Middleton Bay Long-term Management Strategy

A report prepared for the South Taranaki District Council

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EXECUTIVE SUMMARY

The Report Summary in Section 8 has been written so as to also serve as the Executive Summary

GLOSSARY

Accretion: the seaward displacement of the shoreline as beach sand volume increases.

AEE: Assessment of Environmental Effects – a report to accompany a resource consent application which addresses the actual and potential effects on the environment of the activity and where the any such effects are likely to be significant, a description of available alternatives is included.

Andesite: a volcanic rock of moderate viscosity that forms thick lava flows.

Anthropogenic: change resulting from human activity, ie man-made c.f. natural processes.

Astronomical tide: the sea-level variation controlled by lunar cycles (moon orbits).

Attenuation: following shoreline overtopping by storm waves during extreme water level, the landward flow diminishes as it spreads out through ground friction and interaction with other obstructions.

Backshore: that areas landward of the foreshore and typically bounded by sand dune or cliff.

Bathymetry: sea-bed form typically defined by depth measurement.

Coastal Permit is a permit issued by local government councils to carry out coastal activities which required a resource consent under the RMA 1991.

Conglomerate: Course grained sedimentary rock composed of rounded to subangular fragments surrounded by finer sediment that is often cemented.

Debris avalanche: result from crater-collapse with deposits covering large areas often covered with hummocky landforms. With increasing water content they can become lahas.

End-effect erosion: enhanced wave action and associated localised erosion at and beyond the end of a structure.

Escarpment: a steep slope separating areas of relatively flat ground.

Fluvial: processes, deposits and landforms associated with rivers and streams.

Foredune: A sand dune located immediately landward of the beach and aligned parallel to the shoreline at the time of formation.

Formation: layers of rock with comparable properties.

Geomorphology: the study of landforms – their description, how they form and how they may behave in the future.

Georeferencing: plans, photographs and other images are digitized then transformed to a common set of **co-ordinates** so images can be exactly overlaid for comparison and measurement.

Gyre: currents that horizontally move in a circular pattern.

Hazard: a natural or man-made phenomenon with the potential to cause harm to persons or property.

Intertidal beach: that area between low and high tide.

LIDAR: Stands for Light Detection and Ranging. Is a high resolution remote sensing method that uses light in the form of a pulsed laser to measure the earth surface.

Linear regression modelling: a statistical technique for identifying associations and relationships between variables by fitting a straight line (linear model) to a data set and defining the fitting errors (difference between the model and actual data points).

Littoral: A zone extending from the high tide mark to the offshore limit of wave and current-driven sediment transport. **Littoral drift** refers to sediment transported alongshore within this zone.

Lahar: a violent type of mudflow or debris flow composed of a slurry of volcanic material, rocky debris and water.

Mitigation: actions to reduce a hazard impact or effect.

Neap tide levels: the minimum upper and lower sea level driven by moon orbit.

NZTM or New Zealand Transverse Mercator: the current standard method in New Zealand of assigning every point on the earth surface a unique pair of numbers (co-ordinates) measured to the east and north of a particular base position (spatial datum).

Overtopping: where an extreme water level exceeds the shoreline (dune or structure) height and flows inland.

Photogrammetry. Deriving metric data from vertical aerial photography using 3D imaging techniques applied to overlapping photographs.

Pocket beach: small beaches that are formed between headlands, typically in coves with rocky shorelines which may be covered with a wide range of materials including sand or gravels.

Revetment: a lower angle seawall typically constructed of rock or concrete.

Repose (angle of): this is the steepest angle a material can attain without moving down-slope under gravity.

Risk: The potential for losing something of value. In risk management, risk is expressed in terms of the combination of the likelihood of occurrence of a hazardous event with the consequence of the event.

Sand dune (coastal): a mound or hill of sand that forms when air flow characteristics change – typically in association with vegetation.

Sediment budget: refers to sources and volumes of sediment at a particular location.

Shoreline indicators: features used to define the shoreline such as an elevation (e.g. the mean high water mark), the vegetation-front or top of a cliff.

Semi-diurnal tides: where two tidal cycles occur every day.

Significant wave height: the average of the upper one third of wave heights.

Slumping: the movement en masse of (hillside) material involving an element of backward rotation.

Spring tide levels: the maximum upper and lower sea level driven by moon orbit.

Standard error of estimate (SEE): the statistical error measured by a regression analysis where 1 SEE accounts for 68% of the variation about the regression line and 3*SEE accounts for 99%.

Stereo analysis: overlapping vertical images viewed so-as to produce a three-dimensional image.

Still Water Level (SWL), also referred to as Storm Tide (ST): see Section 5.3

Storm surge (SS): refer to Section 5.3

Storm tide (ST) also referred to as Still Water Level (SWL): see Section 5.3

Subtidal: seaward of, or below, the low tide mark.

Tephra: all types of rock fragments including ash ejected during a volcanic eruption.

Transect: a line marking the length and orientation of a survey.

Traverse line: a line accurately located by a surveyor from which intermediate features are measured.

Wave period: the time for successive wave crests to pass a common location.

Wave run-up: refer to Section 5.3

Wave set-up: refer to Section 5.3

Wind set-up: refer to Section 5.3

1 INTRODUCTION

1.1 Background

Middleton Bay lies immediately to the northwest of Ōpunakē Bay, these being two of the most publicly accessible and relatively sheltered parts of the South Taranaki coast (Figure 1). Middleton Bay's (the Bay) major attraction is to launch and retrieve commercial fishing craft, recreational craft, Search and Rescue craft and research/exploration craft. The Bay is also used for other recreational activities including walking, swimming, surfing, picnicking and freedom camping.

At the southeastern (SE) end of the Bay there is substantial infrastructure and amenities while the northwestern (NW) end of the Bay is in an undeveloped state with sand dunes fronting the cliff which surrounds the entire bay and extends out to form headlands on each side. The central section of the Bay is essentially a transition zone which also contains a single privately owned building. These three physical entities or sectors are located in Figure 2

Environment and management issues facing Ōpunakē Bay have recently been described in the 2016 Ōpunakē Beach Master Plan prepared by Boffa Miskell. This was followed with a cliff stability assessment by Opus in 2017, and most recently a report covering the geomorphology, erosion and inundation hazards, and potential management options by Coastal Systems (CSL) in 2019.

It has been over 20 years since the state and management of Middleton Bay received attention by Gibb (1998), the recommendations which were subsequently supported by NIWA (2005). Given the increase in technical information now available, coupled with evolving management and statutory considerations as well as official climate change directives, Coastal Systems were instructed to prepare a long-term management strategy for Middleton Bay.

1.2 Statutory considerations

Several structures within the Bay have coastal permits: the rock revetment and boat ramp (5504); stormwater discharge at the northern end of the bay (6222) and waste water discharge into the Bay off the southeastern headland (0236). These permits require periodic review which include Assessment of Environmental Effects (AEE) reports.

Middleton Bay is also subject to several potential natural hazards including landslip, shoreline erosion and landward inundation which the Resource Management Act (via the New Zealand Coastal Policy Statement 2010 in particular), requires technical assessment of hazard susceptibility, the risk posed by any such identified hazards, and the means to manage/reduce the hazard risk to suit the needs of the community. Hazards and other management issues are also addressed in the Taranaki Regional Council's (TRC) Regional

Policy Statement, Regional Coastal Plan and Regional Freshwater Plan as well as in the STDC's District Plan.

Figure 1 Middleton Bay location map

1.3 Study scope

The STDC has engaged CSL to undertake a study with the goal of addressing the future (long-term) sustainable management of Middleton Bay including the potential impacts of climate change. The following objectives were defined:

1. Collect available relevant information (provide copies to council archive);
2. Carry out the necessary field inspection;
   This were done on 18-7-2019 and 16-3-2020
3. Describe the coastal environment;
4. Overview cliff (landslip) erosion, beach-dune erosion and inundation hazards;
5. Identify management options;
6. Recommend a future long-term monitoring programme, and
7. Consult with long-term local residents Mr Brian Vincent and Mr Gerald Bourke. *These interviews occurred on 16-3-2020 and some of their photographs have been reproduced in this report. In addition, staff at the Dreamtime Surfshop were consulted on 15-4-2020. Several follow-up phone conversations with these parties were also held. Their most useful contributions are hereby acknowledged with thanks.*

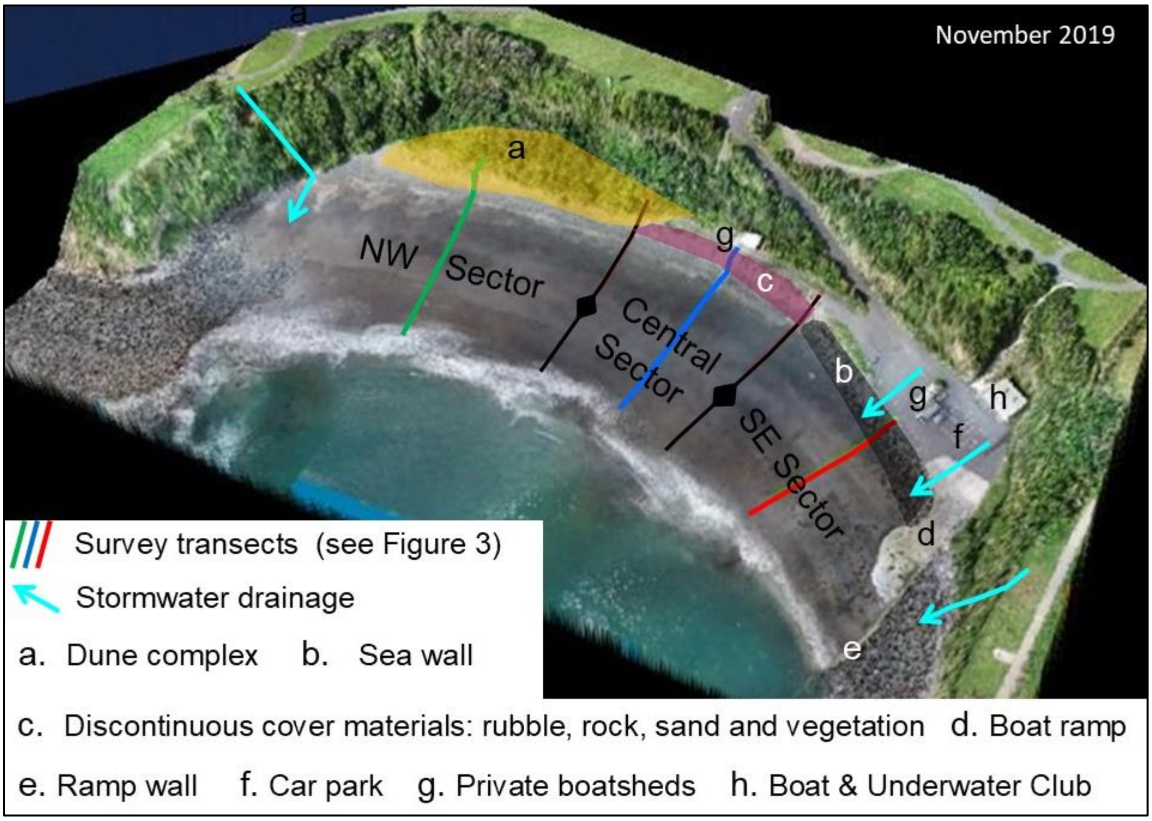

Figure 2 Three-dimensional depiction of Middleton Bay created from drone survey information. Key features referred to in the text are marked.

1.4 Report layout

The report begins (Section 2) by describing the various information sources acquired to compile this report. Section 3 describes the contemporary coastal environment in terms of the present landscape and assets. Section 4 investigates how the environment has changed (evolved or developed) over time. Future behaviour is considered in Section 5 which provides an overview of present and future coastal hazards (beach-foredune erosion, cliff erosion, and inundation by extreme sea levels and storm waves). Section 5 also describes current methods used when carrying out a full hazard assessment - this is to assist the reader in better appreciating the makeup of these hazards. Section 6 describes future management options based on the information presented in earlier sections. Section 7 sets out a long-term monitoring programme, and Section 8 summarises the report such that this also serves as an Executive Summary.

2 AVAILABLE INFORMATION

General coverage of the Ōpunakē coast is given in the topographic map series (Topo50) sheet BJ28 (1:50,000), geological map N118 P20 (1:50,000) and bathymetric chart NZ45 (1:200,000).

