



SCIENCE FOR CONSERVATION 332

Risk-exposure assessment of Department of Conservation (DOC) coastal locations to flooding from the sea

A national risk assessment of DOC assets, archaeological sites, recreation functional locations, destinations and ecosystem and species management units vulnerable to coastal inundation and sea-level rise

Andrew Tait



Cover: Tonga Quarry Picnic Area and (former) Campground, Abel Tasman Coastal Track, 1 February 2018, after ex-tropical cyclone Fehi.
Photo: Margaret Hall.

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A national assessment of DOC assets, archaeological sites, recreation functional locations, destinations and ecosystem and species management units vulnerable to coastal inundation and sea-level rise

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Abstract

This report describes a national-level risk-exposure screening assessment that identifies Department of Conservation (DOC) assets, archaeological sites, recreation functional locations, destinations and ecosystem and species management units located in a potential coastal inundation (flooding caused by high seas) risk zone. This zone represents low-lying coastal land that is potentially vulnerable to inundation from the sea, now and in the future. As the sea level rises over the course of this century and beyond in response to climate change, the inundation risk at these locations will be exacerbated (i.e. occur more frequently and with deeper flooding) and extend increasingly further inland. Currently intersecting with this potential inundation zone are 331 DOC assets and 420 archaeological sites on Public Conservation Land. Furthermore, 119 recreation functional locations and 62 destinations contain at least one potentially vulnerable asset, and 260 Ecosystem Management Units and 99 Species Management Units have some part of their delineated polygon located in the potential coastal inundation zone. Identification of these potentially at-risk sites is of importance to several units within DOC and will be used to inform DOC policy, prioritisation processes and operational management activities.

Keywords: Coastal inundation risk, hazard screening, Department of Conservation assets, archaeological sites, recreation functional locations, destinations, ecosystem and species management units

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1. Introduction

1.1 Purpose of this report

This report (and the associated GIS datasets) identifies DOC assets, archaeological sites, recreation functional locations, destinations and ecosystem and species management units located in a potential coastal inundation (flooding caused by high seas) risk zone, based on a national enhanced Digital Elevation Model (DEM). This zone presents low-lying coastal land¹ that is potentially vulnerable to present and future (within this century) inundation from the sea during high tides and storm events. As the sea rises over the course of this century and beyond², the inundation risk at these locations will be exacerbated as coastal floods become more frequent, deeper and extend increasingly further inland.

The information in this report should be used as a national-scale coastal inundation risk screening assessment to guide DOC priorities – noting that land elevation above Mean High Water Spring (MHWS) is used as a proxy for the coastal-flooding hazard in this application. More detailed risk assessments of specific locations using LiDAR-derived DEM data and appropriate flood hazard scenarios should follow this national-level study – particularly areas or assets with more imminent flooding risk identified from the risk-screening process. Coastal erosion (present or future) may also be an accompanying risk factor for some of the DOC assets (e.g. tracks).

1.2 Context

The identification of potential hazards is of vital importance to DOC. The Department's Statement of Intent 2016–2020³ says that:

We (DOC) manage natural and historical resources for their intrinsic values, for the services that ecosystems provide us with today, to safeguard options for future generations and for recreational use and enjoyment by the public.

Such management, implemented across all DOC functions, necessarily involves hazard identification and the mitigation of risks arising from natural hazards. Safeguarding options for future generations also means identifying potential future hazards and/or the exacerbation of present-day hazards such as those resulting from climate change and sea-level rise (in addition to other social, economic and physical drivers).

Many assets, archaeological sites and ecosystem or species management units located at the coast on Public Conservation Land (PCL) and/or managed by DOC are potentially at risk from inundation (or flooding) from the sea during extreme high tides and storm events. Flooding can result from semi-permanent inundation at high tide as the upper tidal zone extends inland as the sea level rises, and/or coastal flooding beyond the inter-tidal zone from elevated storm-tides and wave processes during adverse weather events. This inundation risk will only increase over the coming decades due to sea-level rise. The New Zealand Coastal Policy Statement (NZCPS) 2010⁴ says that the coastal environment is subject to a *continuing decline in species, habitats and ecosystems* and faces *continuing coastal erosion and other natural hazards that will be exacerbated by climate change*.

¹ Coastal land is based on the delineation of the New Zealand coastline, including offshore islands, derived from Topo50 products and represented in the GIS shape file: NATIS2.NATISADM.TOPOGRAPHIC_TOPO50_CoastlinePolyNational.

² See the Background on Sea-level Rise section below for more information on sea-level rise projections for the globe and around New Zealand.

³ See <http://www.doc.govt.nz/Documents/about-doc/annual-report-2016/annual-report-2016.pdf>

⁴ See <http://www.doc.govt.nz/about-us/science-publications/conservation-publications/marine-and-coastal/new-zealand-coastal-policy-statement/new-zealand-coastal-policy-statement-2010/>

As an example, coastal flooding caused by the passage of a deep low-pressure system combined with the highest king (perigean-spring) tide for 2018 was experienced in many parts of New Zealand on 4–5 January 2018. Small communities on the western coast of the Firth of Thames (Fig. 1) were among the hardest hit. A similar situation occurred on 1 February 2018 in Tasman/Nelson and the West Coast during ex-tropical cyclone *Fehi*.

Flooding of this nature can significantly impact buildings, walking tracks, infrastructure, historic sites, farmland, and natural ecosystems due to the high energy of waves eroding and overtopping coastal sand dunes and other defences in addition to the impact of land and waterways being inundated for extended periods with saline water and the deposition of silt.

DOC's work in this area is guided by Government guidance on coastal hazard management, in particular the 'Coastal hazards and climate change guidance'⁵ issued by the Ministry for Environment and the NZCPS 2010 guidance note: coastal hazards⁶ from DOC. Both documents have 'managed retreat' as one of the core principles as opposed to simply reinstating or implementing hard-protection measures for eroded or inundated assets within hazard-prone areas. The NZCPS is implemented through the Resource Management Act 1991 (RMA). It directs councils to proactively identify coastal hazard risk and to adopt long-term risk reduction approaches. Available risk-reduction measures include, but are not limited to, managed retreat. Other options include redesign of existing developments (e.g. designing for relocatability), changes in land use and, in limited circumstances, hard or soft engineered protection.

RMA consents/permits may be required for some hazard management responses by DOC. Other statutory considerations include the relevant PCL legislation, conservation management strategy, and management plans⁷.



Figure 1. Coastal flooding in Kaiaua, Firth of Thames, Friday 5 January 2018. *Photo: TVNZ One News.*

⁵ <http://www.mfe.govt.nz/publications/climate-change/coastal-hazards-and-climate-change-guidance-local-government>

⁶ <http://www.doc.govt.nz/about-us/science-publications/conservation-publications/marine-and-coastal/new-zealand-coastal-policy-statement/policy-statement-and-guidance/>

⁷ <http://www.doc.govt.nz/about-us/our-policies-and-plans/>

Relevant NZCPS content includes Objectives 1, 2 and 5 and the coastal hazard policies 24-27. Objectives 1 and 2 direct decision makers to protect, maintain and, potentially, enhance the natural environment of coastal areas.

Objective 1: To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land, by:

- *maintaining or enhancing natural biological and physical processes in the coastal environment and recognising their dynamic, complex and interdependent nature;*
- *protecting representative or significant natural ecosystems and sites of biological importance and maintaining the diversity of New Zealand's indigenous coastal flora and fauna; and*
- *maintaining coastal water quality and enhancing it where it has deteriorated from what would otherwise be its natural condition, with significant adverse effects on ecology and habitat, because of discharges associated with human activity.*

Objective 2: To preserve the natural character of the coastal environment and protect natural features and landscape values through:

- *recognising the characteristics and qualities that contribute to natural character, natural features and landscape values and their location and distribution;*
- *identifying those areas where various forms of subdivision, use, and development would be inappropriate and protecting them from such activities; and*
- *encouraging restoration of the coastal environment.*

Objective 5 directs the management of coastal hazard risks through appropriate measures:

Objective 5: To ensure that coastal hazard risks taking account of climate change, are managed by:

- *locating new development away from areas prone to such risks;*
- *considering responses, including managed retreat, for existing development in this situation; and*
- *protecting or restoring natural defences to coastal hazards.*

For DOC, such management is taken to include coastal hazard risk identification (NZCPS Policy 24) and careful evaluation of risk management options (Policies 25-27) for PCL assets and sites at risk from present-day and future coastal hazards.

1.3 Background on sea-level rise

The Intergovernmental Panel on Climate Change Fifth Assessment Report Working Group 1 Summary for Policymakers (IPCC 2013) includes the following headline statements on sea-level rise (bold text has been added by the author of this report):

- *Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, **sea level has risen**, and the concentrations of greenhouse gases have increased.*
- *The **rate of sea-level rise** since the mid-19th century has been larger than the mean rate during the previous two millennia (high confidence⁸). Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m.*

⁸ IPCC statements with a confidence rating are based on the author teams' judgments about the validity of findings as determined through evaluation of evidence and agreement. Confidence ranges from 'very low' (depicting low agreement and limited evidence) to 'very high' (depicting high agreement and robust evidence).

- Global mean sea level **will continue to rise** during the 21st century. Under all RCP⁹ scenarios, the rate of sea-level rise will very likely exceed that observed during 1971 to 2010 due to increased ocean warming and increased loss of mass from glaciers and ice sheets.

Furthermore, Bell et al. (2015), in a report to the New Zealand Parliamentary Commissioner for the Environment titled 'National and regional risk exposure in low-lying coastal areas' concluded that:

- Over the past century up to present, New Zealand's average rise in mean sea level has been **similar to the global-average rate** – therefore future projections of global-average sea-level rise are generally applicable to Aotearoa-New Zealand (Fig. 2).
- In tandem with this rise in sea level, the **frequency of coastal storm inundation** has increased (Stephens 2015), as evident in Auckland such as Tamaki Drive, with the occurrence of these events set to escalate as sea-level rise accelerates.
- **Credible projections of sea-level rise** by 2100 range from 0.5 to 1 m (Church et al. 2013). However, rises above 1 m by 2100 are still possible.
- Next century and beyond, sea level will continue rising, **possibly for several centuries or more**, with the rate of increase and the ultimate SLR determined by the time-trajectory of mitigation of greenhouse gas emissions (Church et al. 2013).

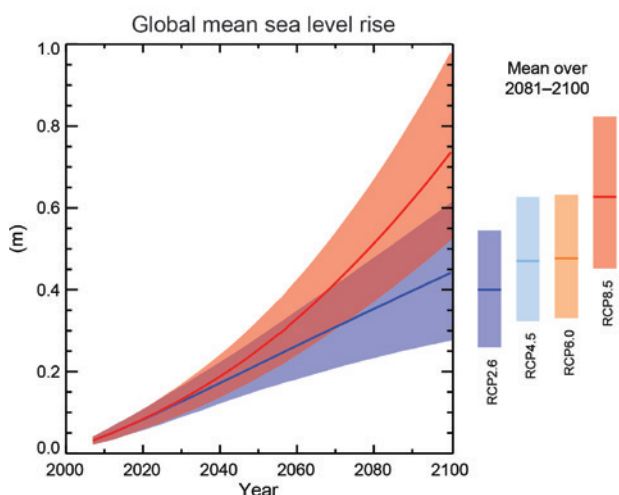


Figure 2. Projections of global mean sea-level rise from 2006 to 2100, relative to the 1986–2005 global mean sea level, for a low and high Representative Concentration Pathway (RCP). IPCC 2013.

