APPENDIX C

An assessment of ecological effects of the proposed Eastern Bays Shared Path Project on coastal vegetation and avifauna

Prepared for:

Hutt City Council

11 April 2019

Sustainability Solutions

Mapua

An assessment of ecological effects of the proposed Eastern Bays Shared Path Project on coastal vegetation and avifauna

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Date:	11 April 2019
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COVER PHOTOGRAPH: Variable oystercatcher pair feeding in bedrock and cobble field habitat, Sorrento Bay. The prey item held by one bird is probably a blue mussel (*Mytilus galloprovincialis*; Nick Hempston, EOS Ecology, pers. comm.). A juvenile bird was seen with two adults at this locality the following day. Photo: P1090841, 2016-05-02.

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Revision History

Revision Nº	Prepared By	Description	Date
V1	Fred Overmars	1st draft	2018-05-18
V2	Fred Overmars	2nd draft	2018-09-18
V3	Fred Overmars	Draft for client comment	2019-03-03
	Fred Overmars	Final	2019-04-11

Document Acceptance

Action	Name	Signed	Date
Reviewed by	Dr John Cockrem (Kororā Ornithology)		2018-05-20, 2019-03-11
Approved by	Fred Overmars for Sustainability Solutions		2019-04-11

Suggested Citation

Overmars, F. 2019. An assessment of environmental effects of the proposed Eastern Bays Shared Path project on coastal vegetation and avifauna. Mapua, NZ: Sustainability Solutions. 122 p. + appendices.

EXECUTIVE SUMMARY

1. Hutt City Council proposes to construct a shared path for pedestrians and cyclists along the coastal edge of Marine Drive between Point Howard Ngau Matau and Eastbourne, in the Eastern Bays (Shared Path Project, SPP). The shared path has two parts: Point Howard to Sunshine Bay (3.29 km) and Windy Point (513 m). The proposed predominant path widths are 3.5 m and 2.5 m.

2. Where the shared path adjoins Wellington Harbour Te Whanganui-a-Tara (3.08 km), it is proposed in the main to replace existing seawalls of older design by fit-for-purpose modern structures intended to be resilient to storm surges, to reduce current wave overtopping on Marine Drive, and to be adaptable to accommodate sea-level rise. Minor lengths are proposed for seawall upgrade or for new seawalls. There are three proposed seawall structure types: curved concrete seawalls (principally double, also single and triple); revetment (new or upgraded); and access steps and ramps.

3. A primary aim for the coastal vegetation and avifauna of the SPP area[1] must now be their long-term ecological resilience and restoration in an environment characterised by the inevitability of significant sea-level rise (but deep uncertainty over its rates and consequences). Mitigations proposed for the SPP should consider ways in which they can continue to provide ecological benefit as sea level rises.

Study Methods

4. Surveys of coastal vegetation and avifauna were undertaken over the project area plus a 'zone of influence' that covers the likely maximum spatial extent of potential project effects. Little penguins in eastern Wellington Harbour were surveyed. Survey data and other information were compiled and analysed, including use of GIS in conjunction with SPP design data. Methods for ecological value and effects assessments are based on the Environment Institute of Australia and New Zealand guidelines for Ecological Impact Assessment in New Zealand.

Existing vascular vegetation and flora

5. The SPP area lies in a transition zone from Marine Drive (on an emergent coastal platform raised by the 1855 Wairarapa earthquake), through seawalls (on the platform margin plus some encroachment), to the backshore, foreshore and marine environments. Marine Drive and the seawalls are highly modified now terrestrial environments. Seaward, the coastal environment has experienced modification to the sediment regime but remains characterised by largely indigenous biota in an environment of dynamic natural coastal processes (such as tides, wind, salinity, high solar radiation, desiccation, sediment movement, waves and water habitat).

[1] The term 'SPP area' in this report refers to the SPP footprint and its immediate environs relevant to the biota and ecosystems being addressed, including beach nourishment areas.

6. Vegetation habitats in the SPP area are seagrass in the intertidal and subtidal, beach gravels and sands, rocky islets, rocky headlands and promontories, landscape plantings and open space habitats.

7. Three seagrass (rimurēhia, *Zostera muelleri* subsp. *novazelandica*) occurrences of varied densities were found in the intertidal and subtidal zones at south Whiorau / Lowry Bay (total area 1940 m^2). A small number of flowering shoots were found, an indicator of seagrass health. Seagrass was not found at Point Howard or York Bay. This seagrass occurrence is small relative to its regional and national extent. Seagrass is no longer present at two historical sites in Wellington Harbour and the Lowry Bay site is now the only known occurrence remaining in the Harbour.

8. A sparse vegetation cover (<20%) occurs on narrow stretches of beach gravels and sands above Mean High Water Springs (MHWS) in Whiorau/Lowry, York and Sunshine Bays and at Windy Point. Two native sand binders, pīngao (*Ficinia spiralis*) and kowhangatara (*Spinifex sericeus*), were found at Lowry Bay. Introduced herbaceous species were the most frequent and had the greatest cover. Erosion over the past 2–3 years has caused significant loss of beach gravel and sand vegetation cover.

9. The vascular flora of the survey area is comprised largely of introduced species (44 of 77 species identified, 58%). Thirty species (39%) are indigenous. One Nationally Critical (*Atriplex cinerea*) and eight At Risk indigenous plant species occur within, or very near to, the shared path footprint. Two of these species are restoration plantings (*Atriplex cinerea*, pīngao). Six are in HCC landscape plantings at Point Howard and Windy Point. The seagrass in Lowry Bay is the only one not derived in some way from human agency.

10. The small gravel beaches or narrow gravel lenses present in all five bays that belong to a naturally uncommon ecosystem (shingle beaches) that is classified as Endangered.

Assessment of effects on vascular vegetation and flora

11. Sites within the project area and zone of influence have high ecological value associated with the presence of seagrass and eight other Threatened and At Risk plant species.[2] The part of the project area seaward of existing seawalls and Marine Drive has high ecological context value as an environment of natural coastal processes, and the gravel beaches have a moderate ecological value.

12. Seagrass beds are potentially at risk during construction from partial burial when extending the seaward toe of the existing beach during the placement of beach nourishment sediments, and from turbidity in excess of the ambient turbidity from release of fines. Post-construction, they are at risk of partial burial from movement of the beach profile and flattening of its slope in response to coastal processes. Proposed mitigation includes separation and disposal offsite

[2] The conservation status, location, abundance, potential effects and mitigation for all Threatened and At Risk vascular plant and coastal avifauna species in the SPP area are shown at **Table ES 1.**

of silts and clays in beach excavation sediments; use of beach nourishment sediments that similar or slightly coarser than in situ sediments, that will maintain the existing profile without spreading onto seagrass beds; excluding fine sediments from beach nourishment sediments; and undertaking beach nourishment in winter when seagrass metabolism is least active. After mitigation, there likely will be minor change in seagrass and seagrass sediment systems adjoining beach nourishment sites. These will be within the existing dynamics, resulting in minimal effects on seagrass beds. The post-mitigation level of effects on seagrass will be low.

13. The beach nourishment will marginally raise the seabed level in Lowry Bay, benefitting seagrass at its nearshore margin for a period as it responds to sea-level rise (an adaptive pathway). Seagrass has some capability to respond to sea-level rise but without future human intervention is at high risk of being squeezed out of its natural depth range at Lowry Bay.

14. The proposed shared path alignment will affect six At Risk species in HCC landscape plantings. Proposed mitigation is transplanting existing plants to adjoining currently grassed areas or to adjoining reserves such as Whiorau. Some *Atriplex cinerea* plantings may be vulnerable to crushing by project vehicles and machinery: proposed mitigation includes recognition of sites in the CEMP, and landscaping to create a low barrier for vehicles. The anticipated post-mitigation level of effects for all these species is negligible.

15. A single pīngao plant is located within the 3.5 m wide seawall/shared path footprint at Lowry Bay and its habitat will be lost. It is proposed to translocate the plant immediately seaward of the footprint in conjunction with beach nourishment, resulting in negligible post-mitigation level of effects. The translocation is an adaptive sea-level rise option and will prolong its existence at Lowry Bay in the face of sea-level rise.

16. Although a naturally uncommon ecosystem that is classified as Endangered, the gravel beach ecosystem in the SPP area is of moderate ecological value because of its small extent, highly modified condition, and the erosion occurring within the natural variability of the coastal sediment system in the Eastern Bays. The vegetated parts of the gravel beach ecosystem at Lowry Bay will be translocated into the beach nourishment area (with the pīngao). Elsewhere this ecosystem will be largely lost at construction time under the shared path and seawalls footprint. Any habitat remaining in the construction zone may be disturbed by works or machinery. Mitigation includes translocation at Lowry Bay and measures in the CEMP to ensure that construction effects on remaining gravel beach ecosystems is appropriately mitigated. The post-mitigation level of effects on the gravel beach ecosystem is low.

17. Given predicted sea-level rise projections and current erosion, the gravel beach ecosystem will be sustained for a period at Lowry Bay by the beach nourishment. Future retention elsewhere in the SPP area is unlikely.

Existing avifauna and habitats

18. The survey results and long-run Ornithological Society of New Zealand survey data indicate the most numerous bird species using coastline and harbour habitats within the Eastern Bays

area are fluttering shearwater, southern black-backed gull, red-billed gull, little black shag, little shag, variable oystercatcher and white-fronted tern. There are small numbers of Australasian gannet, black shag and spotted shag, while reef heron, pied shag, Caspian tern and NZ kingfisher are in very low numbers or irregularly present. Habitat use is greatest during the autumn and winter influx for fluttering shearwater, Australasian gannet, little shag, little black shag, spotted shag, red-billed gull and white-fronted tern (mainly autumn). Species resident through the year include black shag, reef heron, variable oystercatcher, southern black-backed gull and Caspian tern. Variable oystercatcher was the only confirmed breeding species (at Sorrento Bay).

19. Coastal avifauna habitat use above MHWS includes little shag, black shag, spotted shag and little black shag roosting on rocky islets and headland spots; and red-billed gull, black-backed gull and variable oystercatcher roosting and feeding on beaches especially when the tide is in. Red-billed gull, black-backed gull and variable oystercatcher are the primary users of the intertidal zone on beaches, while rocky intertidal habitats are also the domain of oystercatchers and reef heron. Shallow offshore waters with rocky subtidal reefs are feeding habitat for the red-billed gull, southern black-backed gull, and little shag, little black shag and black shag. Fluttering shearwater, giant petrel, Australasian gannet, spotted shag, Caspian tern and white-fronted tern are found in deeper offshore waters.

20. During the field surveys, highest numbers of birds were observed in Point Howard-Sorrento Bays (79% of all birds). This may be related to the greater variety of habitats present and sheltered conditions at the time.

Assessment of effects on indigenous avifauna and habitats

21. Backshore, intertidal and close inshore habitats of the SPP area include very high value avifauna habitat for the presence of one Nationally Threatened species (reef heron, in very low and declining numbers), and high value avifauna habitat for five At Risk species: black shag, pied shag, little black shag, variable oystercatcher and red-billed gull.

22. Potential effects on coastal avifauna and habitats during the construction phase (sedimentation, food and waste, noise and disturbance, artificial lighting) are localised in space and time and effective mitigation measures are proposed.

23. The primary SPP operational phase effect on coastal avifauna is encroachment and the consequential loss of avifauna habitat. The effect of the proposed beach nourishment will be to retain the existing extent of backshore habitat at Point Howard and in Lowry and York Bays (reducing with sea-level rise), and to shift almost the full extent of encroachment in those three bays into the intertidal zone. Total proposed encroachment is 5836 m^2, of which *c.* 1506 m^2 is backshore habitat (37% of its local extent) and *c.* 4260 m^2 is intertidal habitat (12% of its local extent).

24. Project design measures to reduce the extent of encroachment include the choice of steeply rising curved seawalls as the predominant seawall design, adoption of curved seawall designs

rather than large revetment structures at north Lowry Bay and south Lowry Bay, landward realignment of Marine Drive to reduce beach encroachment at two areas, and the use of parallel steps, ministeps and boat ramps and an increased angle for ramps.

25. Potential effects of encroachment will be most significant for one Threatened and two At Risk species: reef heron, variable oystercatcher, and red-billed gull.

26. Reef heron numbers in the Eastern Bays have declined in recent decades and currently there is just one regularly seen but non-resident bird in the Point Howard-Sorrento Bay area. While it is undesirable to lose any habitat area in one of the very few known reef heron locations on the Wellington Harbour shoreline, any effect of encroachment in this locality is unlikely to be distinguishable from other causes contributing to this decline.

27. Available data indicates there is likely to be a reduction, caused by encroachment, in red-billed gull and variable oystercatcher numbers within the SPP area, perhaps of the order of 15–25% and less than 10 birds at any one count for each of the two species. Opportunities to mitigate the effects of the proposed habitat loss through increasing habitat quality or creating new habitat in the SPP locality are not readily available. The red-billed gull total population is currently estimated at >100 000 mature individuals with a predicted decline of 10–70%; the variable oystercatcher population is 1000–5000 mature individuals with a predicted increase of >10%. While it is undesirable to lose habitat area for these two At Risk species, and there will be an effect on the SPP area population, the effect on a population basis is low.

28. In creating a safe facility for human walking and cycling between Marine Drive and the coastline, the shared path will increase the number of people, and potentially dogs, recreating in the coastal zone, which will potentially increase the existing levels of disturbance of coastal avifauna. The coastal avifauna species present will be at some risk from increased disturbance. Proposed mitigation for this effect is to educate the public on the need for responsible dog management through signage on the high avifauna values within the SPP area and the provisions of the Hutt City Council Dog Control Policy 2015.

29. Overall, the post-mitigation level of effects on Threatened and At Risk indigenous avifauna and their habitats in the SPP area have been assessed as low (black shag, pied shag, little black shag, reef heron, variable oystercatcher, red-billed gull). There will be no effects on fluttering shearwater, giant petrel, Caspian tern or white-fronted tern present in offshore habitats.

Little penguins and their habitats

30. Australasian little penguins comprise two genetically distinct species, one restricted to New Zealand (*Eudyptula minor*, 'NZ little penguin') and the other occurring in Australia and Otago. The NZ little penguin has an At Risk - Declining conservation status.

31. Because of their evolutionary history, little penguins must balance living in two worlds—water for feeding, land for breeding.

32. Little penguin surveys in 2016 and 2017 in the Eastern Bays (and four local records) found an estimated 101 breeding sites, 42 of them in the SPP area. Six breeding sites were inland of Marine Drive. The survey data underestimate the number of penguin breeding sites in the SPP area. This report accepts that an additional 5–15 breeding sites are likely to be present inland of Marine Drive in the SPP area.

33. Survey data and other evidence indicate the current little penguin population is of the order of 50–60 pairs in the SPP area and 110–120 pairs in the wider Eastern Bays (*c.* 12–14% and *c.* 26–28% respectively of the estimated 420 pairs in Wellington Harbour). Given the life history strategy of little penguins relies on a high level of adult survival, the numbers of injured penguins cared for in the late 1990s by the Eastern Bays Little Blue Penguin Foundation in conjunction with the survival of the population suggest significantly higher numbers were then present in the Eastern Bays.

34. Twenty little penguin mortalities are known in the Eastern Bays in the period mid-2015 to mid-2018. Nine were road fatalities and three were caused by predation (dogs, cat), while cause of death was unknown or uncertain for the other eight. There is limited evidence of juvenile dispersal to the Eastern Bays from the strong population on Matiu Somes Island, but it does not match this level of mortality. The Eastern Bays population is likely to continue to decline due to a gradual reduction in suitable habitat, road mortality and ongoing predation by dogs and other mammals.

35. The predominant habitat of existing breeding sites is artificial rock. Fifty-nine percent of sites in the survey area and 48% in the SPP area are less than one metre above sea level and are at current risk of inundation by storms. With only 16 cm of sea-level rise (occurring within 10–20 years), the frequency of the present day '100-year storm' in Wellington is predicted to increase to yearly on average, greatly increasing inundation risk. Unless current rock revetment habitats are built upon to match rising sea levels, an effective long-term strategy for survival of little penguins in the Eastern Bays will require maintenance of a population inland of Marine Drive and/or at Eastbourne.

36. Currently *c.* 2.55 km (66%) of the coastline between Point Howard and southern Sunshine Bay and at Windy Point is inaccessible to little penguins due to barrier effects from existing seawalls. Under the SPP, this would increase to *c.* 2.99 km (78%).

37. Nine stormwater pipes under Marine Drive in the SPP area were identified as being currently accessible or used by penguins, or potentially accessible. Three are currently being used or likely to be used as breeding habitat and/or for access inland of Marine Drive, one is currently accessible and may be being used, and five have some potential for future penguin access.

Assessment of effects on little penguins and their habitats

38. Those parts of the SPP area used by little penguins for access, nesting and moulting are of high ecological value.

39. Potential noise and disturbance effects on little penguins will be greater during breeding and moulting but may also occur during the wintering and pre-breeding stage when little penguins continue to return to land in varying numbers. Penguins sitting on nests in burrows are still exposed to noise from construction activities during daytime hours.

40. Given little penguins do not have the highest risk of noise and disturbance sensitivity, the estimated maximum harassment distance for breeding sites in the SPP area from disturbance and elevated action-generated sound levels given ambient noise levels is taken as 50 m.

41. Construction phase activities may be classed into four groups for the nature of their potential noise and disturbance effects on little penguin nesting and moulting sites: revetment upgrade works, curved and revetment seawalls, stormwater pipes, and terrestrial habitat works.

42. Two breeding sites are located within the proposed revetment upgrade areas and six others within 10 m. These may also be used as moulting sites, there may be moulting sites not at breeding sites, and there may be additional breeding sites not yet found. Potential construction impacts include removal or displacement of nest, moulting or other occupational sites, disturbance and destruction of adults, chicks and eggs, and penguin injury or mortality through interaction with machinery. The magnitude of potential effect is assessed as high.

43. There are 13 known breeding sites within 20 m of curved and revetment seawalls. Of nine actual or potential stormwater drain penguin accesses, three have breeding or possible breeding sites within the pipes themselves. Potential construction effects include disturbance and destruction of adults, chicks and eggs, and blocking of penguin access. The overall potential effect of construction phase disturbance and noise on little penguins is assessed as high (localised in space and time).

44. There are no known breeding sites within the proposed shared path or seawalls footprints, but there are two sites within revetment upgrade areas and 24 within 10 m of SPP components. Thus the potential direct impact of the SPP footprint is small (two sites directly lost) but further losses are possible given alteration of surrounding habitat is known to result in abandonment of nests. Specific mitigation is proposed for the loss of the two sites through revetment design favourable for little penguin breeding habitat and natural recolonisation.

45. Access between land and sea for five of six known breeding sites inland of Marine Drive is likely gained by drains or steps. A double curve seawall is proposed for the remaining site (northern Windy Point) but is unlikely to impact penguin access because a small local detour is available. It is possible that access via steps will be lost at the York Bay North site.

46. As for other coastal avifauna, in creating a safe facility for human walking and cycling between Marine Drive and the coastline, the shared path will increase the number of people, and potentially dogs, recreating in the coastal environment. The flightless little penguin is the species in the Eastern Bays that is most vulnerable to dogs.

47. Effective mitigation is available for SPP construction and operational phase effects on little penguins. Little penguin natural recolonisation of the revetment and revetment upgrade sites is likely, and purpose-designed revetment nesting sites are proposed. Revegetation of Claphams Rock in shrubby coastal species will, over time, enhance habitat suitability for little penguin breeding there. Access opportunities to breeding sites inland of Marnie Drive via drains and steps will largely be retained. There will be signage to educate the public on the presence of little penguins and the need for responsible dog management within the SPP area.

48. Overall the likely outcome for little penguin breeding and moulting habitat from the SPP footprint may include the loss of up to three current sites, and the indirect loss of several others through loss of access. There is likely to be an increase in the number of sites from colonisation or recolonisation of revetment sites, and a small increase over time through the revegetation of Claphams Rock. The revetment sites, unless raised in future, will be progressively lost to sea-level rise.

49. Due to the proposed mitigation measures, the post-mitigation construction and operational level of effects on little penguins have been assessed as low.

Conclusions

50. This study has described the coastal vegetation and avifauna (including little penguins) of the SPP area, on the eastern Wellington Harbour coastline. The SPP area lies in a transition zone from Marine Drive and existing seawalls on an earthquake-elevated platform (highly modified environments), to abutting backshore, foreshore and marine environments. The latter are characterised by largely indigenous biota and an environment of dynamic natural coastal processes (such as waves, tides, wind, salinity and sediment movement).

51. The SPP environment has occurrences of 20 Threatened and At Risk plant and animal species and a naturally uncommon ecosystem (shingle beaches) classified as Endangered. The part of the project area seaward of existing seawalls and Marine Drive has high ecological context value.

52. Potential SPP effects have been assessed and effective mitigation measures and monitoring recommended. This includes provisions in the Construction and Environmental Management Plan, Beach Nourishment Management Plan and Little Penguin Management Plan. Overall, the effects of the SPP on and vegetation and coastal avifauna will be low.

53. The SPP exemplifies ‘coastal squeeze’, a global phenomenon where coastal development and hard sea defences prevent coasts from adapting and shifting landwards in response to sea-level rise, causing progressive loss of backshore and intertidal habitat. Unless sea-level rise prospects are rapidly mitigated, it very likely will result progressively in change to and some loss of the present character of coastal habitat and the biota in the SPP area.

Table ES 1: Ecological value, potential effects, principal mitigation and post-mitigation level of effects of Threatened and At Risk naturally uncommon ecosystem and indigenous vascular plant and avifauna species within or adjoining shared path project footprint. Construction timing options for several species are determined by the presence or absence of little penguins (see **Section 5.2.5)**. Several sea-level rise (SLR) adaptive pathways and other outcomes noted.

Scientific name	*Common / Māori name(s)*	*Location*	*Abundance*	*Conservation status*	*Ecological Value*	*Potential effects*	*Magnitude of potential effects*	*Mitigation (principal)*	*Post-mitigation level of effects*
Ecosystem									
Gravel beaches		All five bays and Windy Point	Narrow lenses, subject to erosion	Naturally uncommon ecosystem; Endangered	Moderate	Largely displaced	Low (in relation to site condition and national extent)	Translocation at Lowry Bay; minimise construction impacts on remaining occurrences	Low. Translocation will prolong existence at Lowry Bay but retention elsewhere unlikely in face of SLR
Plants									
Aciphylla squarrosa var. squarrosa	Cook Strait speargrass	Windy Point	*c.* 10 (landscape planting)	At Risk – Declining, data poor, partial decline	High	Loss	Moderate	Transplant to adjoining currently grassed areas or nearby reserves, and/or Claphams Rock revegetation site	Net gain
Astelia chathamica	Chatham Islands kakaha	Point Howard	Several (landscape planting)	At Risk – Recovering	Moderate	Partial loss	Low	Transplant to adjoining currently grassed areas or nearby reserves	Negligible
Atriplex cinerea	Grey saltbush	York Bay, Claphams Rock	*c.* 15 (restoration planting)	Nationally Critical, secure overseas	Very high	Vehicle crushing (several)	Moderate	Low landscape barrier for vehicles, recognition of sites in CEMP	Negligible

Scientific name	***Common / Māori name(s)***	***Location***	***Abundance***	***Conservation status***	***Ecological Value***	***Potential effects***	***Magnitude of potential effects***	***Mitigation (principal)***	***Post-mitigation level of effects***
Brachyglottis compacta		Point Howard	Several (landscape planting)	At Risk – Naturally Uncommon, range restricted	Moderate	Partial loss	Moderate	Transplant to adjoining currently grassed areas or nearby reserves	Negligible
Euphorbia glauca	Waiūatua, shore spurge	Point Howard	Numerous (landscape planting)	At Risk – Declining, conservation dependent	High	Possible partial loss	Low	Transplant to adjoining currently grassed areas or nearby reserves	Negligible
Ficinia spiralis	Pīngao	Lowry Bay	1	At Risk – Declining, partial decline, range restricted	High	Local loss (1 plant)	Moderate	Translocate with substrate, in conjunction with beach nourishment, in winter	Negligible. Existence at Lowry Bay prolonged in face of SLR
Melicytus crassifolius	Thick-leaved porcupine plant	Windy Point	*c.* 5 (landscape planting)	At Risk – Declining	High	Partial loss	Moderate	Transplant to adjoining currently grassed areas or nearby reserves	Negligible
Veronica speciosa	Tītīrangi	Windy Point	3 (landscape planting)	At Risk – Declining, range restricted	High	Loss	Moderate	Transplant to adjoining currently grassed areas or nearby reserves	Negligible
Zostera muelleri subsp. novazelandica	Seagrass, eelgrass, rimurēhia	Lowry Bay	Three seagrass beds	At Risk – Declining, extreme fluctuations	High	Construction disturbance, sedimentation and partial burial, turbidity	Moderate	Isolation of site within construction zone; separation and disposal offsite of silts and clays in beach excavation sediments; use of similar or slightly coarser	Low. Possible minor change adjoining beach nourishment sites within existing seagrass dynamics; minimal effects on most of the seagrass

Scientific name	***Common / Māori name(s)***	***Location***	***Abundance***	***Conservation status***	***Ecological Value***	***Potential effects***	***Magnitude of potential effects***	***Mitigation (principal)***	***Post-mitigation level of effects***
								sediments that will maintain existing profile without spreading onto seagrass beds; excluding fines from beach nourishment sediments; minimise risk of wave overtopping of sediment control measures; undertake beach nourishment at Lowry Bay in winter	beds and possible positive effect for the northern seagrass bed. Seagrass has some capability to respond to SLR; without future intervention it is at high risk of being squeezed out of its natural depth range at Lowry Bay
Avifauna									
Puffinus gavia	Fluttering shearwater, pakahā,	Harbour, offshore	Frequent, April–Oct	At Risk - Relict, range restricted	Moderate	Minimal	Negligible	–	No effect
Macronectes sp.	Giant petrel, pāngurunguru	Harbour, offshore	Very small numbers	Northern, At Risk - recovering; southern - migrant	Moderate	Minimal	Negligible	–	No effect
Phalacrocorax carbo novaehollandiae	Black shag, kawau	Harbour, inshore, onshore	Small numbers, mainly winter visitor	At Risk - Naturally Uncommon, sparse	Moderate	Construction noise and disturbance; increased dog disturbance (operational phase)	Low	Noise provisions within CEMP; signage on avifauna values and responsible dog management	Low

Scientific name	*Common / Māori name(s)*	*Location*	*Abundance*	*Conservation status*	*Ecological Value*	*Potential effects*	*Magnitude of potential effects*	*Mitigation (principal)*	*Post-mitigation level of effects*
Phalacrocorax varius varius	Pied shag, kāruhiruhi	Harbour, inshore, onshore	Very small numbers	At Risk - Recovering	Moderate	Construction noise and disturbance; potential increased dog disturbance (operational phase)	Low	Noise provisions within CEMP; signage on avifauna values and responsible dog management	Low
Phalacrocorax sulcirostris	Little black shag, kawau tūi	Harbour, islets, inshore	Frequent, mainly winter visitor	At Risk - Naturally Uncommon, range restricted	Moderate	Construction noise and disturbance; potential increased dog disturbance (operational phase)	Low	Noise provisions within CEMP; signage on avifauna values and responsible dog management	Low
Egretta sacra sacra	Reef heron, matuku moana	Intertidal rocky shore	Very small numbers	Nationally Endangered, data poor, secure overseas, sparse	Very high	Construction noise and disturbance; intertidal feeding and roosting habitat loss; potential increased human and dog disturbance (operational phase)	Moderate	Noise provisions within CEMP; survey for presence of reef heron at Point Howard-Sorrento Bay during breeding season (September-December), if present avoid undertaking construction works at that time; signage on avifauna values and responsible dog management;	Low. Local intertidal rocky reef habitat loss small (200 m²), permanent. Any population effect from this loss unlikely to be distinguishable from other causes contributing to local decline.
Haematopus unicolor	Variable oyster-	Backshore and intertidal	Fairly frequent throughout,	At Risk - Recovering	Moderate	Construction noise and disturbance; intertidal feeding	Moderate	Noise conditions within CEMP; at Sorrento Bay, survey for oystercatcher	Low. Backshore beach habitat partially retained for a period

Scientific name	*Common / Māori name(s)*	*Location*	*Abundance*	*Conservation status*	*Ecological Value*	*Potential effects*	*Magnitude of potential effects*	*Mitigation (principal)*	*Post-mitigation level of effects*
	catcher, tōrea		breeding at Sorrento Bay			and roosting habitat loss; potential increased dog disturbance (operational phase)		breeding, and if so avoid undertaking works until breeding safely complete (December- January); elsewhere undertake construction works between 1 March–30 June if little penguins are present in locality, and in spring to autumn if little penguins are not present; signage on avifauna values and responsible dog management	at Point Howard, Lowry Bay and York Bay through beach nourishment (adaptive planning). Small loss of backshore and intertidal habitat (0.58 ha), permanent. Likely small population decline within SPP area. Rocky reef habitat loss would also occur in time with SLR, and beach habitat later without further beach nourishment
Larus novaehollandiae scopulinus	Red-billed gull, tarāpunga	Harbour, inshore, onshore, backshore	Frequent, March–August, most common bird in winter	At Risk - Declining	High	Food and waste; construction noise and disturbance; intertidal feeding and roosting habitat loss; potential increased dog disturbance (operational phase)	Moderate	Noise conditions within CEMP; secure waste storage and removal; signage on avifauna values and responsible dog management	Low. Backshore beach habitat partially retained for a period at Point Howard, Lowry Bay and York Bay through beach nourishment (adaptive planning). Small loss of backshore and intertidal habitat

Scientific name	Common / Māori name(s)	Location	Abundance	Conservation status	Ecological Value	Potential effects	Magnitude of potential effects	Mitigation (principal)	Post-mitigation level of effects
									(0.58 ha), permanent. Likely small population decline within SPP area. Beach habitat loss would also occur in time with SLR
Eudyptula minor	NZ little penguin, kororā	Harbour, coast, terrestrial	42 known breeding sites, additional 5–15 likely; local population declining	At Risk - Declining, data poor	High	Noise and disturbance; loss of two or more breeding sites at revetment upgrade areas and probable loss of another at Point Howard; possible loss of access to one breeding site at York Bay and possibly to other unknown sites (estimate 2–5); dog disturbance (operational phase)	High	Noise conditions within CEMP; Little Penguin Management Plan (including construction and street lighting mitigation); undertake construction works from 1 March–30 June where present; revegetation of Claphams Rock and spot enhancement of little penguin breeding habitat within revetment seawalls, leading to an increase in the number of breeding sites; retention of existing stormwater pipe and steps access opportunities; signage on little penguin values and responsible dog	Low. Loss of two known breeding sites, probable loss of one other breeding site. Probable or possible loss of several others inland of Marine Drive through loss of access; increased breeding sites in revetment seawalls (estimate 2–10) but will be progressively lost to SLR unless revetment is raised; small increase in breeding sites in time at Claphams Rock (less vulnerable to SLR)

Scientific name	*Common / Māori name(s)*	*Location*	*Abundance*	*Conservation status*	*Ecological Value*	*Potential effects*	*Magnitude of potential effects*	*Mitigation (principal)*	*Post-mitigation level of effects*
								management; install temporarily visible road signage at live sightings on Marine Drive for the breeding and moulting period (July-February)	
Hydroprogne caspia	Caspian tern, taranui	Harbour, offshore, inshore	Very small numbers	Nationally Vulnerable, secure overseas, sparse	Very high	Minimal	Negligible	–	No effect
Sterna striata	White-fronted tern	Harbour, offshore	March-May, numbers declining, now low	At Risk - Declining, data poor	High	Minimal	Negligible	–	No effect

1 INTRODUCTION

The completion of an Eastern Bays Shared Path is a key component of the Hutt City Council (HCC) objective to provide a safe and integrated walking and cycling network: the ‘principal aim is to encourage more people to cycle and walk more often and further, for commuting and recreational purposes’ (Hutt City Council 2014). The proposed Shared Path will provide a safe connection for cyclists and pedestrians to workplaces, schools, shops and public transport facilities and to the rest of Hutt City and Wellington City by connecting to existing and planned cycleways (NZ Transport Agency 2018). The shared path project (SPP) has been an aspiration of the Eastern Bays community for many years (Eastbourne Community Board 2014).

The shared path forms part of Te Aranui o Pōneke (the Great Harbour Way), a 72 km long shared walking and cycling route around Te Whanganui-a-Tara, the harbour of Wellington, from Sinclair Head in the west to Fitzroy Bay in the east (Great Harbour Way Trust 2018).

The shared path would extend mostly alongside Marine Drive on its coastal side for 3.80 km between Point Howard Ngau Matau and Eastbourne, in two parts (**Figure 1-1**): [3]

- Point Howard to Sunshine Bay (3.29 km; excluding existing shared path at south York Bay)
- Windy Point (513 m; southern Days Bay to Muritai Road / Marine Parade intersection).

Days Bay Oruamotoro (950 m) is not included because of its existing cycling and walking facilities and a lower speed limit. The predominant proposed path widths are 3.5 m and 2.5 m.

Where the Shared Path adjoins Wellington Harbour (3.08 km), it is proposed in the main to replace existing seawalls of older design by fit-for-purpose modern structures intended to be resilient to storm surges, to reduce current wave overtopping on Marine Drive and to be adaptable to accommodate sea-level rise (**Figure 1-2**). Minor lengths are proposed for existing revetment seawall upgrade or for new seawalls. There are 726 m of ‘non-seawall’ lengths (away from the shoreline).

The seawalls will provide a platform for the shared path and protection for Marine Drive and the infrastructure under it as an adaptation strategy to sea-level rise (for some time). The additional width required for the shared path atop seawalls would be sourced from some combination of:

- the change from existing mostly sloped seawalls to new more vertical/concave curved seawalls

[3] The distance of 3.80 km is based on the length of shared path footprint; other reports have a 4.4 km project length, being the lineal shoreline.