Local tides are described in LINZ (2019), and Ōpunakē wave conditions have been recently documented in MetOceans (2019). Currents within the Bay were measured by Resource and Environment (2000) as part of an AEE for waste water discharge permit 0230.

Regional sediment processes have been described by Gregory (1982) with a cursory description of local sediment by Gibb (1998).

Regional geology is described by Townsend (2008), with further detail of the Bay area provided by Neall (1979), Palmer and Neall (1991) and Neall (2003).

The first historical documentation we found relating to Middleton Bay is de Jardine (1992) – in particular, that boulders along the base of Middleton Bays's southeastern cliff were winched up the cliff-face in the mid 1920s for use in constructing the Ōpunakē Breakwater.

The geomorphological setting of Middleton Bay was briefly described by Gibb (1998) along with an erosion assessment and management proposals. NIWA (2005) reconsidered erosion management when the council were looking to extend the seawall. Gibb's report included several photographs taken in October 1998 and these are reproduced in Appendix A as they provide a useful record as to the state of the coastal environment prior to the March 1999 storm event; this event had significant shoreline impacts and management consequences.

Tonkin and Taylor included a brief environmental description of Middleton as part of their 2001 report on a compliance monitoring programme for Taranaki coastal structures, and the Taranaki Regional Council (TRC) produces an annual compliance report on all STDC consented structures .

AEE reports have recently been prepared for reconsenting the storm water discharge at the NW end of the Bay by Renaissance Consulting in 2018, and also for the seawall/boat ramp by STDC in 2019.

The first survey plan to include Middleton Bay (SO 7699) dates from 1867 and defines the cliff top. The 1882 bathymetric map by Hursthouse shows a single sounding line seaward of 5 feet below low water; it also plots an undefined line along the beach possibly relating to low water. The Henderson Plan of 1886 depicts the clifftop (apparently reproduced from the 1867 plan), and includes an unmarked line closer to the cliff which may to relate to high water. Plan SO 15476 (1927) defines the cliff edge, but this may be reproduced from earlier surveys. A 1959 contour plan above MSL (SO 9693) is based on aerial photograph series SN 1137A and shows the Bay above MWL. Plan SO 13535 by surveyors GSR consultants Ltd., defines the MHWS in February 1995 but uses the 1867 clifftop! Gibb (1998) includes a 1997 survey of the MHWM, dune toe and cliff top and base again by GSR consultants, but these cannot be georeferenced (fixed in space to enable comparison with other data) and the source data have eluded an extensive search. A survey carried out in 2010 by surveyors Bland and Howarth Ltd provided 3D data from below MSL to the clifftop and output a 0.5 m contour plan. And most recently a high resolution drone-based 3D survey was carried out by TPL on 12 November 2019.

Terrestrial photography dates from 1924 (photographer Feaver, source Puki Ariki) along with photos from the 1940s (provided by Ōpunakē residents Mr Brian Vincent and Mr Gerald Bourke) illustrating development of the boat ramp and seawall, buildings, stormwater drainage and storm-wave impacts.

The following vertical photography has been acquired:
1953, 1959, 1965, 1967, 1970, 1977, 1979, 1980, 1982,1994, 1996, 2002, 2007, 2012, 2017, 2019.

The following satellite images have been acquired:
2001-4-8, 2004-6-11, 2007-3-24, 2007-5-9, 2012-11-8, 2013-3-6, 2013-9-1, 2015-12-18, 2016-4-13, 2018-6-28, 2018-10-18, 2019-5-4

The following description of the Contemporary Environment is based primarily on the November 2019 drone-based aerial-photo survey by Taylor Patrick Ltd, a photogrammetrically generated 3D image from this survey is shown in Figure 2.

Copies of information used in the present report and provided to the STDC archive are listed in Appendix C.

3 CONTEMPORY ENVIRONMENT

3.1. Form and geology

Middleton Bay is a sandy pocket beach approximately 380 m wide (measured along the high tide line) and has a southeast-northwest orientation. The beach is composed of fine to medium grade sand overlying boulders which outcrop along both headlands. The spring inter-tidal beach is relatively uniform being about 60 m wide and has an average slope about 3 degrees or 1 : 20 based on the 2019 TPL survey profiles in Figure 3. This beach form contrasts markedly with Ōpunakē Bay which is narrower (about 180 m wide along the high tide line) and flatter (mean slope of about 1 degree or 1H : 60H). However, variation in beach slope at both beaches cannot presently be defined as no sequential profile data are available. Nonetheless, change can be expected based on research at nearby Oaonui Beach some 8 km to the northwest where eight years of profile sampling at 2 to 3 monthly intervals clearly demonstrated seasonal behavior with upper beach accretion during the summer and lowering during the winter (Gregory, 1985). In addition, inspection of available aerial and satellite images of Middleton taken at low tide indicate variation in both width and form.

The southeastern (SE) Sector is fronted by the 110 m long boulder revetment (the seawall) which has a 16 m wide boat ramp at its southernmost end with a 1 m high concrete wall (referred to locally as the "ramp wall") separating the ramp from the boulder beach which extends right out along the SE headland. The revetment is backed by a 35 m wide car park and various buildings. The upper beach along the SE Sector is truncated as is evident when comparing the profiles in Figure 3.

The Northwestern (NW) Sector has a well vegetated and presently stable foredune some 140 m long and crest some 2 to 4 m above the toe (which is approximately 4 m above MSL). The dune complex extends landward some 15 to 25 m to then base of the cliff.

Between the southeastern (developed) and northwestern (natural) sectors lies the Central Sector, a 90 m transition zone some 10 to 15 m wide from beach to cliff. This area is made up of unstable dune sand, scattered vegetation, boulders and other debris which are backed by an unpaved accessway and private building. These three sectors were spatially defined in Figure 2 and are illustrated in Figure 4.

Storm water from the surrounding residential area discharges from the cliff-top to the sea at each end of the bay with surface water from the paved accessway and car park entering the bay through the rock revetment (locations shown in Figure 2). The drainage system affects bay morphology and has undergone considerable anthropogenic change which is described in Section 4.1.

The Bay is surrounded by a 22 to 23 m (above MSL) high cliff which extends seaward to the NW headland some 100 m beyond the foredune and to the SE headland some 350 beyond the seawall. The upper cliff is composed of debris avalanche materials and layers of tephra which are evident in the exposure at the vehicle access cutting and are described by Neall (1979). However, it is the underlying geology that is of interest and relevance to the coastal geomorphology.

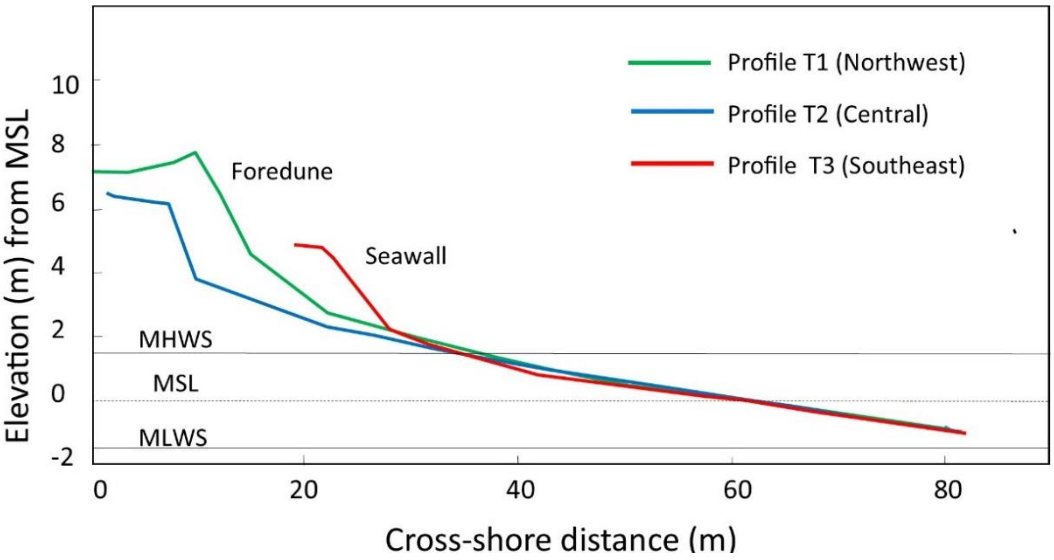

Figure 3 Profiles of the 3 transects marked in Figure 2 surveyed in November 2019. The profiles have been centred on MSL intersect and tide levels are marked.

The Ōpunakē Formation (30,000 to 38,000 years old) contains the controlling geology at Middleton. It outcrops in the mid to lower cliffs and comprises layers of volcanic sandstone, conglomerate and andesite boulders from numerous lahas which occurred during a constructional phase of the volcano's history. As the cliffs erode these boulders drop out and form the protective apron along and around the headlands which later (as cliff erosion proceeds) become the offshore reefs which extend seaward for several hundred metres off the headlands (Figure 5). The reef and bay topography result from spatial variation in boulder concentration with less boulders providing less shoreline protection and faster cliff retreat and visa versa. This variation also explains the shorter northwestern headland and a longer southeastern headland as the northwestern promontory contains considerably less boulders than the southeastern promontory (Figure 6).

The short northwestern headland also exposes the Bay's shoreline to greater wave energy and this results in the steeper, narrower beach compared with nearby Ōpunakē Bay where longer headlands and breakwater greatly reducing the level of wave energy reaching the shoreline.

Clear water satellite imagery (Figure 5, upper photo) shows the subtidal bay comprises rock on the northwestern side, and sand in the center and southeast which extends seaward. The rock intertidal apron along the southeast headland continues into the Bay for a further 50 m below low tide. These regions have been marked in Figure 5.

Figure 4 The three physically contrasting sectors; developed SE Sector in upper photo (inset is the ramp wall on the south side of the boat ramp); the transitional (Central) sector in middle photo, and the natural (NW) sector in lower photo. All photos were taken on 16 March, 2020.

Gibb (1998) records resident observations that during southeast gales and short period storm waves sand erosion exposes underlying boulders. During subsequent west to southwest swell this sand forms a subtidal sandbar attached to the southeast headland.

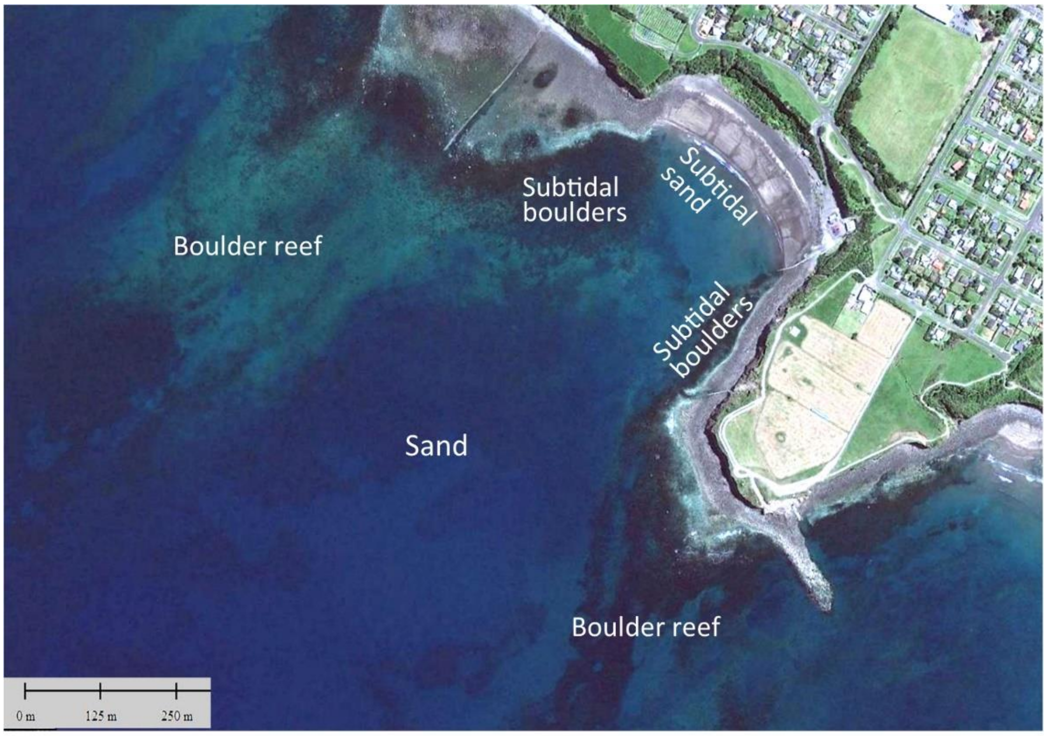

Figure 5 Offshore reef configuration illustrated by submarine patterns on the seabed in the upper photo (8-11-2012) and corresponding wave breaking in the lower photo (13-4-2016). Subtidal sediment distribution within the Bay has also been marked in the upper photo, while currents are depicted in the lower photo.

