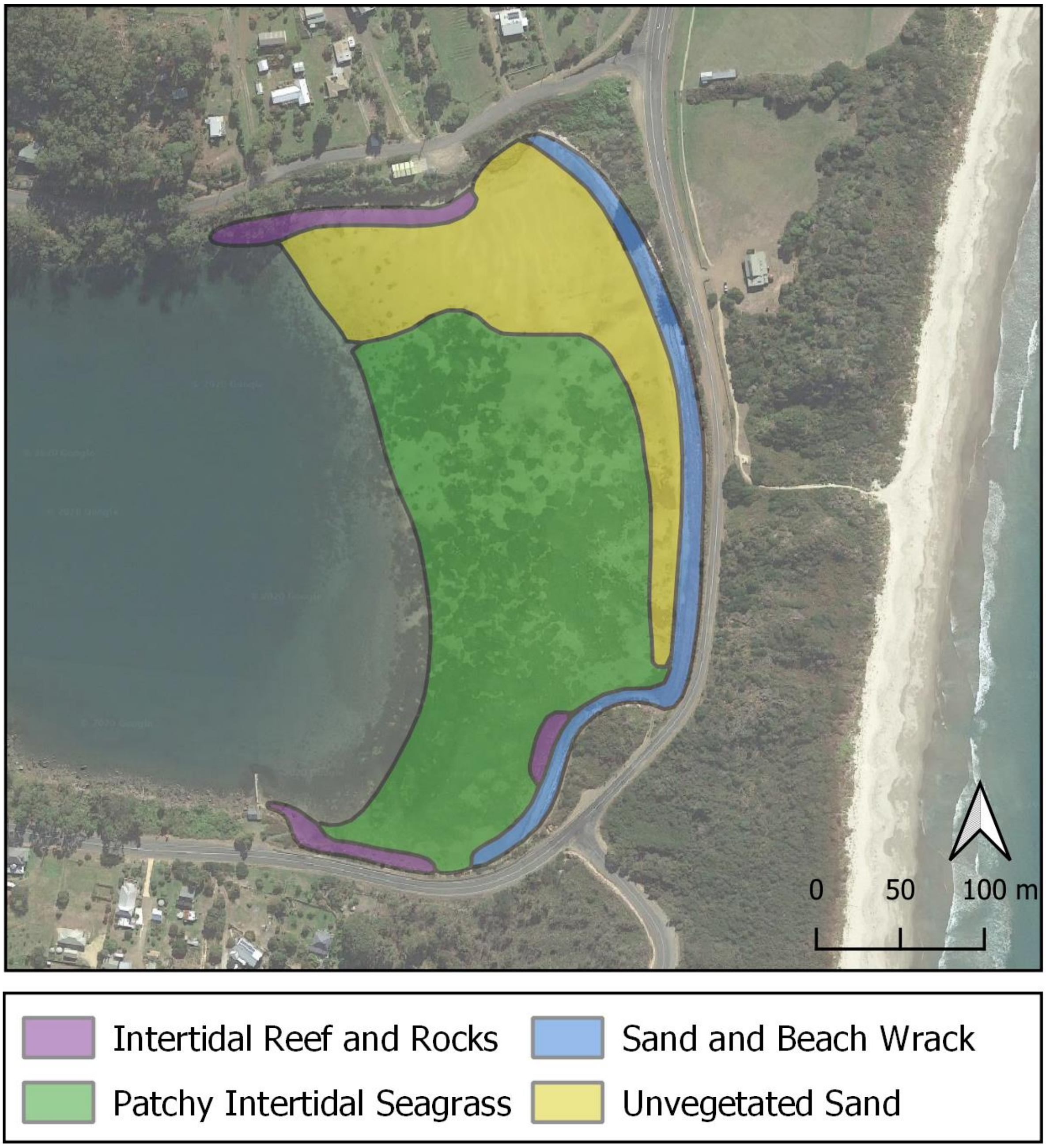


Figure 4 Marine habitats in the vicinity of Eaglehawk Bay.