The recently-published Coastal Hazards and Climate Change: Guidance for Local Government (MfE 2017)¹⁰ recommends the use of four New Zealand-specific sea-level rise scenarios out to 2120 (for planning timeframes of at least 100 years as required by the NZCPS) and extended out to 2150. For example, by 2120, the four scenarios cover a sea-level rise between 0.55 m (RCP2.6) and 1.36 m (RCP8.5 H*), with local vertical land movement to be included where it is significant. The scenarios are intended for use with an adaptive pathways planning approach, building in adaptation thresholds and triggers when a switch to an alternative pathway or response option is required before the risk becomes intolerable (e.g. NZCPS Policy 27).

⁹ RCPs are Representative (atmospheric greenhouse gas) Concentration Pathways to the end of the century and beyond. The four RCPs range from RCP2.6 (a strong greenhouse gas emissions mitigation pathway) to RCP8.5 (growth in emissions and rapid rise in concentrations).

¹⁰ See <http://www.mfe.govt.nz/publications/climate-change/coastal-hazards-and-climate-change-guidance-local-government>

It is therefore prudent and timely to investigate the potential risk of current and future coastal inundation on DOC assets, archaeological sites and Ecosystem and Species Management Units. The MfE coastal Guidance specifies this type of assessment as a hazard or risk screening (see Section 6.5.3 and 8.2.1 of the MfE Guidance) – in this case it can be described as a risk-exposure screening, as assets and natural habitats are enumerated (i.e. potentially exposed), but no detailed direct and indirect impacts are assessed. Detailed hazard, vulnerability and risk assessment should be undertaken as a next step for locations of historical, ecological and/or economic importance (Section 8 of the MfE Guidance).

2. Data used for this study

2.1 National potential coastal inundation risk zone

A national enhanced DEM has been derived from the Landcare Research enhanced DEM generated from the LINZ topographic contour data and blended with a NASA Shuttle Radar Topography Mission (SRTM) DEM. Under LINZ licensing arrangements, the DEM data were available for use by DOC as a government department and as a partner in the KiwiImage Quickbird imagery project, for which the national DEM was modified (SKM 2008). The geographic projection of the DEM data is NZGD2000 New Zealand Transverse Mercator (NZTM).

NIWA produced an elevation contour GIS shapefile derived from the national enhanced DEM with three elevation bands: 0–3 m, 3–5 m, and 5–10 m, as part of the Bell et al. (2015) assessment for the Parliamentary Commissioner for the Environment (PCE). The 0–3 m elevation contours were compared with the same contours derived from more accurate¹¹ LiDAR DEM data, where these data are available. The authors concluded:

- *While there is not full LiDAR coverage available for Aotearoa-New Zealand coastal areas, (where there is coverage) the total land-cover area and population within the cumulative 0–3 m coastal zone derived from LiDAR DEMs is **nearly double** those enumerated from the national modified DEM for the same elevation range.*

Because of this sizeable underestimation of low-lying coastal land area, the PCE report authors have suggested that the 0–3 m elevation contours derived from the national enhanced DEM are more likely to better represent 0–1.5 m, but because of the poor accuracy the data should be used with caution (Rob Bell, NIWA, pers. comm., October 2017). Note: elevation inaccuracy of the enhanced DEM is likely to be higher in coastal areas where the adjacent land elevation rises quickly from the water's edge and higher again for cliffs or bluffs.

Taking on this advice, the national elevation contour data have been used in this study to identify coastal locations that are **potentially vulnerable** to inundation from the sea, now and in the future within this century. More detailed risk assessment of specific at-risk locations using a two-stage approach involving analysis of historical records, local knowledge and site visits followed by detailed mapping using LiDAR-derived DEM data should follow this national-level risk-exposure screening study.

¹¹ LiDAR-derived elevation data accuracy is typically around 0.15 m.

2.2 DOC assets, archaeological sites, recreation functional locations, destinations and EMUs/SMUs

The following DOC GIS datasets were utilised in this study:

- NATIS1.NATISADM.INFRASTRUCTURE_AMIS_Equipment

This is a spatial representation of DOC-managed equipment represented as points and includes a range of assets (e.g. huts, campsites and boardwalks). Each asset in the dataset, if appropriate, is also linked to a recreation functional location.

- NATIS1.NATISADM.INFRASTRUCTURE_AMIS_Tracks

This is a spatial representation of DOC-managed track centrelines categorised into nine different types reflecting a range of experiences (i.e. short walks, tramping tracks or mountain biking trails).

- NATIS1.NATISADM.INFRASTRUCTURE_DOC_DestinationPly

This is a polygon feature class representing Icon and Gateway Destinations generated from NATIS AMIS feature classes (Tracks, Roads and Equipment). DOC is using the term 'destination' to mean a geographic area that is the focus of a single trip by a visitor.

- NATIS1.NATISADM.OPERATIONAL_DOC_PrescriptionManagementUnits

This dataset comprises Management Units that fall under the Natural Heritage Intermediate Outcome Objectives (IOO) framework. This data is used within DOC for systematic conservation prioritisation to support the cost-effective management of a full range of New Zealand's ecosystems and species.

The analysis carried out for this report used the subset of this dataset which comprised:

- Ecosystem management units (EMUs) created to support IOO 1.1: A full range of New Zealand's ecosystems is conserved to a healthy functioning state; and
- Species management units (SMUs) created to support IOO 1.2: Nationally threatened species are conserved to ensure persistence.

EMUs are based around sites identified for DOC by panels of experts as being best examples of each ecosystem type. They were designed to be large enough to provide a functioning example of one or more ecosystems and of an appropriate size for management. Many EMUs also support potentially viable populations of threatened species.

SMUs are sites identified for DOC by panels of experts as being critical for the long-term security of each species. They were designed to be large enough to provide for a viable population of one or more species.

- NATIS2.NATISADM.ADMINISTRATIVE_NZAA_ArchSiteSites

This dataset is part of a set of information that comprises Site, Accuracy and Area information for over 60,000 Archaeological Sites in New Zealand. This data is sourced from the New Zealand Archaeological Association's ArchSite database.

3. Methodology

The national elevation contour shapefile was made available by NIWA to DOC for use in this study¹². This layer was clipped to the coastline¹³ and overlaid on LINZ Topo50 map GeoTIFF¹⁴ data, using the GIS package ArcMap 10.3.1, and the lowest-elevation band was filled with a solid colour (see Figs 3 and 4 for example maps). It should be noted that the limited accuracy of both the national enhanced DEM and the Topo50 coastline shape file limit the extent to which this information can be utilised to examine the inundation risk of specific localities in detail, such as the intertidal zone around the New River Estuary shown in Fig. 3. For such site-specific studies, high-resolution LiDAR data and detailed site and hazard assessments are required.

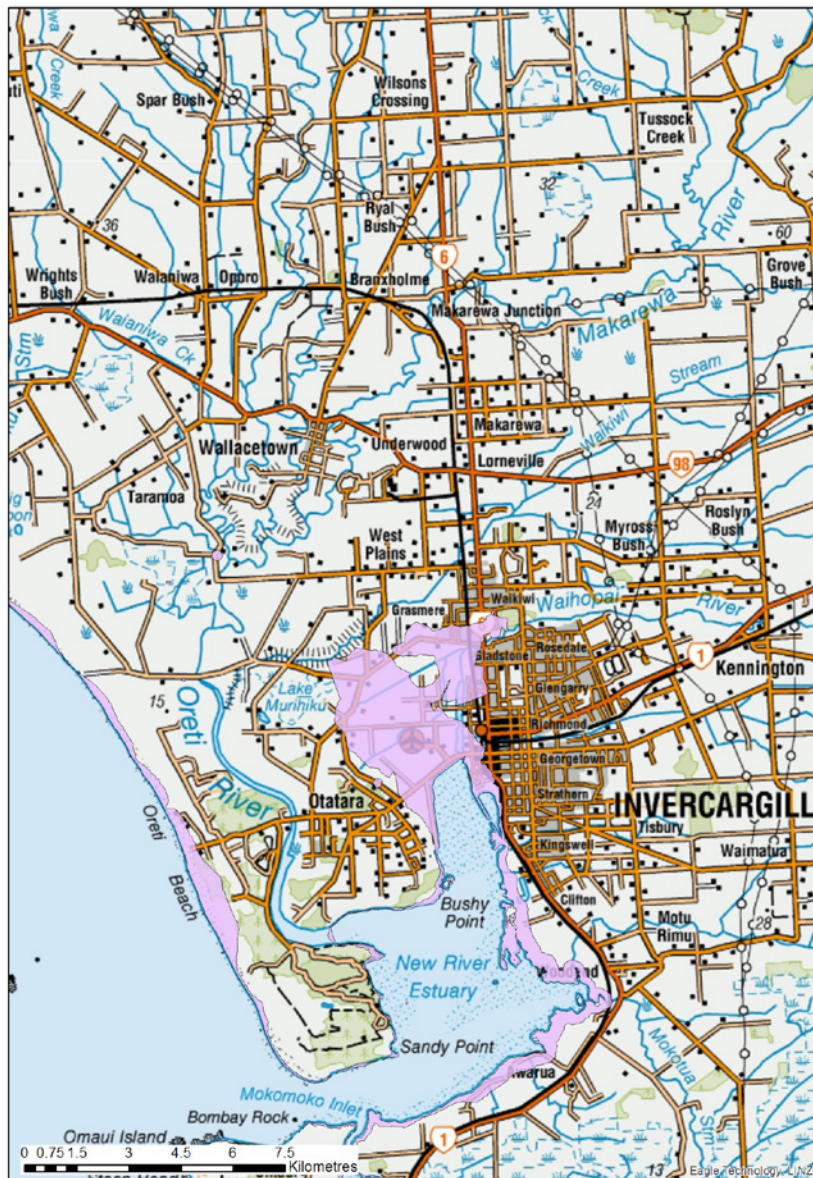


Figure 3. Example map of the extent of the potential coastal inundation risk zone encompassing the environs of the New River Estuary (including Invercargill airport).

¹² A data use agreement associated with this shapefile was signed by both NIWA and DOC (see: <https://doccm.doc.govt.nz/wcc/faces/wccdoc?dID=4352533&dDocName=DOC-3224301>)

¹³ The delineation of the New Zealand coastline is derived from Topo50 products and represented in the GIS shape file: NATIS2. NATISADM.TOPOGRAPHIC_TOPO50_CoastlinePolyNational.

¹⁴ GeoTIFF is a public domain metadata standard which allows geo-referencing information to be embedded within an image file.



Figure 4. Example map of the extent of the potential coastal inundation risk zone which extends 10 km inland on the Hauraki Plains. Note: The plains are currently protected by a stopbank along the southern shoreline of the Firth of Thames – but there remains a residual risk of flooding including increased impacts from elevated groundwater levels.