Figure 6 Middleton Bay headlands. The northwestern headland in the upper photos is considerably shorter and contains less boulders than the southern headland. Photos taken on 16-3-2020.

3.2 Waves and sediment transport

Tides at Ōpunakē are semi-diurnal with the second having a slightly higher elevation. The mean spring range is 3 m and the mean neap range is 1.7 m.

The following wave statistics are from MetOceans (2019). At 40 m depth (approximately 4 km offshore), the mean significant wave height is 2.12 m (0.41 to 8.31 m) and the mean period is 12.8 seconds (5 to 21 seconds). The annual mean significant wave height is 5.9 m. As these waves propagate shoreward they lose energy from friction and deformation associated with sea-bed irregularities and the mean annual wave height reduces to 3.8 m just beyond the headlands. Wave climate statistics demonstrate seasonality with the summer mean significant height of 1.85 m increasing to 2.29 m in the winter.

Waves predominantly approach Ōpunakē from the west south west. Waves approaching from the SE quarter are locally generated, of lesser height and typically superimposed upon the longer period swell from the southern ocean.

As noted earlier, the sand in Middleton Bay is of fine to moderate – this being somewhat coarser than in Ōpunakē Bay and reflects the increase in wave exposue. Sand is transported to the Ōpunakē coast from the northwest under west to east-directed longshore current . According to Gregory (1982), the main origin of sand along the Cape Egmont to Ōpunakē coast is from fluvial input followed by cliff erosion, with approximately 30,000 to 60,000 m^3 being added to the littoral stream annually.

Only limited current measurements are available for Middleton Bay, these being surface drogue measurements carried out on 10 December, 1999 as part of a coastal permit application for the STDC waste water discharge (Resource and Environment, 2000). The field work was carried out under moderate wind (up to 15 kts) and wave (about 2 m) conditions, and 4 hours before and 2.5 hours after a spring high tide. While the study concluded the current was generally low (<0.1 m/s) and no coherent circulation pattern was evident, their data are in fact consistent with a general clockwise gyre similar to that documented for Ōpunakē Bay (CSL, 2019, p 16). In particular, current travels into the Bay from the northwest reef, flows northwest to southeast closer to the beach then exits around the southeastern headland (as marked in Figure 5, lower photo). This pattern was confirmed by staff at the Dreamtime Surfshop based on surfing experience. The staff also noted that current strength increases with wave size and this is again consistent with documentation for Opunake; in particular, “Current strength showed an association with wave height but little with tide or wind” (ASR, 2001, 2004).

Boulder pile-up between the southeastern cliff and ramp wall protecting the boat ramp (Figure 4 inset) indicates a local current flows landward along the southeastern headland – likely driven by breaking storm waves. Gibb (1998) noted that such interception was reducing sediment availability for the landward beach area perhaps making it more erosion-prone. However, the primary source of beach sand is undoubtedly of littoral origin and is transported onto the intertidal beach by the dominant clockwise wave-driven current marked in Figure 5 under fairweather conditions. Most of this sand will later be swept seaward to rejoin the southward directed littoral stream under storm conditions.

4 ENVIRONMENTAL CHANGE

4.1 Anthropogenic change

Over the past 100 years the southeastern half of Middleton Bay has been subjected to increasing human activity and associated effects on the coastal environment. The earliest evidence of human activity thus far located is the 1924 Feaver photograph (Figure 7 upper) which shows three buildings at the far (SE end). Gibb (1998) notes that these historical building were "…for clinker built surfboats used for recreational fishing. The sheds were constructed close to the seaward face of the foredune. Fishermen would haul the heavy boats down the foredune face and launch them through the surf. On return the boats were winched up the foredune and into the sheds". A 1940s photo (see Figure 7, lower) shows additional boatsheds fronted by young sand dunes.

Unfortunately the earliest (1953) aerial photograph has shadow obscuring the accessway and boat sheds. The 1959 aerial photo shows 13 sheds/buildings and the present vehicle accessway in place. Subsequent aerial photos show the number of sheds increasing to 24 by 1967 and 20 in 1982. Gibb (1998) reported 8 sheds in late 1998, several of which required dismantling after the destructive storm in March 1999 (Figure 8, upper). By this time a new commercial fishing building had been constructed along with the present Boat and Underwater Club rooms. Today only a single (privately owned) example of the early boat sheds remain (Figure 8, lower photo).

Quarrying of the cliff above the Boat and Underwater Club room occurred during the 1950s when the council hoped to obtain gravel for local projects. This location appears to correspond to a natural drainage channel, see * in Figure 7. The overburden was stripped and volcanic stone excavated then trucked up the new access road. However, the material proved to be unsuitable and the project appears to have been abandoned by the early 1960s. The exposed material was used thereafter to build out the fronting shoreline – with the reclamation becoming the present car park.

In July 1999, the present seawall (boulder revetment) was constructed along the length of southeastern sector (Fig 9 lower). This structure replaced a previous structure that had developed piecemeal over time and was fronted was boulders, rubble and waste concrete capping as illustrated in the background of Figure 9 (center photo) and in Gibb's 1998 photos in Appendix A. The new structure was consented (coastal permit 5504).

Gibb (1998, p12) noted that when a replacement seawall structure was established it should have a curved alignment which he diagrammatically depicted. But this advice was not followed and the new structure had a straight alignment. Consequently, the seawall face is misaligned to the wave crests during high-tide, storm-wave conditions and this increases wave reflection toward the northwest. This process has potential to exacerbate shoreline erosion in the Central Sector, in addition to potential erosion caused by waves interacting with the end of the seawall (end-effect erosion).

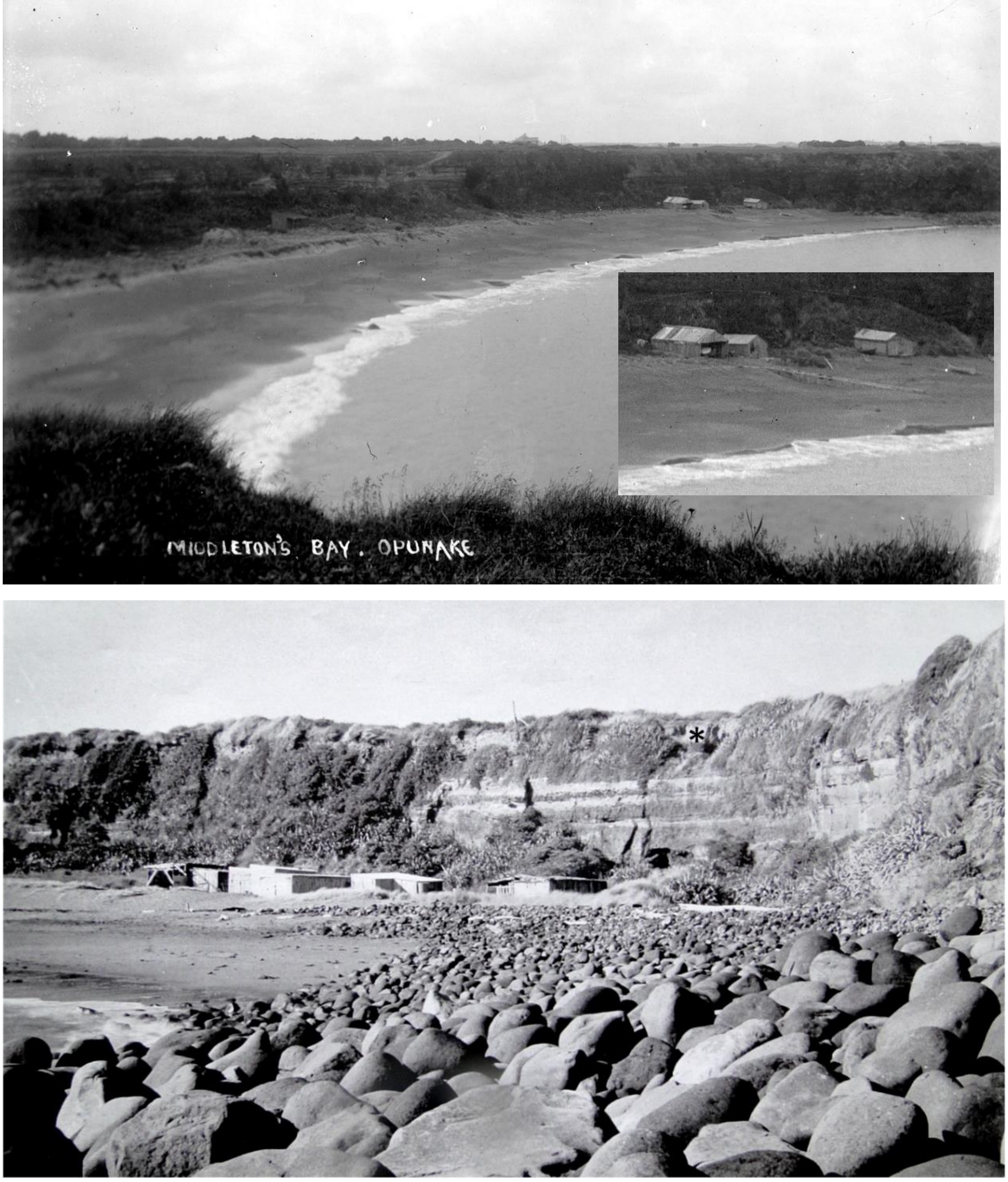

Figure 7 The earliest photo (upper) of Middleton Bay taken in February 1924, shows a scarped foredune in the foreground (NW sector), a single dwelling? behind the foredune in the foreground, and 3 boatsheds at the far (SE) end. The lower photo is estimated to have been taken in the early 1940s and shows additional boat sheds and sand dunes developing to seaward. The asterisk marks stormwater channelling incised into the clifftop. Photo supplied by Mr Gerald Bourke.

Following reconstruction of the revetment, residents became concerned with an increase in erosion within the Central Sector and this led to the council engaging Gibb to produce a further report in 2002. However, he concluded that any increase in erosion was caused by variation in sediment supply, climate factors and local drainage rather than the structure. Then in 2005 NIWA was commissioned to investigate whether further extension of the 1999 seawall was justified to protect against the ongoing erosion. While noting that end-effect erosion was likely to occur immediately northwest of the structure terminus, any such adjustment should have been complete by 2005 so ongoing erosion would be associated with the factors outlined by Gibb. The NIWA authors rejected the need for any seawall extension.

Figure 8 The top photo shows 3 boat sheds undermined by the March 1999 storm (source: Taranaki Daily Mail, 19 April 1999). Note rubble littering the beach – this was originally placed against the bank to provide wave protection. Lower photo shows the last remaining boat shed at 16 March, 2020.

The boat ramp at the southeastern end of the Bay (Figure 4, upper) was largely constructed during the 1970s and 80s by local Boat and Underwater club members supported by the wider community and business (Figure 9, upper). The ramp wall was constructed during the 1980s to assist launching craft(Figure 9, centre). The car park was sealed in the early 2000s.

Figure 9 Upper photo: pouring concrete for the boat ramp, May, 1977 (Mr Brian Vincent photo). Central photo: constructing the (present) ramp wall using concrete blocks, c. 1986 (Mr Brian Vincent photo). Lower photo: constructing the current rock revetment in July 1999 (Mr Gerald Bourke photo).

Much of the township's stormwater runoff flows through open roadside drains to coastal outlets. At Middleton Bay the present entry points are marked in Figure 2 while more previous entry points are marked in Figure 10. However, variation in the clifftop outline indicate numerous locations of past stormwater incision and entry into the bay.

At the NW end of the Bay, the aerial photo record shows stormwater entered the sea via a gully and waterfall (Appendix A, Figure 9) then via a channel between the cliff and sand dune (Figure 11). However, this channel affected local dune stability (discussed in Section 4.2) so in 2003/4 a new clifftop discharge structure (750 mm concrete pipe with overhanging "drip lip") was constructed some 30 m from the end of the headland (under TRC coastal permit 6222). Unfortunately this was also problematic with stormwater blowing inland under strong SE winds (Figure 13, central photo) and also exacerbating cliff-face erosion in the vicinity of the structure. The present outlet was then established further landward by drilling a pipe through the cliff to exit about the high tide mark under the same coastal permit (6222). This outlet has operated successfully and its permit was renewed in 2018.