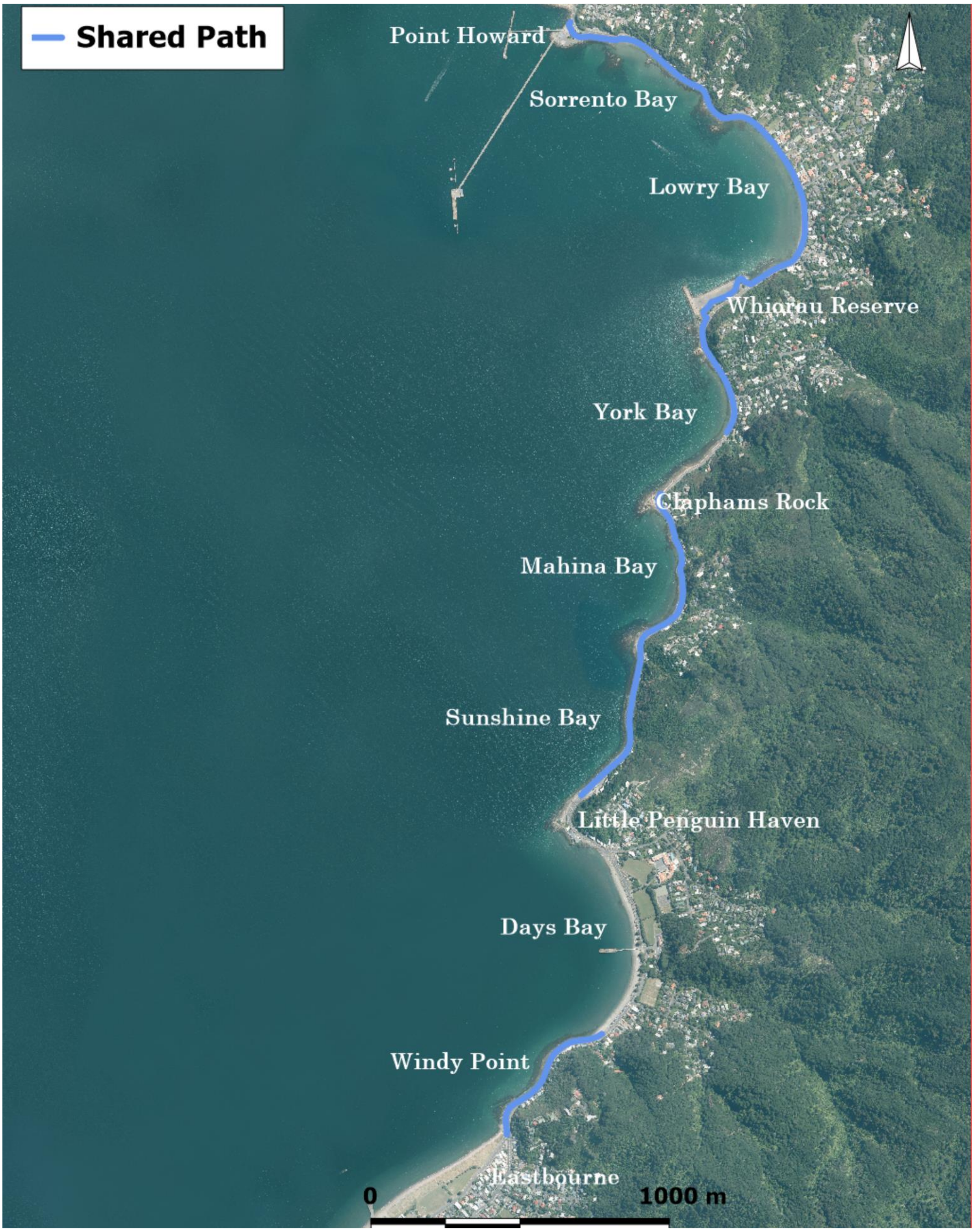

Figure 1-1: Location of proposed Eastern Bays shared path project, Wellington Harbour. Places referred to in text are also shown. Sources: project location – Stantec preliminary designs, GIS data, Revision J, 2018-08; aerial imagery (2012-2013) – LINZ Data Service, licensed by Wellington Regional Council for re-use under the Creative Commons Attribution 4.0 International licence.

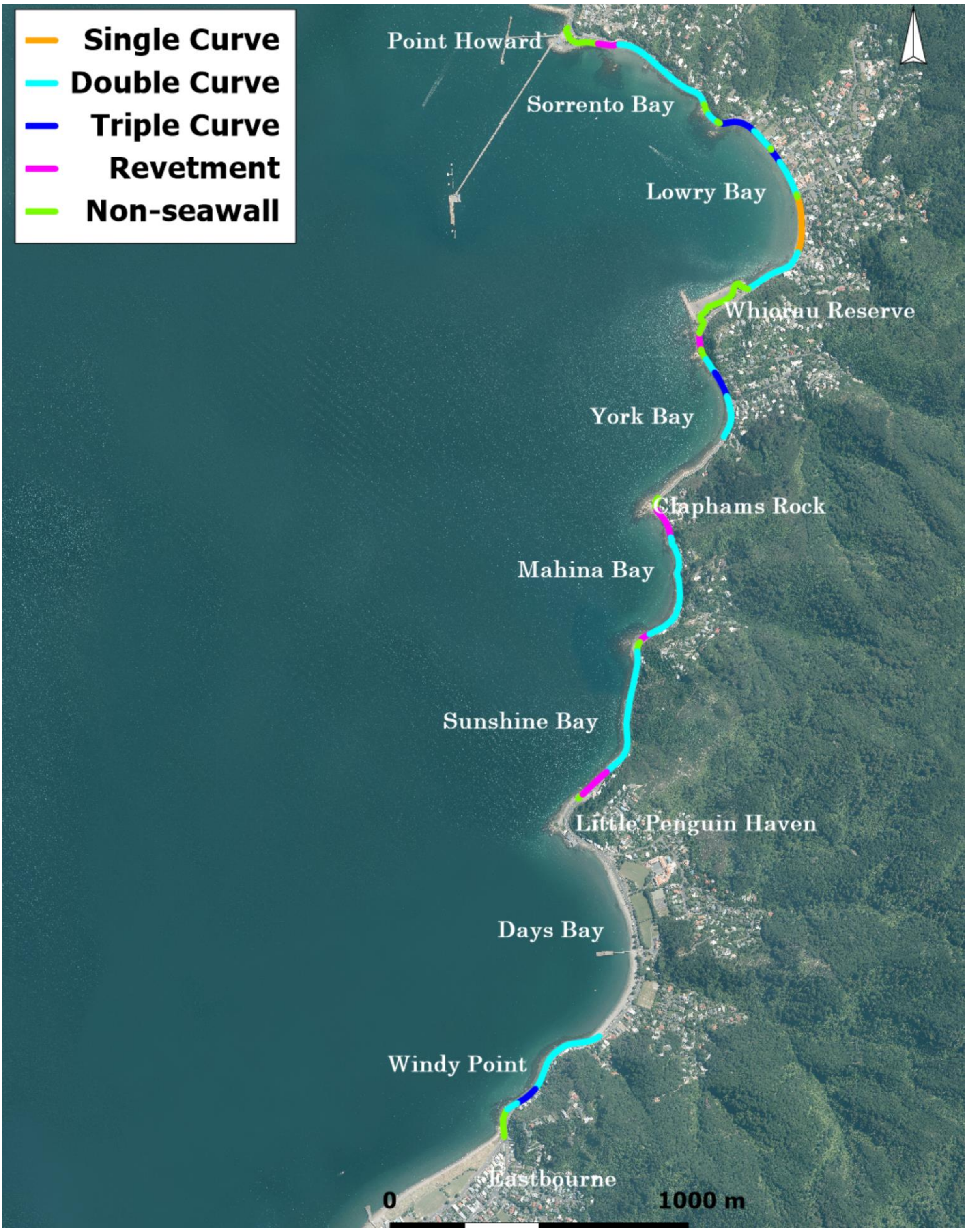

Figure 1-2: Locations of proposed seawall types and non-seawall lengths, Eastern Bays shared path project. Triple curve includes sites currently designated double/triple curve, where the final choice will be made during the detailed design phase. Revetment includes revetment upgrade sites. Access steps and ramps not shown. Sources: project treatments – Stantec preliminary designs, GIS data, Revision J, 2018-08; aerial imagery (2012-2013) – LINZ Data Service, licensed by Wellington Regional Council for re-use under Creative Commons Attribution 4.0 International licence.

- beach or rocky shore habitats above Mean High Water Springs (MHWS)[4]
- encroachment into the Coastal Marine Area (CMA, below MHWS).

The SPP is envisaged to be constructed over six years, one section per year (subject to funding): in order, Windy Point, Point Howard/Sorrento bays, Whiorau/Lowry Bay (hereafter Lowry) Bay, followed by the other bays.

A challenge for assessing long-term SPP effects on coastal vegetation and avifauna is their complex inter-relationships with sea-level rise (**Section 3.6).** This report acknowledges that the SPP is not a long-term solution to the increasing level of coastal hazard exposure of human assets due to climate change and sea-level rise, but that design elements will 'buy some time' to allow Councils and their communities to develop a detailed dynamic adaptive pathways coastal hazards plan for the Eastern Bays area to adapt to climate changes and sea-level rise (Resource Consent Application Appendix E; Allis 2019). This is consistent with recent Ministry for the Environment guidance for local government on coastal hazards and sea-level rise (Bell et al. 2017).

The potentially substantial and long-term nature of sea-level rise (**Section 3.6)** and predicted major modification and loss of coastal ecosystems (IPCC 2018) necessitate a different adaptive approach for ecosystems and biota. Rather, a primary aim for the coastal vegetation and avifauna of the SPP area must now be their long-term ecological resilience and restoration in an environment characterised by the inevitability of significant sea-level rise, plus 'deep uncertainty' about its rates and consequences (Bell et al. 2017). Principles of ecological resilience include maintaining diversity and redundancy, managing connectivity and feedback systems, viewing events in a regional rather than local context, anticipating that future events will be unexpected, and applying complex adaptive systems thinking (Holling 1996; Biggs, Schlüter & Schoon 2015).

HCC commissioned Sustainability Solutions to prepare this vegetation and coastal avifauna ecological effects assessment as part of the Assessment of Environmental Effects (AEE), in support of the SPP resource consent applications to Greater Wellington Regional Council (GWRC) and HCC. The study describes and assesses SPP effects on:

- the existing vascular vegetation and flora
- the indigenous coastal avifauna and their habitats, and (separately)
- NZ little penguins kororā (*Eudyptula minor*) and their habitats.

The study complements the assessments of effects on coastal physical processes (Resource Consent Application Appendix E; Allis 2019) and intertidal ecology (Resource Consent Application Appendix A; McMurtrie & Brennan 2019) in covering the coastal biophysical environment, the highly dynamic transition zone between marine and terrestrial environments.

[4] MHWS values used in this report rely on a single LiDAR survey (*c.* 2013). Values can change daily and seasonally in response to wind, wave and storm effects on the elevation and distribution of beach sediments (Allis 2018).

2 SHARED PATH PROJECT AND ENVIRONMENTAL MANAGEMENT

2.1 Project Components and Dimensions

2.1.1 Shared Path

The Shared Path design plan[5] proposes 910 m of 2.5 m path width, 2474 m of 3.5 m width, 24 m of narrow constrictions (boatsheds, bus stop) and 393 m of width transitions (**Table 2-1**).[6] The path would adjoin seawalls for 3075 m, and 726 m is away from the shoreline (including road shoulders, boatsheds, open spaces at Point Howard and Whiorau Reserve, and near to existing seawalls and accesses). Between the Marine Drive road edge white line and the shared path are a 300 mm shoulder and a 300 mm wide/250 mm high concrete block kerb to separate road from path. There is already 305 m of existing shared path (2.5–3.0 m width) atop modern single and double curve seawalls in south York Bay.

Table 2-1: Lengths of shared path widths and seawall types of proposed Eastern Bays shared path project. Totals may not sum because of rounding.

Shared path widths [a]	**2.5 m width**	**3.5 m width**	**Width constrictions**	**Width transitions**	**No shared path**		**Total**
Seawalls (m) [b]	732	2087		255	[24]		3075
%	*23.8*	*67.9*		*8.3*			*100.0*
Non-seawalls (m)	178	387	24	138			726
%	*24.5*	*53.2*	*3.3*	*19.0*			*100.0*
Total (m)	910	2474	24	393	[24]		3801
%	*23.9*	*65.1*	*0.6*	*10.3*			*100.0*
Seawall types	**Single curve**	**Double curve**	**Triple curve** [c]	**Steps + ramps**	**Revetment** [d]	**Revetment upgrade** [e]	**Total**
Seawalls (m) [2]	190	2127	329	55	358	40	3098
%	*6.1*	*68.6*	*10.6*	*1.8*	*11.6*	*1.3*	*100.0*

[a] Lengths of small gaps in shared path source GIS data drawn consistent with constraints at constrictions, and otherwise to widths of adjoining sections if these are the same or as transition zones if different.

[b] Seawall lengths are for the existing shoreline and include steps and ramps sites.

[c] Includes tentative double curve-triple curve sections (the final choices to be determined at detailed design).

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[5] The design features report (Resource Consent Application Appendix J; Corin, Povall & van Halderen 2019), beach nourishment report (Resource Consent Application Appendix E; Reinen-Hamill 2019), and preliminary design plans (Resource Consent Application Appendix N) provide a full project description. Designs are subject to detailed design, consent outcomes, management plans, and the Contractor’s construction methodology.

[6] GIS based data in this report is sourced or derived from GIS project data from EOS Ecology and Stantec Design Plans files (Rev J), and tidal stage data from Stantec. GIS calculations are intended to provide best estimates prior to detailed design.

[d] Includes sites where new revetment co-occurs with upgrade of existing revetment.

[e] Includes 24 m of revetment upgrade at Whiorau Reserve outside the shared path alignment.

2.1.2 Seawalls

There are three proposed seawall types:

- curved concrete seawalls - mainly double curve, also single and triple curve (2646 m, 85.4%)
- revetment (rock armour on sloping shoreline profiles), new or upgraded (398 m, 12.8%)
- access steps and ramps (55 m, 1.8%).

Of the 3098 m total seawalls length, 2818 m (92%) are replacements of existing seawalls of various types that have been in place since the 1980s (EOS Ecology data; Allis (2019)) and 257 m (8%) are new seawalls. The latter consist of single curve seawall at Lowry Bay (183 m), double curve seawall and access steps at Sunshine Bay (54 m), and revetment at Mahina Bay (20 m). Some small existing non-curved seawall lengths at Sorrento and York Bays (*c.* 85 m) will not be upgraded.

The seawalls will be permanent structures; decommissioning is not planned. Rather, incremental raising of seawalls is envisaged as adaptation to sea-level rise, within a coastal hazards dynamic adaptive planning pathways (DAPP) framework (Bell et al. 2017).

2.1.3 Beach nourishment

The SPP includes the construction of a 3.5 m wide shared path at Point Howard, Lowry Bay and York Bay, which will result in beach encroachment between *c.* 0.5–3.5 m in width. It is proposed that 'beach nourishment'[7] will be undertaken at these bays to reinstate the existing beach dimensions and associated amenity and recreational values that would be lost by this encroachment, by nourishing the beaches with beach-compatible fill, with the secondary benefit of improved coastal hazards protection (Reinen-Hamill 2019).

The beach nourishment is proposed only along those parts of the shoreline where there are existing high tide beaches at Point Howard (80 m), Lowry Bay (160 m) and York Bay (80 m). There is no intention to increase the beach areas beyond the existing beaches, except temporarily during construction or to offset increased sediment loss rates after construction (Reinen-Hamill 2019).

[7] Beach nourishment is the deliberate addition of sand or similar sediments from sources outside the beach system to an eroding beach or for the construction of a beach where only a small beach, or no beach, previously existed (Committee on Beach Nourishment and Protection 1995).

2.1.4 Project and construction zone footprints

Encroachment[8] occurs when a proposed seawall toe is seaward of the existing seawall toe (**Figure 2-1**). Reverse encroachment occurs when the proposed toe is inland of the existing toe. Encroachment may occur above or below MHWS. Revetment upgrade areas are areas of existing rock riprap that are to be upgraded; as their toe is not extended seawards, these are not captured by encroachment measures.

Figure 2-1: Proposed 3.5 m shared path width (indicated by tape measure), 45 m south of Cheviot Road bus stop, Whiorau Lowry Bay. The toe of the single curve seawall here would extend a further 600 mm seawards from the tape measure end. The effective encroachment distance (from toe of existing low seawall to toe of proposed new seawall) is 3.1 m. Photo: PC310808.JPG, 2018-12-31, 15 minutes after high tide.

[8] Encroachment is used here as the loss of habitat in the conversion of coastal habitats (e.g. backshore and intertidal) to artificial structures such as seawalls.

The construction zone is a working area beyond the new seawall toe, on the backshore and in the intertidal and (to a small extent) subtidal zones[9], that is necessary for machinery access to undertake seawall and beach nourishment works. The construction zone is 5 m wide for curved seawalls, steps and ramps, and 3 m wide for revetment. The construction zone has a temporary timeframe.

Proposed total encroachment is 5836 m^2, comprised of 2481 m^2 (42.5%) above MHWS and 3355 m^2 (57.5%) in the intertidal zone (**Table 2-2**).The revetment upgrade areas cover 669 m^2, mostly above MHWS (579 m^2, 86.5%). The SPP direct footprint, as the sum of the encroachment areas and revetment upgrade areas, totals 6505 m^2 (89.7% encroachment and 10.3% revetment upgrade).

Reverse encroachment is mostly above MHWS and is of minor extent (total 202 m^2, 3.5% of the size of the encroachment area).

Table 2-2: Eastern Bays shared path project footprint composition in relation to terrestrial habitat and CMA intertidal and subtidal zones. Excludes the beach nourishment footprint. The boundary between the intertidal and subtidal zones is taken as MLW, in the absence of GIS mapping of MLWS. Encroachment areas are for the triple curve seawall where the choice of double or triple curve has yet to be determined. Totals may not sum because of rounding. Data derived from GIS files sourced from EOS Ecology and Stantec (Rev J).

Shared Path component footprints	**Terrestrial (>MHWS)**		**CMA intertidal (MHWS–MLW)**		**CMA subtidal (<MLW)**		**Total**	
	m^2	*%*	m^2	*%*	m^2	*%*	m^2	*%*
Curved seawall	2003	*51.4*	1896	*48.6*	-	-	3899	*100%*
Revetment	425	*23.0*	1422	*77.0*	-	-	1846	*100%*
Steps and ramps	53	*58.7*	37	*41.3*	-	-	91	*100%*
Total Encroachment (A)	2481	*42.5*	3355	*57.5*	-	-	5836	*100.0%*
Revetment upgrade (B)	579	*86.5*	90	*13.5*	-	-	669	*100%*
Total SPP Footprint (A + B)	3060	*47.0*	3445	*53.0*	-	-	6505	*100%*
Reverse encroachment	92	*45.5*	110	*54.5*	-	-	202	*100%*
Construction zone	3848	*25.7*	10976	*73.3*	148	*1.0*	14972	*100%*

[9] The backshore is that part of the beach that is usually dry, reached only by the highest tides, and by extension, a narrow strip of relatively flat coast bordering the sea (NOAA Office for Coastal Management 2017). MHWS is the backshore-intertidal zone boundary and also the CMA boundary. Because mapping is available for mean low water (MLW) but not mean low water springs (MLWS), calculations in this report of the intertidal (foreshore) zone are for between MHWS and MLW, and of the subtidal zone are for below MLW.

Approximately one-quarter of the construction zone is above MHWS (3848 m^2, 25.7%), almost three-quarters is in the intertidal zone (10 796 m^2, 73.3%), and a small part is in the subtidal zone (148 m^2, 1.0%).

The berm to be constructed for the placement of beach nourishment sediments at the Point Howard, Lowry Bay and York Bay beaches will extend out to 10 m beyond new seawalls (Reinen-Hamill 2019). This is an additional component of the SPP footprint but is difficult to quantify because it entails subsequent movement of sediments by natural shore processes from the placement sites to the full lengths of the three beaches.

2.2 Seawall Designs and Locations

Seawall designs and locations were initially selected in a multi-criteria assessment (MCA) process during three workshops led by Stantec and involving technical experts in the fields of coastal processes (Allis 2017), intertidal ecology (McMurtrie & Brennan 2017), vegetation/avifauna/little penguins (Overmars 2017), landscape and visual, civil design, planning and consenting, and community engagement. Scores were differentiated by beach and non-beach (rocky) areas. Several possible seawall designs were discarded. Designs and location selections were subsequently refined during project development, community consultation and assessments of potential effects.

2.2.1 Curved seawalls

Vertical curved seawalls have been chosen across most of the SPP length because they deflect wave overtopping most effectively and cause a reduced footprint compared to other less vertical seawalls.

The concrete curved seawall has a near-flat top that forms the base of the shared path, and a single, double or triple curve face, each with a 900 mm tread (600 mm nose to nose) and an 800 mm riser (**Figure 2-2**, **Figure 2-3**). The angle of successive noses in double and triple curve seawalls is 36.9°. The number of curves is determined by the height between shore and shared path levels. The toe is embedded 300 mm into rock, deeper at beach locations. Voids inland of the curved seawall structure are infilled with mass concrete to achieve the shared path profile. This design follows the existing single and double curve seawalls at the south end of York Bay (Corin, Povall & van Halderen 2019).

The double curve seawall is the most widespread proposed seawall type. Triple curve seawalls will be used at north Lowry Bay, York Bay and Windy Point, where there are large differences between shared path and shore elevations. The choice of double or triple curve for a 104 m length in north Lowry Bay will be made during the detailed design phase. A single curve seawall is planned for southern Lowry Bay where the shore is above MHWS and its elevation is close to the shared path level, with the benefits of reduced excavation depth and smaller CMA encroachment compared to the double curve design (600 mm less width). Transition zones from curved seawalls to revetment will have revetment placed around the ends of the curved seawalls.

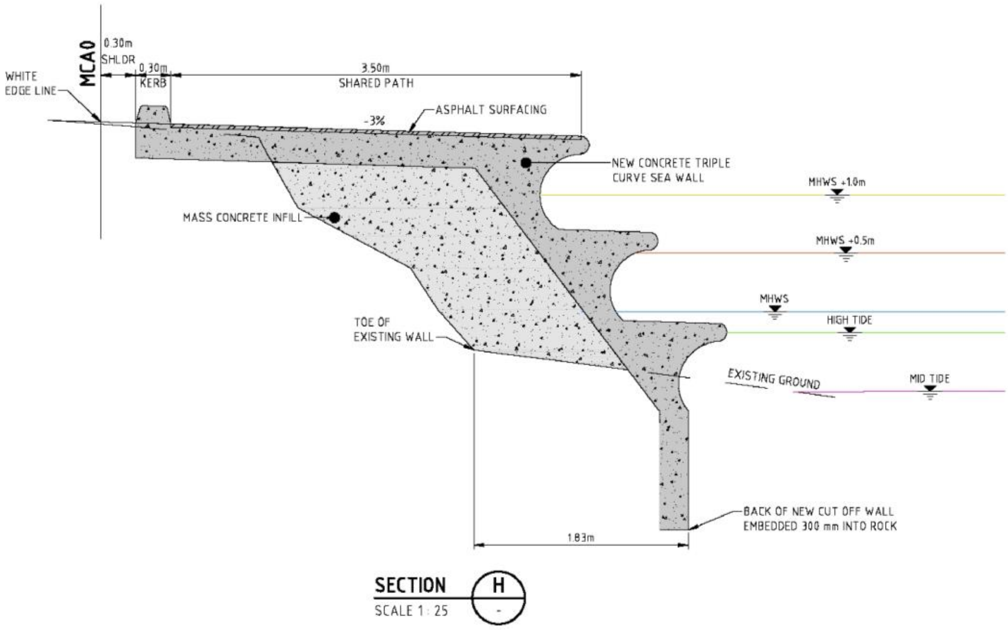

Figure 2-2: Schematic of triple curve seawall in profile, York Bay. MHWS here would reach to just above the lowest seawall curve. MHWS elevations for 0.5 m and 1.0 m sea-level rise also shown. Scale shown is for the preliminary design plan. Source: Stantec 2018.

Figure 2-3: Simulated shared path view, northern York Bay, 3.5 m path width, double curve seawall in the foreground and triple curve seawall beyond to Taungata Road. Source: Hutt City Council (2018).

The in situ founding material is mostly competent weathered rock. While excavation will generally be shallow (<1 m), seawall foundations in some locations may need to extend as far as 5 m below current beach level to reach material of acceptable bearing capacity and ensure seawalls are not undermined by future coastal erosion or scour. These deeper foundations will utilise traditional deep foundation techniques such as reinforced concrete cut-off walls, sheetpiling, or bored or driven reinforced concrete piles, depending on depth and loading on the foundation. Potential sites are at Sorrento Bay, Lowry Bay, York Bay, Mahina Bay and Sunshine Bay (Corin, Povall & van Halderen 2019). Current planning is for sheet piles to be vibratory driven, at Lowry Bay (Skerrett Boat Shed to Gill Road, 415 m) and York Bay (Taungata Road junction to existing shared path/seawall, 145 m) (Walters 2018).

The curved walls will be cast in situ to aid constructability given the irregularity in the coastal area for construction. Environmental risks with this approach will be managed (**Section 2.4**).

Textures are to be incorporated into curved seawall surfaces to provide habitat for biota to re-establish; this is currently envisaged to apply to one curve only (McMurtrie & Brennan 2019). A form liner or void former will be used to create a textured surface on the vertical curved faces (*c.* 5 mm deep) and deeper holes on the flat step of the curved seawall (*c.* 50–70 mm deep). These holes will increase surface area and complexity of the seawall, providing additional habitat and protection for biota at different tidal zones (McMurtrie & Brennan 2019) without compromising structural performance (Allis 2019).

2.2.2 Revetment

The revetment seawall type is proposed for rocky shore areas where it is desirable to maintain a non-concrete shoreline or upgrade existing rock revetment areas, and to provide additional protection to reduce wave overtopping (Allis 2019). Revetment and upgrade of existing revetment are proposed at five sites (**Table 2-3**), four of them at the end of a bay and adjoining a headland. The exception is at Sunshine Bay, where the structure would overlay and extend an existing revetment upgraded in 2016.

The revetment structure consists of a top double layer of large rocks (primary armour), median diameter (D50) of 500 mm, overlaid onto smaller rocks (secondary armour) and a bedding layer (**Figure 2-4**). The structure has three rocks on a level surface (i.e. *c.* 1.5 m wide) before it slopes down towards the sea, typically at a gradient of 1V:2H (27°). The interface between revetment and shared path may include:

i. A standalone reinforced concrete cantilever wall supports the shared path; its top is flush with the path and the revetment is at grade with the seawall top. Voids inland of the cantilever wall are infilled with backfill material.

ii. The revetment top is *c.* 300 mm above the shared path and is level for 1.5 m before it slopes down to the water.

Table 2-3: Areas of new revetment and revetment to be upgraded, Eastern Bays shared path project. Revetment data based on areas between existing seawall toes and proposed toes. Revetment upgrade areas are inland of existing seawall toes. For consistency with encroachment measures, these revetment areas include small portions that would go under the shared path footprint.

Location	Revetment (m^2)	Revetment upgrade (m^2)	Revetment total (m^2)
Point Howard	354	87	441
York Bay North	261	113	374
Mahina Bay North	431	139	570
Mahina - Sunshine Bays headland	176	28	205
Sunshine Bay	624	301	926
Total	**1846**	**669**	**2515**

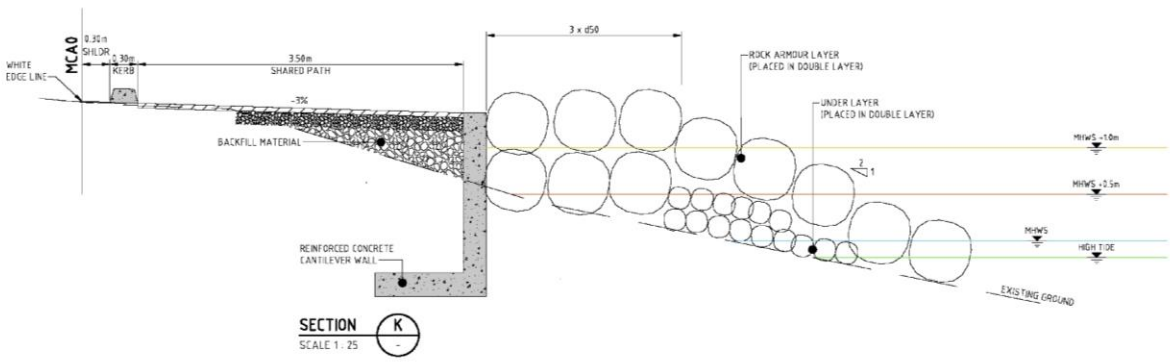

Figure 2-4: Schematic of revetment with reinforced concrete cantilever wall, in profile, for 3.5 m wide shared path at Sunshine Bay. MHWS elevations for 0.5 m and 1.0 m sea-level rise also shown. Source: Stantec 2018.

Revetment design specifications for specific sites will be refined during detailed design. The specific rock to be used has yet to be chosen but it will be of a suitable hardness (e.g. granite or andesite). Greywacke and argillite on-site are not suitable, and greywacke from local quarries are not likely to be available in required quantities. The final selection of rock material for the revetment will be addressed by the contractor.

At revetment upgrade sites, existing rock where present under the shared path footprint will be moved seaward to enable construction of the path foundations and cantilevered wall (if present). Part of the revetment upgrade area at north York Bay is off the shared path alignment.

Revetment seawalls have larger footprints than curved seawalls, with distances between the toes of existing and corresponding proposed seawalls between 3.2–9.0 m (i.e. encroachment), compared with -2.1–4.6 m for curved seawalls (negative values indicate reverse encroachment). With sea-level rise, one option for raising the revetment seawalls (to maintain the slope of the revetment itself) would entail further horizontal seaward encroachment.

2.3 Other Structures and Features

2.3.1 Access steps and boat ramps

The SPP intends to replace existing steps and ramps for beach access for walkers and for non-vehicular boats and kayak access. There will generally be two accesses per beach, usually located close to or in the same location as existing steps and ramps. Sixteen access points are proposed.

Steps will be of two designs:

- standard access stairs, 1500 mm (upper level) and 1200 mm (lower level) wide, 200 mm vertical rise per step, parallel to seawalls to reduce encroachment, either on double curve seawalls or on transitions to revetment
- ministeps on double curve seawalls, 600 m wide and with a vertical rise of 350 mm.

Ministeps reduce encroachment into the CMA. The 350 mm riser may also provide access for little penguins across curved seawalls.

Boat ramps will be oriented parallel to the seawall, rather than perpendicular, to reduce beach encroachment. Maximum boat ramp grades have been set at 1V:4H (instead of 1V:8H) and they will be provided only in locations where the seawall height is low to minimise encroachment.

Existing ramps at Point Howard and at the south end of Windy Point will be retained.

2.3.2 Stormwater outlets

There are many culverts under the existing Marine Drive carriageway that will need to be extended to accommodate the increased width of the new path. The culverts will be extended using standard couplers connecting onto new plastic pipes tied into and terminating flush with the new seawall. For larger stormwater outlets that provide access for fish and possibly little penguins, extensions are in the ranges of -0.9–2.4 m (negative value indicates contraction).

Nine stormwater outlets have been identified as of value for little penguin access and habitat use or potential access (**Section 9.3.3**). Having pipe extension outlets be flush with the new curved seawalls will help avoid creating access obstructions. Pipe outlets in curved seawalls also will be configured in relation to the curves and tread(s) to not create overhangs. In revetment, there will be specific discharge structures including a sloping concreted/rock platform at the discharge point of stormwater pipes. In curved seawalls and revetment, the ramps or steps for the outlets will be faced with local greywacke rock where they are located over rocky intertidal or beach sites, or with the same imported rock where they discharge through the imported rock revetment.

2.3.3 Bus shelters

The northbound bus stops at Mahina Bay and York Bay will require relocation. The design of the new bus shelters will include providing for sufficient shared path width and providing a foundation for the new structures.

2.3.4 Further structures and features

Other proposed structures, features and works include new and relocation of existing street lighting, signage and markers, provision of seating, and traffic services including kerb separators, parking, safety barriers, signage and marking. It is proposed to remove a pohutukawa (*Metrosideros excelsa*) tree in York Bay ('Atkinson tree') that is within the seawall footprint: transplant is not recommended because a rootball cannot be formed in beach gravel and because the tree is growing from a man-hole riser, and the tree is of poor form (Spencer 2018).

2.4 Seawalls and Shared Path Construction

2.4.1 Staging and timing

The intention is to stage the works at one bay (and Windy Point) per year and complete the Project over six financial years (subject to funding). Windy Point, Point Howard/Sorrento Bays and Lowry Bay would be completed in the first three years, and then the other bays. Each bay is expected to take *c.* 3–6 months, depending on length and complexity.

Works will generally be undertaken during daylight hours except where operations need to be carried out at low tide or on the road during off-peak hours or at night.

2.4.2 Site preparation, demolition and excavation

The following construction tasks and processes will typically be carried out (see **Section 2.6** for environmental procedures).

- Breaking out of the existing seawall as necessary to allow for construction of the new seawall. Complete removal of the existing seawall may be required at some sites to provide access to construct the new wall. Demolition and removal of the existing wall would be undertaken using an excavator and/or excavator-mounted breaker. Excavator access to the beach will be via existing accessways (boat ramps) or constructed access. Most if not all seawall demolition material will be removed to an appropriate landfill site.

- Excavation will be necessary to embed into the substrate the toes of curved seawalls and cantilevered retaining walls at revetment. Excavation will also be necessary for the foundations of boat ramps and access steps and to toe-in the base of some revetment treatments. Excavations will be dewatered to enable foundations for the seawall and revetment to be constructed.