The low-lying elevation band (nominally 0–3 m above mean sea level, but likely to be closer to 0–1.5 m) has been termed the ‘potential coastal inundation risk zone’ and represents low-lying coastal land that is ‘potentially vulnerable’ to inundation from the sea during high tides and storm events, now and in the future within this century. This zone, plus more landward areas, will be steadily **more exposed** to inundation over the course of the century and beyond, as the sea level rises.

GIS layers of DOC assets, archaeological sites, EMUs and SMUs were added to the GIS assessment, and the ArcGIS ‘intersect’ tool was used to identify the DOC features located within the potential coastal inundation risk zone. These features were identified as ‘potentially vulnerable’ to sea water flooding now. The same features are also ‘potentially highly vulnerable’ in the future, as the sea level rises. The DOC features were also qualitatively ranked to identify priority features which are highlighted for more detailed analysis and risk assessment.

4. Results

4.1 Assessment of DOC assets

The GIS layer 'NATIS1.NATISADM.INFRASTRUCTURE_AMIS_Equipment' includes the location and attribute information of DOC assets, including the following categories:

- Amenity areas
- Archaeological/artefact
- Boats and vessels
- Buildings
- Counters
- Earthworks
- Fleet/vehicles
- Infrastructure
- Machinery
- Signs
- Structures

For the purposes of identifying 'priority' assets that are potentially vulnerable to coastal inundation and sea-level rise, only the 'amenity areas', 'buildings', 'fleet/vehicles', 'infrastructure', 'machinery' and 'structures' categories were analysed. All other assets can either be easily moved or are relatively low value. Note that the 'archaeological/artefact' category was not analysed in this section.

4.1.1 Amenity areas

A total of 50 amenity areas are located in the potential coastal inundation risk zone, representing 3% of all DOC amenity areas in the country (see Table 1 and Fig. 5).

Table 1. Summary of the 50 Department of Conservation (DOC) amenity areas located in the potential coastal inundation zone. The percentage is rounded to the nearest whole number. The numbers in brackets are the total number of amenity areas.

AMENITY AREA CLASS	NUMBER OF AMENITY AREAS IN COASTAL RISK ZONE (TOTAL NUMBER MANAGED BY DOC)	PROPORTION OF TOTAL NUMBER OF DOC AMENITY AREAS (%)
Campgrounds	20 (329)	6
Maintained area	29 (1213)	2
Playground	1 (47)	2
TOTAL	50 (1589)	3



Figure 5. Locations of the 50 Department of Conservation (DOC) amenity areas in the potential coastal inundation zone.

4.1.2 Buildings

A total of 127 buildings are located in the potential coastal inundation risk zone, representing 2% of all DOC buildings in the country (see Table 2 and Fig. 6).

Table 2. Summary of the 127 Department of Conservation (DOC) buildings located in the potential coastal inundation zone. The percentage is rounded to the nearest whole number. The numbers in brackets are the total number of buildings.

BUILDING CLASS	NUMBER OF DOC BUILDINGS IN COASTAL RISK ZONE (TOTAL NUMBER OF DOC BUILDINGS)	PROPORTION OF TOTAL NUMBER OF DOC BUILDINGS (%)
Accommodation staff	7 (418)	2
Accommodation visitor	1 (78)	1
Amenity unit/block	4 (105)	4
Building government	2 (81)	3
Building industrial	3 (69)	
Building military	10 (256)	4
Building residential	33 (137)	24
Building visitor centre	1 (13)	8
Hut	5 (989)	1
Shed	16 (727)	2
Shelter	11 (573)	2
Toilet	34 (1998)	2
TOTAL	127 (5444)	2

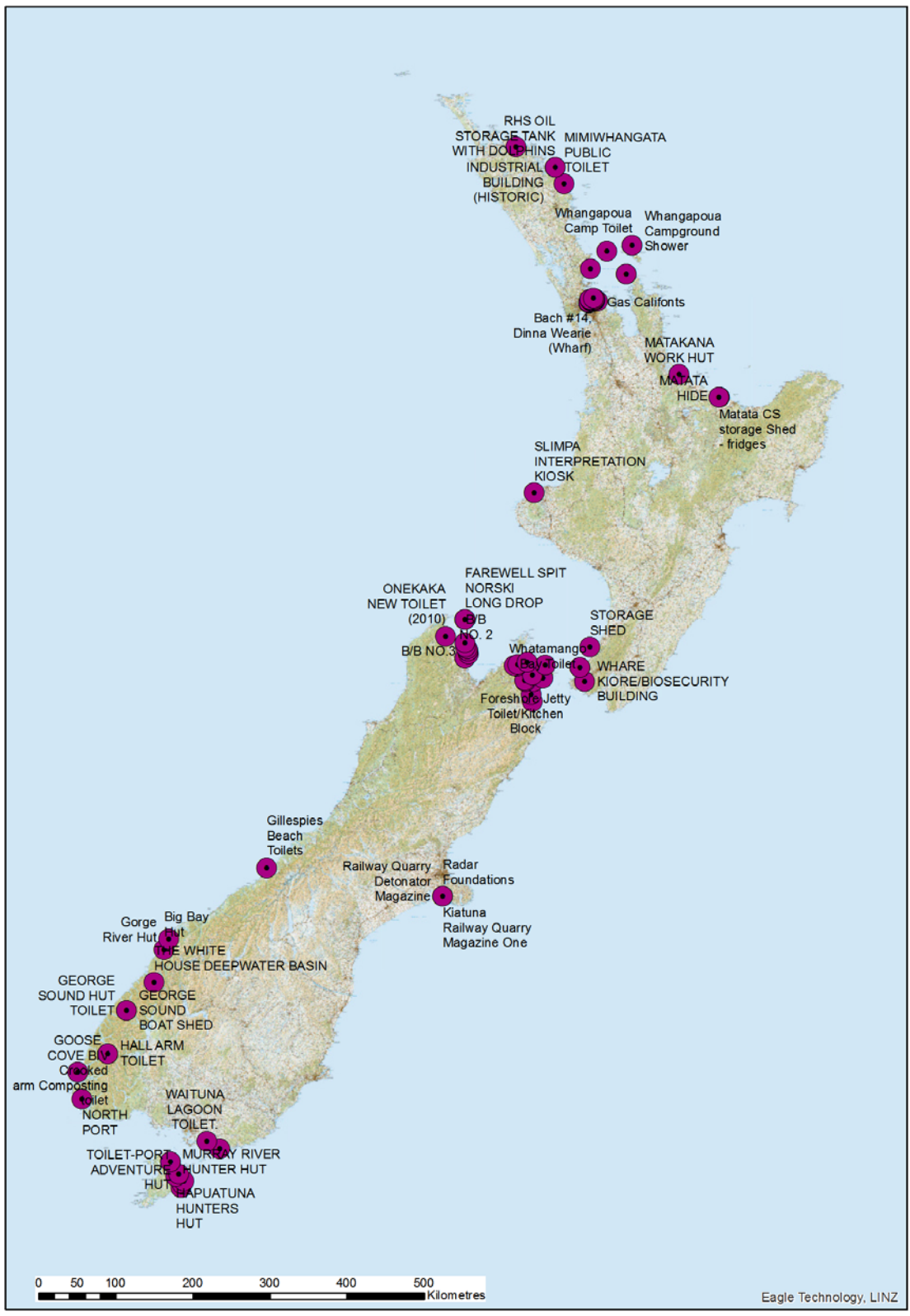


Figure 6. Locations of the 127 Department of Conservation (DOC) buildings in the potential coastal inundation zone.

4.1.3 Fleet/vehicles

No DOC fleet/vehicle assets are located in the potential coastal inundation risk zone.

4.1.4 Infrastructure

A total of 26 DOC infrastructure assets are located in the potential coastal inundation risk zone, representing 4% of all DOC infrastructure assets in the country (see Table 3 and Fig. 7).

Table 3. Summary of the 26 Department of Conservation (DOC) infrastructure assets located in the potential coastal inundation zone. The percentage is rounded to the nearest whole number. The numbers in brackets are the total number of infrastructure assets.

INFRASTRUCTURE CLASS	NUMBER OF DOC INFRASTRUCTURE ASSETS IN COASTAL RISK ZONE (TOTAL NUMBER OF DOC INFRASTRUCTURE ASSETS)	PROPORTION OF TOTAL NUMBER OF DOC INFRASTRUCTURE ASSETS (%)
Sewerage	2 (186)	1
Water catchment	1 (33)	3
Water systems	23 (431)	5
TOTAL	26 (650)	4



Figure 7. Locations of the 26 Department of Conservation (DOC) infrastructure assets in the potential coastal inundation zone.

4.1.5 Machinery

A total of two machinery assets are in the potential coastal inundation risk zone, representing 1% of all DOC machinery assets in the country (see Table 4 and Fig. 8).

Table 4. Summary of the two Department of Conservation (DOC) machinery assets located in the potential coastal inundation zone. The percentage is rounded to the nearest whole number. The numbers in brackets are the total number of machinery assets.

MACHINERY CLASS	NUMBER OF DOC MACHINERY ASSETS IN COASTAL RISK ZONE (TOTAL NUMBER OF DOC MACHINERY ASSETS)	PROPORTION OF TOTAL NUMBER OF DOC MACHINERY ASSETS (%)
Machinery	2 (169)	1
TOTAL	2 (169)	1