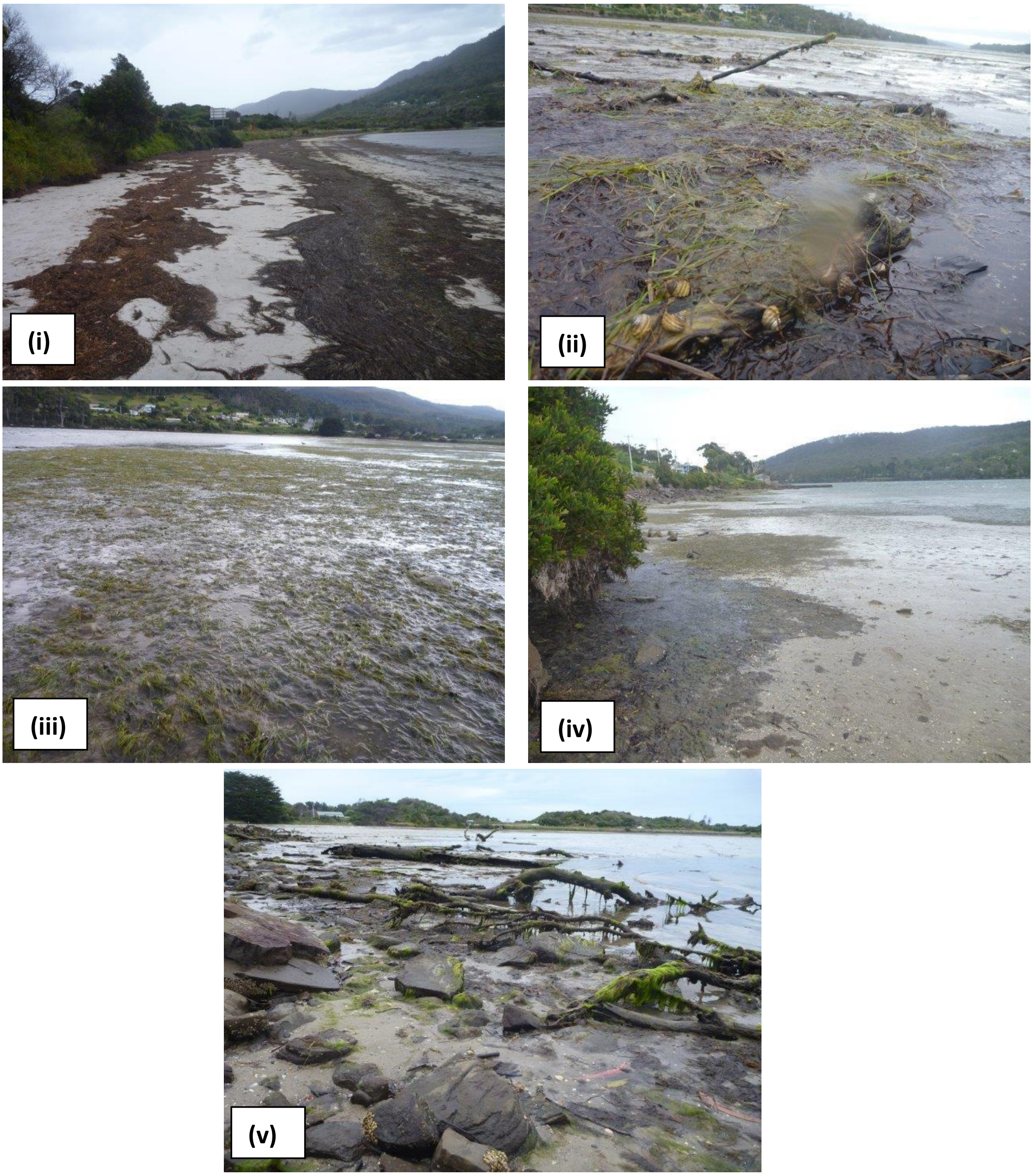


Figure 5 Representative images for survey areas including (i) beach and upper intertidal sandflat at SU-2; (ii) mid-intertidal sandflat at SM-2; (iii) lower-intertidal sandflat at SL-3; (iv) southern rocky shore at RS-2; and (v) northern rocky shore at RN-2.

3.2.2 Intertidal flora and fauna surveys

A range of fauna and flora was observed during the survey, mainly comprising molluscs and crustaceans (Table 4). Bivalve molluscs (e.g. *Katelysia scalarina*) were most prevalent amongst soft sediments, while gastropod molluscs were common amongst seagrass and on rocky substrates (e.g. *Austrocochlea constricta*). Intertidal assemblages were typical of sheltered environments in south-east Tasmania. Images of selected representative taxa are provided in Appendix 4.

Table 4 Summary of taxa observed during the survey.