- The in situ founding material is mostly competent weathered rock. Whilst excavation will generally be shallow (<1 m), seawall foundations in some locations may need to extend down by 2–5 m below current beach level to reach material of acceptable bearing capacity and ensure seawalls are not undermined by future coastal erosion or scour (Watts 2017). These deeper foundations will utilise traditional deep foundation techniques such as reinforced concrete cut-off walls, sheetpiling, or bored or driven reinforced concrete piles, depending on depth and loading on the foundation. These sites, totalling 1.55 km, are at Sorrento Bay (50 m), Lowry Bay (585 m), York Bay (450 m), Mahina Bay (220 m) and Sunshine Bay (250 m).

- At beaches, buried sediments excavated for constructing the shared path foundation will typically comprise alternating gravels, sands, silts and fine sediments (clays, silty clays and clayey silts) (Watts 2017). These will be separated into materials suitable for placement on beaches, and those with significant levels of silts and clays that will be disposed offsite to avoid sedimentation and turbidity effects in the CMA.

- In rocky intertidal areas, to aid subsequent biotic reintroduction and create additional habitat in the new environment, excavated larger natural weathered rock material that has been colonised by intertidal biota will be stockpiled nearby in a similar zone, and replaced on the beach in front of the new curved seawalls after construction of each intertidal section.

- It is expected that the revetment upgrade works will entail using an excavator for partial or complete deconstruction and re-laying of the existing rock and addition of new rock to conform to the overall revetment specifications (Corin, Povall & van Halderen 2019).

2.4.3 Construction

- The reinforced concrete cantilever retaining wall in revetment will be poured in situ using prefabricated vertical formers. The rock layers are placed in front of this structure on a geofabric and AP65 granular bedding layer. Geofabric may only be necessary for revetment on unconsolidated sediment (beach, gravels, cobbles). If geofabric is placed, the edge and tails of the geotextile will be hidden beneath the rock. Ground treatment prior to rock placement may require excavator access to the shore and working in seawater (e.g. excavating the toe using a rock breaker or concrete saw). The revetment rock itself is expected to be placed from road level (via excavator), but the final method is at the discretion of the Contractor.

- Curved seawalls (incorporating textures) will be cast in situ (rather than precast) to aid constructability given the potentially difficult horizontal and vertical construction challenges of the site. The void to the rear of the curved façade will be backfilled with no-fines mass concrete. Drainage will be provided in the form of weepholes. Steps and boat ramps will also be built of in situ reinforced concrete.

- Following completion of the foundations, the lower level of the seawall is poured on site in sections using prefabricated shaped formers. Higher levels, as necessary, will be formed in ‘lifts’ to aid construction and minimise time in the intertidal zone. Following the pouring of the upper section of wall the surface is prepared and sealed with asphalt and concrete kerb separator blocks are installed.

- Working within the tidal zone poses constraints on construction zones and concrete pours. Shoring will be required at some locations to enable construction to take place in a timely and environmentally acceptable manner.

2.5 Beach Nourishment Design and Construction

Addition of sediments to beach environments in the SPP will arise from two sources:

- buried former beach deposits that would be excavated for the construction of the shared path foundations and that may remain on beaches (‘proxy nourishment’)
- the specific beach nourishment programme at Point Howard, Lowry Bay and York Bay to restore existing beach dimensions and associated amenity and recreational values to compensate for proposed beach encroachment.

2.5.1 Proxy nourishment

Whilst excavation will generally be shallow (<1 m) for the majority of the SPP beaches, seawall foundations in some locations may need to be up to 5 m below current beach level in order to reach material of acceptable bearing capacity (Corin, Povall & van Halderen 2019). These locations include Sorrento Bay, Lowry Bay, York Bay, Mahina Bay and Sunshine Bay. Suitable excavated beach material is to be stockpiled nearby and replaced on the beaches after construction of each section of seawall is completed.

Proxy nourishment is a potential source of suitable beach sediments for the beach nourishment programme at Point Howard, Lowry Bay and York Bay. Total volumes of sediment that may arise from this source are between 2350 m^3 (for 0.9 or 2 m deep foundations) and 5600 m^3 (for 5 m deep foundations at Lowry and York Bays) (**Table 2-4**).

2.5.2 Beach nourishment

Design guidance for imported beach nourishment recommends use of a similar to slightly coarser sediment than the ‘native’ sediment as this will provide a similar slope, look and feel to the existing beach. The fill would be sourced from the re-use of native beach material removed during shared path foundation construction, and from imported fill from existing dredging of the Hutt River mouth. It is assumed that all imported sediment would be processed to remove fines (<2% passing 150 microns), and proxy nourishment sediments selected, to closely match the in situ sediment properties and to reduce risks of increased turbidity from fines washing out into the Coastal Marine Area (Reinen-Hamill 2019).

Table 2-4: Proxy nourishment total sediment volumes at Point Howard, Lowry Bay and York Bay. Volumes refer to pre-excavated condition. Seawall foundation lower and upper estimated depths from Watts (2017).

Beaches	Beach length (m)	Net encroachment area (m^2)	Beach width loss (mean) (m)	Seawall foundation depth (m)		Proxy nourishment sediment volume (m^3)	
				Lower	*Upper*	*Lower*	*Upper*
Point Howard	115	182	1.58	0.9	0.9	164	164
Lowry Bay (N of boatshed)	75	-31	-0.41	2.0	5.0	-62	-156
Lowry Bay (S of boatshed)	415	824	1.99	2.0	5.0	1648	4119
York Bay	230	300	1.30	2.0	5.0	600	1500
Total	**835**	**1275**				**2349**	**5628**

The beach nourishment is proposed at existing high tide beaches and the sediments are then expected to be redistributed by coastal processes within the full length of each embayment (**Table 2-5**). Around 6000 m^3 of sediment will need to be derived from proxy nourishment sources or imported, which will rapidly consolidate to around 4600 m^3 when in place (over periods of days to weeks). Between 11.5–15.4 m^3 per linear metre would be placed in the nourishment zones, reducing to around 5.5–10.3 m^3 per linear metre after redistribution along the effective beach length.

A shorter and wider beach will result at the initial placement sites for the three bays (shown at Appendix D, Reinen-Hamill 2019). These placement areas are the widest areas of beach with the most substantial high tide area. They are intended not to extend across significant stormwater outlets if possible.

Over time it is anticipated that the proposed beach area will be the same as the present day effective beach length (**Table 2-5**) and will follow the contours of the existing upper beach. The imported material will be re-distributed along each bay and will respond to the incident wave energy and direction in a similar way to the existing beach sediment.

The proposed beach nourishment will result in a maximum net seaward shift of the beach profile by around 6 m at Lowry Bay and Point Howard and about 4.6 m at York Bay.

Table 2-5: Beach extents and proxy nourishment or imported sand volumes. Effective beach length = full length of each embayment; linear length nourished = initial placement sites. Volume refers to pre-consolidated condition. Lin.m = linear metre. Source: Reinen-Hamill (2019)

Location	Effective beach length (m)	Linear length nourished (m)	Volume (incl. 1.3 x overfill) (m^3)	Placed volume after consolidation (m^3/lin.m)	Expected average volume over effective beach length (m^3/lin.m)
Point Howard	120	80	1600	15.4	10.3
Lowry Bay	450	160	3200	15.4	5.5
York Bay	150	80	1200	11.5	6.2
Total	**720**	**320**	**6000**	**-**	

2.5.3 Beach nourishment construction

Beach nourishment bench

It is anticipated the existing beach sediments present within the proposed footprint and immediately seaward of the construction area will be moved down the beach face prior to the construction of the shared path structure, rather than removing and stockpiling. This serves the dual purposes of retaining the material on the foreshore to provide a buffer against coastal processes during foundation excavation and construction, and providing a bench for the beach nourishment. The bench would be formed at about MHWS level, largely within the existing beach footprint.

Forming the bench is likely to be done initially by a hydraulic excavator operating along the crest of the existing seawall or road surface, although once the bench is formed, it could be carried out by machinery working along the upper part of the beach during low tide periods (two hours either side of low water). Bench formation during the construction of the shared path will be limited to the immediate area of the works planned for that period plus a transition zone of around 20 m either side of the work area.

The beach nourishment bench will create an over-steepened upper intertidal beach face within the existing beach footprint, typically with a seaward slope of 1(V):5 to 1(V):4(H) depending on the reach of the excavator. Over the construction process this sediment will be transported down and along the beach face depending on the incident wave conditions, with the net result being a slight increase in levels along the beach area. This activity may need to be done several times during the construction of the path and immediately prior to importing beach sediment, as wave action is likely to move the material back up the beach face.

It is envisaged that the beach nourishment bench will be progressively extended as shared path construction proceeds in 20 m lengths through the beach nourishment areas (eight lengths in Lowry Bay, four lengths each at Point Howard and York Bay).

Beach nourishment placement

Imported sediment would be transported to the site either by truck or barge. A single deposition location within each bay onto the formed high tide bench is preferred (over end-tipping along the beach). The sediment would then be transferred by excavator along the bench during low tides to form a beach berm, or crest, up to 10 m out from the shared path seawall, around 0.6 m above MHWS with a seaward slope of around 1(V):4(H) (Appendix D, Reinen-Hamill 2019).

It is envisaged that beach nourishment itself would be undertaken once seawall construction in each bay has been completed.

2.5.4 Anticipated movement of placed sediment

With the linear placement of sediment on the formed bench, it is expected sediment will move by cross-shore transport down the beach face during periods when wave action is sufficient to generate waves during the upper stages of the tide (typically during mid tide and higher tide levels). This would result in the landward retreat of the beach crest and a seaward movement of the beach toe. This process is expected to result in a beach face slope similar to the existing beach profile slope and sorting will occur with sands and gravels moving to their preferred locations on the beach profile (**Figure 2-5**; Reinen-Hamill (2019)).

Alongshore transport will act to distribute the placed sediment wider within the embayments. The speed of this process will depend on the persistency of waves that break at an angle to the shoreline creating alongshore velocity vectors. It is likely that this will result in movement both to the south and north of the placed sediment, and in retreat of the placed sediment profile (**Figure 2-5**) and gains in the adjacent beach profiles. Sediment transport will only be at the rate that the natural processes of waves, tide and wind allow. Due to the shape of the bays, alongshore loss from the bay where the sediment is placed is not anticipated.

2.5.5 Control structures and ongoing re-nourishment

Control structures and ongoing beach re-nourishment are not anticipated.

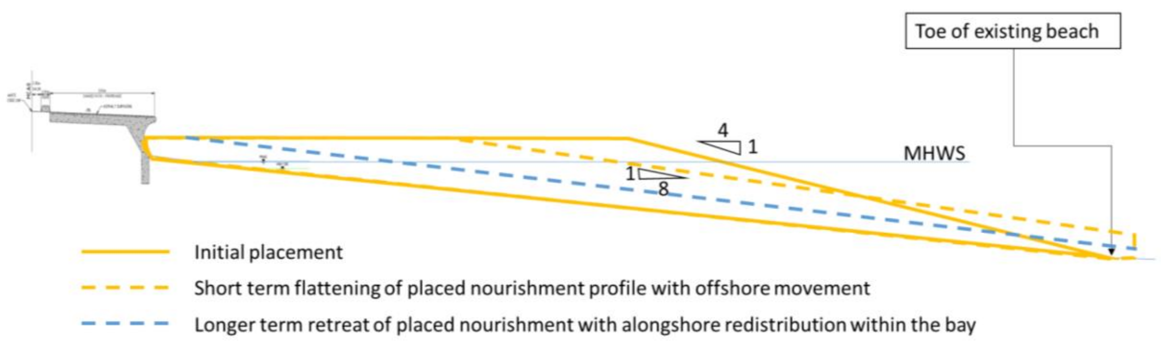

Figure 2-5: Illustration of sand nourishment placement and expected cross shore redistribution and landward retreat of the placed profile due to alongshore processes. Source: Reinen-Hamill (2019).

2.6 Site Environmental Management

Excavation over much of the 3.1 km seawalls length to embed seawall toes, cantilever retaining walls and the base of revetment treatments, and boat ramps and access steps foundations will occur within the CMA intertidal zone and be subject to tidal processes. By the currently available representation of low tide (MLW), a five metre length of triple curve seawall at north Lowry Bay is the only site that necessarily entails operational works within or very near to the subtidal zone at low tide. Such sites will be more extensive during neap low tide periods and less extensive during spring low tide periods. Of the 14972 m^2 in the construction zone, 3848 m^2 (25.7%) is above MHWS, 10 976 m^2 (73.3%) is in the intertidal and 148 m^2 (1%) is in the subtidal zone.

The design features report (Corin, Povall & van Halderen 2019) lists measures to reduce the potential environmental effects of the construction phase in this environment, as summarised below. Additional mitigation of construction effects is recommended elsewhere in this report.

2.6.1 General construction and site environmental management procedures

- Up to 20 metre lengths of seawall would be under replacement at any one time to have small increments of potential discharge of sediments and reduce the risk of wave overtopping.

- To minimise encroachment of the construction on adjacent areas, a construction zone on the beach floor/intertidal area will be defined as the minimum working distance beyond the seawall toe necessary for machinery access to the beach floor/intertidal area to excavate the bed and construct and bury the seawall edge. This construction zone will be physically demarcated. The proposed widths are 3 m for revetment and 5 m for curved seawalls.

- Where there is adequate space, machinery would work from the road verge rather than the beach/foreshore, to minimise the area outside of the direct excavation zone subject to construction plant.

- Use of the excavator on the beach would be minimised to limit damage to the beach area. Machinery working in the foreshore/harbour floor would track across weight-bearing mats to reduce compaction of softer/looser substrate and help to protect the intertidal surface structure within the beach areas. It will also provide a defined route for the machinery to work from, reducing unnecessary impact to the beach/harbour floor substrate.

- The excavator would not be stored overnight or maintained or refuelled on the beach.

- Working in seawater will be avoided wherever possible. Placing the lowest revetment rocks may require an excavator to reach into seawater during final positioning of the toe and lower armour. This would entail the occasional dipping of the bucket head into the water to place each rock in a specific position to maximise structural integrity. This dipping will only be required for the lowest rocks or to retrieve rocks which may have rolled away under wave action before the revetment has been completed.

- Given the risks to works and of sediment and cementitious discharges, careful consideration and multi-day forecasting of tide, wind and wave conditions will be undertaken to avoid overwhelming of sea defence during construction.

2.6.2 Sediment control and water management

Principal risks to the intertidal environment during construction are release into the environment of sediment, of water contaminated with cementitious products, and of other contaminants. Measures to avoid or minimise these include:

- Installation of silt control measures. All demolition will be contained within a silt-fence or behind the new seawall. There would be no exposure of non-native backfill material to the sea (to be enclosed by seawall and silt fences).

- Crushed material used for shared path construction will be clean of fines smaller than sand particles, to promote quick settling of suspended particles.

- Bunding / shuttering will be used to contain and isolate the construction area from the incoming tide until construction is completed (e.g. clean beach gravel sourced from the excavated area, or sheet piling). Such a structure will need to be large enough to allow construction to continue 'in the dry' and strong enough to withstand waves and the incoming tide.

- In rocky shore habitats with their larger material, and where seawall works occur close to the mid-tide mark, alternative sediment control devices will be used, which may include sand-filled geotextile containers or tubes (sand to be locally sourced) that can be easily removed at works completion.

- Earthwork and construction activities will consider tide timing, tidal height and possible storm events to avoid movement of sediment containing fine sediment in a wet environment. Storm events will very likely overtop any sediment control mechanism used. During overtopping, sediment will likely be shifted into the excavated seawall footing area. A site plan for sediment removal will be developed.

- Machinery working on the beach floor/intertidal area would use biodegradable hydraulic fluids. A spill kit would be maintained on site to contain any accidental spills.

- Procedures for dewatering of excavations and for ensuring all water discharged into the environment has been treated to standards for sediment and cementitious products, as described in the design features report.

2.7 Construction and Environmental Management Plan

A Construction and Environmental Management Plan (CEMP) will be prepared for the various stages of the Project. It will include the environmental management and monitoring procedures to be implemented during the Project's construction phases. The CEMP outlines details of the ‘who, what, where and when’ in respect of the environmental management and mitigation measures to be implemented. The CEMP will be a condition of the consent and will be updated and modified as appropriate once a Contractor is appointed.

Other plans to be prepared within the CEMP are a Beach Nourishment Management Plan (BNMP), Construction Traffic Management Plan (CTMP), and Landscape and Urban Design Plan (LUDP). The intention is that all construction, demolition and maintenance work comply with NZS 6803P "Measurement and Assessment of Noise from Construction, Maintenance and Demolition Work" and therefore comply with the activity status in the HCC District Plan.

The CEMP, its subplans and other site-specific environmental management plans are to be consistent with and complement the AEE report. They will be developed in accordance with the proposed consent conditions.

3 STUDY METHODS

3.1 Spatial Coverage

Surveys and assessments of the existing vegetation and avifauna and their habitats covered the SPP footprint area, together with a 'zone of influence' (ZOI) considered prior to the survey to cover the likely maximum spatial extent of potential effects (Roper-Lindsay et al. 2018).

The survey area for vascular plants covered the SPP footprint and adjoining areas on the ecological gradient from the intertidal zone up to Marine Drive. A separate survey for seagrass (rimurēhia, *Zostera muelleri* subsp. *novazelandica*) was undertaken in the intertidal and subtidal zones at Point Howard, Lowry Bay and York Bay (Overmars & van Kampen 2019).

For coastal avifauna (other than little penguins), the survey area in the CMA was the intertidal zone plus coastal waters extending *c.* 200 m into Wellington Harbour. For terrestrial habitats, the survey area encompassed the SPP area and adjoining terrestrial habitats that may be used by coastal birds. Rocky islets were viewed with binoculars.

For little penguins, two surveys were undertaken along the eastern side of Wellington Harbour (Rumble 2016b; Judkins 2018a) to provide baseline information for this study.

3.2 Vascular Vegetation and Flora

Methods for description of the existing vascular vegetation and flora were:

i. Information search, including Threatened and At Risk species.

ii. Field surveys to compile a species list and habitats list (Point Howard to northern Days Bay, 2016-05-04; Windy Point, 2017-05-17). The survey covered terrestrial habitats between Marine Drive and the sea, including Claphams Rock (York Bay-Mahina Bay headland) but excluding sites outside the ZOI (Little Penguin Haven and the islet at the south end of Sorrento Bay). Some taxa were identified to genus or family only (e.g. seedlings, grasses). Location data recorded using Trimble Geoexplorer 6000 GPS was typically to sub-metre accuracy after differential correction.

   Landscape and restoration plantings of indigenous (including Threatened and At Risk) species at Point Howard, York Bay, Claphams Rock and Windy Point were inventoried (December 2018). A search of the shared path route at Point Howard was undertaken for *Melicytus orarius*.

iii. A snapshot survey for seagrass was undertaken at Point Howard, Lowry Bay and York Bay in December 2018 (Overmars & van Kampen 2019).

iv. The status of other past seagrass records around Wellington Harbour was investigated, including surveying the Hutt River Estuary.

v. Data compilation and analysis, including use of Manifold GIS in conjunction with shapefile data on SPP design and LIDAR-derived low, mid, high and MHWS tidal levels, sourced from EOS Ecology and Stantec.

3.3 Avifauna and their Habitats

Methods for description of the existing coastal avifauna and their habitats were:

i. Information search and collation of past and present records of populations and roosting, feeding and breeding activities, including New Zealand eBird (Birds New Zealand 2018) and iNaturalist NZ — Mātaki Taiao (iNaturalist NZ 2018a), and records by the EOS Ecology aquatic habitats team during shared path surveys in May 2016.

ii. Collation of Ornithological Society of New Zealand (OSNZ) data, provided by the Society, from four series of 24 monthly surveys (the last in 2008–2010) of shore and coastal birds along the Wellington Harbour coastline (Robertson 1992). This data was in two sections: from Burdans Gate to northern Days Bay (where Windy Point is the only part within the SPP area); and from northern Days Bay to Point Howard (coinciding with the northern length of the SPP). This data provides historical information on local bird numbers and seasonal and decadal variation and helps interpret data from the field surveys (which were snapshots in time and excluded the breeding season).

iii. Survey (with 8x30 binoculars) to assess species numbers and habitats and habitat use (including terrestrial habitats such as large trees that may nesting/roosting sites for shags).

   Point Howard to Days Bay was surveyed on 2–3 May 2016, from north to south, on the sea margin, on rising tides. The tidal range was 1.1–1.2 m, towards the upper end between neap (0.76 m) and spring (1.36 m) tidal range (Berthot & Dengate 2015). The weather was cloudy and mild, with a moderate northerly wind on the first day and fresh northerly on the second. White-fronted terns tara (*Sterna striata)*, fluttering shearwaters (pakahā, *Puffinus gavia*) and southern black-backed gulls (karoro, *Larus dominicanus dominicanus*) were less conspicuous on the second day in choppy wave conditions beyond the survey area, but this was not evident in the more sheltered waters of the survey area. The small islet at the south end of Sorrento Bay was surveyed with binoculars on two occasions at approximately high tide to assess high tide roost use.

   The Windy Point section was surveyed on 14 and 17 May 2017, on a rising tide and falling tide respectively. The tidal range over the two survey days was 0.7–0.8 m, towards the lower end between neap and spring tidal range, so with less intertidal habitat exposed. Weather on the survey days was partly cloudy or cloudy with moderate northerly breezes and moderate to mild temperatures.

   These survey times coincided with the autumn-winter influx of many coastal bird species into Wellington Harbour (Robertson 1992). Observations of interest outside survey times were also recorded.

vi. Data compilation and analysis, including use of Manifold GIS in conjunction with SPP design data sourced from Stantec.

3.4 NZ Little Penguins

Methods for description of the little penguin population and its habitats were:

i. Information search and compilation, particularly records of populations and habitat use in Wellington Harbour. Records offered by residents during field surveys, by local observers, and via feedback forms from community consultation (Olden 2017) were collated.

ii. Two baseline surveys were undertaken in October 2016 and October 2017 by an Eastern Bays Little Penguins Group and Kaikoura Ocean Research Institute team using a penguin detection dog certified by the Department of Conservation (DOC). The 2016 survey extended along the Wellington Harbour eastern shoreline from Seaview to Pencarrow Head, seaward of Marine Drive (Rumble 2016a). The 2017 survey covered from the Hutt River Estuary bridge to Burdans Gate, and included lands directly inland of Marine Drive: private properties for which access permission had been granted and council reserves and non-formed legal road (Judkins 2017; Judkins 2018a). Survey timing on both occasions was intended to coincide with the peak of the breeding season (October). The primary variable sampled was breeding sites: sites with birds or eggs or penguin sign. Data attributes collected were: number of penguins (adults, chicks, eggs); penguin sign (faeces, burrow); habitat (nest box, pipe/drain, rocks, trail, vegetation) and detection type (handler, interest, point, sit) (Judkins 2018b). The location accuracy of the Garmin eTrex Vista GPS used when operating in autonomous mode is typically 10 m (e.g. Abdi et al. 2014).

iii. Stantec in conjunction with two members of the Eastbourne Community Board arranged for landowner access consent for the 2017 penguin survey component inland of Marine Drive, between Seaview and the junction of Muritai Road and Marine Parade at Eastbourne. Access was sought only for roadside properties, given the logistical constraints for surveying the full possible extent of penguin nesting sites up to several hundred metres inland (Heather, Robertson & Onley 2015). Access consent was granted for 65 out of 195 addresses (33.3%). A small number of these and of areas of reserves and legal road that were unsafe to search or had terrain or boundary fences that would exclude penguins was not searched.

iv. Relying on the known philopatry of little penguins (nearly always returning to their home territories when coming ashore; Kinsky 1960), likely duplicate site records in the two surveys were identified and then treated as one site in a combined dataset of the two surveys. Duplicate sites were regarded as ones of different years with GPS locations within *c.* 15 m of each other, but also taking account of similarity in habitat data and survey notes. Survey notes on the re-finding of three 2016 survey site markings by the 2017 survey (GPS locations 2–11 m apart between years) provided some verification of this process. Two other records obtained from Shared Path consultation with Eastern Bays residents (Olden 2017) and two from a local observer were added to the 2017 dataset. Records were also compiled of little penguin mortalities, principally sourced from iNaturalist NZ (2018a) and contact with local residents. Habitat data and mortality data were compiled.

v. Stormwater drains draining local catchments between Point Howard and Windy Point were surveyed and photographed during a rain event, for flow and potential utility for penguin under-road access to breeding habitats inland of Marine Drive without risk of road mortality. HCC stormwater and storm hydrography GIS data were obtained.

vi. Little penguin accessibility for existing and proposed seawalls configurations was assessed. The EOS Ecology GIS file for existing seawall types was used for the Point Howard to Sunshine Bay project section, and the Stantec toe of existing seawall GIS file was used for the Windy Point section. Seawalls were judged (largely from photographs) to be accessible for slopes up to 45°, where birds can get a grip on a rough surface or crack in the rock, and where vertical levels are less than 300–400 mm (Rumble 2016b).

vii. Data compilation and analysis, including use of Manifold GIS in conjunction with SPP design and tidal data (MHWS, high tide, mid-tide, low tide) sourced from Stantec.

3.5 Assessment of Ecological Value and Level of Effects

3.5.1 Assessment of ecological value

Assessment of ecological value is based on:

i. Previous assessments, and/or

ii. Environment Institute of Australia and New Zealand (EIANZ) guidelines for Ecological Impact Assessment in New Zealand (Roper-Lindsay et al. 2018) [10]

iii. Full or partial legal protection of indigenous biodiversity in relevant planning documents: NZCPS, Regional Policy Statement for the Wellington Region (Greater Wellington Regional Council 2013), Regional Coastal Plan for the Wellington Region (Wellington Regional Council 2000) and the Proposed Natural Resources Plan for the Wellington Region (Greater Wellington Regional Council 2015).

Five previous assessments are relevant.

i. Habitats with significant biodiversity values for indigenous birds in the CMA that are listed at Schedule F2c (Habitats for indigenous birds in the coastal marine area) of the Proposed Natural Resources Plan. These sites were derived from an ecological value assessment using the criteria of representativeness, rarity, diversity and ecological context, specified in Policy 23 of the Regional Policy Statement (Greater Wellington Regional Council 2013).

ii. Schedule F5 (Habitats with significant indigenous biodiversity values in the coastal marine area) of the Proposed Natural Resources Plan includes kelp beds, seagrass and subtidal rocky reefs (Greater Wellington Regional Council 2015).

iii. Terrestrial ecosystems and habitats with significant biodiversity values listed in the City of Lower Hutt District Plan (Hutt City Council 2017). The District Plan acknowledges that the schedule of significant natural resources is not complete, and sites may be added or removed through statutory procedures using these assessment criteria: representativeness, rarity, diversity, distinctiveness, continuity and linkage in the landscape, and ecological restoration.

iv. Indigenous vegetation associated with 'originally rare' terrestrial ecosystem types (Williams et al. 2007; Holdaway, Wiser & Williams 2012).

[10] The tables in the EIANZ guidelines for assessing ecological value, magnitude of effect and level of effects are shown at **Appendix A**.

v. The New Zealand species Threat Classification System (Townsend et al. 2008) and assessments for vascular plants (de Lange et al. 2017) and indigenous birds (Robertson et al. 2017).

Items iv and v correspond to 'National Priorities' 3 and 4 of the Government 'Statement of national priorities for protecting rare and threatened indigenous biodiversity on private land' (Ministry for the Environment & Department of Conservation 2007). National Priorities 1 and 2 are not relevant: respectively, the Land Environments of New Zealand units at Level IV in the SPP area (C2.1a, F1.4b) are not specific to its coastal environment, and the SPP area lacks sand dunes and terrestrial wetlands.

Protected Area Status [11]

There are no protected natural areas within the SPP footprint but works or activities will or may occur in two local reserves. Whiorau Reserve is a local purpose reserve (New Zealand Gazette 2000 p 4264) and Claphams Rock is a recreation reserve (New Zealand Gazette 1954 p 1008).

There is one nearby protected natural area administered by DOC (Waitohu Road Conservation Area, 103 m^2; primarily a stairway, pers. obs.), and one recreation reserve (Lowry Bay recreation reserve, 3.47 ha). There are two nearby scenic reserve areas administered by HCC at Sorrento Bay (0.47 ha) and another at Sunshine Bay (also 0.47 ha).

The Little Penguin Haven at the northern end of Days Bay consists of a local purpose reserve (wildlife management, gazetted 1996), and adjoining land containing the Days Bay pumping station but managed with the reserve (Hutt City Council 2003).

The SPP vicinity also includes legal road, local reserves and other land administered by HCC that also have natural habitats. Much of the land east of Marine Drive is managed by Greater Wellington Regional Council as the East Harbour Regional Park (Greater Wellington Regional Council 2007).

3.5.2 Assessment of magnitude and level of effects

The term 'effect' includes (Section 3 of Resource Management Act 1991):

(a) any positive or adverse effect; and

(b) any temporary or permanent effect; and

(c) any past, present, or future effect; and

(d) any cumulative effect which arises over time or in combination with other effects—

regardless of the scale, intensity, duration, or frequency of the effect, and also includes—

(e) any potential effect of high probability; and

(f) any potential effect of low probability which has a high potential impact.

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[11] NZCPS Policy 11 (a) vi.

Criteria in the EIANZ guidelines for assessing magnitude of effects (Roper-Lindsay et al. 2018)[12] have two components, one related to alteration to key elements/features/character/composition and/or attributes of the existing baseline conditions, the other to the known population or range of the element/feature. These are interpreted here to apply to habitats and species respectively. The scale for the first component is not specified and is interpreted here as local and national scales.

Level of effects is derived from a matrix that has ecological value in one dimension (very high, high, moderate, low) against magnitude of effect (very high, high, moderate, low, negligible) in the second dimension (Roper-Lindsay et al. 2018).[13]

3.6 Sea-level Rise

Although direct and indirect consequences from ocean and atmospheric warming and ocean acidification will also occur, sea-level rise will be the most important consequence of global climate change for coastal ecosystems (McGlone & Walker 2011). This section summarises sea-level rise parameters used here towards assessing SPP effects.

3.6.1 'Mitigation' and adaptation

The Intergovernmental Panel on Climate Change (IPCC) strategy to address climate change and sea-level rise is built around knowledge of the physical science (IPCC 2013), 'mitigation' (IPCC 2014c), and adaptation (IPCC 2014a, b). 'Mitigation' is the reduction of sources and enhancement of sinks of greenhouse gases, or interventions that contribute to these aims. Adaptation is the process of adjustment to actual or expected climate and its effects: in human systems, the moderation or avoidance of harm or exploitation of beneficial opportunities; in some natural systems, the facilitation of adjustment to expected climate and its effects.[14]

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[12] See **Appendix A**.

[13] See **Appendix A**.

[14] Adaptation approaches to sea-level rise (primarily for human assets) fall into four general categories (Wong et al. 2014; Bell et al. 2017):

i. Protection of people, property, and infrastructure; including 'hard' protection measures such as seawalls and 'soft' measures such as enhancing coastal vegetation and reducing erosion. Protection is a typical first response.

ii. Accommodation involves adjusting existing assets by using measures that anticipate hazard risk, such as retrofitting buildings and insurance programmes.

iii. Avoidance is stopping putting people and assets in harm's way, primarily using land-use planning measures.

iv. Retreat /managed retreat; moving existing people and assets away from the coast, or because of erosion and inundation damage after climate-related events. It may be the only viable option when nothing else is possible.

The choice between hard protection or managed retreat as the adaptation strategy for built environments in the coastal zone (Reisinger et al. 2015) will have profound consequences for coastal ecosystems and biota. Hard protection such as seawalls will increasingly present a barrier that prevents the inland movement of habitats and biota at the coastal-terrestrial interface, and it will result in their increasing and eventual total inundation. This phenomenon, known as 'coastal squeeze' (Doody 2013; IPCC 2014b)[15], will result in major losses of coastal ecosystems globally. The SPP project is a microcosm of this phenomenon.

As a sea-level rise coastal hazard strategy, the upgrading and replacing hard protection structures by the SPP 'buys some time' (decades) to allow Councils and their communities to develop and implement a dynamic adaptive pathways coastal hazards plan for the Eastern Bays area including options for managing the road access to Eastbourne in adaptation to sea-level rise (Allis 2019).

3.6.2 Sea-level rise projections

Even if there are no further net global emissions, because of the substantial lags in global mean sea-level response to atmospheric warming, there is already a commitment to long-term sea-level rise up to 1.6–1.7 m relative to the present level that will be realised over coming centuries and millennia (IPCC 2014c; Bell et al. 2017; Mengel et al. 2018). Each 5-year delay in near-term peaking of CO_2 emissions to net zero greenhouse gas emissions increases median year 2300 sea-level rise estimates by *c.* 0.2 m (Mengel et al. 2018). The rate at which sea level will rise and the magnitude of this rise become increasingly uncertain as the timeframe lengthens. Emissions decisions made in the next few years to one-to-two decades will have a profound effect on global climate and human societies, particularly for sea-level rise, not just for this century but for the next several millennia (Clark et al. 2016; Bell et al. 2017).

In the context of coastal hazards and sea-level rise, Ministry for the Environment guidance for local government (Bell et al. 2017) advises the use of four sea-level rise scenarios, over timeframes out to 2120, consistent with the NZ Coastal Policy Statement (**Table 3-1**). These are median projections for three Representative Concentration Pathways emissions scenarios (RCP 2.6, RCP 4.5 and RCP 8.5) and an 83rd percentile projection as a high-end projection (RCP 8.5 H^+). Sea-level rise at the year 2100 under these projections ranges between 0.46 m (RCP 2.6) and 1.05 m (RCP 8.5 H+).

Sea-level rise will increase the frequency of wave overtopping and coastal inundation (Gorman et al. 2006; Allis 2019). With only 16 cm of sea-level rise (occurring within 10–20 years, **Table 3-1**) the frequency of the present day '100-year storm' in Wellington will have increased to once per year on average (Stephens 2015).