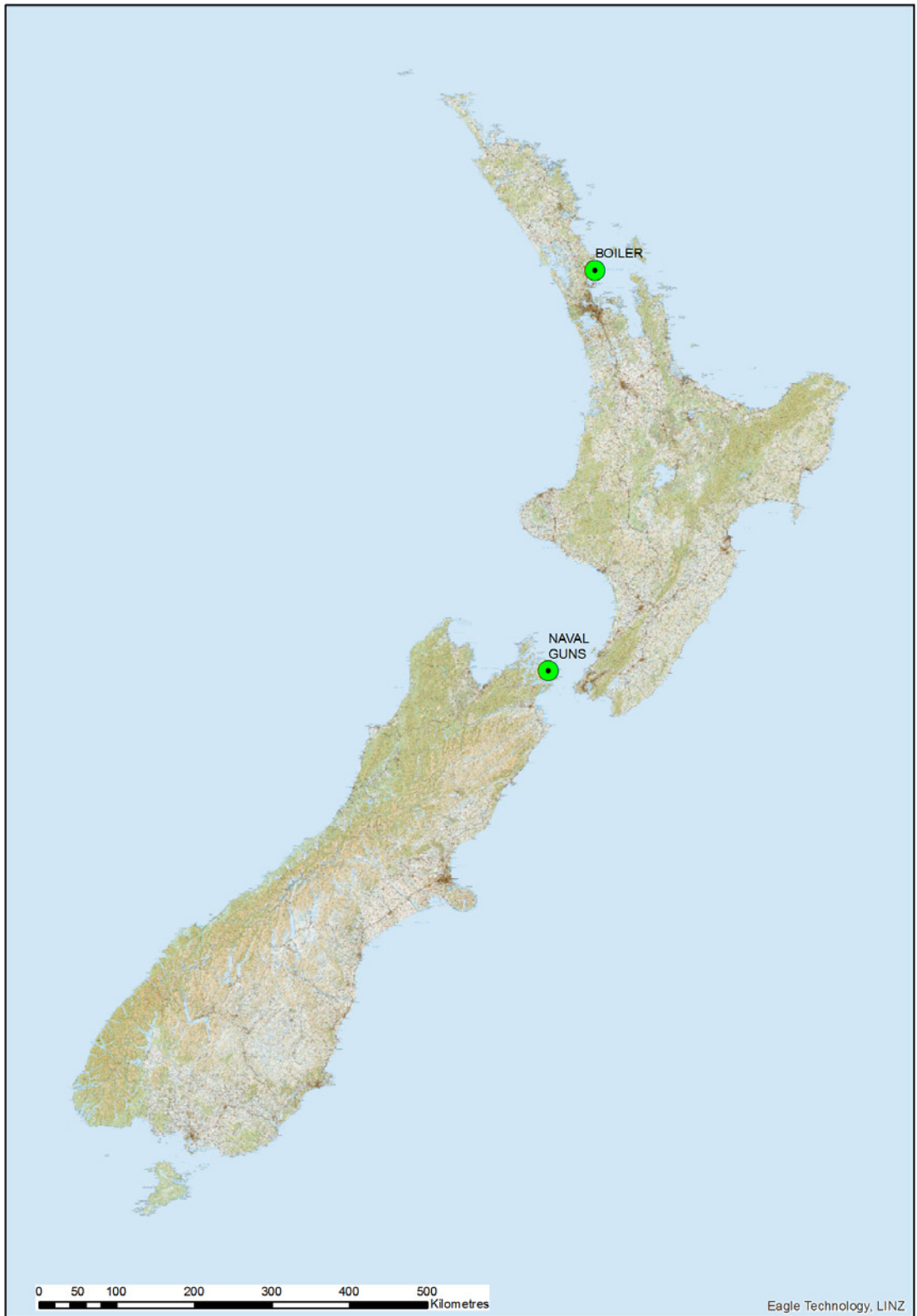


Figure 8. Location of the two Department of Conservation (DOC) machinery assets located in the potential coastal inundation zone.

4.1.6 Structures

A total of 126 structures assets (excluding ‘barrier’, ‘ladder/stair/stile’ and ‘retaining wall’) are in the potential coastal inundation risk zone, representing 1% of all DOC structure assets in the country (see Table 5 and Fig. 9).

Table 5. Summary of the 126 Department of Conservation (DOC) structures assets located in the potential coastal inundation zone. The percentage is rounded to the nearest whole number. The numbers in brackets are the total number of structures.

STRUCTURES CLASS	NUMBER OF DOC STRUCTURES IN COASTAL RISK ZONE (TOTAL NUMBER OF DOC STRUCTURES)	PROPORTION OF TOTAL NUMBER OF DOC STRUCTURES (%)
Boardwalk	41 (4474)	1
Pedestrian bridge – cabled	1 (523)	<1
Pedestrian bridge – concrete	1 (23)	4
Pedestrian bridge – steel	4 (519)	1
Pedestrian bridge – timber	40 (2828)	1
Vehicle bridge – concrete	1 (47)	2
Monument/memorial	3 (26)	12
Platform	13 (366)	4
Wharf/Jetty	22 (88) ¹⁵	25
TOTAL	126 (8894)	1

¹⁵ DOC-1569663 has a definition of ‘recreation functional locations’ (section 3) and a section that sets out rules for creating them (section 8.2).

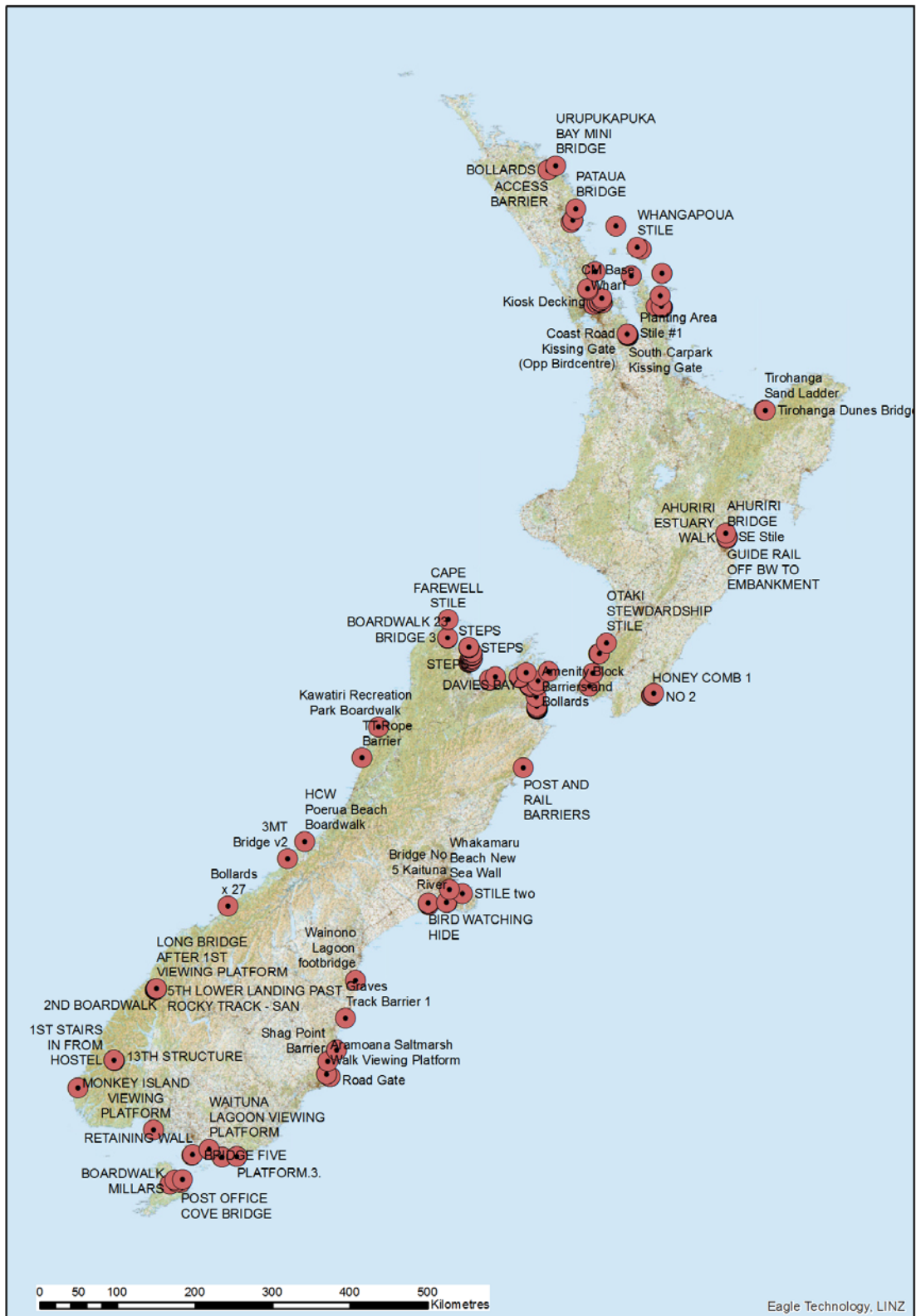


Figure 9. Location of the 126 Department of Conservation (DOC) structures located in the potential coastal inundation zone.

The grand total of amenity areas, buildings, fleet/vehicles, infrastructure assets, machinery assets, and structures located in the potential coastal inundation risk zone is 331 (see Fig. 10), representing 2% of the national DOC asset inventory.

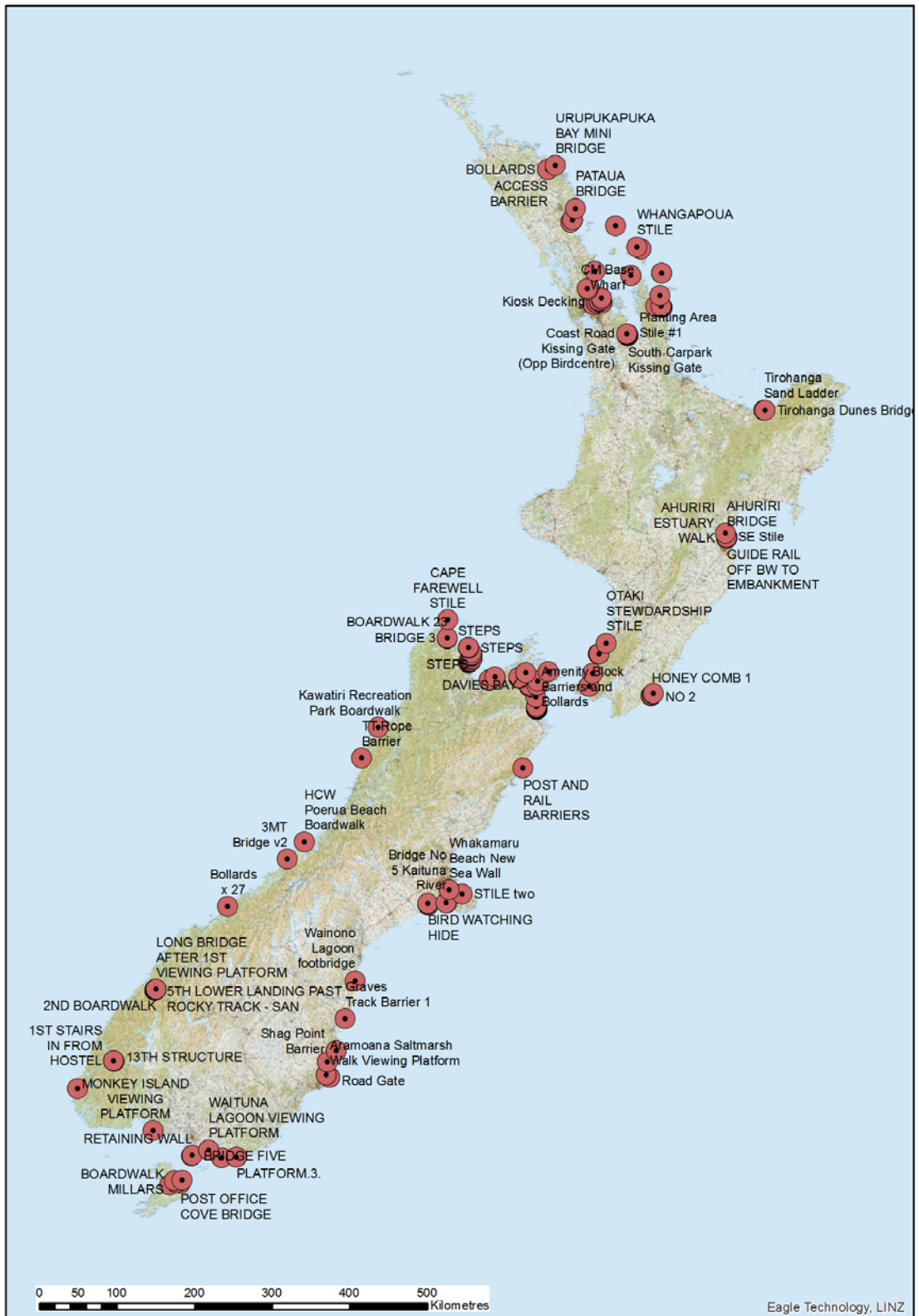


Figure 10. Location of the 331 Department of Conservation (DOC) assets (as identified above) located in the potential coastal inundation zone.