Fauna	Flora
Ascidian: *Pyura stolonifera* Barnacle: *Elminius modestus* Crustaceans: *Petrolisthes elongatus*, Paragrapsus gaimardii, Cyclograpsus granulosus, Brachynotus spinosus, Mictyris platychelus, Bellidilia undecimspinosa* Mollusc – bivalves: *Crassostrea gigas*, Mytilus galloprovincialis, Katelysia scalarina*, *Macamona deltoidalis, Paphies elongata* Mollusc – chiton: *Spharochiton pelliserpentis* Mollusc – gastropods: *Austrocochlea constricta, A. brevis*, *Austrolittorina unifasciata*, *Columinella lineolata*, *Bembicium* sp., Nassaridae sp. Mollusc - false limpet: *Siphonaria diemenensis* Mollusc - limpet: *Notoacmea flammea* Polychaetes: *Galeolaria caespitosa*, Nereid sp.	Seagrass *Zostera muelleri,* filamentous brown algae, filamentous green algae

*Introduced or cryptogenic species

4. Discussion and Recommendations

No threatened intertidal species were identified in the desktop analysis and intertidal field survey. Species identified in the NVA search were marine mammals and subtidal species and the risk of the proposed development was considered negligible for these species.

Potential impacts which may occur during earthworks relate to disturbance of soft sediments and seagrass beds within the intertidal zone . A small section of the upper intertidal zone would be covered by the rock fill and permanently affected. No marine species of conservation significance were present in this upper intertidal zone based on desktop and field surveys. Sediment disturbance impacts in the intertidal zone are likely to be highly localised and mainly restricted to a short time period associated with construction activities.

The field survey recorded relatively coarse sediments in the upper intertidal zone that are likely to settle out rapidly upon disturbance. The site is subject to tide and wave action so any sediment plume should also disperse within a short timeframe. Despite the limited potential impacts, wherever practical, it is recommended that disturbance to intertidal sediments should be minimised during construction activities.

Potential impacts on seagrass beds may also be associated with altered geomorphological processes linked to the revetment. Modelling of sediment dynamics following large storm events (i.e. 50 year annual recurrence interval) indicated that some lowering of beach levels may occur, primarily as the wave heights are reflected from the new revetment (GHD 2021). The predicted sediment movement mainly consists of lowering of the foreshore by approximately 0.2 m, at about 10 to 30 m in front of the revetment. It is expected that the beach level would be expected to re-establish given the closed morphological environment of Eaglehawk Neck Bay (GHD 2021).

Changes to beach level are not expected to have significant impacts on seagrass, since the majority of the observed seagrass was outside the expected area of potential sediment movement (i.e. further than 30 m from the revetment). If localised loss of seagrass occurred on the shallow edge of the beds, recovery would be expected, likely through vegetative growth from nearby unaffected plants. Unlike some other seagrass species, *Zostera muelleri* is known as an opportunistic species with a capacity to adapt to a range of environmental conditions (Ferguson et al. 2018). While there are limited local studies examining recovery of *Z. muelleri* communities following disturbance in Tasmania, recovery has been shown for *Z. muelleri* elsewhere (Campbell and McKenzie 2004). It is also notable that aerial imagery form 1970 -2016 shows seagrass to be a relatively recent feature of Eaglehawk Bay, with patches appearing after 2010 (GHD 2021). These patterns highlight the dynamic nature of *Z. muelleri* seagrass beds and their ability to undergo natural fluctuations, as has been shown elsewhere in Tasmania (Mount and Otera 2011).

In summary, provided that disturbance to intertidal sediments is minimised during construction activities, the proposed development is expected to have minimal impacts on intertidal marine environmental values in the study area.

5. References

Campbell SJ, McKenzie LJ (2004) Flood related loss and recovery of intertidal seagrass meadows in southern Queensland, Australia. Estuar Coast Shelf Sci 60:477–490.

Ferguson, A. P., Scanes, R. J. Potts, J.D., Adams, M.P. and O'Brien, K.R. (2018). Seagrasses in the South-East Australian Region—Distribution, Metabolism, and Morphology in Response to Hydrodynamic, Substrate, and Water Quality Stressors. Chapter 14 in Seagrasses of Australia Structure, Ecology and Conservation (eds. Anthony W. D. Larkum, Gary A. Kendrick, Peter J. Ralph), p 419-444.

GHD (2021) Department of State Growth Arthur Highway - Eaglehawk Neck Safety Upgrade Project Coastal Geomorphology Assessment, July 2021, 28pp.