[15] Coastal squeeze: 'A narrowing of coastal ecosystems and amenities (e.g. beaches, salt marshes, mangroves, and mud and sand flats) confined between landward-retreating shorelines (from sea level rise and/or erosion) and naturally or artificially fixed shorelines including engineering defences (e.g. seawalls), potentially making the ecosystems or amenities vanish' (IPCC 2014b).

Table 3-1: Increments for selected decades out to 2150 for projections of sea-level rise (metres above 1986–2005 averaged baseline) for New Zealand region for four future scenarios. Figures for Wellington would be 1.8 cm per decade larger if current tectonic subsidence continues. SLR = sea-level rise, M = median. Source: Bell et al. (2017).[16]

NZ SLR scenario Year	NZ RCP 2.6 M (median) [m]	NZ RCP 4.5 m (median) [m]	NZ RCP 8.5 m (median) [m]	NZ RCP 8.5 H+ (83rd percentile) [m]
1986–2005	0	0	0	0
2020	0.08	0.08	0.09	0.11
2030	0.13	0.13	0.15	0.18
2040	0.18	0.19	0.21	0.27
2050	0.23	0.24	0.28	0.37
2060	0.27	0.30	0.36	0.48
2070	0.32	0.36	0.45	0.61
2100	0.46	0.55	0.79	1.05
2110	0.51	0.61	0.93	1.20
2120	0.55	0.67	1.06	1.36
2150	0.69	0.88	1.41	1.88

3.6.3 Uncertainty and decision-making in sea-level rise adaptation

Decision-making in sea-level rise contexts faces different levels of uncertainty (EIANZ 2018). Sea-level rise uncertainty for timeframes extending beyond 2100 arises mainly from the unknown future rate and magnitude of sea-level rise, which locates it in the 'deep uncertainty', high-consequence range (Bell et al. 2017). A dynamic adaptive pathways planning approach has been proposed in planning adaptation responses to sea-level rise (Haasnoot et al. 2013; Bell et al. 2017). Central to adaptation pathways (scenarios) are adaption tipping points, which are the conditions under which an action no longer meets the clearly specified objectives and additional actions are needed. As a result, a pathway emerges.

Consideration of sea-level rise effects in this report is intended to illustrate inter-relationships between the SPP and sea-level rise effects on coastal ecosystems and biota. A degree of significant sea-level rise is recognised as inevitable, but timeframes are expressed in general terms because of the uncertainty of future outcomes. No rationale that the SPP acceptably brings forward sea-level rise effects is implied.

[16] The United States National Oceanic and Atmospheric Administration (NOAA) provides six scenarios for global mean sea-level rise to the year 2100: 0.3 m, 0.5 m, 1.0 m, 1.5 m, 2.0 m and 2.5 m (Sweet et al. 2017). The 0.3–2.5 m range spanned by these six scenarios increases to 0.4–5.5 m by 2150, and to 0.4-9.7 m by 2200.

4 VASCULAR VEGETATION AND FLORA [17]

4.1 Existing Coastal Environment

The existing Eastern Bays coastal environment is characterised by a series of rocky headlands separating sand and gravel-filled embayments. Much of Marine Drive is formed on a wave-cut platform uplifted *c.* 2 m as a result of the 1855 Wairarapa Earthquake that created an exposed strip of sea bed around the Wellington Harbour beaches (McSaveney & Pillans 1996, cited in Begg & Johnston 2000; Olson 2009). The predominant surface rock type is Rakaia Terrane alternating sandstone and mudstone (greywacke and argillite), evident as headlands and fringing the embayments, plus Holocene beach deposits consisting of marine gravel with sand and mud, and beach ridges, at Lowry Bay and Days Bay (Begg & Johnston 2000). The Wellington Region is tectonically active, with a history of episodic earthquakes on the Wellington Fault, Wairarapa Fault and others (Rhoades et al. 2011; Berryman et al. 2018).

The SPP area is in the Eastbourne - Point Howard / Seatoun - Scorching Bay eco-domain (Gabites 2002). This is characterised as a narrow coastal strip, extending 200–400 (–500) m inland from the coastline, with steep, stable hills behind; shallow sandy or pebbly beaches separated by rocky shorelines and headlands; influence of salt-laden gales in a narrower belt than further towards the harbour entrance, often with a calm belt immediately below the cliffs; mild winters and few frosts; and low rainfall seasonality (mean annual 1100–1400 mm).

Wellington Harbour is a semi-enclosed embayment, with mean water depth of *c.* 14 m, maximum depth of 32 m and semi-diurnal tides with a range of 1.5 m (Goff, Dunbar & Barrett 1998). The Harbour has an area of 8900 ha (Greater Wellington Regional Council 2018c). Habitats include the seawater surface and water column, rocky islets, moderately sheltered to sheltered subtidal habitats, and giant kelp (*Macrocystis*) (East Harbour Environmental Association 1998; Greater Wellington Regional Council 2015). Coastal habitat types and environmental factors are further described by McMurtrie & Brennan (2019, Section 3).

Lower salinity, shallow water habitats between Petone Beach and Lowry Bay and Days Bay are caused by freshwater discharge from the Hutt River (Brodie 1958; East Harbour Environmental Association 1998; Stephenson, Milne & Sorensen 2008). Shallow-water soft substrates in these habitats support large beds of cockles (tuangi, *Austrovenus stutchburyi*). Higher salinity environments occur towards the harbour entrance, south from Days Bay.

In the Eastern Bays, concrete seawalls and rock revetments at the interface between Marine Drive and the tidal zone and harbour have encroached onto the upper beach and have disrupted the natural sediment transport regime within each bay, particularly during storm events (Allis 2019). Over time,

[17] 'Vegetation' refers to assemblages of plant species and the ground cover they provide, and 'flora' refers to species composition. 'Vascular plants' are plants with vascular tissues that distribute resources through the plant (e.g. ferns, conifers and flowering plants), as distinct from seaweeds (marine algae that lack a vascular system and roots, stems, leaves and flowers or cones).

the effect of the seawalls (compared to the natural undeveloped state) on beach sediments has been to lower the beach elevation (a common beach response with seawall placement), reduce the proportion of fines within the beach material (due to increased wave reflections) and subtly change the overall plan shape of the beach through altered hydrodynamics and sediment processes.

Currently the Eastern Bays experience short-term cyclical fluctuations in shoreline position (i.e. periods of erosion and accretion) and sediment distribution (i.e. concentration of sediment according to size) on daily, weekly, seasonal, annual and interannual timescales (Allis 2019). These short-term changes reflect the redistribution of sediment within each embayment by wind and wave current action rather than a long-term trend. Storms such as occurred in June 2013 have a strong influence on the ecological character of the coastal environment.

The Eastern Bays coastal environment remains characterised by largely indigenous biota in an environment of dynamic natural coastal processes, abutting the emergent, now terrestrial, wave-cut platform created by the 1855 Wairarapa earthquake and occupied by Marine Drive and seawalls on the coastal platform margin.

4.2 Vascular Vegetation

The vascular vegetation of the SPP area is entirely coastal (influenced by salinity, high solar radiation and desiccation, erosion, nutrient poor soils, winds, tides and waves), and reflects an interplay of strong natural factors (e.g. sediment movement, storm inundation) and human disturbance (including past road construction) (Wassilieff 1996). Vascular vegetation is generally absent from Marine Drive and other vehicular surfaces, concrete seawalls and rock riprap, exposed rocky substrate and most rocky islets.

4.2.1 Seagrass

Three seagrass occurrences were found at south Lowry Bay (**Figure 4-1**) (Overmars & van Kampen 2019). Given the primary limitation on the maximum depth of seagrass is light availability (de Boer 2007), it is unlikely that there are any seagrass occurrences deeper than 60-80 cm below low tide level that were not found by the survey. Seagrass was not found at Point Howard or York Bay (and Sorrento Bay was not surveyed).

From north to south, the three seagrass occurrences had areas of 150, 1620 and 170 m^2 respectively (total 1940 m^2; 0.194 ha). Seagrass density was high in the northern occurrence, low and patchy in the central occurrence, and low to high in the southern occurrence. Sediments at eight of ten quadrats were predominantly sand while pebbles (4–64 mm) were dominant at two quadrats in the northern seagrass occurrence. Seagrass density and sediment substrate appear to be correlated. The northern occurrence has a closely-knit structure of rhizomes and roots that have resulted in raised beds and larger sediments relative to non-vegetated habitats adjoining (**Figure 4-2**). The lower densities at the central and southern occurrences appear to result from establishment or reestablishment of seagrass in relatively mobile fine sediments (**Figure 4-3**), possibly associated with sediment accumulation within the extended embayment created by the Whiorau reclamation in the 1960s. Some seagrass in the southern occurrence is in small sediment patches within rocky substrates.

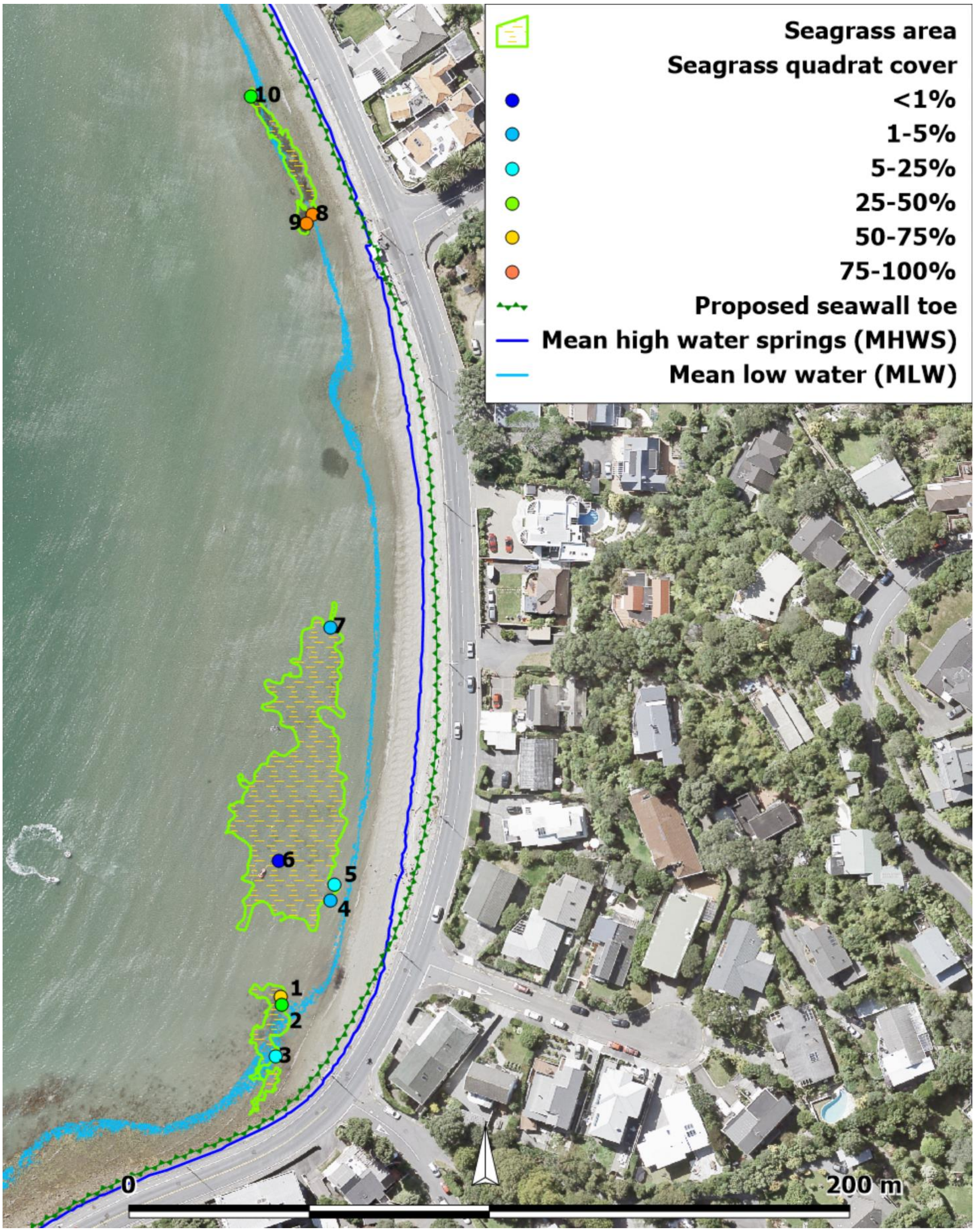

Figure 4-1: Locations of seagrass and seagrass survey quadrats, south Lowy Bay, December 2018. Source: Overmars & van Kampen (2019). Tidal levels and proposed seawall toe based on GIS files sourced from EOS Ecology and Stantec (Rev J). Aerial photography courtesy of HCC.

Figure 4-2: Seagrass bed, north of Cheviot Road bus stop, Lowry Bay. Sediment retention by seagrass is evident in the raised seagrass beds. Photo taken close to extreme low water of spring tides, indicating maximum tidal exposure. Photo: PC280715, 2018-12-28, close to spring low tide.

Figure 4-3: Low density seagrass bed, middle occurrence, south Lowry Bay. Fine mobile sand sediments. Photo: IMG_0389, 2018-12-28.

A small number of flowering shoots were found. The finding of flowering is significant because sexual reproduction facilitates dispersal, enhances genetic diversity, and is an indicator of seagrass health because it is correlated with seagrass bed density (Dos Santos & Matheson 2017).

4.2.2 Beach gravels and sand

A sparse vegetation cover (<20%) of adventive and indigenous species occurs on narrow stretches of beach gravels and sands above MHWS in parts of Lowry, York and Sunshine Bays and at Windy Point. The gravels and sands are subject to accretion and erosion, are freely drained, have raw soils (no topsoil development) and are inundated by storm high tides. Vegetation is mostly confined to a narrow zone adjoining Marine Drive or seawalls. It is mostly short (<50 cm high) except for taller taupata at some places.

Two native sand binders, pīngao (*Ficinia spiralis*, At Risk - Declining) and kowhangatara (*Spinifex sericeus*), were found at the south end of Lowry Bay (**Figure 4-4**). One pīngao plant each was found at two nearby sites in beach gravels within 1–2 m of Marine Drive, above the level of MHWS. These occurrences were not recorded earlier (Freegard & Weeber 1986; East Harbour Environmental Association 1998), suggesting they (and the kowhangatara) were planted through a dune restoration programme. One of the plants has been lost to erosion since first found in 2016. Pīngao formerly covered active and recently stabilised sand dunes throughout New Zealand but has declined and continues to decline through competition from marram grass, loss of habitat through dune stabilisation and compaction, pollination loss in small populations and other factors (de Lange 2014). Marram grass is not present at Lowry Bay but the remaining pīngao plant is vulnerable to erosion, reproductive failure and human disturbance.

Other beach native species included taupata (*Coprosma repens*), New Zealand celery (*Apium prostratum* subsp. *prostratum* var. *filiforme*) and shore bindweed (*Calystegia soldanella*). Introduced herbaceous species were the most frequent and had the greatest cover. The introduced marram grass (*Ammophila arenaria*) had significant cover in areas at Windy Point. A small, planted pohutukawa tree is present in beach gravels at York Bay ('Atkinson tree').

The beach gravel ecosystem is part of a dynamic sediment system in Wellington Harbour, currently responding to seismic uplift from the 1855 Wairarapa Fault earthquake (Olson et al. 2012). Erosion over the past 2–3 years has caused significant loss of beach gravel and sand vegetation cover at Lowry and Sunshine bays (**Figure 4-5**) and has left some taupata and marram at Windy Point hanging by roots or clinging to crevices.

4.2.3 Rocky islets

At the south end of Sorrento Bay, a rocky islet had a substantial ground cover of glasswort (*Sarcocornia quinqueflora*) and other species. The vegetation on the islet is probably responding to guano enrichment by birds roosting at high tide. Other rocky islets within the bays lacked vascular plants.

Figure 4-4: Pīngao (*Ficinia spiralis*) amongst dune vegetation on beach gravels, Whiorau/Lowry Bay. A smaller patch at the foot of the next streetlight pole northwards (distant) has since been lost to beach erosion. Photo: P5040279, 2016-05-04.

Figure 4-5: Views of vegetation loss by erosion in Sunshine Bay, 2016–2017 (from opposite directions). Vegetation cover (mainly adventive *Atriplex prostrata*) present in May 2016 (left photo, foreground) was absent in May 2017 (right photo, beyond power pole). Photos: P5020141, 2016-05-02; P5170103, 2017-05-17.

4.2.4 Rocky headlands, promontories and platforms

Rocky headlands, promontories and platforms had the greatest vegetation cover of the surveyed habitats. Characteristic species at Claphams Rock were knobby clubrush (*Ficinia nodosa*), coastal flax (*Phormium cookianum* subsp. *hookeri*) and taupata shrubs (up to 2 m high). Taupata also had significant cover at the Mahina Bay-Sunshine Bay headland and at Windy Point. Grass and herbaceous cover at the Mahina Bay-Sunshine Bay headland and at York Bay had been sprayed and there has been recent vegetation loss there due to coastal erosion.

A previous record of *Aciphylla squarrosa* var. *squarrosa* (At Risk - Declining) at Claphams Rock (Freegard & Weeber 1986) was not re-found. Nine *Atriplex cinerea* plants (Nationally Critical) were recorded near Claphams Rock and six plants at York Bay (restoration plantings). The habitat at the two *Atriplex* sites (earthquake-elevated marine platform) is not one naturally occupied by the species elsewhere in New Zealand: boulder and sand beaches, sand dunes, estuaries, and shell banks (de Lange, Murray & Gardner 1998).

4.2.5 Landscape plantings

Fifteen indigenous species were recorded in HCC landscape plantings at Point Howard and Windy Point (**Appendix B: Vascular flora survey data; Figure 4-6**). Six are Threatened and At Risk species: *Aciphylla squarrosa* var. *squarrosa* (Cook Strait speargrass, At Risk – Declining); *Astelia chathamica* (Chatham Islands kakaha, At Risk – Recovering); *Brachyglottis compacta* (At Risk – Naturally Uncommon); *Euphorbia glauca* (waiūatua, shore spurge, At Risk – Declining); *Melicytus* crassifolius (thick-leaved porcupine plant, At Risk – Declining); and *Veronica speciosa* (tītīrangi, At Risk – Declining).

4.2.6 Open space habitats and artificial habitats

A mixture of exotic grassland and woody vegetation including pohutukawa on two rocky knobs and at the sea margin, together with road and parking surfaces, is present at Point Howard headland. Whiorau Reserve is largely on land reclaimed in 1966 (Kenderdine 2001) and has a cover of exotic grassland, amenity plantings and woody vegetation (landward side), together with sealed vehicle surfaces.

Small sites between concrete seawalls and Marine Drive have single or small clumps of pohutukawa trees. Pohutukawa seedlings are establishing in cracks on the road edge at Windy Point. At Sunshine Bay, old rock riprap and earth/soil deposits between the rock riprap and Marine Drive had small taupata shrubs and herbaceous species in May 2016 (some since removed by erosion and riprap seawall upgrade).

4.2.7 Inland of Marine Drive

Vascular vegetation inland of Marine Drive consists of hard beech (*Fuscospora truncata*) and black beech (*Fuscospora solandri*) forest, broadleaved indigenous hardwoods and urban environments (Greater Wellington Regional Council 2007; Landcare Research / Informatics Team 2018), with coastal species such as kohekohe (*Dysoxylum spectabile*). This vegetation occurs on former marine gravels and sands at Lowry Bay and elsewhere on greywacke hillslopes rising to >300 m asl. Much of the vegetation has regenerated since European settlement fires and is now protected within the East Harbour Regional Park.

Figure 4-6: Landscape plantings on alignment of shared path project, Windy Point. Present shared path alignment is in middle and right of photo, including darker green shrubs of *Veronica speciosa* tītīrangi (At Risk – Declining) in centre. Present alignment Photo: PC250684.JPG, 2018-12-25.

4.3 Vascular Flora

The vascular flora of the survey area is comprised largely of introduced species: 44 of the total 77 species (57%) identified (**Table 4-1**). There are 30 indigenous species (39%), two not native to the Wellington region (pohutukawa and karo *Pittosporum crassifolium*). Many of the species are primary colonisers (ruderals), establishing in an environment that is dominated by disturbance.

Table 4-1: Vascular flora survey results summary, Eastern Bays survey area, May 2016 and May 2017. Includes data from iNaturalist NZ and other sources. Full data is at **Appendix B: Vascular flora survey data.**

Species status	Number of species	Percentage
Indigenous species	28	36.4%
Indigenous species not native to Wellington	2	2.6%
Introduced species	44	57.1%
Status not available	3	3.9%
Total	**77**	**100%**

4.4 Threatened and At Risk Plant Species

One Nationally Critical (*Atriplex cinerea*) and eight At Risk indigenous plant species occur within or very near to the shared path footprint (**Table 4-2**).

Two of the species are restoration plantings into semi-natural habitats: *Atriplex cinerea* (York Bay and Claphams Rock) and pīngao (Lowry Bay). Six are in HCC landscape plantings at Point Howard and Windy Point. All these plantings are understood to be eco-sourced rather than cultivars and as such have genetic conservation value.

The seagrass in Lowry Bay is the only one of the species listed that is not derived in some way from human agency.

The recently described shrub *Melicytus orarius* (Heenan et al. 2018), also classified nationally as At Risk - Declining, Data Poor (de Lange et al. 2017) but regionally critical (Sawyer 2004), has been reported from Point Howard. A search of the shared path route at Point Howard did not find *Melicytus orarius*.[18]

[18] The possibility that it occurs in the relatively limited area of less modified shrub vegetation on the two rocky knobs at Point Howard cannot be discounted.

Table 4-2: Threatened and At Risk indigenous vascular plant species within or very near to Eastern Bays shared path project footprint. Conservation status after de Lange et al. (2017).

Scientific name	Common / Māori name(s)	Conservation status	Location	Numbers	Habitat
Aciphylla squarrosa var. *squarrosa*	Cook Strait speargrass	At Risk – Declining, data poor, partial decline	Windy Point	*c.* 10	Landscape planting
Astelia chathamica	Chatham Islands kakaha	At Risk – Recovering	Point Howard	Several	Landscape planting
Atriplex cinerea	Grey saltbush	Nationally Critical, secure overseas	York Bay, Claphams Rock	15	Restoration planting, rocky headland and coastal platform
Brachyglottis compacta		At Risk – Naturally Uncommon, range restricted	Point Howard	Several	Landscape planting
Euphorbia glauca	Waiūatua, shore spurge	At Risk – Declining, conservation dependent	Point Howard	Numerous	Landscape planting
Ficinia spiralis	Pīngao	At Risk – Declining, partial decline, range restricted	Lowry Bay	1	Probably restoration planting, beach
Melicytus crassifolius	Thick-leaved porcupine plant	At Risk – Declining	Windy Point	*c.* 5	Landscape planting
Veronica speciosa	Tītīrangi	At Risk – Declining, range restricted	Windy Point	3	Landscape planting
Zostera muelleri subsp. *novazelandica*	Seagrass, eelgrass, rimurēhia	At Risk – Declining, extreme fluctuations	Lowry Bay	Numerous	Intertidal and subtidal, Lowry Bay

4.5 Gravel Beaches - Naturally Uncommon Ecosystem

Small gravel beaches or narrow gravel lenses are present above MHWS in all five bays of the SPP area. These beaches belong to a naturally uncommon ecosystem, shingle beaches, comprised primarily of a mixture of sand, water-smoothed gravel (>50%) and cobbles. Naturally uncommon ecosystems often have a highly specialised and diverse flora characterised by endemic and nationally rare species (Williams et al. 2007).

The vegetation on the gravel beaches within the SPP area has a predominance of introduced species. Erosion is occurring, a feature of the natural variability of the coastal sediment system (Allis 2019).

4.6 Weed Species

Much of the SPP area is favourable to the establishment of introduced plant species. Two weed species found on the beach at Sunshine Bay in 2016 are listed in the Greater Wellington Regional Pest Management Strategy (Greater Wellington Regional Council 2009). The boneseed (*Chrysanthemoides monilifera*) occurrence is within a containment zone that has limited control provisions by Greater Wellington Regional Council. Two seedlings of old man's beard (*Clematis vitalba*) were identified. They were not present in 2018 and appear to have been site-eradicated.

5 ASSESSMENT OF EFFECTS ON VASCULAR VEGETATION AND FLORA

5.1 Vascular Vegetation and Flora Values

5.1.1 Vegetation and flora status under district and regional plans

The SPP would bisect Significant Natural Resource (SNR) #44 (Point Howard Beach) of the City of Lower Hutt District Plan (Hutt City Council 2017), which seeks to protect the occurrence of *Melicytus orarius*. SNR #44 comprises land at Point Howard seaward of Marine Drive and extends into Wellington Harbour. HCC has been unable to find the origins of SNR #44 and its mapping (Geard 2018). It may be sourced from a DOC significant sites report prepared for HCC (Department of Conservation 1995) in which the *Melicytus* grid coordinates match SNR #44. However, this location differs from an earlier DOC threatened plant database record (on sandstone cliffs, SW of Port Road), that also matches the holotype specimen (Heenan et al. 2018). These location details, the persistence of the species around Wellington Harbour on coastal cliffs and headlands as scattered individuals (Heenan et al. 2018), and the absence of other local records in databases (iNaturalist NZ 2018a; Landcare Research 2018), point to just one occurrence at Point Howard, at the location of the earlier DOC record and the type locality (and outside the SPP footprint). A search of the shared path route at Point Howard did not find *Melicytus orarius* (**Section 0**).

The SPP area does not have remnant nikau palms (*Rhopalostylis sapida*), protected under Section 14G of the District Plan (as updated in July 2012).

The seagrass beds at Lowry Bay are a listed habitat with significant indigenous biodiversity values in the coastal marine area in Schedule F5 of the Proposed Natural Resources Plan (Greater Wellington Regional Council 2015).

5.1.2 Threatened and At Risk species

One Nationally Critical and eight At Risk species are present at sites within, or very near to, the SPP footprint area (**Section 0**). Two of these (*Atriplex cinerea,* pīngao) are restoration plantings into semi-natural habitats where they may have occurred previously (although this is less likely for *Atriplex cinerea*).

Six species are in HCC landscape plantings at Point Howard and Windy Point. Although these plantings are human artefacts, they have genetic conservation value because of the use of genetically sourced wild stock, as well as educational value.

The extent of seagrass habitat around New Zealand is declining, and the species itself was first listed as At Risk - Declining in 2012 (de Lange et al. 2013). The seagrass occurrence at Lowry Bay is small relative to its regional and national extent. There are *c.* 270 ha of seagrass beds in harbours and estuaries in the Wellington Region (MacDiarmid et al. 2012), the largest in Pauatahanui Inlet and Te Awarua-o-Porirua Harbour, with small remnant beds in other estuaries (Greater Wellington Regional

Council 2015). However, the seagrass at Lowry Bay is the only known remaining occurrence in Wellington Harbour (Overmars & van Kampen 2019).

New Zealand's single seagrass species is indigenous but also occurs naturally in southern and eastern Australia. There is a low degree of gene flow between populations, indicating the value of local populations for conserving regional genetic diversity (Jones, Gemmill & Pilditch 2008). Seagrasses are important also for providing ecosystem services such as sustaining a wide range of plant and animal species (Turner & Schwarz 2006a).

5.1.3 Gravel beaches – Naturally Uncommon Ecosystem, Endangered

The gravel beaches of the SPP area belong to a naturally uncommon ecosystem (shingle beaches) that is classified as Endangered (Holdaway, Wiser & Williams 2012). This ecosystem is subject to continuing reduction in ecological function associated with invasion by non-native plants and with residential development. One At Risk - Declining species is present in this habitat in the SPP area (pīngao, planted).

5.1.4 Pohutukawa trees

Single and small groups of pohutukawa between Marine Drive and the sea are a feature of the SPP area. These have a concrete seawall between their root structure and the sea, except for the 'Atkinson tree' in York Bay which is growing directly in beach gravels. This species is not indigenous to the Wellington Region and so has low local ecological value. However, the trees have some value as riparian vegetation on the coastal margin and in storing and sequestering carbon (in relation to climate change).

5.1.5 Vascular vegetation and flora value

The SPP area occurs in modified semi-natural and urban environments, with habitat connectivity between the sea and the Eastern Bay flats and hills truncated by Marine Drive. The SPP and ZOI footprint is a long linear feature and ecological values tend to be site-specific rather than applying to the entire area. Assessments of ecological value are shown at **Table 5-1**.

Table 5-1: Assessment of ecological value of vegetation/habitat/communities, Eastern Bays shared path project area. Refers to habitats excluding existing seawalls and Marine Drive, and assessed in relation to Tables 4 & 5, Roper-Lindsay et al. (2018).

Criteria	Ecological value	Notes
Representativeness: seagrass habitats	Moderate	Low for other vegetation
Rarity/distinctiveness: gravel beaches (naturally uncommon ecosystem, Endangered)	Moderate	Rated lower than ecosystem type because of its small extent, predominance of introduced species, being eroded

Rarity/distinctiveness: seagrass (At Risk - Declining species)	High	Declining extent, only known remaining site in Wellington Harbour, ecosystem value
Rarity/distinctiveness: other Threatened and At Risk - Declining species	High	*Aciphylla squarrosa var. squarrosa, Atriplex cinerea, Euphorbia glauca, Ficinia spiralis, Melicytus crassifolius, Vernonia speciosa.* Site specific
Rarity/distinctiveness: any other category of At Risk species	Moderate	Site specific
Diversity and pattern	Low	Vegetation remnants
Ecological context - seaward of seawalls and Marine Drive	High	An environment of natural coastal processes (seaward of existing seawalls), ecotonal margin of Wellington Harbour coastal marine ecosystem Marine Drive and seawalls are very low value

5.2 Construction Phase Effects [19]

5.2.1 Coastal habitat - proxy nourishment

The buried sediments excavated for constructing the shared path and seawall foundations at SPP beaches (between 2350 m^3 and 5600 m^3 at the three beach nourishment bays and more at Sorrento, Mahina and Sunshine Bays; **Table 2-4**) typically comprise alternating gravels, sands, silts and clays up to 10 m depth (Begg & Johnston 2000; Watts 2017). The silts and clays present a significant risk of fine sediment release into the CMA. Potential effects include reducing light penetration of the water column and availability to plants, clogging of feeding structures, and deposition leading to smothering of seagrass beds, burial of benthic biota and reducing the oxygenation of surficial sediments (Jones 2008; Townsend & Lohrer 2015).

These sediments need to be separated into those suitable for placement on beaches at beach nourishment and non-beach nourishment sites, and those with significant levels of silt and clay to be disposed offsite to avoid sedimentation and turbidity effects in the CMA.

[19] Effects on a component of coastal vegetation that are integrated across construction and operational phases, these are addressed under the dominant phase.

5.2.2 Coastal habitat - beach nourishment

Potential effects of the beach nourishment and proposed mitigation on coastal processes and habitats for marine biota generally during the construction phase are described by Reinen-Hamill (2019):

i. burial of seabed adjacent to beach nourishment during construction
ii. turbidity in the CMA during construction.

In addition, beach nourishment sediments should be transported to the Lowry Bay site by truck, not barging, to avoid risks of scraping of or grounding on seagrass beds.

With the proposed actions, risks are considered low of:

- extending the seaward toe of the existing beach during the placement of the imported sand
- turbidity in excess of the ambient turbidity that can be experienced during wave conditions.

These are accepted in relation to the coastal habitat of seagrass and coastal avifauna, subject to the exclusion of proxy nourishment materials with a significant proportion of fines from beach nourishment sediments.

5.2.3 Threatened and At Risk plant species [20]

5.2.3.1 Landscape plantings

The proposed shared path alignment (Rev J) may affect six At Risk species in the landscape plantings at Point Howard and Windy Point.

Proposed mitigation is transplanting existing plants to adjoining currently grassed areas or to adjoining reserves such as Whiorau. It would be appropriate also to seek to restore *Aciphylla squarrosa* var. *squarrosa* to the Claphams Rock revegetation site where it was previously found (Freegard & Weeber 1986).

5.2.3.2 Restoration plantings

Atriplex cinerea

The *Atriplex cinerea* plantings at York Bay and Claphams Rock are outside the direct SPP footprint. Without appropriate mitigation measures, several are vulnerable to crushing by vehicles and machinery that may be used for shared path and seawall construction. Mitigation includes recognition of these sites in the CEMP, and subtle landscaping to create a low barrier for vehicles while not drawing attention to the plants.

Pīngao

[20] NZCPS Policy 11 (a) i.

The pīngao is located within the 3.5 m wide seawall/shared path footprint at Lowry Bay. Its habitat will be lost.

The preferred mitigation option is to translocate the existing pīngao patch and its gravel and sand habitat immediately seaward of the project footprint, in conjunction with the beach nourishment programme. Compaction of beach sediments at the chosen site would need to be minimised. This would retain the pīngao on-site for a period of some years to decades, until lost to eventual erosion and sea-level rise. To minimise risk to the plants, translocation needs to be undertaken in late autumn or winter.

If this proves to be impracticable, another option is to translocate the pīngao patch to existing dune restoration sites at Days Bay or Muritai Beach that are more durable to sea-level rise.

5.2.3.3 Seagrass [21]

Dynamic environments like seagrass habitats are characterised by continuous local erosion and burial processes, which may induce seagrass decline if disturbances become too intense or frequent (Han et al. 2012). The seagrass at Lowry Bay appears to be tolerant of existing levels of sediment deposition and mobilisation in the sea, including sediment plumes from the Hutt River (Goff, Dunbar & Barrett 1998).

The causes of seagrass decline within New Zealand have been attributed to a range of anthropogenic activities and natural events which can act synergistically, including nutrient enrichment, competition from invasive marine plants and overgrazing. Changes in sediment regimes associated with increased sedimentation rates and associated turbidity, reductions in the amount of photosynthetically available radiation, and changes in sediment textural characteristics have been identified as principal factors in the decline of seagrass in New Zealand (Turner & Schwarz 2006a; Morrison, Jones, et al. 2014; Morrison, Lowe, et al. 2014). Seagrasses require some of the highest light levels of any plant group.