4.2 Assessment of archaeological sites

As described in the previous section, 'archaeological/artefact' is a category in the GIS layer 'NATIS1.NATISADM.INFRASTRUCTURE_AMIS_Equipment'. There are only two classes for this category:

- Archaeological (e.g. pa sites, cemeteries, ruins, historic sites)
- Artefact (e.g. rock drawings, memorials, historic artefacts)

A total of 30 archaeological sites and no artefact sites are located in the potential coastal inundation risk zone, representing 5% of all the sites in the country (see Table 6).

Table 6. Summary of the 30 Department of Conservation (DOC) archaeological/artefact sites located in the potential coastal inundation zone. The percentage is rounded to the nearest whole number. The numbers in brackets are the total number of structures.

SITE CLASS	NUMBER OF DOC ARCHAEOLOGICAL/ARTEFACT SITES IN COASTAL RISK ZONE (TOTAL NUMBER OF DOC ARCHAEOLOGICAL/ ARTEFACT SITES)	PROPORTION OF TOTAL NUMBER OF SITES (%)
Archaeological	30 (542)	6
Artefacts	0 (39)	0
TOTAL	30 (581)	5

The GIS layer 'NATIS2.NATISADM.ADMINISTRATIVE_NZAA_ArchSiteSites' also has archaeological site data.

This is a much broader dataset with around 69,000 records (c. 13 000 recorded sites on PCL), and is an external dataset owned by the New Zealand Archaeological Association. DOC protects these sites from avoidable harm. The majority will also be legally protected under the Heritage New Zealand Pouhere Taonga Act 2014.

A total of 4149 archaeological sites from this database are located in the potential coastal inundation risk zone, representing 6% of all the sites in the country (see Table 7 and Fig. 11). Of these, 420 sites (5%) are located on Public Conservation Land (PCL) (out of a total of 8026 PCL sites).

Table 7. Summary of the 4149 New Zealand Archaeological Association (NZAA) archaeological sites located in the potential coastal inundation zone. The percentage is rounded to the nearest whole number. The numbers in brackets are the total number of structures.

ARCHAEOLOGICAL SITE CLASS	NUMBER OF NZAA ARCHAEOLOGICAL SITES IN COASTAL RISK ZONE (TOTAL NUMBER OF NZAA ARCHAEOLOGICAL SITES)	PROPORTION OF TOTAL NUMBER OF SITES (%)
Artefact find	134 (1720)	8
Burial/cemetery	84 (1024)	8
Historic – domestic	142 (3197)	4
Maori horticulture	66 (1758)	4
Midden/oven	2764 (19460)	14
Pa	192 (7342)	3
Pit/terrace	260 (19077)	1
Transport/communication	106 (1459)	7
Other	401 (14011)	3
TOTAL	4149 (69,048)	6

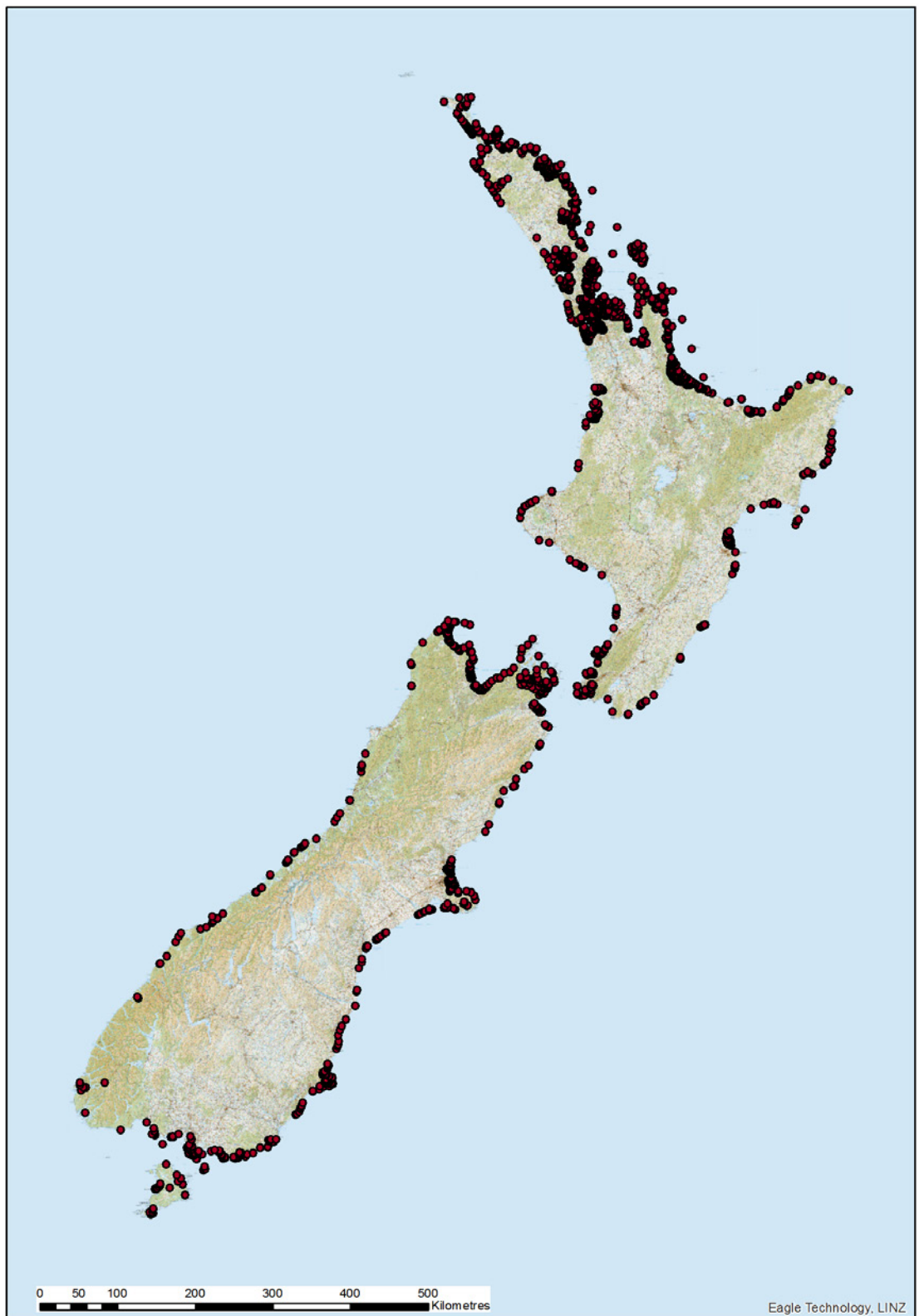


Figure 11. Location of 4129 New Zealand Archaeological Association (NZAA) archaeological sites located in the potential coastal inundation zone.

4.3 Assessment of DOC recreation functional locations

A recreation functional location (or ‘visitor site’, as it used to be known) is currently defined around existing facilities and services owned or managed by DOC. A recreation functional location is not generally created where there are no facilities or services. A recreation functional location has, within its boundaries, the same number of visitors and same main visitor group across all its length or area. It has one predominant visitor group (although it may have several other visitor groups using it). That visitor group is the predominant group across the whole length or area of the site. A recreation functional location can consist of more than one major site type (e.g. a track, plus a road, plus a car park).

Each asset in the ‘NATIS1.NATISADM.INFRASTRUCTURE_AMIS_Equipment’ dataset is linked to a recreation functional location. A total of 361 assets are located in potential coastal inundation zone, and these are linked to 145 unique recreation functional locations. This number is reduced to 119 recreation functional locations if ‘archaeological sites’, ‘machinery’ and ‘sheds’ are not considered (see Fig. 12 and Table A1 in Appendix 1).

The number of potentially vulnerable assets corresponding to each recreation functional location is included in Table A1. These numbers can be used to rank the recreation functional locations in terms of their potential vulnerability to coastal inundation (though total asset value and/or maintenance cost would likely be a better metric to use, if the data were available for all assets).

The following 18 recreation functional locations have five or more potentially vulnerable assets, ranked from greatest to fewest assets (number of assets shown in brackets), and hence may be considered to have moderate to high potential vulnerability to coastal inundation¹⁶:

- 1st: Rangitoto - Historic Bach Community (36)
- 2nd equal: Fishermans wharf, Milford (17) and Wairau Lagoons Walkway (17)
- 4th: Rangitoto - Wharf Area (16)
- 5th: ATC Tk - Bark Bay Hut and campsite (14)
- 6th: ATC Tk - Marahau to Onetahuti (11)
- 7th: Port Jackson Campsite / Muriwai Walk (9)
- 8th equal: Rangitoto - WWII Military Installations (8) and Milford Foreshore Walk (8)
- 10th: Farewell Spit houses (6)
- 11th equal: Gillespies Beach (5), Kaituna Quarry (5), Marahau crpk (5), Motutapu - Island Roads (5), Queen Charlotte Tk - Anakiwa to Te Mahia (5), Waipapa Point picnic area (5), Wairau Bar picnic area (5) and Waituna Lagoon picnic area (5)

¹⁶ The five or more assets threshold is an arbitrary level for determining ‘moderate to high’ potential vulnerability and can easily be altered or removed all together (i.e. all recreation function locations with any land in the potential coastal inundation zone could be considered potentially vulnerable).