Mount, R. and Otera, K. (2011) The status of seagrass extent in North West Bya. A technical report for the Kingborough Council by the Blue Wren Group, School of Geography and Environmental Studies, Hobart, University of Tasmania

Natural and Cultural Heritage Division (2020) Guidelines for Natural Values Surveys - Estuarine and Marine Development Proposals. Department of Primary Industries, Parks, Water and Environment

Fletcher, W.R.J. (2014) Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based management framework. ICES Journal of Marine Science,72(3), pp. 1043-1056.

Appendix 1 Geographical coordinates (WGS 84, Zone 55) for survey locations

Site	East	North	Zone
SU-1	575299	5237130	Sandflat-upper intertidal
SU-2	575376	5236975	
SU-3	575355	5236796	
SM-1	575336	5236806	Sandflat-mid intertidal
SM-2	575346	5236909	
SM-3	575283	5237115	
SL-1	575225	5237087	Sandflat-lower intertidal
SL-2	575279	5236969	
SL-3	575202	5236726	
RS-1	575254	5236705	Intertidal reef - south
RS-2	575201	5236704	
RS-3	575141	5236720	
RN-1	575242	5237108	Intertidal reef- north
RN-2	575170	5237096	
RN-3	575113	5237076	

Appendix 2 Risk Assessment Framework

Table A1 Qualitative risk assessment matrix for threatened marine species identified from the Tasmanian Natural Values Atlas and literature review. The framework and definitions for assessment is included below.

Species	Threat/Impact	Risk Analysis			
		Likelihood	Consequence	Risk Score	Risk Level
Southern elephant seal	Haul out affected	1	1	1	Negligible
	Noise/Acoustic disturbance	1	1	1	Negligible
Humpback whale	Noise/Acoustic disturbance	1	1	1	Negligible
Spotted handfish	Changes in water quality	1	2	2	Negligible
Red handfish	Changes in water quality	1	2	2	Negligible
Australian grayling	Changes in water quality	1	2	2	Negligible

Table A2 Consequence x likelihood risk matrix (adapted from Fletcher 2014). The numbers in the cells indicate the risk score values and the colours/shades represent the levels of risk as described in Table A1. Generic descriptions of each of the consequence and likelihood levels for threatened species and communities are presented in Table A3.

			Consequence			
			Minor	Moderate	Major	Extreme
			(1)	(2)	(3)	(4)
Likelihood	Remote	(1)	1	2	3	4
	Unlikely	(2)	2	4	6	8
	Possible	(3)	3	6	9	12
	Likely	(4)	4	8	12	16

Table A3 Levels of risk and their associated likely management and reporting requirements (adapted from Fletcher 2014)

Risk Score	Risk Level	Possible Management Response
1-2	Negligible (0)	Acceptable with no management actions or regular monitoring
3-4	Low (1)	Acceptable with no direct management actions and monitoring at specified intervals
6-8	Moderate (2)	Acceptable with specific, direct management and regular monitoring
9-16	High (3)	Unacceptable unless additional management actions are undertaken