Studies of the effects of experimental burial of 15 seagrass species (but not including *Zostera muelleri*) found burial level causing 50% shoot mortality ranged between 2–15 cm but most species experienced 50% mortality within the 2-4 cm range. The burial level causing total shoot loss varied between 2–15 cm (Cabaço, Santos & Duarte 2008). Species lacking vertical rhizomes, such as *Zostera marina* and *Zostera noltii*, experienced high mortality (70–90%) under low burial levels (2–4 cm) within 24–56 days; the lack of vertical stems is also a feature of *Zostera muelleri* (Waycott, Lavery & McMahon 2014).

Seagrass restoration is a complicated and expensive undertaking, with no guarantee of success, and so protection of what currently exists, and efforts to increase general environmental conditions, remain the best approaches (Morrison, Jones, et al. 2014).

[21] NZCPS Policy 11 (a) i; (b) i; (b) iii.

Potential direct construction effects on seagrass

The seagrass occurrences in Lowry Bay are located mostly between 10–-55 m from the toe of the proposed curved seawalls, although the southern-most occurrence is as close as four metres. The proposed construction zone (5 m wide at curved seawalls) overlaps with a very small part of the southern-most occurrence (2 m^2) and elsewhere lies 5–-50 m away.

The risk to the seagrass in the construction zone is temporary and will be mitigated by physically demarcating the site.

Beach profile adjustments (Operational phase)

Following beach nourishment, movement of the beach profile to flatten its slope is likely to result in the seaward movement of sand and some encroachment seaward of the existing beach toe (Reinen-Hamill (2019); cf. **Figure 5-1**). This process is expected to occur over a period of weeks to months largely during higher energy onshore events (storms). The beach areas adjacent to the placement areas will likely increase in sediment depth due to along shore drift and this may also manifest as the seaward movement of the beach in these areas, with an associated reduction in beach volume from the constructed placement area. This process is likely to occur over a period of months to years.

The toe of the proposed beach nourishment construction berm lies 2–4 m at its closest from the largest seagrass bed in Lowry Bay, and the toe of the initial adjusted profile (some weeks to months after construction) adjoins and includes a very small part (7 m^2) of the southern seagrass bed (**Figure 5-1**).

This risk to the seagrass within and adjoining the beach nourishment adjusted profile is temporary and small. It is based on the theoretical maximum increase in height of the beach at the toe of the existing beach (Reinen-Hamill 2019). Possible small design variations to reduce the risk further include steepening the berm face where closest to seagrass using coarser sediments or narrowing the beach nourishment berm there and extending it northwards closer towards the Cheviot Road bus stop.

The northern seagrass occurrence lies *c.* 8 m from the toe of a proposed double curved seawall. The locality will be subject to a degree of proxy nourishment from local encroachment of *c.* 2–3 m width and alongshore drift from the Lowry Bay beach nourishment site about 60 m southwards. This site appears to be subject to some scour of its margins (**Figure 4-2**). Because of wave processes this additional sediment will likely move to the base of the new seawall but there may be some settlement on and near the seagrass bed. Settlement near the seagrass bed may reduce or reverse the scour that is occurring (a beneficial effect).

Timing of beach nourishment in relation to seagrass

Seagrass generally grows most strongly and flowers in spring and summer (although high productivity and leaf growth has been reported from northern New Zealand in winter) (Turner & Schwarz 2006b; Turner 2007; Dos Santos & Matheson 2017). It is a perennial plant and likely stores carbohydrates to survive over the winter period.

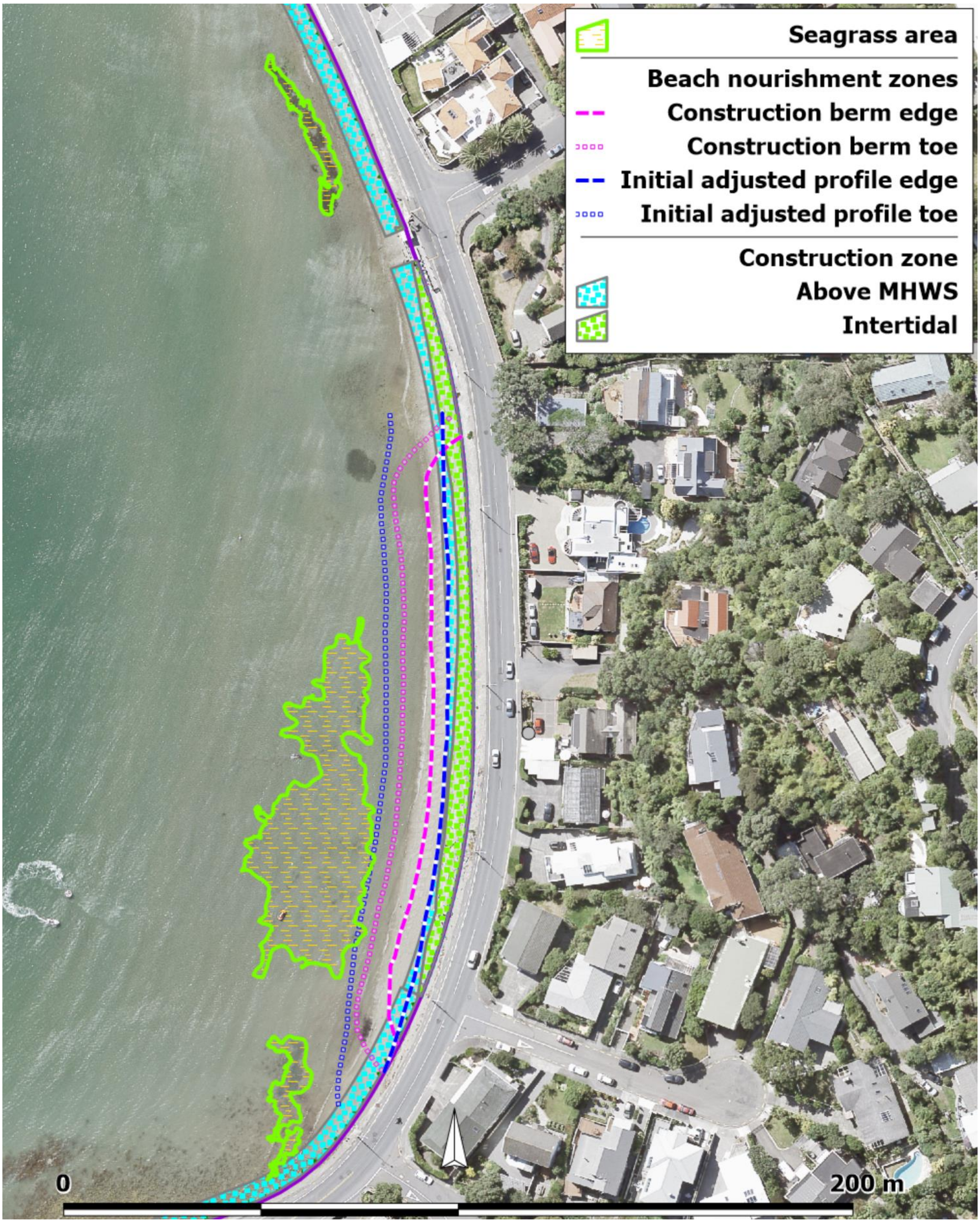

Figure 5-1: Proposed seawall construction zone and beach nourishment zones near seagrass sites, Lowry Bay. Construction zones based on GIS files sourced from EOS Ecology and Stantec (Rev J). Beach nourishment zones re-drawn from Reinen-Hamill (2019). Aerial photography courtesy of HCC.

If sediment deposition was to occur (resulting in the loss of above-ground biomass), it is likely that winter timing of beach nourishment will cause the least depletion of overall plant biomass and least damage to the potential of seagrass to recover in the forthcoming growing season.

In summary, the magnitude of potential SPP construction phase effect on seagrass is moderate, but overall level of effects is low.

5.2.4 Gravel beaches ecosystem [22]

The gravel beach ecosystem has the greatest extent of vascular vegetation and flora habitat within the SPP footprint.[23] Vegetation on this landform occurs primarily in Lowry and Sunshine Bays and at Windy Point, confined to a narrow zone (up to 1–2 m) adjoining Marine Drive or seawalls. Some has recently been lost to erosion. This ecosystem will be largely lost at construction time under the shared path and seawalls footprint, while any habitat beyond that may be disturbed by works or by machinery in the construction zone.

Although gravel beaches are a naturally uncommon ecosystem that is classified as Endangered (Holdaway, Wiser & Williams 2012), the ecological value of the gravel beaches ecosystem that would be lost to the SPP is assessed as moderate because of its small extent, highly modified condition, and the erosion occurring within the natural variability of the coastal sediment system in the Eastern Bays (**Table 5-1**). The magnitude of potential effect is high locally but negligible in relation to the national extent of gravel ecosystems and better condition elsewhere (Wiser et al. 2010).

It is proposed to translocate the existing gravel beach vegetation at Lowry Bay (native and adventive species, including the pīngao) into the beach nourishment area immediately seaward of the shared path footprint. Vegetation direct transfer rehabilitation principles would be applied as practicable (Ross et al. 2000) at this site: remove vegetation and the top substrate separately from underlying gravels to prepared rehabilitation sites nearby.

Elsewhere this ecosystem will be largely lost under the shared path and seawalls footprint; this loss is difficult to mitigate. Any habitat that may remain in the construction zone will be marked out with the intention of avoiding disturbance by works or machinery.

It is possible that sediment disturbance with construction works and gravel beach translocation will result in establishment of weeds (such as gorse, boneseed, old man’s beard) from the seed bed(Panetta & Timmins 2004).

The post-mitigation level of construction phase effect on the gravel beaches ecosystem is therefore considered to be low.

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[22] NZCPS Policy 11 (a) iii.

[23] Rocky headlands and promontories have greater vegetation cover but are of minor extent within the SPP operational footprint and construction zone.

5.2.5 Construction timing

The different plants and animal species covered in this report have different requirements to minimise construction phase effects. The following hierarchy is proposed, giving priority to the more vulnerable species.

i. Undertake beach nourishment and pīngao translocation at Lowry Bay in winter (preferred time for seagrass and pīngao; little penguins not known to be present).

ii. In revetment upgrade areas and other sites within 50 m of known little penguin breeding sites or access to breeding sites, undertake seawall, beach nourishment and shared path works during the post-moulting to pre-breeding stage of the annual cycle (1 March–30 June).

iii. at Sorrento Bay-Point Howard, surveying during the breeding season for the presence of reef heron (feeding, not necessarily breeding) and for breeding variable oystercatchers; and avoiding undertaking works if reef heron(s) are present (September-December) and until any variable oystercatcher breeding is safely complete (likely to be December- January);

iv. Generally, avoid construction works in winter (time of stress for birds).

v. Undertake transplanting of HCC landscape plantings and Claphams Rock revegetation in winter.

Other than for specific provisions for reef heron and variable oystercatcher at Point Howard-Sorrento Bay, effects of construction activities in relation to timing are minimised for avifauna by undertaking works between 1 March and 30 June if little penguins are present, and in spring through to autumn if little penguins are not present.

5.3 Operational Phase Effects

5.3.1 Threatened and At Risk plant species [24]

Operational phase effects on Threatened and At Risk plant species in landscape plantings are not anticipated (also *Atriplex cinerea* plantings).

Operational phase effects on pīngao if translocated within Lowry Bay may occur if there are changes in the beach profile, but this is not anticipated (**Section 5.3.2**). It likely will remain for some years to decades but at increasing risk to sea-level rise. The translocation is an adaptive sea-level rise action. The level of SPP operational phase effect on pīngao is negligible.

Seagrass has the ability to respond to environmental change when suitable environmental conditions are present (Turner & Schwarz 2006a), and has some adaptability to survive in a range of shallow depths. As sea-level rises, its seaward margin (possibly governed by light availability) will likely be reduced. The addition of sediments similar or slightly coarser than now present, from the proposed beach nourishment and proxy nourishment, will marginally raise the seabed level in Lowry Bay. This will likely benefit seagrass at its nearshore margin for a period as it responds to sea-level rise (an

[24] NZCPS Policy 11 (a) i.

adaptive pathway). Without subsequent intervention, seagrass in Lowry Bay is at high risk of being squeezed out of its natural depth range.

There is low potential from the beach nourishment for increased recreational use impacts arising from the greater closeness of seagrass beds to beach recreation areas. Observed recreational use in Lowry Bay in late December 2018 was low and principally away from seagrass beds.

The level of SPP operational phase effect on seagrass is low.

5.3.2 Gravel beaches ecosystem [25]

Two factors will influence ongoing operational effects on any remnant vegetation gravel beach areas: consequential beach profile changes from the seawalls and sea-level rise.

GHD beach profile modelling (Berthot & Dengate 2015) indicates that with the construction of a seawall, 100 year storm erosion is not expected to significantly change the beach vertical profiles of the SPP area. Beach nourishment as mitigation will also serve to retain the beach profile at Lowry Bay for a period (an adaptive pathway), as rapid loss of sediment from the bay system is not anticipated.

Given predicted sea-level rise projections (**Section 3.6.2**) and current erosion, the gravel beach ecosystem will be sustained for a period at Lowry Bay by the beach nourishment, and future retention elsewhere in the SPP area is unlikely.

5.3.3 Other vegetation

Retention of the limited amounts of riparian vegetation (and their ecological functioning) at revetment sites without cantilevered walls (Wiecek 2012) is recommended.

5.4 Recommended Mitigation

The following additional mitigation for potential construction and operational phase effects on coastal vegetation and flora is recommended. The post-mitigation level of effectss will be low.

a. Include the following provisions in the Construction and Environmental Management Plan:

    i. Translocate the existing gravel beach vegetation at Lowry Bay (native and adventive species, including the pīngao) into the beach nourishment area immediately seaward of the shared path footprint. Apply vegetation direct transfer rehabilitation principles as practicable.

    ii. Aim to avoid the use of machinery and any other disturbance at existing vegetation on gravel beaches in the construction zone, provided that vegetation is proposed to remain in-situ.

[25] NZCPS Policy 11 (a) iii.

iii. Transplant the six At Risk species in the landscape plantings at Point Howard and Windy Point to adjoining currently grassed areas or to adjoining reserves (such as Whiorau).

iv. Recognise *Atriplex cinerea* plantings at York Bay and Claphams Rock as sensitive sites in the CEMP and create low landscaping barriers to avoid vehicles crushing at risk plants.

v. Where revetment is constructed without a cantilever wall, retain existing isolated shrub vegetation patches between the shared path margin and the revetment.

vi. Thoroughly clean off earth materials any machinery that would be working on the backshore where vegetation is present.

vii. Physically demarcate the location of seagrass within the 5 m seawall construction zone at south Lowry Bay.

viii. Undertake works near seagrass localities outside spring tide periods, to minimise the risk of sediment mobilisation into the sea caused by higher tide levels overtopping sediment control measures.

b. Include the following provisions in the Beach Nourishment Management Plan:

i. At all three beaches, specify the methods to separate excavated beach sediments from shared path foundations into those suitable for placement on beaches, and dispose offsite those that have significant levels of silt and clay (<63 microns).

ii. At Lowry Bay, ensure any barging of beach nourishment material is appropriately separated from seagrass beds to avoid any disturbance.

iii. Prepare a site within the beach nourishment area immediately seaward of the shared path footprint at Lowry Bay near the present pīngao location that has a top layer of uncompacted beach sediments. Translocate the existing pīngao patch and other vegetation and their gravel and sand habitat at Lowry Bay to this site.

iv. Undertake beach nourishment at Lowry Bay during winter.

c. At the detail design phase, consider small design variations to reduce the residual risk to seagrass at south Lowry Bay, such as steepening the berm face where closest to seagrass using coarser sediments or narrowing the beach nourishment berm there but extending it northwards closer towards the Cheviot Road bus stop.

5.5 Recommended Monitoring

Include the following monitoring provisions and contingent actions in the Construction and Environmental Management Plan or Beach Nourishment Management Plan:

i. Undertake a pre-construction baseline assessment and post-construction outcome assessment for Threatened and At Risk plant species, and the vegetated gravel beaches.

ii. Monitor for any post-construction establishment of invasive weeds (including boneseed and old man's beard) and remove as necessary, for a period of two years after works in any one bay are completed.

iii. Include provisions in the beach nourishment monitoring plan to monitor seagrass mortality/survival and changes in densities and distribution. Undertake monitoring on one occasion before works occur and on two annual occasions after works occur (giving four measurements with the existing baseline survey, recognising temporal and spatial seagrass variability).

iv. Undertake seagrass restoration if there is a significant net loss that is likely to be attributable to proxy nourishment or beach nourishment.

6 AVIFAUNA AND HABITATS

6.1 Avifauna

6.1.1 Avifauna survey results

Seven species were recorded in the SPP area and ZOI over the four survey days: Australasian gannet (tākapu, *Morus serrator*), black shag (kawau, *Phalacrocorax carbo novaehollandiae*), little shag (kawau paka, *Phalacrocorax melanoleucos brevirostris*), little black shag (kawau tūi, *Phalacrocorax sulcirostris*), variable oystercatcher (tōrea, *Haematopus unicolor*), southern black-backed gull and red-billed gull (tarāpunga, *Larus novaehollandiae scopulinus*) (**Table 6-1**). Two additional species were recorded in Wellington Harbour beyond the 200 m ZOI boundary (fluttering shearwater and white-fronted tern). All coastal birds observed are indigenous species.

Table 6-1: Coastal avifauna survey counts, Eastern Bays survey area, May 2016 and May 2017. Australasian gannet record (2016-05-05) courtesy of Kirsty Brennan (EOS Ecology, pers. comm.). Full survey data is shown at **Appendix C: Avifauna survey data**.

Species	Date	Pt Howard - Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Total
Australasian gannet	2016-05-02							
	2016-05-03							
	2016-05-05				4			4
	2017-05-14						1	1
	2017-05-17							
	Total				4		1	5
Black shag	2016-05-02							
	2016-05-03							
	2017-05-14						1	1
	2017-05-17							
	Total						1	1
Little shag	2016-05-02	6		1	3			10
	2016-05-03	2			1			3
	2017-05-14						2	2
	2017-05-17							
	Total	8		1	4		2	15
Little black shag	2016-05-02	42						42
	2016-05-03				2			2
	2017-05-14							
	2017-05-17							
	Total	42			2			44

Species	Date	Pt Howard - Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Total
Variable	2016-05-02	3		2				5
oystercatcher	2016-05-03	3			1	1		5
	2017-05-14						2	2
	2017-05-17						6	6
	Total	6		2	1	1	8	18
Southern	2016-05-02	56	2			2		60
black-backed	2016-05-03	55	4	3	2			64
gull	2017-05-14						2	2
	2017-05-17						1	1
	Total	111	6	3	2	2	3	127
Red-billed gull	2016-05-02	31		2				33
	2016-05-03	4	2	4	2			12
	2017-05-14							
	2017-05-17							
	Total	35	2	6	2			45
All Species	**2016-05-02**	**138**	**2**	**5**	**3**	**2**		**150**
	2016-05-03	**64**	**6**	**7**	**8**	**1**		**86**
	2016-05-05				**4**			**4**
	2017-05-14						**7**	**7**
	2017-05-17						**8**	**8**
	Total	**202**	**8**	**12**	**15**	**3**	**15**	**255**
	%	**79%**	**3%**	**5%**	**6%**	**1%**	**6%**	**100%**

In the five northern bays in 2016, southern black-backed gull was the most numerous species, with *c.* 60 birds observed on each survey occasion. A flock of little black shags (42) was observed on the first survey occasion and two birds on the second. Red-billed gulls were also numerous (33, 12). Five variable oystercatchers were observed on each survey day, three in Point Howard-Sorrento Bays (including a juvenile) and two in the southern bays (York, Mahina and Sunshine).

Fifteen birds in total were recorded at Windy Point on the two survey occasions in 2017. Variable oystercatcher was the most numerous species (2, 6 birds). The single black shag recorded during surveys was roosting on rocks at the south end of Windy Point. Post-survey, 40 little black shags were observed flying and feeding sequentially in shallow waters.

The following birds were observed at the Sorrento Bay rocky islet (2016-05-02): southern black-backed gull (26, a few roosting on water), little shag (3) and little black shag (2).

A colony of little shags and little black shags, including juveniles, was observed in several large macrocarpa (*Cupressus macrocarpa*) trees at a pond at the Williams Park carpark at Days Bay (*c.* 600 m from the SPP area). Other roosting/nesting sites of any coastal bird species were not observed.

Across both surveys, Point Howard-Sorrento Bays had the highest number of birds (202 out of 255 records, 79%) and Sunshine Bay had the fewest (3 birds, 1.2%).

All birds other than the shags in Williams Park were in the intertidal zone or in the harbour. No birds were seen using Marine Drive itself or the existing concrete seawalls, although black-backed gulls used sealed road surfaces at Whiorau Reserve for breaking shellfish. The most frequent activity recorded for red-billed gull, southern black-backed gull, black shag and little shag was roosting on sand, rock and seawater. Little black shags were most frequently seen diving (feeding). Variable oystercatchers were most frequently roosting (4 records), flying (4) and feeding (2) (**Cover Photograph**).

6.1.2 OSNZ avifauna survey data

OSNZ has undertaken a series of coastal bird surveys along the Wellington Harbour and south Wellington City coastline, comprising 24 monthly counts at approximately 10 year intervals (Robertson 1992; Tonkin & Taylor 2016). Surveys were undertaken in 1975–1977, 1986–1988, 1998–2000, and between December 2008–November 2010.

The 67 km of coastline from Lake Kohangapiripiri to the end of the public road west of Owhiro Bay was divided into 17 survey sections based on geographical and habitat features (**Figure 6-1**). OSNZ members walked or cycled the length of their survey section between 1300 and 1500 hours on the second Sunday of the month. All birds below MHWS seen with the naked eye were recorded, with identification confirmed by binoculars or telescope. The limit of detection was usually *c.* 300–500 m, though birds following fishing boats could be detected at greater range, especially if they were larger species. Assuming each section took on average 1 hour to survey by one person (often there were several observers), this represents 408 hours effort for each two-yearly survey and 1632 hours in total.

Section 2 of the OSNZ surveys extends from Burdans Gate to the northern end of Days Bay (4.3 km); this contains the small length of the SPP area at Windy Point (0.38 km). Section 3 extends from northern Days Bay to Point Howard (3.9 km) and covers the balance of SPP area.

The most numerous of the 23 species recorded in Sections 2 and 3 were fluttering shearwater, southern black-backed gull, red-billed gull, little black shag, little shag, white-fronted tern and variable oystercatcher (**Table 6-2**). There were low numbers of Australasian gannet, black shag, spotted shag kawau paka (*Stictocarbo punctatus*) and reef heron (matuku moana, *Egretta sacra sacra*). Species recorded in very low numbers or irregularly present in both sections were giant petrel (pāngurunguru, *Macronectes* sp.), pied shag (kāruhiruhi, *Phalacrocorax varius varius*), black swan (kakīānau, *Cygnus atratus*), mallard (*Anas platyrhynchos platyrhynchos*), grey duck (parera, *Anas superciliosa*), Caspian tern (taranui, *Hydroprogne caspia*) and NZ kingfisher (kotare, *Todiramphus sanctus vagans*). Species in Section 2 only were banded dotterel (tūturiwhatu, *Charadrius bicinctus bicinctus*), spur-winged plover (*Vanellus miles novaehollandiae*), Arctic skua (*Stercorarius parasiticus*) and welcome swallow (warou, *Hirundo neoxena neoxena*). Species in Section 3 only were white-faced heron (matuku moana, *Egretta novaehollandiae novaehollandiae*) and black-billed gull (tarāpuka, *Larus bulleri*).

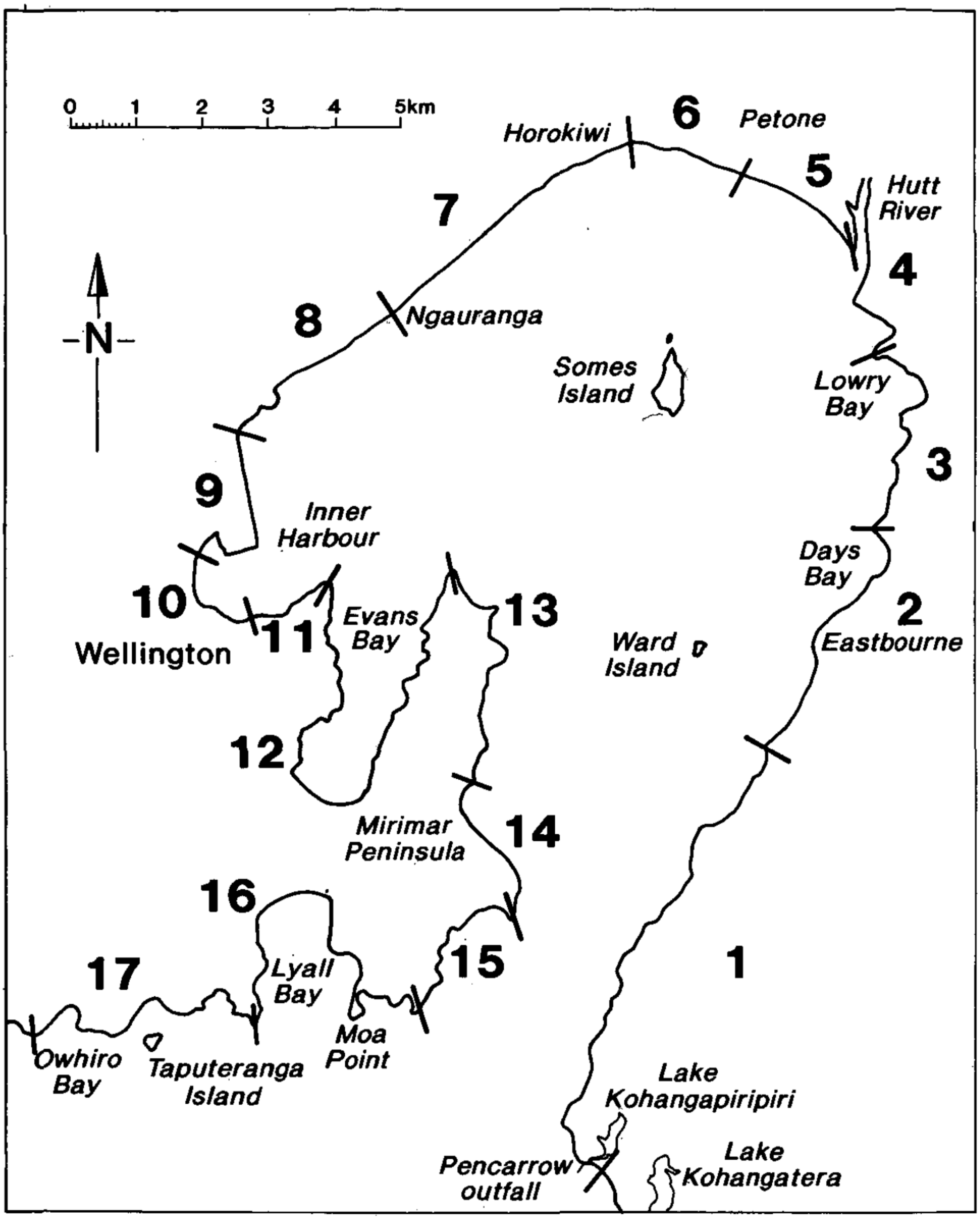

Figure 6-1: Seventeen sections of Wellington Harbour coastline used in OSNZ coastal bird surveys, 1975–2010. The SPP area is mainly in Section 3 (northern Days Bay to Point Howard, 4.3 km), while the Windy Point part is at the northern end of Section 2 (3.9 km). Source: Robertson (1992).

Table 6-2: OSNZ coastal avifauna counts for four series of 24 monthly surveys, Burdans Gate to northern Days Bay (Section 2) and northern Days Bay to Point Howard (Section 3), 1975–2010. Species recorded by current SPP surveys marked with an asterisk (*). Seasonal trends and additional records noted. Little penguins recorded elsewhere by the surveys but not Sections 2 and 3. Sources: Robertson (1992), Geoff de Lisle (OSNZ, pers. comm., 2016-07-30) and Hugh Robertson (OSNZ, pers. comm., 2017-10-13), unless otherwise stated.

	Burdans Gate to Days Bay				Days Bay to Point Howard				
Species	**1975-1977**	**1986-1988**	**1998-2000**	**2008-2010**	**1975-1977**	**1986-1988**	**1998-2000**	**2008-2010**	**Seasonal trends / notes**
Fluttering shearwater	318	21	300	27	780	4	705	656	Most in Wellington Harbour from April to October; breeding elsewhere
Giant petrel	1	1	0	0	1	0	0	0	Lowry Bay (https://ebird.org/newzealand/hotspot/L585134), Whiorau (pers. obs. 2016-05-04)
Australasian gannet *	3	3	1	3	6	3	1	9	Mainly winter visitor to Harbour; breeding elsewhere
Little shag *	8	35	48	116	17	166	151	110	Mainly winter visitor to Harbour; Sections 2 & 3 numbers increasing; ~20 active nests in nesting colony at Williams Park in October 2014 (OSNZ—Birds New Zealand 2015)
Black shag *	0	4	12	7	6	46	8	11	Present in Harbour in small numbers all year; breeding elsewhere
Pied shag	0	1	0	1	0	2	1	1	Small numbers in Harbour. Lowry Bay, pair (https://ebird.org/newzealand/hotspot/L585134), Windy Point (http://inaturalist.nz/observations/971219)
Little black shag *	0	2	73	99	20	60	133	233	Present in Harbour mainly May to August but a few in all months; Sections 2 & 3 numbers increasing; breeding elsewhere. Also seen in flocks of up to 40 birds at Windy Point and Point Howard-Sorrento Bays, in sea or on rocks (Kirsty Brennan/Nick Hempston, 8–9 June 2017; pers. obs.).
Spotted shag	0	0	2	5	18	5	1	5	Influx to Harbour, autumn to early spring (Waugh et al. 2013); breeding June to February, Matiu/Somes and Mokopuna Islands. Small numbers (2–10) roosting on emergent rocks at Windy Point (Kirsty Brennan/Nick Hempston, 8–9 June 2017) and at Sorrento Bay (pers. obs.).
White-faced heron					0	0	1	1	
Reef heron	1	0	5	0	16	9	6	4	Resident and breeding in Harbour; Lowry and York Bays (Robertson 1992); often seen in Lowry Bay and York Bay (East Harbour Environmental Association 1998);

Species	Burdans Gate to Days Bay 1975-1977	1986-1988	1998-2000	2008-2010	Days Bay to Point Howard 1975-1977	1986-1988	1998-2000	2008-2010	Seasonal trends / notes
									one in Mahina Bay in 2006 (Ornithological Society of New Zealand 2006); one in 2018-09 at Point Howard-Lowry Bay frequently but not permanently present (de Lisle 2018b); Sections 2 & 3 numbers declining
Black swan	10	0	0	0	0	0	0	1	
Mallard	2	4	6	0	7	4	5	0	Introduced species
Grey duck					0	0	2	0	
Variable oystercatcher *	43	45	258	322	6	36	116	74	Resident and breeding in Harbour, most on Matiu/Somes Island; Sections 2 & 3 numbers increasing (2.5% of Harbour population in 1986–88; Robertson 1992); bred in 2016, 2017 and 2018 at Sorrento Bay (OSNZ—Birds New Zealand 2016; Anon. 2017; pers. obs.); possibly breeding under Sorrento Bay boatshed (de Lisle 2018a).
Banded dotterel	0	0	0	10					
Spur-winged plover	0	0	0	2					
Arctic skua	2	0	0	0					
Southern black-backed gull *	4059	2065	1678	1507	1393	1057	604	408	Resident and breeding in Harbour and on harbour islands, most numerous and widespread resident species; Sections 2 & 3 numbers declining
Red-billed gull *	1025	693	1052	831	959	466	189	214	Most common Harbour bird March–August, few present rest of year; breeding elsewhere; Section 3 numbers have declined
Black-billed gull					0	0	2	0	Lowry Bay (https://ebird.org/newzealand/hotspot/L585134)
Caspian tern	1	0	3	0	4	0	4	0	Low numbers in Harbour through year; breeding elsewhere
White-fronted tern	486	36	133	52	542	392	17	14	Most frequent in Harbour March-May; consistently small numbers rest of year; local breeding Scorching Bay; Section 3 numbers declining; Point Howard wharf
NZ kingfisher	1	0	5	2	4	5	1	1	Mainly winter visitors
Welcome swallow	0	1	8	17					

Fourteen species recorded by the OSNZ surveys were not found during the SPP field surveys (**Table 6-2**). Eight of these (giant petrel, fluttering shearwater, pied shag, spotted shag, reef heron, Caspian tern, white-fronted tern and kingfisher) most likely occur on the SPP foreshore or in nearby coastal waters (McArthur & Lawson 2014). Several of these 14 species occur in parts of Section 2 outside the SPP areas surveyed (e.g. black swan, banded dotterel, spur-winged plover, welcome swallow).

The colony of little shags and little black shags in Williams Park (outside the SPP area) (**Section 6.1.1**) is the only known seabird breeding colony within the survey area. Potential variable oystercatcher breeding habitat (Heather, Robertson & Onley 2015) is present but widespread breeding is unlikely because of the level of human disturbance. However, breeding occurred at Sorrento Bay in 2015, 2016, 2017 and 2018 (OSNZ—Birds New Zealand 2016; Anon. 2017; pers. obs.) despite vulnerability to local human disturbance including dogs (Dowding 2017). Overall, the first two OSNZ surveys (1975–77 and 1986–88) found the mainly rocky shore of the eastern side of Wellington Harbour, from Pencarrow Lighthouse to Point Howard (OSNZ Sections 1–3), had relatively few birds compared with elsewhere on Wellington Harbour (Robertson 1992).