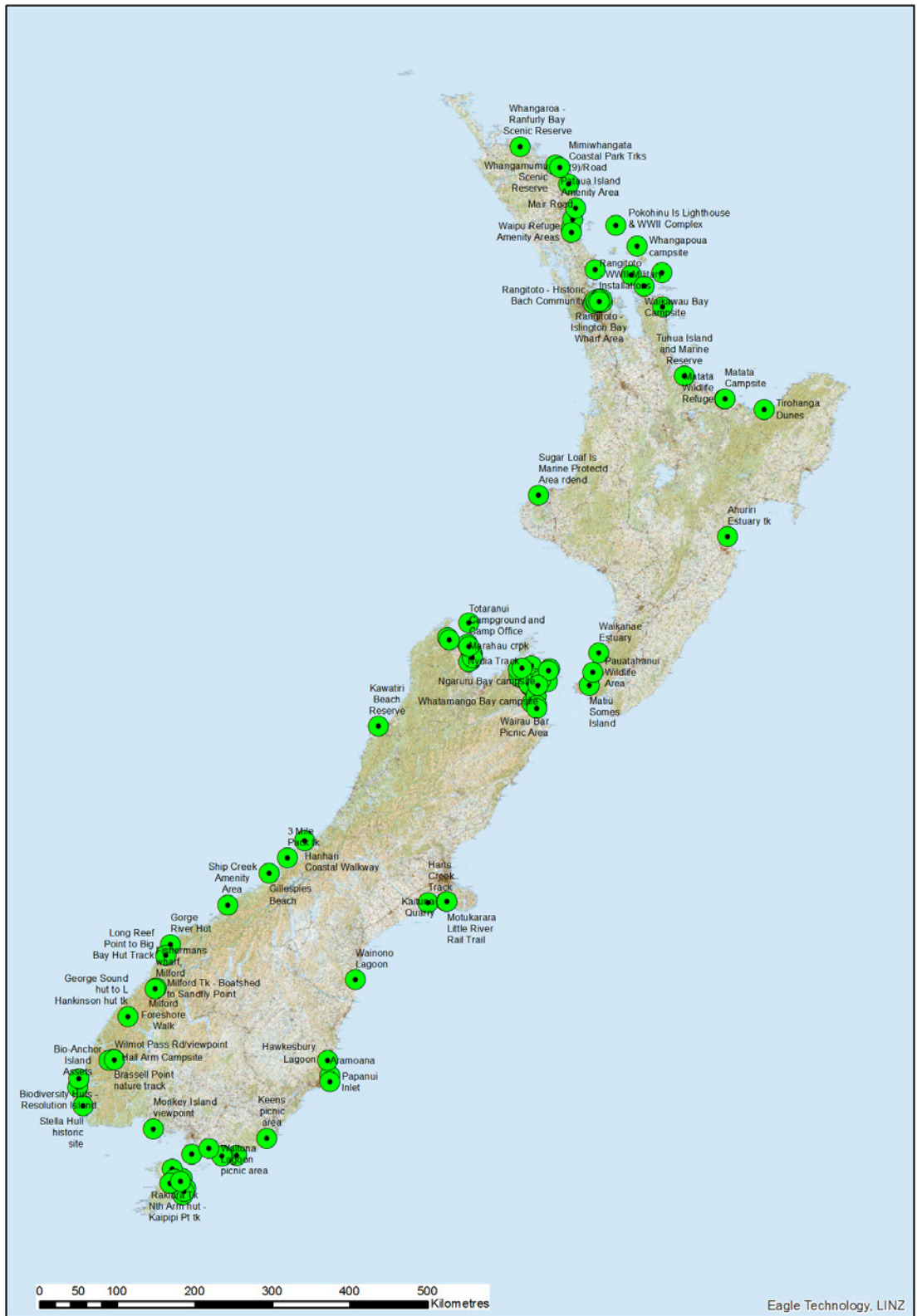


Figure 12. Location of 119 Department of Conservation (DOC) recreation functional locations containing one or more assets located in the potential coastal inundation zone (discounting archaeological sites, machinery, and sheds).

4.4 Assessment of DOC destinations

All visitor sites are categorised into one of four destination categories¹⁷. Each category was developed to meet the needs of a different user group. No category is more or less important than another. They help DOC to manage a destination to meet the primary user needs and determine where to focus to gain the best return for our efforts. The destination categories are:

- *Icon* sites are the places that support the growth of domestic and international tourism.
- *Gateway* destinations introduce new participants to outdoor recreation and are the best places to grow recreation in the outdoors
- *Local treasure* destinations are managed to grow community connection with, and use of, their locally important places.
- The *backcountry* network attracts a wide range of visitors to the more remote parts of the country.

The GIS layer 'NATIS1.NATISADM.INFRASTRUCTURE_DOC_DestinationPly' includes the location and attribute information of 169 DOC *Icon* and *Gateway* destinations¹⁸. Of these destinations 62 (37%) have some portion located in the potential coastal inundation zone (Table 8).

Table 8. Summary of the 62 Department of Conservation (DOC) *Icon* and *Gateway* destinations (as at 2012) with some part located in the potential coastal inundation zone. The number of potentially vulnerable assets¹⁹ is based on the intersect of 'destination', 'assets' and 'coastal inundation risk zone'. The length of potentially vulnerable track (in metres) is based on the intersect of 'destination', 'tracks' and 'coastal inundation risk zone'. The numbers in brackets are the percentage of the 'destination' total track length that is located in the coastal inundation zone. Destinations with 10 or more potentially vulnerable assets and/or more than 5% of potentially vulnerable track are highlighted.

DESTINATION	DESTINATION TYPE	NUMBER OF POTENTIALLY VULNERABLE ASSETS	METRES OF POTENTIALLY VULNERABLE TRACK (PERCENTAGE OF OVERALL TRACK LENGTH)
Abel Tasman Coast Track	Icon	62	4286 (5.9)
Cape Brett lighthouse/hut	Icon	0	0 (0)
Cape Foulwind	Icon	0	0 (0)
Cape Kidnappers Gannet Reserve	Icon	0	66 (2.8)
Cape Reinga (Te Rerenga Wairua)	Icon	0	0 (0)
Cape Reinga Coastal Track	Icon	0	2932 (6.4)
Cathedral Cove	Icon	1	51 (1.3)
Dolomite Point	Icon	0	0 (0)
Godley Head	Icon	0	0 (0)
Government Buildings	Icon	0	0 (0)
Kaikoura Peninsula Walkway	Icon	1	16 (0.3)
Kāpiti Island Nature Reserve	Icon	3	1872 (14.6)
Kerikeri Basin	Icon	0	62 (1.8)
Leigh Marine Reserve	Icon	0	333 (30.5)
Milford Sound/Piopirotahi	Icon	8	599 (53.7)
Milford Track	Icon	3	0 (0)
Moeraki Boulders	Icon	0	30 (7.8)
North Head	Icon	2	174 (6.6)

Continued on next page

¹⁷ Destinations are defined here: <http://intranet/recreation/managing-destinations/The-4-destination-categories/>

¹⁸ This GIS data layer was created in 2012 and is being updated. Currently, the layer does not include local treasure or backcountry destinations.

¹⁹ Assets include: amenity areas, buildings, fleet/vehicles, infrastructure, machinery and structures.

Table 8 continued

DESTINATION	DESTINATION TYPE	NUMBER OF POTENTIALLY VULNERABLE ASSETS	METRES OF POTENTIALLY VULNERABLE TRACK (PERCENTAGE OF OVERALL TRACK LENGTH)
Nugget Point	Icon	0	0 (0)
Poor Knights Marine Reserve	Icon	0	0 (0)
Rangitoto Summit and short walks	Icon	57	3099 (29.6)
Ship Cove	Icon	2	252 (18.4)
Ship Creek	Icon	4	0 (0)
Taiaroa Head	Icon	0	0 (0)
Tiritiri Matangi Island	Icon	0	53 (0.5)
Ulva Island	Icon	5	3 (0.1)
Ahuriri Estuary	Gateway	9	2431 (80.2)
Aotea Track	Gateway	0	70 (0.1)
Bluff Hill/Motupohue	Gateway	1	22 (0.4)
Bream Head tracks	Gateway	0	0 (0)
Castlepoint Scenic Reserve	Gateway	3	31 (1.3)
Fletcher Bay Campsite	Gateway	0	0 (0)
Heaphy Track	Gateway	0	194 (0.3)
Hollyford Track	Gateway	0	0 (0)
Home Bay/Motutapu	Gateway	12	575 (2.4)
Kawau Island Historic Reserve	Gateway	3	9 (0.2)
Kohaihai Campsite	Gateway	0	0 (0)
Little River Rail Trail	Gateway	2	2933 (12.9)
Maitai Bay	Gateway	0	307 (30.0)
Matata	Gateway	3	1075 (100)
Matiu (Somes) Island	Gateway	4	161 (5.1)
Mimiwhangata	Gateway	1	533 (3.3)
Momorangi Bay	Gateway	1	0 (0)
Okarito walks	Gateway	1	55 (1.0)
Oparara Basin	Gateway	0	0 (0)
Otamure	Gateway	0	5 (0.3)
Papatowai	Gateway	0	20 (0.3)
Puponga Farm Park	Gateway	6	8293 (38.5)
Putangirua Pinnacles	Gateway	0	0 (0)
Quail Island	Gateway	0	179 (3.1)
Queen Charlotte Track	Gateway	12	855 (1.2)
Rakiura Track	Gateway	1	798 (2.6)
Rangitoto tracks	Gateway	50	4964 (34.1)
Sandymount tracks	Gateway	0	6 (0.1)
Stony Bay Campsite	Gateway	0	0 (0)
Tapuae Marine Reserve and SLIMPA	Gateway	1	0 (0)
Te Tapuwae o Rongokako Marine Reserve	Gateway	0	0 (0)
Totaranui Campground	Gateway	2	102 (2.0)
Urupukapuka Island	Gateway	1	342 (3.1)
Waikawau Bay	Gateway	1	189 (18.2)
Whangaruru	Gateway	0	3 (0.1)
Whites Bay	Gateway	3	69 (0.9)

Seven Icon Destinations are highlighted in Table 8 as having 10 or more vulnerable assets and/or more than 5% of vulnerable track. Subjectively ranked from greatest to least vulnerable, these are:

- Abel Tasman Coast Track
- Rangitoto Summit and Short Walks
- Milford Sound/Piopiotahi
- Kāpiti Island Nature Reserve
- Cape Reinga Coastal Track
- Ship Cove
- North Head

Ten Gateway Destinations are also highlighted in Table 8. Subjectively ranked from greatest to least vulnerable, these are:

- Rangitoto tracks
- Pūponga Farm Park
- Ahuriri Estuary
- Queen Charlotte Track
- Home Bay/Motutapu
- Little River Rail Trail
- Matata
- Matiu (Somes) Island
- Waikawau Bay
- Maitai Bay

All these 17 Destinations may be identified as having *moderate to high potential vulnerability* to coastal inundation²⁰, with the **Abel Tasman Coast Track** (Icon), **Rangitoto Summit and Short Walks** (Icon), and **Rangitoto tracks** (Gateway) *requiring urgent detailed inundation risk evaluations*.

4.5 Assessment of DOC natural heritage management units

Ecosystem management in DOC is prioritised using a candidate set of around 1000 ecosystem management units (EMUs) that range in size from less than 1 ha to over 50,000 ha, with an average size of just over 3400 ha²¹. Wherever possible, EMUs contain sequences of related ecosystems, often with catchment-defined boundaries.

EMUs were identified using information from a range of sources, including expert identification of high-quality examples of particular ecosystems, previously identified sites of high ecological value (e.g. ecological areas), and sites that are currently receiving intensive management, including mainland islands. Together, the current set of EMUs contain a full range of New Zealand's terrestrial and freshwater ecosystems, including offshore islands, coastal turfs, lowland to montane forests, tussock grasslands, wetlands, lakes and rivers.

For management purposes, EMUs have been ranked using spatial prioritisation software (Zonation). Information about the distributions of threatened species is included with a low weight to favour the selection of sites where threatened species will also benefit from

²⁰ The 10 or more assets and/or more than 5% of track threshold is an arbitrary level for determining 'moderate to high' potential vulnerability and can easily be altered or removed all together (i.e. all destinations with any land in the potential coastal inundation zone could be considered potentially vulnerable).

²¹ See <http://intranet/natural-heritage/managing-natural-heritage/natural-heritage-management-system/prioritisation/ecosystems-prescriptions/>

management. The ranking process also takes account of existing gains from management, recognising that maintaining sites that are already in good condition is generally more cost effective than initiating work at new sites.

A smaller number of species management units (SMUs) have also been identified, containing sites that support significant populations of threatened species, but that were not considered to have significant ecosystem values.

The GIS layer 'NATIS1.NATISADM.OPERATIONAL_DOC_PrescriptionManagementUnits' includes the location and attribute information of DOC Prescription Management Units, including 'Ecosystem Management Units' (EMUs) and 'Species Management Units' (SMUs).

4.5.1 Ecosystem Management Units (EMUs)

In total, 260 EMUs have some fraction of land in the potential coastal inundation risk zone (out of a total of 980²² EMUs (26.5%) currently identified and mapped in New Zealand). Table 9 breaks down these 260 EMUs based on the proportion of potentially vulnerable land and EMU rank.