Historically, a central discharge point entered the Bay at the Heaphy Road/accessway intersection (Figures 10 and 11). The 1998 Gibb report noted this discharge was resulting in local foredune erosion (Appendix A, Figure 8), and the council subsequently installed a 450 mm diameter concrete pipe to divert this drainage around the clifftop to the SE discharge point. Now only minor stormwater discharges occur within the central bay; these being from buildings, paving and cliff seepage within the Central and Southern sectors.

The present SE drainage was established in the mid 1970s by extending the previous (1960s) clifftop discharge point (Figure 10) some 50 m toward the southern headland via an open drain. It appears this relocation was to stop stormwater and sediment entering the then developing car park/boat launch area. This discharge consists of the 450 mm diversion pipe from the Heaphy Road area, a 900 mm pipe (road culvert diameter) from the Longfellow Road area, plus stormwater from the Hector place area. At the clifftop discharge location, a gully has developing over the past 45 years (Figure 13, lower photo) with the head eroding landward into the cliff-top at some 0.2 m per year on average (measurements taken between 2007 and 2019). This gully is considered further in Section 6.2.

It appears diversion water rights were not issued by the Taranaki Catchment Commission for the 1970s extension of the drain. Nor were permits issued when the Heaphy Road discharge was diverted as this exceeded the permitted thresholds (equivalent pipe diameters) as now required by the Freshwater Plan's discharge rule 23. The gully erosion also appears to contravene this Freshwater Plan discharge rule. In addition, this area lies within the Coastal Protection Area of the District Plan so an alternative means of delivering stormwater into the sea would seem appropriate.

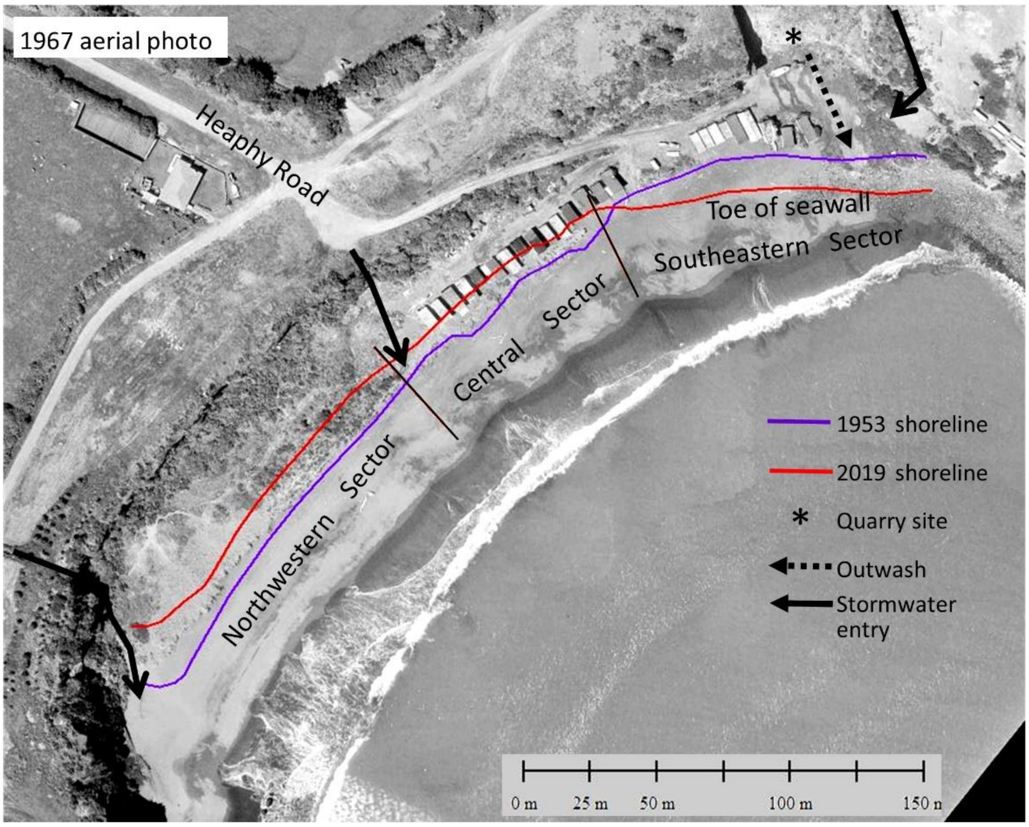

Figure 10 1953 and 2019 shorelines overlaid on the 1967 aerial photo. The 3 sectors are marked along with the quarry site (*) which appears to correspond with the early natural cliff drainage channels marked by the * in Figure 7. Quarry outwash (arrowed) contributed to local buildout (accretion) of the shoreline.

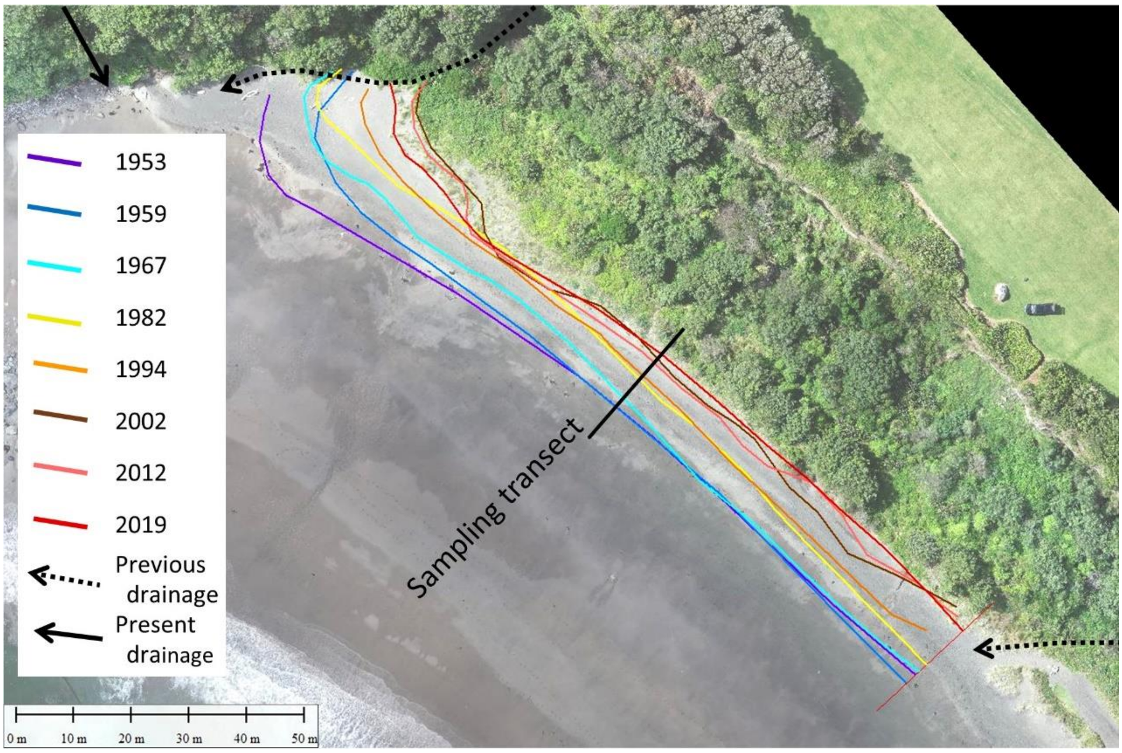

Figure 11 Shorelines in the (natural) Northwestern Sector from 1953 to 2019. Location data from the marked "sampling transect" are graphed in Figure 12A.

4.2 Shoreline change

4.2.1 Beach-dune shoreline

While shorelines were marked on early survey plans, their nature and accuracy were too uncertain to be used for a comparative analysis. Consequently, we must rely on historical vertical aerial photographs and later satellite imagery to provide reliable data. These were georeferenced and the vegetation-front of the foredune in the NW sector, the base of the escarpment in the Central Sector, and the toe of the seawall in the SE Sector were all digitized.

Figure 10 shows these shorelines for 1953 and 2019 superimposed upon the 1967 aerial photo. These bracketing shorelines show the following overall behaviour during the 66 year time span:

- The (natural) NW sector's shoreline had eroded on average 14 m (0.21 m/yr). It is noted that this shoreline may have been unstable well before 1953 with the early 1924 photo (Figure 7) showing a scarped foredune indicative of erosion.

- The central sector, which has been subject to isolated protection works during that 66 year time period, had eroded on average some 9 m (0.14 m/yr), and

- The SE sector shoreline (which had undergone reclamation and had a continuous seawall since 1999, has moved seaward on average some 12 m. Note that surface features in Figure 10 indicate fine sediment washing out of the quarry site and down (arrowed) past the buildings to help buildout the shoreline.

Further analysis was then undertaken for the NW Sector using 6 intermediate samples (1959, 1967, 1982, 1994, 2002, 2012) and this expanded set of shorelines is displayed in Figure 11. These shorelines show a steady landward migration which is enhanced at the NW end. However, here the shoreline moves somewhat seaward after 2002 which likely resulted from relocating the stormwater outlet further seaward from 2004.

In addition, data was abstracted for a transect midway along the NW-Sector (marked in Figure 11), which is beyond the influence of the early stormwater outlet. In total the following 12 intermediate samples were used: 1959, 1967, 1970, 1977, 1982, 1994, 2002, 2007, 2012, 2013, 2015 and 2017. The advantage of using a high number of samples is that it also provides a more complete picture of shorter-term change. The resulting shoreline behaviour is displayed graphically in Figure 12 upper, to which a linear regression model has been fitted. The straight line represents the overall trend which is erosional at a rate of 0.18 m/yr, this being slightly less, but more accurate, than the rate derived from the end points (1953 and 2019). The fluctuations about the regression line defining the shorter-term shoreline behaviour has a maximum deviation of 2.1 m in 2002.

Shorter and longer-term beach changes are a response to different drivers. In the shorter-term, beaches respond to periods of storminess and calm by sediment moving seaward and landward respectively and the profile shape and level adjusting up and down respectively. Shorelines thus tend to fluctuate in cross-shore location. In the longer term, the shoreline may be systematically eroding or accreting if there is a change in sediment availability, wave climate or sea level, with reduced sediment, higher waves or higher sea-level resulting in erosion and vias versa.

Gibb (1998) analysed a shorter 38 year data set (1959, 1967, 1980 and 1997 samples) provided by GSR Consultants (Hawera). That study reported an overall advance of 5 to 18 m (0.13 to 0.47 m/yr). These results are inconsistent with the results from the more comprehensive present study which showed a clear erosional trend for the NW and likely erosional trend in Central Sector. Unfortunately any explanation of the difference is not possible as Gibb's report provided no supporting information on the spatial distribution and the raw data provided to the council (Gibb, 2002) has been lost.

Gibb also noted that the beach sand comprised both light and dark minerals which he interpreted as indicating the beach was not eroding. However, light and heavy content in beach sand depends also on previous storm/fairweather conditions coupled with the tidal state (neap or spring).

The comparative shoreline behaviour from Ōpunakē Bay is shown in Figure 12B as adapted from the CSL (2019) study. Note that a different shoreline indicator was used for Ōpunakē Bay (spring high water mark) as dunes were often absent. Use of a beach indicator always results in greater variation in the shoreline position compared with a dune indicator due to the flatter slope and as sediment is continually moved by marine processes. Nonetheless, these results show some interesting qualitative comparisons. In particular, opposite long-term trends: erosion at Middleton compared with accretion at Ōpunakē Bay. The most obvious explanations being wave sheltering by the Ōpunakē breakwater and longer headlands which facilitates shoreline accretion. In addition, the shoreline fluctuations about the regression(trend) lines are temporally similar – this being consistent with both locations experiencing the same general sediment and wave patterns.

4.2.2 Cliffed shoreline

Gibb (1998) estimated the cliffs at each end of the Bay had retreated 1 to 10 m between 1959 and 1997 giving an annual rate of 0.03 to 0.26 m/year. Gibb also noted that individual landslips have resulted in instantaneous cliff retreat in the order of 1 to 3 m. As with the beach-dune shoreline results, there was no spatial distribution provided in the Gibb report. However, given that the SE clifftop stormwater discharge site has been eroding at 0.2 m per year, Gibb's higher values may be associated with drainage courses cut into soft upper cliff material.