6.1.3 Survey data limitations

The survey data from the two sources has several limitations:

- Avifauna surveys collect data from samples in time (snapshots), and often do not capture variation on daily, seasonal, annual and longer timescales and variation with changing environmental conditions. This limitation is strongest for the May 2016 and 2017 surveys, which covered only several days in late autumn; although this does cover the autumn-winter influx of many coastal bird species into Wellington Harbour.
- The OSNZ surveys were undertaken monthly for two-year periods, at ten yearly intervals, within a wider survey programme covering the full Wellington Harbour. However, the data are somewhat out of date, the last being collected nine years ago.[26]
- The OSNZ surveys extended beyond the *c.* 200 m ZOI (out to 300–500 m) and they covered lengths that will not have SPP works. The OSNZ data thus likely includes records from more central harbour waters (e.g. fluttering shearwater) and from coastline lengths not in the SPP area (especially OSNZ Section 2).
- There is an absence in both surveys of data on breeding and nocturnal use, and there has been no statistical analysis of the OSNZ surveys.

Strengths of the data include a thorough approach following the water's edge during the 2016 and 2017 surveys and the long historical OSNZ data set in tandem with the recent surveys. Little penguins, the only nocturnal species present, were surveyed separately (**Section 8.2.1**).

The survey data are considered adequate for the purpose of assessing SPP effects on avifauna, but full avifaunal habitat use and population variability have not been captured.

[26] A new two-year period of surveys began in August 2018 (de Lisle 2018b).

6.2 Threatened and At Risk Coastal Avifauna Species

Two nationally Threatened avifauna species were recorded during SPP and OSNZ surveys: reef heron (Nationally Endangered) and Caspian tern (Nationally Vulnerable) (**Table 6-3**). There are nine At Risk species: northern giant petrel (Recovering), fluttering shearwater (Relict), black shag (Naturally Uncommon), pied shag (Recovering), little black shag (Naturally Uncommon), variable oystercatcher (Recovering), red-billed gull (Declining), NZ little penguin (Declining) and white-fronted tern (Declining). Five species are not Threatened or At Risk.

The high number of Threatened and At Risk species reflects the high proportion of coastal birds in these categories (Wallace 2016).

Table 6-3: Threatened and At Risk status, distribution / endemism, and numbers / habitat of avifauna species recorded during SPP and OSNZ Sections 2 and 3 surveys. Data shown for species recorded on more than two occasions. NZ little penguin shown; banded dotterel not shown (outside the SPP area; Jones 2017). Sources: Robertson (1992); Gill et al. (2010); Mills (2013); Grosser et al. (2015a); Robertson et al. (2017).

Species	Conservation status	Distribution / endemism	Numbers / habitat
Fluttering shearwater	At Risk - Relict, range restricted	Endemic species	Frequent, most in Wellington Harbour April–October, offshore
Giant petrel	Northern, At Risk - recovering; southern - migrant	Northern - indigenous species; southern - migrant	Very small numbers, Wellington Harbour, offshore
Australasian gannet	Not Threatened	Indigenous species	Small numbers, mainly winter visitor to Harbour, offshore
Little shag	Not Threatened	Endemic subspecies	Frequent, onshore or inshore, mainly winter visitor to Harbour
Black shag	At Risk - Naturally Uncommon, sparse	Australasian subspecies	Small numbers, onshore or inshore, mainly winter visitor to Harbour
Pied shag	At Risk - Recovering	Indigenous species, endemic subspecies	Very small numbers, onshore or inshore
Little black shag	At Risk - Naturally Uncommon, range restricted	Indigenous species	Frequent, islets or inshore, mainly winter visitor to Harbour but present in all months
Spotted shag	Not Threatened	Endemic species and subspecies	Small numbers, onshore, inshore, offshore, autumn to early spring
Reef heron	Nationally Endangered, data poor, secure overseas, sparse	Indigenous subspecies	Nationally 300–500 mature individuals, stable population (Adams 2013); regionally critical, with predicted decline of 10–50% over the next 10 years or three generations (Greater Wellington Regional Council 2018b); very low and declining numbers in SPP area; intertidal rocky reefs

Variable oystercatcher	At Risk - Recovering	Endemic species	Fairly frequent, regular, backshore and intertidal, numbers increasing, breeding at Sorrento Bay
Southern black-backed gull	Not Threatened	Indigenous subspecies	Numerous, regular, onshore, inshore, numbers declining
Red-billed gull	At Risk - Declining	Indigenous species, endemic subspecies	Frequent, most common bird in Wellington Harbour March–August, onshore, inshore
NZ little penguin	At Risk - Declining, data poor	Endemic species	42 known breeding sites in SPP area, additional 5–15 likely; presence varies seasonally; local population declining; use onshore, inshore, offshore habitats
Caspian tern	Nationally Vulnerable, secure overseas, sparse	Indigenous species	Very small numbers, inshore, offshore
White-fronted tern	At Risk - Declining, data poor	Australasian species	Numbers declining and now low, mostly present March-May, offshore
NZ kingfisher	Not Threatened	Endemic subspecies	Very small numbers, Days Bay southwards, onshore

6.3 Avifauna Habitats and Habitat Use

6.3.1 Avifauna habitats

The main avifauna habitats in the survey area are:

- Intertidal and backshore zones: rocky shore, cobble field, gravel beach, sand beach, seawater surface and water column when inundated; sheltered and moderately sheltered intertidal and subtidal rocky reef habitats reflect exposure to wind and waves (East Harbour Environmental Association 1998).
- Part of the waters of Wellington Harbour: water surface and water column
- Seawalls at most of the interface between Marine Drive and the tidal zone: smooth concrete, curved smooth concrete, concrete aggregate and riprap.
- Inland of Marine Drive: urban environments and scrub and regenerating forest, on valley floors and hillslopes, including some steep faces.

Monitoring results indicate that coastal environments in the Eastern Bays are generally in a healthy condition with respect to water and sediment quality (Oliver & Milne 2012).

Donaldson (1974) noted 'the remarkable availability of cockles … in [Lowry] Bay and the shallow siting of the beds', and that the site supported a significant recreational fishery. These dense beds may have been related to sewage from the overflows of community septic tanks (East Harbour Environmental Association 1998). The presence of abundant small cockles in the low intertidal and shallow subtidal zones, and of mollusc harvesting, was observed in south Lowry Bay in December 2018 (Overmars & van Kampen 2019).

6.3.2 Avifauna habitat use

The SPP and OSNZ survey results indicate that the most numerous bird species using coastline and harbour habitats within the SPP area and ZOI are fluttering shearwater, southern black-backed gull, red-billed gull, little black shag, little shag, variable oystercatcher and white-fronted tern. There are small numbers of Australasian gannet, black shag and spotted shag, while giant petrel, pied shag, reef heron, Caspian tern and NZ kingfisher were in very low numbers or irregularly present.

Habitat use is greatest during the post-breeding autumn and winter influx for fluttering shearwater, Australasian gannet, little shag, little black shag, spotted shag, red-billed gull and white-fronted tern (mainly autumn). This is mostly internal migration from New Zealand breeding sites (Robertson 1992), although white-fronted tern also migrate to Australia (Williams et al. 2006). Species resident through the year include black shag, reef heron, variable oystercatcher, southern black-backed gull and Caspian tern.

Tall macrocarpa trees at Williams Park provide nesting and roosting habitat for little shags and little black shags. Rocky platforms at Sorrento Bay probably provide nesting habitat for the pair of oystercatchers recorded breeding over successive years between 2015-2018.

Coastal avifauna habitat use above MHWS includes little shag, black shag, spotted shag and little black shag roosting on rocky islets and headland spots; and red-billed gull, black-backed gull and variable oystercatcher roosting and feeding on beaches especially when the tide is in.

Red-billed gull, black-backed gull and variable oystercatcher are the primary users of the intertidal zone on beaches, while rocky intertidal habitats are also the domain of oystercatchers and reef heron. Shallow offshore waters with rocky subtidal reefs are feeding habitat for the two gull species and little shag, little black shag and black shag.

Deeper offshore waters are the domain of fluttering shearwater, giant petrel, Australasian gannet, spotted shag, Caspian tern and white-fronted tern.

No coastal birds were seen during the field surveys on Marine Drive and the existing concrete and revetment seawalls, probably because of the unsuitable habitats and proximity to the road where there is disturbance by vehicle, cyclist and pedestrian use.

During the field surveys, highest numbers of birds were observed from Point Howard to Sorrento Bay (79%). This may be related to the greater variety of habitats present (sandy beaches, gravel beaches and gravel lenses, rock habitats including islets and shallow water) and shelter from northerly wind and wave action. This concentration of birds was not observed during southerly conditions (2017-05-17). However, the two bays are the most sheltered in the SPP area from the predominant northerly winds (Allis 2019) and greater use during these conditions is likely. Sorrento Bay has been considered to have a medium richness of bivalve molluscan species, in contrast to high richness at sites off Claphams Rock, Sunshine Bay and Windy Point (Booth 1972).

7 ASSESSMENT OF EFFECTS ON AVIFAUNA AND HABITATS

7.1 Avifauna Species and Habitat Values

7.1.1 Habitat status under Proposed Natural Resources Plan for the Wellington Region

The foreshore component of the SPP area between Point Howard and Sunshine Bay lies within the Wellington Harbour (Port Nicholson) habitat for indigenous birds listed in Schedule F2c of the Proposed Natural Resources Plan (**Table 7-1**). The foreshore adjoining the SPP Windy Point section is not within this habitat. Subtidal habitats in and adjoining the SPP area are in the Wellington Harbour inland waters listed habitat.[27]

Table 7-1: Avifauna habitats in Eastern Bays shared path project area listed in Schedule F2c of Proposed Natural Resources Plan for the Wellington Region. Conservation status as shown in Schedule F2c (since amended by Robertson et al. (2017)). 'Critical periods' as cited in the Plan, and refers to critical times of year during which key threatened or at risk bird species are present and so are particularly susceptible to human-related impacts (McArthur et al. 2015). Habitat values for indigenous fish species not shown. Source: Greater Wellington Regional Council (2015).

Avifauna habitat	Description	Critical periods
Wellington Harbour (Port Nicholson) foreshore; northern end of Days Bay to Point Howard	Five threatened or at-risk indigenous bird species are known to be resident or regular visitors: black shag, pied shag, little black shag, red-billed gull and variable oystercatcher	
Wellington Harbour (Port Nicholson) - inland waters	Five threatened or at-risk species are known to be resident or regular visitors: little penguin, fluttering shearwater, red-billed gull, Caspian tern and white-fronted tern	All year round
	Large numbers (up to several thousand) fluttering shearwaters enter the harbour during winter months to rest and feed, at times comprising a large, but unknown proportion of the Cook Strait population of this species	Important winter habitat for fluttering shearwaters
	Wellington Harbour (Port Nicholson) provides foraging habitat and access for little penguins to several large, secure nesting colonies on Matiu/Somes, Mokopuna and Mākaro/Ward Islands	1 July–1 March, little penguin breeding
	The harbour provides foraging habitat for much of the regional population of spotted shags	Year-round foraging habitat

[27] The 5–10 m gap between these two habitats shown in the GWRC GIS map viewer (Greater Wellington Regional Council 2017b) is an artefact of the mapping process (Dawe 2018). The Wellington Harbour inland waters habitat is intended to dovetail with the linear foreshore sites.

7.1.2 Habitat status under City of Lower Hutt District Plan

The City of Lower Hutt District Plan (Hutt City Council 2017) does not list any Significant Natural Resource site for coastal avifauna (excluding little penguins). HCC is currently undertaking an Ecological Sites and Landscapes project with the intention of replacing the existing SNRs of the District Plan. A coastal strip between Marine Drive and Wellington Harbour, between Point Howard and Eastbourne, has been identified as a potential Significant Natural Area for its avifauna values (Geard 2018).

7.1.3 Threatened and At Risk avifauna species [28]

The SPP area and ZOI provide seasonal or core habitat for one Nationally Endangered indigenous bird species (reef heron in very low and declining numbers) and one Nationally Vulnerable species (Caspian tern in low numbers) (**Table 6-3**). Nine At Risk species are present: fluttering shearwater (Relict); giant petrel, pied shag and variable oystercatcher (Recovering); black shag and little black shag (Naturally Uncommon); and red-billed gull, NZ little penguin and white-fronted tern (Declining).

7.1.4 Important Bird Area

The Cook Strait seaward extension Important Bird Area (IBA) for New Zealand Seabirds (Forest & Bird 2014) encompasses the South Taranaki Bight, Tasman Bay, Cook Strait and Wellington Harbour (total area 37 776 km^2). It meets three IBA criteria: A1 - regular presence of threshold numbers of ≥1 globally threatened species; A4ii - >1% of global population of ≥1 congregatory species; A4iii - >10 000 pairs seabirds or 20 000 individual waterbirds. The major seabird colonies for this IBA are all in the Marlborough Sounds or at Farewell Spit. Two of the 14 listed IBA trigger species were confirmed in the SPP area and its ZOI (fluttering shearwater and Australasian gannet).

7.1.5 Avifauna and habitat value

Applying criteria for assigning values to species (Table 5, Roper-Lindsay et al. 2018), backshore, intertidal and close inshore habitats of the SPP area have very high value for avifauna for the presence of one Nationally Threatened species (reef heron, in very low and declining numbers), and high value for five At Risk species: black shag, pied shag, little black shag, variable oystercatcher, and red-billed gull.

Policy 23 of the Regional Policy Statement specifies four biodiversity criteria for identifying indigenous ecosystems and habitats with significant indigenous biodiversity values: representativeness, rarity, diversity and ecological context (Greater Wellington Regional Council 2013, 2016). Notwithstanding modification associated with existing seawalls, the backshore, intertidal and subtidal parts of the SPP area satisfy all four criteria. They are representative of the current natural diversity of coastal ecosystem and habitat types in Wellington Harbour; they provide habitat for a high number of Threatened and At Risk avifauna species (and two plant species); they have a diversity of ecosystems,

[28] NZCPS Policy 11 (a) i.

species and physical features; and they provide connectivity and buffering of indigenous ecosystems and habitat, and seasonal and core habitat for protected and threatened indigenous species.

The backshore, intertidal and subtidal parts of the SPP area are significant habitats of indigenous fauna for the purpose of Section 6(c) of the Resource Management Act 1991.

7.2 Construction Phase Effects

7.2.1 Excavation and construction effects

Demolition and excavation works will entail significant movement of concrete and underlying materials, including stockpiling of excavated material and its return (in part or in full) at works completion (**Section 2.4.2**). Prevention of sediment effects on lower trophic levels (phytoplankton and marine algae) and upwards is important for coastal avifauna (including little penguins).

The construction methodology includes provision for a site plan for sediment removal within the CEMP (**Section 2.6.2**).

McMurtrie & Brennan (2019) assess potential effects from sedimentation and release of other contaminants by machinery operating in the construction zone and works that may extend into the subtidal zone. They recognise three potential sources of sediment: temporary disturbance of existing beach sediment and beach profile; terrigenous (land-derived) sediment from the addition of material; and potential for unanticipated fine sediment deposits below the seawall footings. They find the sediment management measures in the proposed construction methodology generally adequate. They further recommend relocation of fish stranded in intertidal rock pools; and in respect of works in the subtidal zone, to ensure that construction areas are kept isolated from seawater, minimise encroachment into the subtidal zone, and avoid operating heavy machinery in the sea. These recommendations are endorsed. No further sedimentation control measures are recommended.

A further risk associated with construction works is food, litter and other ingestible materials, especially for red-billed gull. These may have direct effects on avifauna and their prey or may foster the presence of predators such as rodents and mustelids. This risk is readily mitigated by storage of such materials in secure containers and removal offsite.

7.2.2 Noise and disturbance

Construction noise and disturbance may have potentially significant adverse effects on avifauna. Some species are more overtly responsive than others to noise and disturbance, and effects may vary seasonally (Harbrow, Cessford & Kazmierow 2011). One of the main wildlife responses to noise-related disturbances is tolerance or habituation to regular or constant noise. However, apparent tolerance and an absence of an obvious behavioural response do not necessarily indicate there is no impact on an individual or species; physiological changes can occur even when there are no outward changes in behaviour. ‘The literature on noise-related disturbance to wildlife suggests that there is no simple or generalisable relationship between noise and its effect on wildlife’ (Harbrow, Cessford & Kazmierow 2011, p. 47).

Parameters of noise and disturbance and their potential effects on avifauna at a broad level include:

i. Highest construction noise levels are likely to be caused by activities such as impacting devices (typically 91–100 decibels (dB) and pile driving (up to 101–110 dB) (U.S. Fish and Wildlife Service 2006). These would be used for cutting and breaking concrete, and pile driving and pile boring for seawall foundations underneath the beach.

ii. Daytime ambient noise levels in the SPP area are relatively high, but quieter at night.[29] Levels associated with the presence of passenger road vehicles and street-legal motorcycles (as on Marine Drive) are typically 71–80 dB (ibid.). Power boats also contribute to noise levels at times (Donaldson 1974).

iii. A method for assessment of noise and disturbance at the level of 'harassment' has been developed for two threatened Northwestern Californian species sensitive to noise and disturbance, northern spotted owl (*Strix occidentalis caurina*) and marbled murrelets (*Brachyramphus marmoratus*) (ibid.). Harassment occurs when:

    - project-generated sound exceeds ambient nesting conditions by 20–25 dB
    - project-generated sound, when added to existing ambient conditions, exceeds 90 dB
    - human activities occur within a visual line-of-sight distance of 40 m or less from a nest.

    By this methodology, the estimated harassment distance for sensitive coastal avifauna in the SPP area from proposed elevated action-generated sound levels extends 100 m out from a works site.

iv. New Zealand bird species known to be sensitive to noise and disturbance include shags (particularly black shag), kötuku (white heron, *Ardea modesta*) and royal spoonbills (*Platalea regia*) (Harbrow, Cessford & Kazmierow 2011).

Local factors in SPP noise and disturbance effects on coastal avifauna include:

i. Effects will occur mainly on feeding and roosting activities. Known breeding is confined to little penguins (**Section 9.2.1**) and an occurrence of variable oystercatcher at Sorrento Bay.

ii. Species that use harbour waters largely beyond 100 m of works are not expected to be affected (fluttering shearwater, giant petrel, Australasian gannet, Caspian tern and white-fronted tern).

iii. Species utilising habitats closest to the source of disturbance and noise will be most impacted, particularly those confined to the intertidal zone (variable oystercatcher, reef heron). The other susceptible At Risk species are black shag, pied shag, little black shag and red-billed gull.

iv. Effects will be of greater significance for the most threatened conservation status species (reef heron).

v. Effects will be greater on species that are more sensitive to noise and disturbance (reef heron, shag species).

[29] Marine Drive carries between 6000 – 8000 vehicles per day, including buses and trucks (Gottschalk & Povall 2016).

vi. Effects of noise and disturbance are potentially greater during the breeding season, especially when eggs and young chicks are present, and at times of stress such as in winter cold and summer drought (Walls 1999).

vii. Point Howard-Sorrento Bays have higher avifauna numbers than other parts of the SPP area.

viii. Birds in the coastal environment are currently subject to disturbance from recreational users (Donaldson 1974) and dogs, and vehicles on Marine Drive.

ix. Project construction activities are likely to be spread in relatively small segments in space (20 m) and time (3–6 months maximum), thus localising disturbance and noise effects.

x. All bird species present in the SPP when construction is happening will be disturbed by sudden loud noises.

Effects of noise and disturbance on coastal avifauna during the construction phase will be mitigated by:

- noise management under the proposed conditions of consent (Resource Consent Application Appendix R)
- at Sorrento Bay-Point Howard, surveying during the breeding season for the presence of reef heron (feeding, not necessarily breeding) and for breeding variable oystercatchers; and avoiding undertaking works if reef heron(s) are present (September-December) and until any variable oystercatcher breeding is safely complete (likely to be December- January);
- otherwise, by undertaking construction works between 1 March and 30 June if little penguins are present, and in spring to autumn if little penguins are not present.

7.2.3 Construction lighting

There is generally no intention to conduct construction activities with artificial light at night time (Corin, Povall & van Halderen 2019), but given the need to work to weather and tidal conditions, there may be occasions where working on the road level or at low tide will require some night work.

The effects of artificial lighting on avifauna is reviewed at **Section 7.3.4** and recommendations offered to reduce potential adverse effects of artificial light in the local environment in relation to construction lighting and street lighting on avifauna (and little penguins).

7.3 Operational Phase Effects

7.3.1 Migratory routes [30]

The SPP area as part of Wellington Harbour is an autumn and winter internal migration destination for seven species: fluttering shearwater, Australasian gannet, little shag, little black shag, spotted shag, red-billed gull and white-fronted tern. However, white-fronted terns excepted, the SPP area is not used as an onwards international bird migration route (Robertson 1992). Because white-fronted

[30] NZCPS Policy 11 (b) v.

terns in the SPP area are generally beyond 100 m of the shoreline, no effects on white-fronted tern habitat use or onwards migration to Australia are expected.

7.3.2 Encroachment [31]

7.3.2.1 Encroachment extent

The primary SPP operational phase effect on coastal avifauna is encroachment and the consequential loss of avifauna habitat. The proposed encroachment occurs mainly as a long thin stretch of habitat directly adjoining the seawalls, broken at some mainly rocky shore sites where there will be no seawall works. Encroachment widths vary from bay to bay, up to 3.5 m for curved seawalls and 9.3 m for revetment.

The proposed beach nourishment will result in a maximum net seaward shift of the beach profile by around 6 m at Lowry Bay and Point Howard and about 4.6 m at York Bay (Reinen-Hamill 2019). The effect will be to retain all the existing backshore habitat in these three bays, and to shift almost the full extent of encroachment there (975 m^2) into the intertidal zone.

The total proposed encroachment is 5836 m^2. After accounting for the transfer of beach nourishment encroachment in these three bays into the intertidal zone, *c.* 1506 m^2 of the total encroachment area is backshore habitat (37% of its local extent) and *c.* 4260 m^2 is intertidal habitat (12% of its local extent) (**Table 7-2**). [32]

Table 7-2: Seawall lengths and areas of habitat encroachment in relation to the CMA, and the extent of similar habitat directly adjoining the SPP area. These post-beach nourishment encroachment calculations assume uniform distribution of sediments through the effective beach lengths and are indicative only. Totals may not sum because of rounding.

Shared Path component	**Length**		**Area terrestrial (>MHWS)**		**Area CMA intertidal (MHWS–MLW)**		**Total**	
	m	%	m^2	%	m^2	%	m^2	%
Curved seawall	2646	85.4%	1028	*68.3%*	2871	*66.3%*	3899	*66.8%*
Revetment	398	12.8%	425	*28.2%*	1422	*32.8%*	1846	*31.6%*
Steps and ramps	55	1.8%	53	*3.5%*	37	*0.9%*	91	*1.6%*
Total			1506	*100.0%*	4330	*100.0%*	5836	*100.0%*
Local habitat extent			4064		35172			
Encroachment %			*37.1%*		*12.3%*			

[31] NZCPS Policy 11 (b) iii.

[32] Proposed encroachment areas are conservative based on information available and are expected to reduce with detailed design.

Curved seawalls comprise 85.4% of the total seawall length, 80.7% of the encroachment area above MHWS and 56.5% in the intertidal zone. Revetment areas contribute disproportionately to encroachment areas: they comprise 12.8% of total seawall length, 17.1% of the encroachment area above MHWS, and 42.4% of the encroachment area in the intertidal zone.

7.3.2.2 Design measures to reduce encroachment

The following measures have been incorporated into the project design with an intention to reduce the extent of encroachment:

i. Choice of steeply rising curved seawalls as the predominant seawall design.

ii. Adoption of curved seawall designs rather than large revetment structures at north Lowry Bay and south Lowry Bay (reducing encroachment by *c.* 2100 m^2).

iii. After discussions with residents over beach encroachments, landward realignment of Marine Drive is proposed to reduce beach encroachment at two areas (Sorrento Bay and York Bay) (Povall 2018). This avoided 0.5-1 m of widening into the beach.

iv. The use of parallel steps, ministeps and boat ramps, and an increased angle for ramps (Corin, Povall & van Halderen 2019).

7.3.2.3 Potential to reduce encroachment

There are strong constraints on the potential to reduce encroachment by shifting Marine Drive landward (Povall 2018). Just two sections at Mahina and Sunshine Bays (230 m length total) with potential to shift the road landward up to 0.5–1 m were not pursued (*c.* 50 m^2, 0.9% of SPP encroachment). The use of resources needed to shift Marine Drive landwards for these small benefits is not warranted.

Proposed revetment structures have a disproportionate effect on the loss of intertidal habitats from the SPP, and they imply possible future encroachment in response to sea-level rise (although this may be avoided by developing a steeper revetment face). Opportunities to further reduce encroachment at revetment areas are constrained by the presence of some form of revetment structure at four of the five remaining revetment sites (except Mahina Bay North).

The predominant shared path width atop seawalls under the current preliminary design is 3.5 m (2087 m, 67.9% of total seawalls length; **Table 2-1**). Seawalls with 3.5 m path width have an encroachment area of 4373 m^2, 75% of the total seawall encroachment area (**Table 7-2**). Where the distance between the existing seawall toe and the proposed toe exceeds 1.0 m, the choice of one metre extra over a 2.5 m width to achieve a 3.5 m path width is a discretionary loss of avifauna habitat. This discretion amounts to 1728 m^2 encroachment, 29.6% of the total encroachment area. [33]

[33] It is recognised that there are multiple factors in the choice of shared path widths.

Table 7-3: Encroachment areas of seawall sections of 3.5 m width shared path and corresponding areas for 2.5 m width, Eastern Bays shared path project. Areas of width transitions between 3.5 m and 2.5 m not included, and so encroachment area figures are under-estimates. Totals may not sum because of rounding.

	3.5 m width		**2.5 m width**		**Difference**	
	Curved seawall	**Revetment**	**Curved seawall**	**Revetment**	**Curved seawall**	**Revetment**
Location	m^2	m^2	m^2	m^2	m^2	m^2
Point Howard-Sorrento Bays	383		147		236	
Lowry Bay	997		586		411	
York Bay	414	261	165	208	249	53
Mahina Bay		624		455		169
Sunshine Bay	439	427	241	357	198	70
Windy Point	829		485		343	
Subtotal	3061	1312	1625	1020	1436	292
Total	**4373**		**2644**		**1728**	

Proposed widths of two non-seawalls sections are less than the 3.5 m overall preferred SPP design width. These are at Point Howard (2.5 m width, 140 m long) and at the south end of Sunshine Bay (3 m width, 90 m long). These sections are an opportunity to increase the extent of 3.5 m wide shared path for users without the effect of encroachment onto the backshore and into the CMA.

7.3.2.4 Encroachment effects on avifauna and avifauna habitat

Encroachment represents loss of avifauna habitat in the case of curved seawalls and almost complete loss for revetment. [34]

Potential effects of encroachment will be most significant for one Threatened and two At Risk species: reef heron, variable oystercatcher, and red-billed gull.

The shoreline habitat of reef herons has ongoing threats from encroachment by development, and the birds are vulnerable to disturbance by people and dogs (Adams 2013). Numbers in the Eastern Bays have declined in recent decades, from unknown specific cause(s)—but not encroachment. Recently there has been just one regularly seen but non-resident bird in the Point Howard-Sorrento Bay area, possibly visiting from Matiu-Somes Island and one of only two recorded on a recent survey of the Wellington Harbour mainland shoreline (de Lisle 2018a, b). This locality has sections where no encroachment is proposed, and the proposed encroachment of rocky shore intertidal habitat amounts

[34] Void spaces in revetment are available as habitat for some marine species (e.g. cover for fish, substrate for filter feeders), but primary production by phytoplankton and marine algae is absent.

to *c.* 200 m^2. While it is undesirable to lose any habitat area in one of the very few known reef heron locations on the Harbour shoreline, any effect from this level of encroachment is unlikely to be distinguishable from other causes contributing to the decline of reef heron in the Eastern Bays. The level of effects of this level of encroachment is low.

The amount of proposed habitat loss relative to its local extent is a broad measure of its significance: 37% of local backshore habitat and 12% of local intertidal habitat (**Table 7-2**). A total of 45 red-billed gulls and 18 variable oystercatchers were observed in these habitats during the two counts of this study's survey, and 214 red-billed gulls and 74 variable oystercatchers by OSNZ surveys (24 counts) in 2008–2010 between Days Bay and Point Howard (**Table 6-1**, **Table 6-2**). Available data does not permit an accurate estimation of the effects on these two species locally of the loss of habitat; the sample is small and the distribution of birds between intertidal and backshore habitats was not recorded. However, assuming a relationship between habitat size and population numbers, the data does indicate that there is likely to be a reduction in their numbers locally, perhaps of the order of 15–25% and less than 10 birds at any one count for each of the two species.

Effects on shags using shallow inshore habitats for feeding and foreshore and backshore habitats for roosting are expected to be minor. Black shag, little black shag and pied shag (and the locally abundant but not threatened little shag) are highly mobile and local loss of this feeding habitat (12%) represents a very small part of their feeding range. Roosting occurs primarily on offshore rocks and islets, probably in response to existing levels of disturbance.

Given the similar to slightly coarser proposed beach nourishment grain size to the existing sediments (Reinen-Hamill 2019) and it will mix with existing sediments, it is likely that the beach nourishment surface and near-surface habitats will be similar as avifauna habitat to the existing environment.

Cumulative effects through continued attrition of coastline habitat and through other developments in Wellington Harbour are possible although difficult to quantify (e.g. other current proposals for cycleways/shared paths).

Habitat loss will also occur in time against existing protection seawalls (**Section 3.6; Figure 7-1**), leading to progressive coastal squeeze and loss of backshore avifauna habitat and then also of intertidal habitat from the SPP area.

7.3.2.5 Mitigation for habitat loss

Opportunities to mitigate the effects of proposed habitat loss through increasing habitat quality or creating new habitat in the SPP locality are not readily available.

Figure 7-1: Existing double curved seawall, York Bay, built 2007–2008. Photo (taken close to high tide) illustrates loss of a narrow zone of intertidal habitat, and outcomes against hard protection structures (that will increase with sea-level rise). Textures are proposed to be incorporated into one curve face (5 mm depth) and a flat step (50-70 mm depth) to enhance habitat complexity and protection for biota. Photo: P5040292, 2016-05-04

A possibility is to look for opportunities at the detailed design stage to reduce the 3.5 m shared path width at lower use parts (e.g. Mahina and Sunshine Bays) without compromising its overall functionality. Another is to create new avifauna habitat on the Seaview Marina - Point Howard breakwater or by raising the small rocky islets in northern Lowry Bay, but these would entail costly works, have their own environmental effects, and require future raising in response to sea-level rise to remain effective. A region-wide strategy to respond to coastal squeeze effects on coastal avifauna habitats may identify possibilities that could be pursued but such a strategy is not currently available.

McMurtrie & Brennan (2019) propose measures to enhance curved seawall habitat suitability for intertidal biota: [35]

- a textured surface on the lowermost seawall curve face
- depressions in the flat step
- weepholes discharging onto the lowermost step (and second lower step for triple curve seawalls)
- rock pools on the vertical face of curved seawalls
- return in front of new seawalls of larger natural weathered rock material that has been colonised by intertidal biota.

Proposed measures for revetment seawalls include:

- placement of natural rock within revetment voids and placement on rock platforms
- some flexibility in the rock type and void sizes in the revetment seawall type
- drilling rock pools into some of the hard revetment rock in the mid-low tide zone
- look for opportunities to reduce footprints where it is possible to do so without substantial compromise of seawall structural integrity.

These measures are not direct mitigation for the loss of avifauna habitats to encroachment but offer some benefit through increased habitat diversity and complexity in food chains compared with the largely unproductive existing seawalls (McMurtrie & Brennan 2019).

7.3.2.6 *Post-mitigation level of effects of encroachment*

The intertidal habitats to be lost to encroachment (0.43 ha) are biologically productive and diverse, the backshore (0.15 ha) less so (McMurtrie & Brennan 2019). It is additional to historical loss from extensive reclamation, seawalls and groynes in Wellington Harbour (Robertson 1992; East Harbour Environmental Association 1998; Waitangi Tribunal 2003). Approximately half of the harbour margin has been modified (rip-rap seawalls, flanking road and rail corridors) (Stevens 2018). The loss is permanent on human time scales—but this will also occur with sea-level rise. Further encroachment is possible when revetment seawalls are raised in future in response to sea-level rise.

Any effect from the proposed encroachment is unlikely to be distinguishable from other causes contributing to the decline of the Nationally Endangered reef heron in the Eastern Bays (now down to one bird).

For the At Risk-Declining red-billed gull and variable oystercatcher, the data indicates there is likely to be a reduction in their numbers locally, perhaps of the order of 15–25% and less than 10 birds at any one count for each of the two species. The red-billed gull population is currently estimated at >100 000 mature individuals with a predicted decline of 10–70%; the variable oystercatcher population is 1000–

[35] Given sea-level rise, it would be desirable to extend texturing and depressions to parts now above MHWS, but its high cost is acknowledged.

5000 mature individuals with a predicted increase of >10% (Robertson et al. 2017). While it is undesirable to lose habitat area for these two At Risk species, and there will be an effect on the local population, the effect on a population basis is low.

7.3.3 Increased human and dog disturbance

In creating a safe facility for human walking and cycling between Marine Drive and the coastline, the shared path will bring an increase in the number of people (Corin, Povall & van Halderen 2019), and potentially, dogs recreating in the coastal zone, which will significantly increase levels of disturbance of coastal avifauna (Wallace 2016). Dogs are much the greater potential risk: the mere presence of dogs has adverse effects on birds (Banks & Bryant 2007), and every time a dog runs at a bird the bird is being disturbed.

The effect of increased disturbance could be accentuated at Sorrento, Mahina and Sunshine Bays by the increased confinement of recreationists and dogs within the reduced extent of beaches in the absence of beach nourishment there. However, bird numbers are lower at Mahina and Sunshine Bays (**Table 6-1**) and at the Sorrento Bay beach.

The flightless little penguin is the species in the Eastern Bays that is most vulnerable to dogs (see **Section 9.3.5**) but all the other avifauna species present will be at risk from increased disturbance, including variable oystercatchers nesting at Sorrento Bay.