Table 9. Number of Department of Conservation (DOC) Ecosystem Management Units (EMUs) located in the potential coastal inundation zone, listed by decile bands (representing the proportion of vulnerable land). Also shown are the number of EMUs ranked in the top 100 and top 500²³ in each decile band. Superscripted numbers are the absolute rank of EMUs if ranked in the top 20.

PROPORTION OF EMU LAND LOCATED IN POTENTIAL COASTAL INUNDATION ZONE (%)	NUMBER OF EMUs IN THIS BAND	NUMBER OF EMUs RANKED IN TOP 100 IN THIS BAND	NUMBER OF EMUs RANKED IN TOP 500 IN THIS BAND
90.0–100.0	11	0	7
80.0–89.9	1	0	0
70.0–79.9	4	1	2
60.0–69.9	3	1	2
50.0–59.9	3	11	2
40.0–49.9	4	1	3
30.0–39.9	10	1	5
20.0–29.9	17	8 ^{2,7}	14
10.0–19.9	25	5 ^{3,16}	14
0.0–9.9	182	26 ^{4,5,9,10,11,13,14,18,19,20}	96
TOTAL (10.0–100.0)	78	18	49
TOTAL (0.0–100.0)	260	44	145

The following summary points can be made from the numbers in Table 9:

- 182 of the 260 potentially vulnerable EMUs (70%) have less than 10% of their total land area in the potential coastal inundation zone²⁴ – these 182 EMUs may be identified as having *low potential vulnerability*;
- The remaining 78 EMUs have 10% or more of their total land area in the potential coastal inundation zone – these 78 EMUs may be identified as having *moderate to high potential vulnerability*;

²² This total includes 35 Marine Reserves.

²³ Current operational targets are to prioritise work in the top 500 EMUs, hence this figure has been used here.

²⁴ The 10% or more threshold is an arbitrary level for determining 'moderate to high' potential vulnerability and can easily be altered or removed all together (i.e. all management units with any land in the potential coastal inundation zone could be considered potentially vulnerable).

- Of these 78 EMUs, 49 are ranked in the top 500 and 18 are ranked in the top 100 (including the top three ranked EMUs [1. **Sentinel Rock**, Marlborough Sounds; 2. **The Noises Islands**, Hauraki Gulf; and 3. **Motunau Island**, Bay of Plenty]) – these 49 EMUs may be identified as *requiring detailed inundation risk evaluation*;
- Seven EMUs ranked in the top 500 have between 80 and 100% of their land area located in the potential coastal inundation zone [**Brooklands**, Waimakariri River Mouth, Canterbury; **Opunake**, Taranaki; **Horseshoe Lagoon**, near Opihi River Mouth, Canterbury; **Opihi Rivermouth**, Canterbury; **Te Waihora/Lake Ellesmere**, Canterbury; **Wainono Lagoon**, Canterbury; and **Tuiraho (Stent Road)**, north of Cape Egmont, Taranaki] – these seven EMUs may be identified as *requiring urgent detailed inundation risk evaluation*.

4.5.2 Species Management Units (SMUs)

In total, 99 SMUs have some fraction of land in the potential coastal inundation risk zone (out of a total of 479 SMUs (20.7%) currently identified and mapped in New Zealand). Table 10 breaks down these 99 SMUs based on the proportion of potentially vulnerable land.

Table 10. Number of Species Management Units (SMUs) located in the potential coastal inundation zone, listed by decile bands (representing the proportion of vulnerable SMU land). Note, SMUs are currently unranked.

PROPORTION OF SMU LAND LOCATED IN POTENTIAL COASTAL INUNDATION ZONE (%)	NUMBER OF SMUs IN THIS BAND
90.0–100.0	3
80.0–89.9	3
70.0–79.9	1
60.0–69.9	1
50.0–59.9	3
40.0–49.9	7
30.0–39.9	4
20.0–29.9	3
10.0–19.9	11
0.0–9.9	63
TOTAL (10.0–100.0)	36
TOTAL (0.0–100.0)	99

The following summary points can be made from the numbers in Table 10:

- 63 of the 99 potentially vulnerable SMUs (64%) have less than 10% of their total land area in the potential coastal inundation zone – these 63 SMUs may be identified as having *low potential vulnerability*;
- The remaining 36 SMUs have 10% or more of their total land area in the potential coastal inundation zone – these 36 SMUs may be identified as having *moderate to high potential vulnerability*;
- Six SMUs have between 80 and 100% of their land area located in the potential coastal inundation zone [**Waioioi Reef**, Albatross Point, Waikato; **Bird Island**, off the Otago Peninsula; **Chesterfield**, West Coast; **Bridge Point**, near Orore Point, South Canterbury; **Waikoura Point Coast**, Matakana Island, Tauranga Harbour, Bay of Plenty; and **Maketu Spit**, Maketu, Bay of Plenty] – these six SMUs may be identified as *requiring urgent detailed inundation risk evaluation*.

5. Conclusions

This report (and the associated GIS datasets) identifies DOC assets, archaeological sites, recreation functional locations, destinations and ecosystem and species management units located in a potential coastal inundation (flooding caused by high seas) risk zone, based on a national enhanced Digital Elevation Model (DEM). This zone presents low-lying coastal land that is '*potentially vulnerable*' to inundation from the sea, now and in the future within this century. As the sea rises over the course of this century and beyond, the inundation risk at these locations will be exacerbated (i.e. occur more frequently and deeper flooding) and increasingly extend inland. The identification of these potentially at-risk sites will inform DOC policy, prioritisation processes and operational management activities as part of DOC's overall responsibilities for these areas.

Due to accuracy limitations of the national DEM, the elevation contour data have been used to identify coastal locations that are '*potentially vulnerable*' to inundation from the sea, now and in the future. Thus, the information in this report should be used as a national-scale coastal risk-exposure screening assessment to guide DOC priorities. More detailed risk assessment of specific locations using a two-stage approach involving analysis of historical records, local knowledge and site visits followed by detailed mapping using LiDAR-derived DEM data should follow this national-level study and where appropriate. These assessments could also include the potential for coastal erosion and elevated groundwater impacts.

5.1 Assets

While by far the majority (approx. 97%) of DOC assets are *not located* in the potential coastal inundation zone, a total of **331 assets** are potentially at risk. In summary, there are 20 campgrounds, 29 maintained areas, 1 playground, 127 buildings (ranging from 34 toilets to 1 visitor centre), 26 infrastructure assets, 2 items of machinery and 126 structures (ranging from 41 boardwalks to 4 steel pedestrian bridges).

5.2 Archaeological sites

Based on the dataset owned by the New Zealand Archaeological Association, a total of 4149 archaeological sites are located in the potential coastal inundation risk zone, representing 6% of all the sites in the country. Of these, **420 sites (5%) are located on PCL** (out of a total of 8026 PCL sites). DOC has a responsibility to protect these sites from avoidable harm.

5.3 Recreation functional locations

Each DOC asset is linked to a recreation functional location. If 'archaeological sites', 'machinery' and 'sheds' are not considered, then a total of **119 recreation functional locations** containing at least one potentially vulnerable asset are potentially at risk. The following 18 recreation functional locations have five or more potentially vulnerable assets (the number of assets shown in brackets), and hence have *moderate to high potential vulnerability* to coastal inundation: Rangitoto – Historic Bach Community (36); Fishermans wharf, Milford (17); Wairau Lagoons Walkway (17); Rangitoto – Wharf Area (16); Abel Tasman Coast Track – Bark Bay Hut and campsite (14); Abel Tasman Coast Track – Marahau to Onetahuti (11); Port Jackson Campsite / Muriwai Walk (9); Rangitoto – WWII Military Installations (8); Milford Foreshore Walk (8); Farewell Spit houses (6); Gillespies Beach (5); Kaituna Quarry (5); Marahau carpark (5); Motutapu – Island Roads (5); Queen Charlotte Track – Anakiwa to Te Mahia (5); Waipapa Point picnic area (5); Wairau Bar picnic area (5); and Waituna Lagoon picnic area (5).

5.4 Destinations

The 'destination' GIS layer includes the location and attribute information of 169 DOC *Icon* and *Gateway* destinations. **62 of these destinations** (37%) have some part of their delineated polygon located in the potential coastal inundation zone. **Seven Icon Destinations** have 10 or more vulnerable assets and/or more than 5% of vulnerable track. These are: Abel Tasman Coast Track; Rangitoto Summit and Short Walks; Milford Sound/Piopiota; Kapiti Island Nature Reserve; Cape Reinga Coastal Track; Ship Cove and North Head. A further **10 Gateway Destinations** also meet this criterion. These are: Rangitoto tracks; Puonga Farm Park; Ahuriri Estuary; Queen Charlotte Track; Home Bay / Motutapu; Little River Rail Trail; Matata; Matiu (Somes) Island; Waikawau Bay and Maitai Bay. All these 17 Destinations therefore have *moderate to high potential vulnerability* to coastal inundation, with the **Abel Tasman Coast Track** (Icon), **Rangitoto Summit and Short Walks** (Icon), and **Rangitoto tracks** (Gateway) *requiring urgent detailed inundation risk evaluation*.

5.5 Ecosystem Management Units (EMUs)

260 Ecosystem Management Units (EMUs) have some portion of land in the potential coastal inundation risk zone (out of a total of 980 EMUs (26.5%) currently identified and mapped in New Zealand). 78 of these 260 EMUs have 10% or more of their total land area in the potential coastal inundation zone – these 78 EMUs therefore have *moderate to high potential vulnerability*. Of these 78 EMUs, 49 are ranked in the top 500 and 18 are ranked in the top 100 (including the top three ranked EMUs [**1. Sentinel Rock**, Marlborough Sounds; **2. The Noises Islands**, Hauraki Gulf; and **3. Motunau Island**, Bay of Plenty]) – these 49 EMUs therefore *require detailed inundation risk evaluation*. Seven EMUs ranked in the top 500 have between 80 and 100% of their land area located in the potential coastal inundation zone [**Brooklands**, Waimakariri River Mouth, Canterbury; **Opunake**, Taranaki; **Horseshoe Lagoon**, near Opihi River Mouth, Canterbury; **Opihi Rivermouth**, Canterbury; **Te Waihora / Lake Ellesmere**, Canterbury; **Wainono Lagoon**, Canterbury; and **Tuiraho (Stent Road)**, north of Cape Egmont, Taranaki] – these seven EMUs therefore *require urgent detailed inundation risk evaluation*.

5.6 Species Management Units (SMUs)

99 Species Management Units (SMUs) have some portion of land in the potential coastal inundation risk zone (out of a total of 479 SMUs (20.7%) currently identified and mapped in New Zealand). 36 SMUs have 10% or more of their total land area in the potential coastal inundation zone – these 36 SMUs therefore have *moderate to high potential vulnerability*. Six of these SMUs have between 80 and 100% of their land area located in the potential coastal inundation zone [**Waioioi Reef**, Albatross Point, Waikato; **Bird Island Otago**, off the Otago Peninsula; **Chesterfield**, West Coast; **Bridge Point**, near Orore Point, South Canterbury; **Waikoura Point Coast**, Matakana Island, Tauranga Harbour, Bay of Plenty; and **Maketu Spit**, Maketu, Bay of Plenty] – these six SMUs therefore *require urgent detailed inundation risk evaluation*.