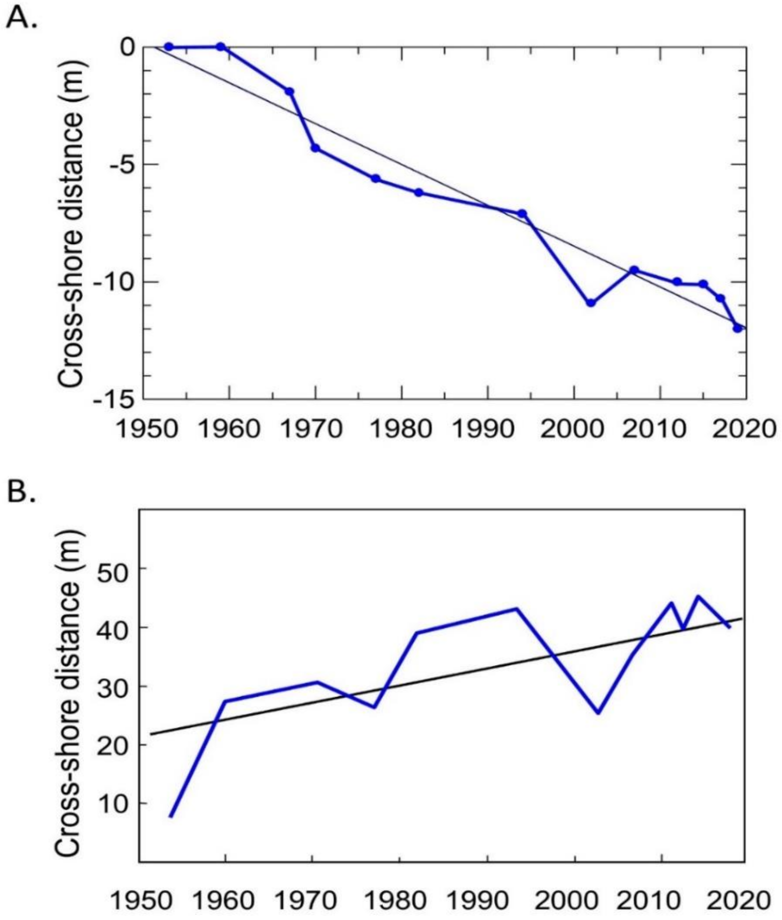

Figure 12 Shoreline time-series graph for Middleton (A) at the Northern Sector transect (Figure 11). For comparison, the Ōpunakē Bay shoreline is shown in (B) for the northwestern half of the beach (adapted from CSL, 2019, Figure 9). Linear regression models have been fitted and define (contrasting) longer-term trends and qualitatively similar shorter-term shoreline fluctuations.

Acquiring longer-term high quality/accurate cliff-lines was beyond the scope of the present study. However, the 1867 survey plan (SO 7699) shows the NW headland defined by the early surveyors using cliff-top traverse lines – indicating high accuracy. The high definition 2019 TPL aerial survey enabled the current cliff top in this area to be accurately defined. The 1867 and 2019 clifftops are overlain in Figure 13, upper image.

The seaward face has eroded 0.6 to 2.8 m over the 152 year period with a mean value of 1.5 m or 0.02 m/yr. By comparison the cliff top facing the Bay has undergone 10.5 yr 13.6 m with a mean of 11.0 m or 0.08 m/yr. These values are at lower end of Gibbs range. This result indicates that the seaward face of the cliff is considerably less erosion-prone than the adjacent side facing into the Bay. Such a result is helpful and welcome as it indicates the headland length is changing very slowly so there will be minimal additional wave energy entering the Bay in the foreseeable future to drive beach-dune erosion. The contrasting seaward and bay-facing rates may result from geological (boulder concentration) variation observed during the site visit, variation in wave energy around the headland, and for a brief period in the 2000s, stormwater drainage down the cliff face (Figure 13).

Figure 13 Upper figure compares the NW headland’s cliff-top location in 1867 and 2019, and also locates the 2004 stormwater discharge which is shown operating in the central photo taken in February 2004. The lower photo shows the present SE stormwater discharge operating. Middle and lower photographs supplied by Mr Brian Vincent.

4.3 Future change

Future geomorphology depends on the energy drivers and sediment supply controls. In addition, anthropogenic activities have modified the southeastern half of the Bay and can be expected to affect future coastal processes. The following section on erosion and inundation hazards will consider such future change.

]

5. COASTAL HAZARDS

This section provides an overview of beach-dune erosion, cliff erosion and storm inundation hazards at Middleton Bay in terms of available information. While carrying out full hazard assessments was beyond the terms of reference; best practice current methodologies are described to help the reader understand the composition of these hazards

5.1 Beach-dune erosion

Erosion hazard assessment for sandy shorelines was described in CSL (2019) for Ōpunakē Bay and involves combining the following 4 components which are illustrated in Figure 14:

ST = Short-term cross-shore fluctuation in shoreline position resulting from storminess and sediment pulses;
DS = Dune stability adjustment. Following storm-wave erosion (cut) the dune has a near-vertical face that subsequently adjusts by slumping and sliding to achieve the stable slope angle – the so called “angle of repose”;
LT = Long-term retreat of the shoreline: this occurs on coasts where there is a long-term sediment deficit relative to the available energy, and
RSLR = Shoreline retreat due to the effects of projected sea level rise (SLR). A rise in sea-level enables storm waves to erode higher up the profile and this sediment is then deposited to seaward.

LT and RSLR are computed by multiplying the time period of interest (in years) by the annual rate of change. The prediction period is required to cover change over at least 100 years (NZCPS, 2010), so typically the current situation is assessed together with 50 years and 100 years. Where major assets are involve a 150 year prediction period is also assessed

These components are combined to define the current hazard distance ($EHD_{current}$) in equation 1, and future erosion hazard distance (EHD_{future}) in equation 2.

$$EHD_{current} = ST + DS \quad (1)$$

$$EHD_{future} = ST + DS + LT + RSLR \quad (2)$$

NW Sector

While derivation of all component values is beyond the scope of the present report, the shoreline analysis carried out for the natural NW Sector in Section 3.2.2 provide a 100 year value for LT of 18 m. The ST value is derived by calculating 3 times the “standard error of estimate or SEE (see Glossary)” about the regression line, which comes to 3 m in this case.

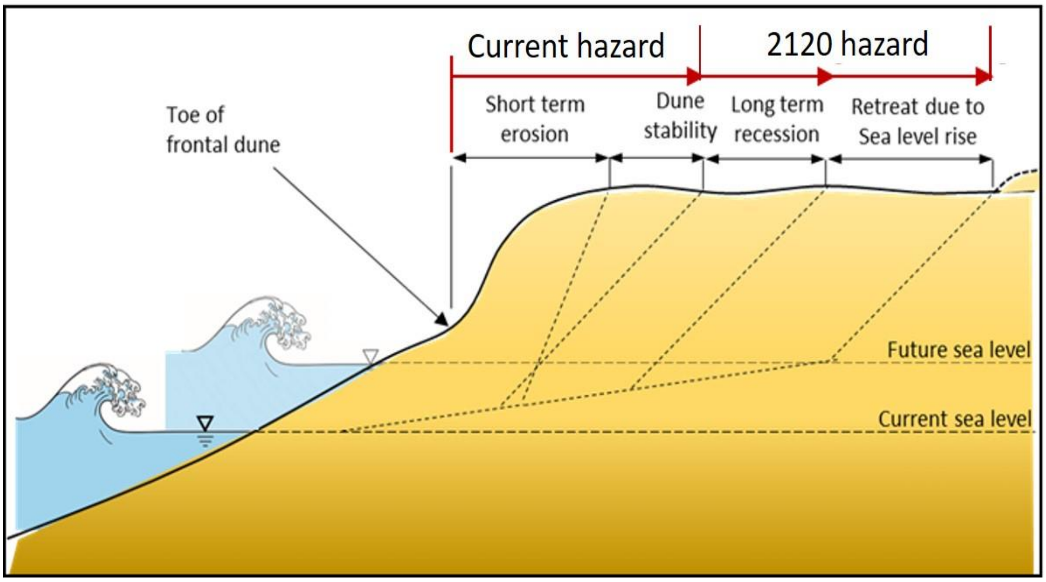

Figure 14 Definition sketch of beach-dune-line erosion hazard assessment components for current and future scenarios.

These results give a 100 year retreat distance of 22 m for the NW sector. Details on exactly how the system would retreat through time requires the full erosion hazard assessment which would also include the other hazard components (DS and RSLR). However, given that the dune complex ranges between 15 and 25 m wide, they will have likely disappeared well within 100 years.

SE Sector While anthropogenic modification has fixed the shoreline and prevented the derivation of a LT value as was carried out in the NW Sector, it is seems likely that the erosion measured in the NW and Central Sectors also underlies the SE sector. The erosion response at a seawall where the coast would be otherwise be eroding is a lowering of the seabed. This occurs as a consequence of the natural profile translating landward as illustrated in Figure 15.

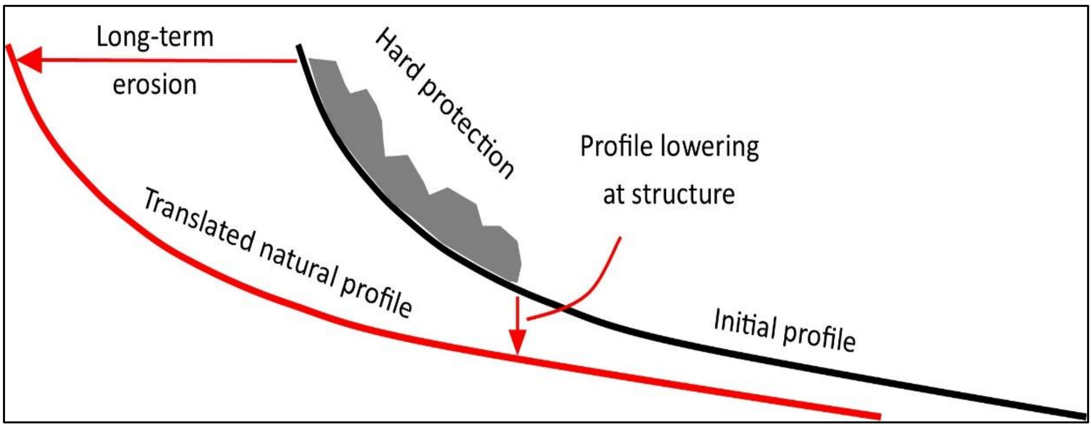

Figure 15 Landward profile translation in response to long-term shoreline erosion (red line) results in seabed lowering where the shoreline is fixed by a hard structure.

Central sector
While the bracketing erosion (1953 to 2019) in the Central Sector was less that for the NW Sector (Figure 10), it seems reasonable to assume it is at least as high as in the NW sector given that (i) this shoreline has been held somewhat seaward by the ongoing placement of rubble, and (ii) the profiles in Figure 3, fixed at the MSL intersect, shows the upper central profile landward of the upper NW profile.

Retreat during the March 1999 storm was reported as up to 10 m in the Daily Mail (19 April, 1999). However, the retreat was likely much greater than that of a natural shoreline response as the embankment contained large pieces of rubble (Figure 8, upper photo) which increase wave turbulence and enhance erosion. In addition, close proximity to a 20 m long rubble revetment to the NW and the 80 m revetment to the SE (both described by Gibb (1998) and illustrated by several of the photographs in Appendix A) would have further exacerbated shoreline erosion at the reported site, i.e. fronting the 3 damaged boat sheds.

5.2 Cliff erosion

The mechanisms of cliff erosion typically consist of two types. Firstly, episodic failure due to over-steepening of the cliff base by wave erosion with cliff debris accumulating at the toe being subsequently removed by marine processes. But if systematic erosion of the cliff base slows, or is halted through either natural processes such the formation of a protective beach (as applied to the Middleton cliffs to the rear of the beach), or anthropogenic intervention such as boulder protection (as occurs at the southeastern end at Middleton), then the second type of erosion occurs. Namely, weathering and bio-erosion processes will cause the cliff above the toe to continue to retreat and debris accumulate at the toe until a stable angle of repose is reached and vegetation is able to establish.

Cliff erosion ranges from small-scale slips to large scale and deep-seated mass movement depending on geology and wave climate.

Cliffs are not able to rebuild following periods of erosion, but rather are subject to a systematic one-way process - hence there is no ST component in the assessment model.