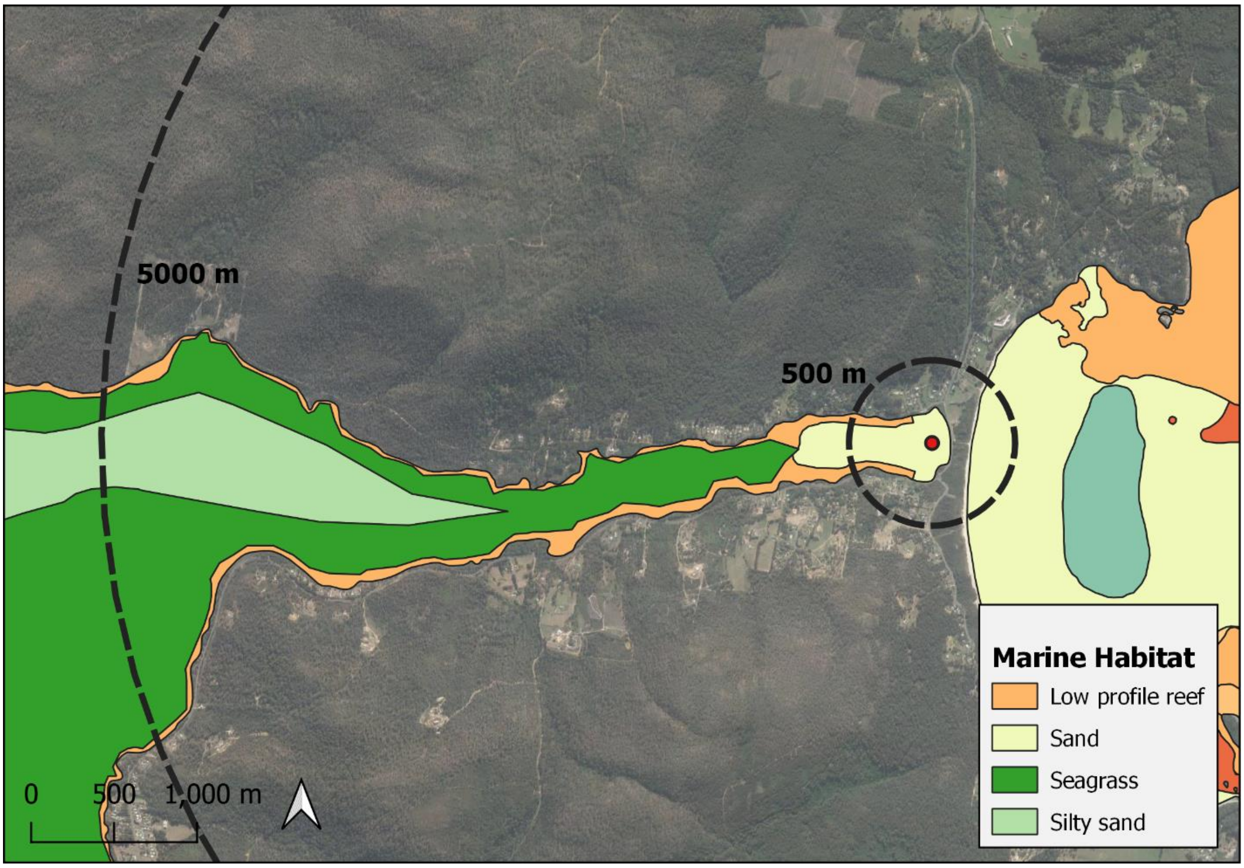
Table A4 Description of likelihood ratings using a four-level system (adapted from Fletcher et al. 2014)

Likelihood	**Description**
Remote	The consequence is not heard of in these circumstances but still plausible within the time frame (indicative probability 1-2%)
Unlikely	The consequence is not expected to occur in the time frame but some evidence that it could occur under special circumstances (indicative probability (3-9%)
Possible	Evidence to suggest this consequence may occur in some circumstances within the time frame (indicative probability 10-39%)
Likely	A particular circumstance is expected to occur in the time frame (indicative probability 40-100%)

Table A5 Description of consequence ratings for protected species and ecosystem structure (adapted from Fletcher 2014 and de Jong and Tanner 2004).

Consequence	Threatened Species	Threatened Communities
Minor	Few individuals directly impacted in most years. Possibly detectable, but minimal impact on populations.	Measurable but minor changes to ecosystem structure but no measurable change to function
Moderate	Impact at the maximum acceptable level.	Maximum acceptable level of change in ecosystem structure with no material change in function
Major	Recovery may be affected and serious and long-term impacts occurring.	Ecosystem function no altered with some function or major components now missing/ and or new species are prevalent
Extreme	Population declines generated with widespread and irreversible effects.	Extreme change to structure and function. Complete species shift in prevalence in system

Appendix 3 SEAMAP Tasmania benthic habitats within 500 m and 5000 m of Eaglehawk Bay



Appendix 4 Intertidal flora and fauna – representative taxa

Plate (A) Bivalve *Katelysia scalarina;* (ii) bivalve *Paphies elongata*; (iii) bivalve *Macamona deltoidalis;* (iv) gastropods *Bembicium* sp. and *Austrocochlea brevis*; (v) gastropod *Austrocochlea constricta*; (vi) chiton *Spharochiton pelliserpentis*.

Plate (B) Shore crab *Paragrapsus gaimardii;* (ii) soldier crab *Mictyris platychelus*; (iii) crab *Brachynotus spinosus;* (iv) porcelain crab *Petrolisthes elongatus*; (v) ascidian *Pyura stolonifera*; (vi) seagrass *Zostera muelleri*.

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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1	CY Chen	S Hosseini	On File*	S Lukies		23/07/21

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