6. Recommendations

The GIS layer showing the national potential coastal inundation zone plus all the intersect layers created as part of this assessment **should be made available to DOC's GIS team**, be included in the NATIS1 database, and depicted in the 'DOC GIS' interface system.

Locations with moderate to high potential vulnerability identified in this report should be assessed in greater detail using a two-stage risk assessment approach. Firstly, these locations should be analysed based on photos, records of historical flooding events, local knowledge and site visits. Secondly, LiDAR-derived²⁵ DEM data, if available, should be utilised to produce detailed maps of current and future inundation risk.

Identifying potentially vulnerable assets, heritage sites and places provided for visitors (e.g. functional recreation locations and destinations) will **enable more informed actions** by the relevant DOC groups, including the following:

- Long-term planning for recreation and concessions in conservation management strategies and some national park management plans. **The information should be made available to DOC's statutory planners.**
- Planning for future capital investment at these places, either to replace existing assets or to build new ones. **The information should be made available to DOC's regional operations planning teams** who will be able to use it to better inform capital business cases.
- Planning for maintenance of existing at-risk facilities and places. **The information should be made available to DOC's district operations staff responsible for planning and scheduling maintenance.**
- Improving information provided to visitors about the impacts of potential coastal inundation on specific significant assets (like huts and campsites) and places. This may be pre-visit information (e.g. DOC website) or on-site signs. **The information should be analysed to determine whether DOC's visitor information about these places needs to be changed or improved.**
- Advice to be provided at the national level that takes account of this information in regional recreation and tourism (and cultural heritage) planning. **The information should be provided to DOC's Recreation, Tourism and Heritage Unit.**

Identifying **potentially vulnerable Ecosystem and Species Management Units** will better enable the following:

- Identifying natural heritage management units where pressures related to climate change should be included in management prescriptions. At present, 180 EMU and 54 SMU prescriptions include reference to the pressure 'climate change effects', and this may not cover those identified by the spatial analysis summarised above. **The information should be made available to DOC's regional operations planning teams.**
- Consideration of ways to include physical hazard information (e.g. the potential coastal inundation risk zone, as well as other hazard layers such as high winds and river flooding risk) in the current model for EMU prioritisation (i.e. the Zonation model). **The information should be made available to DOC's Planning, Monitoring and Reporting Unit.**
- Advice to be provided to DOC staff involved in planning for species translocations (i.e. it would be undesirable to translocate a species to a location that is potentially vulnerable to coastal inundation). **The information should be made available to DOC's Terrestrial Ecosystems Unit.**

²⁵ Light Detection And Ranging, a laser-based aerial scanning method for measuring elevations.

7. Acknowledgement

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The report was reviewed by Rob Bell (Principal Scientist – Coastal and Estuarine Physical Processes, NIWA) and Jenny Christie (Science Advisor – Threats, DOC).

8. References

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Appendix 1

DOC recreation functional locations (119) containing one or more assets located in the potential coastal inundation zone (discounting archaeological sites, machinery, and sheds)

FUNCTION_LOCATION_DESCRIPTION	FLOC	NUMBER OF VULNERABLE ASSETS
3 Mile Pack tk	DS-34-115-6032	1
Ackers Point tk	DS-40-115-0011	1
Ahuriri Estuary tk	DN-26-105-2033	2
Aramoana	DS-38-115-2103	2
ATC Tk - Akersten Bay campsite	DS-30-110-0164	2
ATC Tk - Apple Tree Bay campsite	DS-30-110-0166	3
ATC Tk - Bark Bay Hut & campsite	DS-30-110-0154	14
ATC Tk - Marahau to Onetahuti	DS-30-110-0150	11
ATC Tk - Medlands Beach	DS-30-110-0156	1
ATC Tk - Mosquito Bay campsite	DS-30-110-0153	1
ATC Tk - Mutton Cove camp	DS-30-105-0111	1
ATC Tk - Onetahuti Bay Campsite	DS-30-110-0151	2
ATC Tk - Te Pukatea Bay Campsite	DS-30-110-0160	1
ATC Tk - Tonga Quarry campsite	DS-30-110-0152	1
ATC Tk - Torrent Bay Village campsite	DS-30-110-0157	1
BIO-ANCHOR ISLAND ASSETS	DS-40-110-0626	1
Biodiversity Huts - Resolution Island	DS-40-110-0631	1
Bluegum Corner Amenity Area	DS-32-110-0979	2
Brassell Point nature track	DS-40-110-0506	1
Bream Bay Southern / Tip Road	DN-10-120-0194	1
Camp Bay campsite	DS-32-105-0610	1
Cannibal Cove campsite	DS-32-105-0623	1
Chew Tobacco Hunter Hut	DS-40-115-0079	1
Cowshed Bay campsite	DS-32-105-0487	1
Curio Bay Petrified Forest walk	DS-40-105-0108	3
Cuvier Island	DN-14-105-1031	1
Farewell Spit houses	DS-30-105-0120	6
Ferndale campsite	DS-32-105-0495	1
Fishermans wharf, Milford	DS-40-110-0334	17
Fort Takapuna Historic Reserve	DN-12-115-1015	1
Foveaux w/way	DS-40-105-0145	1
George Sound hut to L Hankinson hut tk	DS-40-110-0413	2
Gillespies Beach	DS-34-115-7005	5
Gorge River Hut	DS-34-115-8004	1
Grovetown Lagoons Amenity Area	DS-32-110-0967	1
Hahei Beach Short Walk	DN-14-105-2128	1
Hall Arm Campsite	DS-40-110-0528	3
Hapatuna Hunter Hut	DS-40-115-0065	1
Harihari Coastal Walkway	DS-34-115-6014	1
Harts Creek Track	DS-36-105-5064	2
Hawkesbury Lagoon	DS-38-115-2018	1
Jacobs Bay campsite	DS-32-105-0461	1
Kaituna Quarry	DS-36-105-5045	5

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Appendix 1 continued

FUNCTION_LOCATION_DESCRIPTION	FLOC	NUMBER OF VULNERABLE ASSETS
Kauauroa Bay campsite	DS-32-105-0478	1
Kawatiri Beach Reserve	DS-34-105-2024	2
Kawau Sunny Bay	DN-12-105-3005	1
Keens picnic area	DS-40-105-7022	1
Kumutoto Bay (West) campsite/Track	DS-32-105-0618	2
Long Reef Point to Big Bay Hut Track	DS-40-110-0314	1
Mair Road	DN-10-120-0006	1
Marahau crpk	DS-30-110-0169	5
Matai Bay Hut	DS-32-105-0542	1
Matata Campsite	DN-16-115-0299	2
Matata Wildlife Refuge	DN-16-115-0301	1
Matiu Somes Island	DN-28-120-0187	3
Milford Foreshore Walk	DS-40-110-0625	8
Milford Tk - Boatshed to Sandfly Point	DS-40-110-0343	3
Millars Beach - Whalers Base tk	DS-40-115-0027	1
Milnthorpe Reserve	DS-30-105-0136	2
Mimiwhangata Coastal Park Trks (9)/Road	DN-10-120-1051	1
Momorangi Bay motorcamp	DS-32-105-0631	1
Monkey Island viewpoint	DS-40-105-0261	1
Motuihe - HMNZS Tamaki/Quarantine Stn	DN-12-115-2032	1
Motukarara Little River Rail Trail	DS-36-105-5093	2
Motutapu - Home Bay Area	DN-12-115-2021	1
Motutapu - Island Roads	DN-12-115-2025	5
Ngakuta Bay picnic area	DS-32-105-0635	1
Ngaruru Bay campsite	DS-32-105-0630	2
Nikau Cove campsite	DS-32-105-0488	2
North Head - Historic Reserve	DN-12-115-1012	3
North Tikotatahi Hunter Hut	DS-40-115-0071	1
NW Circuit Murray Hunter Camp	DS-40-115-0730	3
Nydia Lodge Associated Track	DS-32-105-0453	3
Nydia Track	DS-32-105-0452	1
Onekaka picnic area	DS-30-105-0039	2
Papanui Inlet	DS-38-115-2032	1
Pataua Island Amenity Area	DN-10-120-0110	1
Pauatahanui Wildlife Area	DN-28-120-0006	1
Penzance crpk	DS-32-105-0469	4
Pitt Head Track	DS-30-110-0172	1
Pokohinu Is Lighthouse & WWII Complex	DN-12-110-5061	1
Port Adventure Hunter Hut	DS-40-115-0068	1
Port Jackson Campsite / Muriwai Walk	DN-14-105-1016	9
Queen Charlotte Tk - Anakiwa to Te Mahia	DS-32-105-0647	5
Rakiura Tk - Nth Arm hut - Kaipipi Pt tk	DS-40-115-0035	1
Rangitoto - Historic Bach Community	DN-12-115-2000	36
Rangitoto - Island Roads	DN-12-115-2009	1
Rangitoto - Islington Bay Wharf Area	DN-12-115-2011	1
Rangitoto - Wharf Area	DN-12-115-2001	16
Rangitoto - WWII Military Installations	DN-12-115-2016	8
Rarangi Campsite	DS-32-110-0764	2
Rarangi Picnic Area	DS-32-110-0765	1
Ratimera Bay campsite	DS-32-105-0621	1

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Appendix 1 continued

FUNCTION_LOCATION_DESCRIPTION	FLOC	NUMBER OF VULNERABLE ASSETS
S.S. Tararua Wreck Site	DS-40-105-0187	1
Ship Cove Historic Reserve	DS-32-105-0612	3
Ship Creek Amenity Area	DS-34-115-8040	2
Stella Hull historic site	DS-40-110-0465	1
Stewart Island Bio Assets	DS-40-115-0765	1
Sugar Loaf Is Marine Protectd Area rrend	DN-22-105-0222	1
Tawa Bay campsite	DS-32-105-0476	2
Tirohanga Dunes	DN-16-115-0140	2
Tolsons tk/Freds Camp to Rakeahua hut tk	DS-40-115-0056	1
Totaranui Campground and Camp Office	DS-30-105-0108	2
Tuhua Island and Marine Reserve	DN-16-110-0354	1
Ulva Is-Sydney Cove/Flagstaf Lookout tks	DS-40-115-0019	2
Urupukapuka Island Recreation Reserve	DN-10-115-1018	1
Waikanae Estuary	DN-28-115-0004	4
Waikawau Bay Campsite	DN-14-105-1025	1
Wainono Lagoon	DS-36-110-3102	1
Waipapa Point picnic area	DS-40-105-0125	5
Waipu Refuge Amenity Areas	DN-10-120-0360	1
Wairau Bar Picnic Area	DS-32-110-0755	5
Wairau Lagoons Walkway	DS-32-110-0767	17
Waituna Lagoon picnic area	DS-40-105-9947	5
Whangamumu Scenic Reserve	DN-10-115-1025	2
Whangapoua campsite	DN-12-110-5008	3
Whangaroa - Ranfurly Bay Scenic Reserve	DN-10-115-2042	1
Whatamango Bay campsite	DS-32-105-0641	2
Wilmot Pass Rd/viewpoint	DS-40-110-0441	1