Current best practice for assessing the erosion hazard of cliffed shorelines has recently been described in CSL (2018) and T&T (2018), and involves computing the following three components which are diagrammatically illustrated in Figure 15:

SS = Slope stability where an over-steeped cliff (from an episode of erosion episode) adjusts to a stable angle (of repose);

LT = Long-term historical shoreline retreat typically associated with a sediment deficit in relation to local wave climate, and

RSLR = Erosion resulting from projected future sea-level rise.

These components are combined as follows to determine the current hazard distance (equation 3) and future hazard distance (equation 4).

$$EHD_{current} = SS \qquad eq\ 1$$

$$EH_{future} = SS + LT + RSLR \qquad eq\ 2$$

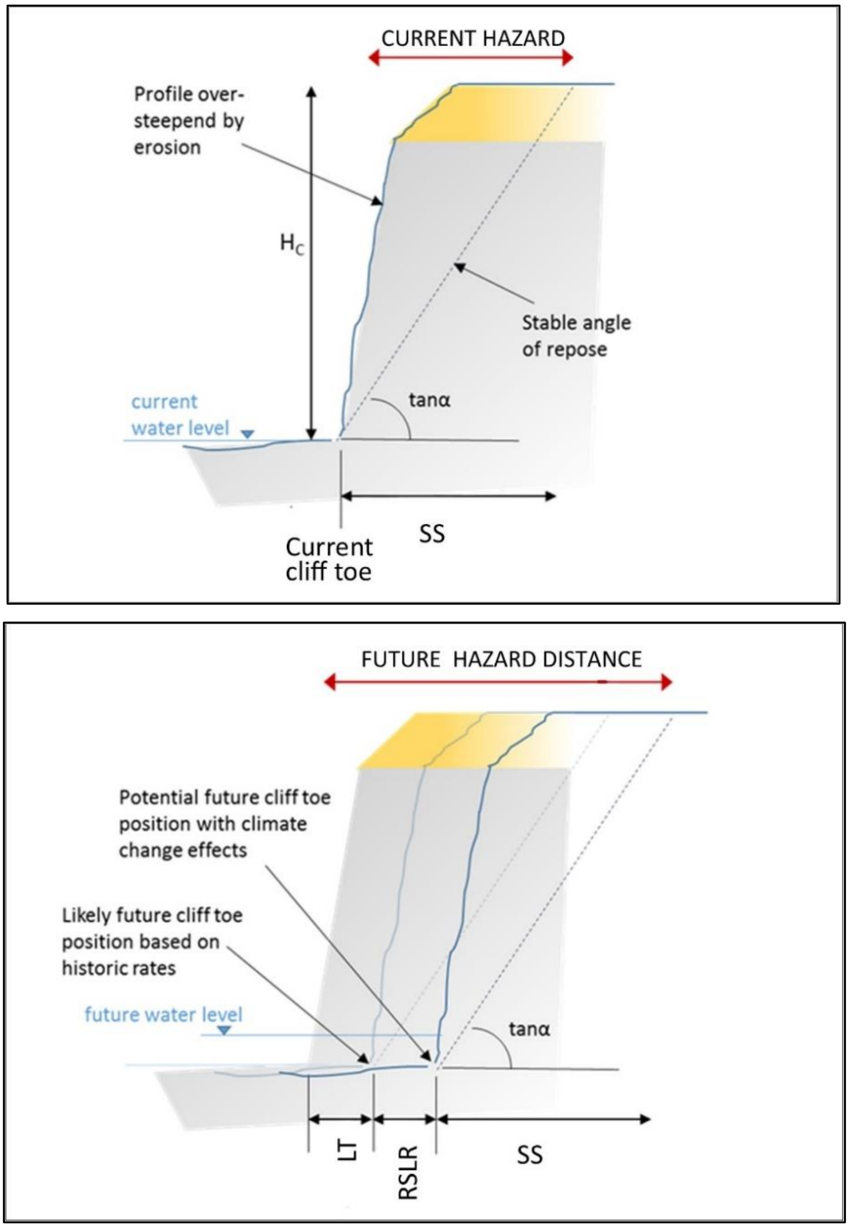

Figure 15 Definition sketch of cliff erosion hazard components for present (upper) and future (lower) scenarios

The cliffed environment can be divided into the seaward sections along each headland where wave action effects the base, and a landward section where dune and seawall protect the base from wave action (see Figure 16). Higher values would be expected along the seaward sections. It would seem reasonable to assume that Gibb's higher rate of 0.26 m/yr applies to the active seaward cliff. However, as noted earlier, this value may result from localised gully erosion and may not be more widely applicable. Further doubt comes from 0.09 m/yr maximum value derived in the present study for the Bay-facing section of wave affected cliff (13.6 m/152 yr). A more robust cliff-top erosion assessment is recommended.

As most of the cliff is now heavily vegetated obtaining SS values from the 2019 drone data could be compromised. More accurate results may be obtained from photogrammetric historical data as would be available if an accurate long-term cliff change assessment were to be undertaken, or from a LIDAR survey. A regional LIDAR survey in conjunction with the TRC is presently in the planning stage.

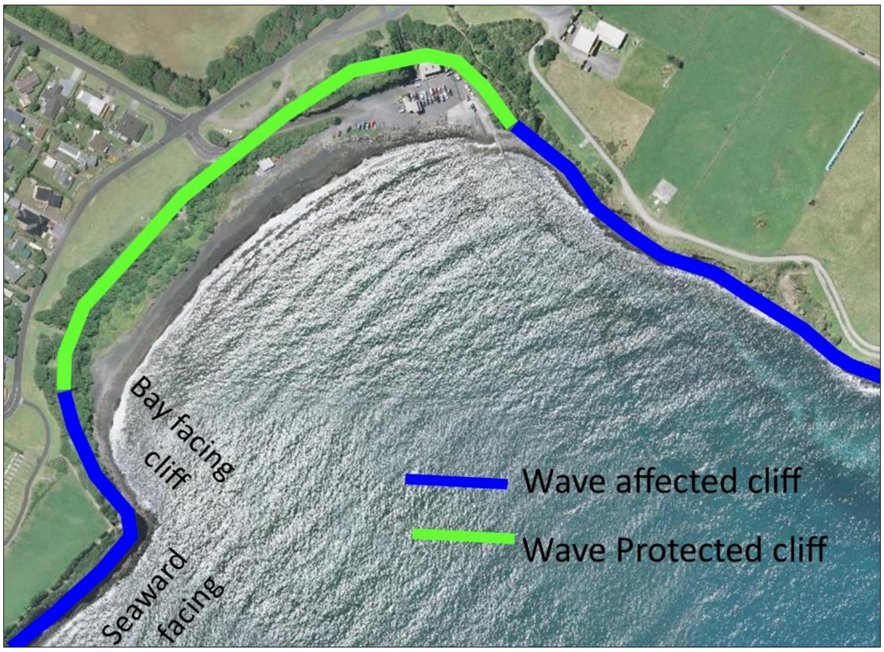

Figure 16 Sections of cliff affected by wave processes at Middleton Bay with the wave-affected cliff having higher erosional rates of change.

5.3 Storm inundation

The Taranaki coast is susceptible to storm-driven coastal inundation hazard and this is likely to increase in frequency and severity under projected climate change scenarios, in particular from sea-level rise.

As described in the CSL (2019) assessment for Ōpunakē Bay, best practice methodology for assessing coastal inundation involves deriving the following components which are diagrammatically illustrated in Figure 17:

SWL = Still Water Level, also referred to as Storm Tide, is defined by the combination of:
-Astronomical tide, PLUS
-Storm surge (SS) which is itself the combination of:

-Wind set-up against the coast PLUS
-Low barometric pressure PLUS
-Low frequency sea level fluctuations (seasonality, ENSO etc).

SU = Wave set-up where the elevation of the mean water surface is caused by wave breaking and subsequent momentum across the surf zone.

RU = Wave run-up is the shoreline elevation reached by individual waves. This component includes wave set-up.

SLR = Sea-level rise

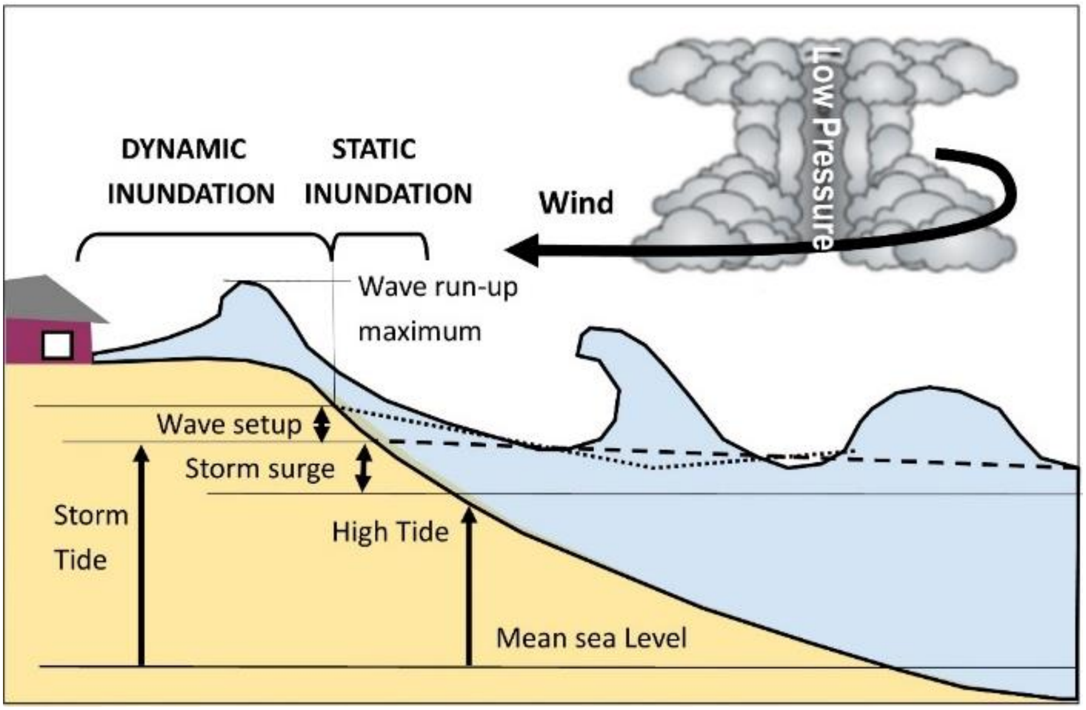

Figure 17 Schematic diagram of tide, wave and atmospheric components driving extreme sea-levels and storm-induced inundation at the coastal margin.

The following two types of extreme water levels can be determined for a range of planning timeframes**:**

The **static extreme water level** (Stat_EWL) is a constant level and has the greatest inundation impact along low-lying beaches and inlets. Stat_EWL is computed using equation 5.

$$\text{Stat\_EWL} = ST + SU + SLR \qquad (5)$$

The **dynamic extreme water level** (Dyn_EWL) results from a pulse of water driven by wave run-up which maximizes at or about the shoreline and dissipates (attenuates) as the pulse progresses inland under the influences of from ground friction, obstacles and ground slope. Dyn_EWL is computed using equation 6:

$$\text{Dyn\_EWL} = \text{ST} + \text{RU} + \text{SLR} \qquad (6)$$

Landward attenuation distance is then calculated using equation 7 from FEMA (2005).

$$d = \left[\sqrt{RU - Y_0} - \frac{5X}{A(1-2m)\sqrt{gT^2}}\right]^2 \qquad (7))$$

Where:

d = Flow depth (in meters) at certain wave run-up attenuation distance (X)
X = Wave run-up attenuation distance (m)
RU = Wave run-up level including the storm tide (m RL)
Y_0 = Dune crest elevation (m RL)
T = Wave period
G = 9.81 m/s^2
A = Friction/resistance factor
M = Positive upward inland slope

Deriving the components values and carrying out the extreme water level modelling and attenuation computations are beyond scope of the present report. However, the following local observations of inundation extent are helpful in providing a first estimate of this hazard's impact and could be useful when testing/calibrating an inundation assessment model.

Both Mr Vincent and Mr Bourke agreed that at present the seawall is overtopped and stones are thrown across the car park some 2 to 3 times per year on average. This is photographically illustrated in Figure 18, and while the landward extent is not shown, the stones reached the historical boat shed some 13 m from the seawall. Mr Bourke said severe events occurred about every 3 years and Mr Vincent said the occurrence of water reaching the Boat and Underwater Club rooms was becoming more common. The New Plymouth Daily News article of 19 April, 1999 describing the March 1999 storm quoted club member, Mr Neil Drought, as saying "water had been lapping at the door of the new headquarters (club rooms)". Given that the car park had not been sealed at that time, wave attenuation would have occurred more quickly, so this was indeed a significant event.