Proposed mitigation for the effect of increased disturbance on avifauna is the installation of signage to educate the public on the high avifauna values present and the need for responsible dog management within the SPP area.

Outside the scope of this report, a recent study of the role of public perceptions of risks to coastal wildlife from interactions with dogs (Banatoski et al. 2017) recommended improvements in approaches in dog management. These are centred on signage, education, assessment/monitoring, and community engagement. They are a resource for any future review of the Hutt City Council Dog Control Policy 2015. A system for reporting and analysing wildlife-dog interactions on and near the shared path before and after construction could provide valuable data for such a review.

7.3.4 Street lighting

The SPP proposes to undertake an assessment of existing street lighting during the detailed design stage to establish if additional lighting will be required along the route (Corin, Povall & van Halderen 2019). Several existing street lighting columns will need to be relocated.

The effects of artificial light pollution on biota are emerging as a major issue in biological conservation as advancing lighting technology has led to a diverse range of low energy light types and a trend towards the increased use of artificial light and broad white spectrum light (Stone, Harris & Jones 2015; Kyba et al. 2017; Royal Society Te Apārangi 2018). Broad "white" lighting associated particularly with LED (light-emitting diode) lighting is problematic because of the greater likelihood of substantial emissions in key parts of the action spectra of many biological processes, particularly emissions in the blue part of the spectrum. Artificial lighting disrupts natural and predictable regimes of moonlight, sunlight and starlight, and may negatively affect gene expression, physiology, reproduction, communication, behaviour and predation rates of animals and plants at different trophic levels, and alter community composition and ecosystem processes (Pawson & Bader 2014; Blackwell, DeVault & Seamans 2015; Gaston & Holt 2018), including those in marine environments (Davies et al. 2014).

Coastal and marine birds, especially nocturnal species, are vulnerable to the effects of artificial light (Montevecchi 2006); Procellariiformes (petrels) appear to be most vulnerable (Rodríguez et al. 2017). Their attraction to artificial light is influenced by the level of ambient light, lunar phase, season, and foggy and overcast weather conditions. Artificial lighting parameters relevant to biota include emission spectra, location, illuminance, shielding and cumulative effects (including on non-target species, such as prey and predators) (van der Ree, Smith & Grilo 2015).

The SPP environment is already subject to a level of ambient lighting from street and house lights, the moving lights of cars, and skyglow from lights elsewhere in Wellington. Just two of the species present (giant petrel, fluttering shearwater) belong to the Procellariiformes and these occur on harbour waters rather than at the coastline. No reports have been found of local mortality associated with artificial lighting, while the magnitude of any other effects is unknown.

A study of little penguin (Australasian clade) behaviour in relation to artificial light at the Phillip Island ecotourism colony found that increased light intensity did not affect colony attendance behaviours of penguins at an artificially site, probably due to penguin habituation to lights, and that penguins tended to use an access tunnel lit with blue light rather the one with red light (Rodríguez et al. 2018). Notwithstanding these findings, the authors recommended keeping lighting as dim and time-restricted as possible because of other potential harmful effects of artificial lights.

Overall, significant adverse effects on coastal avifauna and little penguins are not expected from the proposed use of artificial lighting during the project construction phase and from the changes to the existing street lighting configuration. Nevertheless it is desirable to attempt to reduce potential adverse effects of artificial light in the local environment consistent with road and shared path safety, by considering the following in the choice of lighting or lamp fixture locations and luminaires (van der Ree, Smith & Grilo 2015):

- seek to reduce the use of road lighting
- avoid release of light directly at and above the horizontal
- limit downward emission outside the area to which lighting is required, particularly spread into the coastal zone
- seek to avoid the loss of vegetation or structures that shield the coastal zone from vehicle lights
- limit emission of short-wavelength spectra (e.g. <500 nm, ‘blue light’)
- zone and space to minimise unnecessary lighting
- use on/off scheduling if appropriate.

It is recommended to include the potential effects of road lighting changes on coastal avifauna (including little penguins) in the SPP detailed design stage assessment, through applying the Model Lighting Ordinance (International Dark-Sky Association-Illuminating Engineering Society 2011).

7.4 Recommended Mitigation

The following additional mitigation for potential construction and operational phase effects on avifauna and avifauna habitats is recommended. The post-mitigation level of effects will be low.

a. Include the following provisions in the Construction and Environmental Management Plan:
    i. Ensure that construction areas in the subtidal zone are kept isolated from seawater and avoid operating heavy machinery in seawater to the fullest practicable extent.
    ii. Contain all food and other biodegradable and ingestible materials in secure containers (rodent-proof for food), and regularly remove from the construction site.
    iii. At Sorrento Bay-Point Howard, survey during the breeding season for the presence of reef heron (feeding, not necessarily breeding) and for breeding variable oystercatchers; and avoid undertaking works if reef heron(s) are present (September-December) and until any variable oystercatcher breeding is safely complete (likely to be December-January);
    iv. For other avifauna species and situations, undertake works during spring to autumn (outside little penguin areas).
    v. Include provisions to minimise effects of construction disturbance and noise on coastal avifauna, including monitoring, within the CEMP.
    vi. In the use of artificial lighting for construction purposes, avoid release of light directly at and above the horizontal, confine downward light emission to the area for which lighting is required and avoid spread elsewhere into the coastal zone, and limit emission of short-wavelength spectra (<500 nm).
b. At the detailed design stage:
    i. Look at reducing the footprint of the revetment seawall types where it is possible to do so without compromising on structural integrity of the seawall, overtopping protection, or coastal processes.
    ii. For changes in street lighting, consider identified measures to reduce potential additional adverse effects of artificial light in the local environment on coastal avifauna (including little penguins), consistent with road and shared path safety.

8 LITTLE PENGUINS KORORĀ AND THEIR HABITATS

8.1 Little Penguins Kororā

8.1.1 Taxonomic status

Australasian little penguins comprise two genetically distinct species, one restricted to New Zealand (*Eudyptula minor*; 'NZ little penguin' or 'little penguin') and the other ('Australasian clade') occurring in Australia and in NZ's southeast (Otago) (Grosser et al. 2015a). There are only low levels of hybridisation. Biological differences include morphology (feather colour), vocalisation patterns, behaviour (only colonies of the Australasian clade come ashore after dusk in 'rafts') and breeding (double brooding occurs only in the Australasian clade). The Australasian clade probably arrived in New Zealand between AD 1500 and 1900, following the anthropogenic decline of its sister taxon, the endemic *Eudyptula minor* (Grosser et al. 2016).

Significant genetic structuring exists among NZ little penguin populations, underlining the importance of conservation management for preserving regional genetic diversity (Grosser et al. 2015b).

8.1.2 Population and conservation status

The NZ little penguin is widespread and locally common along the coasts and offshore islands of the North, South, Stewart and Chatham Islands, except southeast Otago (Grosser et al. 2015a; Heather, Robertson & Onley 2015).

Little penguins in the Wellington region are classified within the northern blue penguin (*Eudyptula minor iredalei*) (Robertson et al. 2017). This is assessed as At Risk - Declining (5000–20 000 mature individuals, predicted decline 10–30% over three generations), with the qualifier Data Poor.

A recent review (cited in Poupart et al. 2017) found there are few large (>200 pairs) little penguin populations in New Zealand. The largest little penguin colonies in the Wellington region are on Matiu/Somes and Mana Islands. Five other Wellington islands have significant sized populations: Kapiti Island, Tokomapuna (Aeroplane) Island (off Kapiti Island), Mākaro/Ward Island, Mokopuna Island and Taputeranga Island (McArthur et al. 2015; Cockrem 2019). Six of the seven Wellington islands are managed as reserves (Department of Conservation 2016; New Zealand Government 2016).

Little penguins are common in Wellington Harbour with a minimum estimated population size of 420 pairs (Taylor 2018). The Matiu/Somes Island colony is estimated to have *c.* 300 pairs / 700^{+} adults and is the largest in the lower North Island (de Lisle 2014; Rumble 2018b; Taylor 2018). Mainland occurrences include Wellington south coast, Worser Bay to Point Halswell, Shelly Bay and Evans Bay, Wellington City, Kaiwharawhara, Ngauranga and Eastern Bays including the Little Penguin Haven (McArthur et al. 2015; Boyack 2016; MacDiarmid et al. 2016; Ornithological Society of New Zealand 2017; Taylor 2018).

Threats to eggs, chicks and adults on land include predation by dogs, cats, mustelids and Norway rats, fire, human and dog disturbance, road mortality, and loss of access and breeding habitat including to sea-level rise (Taylor 2000; Stevenson & Woehler 2007; Dann & Chambers 2013). Threats at sea include nets, oil spill and other pollution, watercraft strikes and multiple effects from climate change including sea temperature increases and ocean acidification (Taylor 2000; Trathan et al. 2015; Cannell et al. 2016; Hewitt, Ellis & Thrush 2016; Poloczanska et al. 2016). Predation can severely impact breeding success as adults and chicks can be taken (Allen, Helps & Molles 2011). Mortality of one bird in a pair while nesting has the added impact of causing breeding failure. Resilience to future climate change impacts will almost certainly depend on addressing current habitat degradation threats on land and at sea (Trathan et al. 2015).

8.1.3 Life characteristics

8.1.3.1 Evolutionary and behavioural characteristics

Little penguins, like all penguins, have evolved a distinctive set of life characteristics. They are flightless, air-breathing birds, highly adapted for swimming and diving for food in the sea and spending most of their lives there, but as birds reproducing via external eggs, they are tied to terrestrial environments for breeding (Davis & Morris 2009). Penguins must also come ashore every year to moult—to shed their old, worn feathers and replace them with new ones. Penguins do not eat when ashore, so their foraging areas at sea must be close enough to reach while still managing to mate and raise their eggs and chicks. Hence, ‘penguins must balance living in two worlds — water for feeding, land for breeding — and much of what they do is dictated by how far they must go when at sea’ (Davis & Renner 2003, p. 12).

At sea, little penguins are visual predators, foraging predominantly on squid and small fish at depths of <50 m (Flemming, Lalas & van Heezik 2013; Chilvers 2017). Penguins from three locations around Wellington Harbour foraged mostly in its centre and eastern sides, but some did trips into Cook Strait and Palliser Bay up to 36 km from their colony (Poupart et al. 2017). Trip duration during the incubation and chick rearing stages was between 1–3 days. A foraging study of a small number (N=8) of little penguins from Matiu/Somes Island showed feeding activity regularly occurred in nutrient-rich shallow waters near coastlines, including sites 100–400 m offshore of Mahina Bay and Sunshine Bay where depths quickly reach the harbour bottom (10–12 m) (Zhang et al. 2015). Penguin populations respond to environmental variability in marine environments (Agnew et al. 2015).

When ashore, little penguins are nocturnal, typically coming ashore after dusk and leaving before dawn. Little penguins nest underneath vegetation such as flax bushes, in burrows dug in soil, in piles of rocks and in caves (Kinsky 1960; Marchant & Higgins 1990a; Dann 1994; Perriman & Steen 2000).

These behaviours are a further evolutionary adaptation, to avoid over-heating on land (Davis & Morris 2009).

8.1.3.2 Life cycle

The yearly cycle of little penguins on Matiu/Somes Island (3.5 km from Eastern Bays) has three non-exclusive parts: (a) August to January - breeding; (b) December to March - moult; (c) March to September - occupation of nesting burrows and pair formation (Kinsky 1959, 1960). Egg laying (one or two eggs) occurs from late July through to mid-November, with a peak period from late August to late September (Kinsky 1959, 1960; Bull 2000b; Rumble & Batcheler 2015). The usual incubation period lasts 35–38 days, and the time taken from hatching to leaving the nest is between 49–60 days. The timing of the annual cycle, however, is highly variable across locations and years for Australasian clade little penguins (Agnew et al. 2014), and this is likely for little penguins in the Wellington region.

Parental care is shared by males and females and they must balance the time spent foraging at sea against the time their partner must spend fasting at the nest (Davis & Renner 2003; Numata, Davis & Renner 2004).

On Matiu/Somes Island, nests historically were found from sea level to the island summit (Kinsky 1959). Nests in vegetation and rock crevices and under such items as iron or logs, fledged the highest percentage of chicks; nests located in soil burrows, caves and under boulders recorded the highest percentage of eggs that failed to hatch (Bull 2000b). Currently, most nesting occurs in artificial nest boxes and there is very little use of natural breeding sites (de Lisle 2015; Rumble 2018b). Elsewhere, nests may also be under coastal buildings (Davis & Morris 2009).

Once the chicks leave the nest, adults return to sea for a period of intensive feeding to reach the physiological condition necessary to go through the moult (Kinsky 1959). During this time (average four weeks), they return to land only at irregular intervals for night visits, which they spend in burrows or other places.

The adults then return to moult, some to the breeding site, most to other shelter. During this time (12–18 days), they cannot swim, having impaired insulation, and do not eat (Marchant & Higgins 1990a). The moulting season lasts from the beginning of December to mid-March (3.5 months), peaking in January (Kinsky 1960). Kinsky (1960) found only 20% of birds returned to their own nests to moult, and only 40% of all known nesting sites were occupied by moulting birds. Many burrows chosen for nesting appeared not to be suitable for moulting, and vice versa.

Moulting is followed by a return to sea with irregular night visits to land, but not burrows (Kinsky 1959, 1960). Birds return in large numbers during the second half of March, and re-occupy burrows by the beginning of April (Kinsky 1959). Partners of most pairs join up early during the winter and most burrows contain nesting material by the end of June (Kinsky 1960). Adult birds are highly philopatric, almost always returning to their respective home territories when coming ashore.

Juveniles disperse widely at sea after fledging. Most return to moult at natal colonies after 3 years, some at 2 years, while a few may moult and breed at other colonies (Marchant & Higgins 1990b).

8.1.4 Population dynamics

Breeding success (number of chicks fledged per nest) on Matiu/Somes Island was 0.88 in 1956–57 and 0.77 in 1957–58 (Kinsky 1960); 0.79 in 1995–96 and 1.10 in 1996–97 (Bull 2000a); and 1.44, 1.23 and 1.31 in the 2012, 2013 and 2014 breeding seasons (Rumble 2015). The increase between 1995–96 and 2012–14 may be attributable to the shift to a high proportion of artificial nesting boxes (now >270 boxes; Rumble 2015). Little penguins in the North Island have lower breeding productivity and lower recovery potential than those in Otago, whose productivity is increased by double brooding (i.e. laying a second clutch after a successfully-fledged first double-clutch) (Agnew et al. 2014).

The life history strategy of little penguins relies on a high level of adult survival to maintain the population. Agnew et al. (2016) found for little penguins at Oamaru:

- estimates of first-year survival probability varied widely among years with an overall average of 0.42
- the survival probability of pre-breeding penguins in their second year was 0.82, double the first-year survival
- estimates of breeder survival varied among years, with mean survival probability of 0.86.

Banding records show bird exchange between the Matiu/Somes Island, Balaena Bay and Days Bay colonies in Wellington Harbour (Poupart et al. 2017), and birds banded on Matiu Somes Island have been found as far away as Nelson and Hawke's Bay (Rumble 2018b). Batcheler & Rumble (2014) suggest, based on apparent survival, that there may be significant emigration from the strong population on Matiu/Somes Island. Unbanded birds have been found at the Little Penguin Haven (Eastern Bays Little Penguins 2017b). At the Oamaru main colony and Oamaru Creek colony, 60% of new breeders originated locally as fledglings and 40% were from other colonies (Agnew 2018).

8.2 Little Penguins in the Eastern Bays

8.2.1 Survey population results

Between the Hutt River bridge and south Eastbourne, the 2016 survey found 54 sites with adult penguins, chicks, eggs or clear signs of nesting activity and the 2017 survey found 75 sites (**Table 8-1**).[36] With two additional records from the shared path consultation process and two by a local observer, this gave a total dataset of 133 breeding site records across both years.[37]

A factor in the additional 21 breeding sites between the 2017 and 2016 surveys is likely to be a degree of nesting failure in 2016 rather than an increased population (Rumble 2016a). Only three of the additional 21 sites found in 2017 were in the survey coverage extension (inland of Marine Drive).

In the SPP area, the 2016 survey found 18 sites, and the 2017 survey found 35 sites (**Table 8-1**). The greatest numbers in 2017 were at Whiorau Reserve (11), Point Howard-Sorrento Bay (10) and Windy Point (6). The greatest numbers outside the SPP area in 2017 were at Seaview (29 sites).

After removal of likely duplicates between the two survey samples (**Section 3.4**), there were 101 breeding sites in the total survey area, 42 of them in the SPP area, of which six were inland of Marine Drive (three found by the surveys). These became the primary data set for breeding sites in the Eastern Bays.

[36] The 2016 survey found just one penguin site south of Eastbourne. Maps of site locations are available on request.

[37] Maps of site locations are available on request.

The Little Penguin Haven in northern Days Bay was not included in either survey. There were three nests there in 2016 (Rumble 2016a) and five nests in 2017 (Eastern Bays Little Penguins 2017a).

There were four further records from the shared path consultation process that were not site-specific: i. penguins probably nesting at the base of the cliff from Point Howard to Lowry Bay (some of which was not searched by the penguin dog); ii. penguins occasionally on a property at Days Bay/Windy Point; iii. penguins occasionally run over by cars crossing the road at Windy Point; and iv. penguins on a property but site not specified (van Halderen 2017). The available location details indicate at least two of these are inland of Marine Drive. There are further local reports but without specific sites (Eastbourne Community Notice Board Group 2018).

Table 8-1: Number of little penguin breeding sites found during surveys on eastern side of Wellington Harbour, October 2016 and October 2017. Nest site in 2016 at Pencarrow Head not included. Survey areas within the SPP area shown with an asterisk (*). Data from Alastair Judkins (Kaikoura Ocean Research Institute) and additional 2017 records from consultation process and local observer.

	2016				2017			
Survey area	**Nest**	**Adults**	**Chicks**	**Eggs**	**Nest**	**Adults**	**Chicks**	**Eggs**
Seaview	19	8	8	1	29	6	7	3
Point Howard - Sorrento Bay *	3	1		3	10	6	4	2
Lowry Bay *					2			
Whiorau Reserve *	7	5	1		11	6		6
York Bay					1			
Mahina Bay-Claphams Rock *	1				4	1	1	
Sunshine Bay North *	1	1			1	1		
Days Bay North / Sunshine Bay South	6	3			7	3		
Windy Point *	6	4			6	4		1
Eastbourne	11	5		3	8	5	2	2
Survey Area Total	54	27	9	7	79	32	14	14
SPP Area Total	18	11	1	3	35	18	5	9

Data Reliability

The survey data underestimate the number of penguin breeding sites in the SPP area:

i. The 2017 survey was extended to cover the previously unsurveyed population inland of Marine Drive. Here, it focussed on the roadside properties with the hope that information on penguin passage through them may come from contact with residents. Little penguin nest sites can be located up to 500 m inland (Heather, Robertson & Onley 2015) but it was not feasible to survey this large area. Actual survey coverage amounted to approximately one-third of the roadside properties and no properties further inland, and no information was directly gleaned on penguin passage through the roadside properties.

ii. The data from the two surveys over successive years for the common shoreline length, after removal of duplicate breeding sites, found 16 additional sites (16.7%) over the 2017 survey alone. This increase may indicate a sampling effect in relation to the true population,[38] alongside the poor breeding season in 2016 and other sources of variation. While a marginal increase is possible with further sampling, a substantial increase from this source is unlikely.

By simple ratio, six further sites could be expected from the unsurveyed roadside properties, and more again from the properties further inland that were not surveyed. This is supported by the three non-survey records from this area. The four consultation reports that were not site-specific and Eastbourne Community Notice Board reports also support the presence of additional breeding sites. On the other hand, the general inaccessibility to potential little penguin breeding habitat caused by current seawalls (66% of local coastline; **Section 8.2.6**) and the fact that some habitats inland of Marine Drive are unsuitable for nesting are constraints on possible additional numbers.

8.2.2 Survey habitat results

The predominant habitat associated with the breeding sites was rock (80% in the total survey area, 67% in the SPP area) (**Table 8-2**). The rock was predominantly human-placed (riprap/revetment, breakwater, old seawall and concrete slabs/waste rock).

Five sites in the total survey area were under houses, four of them in the SPP area. Three sites in the SPP area were in stormwater pipes (**Section 8.2.7**).

Most sites were less than one metre above MHWS (59% in the survey area, 48% in the SPP area). No breeding sites were observed in the 190 m revetment length on the northwest side of Whiorau Reserve, which is probably a response to the site being most exposed to wind and waves.

[38] For example: a nesting pair reported in rock riprap at Sunshine Bay in May 2016 (Mike Rumble. pers. comm. 2016-05-30) was not found by the 2016 survey, nor probably three penguins (possibly including the nesting pair) killed on Marine Drive in the same locality in May-June 2017 (iNaturalist NZ 2017a, b, c); that were probably displaced by laying down of new rock; and three nests under houses reported by residents but not found by survey. A recent mortality record at Mahina Bay (iNaturalist NZ 2018b) may also indicate a breeding site not found by survey.

Table 8-2: Habitat and altitude for little penguin breeding sites on eastern side of Wellington Harbour, October 2016 and October 2017. Number of known sites (101) differs from habitat types (102) because habitat types are not exclusive. Altitude is in relation to MHWS-10. Penguin habitat data from Alastair Judkins (Kaikoura Ocean Research Institute) and four locally sourced records. GIS contour data from Greater Wellington Regional Council (2017a). Locations subject to Garmin eTrex Vista GPS accuracy.

Habitats	**Pipe / drain**	**Rock**	**Trail**	**Vege- tation**	**Under house**	**Other**	**Total**			
Survey area	4	82	1	6	5	4	102			
%	3.9%	80.4%	1.0%	5.9%	4.9%	3.9%				
SPP area	3	28		5	4	2	42			
%	7.1%	66.7%	0.0%	11.9%	9.5%	4.8%				
Altitude	**<MHWS -10**	**0-50 cm**	**50-100 cm**	**100-150 cm**	**150-200 cm**	**200-250 cm**	**250-300 cm**	**>300 cm**	**No data**	**Total**
Survey area	15		45	10	19	2	6	3	1	101
%	14.9%	0.0%	44.6%	9.9%	18.8%	2.0%	5.9%	3.0%	1.0%	
SPP area	5		15	7	9	1	3	2		45
%	11.9%	0.0%	35.7%	16.7%	21.4%	2.4%	7.1%	4.8%	0.0%	

8.2.3 Mortality

Twenty little penguin mortalities are known in the Eastern Bays in the period mid-2015 to mid-2018 (**Figure 8-1**). Nine were road fatalities and three were caused by predation (dogs, cat), while cause of death was unknown or uncertain for the other eight. Two or three at Sunshine Bay in May-June 2016 may be associated with revetment upgrade there, leading to the loss of breeding sites amongst rocks and forcing the penguins onto the road. Twelve of the deaths were in the SPP area.

These records are not the result of systematic data collection and underestimate the true extent of penguin mortality in the Eastern Bays, but they are indicative of primary risk factors – deaths by roadkill and dog predation.[39] Roads and dogs are the two largest contributors to little penguin deaths in the Oamaru urban environment (Hocken 2000), and the only sources of injury referred to in an account of the work of the former Eastern Bays Little Blue Penguin Foundation (East Harbour Environmental Association 1998).

[39] One resident in the shared path consultation process wrote: 'Penguins nested behind our garage in the 80s. Only 1 brood matured. Most others died soon after the death of one parent skittled on the Marine Drive' (van Halderen 2017).

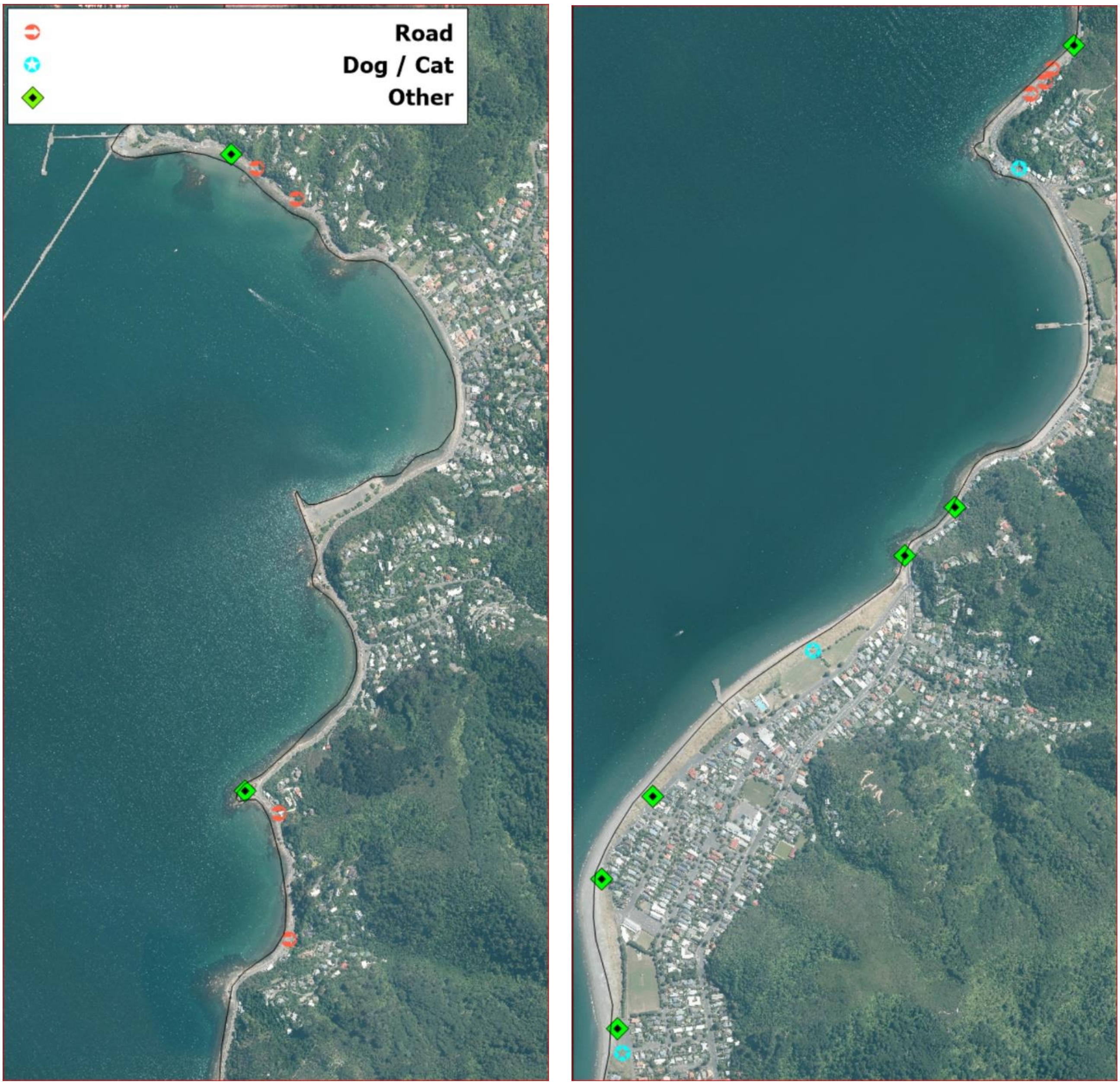

Figure 8-1: Locations of twenty known little penguin mortalities between Point Howard and Eastbourne between mid-2015 and mid-2018. Records sourced from iNaturalist NZ (10), Facebook Eastern Bays Little Penguins Project/ Eastbourne Community Notice Board (2), 2016 survey (1) (Judkins 2018b), Facebook (1), shared path consultation (1), and personal communications with residents (3). One record was of three fatalities.

Predator control and monitoring in the Eastern Bays is currently being undertaken by ERAT (Educating Residents Around Trapping) and over 100 traps have been placed along the foreshore (Mainland Island Restoration Operation 2018; Tso 2019). Hedgehogs, rats and mice have been successfully trapped.

8.2.4 Population and trends

The historical presence of a significant little penguin population in the Eastern Bays has been widely noted, including their propensity to live under houses (Hutt City Council 1998; Kenderdine 2001; Davis & Morris 2009). The population is unusual in that its terrestrial lifecycle occurs in a semi-urban environment, where little penguins are additionally subject to:

- impacts from dog and road-related injury and mortality, loss of habitat (e.g. housing subdivision), lighting, noise and direct human disturbance (Giling, Reina & Hogg 2008)
- seawall barriers to little penguin access to inland breeding sites
- residents blocking little penguin access to one of their preferred habitats (under houses) because of their loud calls.

There is evidence of a higher number of little penguins in the late 1990s than found by the current surveys.[40] Seventy-five penguins injured after traffic or dog confrontations were cared for by the Eastern Bays Little Blue Penguin Foundation in its first three years of operation (1994—1997; East Harbour Environmental Association 1998); 129 were treated between 1996–1999 (Eastern Bays Little Blue Penguin Foundation 1999). This number of birds (average 25–32 annually) likely does not originate entirely from the Eastern Bays but equally takes no account of deaths from road collision or predation by dogs and probably under-sampled penguins breeding in rock habitats by the sea. Given the life history strategy of little penguins (**Section 8.1.3**), a population suffering this level of injury and probable mortality and yet surviving was likely in the many hundreds.

The 2016 and 2017 surveys are the first known comprehensive surveys of little penguins in the Eastern Bays. The current presence of an estimated 101 breeding sites in the total survey area (**Section 8.2.1**), mostly in seawall rock habitats, indicates a significant population decline over the past two decades outside seawall rock habitats. For a species whose life history strategy relies on a high level of adult survival to maintain the population (**Section 8.1.4**), the twenty non-systematically collected mortality records over three recent years (**Section 8.2.3**) indicate continuing decline.

Conceivably the Eastern Bays population is being supported by inwards migration from other populations in Wellington Harbour (**Section 8.1.4**). The immigration level is unknown, but whether it is adequate to compensate for the high local mortality level seems unlikely, and the population is likely to continue to decline under its current settings.

The current population is likely to be a little higher than indicated by the 2016 and 2017 surveys (**Section 8.2.1**). Being conservative, this report considers that an additional 5–15 breeding sites are likely to be present inland of Marine Drive, perhaps with skew towards sites further from the SPP footprint because these were not surveyed.

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[40] Stephenson (1977) and Parrish (1984) reported most suitable headlands on both sides of the Wellington Harbour entrance are used for penguin nesting but they did not survey these sites. The 2016 survey found just one penguin breeding site south of Eastbourne.

Overall the survey data and other evidence indicates the current little penguin population is of the order of 110–120 pairs in the survey area and 50–60 pairs in the SPP area. These figures represent *c.* 26–28% and *c.* 12–14% respectively of the estimated 420 pairs in Wellington Harbour.

The Little Penguin Haven is a legally secure, fenced breeding site that offers protection against dogs and human disturbance and avoids birds needing to cross Marine Drive for access. A 3–4 m high partial seawall has recently been constructed that will protect the site from sea-level rise for a period. It is a core site (outside the SPP area) for sustaining the little penguin population in the Eastern Bays.

8.2.5 Habitats

The 2016 and 2017 surveys habitat results indicate the predominant habitat of existing breeding sites is artificial rock, and 59% of sites in the survey area and 48% in the SPP area are less than one metre above sea level (**Section 8.2.2**). Such sites are at risk of inundation by storms that cause the currently not-infrequent overtopping events on Marine Drive (Eastbourne 2014; Allis 2019).

Storms are predicted to increase in frequency with sea-level rise. With only 16 cm of sea-level rise (occurring within 10–20 years, **Table 3-1**) the frequency of the present day '100-year storm' in Wellington will have increased to once per year on average (Stephens 2015). Consequently, unless current rock revetment habitats are raised to match rising sea levels, an effective long-term strategy for survival of little penguins in the Eastern Bays will require maintenance of a population inland of Marine Drive and/or at Eastbourne.

All six known little penguin habitats inland of Marine Drive are on private property and management is reliant on the good-will of residents.

8.2.6 Access between terrestrial and marine habitats

Unrestricted (nocturnal) access between sea and breeding site is crucial to avoid nest failure and for other terrestrial parts of the little penguin life cycle.

Currently *c.* 2.55 km (66%) of the coastline between Point Howard and southern Sunshine Bay and at Windy Point is considered to be inaccessible to little penguins due to barrier effects from existing seawalls (slope >45° without footholds for little penguins and exceeding *c.* 40 cm height) (**Table 8-3**, **Figure 8-2**). The proposed new seawalls configuration would shift *c.* 520 m in seven lengths from being currently accessible to being inaccessible for little penguins, and *c.* 80 of proposed revetment in two lengths from being currently inaccessible to accessible. This is a 439 m net increase, to a total of 2.99 km (78%). The increase is entirely in the northern part of the SPP; accessibility in the Windy Point section would be unchanged.

Seawall length inaccessibility is a broad measure as features such as steps or rocky headlands between seawalls may provide site specific access, and not all habitat inland of Marine Drive is suitable for breeding sites (e.g. steep exposed rocky slopes).

There is evidence (but unconfirmed) of the presence of two breeding sites inland of the newly inaccessible seawall lengths, one at York Bay and the other at Mahina Bay.

Table 8-3: Accessibility over seawalls to little penguins of current and proposed seawall configurations, Eastern Bays shared path project. Includes existing curved seawalls at York Bay and revetment at Whiorau Reserve. Proposed revetment is considered accessible. Data derived from GIS files sourced from EOS Ecology (existing seawalls) and Stantec (Rev J).

	Current seawalls	Proposed configuration		
		Curved seawall	Revetment	Total
Accessibility	m	m	m	m
Accessible	1285	85	761	846
	33.5%			*22.1%*
Not accessible	2552	2991		2991
	66.5%			*77.9%*
Total	3837	3076	761	3837

Figure 8-2: Older style angled concrete seawall, Mahina Bay. The steep riser up to the road is likely to be a difficult or impassable barrier for little penguin access. Photo: P5020130, 2016-05-02.