Figure 18 The aftermath of wave overtopping the seawall during a storm event in February 2018. Mr Brian Vincent's photo.

6 MANAGEMENT OPTIONS

The long use of Middleton by fishermen, as evident by the their boat sheds, and the incremental development of the assets such as the seawall, boat ramp, community buildings and car park by the wider community is strong testimony that this bay is highly valued. The interviewed stakeholders said there will always be a need for the present facilities in the future.

This section sets out management options (*in italics*) as relate to information presented in this report as well as noting currently relevant management proposals contained in the earlier Gibb (1998) and NIWA (2005) reports. The circled numbers next to each option correspond with the numbering on the aerial photo in Figure 19.

6.1 Beach-dune erosion

The NW Sector is subject to long-term erosion (LT) which averages 0.18 m/yr, and also short-term shoreline fluctuations (ST) of up to 3 m; these process values mean the NW Sector's dune complex has limited lifespan.

To accurately identify dune width reduction over time, a comprehensive erosion hazard assessment is required which will include the other two components: dune stability and retreat from sea-level rise (NB equation 2, p29).

To maximise the lifespan, a foredune cover of runner-type dune grass should be maintained: this will assist post-cut recovery by effectively trapping wind-blown sand. It will also reduce the time an erosion scarp may poses a burial threat to beach users. ①

Over time it is predicted that the beach fronting the SE Sector will systematically deepen threatening revetment stability, and the northwestern terminus will become outflanked. Public beach access across the boulder revetment (sea wall) will become increasingly hazardous.

The seawall will require ongoing maintenance and strengthening of the base as well as construction of a "return" at the northwestern terminus. Such works have been included in the recent reconsent (Appendix B). The recent construction of steps and handrail down NW end of the revetment will reduce risk of injury to the public accessing the beach ②

The Central Sector has a net erosional status although the rate is unclear as the shoreline has been artificially added to over time to protect the boat sheds. This, the narrowest sector, is sandwiched between the systematically eroding shoreline to the NW and the hard structure to the SE, the latter of which will become increasingly prominent and wave-reflective in the future. This sector is likely to have the shortest survival time and will require management interventions. There are 3 possible options:

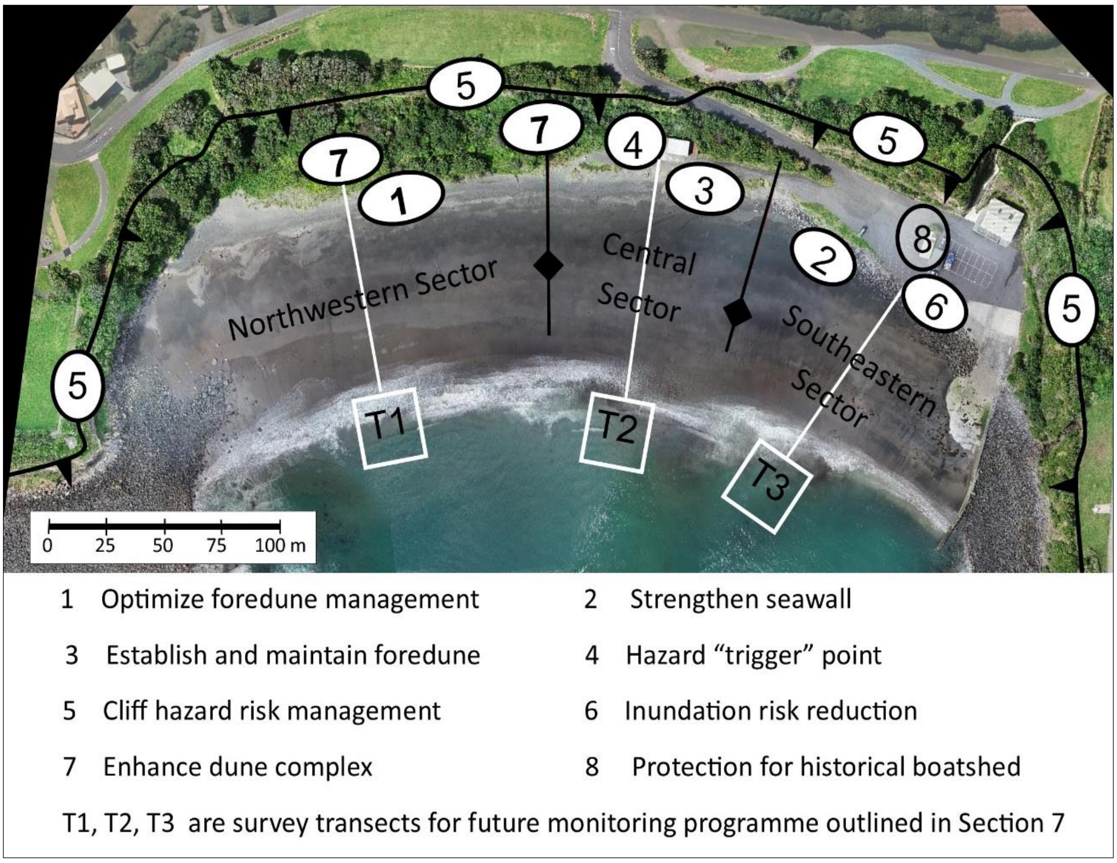

Figure 19 Location of management options and monitoring transects described in the text using corresponding numbering/referencing.

i. *Continuous hard protection will stabilize shoreline; however, it is unlikely consents would be granted given the negative impacts such structures have on the fronting and adjacent beaches.*

ii. *The next most effective stabilization solution is to remove isolated hard materials, add sand (nourish) the face, then plant with runner-type dune grasses and fence off. This has been allowed for in the 2018 seawall consent application and the 2019 AEE for that area close to the structure in recognition of periods of increased wave turbulence and localized erosion. However, applying such as approach to the entire Central Sector would prove costly as it would need to be an ongoing intervention with potential for an increase in nourishment volume and placement frequency in the future.*

iii. *The third (natural) approach accepts the shoreline is subject to systematic erosion, but slows the process as much as possible. Once again remove isolated hard materials, batter the bank to 34 degrees then plant with runner-type dune grass and fence. After episodes of erosion stabilize the face as much as possible by battering and planting. This approach ensures the dune is as healthy and visually appealing as possible. It is the recommended option.*

③

Central Sector management is presently constrained by the private building together with the associated vehicle accessway. This situation can be addressed using hazard mitigation approaches

Restrict vehicle access – this is a provision of the seawall consent application/AEE plan (Appendix B).
A "hazard trigger point" is determined based on the sum of the current hazard distance (SS + DS) measured landward from the present shoreline, with the building's removal being required once erosion reaches that high risk location. ④

6.2 Cliff Erosion

Information in Gibb (1998) indicate the surrounding cliffs could, in places, be eroding at up to 0.26 m/yr with individual landslips resulting in instantaneous cliff retreat up to 3 m. As explained earlier, these numbers may be on the high side and biased by stormwater gully development. None-the-less cliff erosion is occurring and this is hazardous to people and property (such as vehicles and pets) by either accidently falling, from cliff collapse, or by being hit by falling debris.

Potential mitigation options consist of the following:

- *cliff stabilization by removing loose material, benching or cutting back the upper slope,*
- *erecting protective fences or barriers,* ⑤
- *installing warning signs, and*
- *piping (and consenting) the SE stormwater down the cliff as done at the NW end of the Bay.*

To assist in assigning mitigation options, a <u>continuous</u> erosion hazard (and risk) assessment is recommended as the level and nature of cliff stability varies around the Bay.

<u>Of particular urgency</u> is the stormwater drainage gully on the south eastern cliff which presents a particularly high hazard risk as illustrated in Figure 20. The upper part of the gully has a vertical face and is eroding at 0.2 m per year on average. The safety fence is now on the edge of the cliff and the first rail is too high to restrain young children. The warning sign now lies partway done the gully. Mitigatory action is required forthwith and consenting of the present system should also be investigated.

Figure 20 Southeast cliff stormwater gully showing the upper edge, barrier fence and state of the warning sign in May 2020.

6.3 Inundation

Observations show hazardous landward flows carrying revetment stone and debris across the car park occur frequently with occurrence and impact likely to increase in the future. The following management options are available:

- *Raise the seawall/revetment to prevent/minimize overtopping. The 2019 seawall consent application proposed raising the front of the crest to 6 m above MSL (Appendix B);* ⑥
- *Armour the revetment with the recommended size stone as this will minimize their erosion by inundation flows and deposition within the carp park;*
- *Ensure structures and other items (e.g. picnic tables) are secure.*

An inundation assessment would define water levels, landward extent and event frequency both now and in the future thereby assisting in planning mitigation options.

6.4 Previous management proposals

The management proposals contained in the 1998 and 2002 Gibb reports and the 2005 NIWA report which have not yet been implemented are listed below. These are included in the present Management Strategy.

6.4.1 Gibb 1998 and 2002

- *Rubble be removed from the Central Sector and a foredune shaped and planted* ③

- *To accurately account for erosion rates, dune line and cliff top monitoring should be conducted periodically. This is addressed in Section 7 below.*

- *The natural foredune complex in the NW Sector be enhanced by removing exotics and letting natives spread.* ⑦

Gibb considered the natural dune system to have special value “being one of the few coastal forest remnants in on the entire coast south of Cape Egmont it is worthy of being enhanced and preserved”. While the present study shows that shoreline erosion will slowly reduce the size of this area, this recommendation nonetheless is valid and warrants inclusion in the present strategy.

- *One or two of the remaining historical boast sheds could be retained for historical purposes and restored.* ⑧

When Gibb made this recommendation in 1998 there were 8 sheds standing. Today there is only a single example and his call for preservation and restoration also warrants inclusion in the present strategy.

6.4.2 NIWA (2005)

- *A strategy be developed to manage and protect the frontal dune.* (1 & 3)

- *There is an urgent need for a monitoring programme of the beach and dune system to identify any change in the erosion pattern and hence a need to modify the management strategy. This is now addressed in the following section.*

7 MONITORING PROGRAMME

To better understand and define future geomorphological changes, associated hazards and risk, and to develop or refine mitigation approaches, the following measurement-based monitoring programme is recommended.

7.1 Beach and dune profiling

Repeat cross-shore profiling is the standard method of quantifying beach change in the shorter term. As part of the 12 November 2019 survey by TPL, 3 cross-shore transects were established, these extend from the rear of the dune to the spring low tide mark or thereabouts (see Figures 2 and 19). The November 2019 profiles were overlaid in Figure 3. Normal practice is to repeat surveys at 6 monthly intervals to define the extent of seasonal change, then, upon the recommendation of a coastal expert, revert to longer sampling intervals if that is deemed appropriate. In 2019 the council purchased a Total Station/GPS survey equipment so as-build surveys could be carried by staff. Using this equipment for acquiring the profile data should be straightforward and economic. Indeed, a technical officer could survey both Middleton and three profiles in Ōpunakē Bay, as recommended in CSL (2019), on the same day. The second 6-monthly survey now due should be carried out forthwith.

7.2 Topographic survey

This monitoring is to define changes between and beyond the profile transects. Following on from the recent TPL drone survey, this should be repeated at say 5 yearly intervals. As noted earlier, LIDAR is the preferred method as this can “see” through vegetation. The cheaper drone-based method should otherwise be used which provides useful data on bare or grassed surfaces including sand dunes. Again this survey could be combined with a similar survey recommended for Ōpunakē Bay, thus enabling cost savings. In 2019 the drone-based survey cost $10,000 for both bays plus the breakwater.

7.3 Bathymetric survey

It is helpful to identify any trends in subtidal bed level as this may be indicative of subsequent sediment supply change in the beach system. This becomes more important given the uncertainties of future climate change and its impact on the littoral sediment supply. There has never been a bathymetric survey of Middleton Bay so this is long overdue and a survey in the near future is recommended along with repeats at about 10 yearly intervals. And again, a similar survey has been recommended for Ōpunakē Bay so carrying out both at the same time will save on establishment costs. In 2019, hydrographic surveyors DML estimated both bays could be surveyed for a combined cost of $10,000 to $12,000.

7.4 Structures within the Bay

The Taranaki Regional Council (TRC) annually monitor and report on consented coastal structures based on a visual inspection. However, the TRC is changing to measurement-based monitoring (as detailed in Tonkin and Taylor, 2014) to better define longer term change. We recommend the STDC liaise with the TRC when finalizing this long-term monitoring programme.

7.5 Reporting

Reporting for all types of monitoring should be carried out by an expert who will analyse new data, compare these with previous surveys, interpret any change and, if necessary, make recommendations on future surveys and management.

8 SUMMARY

Ōpunakē township has two coastal bays along its seaward margin: Ōpunakē and Middleton. These environments have contrasting physical characteristics and uses. While both are confined by cliffs, Middleton is much steeper and consequently has been developed for boat launching at its SE end. However, it remains undeveloped along its northern end which is used for passive recreation. By contrast, Ōpunakē Bay has been entirely developed for recreation and contains a Holiday Park/Camping Ground, Surf Club, large parking areas, playgound and picnic areas.

Ōpunakē Bay has recently been the subject of a Master Plan (Boffa Miskell, 2016) to guide future usage, a cliff-stability assessment (Opus, 2017) to reduce hazard risk, and a comprehensive study of the geomorphology, hazards and associated management options (CSL, 2019). Middleton Bay was the subject of a management plan in 1998 by Dr Jeremy Gibb. However, over 20 years have now elapsed and there is a greater amount of technical information available to identify the physical processes operating within the Bay. In addition, there is also a range of new legislation, policy, and technical management guidance. Consequently, the STDC engaged Coastal Systems Ltd to prepare a long-term management strategy for Middleton Bay. In particular, the **goal** was to investigate the future sustainable management of Middleton Bay, including the potential impacts of climate change, by addressing the following **objectives:**

-Collect the available relevant information;

-Carry out the necessary field inspection;

-Describe the coastal environment;

-Overview coastal hazards: beach-dune erosion, cliff erosion and inundation;

-Identify management options;

-Address future long-term monitoring requirements, and

-Consult with local residents, in particular Mr Brian Vincent and Mr Gerald Bourke.

The **coastal environment** has been described in terms of the existing man-made features and the existing landscape, and how these have changed over time. Identifying such change is indicative of future behaviour.

In this report, the Bay was been divided into 3 sectors: Northwestern (NW), Central and Southeastern (SE) based on contrasting physical characteristics and usage (see Figure 2).

The **SE Sector** contains boat launch infrastructure and assets including a sealed carpark fronted by a continuous seawall (boulder revetment) and concrete boat-ramp, as well as various buildings and other infrastructure. These assets are very much valued, many having been developed by the community over several decades. Management is required to ensure these assets can resist likely future lowering of the beach immediately in front of the seawall – a process that will be exacerbated by predicted climate change. Options include strengthening the base of the revetment to prevent undermining and curving (“returning”) the NW terminus landward to prevent outflanking.

The **NW Sector** has a natural foredune which was found in the present study to be systematically eroding by 0.18 m/yr on average – this was in contrast to earlier assessments which concluded the shoreline to be essentially stable albeit fluctuating. When coupled with other erosion hazard drivers including predicted sea-level rise, the lifespan of the dunes along NW Sector is limited to well under 100 years. However, a full hazard assessment is required to temporally define this retreat – this being beyond the current terms of reference. Management options have been described for dune conservation to maximize their lifespan, and enhancement of the landward forest remnant is also recommended. All management options have been located in Figure 19.

The beach-dune shoreline in the **Central Sector** is a transition zone between the contrasting NW and SE sectors. The underlying erosion trend, which will be enhanced by any climate change effects, mean this sector will have the shortest lifespan. Structural, nourishment and foredune conservation/enhancement options have been described with the latter being the preferred approach.

The surrounding **cliffs** vary in geological composition and consequently in headland form and behaviour. The short NW promontory has greater exposure to wave energy and this results in Middleton’s steeper beach c.f. Opunake Bay. The 1998 Gibb study found that the surrounding cliffs were eroding at up to 0.26 m/yr but no data or spatial distribution was provided. The present study assessed the NW headland and found rates up to 0.09 m/yr and gully head erosion associated with the SE cliff-top stormwater outlet averaging 0.2 m/yr. A detailed erosion assessment is required to accurately define erosion behaviour along the entire cliff and thus enable the assignment of the following types of management: cliff stabilization, protective fences or barriers, warning signs. However, urgent mitigatory action is required at the SE clifftop stormwater outlet as this presents a particularly high hazard risk. Piping of this stormwater entry into the bay should be considered in the longer term. Consenting associated with the SE stormwater discharge also needs to be assessed

Observations by residents, photographs and newspaper reports show that **inundation** by storm waves coupled with extreme water levels is hazardous with flows reaching well into the car park which is left littered with stone from the revetment on least an annual basis. An inundation hazard assessment has yet to be undertaken to define levels, landward extent and event frequency both now and in the future. In the latter case, predicated sea-level rise could have a significant effect. Management options include raising the revetment crest to prevent/minimize overtopping, armour the revetment face to prevent its stone being transported into the car park, and ensure structures and other items (e.g. picnic tables) are secure. Ongoing protection of the remaining historical boat shed which is located within the carpark, is also recommended.

To better understand and define future changes to the geomorphological system, associated hazards and risk, and future management options, a measurement-based **monitoring programme** has been outlined. Such a programme focuses on regular (biannual) profile surveys, less frequent terrestrial (5 yearly) and sea-bed (10 yearly) surveys, as well as annual structure surveys. Liaising with the TRC is recommended when finalizing the monitoring programme. Of note is the second six monthly profile survey is now due and a first ever bathymetric survey should be planned for the near future. These surveys are also required for Ōpunakē Bay (as detailed in the CSL (2019) Ōpunakē Bay study) so cost saving efficiencies are available.

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COASTAL SYSTEMS LTD

RD Shand

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Dr Roger Shand
Senior Coastal Scientist

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APPENDIX A Photographs taken in October 1998 for the Gibb report

Figure 2: Recent landslip SW of the boat ramp and boulder beach providing some protection to the seacliffs from sea erosion (Photo: 14 October 1998).

Figure 3: Middleton Bay looking SE at low tide showing volcanic-derived sand beach and well vegetated foredune (Photo: 15 October 1998).

Figure 4: View SE of the developed SE half of Middleton Bay showing old and recent buildings and foreshore structures (Photo: 15 October 1998).

Figure 5: Concrete boat ramp and groyne, which has trapped cobbles and boulders on the S side (Photo: 15 October 1998).

Figure 6: View NW from boat ramp showing the 80m-long concrete and rubble revetment overlying the natural boulder beach (Photo: 14 October 1998).

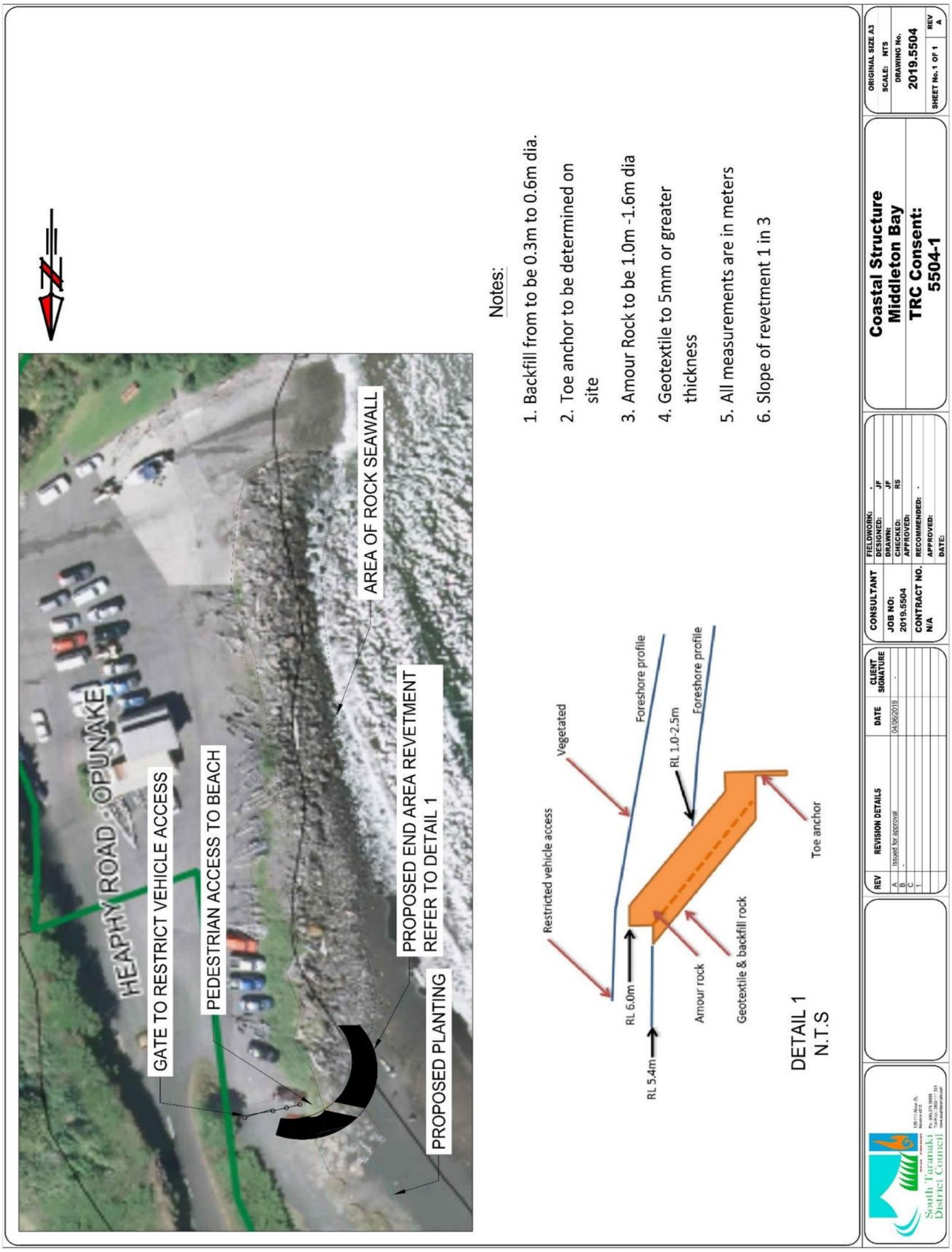
Figure 7: View SE showing the 20m-long rubble revetment which has caused up to 5m outflanking and the undermining of the 2 old boatsheds (Photo: 14 October 1998).

Figure 8: Washout in foredune complex from storm water discharging over the seacliffs behind (Photo: 14 October 1998).

Figure 9: Well vegetated foredune complex and seacliffs at the NW end of the Bay with waterfall from storm water discharge (Photo: 14 October 1998).

APPENDIX B STDC design drawing and specifications (2019) for strengthening the Middleton Bay coastal structure (rock revetment)

The revetment will be raised to 5.4 m above MSL with an additional 0.6 m safety margin (the present crest being about 4.5 to 5 m above MSL), and have a toe depth of 0.1 m above MSL. In addition, the frontal slope would be 3H : 1V and have a 7 m "return" at the NW terminus to prevent future outflanking. To assist the public with safer access to the beach, access steps would be built into the sheltered "return" part of the structure.



Notes:

1. Backfill from to be 0.3m to 0.6m dia.
2. Toe anchor to be determined on site
3. Amour Rock to be 1.0m -1.6m dia
4. Geotextile to 5mm or greater thickness
5. All measurements are in meters
6. Slope of revetment 1 in 3

South Taranaki District Council

REV	REVISION DETAILS	DATE	CLIENT SIGNATURE
A	Issued for approval	04/06/2019	-
B	-		
C			
1			

CONSULTANT
JOB NO: 2019.5504
CONTRACT NO. N/A

FIELDWORK: -
DESIGNED: JF
DRAWN: JF
CHECKED: RS
APPROVED:
RECOMMENDED: -
APPROVED:
DATE:

Coastal Structure
Middleton Bay
TRC Consent:
5504-1

ORIGINAL SIZE A3
SCALE: NTS
DRAWING No. 2019.5504
SHEET No. 1 OF 1
REV A

APPENDIX C Information provided to the STDC archive

CSL have provided the council with the following information (n electronic format) used in the preparation of his report

Consents

Rock revetment and seawall. Coastal permit 5504
NW drainage outlet. Coastal permit 6222
Wastewater discharge. Coastal permit 0236

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2020-3-16 CSL

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Satellite images
2001-4-9, 2004-6-11, 07-3-4, 07-5-9, 2012-11-8, 2013-3-6, 2013-9-1, 2015-12-18, 2016-4-13, 2018-6-28, 2018-10-18, 2019-5-4