8.2.7 Stormwater drains as access and habitat

The stormwater drain survey found road surface drains were of smaller diameters (commonly 22.5–37.5 mm) and invariably grated at their inlet. Some drains had their inland entry well beyond Marine Drive. These did not offer through access for penguins and were not further investigated.

Stormwater drains had larger diameters (300–825 mm). These were classified into two penguin use / accessibility categories (**Table 8-4**):

i. Current or possible use as breeding sites or for access: penguins found breeding or roosting in pipes or up-catchment, no significant access constraint through tidal cycles.

ii. Potentially accessible sites: no known penguin records up-catchment but one or more of these factors: current gravel blockage and/or occurrence of steep rises of >30–40 cm for part of the tidal cycle but potential for access construction, actual or possible presence of freshwater fish (James 2018).

Topographic or structural confinement to channel penguin return access to the sea via the drain (avoiding risk of road mortality) was also noted.

Nine stormwater pipes under Marine Drive in the SPP area were identified as being currently accessible or used by penguins, or potentially accessible. Three are currently being used or likely to be used as breeding habitat and/or for access, one is currently accessible and may be being used, and five have some potential for future penguin access.

The three stormwater pipes in which little penguins were found were at Wilmore Way, northern Sunshine Bay and Windy Point. The pipes all had smaller diameters (225–300 mm). Nesting was confirmed at northern Sunshine Bay and Windy Point. At Wilmore Way (**Figure 8-3**), an eye witness reported (supported by photos) two penguins in the drain on multiple occasions in May 2017, but breeding was not confirmed. Kinsky (1960) and Waugh (2014) reported use of drains as nesting sites nearby on Matiu/Somes Island and at Evans Bay.

Figure 8-3: Stormwater pipe used by little penguins, Wilmore Way, northern end of Whiorau/Lowry Bay. Little penguins were reported in this drain on the inland side of the road in May 2017. The 60 cm vertical rise is a direct access barrier to the drain when the tide is low, but unimpeded access may be gained via rocks to the left (not shown). Photo: PA060034.JPG, 2016-10-06.

Table 8-4: Accessibility to little penguins of stormwater drains under Marine Drive, Eastern Bays shared path project area. Freshwater fish data from James (2018). SPP pipe extension measured from base of existing wall (Stantec GIS file); this may not always be the existing pipe outlet.

Stormwater outlet / chainage (m)	Seawall type	Diameter (mm)	Existing length (m)	Outlet perched / other obstruction	SPP pipe extension (m)	Penguin accessibility / use	Return over road access constricted	Freshwater fish presence	Notes
01 Wilmore Way 1245	Access steps, double curve	300	13.5 m to inland grate; 62 m to inland access	60 cm drop	Up to 2.3 m to access steps edge	Current use, not well defined	Yes, if drain used as breeding or roosting site; no for access use alone	Possible	Eye witness/photos of two penguins in drain on multiple occasions (May 2017). Upstream access / exit or whether it is a roosting site not confirmed. 60 cm vertical drop at downstream side inaccessible to penguins when tide out but nearby access possible onto ledge. Unlikely to be obstructed by gravels (James 2018).
02 Lowry Bay North 1300	Double curve	600 (3 pipes)	16.5	No drop, likely partially obstructed by gravels at times	0.7 m to seawall edge	Potential access use	Partial, fencing and near-vertical banks at inlet	Banded kokopu record	Coastal gravels at outlet base but accessible (2016-10-06). Likely to be fully inundated at high tide, increasingly so with sea-level rise. Habitat restoration project upstream of Marine Drive.
03 Lowry Bay South 1590	Single curve	675 / 750	8.8	Nil	2.2	Potential access use	Partial, incised stream gully and fencing	Banded kokopu record	Water flowing through gravels at upper levels but almost blocked (2107-08-10). Currently inaccessible to penguins because of gravel. Any current penguin access would be over Marine Drive. Consented for duckbill installation Outlet 45 (Greater Wellington Regional Council 2018a)
04 York Bay North 2375	Triple curve	825	21.1	*c.* 5–10 cm drop, flush to existing seawall	1.2	Possible previous access use, currently accessible	Yes, fenced, incised stream gully	Banded kokopu record	Pipe clear and accessible (2017-06-23). Little penguin record inland nearby in 2017 and further inland several years ago. Access could be via drain, nearby steps or over seawall, ideally needs to be confirmed.

Stormwater outlet / chainage (m)	Seawall type	Diameter (mm)	Existing length (m)	Outlet perched / other obstruction	SPP pipe extension (m)	Penguin accessibility / use	Return over road access constricted	Freshwater fish presence	Notes
05 York Bay South 2450	Double curve	525	33.6	Nil	-0.6	Potential access use	No	Juvenile galaxiids	Pipe clear, water flowing, apparently accessible (2017-06-23). Unconfirmed report of penguin(s) in pipe.
06 Mahina Bay North 3095	Double curve	525	15.5	Nil	-0.9	Potential access use	No	Unlikely	Pipe apparently clear, water flowing (2017-06-23), but almost completely filled with gravel March 2018 (James 2018). Inlet not grated.
07 Mahina Bay 3280	Double curve	600	43.5	Nil	2.1	Potential access use	No	Confirmed	Partially blocked by catchment-sourced gravels, water flowing (2017-06-23). Outlet buried by gravels 2018-03-07 (James 2018).
08 Sunshine Bay North 3505	Double curve	200 / 300	9.9	*c.* 20 cm drop, *c.* 30 cm out	2.4	Current nesting site, possible access use	No	Not assessed	Outlet perched above beach gravels, minor flow (2016-05-02, 2017-06-23), another outlet 12 m south. 2017 survey record of penguin nesting in inlet. Perched pipe and steep angled concrete seawall indicate drain pipe is impassable to penguins from the sea side, but penguin use indicates otherwise; penguins perhaps are climbing steep existing seawall and accessing the drain once over the road.
09 Windy Point 5020	Double curve	225 (2 pipes)	11.5	Nil	1.1	Current nesting site	No	Not assessed	Drain pipe(s) used for nesting, at sea end (2016 and 2017 surveys). Accessible at all tides. Pipe(s) previously used for access for breeding under older house and further inland (Sally Bain, pers. comm. 2016-05-04). Current nesting indicates no water passage. Nearby Waerenga Road Stream stormwater pipe blocked by gravels (James 2018), and would not be currently used.

9 ASSESSMENT OF EFFECTS ON LITTLE PENGUINS AND HABITATS

9.1 Little Penguin and Habitat Values

9.1.1 Habitat status under Proposed Natural Resources Plan for the Wellington Region

The CMA zone of the SPP area and ZOI lies partly within two sites listed as habitat for indigenous birds in Schedule F2c of the PNRP: Wellington Harbour inland waters (beyond MLWS), and Wellington Harbour foreshore, northern end of Days Bay to Point Howard (**Table 7-1**).

The Harbour inland waters are recognised as providing foraging habitat and access to large, secure little penguin nesting colonies on Matiu/Somes, Mokopuna and Mākaro/Ward Islands. A critical period is cited for little penguin breeding (1 July–1 March).

Little penguins are not cited in the description of the foreshore habitat. Little penguins at adjoining breeding sites require access between land and sea across this foreshore habitat.

9.1.2 Habitat status under City of Lower Hutt District Plan

The City of Lower Hutt District Plan has one Significant Natural Resource site for avifauna near the SPP area: 11. Little Blue Penguin sanctuary at Days Bay Pumping Station (Hutt City Council 2017, Map Appendix 1 - Significant Natural, Cultural and Archaeological Resources). This is also known as the Little Penguin Haven. It lies *c.* 120 m from the nearest SPP activities and is unaffected.

9.1.3 Threatened and At Risk species [41]

No current conservation status is available for the little penguin in the Wellington Region. Little penguins nationally are At Risk - Declining (with qualifier Data Poor) (**Section 8.1.2**) and this is likely for little penguins in the Wellington region.

9.1.4 Overall avifauna and habitat value

Applying criteria for assigning values to species (Table 5, Roper-Lindsay et al. 2018), those parts of the SPP area and ZOI used by little penguins (At Risk - Declining) for access, nesting and moulting are of high ecological value.

9.2 Construction Phase Effects

9.2.1 Noise and disturbance

Little penguins are vulnerable to disturbance at all times of year, and are especially vulnerable during breeding and moulting (Bull 2000b; Stevenson & Woehler 2007; Larcombe 2015). On Matiu/Somes

[41] NZCPS Policy 11 (a) i.

Island, movement of rocks around nests all resulted in the penguins not only deserting the nest, and hence the clutch, but also not returning to these nests the following season (Bull 2000b). However, human (visitor) disturbance is not incompatible with some nesting activity (Giling, Reina & Hogg 2008), and penguins cohabit with humans when nesting under houses. Little penguins are known to nest successfully in environments with disturbance and noise (McClellan 2017). One current nest in the SPP area is within a very short distance of the traffic on Marine Drive.

Potential noise and disturbance effects on little penguins will be greater during breeding and moulting but will also occur during the wintering and pre-breeding stage when little penguins continue to return to land in varying numbers (**Section 8.1.3**). Penguins sitting on nests in burrows are still exposed to noise from construction activities during daytime hours.

Transmission of underwater noise has been recently recognised as impacting on penguins, which spend much of their time underwater (Pichegru et al. 2017). However, this situation is not expected to occur at the SPP. Driving of reinforced concrete piles will occur in some beach locations in order to reach material of acceptable bearing capacity, but not in the sea (Corin, Povall & van Halderen 2019).

Given little penguins do not have the highest risk of noise and disturbance sensitivity (**Section 7.2.2)**, the estimated maximum harassment distance for breeding sites in the SPP area from disturbance and elevated action-generated sound levels given ambient noise levels is taken as 50 m.

Construction phase activities may be classed into four groups for the nature of their potential effects on little penguin nesting and moulting sites:

i. revetment upgrade works
ii. curved and revetment seawalls
iii. stormwater pipes
iv. terrestrial habitat works.

Distances of these activities in relation to known breeding sites (up to 50 m) are shown at (**Table 9-1**).

9.2.2 Revetment upgrade works

Two breeding sites are located within existing revetment, and six others within 10 m but possibly inside given GPS location accuracy (**Figure 9-1**). The caution about possible additional breeding and moulting sites particularly applies here.

Potential construction impacts of the works in the revetment upgrade area and its vicinity include removal or displacement of nest, moulting or other occupational sites, disturbance and destruction of adults, chicks, and eggs, and penguin injury or mortality through interaction with machinery.

Table 9-1: Distances of known little penguin breeding sites within 50 metres of Eastern Bays shared path project components. Numbers of nests shown are not exclusive to a project component (N=38). Penguin locations from Alastair Judkins (Kaikoura Ocean Research Institute) and additional 2017 records from consultation process and a local observer. Subject to Garmin eTrex Vista GPS accuracy.

Shared path project component	Distance from project component	Number of nests
Revetment upgrade	Within	2
	0–10 m	5
	10–20 m	1
	20–50 m	14
Curved and revetment seawalls	0–10 m	7
	10–20 m	6
	20–50 m	15
Stormwater drains	0–10 m	3
	10–20 m	0
	20–50 m	2
Terrestrial habitat works	0–10 m	18
	10–20 m	3
	20–50 m	13

Figure 9-1: Existing revetment to be upgraded, north end of Mahina Bay. The shared path project proposes to upgrade this existing revetment and to extend it seaward to achieve a 5.3 m total revetment width (covering much of the gravel in the foreground). Photo: P5020121, 2016-05-02.

The little penguin management plan for the St Kilda (Melbourne) breakwater redevelopment (Kowalczyk, Blake & Finger 2013) provides a model for managing the construction phase effects of SPP revetment upgrade works (on a smaller scale). HCC has experience has experience of managing the protection of little penguins and their nest sites in current revetment upgrade works beside Port Road at Seaview (Rumble 2019).

Four of the five proposed revetment upgrade areas in the SPP have or will have adjoining revetment areas to which little penguins found can be transferred, reducing (but not eliminating) the risk the birds may attempt to return to the nest site. Care will be required at Mahina Bay north where there is no adjoining revetment that might provide new suitable habitat nearby.

The handling and disturbance of birds within existing revetment (and at other sites) and the destruction of known little penguin breeding sites will require a permit under the Wildlife Act 1953 from the Department of Conservation and a management plan for the penguins.

9.2.3 Curved seawalls and revetment works

There are 13 known breeding sites within 20 m of curved and revetment seawalls. Potential construction effects of curved seawall and revetment works include noise and disturbance of nest, moulting or other occupation sites.

One breeding site is very close to proposed revetment and revetment upgrade works at Point Howard. Given known nest loss from close disturbance by altering the placement of rocks (Bull 2000b), this site is at high risk of nest abandonment from the revetment structure itself, use of excavators, and shared path construction. Care will be required to minimise noise and disturbance, to keep rocks as far as practicable from the nest site, and to time works between 1 March and 30 June, outside the little penguin breeding and moulting period.

9.2.4 Stormwater pipes works

Of nine actual or potential stormwater drain penguin accesses (**Section 8.2.7**), three have breeding or possibly breeding sites within the pipes themselves.

Potential construction effects include disturbance and destruction of adults, chicks, and eggs, and blocking of penguin access. Any upstream egress block could result in drowning of moulting birds under adverse conditions (Hocken 2000).

9.2.5 Terrestrial habitat works

Construction activity sites in terrestrial habitats have the highest number of nearby breeding sites (18 within 10 m, a further three within 20 m). These activities are mostly low impact (such as alterations to the existing path surface, kerbs and road markings) but noise and disturbance impacts are possible.

There are three known nesting sites in Whiorau Reserve that are inland of shared path upgrade works and that have the potential to impede nocturnal access to and from the foreshore. Activities such as overnight parking of machinery or construction materials should be avoided. Any fencing of revegetation sites should have regard to potential little penguin access routes.

9.2.6 Artificial lighting for construction

Although a study of little penguins at viewing colonies in Australia did not find adverse effects from artificial lighting, and one nest is known on Marine Drive close to street lighting, it is prudent to apply measures to mitigate the potential effects of artificial construction lighting (**Section 7.3.4**) near little penguin breeding sites.

9.2.7 Proposed little penguin construction phase mitigation

A Little Penguin Management Plan will be prepared. Planning and management of potential noise and disturbance effects will be done site-by-site. It would treat all breeding sites also as moulting sites unless determined otherwise, recognise there may be moulting sites elsewhere in the works vicinity and recognise there may be additional breeding sites not yet found including inland of Marine Drive.

Revetment upgrade works and works at revetment and curved seawalls and at stormwater pipes close to (generally <20 m) known little penguin breeding sites will be undertaken under specific provisions in the CEMP. These works will occur between 1 March and 30 June, outside the little penguin breeding and moulting period.

9.3 Operational Phase Effects

9.3.1 Effects on breeding sites [42]

There are no known breeding sites within the proposed shared path or seawalls footprints, but there are two sites within revetment upgrade areas and 24 within 50 m of SPP components. Thus the potential direct impact of the SPP footprint is small (two sites directly lost) but further losses are possible given alteration of surrounding habitat has resulted in abandonment of nests (Bull 2000b).

Specific mitigation is proposed for the loss of the two sites in the revetment upgrade area through revetment design favourable for little penguin breeding habitat and natural recolonisation, including in new revetment areas (**Section 9.3.2**).

The Point Howard breeding site is vulnerable to shared path and revetment operational effects (as well as construction effects; **Section 9.2.3**). Because the shared path would lie between the site and the sea, little penguins crossing the path nightly for access between nest and the sea would be vulnerable to disturbance, collision by cyclists and predation by off-lead dogs. The option of changing the route to the inland side of the rock has been discounted because it would create a narrow path construction adjoining Marine Drive with safety risks for path users. Proposed mitigation includes:

[42] NZCPS Policy 11 (b) ii.

- Install signs and pavement markings: ‘penguins in area, please slow down: all dogs must be on a lead’.

- Establish a potential breeding site in the revetment on the seaward side (see **Section 9.3.2**); it is acknowledged this is not a long-term option because of the site’s exposure to southerly waves and increasing over-topping risk with sea-level rise.

Continued little penguin access to and from the sea at this site would remain available via the revetment. It may be facilitated by a discretely placed concrete ramp through the rocks (as at Nelson; Woehler 2015).

Two little penguin breeding sites are currently known at Claphams Rock. The Rock predominantly has steep rocky slopes with thin soils and grass and herbaceous cover, and ledges and crevices with taupata shrubs and coastal flax. Revegetation of Claphams Rock in shrubby coastal species will result in slowly increasing vegetation cover that will reduce accessibility and disturbance and may provide opportunities for an increase in little penguin breeding using natural nesting sites. The existing vehicular access track would be narrowed to a walking track, so still retaining foot access to the coastline.

9.3.2 Revetment design for little penguin breeding habitat

Little penguins are likely to attempt to colonise the new revetment habitat for breeding sites (as has occurred with existing revetment at Point Howard and the southern end of Sunshine Bay). There is then an opportunity to enhance the potential breeding habitat quality through judicious placement of suitably-sized rocks and fill materials to create tunnels, inter-connected voids and potential nesting sites within the rock labyrinth (Woehler 2015).

The median diameter (D50) rock size of 500 mm for the SPP revetment is too small to create suitable voids for penguin breeding. Rather, it is proposed to incorporate potential nesting sites in the SPP revetment structures through the preferential placement at selected spots of larger rocks in the rock size grading curve. Sunshine Bay and Mahina Bay North, the largest of the six proposed revetment sites (**Table 2-3**), are preferred places because their size will offer greater protection from waves.

Detailed design guidelines are at **Appendix D: Guidelines for little penguin breeding habitat in rock seawalls**.

Staged further building of the revetment will be required to compensate for the loss of breeding sites that will occur with rising sea levels in coming decades (**Section 3.6.2**). The endeavour is considered worthwhile in the context of mitigating the effects of the proposed revetment upgrade works, and developing adaptive capability towards mitigating the effects of sea-level rise on coastal biological habitat and biota when these would be lost through anthropogenic hardening of coastal defences (McGlone et al. 2010).

Revetment may create opportunity for little penguin access inland across Marine Drive, with risk of road mortality. Monitoring and mitigation measures would then need to be implemented (**Section 9.3.4**).

9.3.3 Little penguin access between land and sea [43]

Given possible sea-level rise outcomes, an effective long-term strategy for survival of little penguins in the Eastern Bays will require maintenance of a population inland of Marine Drive (**Section 8.2.5**). This will require maintenance of access outside the inaccessible SPP curved seawalls and via stormwater drains and steps, and monitoring and reduction of risks for little penguins seeking access directly across Marine Drive.[44]

Loss of access between land and sea is a potential effect for the 10 known breeding sites in the SPP area inland of the proposed shared path and seawalls. Four are between the Shared Path and Marine Drive and six are inland of Marine Drive. The former group includes three sites on the inland side of Whiorau Reserve and the Point Howard breeding site. Potential access issues at Whiorau Reserve relate to the construction phase only (**Section 9.2.5**). The Point Howard site is addressed above.

9.3.3.1 Stormwater drains

The SPP design for stormwater drain pipe extensions (Corin, Povall & van Halderen 2019) specifies that the extensions will be of the same diameter as currently, will be flush with the new curved seawalls, and will be open outlets (i.e. no flap gates, tidal gates, louvres or other impediments to biota passage). These provisions are supported (although needs for effective stormwater drainage given gravel buildup and for managing sea-level rise are acknowledged). Design solutions will be site-specific as they will depend on the relative level of the outlet and seawall design at each location. Additional design mitigation to avoid creating overhanging discharges at curved seawalls and revetment is specified for the detailed design stage (in conjunction with providing for indigenous fish access).

Of the nine stormwater pipes in the SPP area that are currently accessible or used by little penguins, or are potentially accessible (**Table 8-4**), the York Bay North site is likely to be the only reliable

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[43] NZCPS Policy 11 (b) vi.

[44] There have been suggestions to provide a tunnel under the road for little penguin access to breeding habitat inland of Marine Drive, as at the Oamaru little blue penguin colony (Sekula 2018), to avoid mortality of little penguins crossing the road. This was closely considered as an SPP mitigation option but is not considered feasible because:

- The Oamaru tunnel is used by *c.* 40 little penguins (Agnew 2018), but there are no similar breeding concentrations inland of Marine Drive to use a tunnel.
- Alternative access across the road would need to be fenced or otherwise blocked off (on both sides) so that penguins have no choice other than to use the tunnel for access between breeding grounds and the sea (or else risk mortality on the road).

Restoration of a clustered little penguin breeding colony at a site inland of Marine Drive is not feasible because the high-volume sound system needed to attract penguins into a currently uninhabited or low density site would be unacceptable to human neighbours (Cockrem 2017).

stormwater pipe for access once the SPP is completed (**Figure 9-2**). The outlet is currently flush to the seawall with only minor perching (*c.* 5–10 cm height). MHWS currently reaches into the pipe, while low tide will be *c.* 7.5 m beyond the extended pipe. The beach gravels level is expected to rise and fall with the seasons (estimated up to *c.* 50 cm), the lowest and highest levels being after storms (Mike Allis, pers. comm., 2018-03-16). Access may be buried after storms but will be flushed by the freshwater discharge. Long-term change in beach gravel dynamics is not expected. Penguin access would be difficult if the beach level falls more than 30–40 cm below the pipe outlet; this is a natural situation, and it will become of less significance as sea-level rise reduces the height of any outlet perching. With a 1.2 m pipe extension, the post-construction degree of perching and the beach dynamics will be similar.

Minor pipe extensions would be required at the two known nesting sites and one suspected nesting site within drains (2.3 m at Wilmore Way, 2.4 m at Sunshine Bay North, 1.1 m at Windy Point). No long-term effects are expected at these sites. Pipe extensions at the other five stormwater outlets of potential little penguin access value are also small (up to 2.2 m) and no long-term effects are expected.

Stormwater pipes identified as potential access or habitat use sites are not currently used but retention of accessibility is recommended to retain options for the future. This is provided for in the current SPP design.

It is noted that continuing to provide for little penguin access to inland breeding sites via stormwater pipes will require appropriate design when drain levels are raised in future with sea-level rise.

Figure 9-2: York Bay North stormwater outlet. Photo P6230205, 2017-06-23, taken 4 hours before high tide on 1.3 m tidal range.

9.3.3.2 Steps and ramps

The SPP intends to replace existing steps and ramps for beach access with generally two accesses per beach (total 16 proposed accesses). Step heights of 200 mm and 350 mm for standard parallel access steps and ministeps respectively are expected to be accessible by penguins (although 350 mm is towards the upper end of their jumping ability). Existing ramps will be retained at Point Howard and at the south end of Windy Point (Rona Bay ramp).

Present access to two breeding sites inland of Marine Drive is likely gained via steps. At Sorrento Bay, current access through otherwise steep seawalls is probably via steps at the beach, and if so, would be retained by proposed replacement parallel access steps at the same site. At Lowry Bay, current access is quite likely via steps at the historic Skerrett boatshed, and if so would be retained; future access may also be possible by proposed ministeps 15 m southwards.

Current access at the York Bay North breeding site may be gained via adjoining steps, or via the nearby stormwater drain pipe. Access if via the steps would be lost to a triple curve seawall; replacement steps are proposed *c.* 60 m southwards.

9.3.3.3 Access to inland of Marine Drive - Summary

Of the six known breeding sites inland of Marine Drive, two likely obtain access via drains (**Section 9.3.3.1**), two via steps (**Section 9.3.3.2**) and one via drain and/or steps. Access is likely to be maintained at four of these sites but may be lost at the steps and/or drain site because of the distance to replacement steps.

A double curve seawall is proposed for the sixth site (northern Windy Point). An effect on access there is unlikely if current beach gravel levels are maintained, but otherwise access would remain possible via a small deviation (<10 m) by the penguins.

In the absence of comprehensive survey coverage, this report accepts that an additional 5–15 breeding sites are likely to be present in the SPP area inland of Marine Drive (**Section 8.2.4**). There is evidence (but not confirmed records) of the presence of two such breeding sites inland of the newly inaccessible seawall lengths, one at York Bay and the other at Mahina Bay (**Section 8.2.6**). If so, access is gained over Marine Drive in some way and could be lost to the increased inaccessibility of seawalls to little penguins, as may occur for other unknown breeding sites.

Being conservative, it is assumed that loss of access caused by changes to steps and by increased length of inaccessible seawalls totalling 2–5 breeding sites is probable or possible.

Elsewhere, the proposed SPP steps and ramps configuration is largely a replacement of the existing one and any net adverse effect on little penguin access to inland of Marine Drive is considered unlikely.

9.3.4 Access mortality on Marine Drive

Little penguins will continue to be at risk of road mortality in future when seeking access to breeding and moulting sites directly across Marine Drive[45] in four potential situations: access via non-seawall parts of the coastline to known or unknown breeding sites; access via ramps and steps; access resulting from standard and penguin-enhanced revetment seawalls; and possibly in future as little penguins are forced out of their sea-side burrows as a result of sea-level rise.

Information available for this report does not indicate little penguin mortality hotspots on Marine Drive, but rather mortality is spread through the Eastern Bays from Sorrento Bay to Eastbourne.

The risk of mortality for little penguins seeking access across Marine Drive could be reduced in the revetment situation by erecting low fencing between revetment and the road. However, fencing would prevent access inland of Marine Drive when such access is important for the continuing presence of a little penguin presence in the Eastern Bays in the face of sea-level rise.

A system for members of the public to report wandering, sick, injured or dead penguins to the DOC emergency hotline (0800 362 468), or the HCC Contact Centre, has been recently established (Rumble 2018a). The Eastern Bays Little Penguins group co-ordinator is available to respond to little penguin related callouts where a response is necessary.

Proposed mitigation to address the risk of road mortality is to publicise the availability of the DOC emergency hotline for the public to report little penguin sightings on Marine Drive (alive, injured or dead), and to install temporarily visible road signage at live sightings for the duration of the breeding and moulting period (July–February). The data collected will also enable the identification of any crossing hotspots which could become a focus of further responses in future.

9.3.5 Increased human disturbance and dog disturbance and predation risk

In creating a safe facility for human walking and cycling between Marine Drive and the coastline, the shared path will bring an increase in the number of people and dogs into the coastal zone, including to places that are currently less accessible, and likely significantly increase levels of disturbance of little penguins and other avifauna (Wallace 2016).

Giling, Reina & Hogg (2008) found that little penguins at the St Kilda breakwater showed a clear preference to nest in sites not accessible to humans but human disturbance including people walking their dogs was not incompatible with some nesting activity. The breakwater consists of an extensive rock labyrinth that provides some security for breeding and moulting sites (Kowalczyk, Blake & Finger 2013).

Dogs readily detect the presence of little penguins by smell and sight. Little penguins breeding and moulting in SPP revetment habitat and deep burrows may be secure from larger uncontrolled dogs

[45] Current Marine Drive speed limits are 50 km/hr and 70 km/hr.

but not small dogs, while those outside burrows at night (including those crossing the shared path) are vulnerable.

Banatoski et al. (2017) found dog-owners typically respected regulations and followed the examples set by other dog-owners, and they respected the presence of native wildlife on beaches and were willing to follow protective regulations. However, they found inconsistency in how information is conveyed and a wide spectrum of awareness and knowledge regarding coastal wildlife on beaches. Fewer participants were awa.re of penguins.

Parts of the shared path will lie within and much will adjoin an area specified under the Dog Control Bylaw 2015 as a dog prohibition area (Number 46, Eastbourne) (Hutt City Council 2016). Dogs are prohibited between 9.00 am and 8.00 pm during daylight saving time each year. Outside those times, and in any adjoining pubic place, a dog must be kept under continuous control by an effectual leash or chain held by a person and securely attached to a collar on the dog (Clause 6.1). In effect, the Bylaw prohibits dogs in the SPP area for a specific time and period of the year, and otherwise bans the taking of dogs that are not on a leash.

Presently, 32 out of 42 little penguin breeding sites in the SPP area are within this dog prohibition area, indicating a degree of successful cohabitation. Responsible ownership by most Eastern Bays dog owners is acknowledged, as also advocacy in the community to promote penguin protection alongside dog ownership. However, several recent little penguin deaths caused by dogs have been recorded (**Section 8.2.3)**, with significant consequence for little penguin population viability.

Proposed mitigation for the potential effects of increased disturbance particularly from dogs are:

- acknowledgement when the shared path is formally opened that it is shared by little penguins, walkers and cyclists
- placing signage advising dog owners of the presence of little penguins at accessible sites (Point Howard, Whiorau Reserve, southern Sunshine Bay, Windy Point)
- promoting responsible dog management in terms of the HCC Dog Control Bylaw 2015 in the SPP area.

Outside the scope of this report, it is recommended that HCC consider proposed improvements in approaches aimed at preventing or reducing interactions between dogs and coastal wildlife (Banatoski et al. 2017) as a resource for any future review of the Hutt City Council Dog Control Policy 2015. A system for reporting and analysing wildlife-dog interactions on and near the shared path before and after construction could provide valuable data for such a review.

9.3.6 Street lighting

Although a study of little penguins at viewing colonies in Australia did not find adverse effects from artificial lighting, and one nest is known on Marine Drive close to street lighting, it is prudent to apply measures to mitigate the potential effects of street lighting (**Section 7.3.4**) near little penguin breeding sites.

9.3.7 Little penguin management beyond the Shared Path Project

To sustain a little penguin population in the Eastern Bays requires the maintenance of habitat values in and access through the SPP area as addressed in this report, but this is not sufficient. Other actions and current community activities are acknowledged.

9.4 Recommended Mitigation

The following additional mitigation for potential construction and operational phase effects on little penguins and their habitats is recommended. The post-mitigation level of effectss will be low.

a. Prepare a Little Penguin Management Plan (by a suitably qualified and experienced person) within the CEMP, in consultation with the Department of Conservation, the Eastern Bays Little Penguins Group and other appropriate person(s), that covers the following:

   i. For works in the revetment upgrade areas, an action plan to manage construction phase effects on little penguins to include:

   - undertake the works during the post-moulting to pre-breeding stage of the annual cycle (1 March–30 June)
   - use of a penguin monitor and detector dog for baseline monitoring for little penguins (February to mid-March)
   - briefing by the penguin monitor of contractor representative(s) and equipment operator(s) on site before construction begins
   - the primary action once construction work starts is to STOP immediately a penguin, or nest material, or other signs of penguins are seen or a suspected site is seen
   - the penguin monitor will come to the site and advise what needs to be done before work restarts, including removal to safe waters nearby of penguins found within works areas
   - undertake annually for two years a penguin-dog assisted survey to assess the recolonisation of revetment upgrade and the colonisation of new revetment habitat, with recommendations if warranted for any practicable changes to the revetment habitats to achieve the intended outcomes
   - a permit under the Wildlife Act 1953 from the Department of Conservation for handling and disturbance of protected wildlife (also to cover any handling or disturbance required of little penguins at other sites such as stormwater pipes).

   ii. For works at revetment and curved seawalls and at stormwater pipes close to (generally <50 m) known little penguin breeding sites:

   - consideration of the machinery to be used and associated noise levels
   - care where there are multiple construction activities at individual sites)
   - ensure there are no blockages of stormwater pipes during pipe extension works
   - undertake works during the post-moulting to pre-breeding stage of the annual cycle (1 March–30 June).

iii. For works at terrestrial habitat sites close to (generally <50 m) or inland of known little penguin breeding sites or potential suitable habitat:

- assess potential for noise and disturbance effects and plan to avoid or mitigate them
- ensure construction activities, machinery or supplies, fencing or the like do not present an obstacle to nocturnal little penguin access to and from the foreshore
- undertake works during the post-moulting to pre-breeding stage of the annual cycle (1 March–30 June).

iv. In the use of artificial lighting for construction purposes (and for street lighting changes), avoid release of light directly at and above the horizontal, confine downward light emission to the area for which lighting is required and avoid spread elsewhere into the coastal zone, and limit emission of short-wavelength spectra (<500 nm).

v. Install signage highlighting the risks of uncontrolled dogs to little penguins (in consultation with the Department of Conservation).

vi. Publicise the availability of the DOC emergency hotline for the public to report little penguin sightings on Marine Drive (alive, injured or dead), and install temporarily visible road signage at live sightings for the duration of the breeding and moulting period (July-March).

vii. Revegetate Claphams Rock in shrubby coastal species, as practicable, to improve little penguin habitat (while retaining foot access to the coast).

viii. Annual review and reporting to the consent authority of provisions for avoiding and mitigating adverse construction phase effects on little penguins over the six-year course of the shared path project.

b. At the shared path project detailed design phase:

i. Design the shared path and revetment structures to maintain little penguin access at the Point Howard site and reduce the potential for ongoing disturbance to breeding.

ii. Design to ensure that overhanging stormwater pipe discharges are avoided for little penguins (and indigenous fish) by:

- configuration of pipe outlets in relation to the shape of the curves and tread(s) of curved seawalls or using miniature steps below the outlet
- design of specific structures such as a sloping concreted or riprap apron at the discharge point in revetment.

iii. Design revetment and revetment upgrade structures to provide little penguin breeding habitat that has some resilience to sea-level rise.

a. Recommended Condition

i. That a little penguin management plan be prepared as part of the CEMP by a suitably qualified and experienced person in consultation with the Department of Conservation, and the Eastern Bays Little Penguins Group and other appropriate person(s). The purpose of the plan shall be to as far as practicable avoid, but otherwise mitigate or remedy adverse effects on the little penguin population established in and near the shared path project, during the construction period.

The little penguin management plan shall address the following:

- measures to minimise adverse effects on the little penguin population during construction
- programme for the monitoring of little penguins within or adjacent to the construction area during the construction works
- staff and contractor training
- contribute to the detailed design phase of the project, including habitat enhancement for the future.

10 STATUTORY ASSESSMENT

The NZCPS is particularly important for ecological impact assessment in coastal environments (Roper-Lindsay et al. 2018). Policy 11 Indigenous biological diversity (biodiversity) provides:

'To protect indigenous biological diversity in the coastal environment:

(a) avoid adverse effects of activities on:

i. indigenous taxa that are listed as threatened or at risk in the New Zealand Threat Classification System lists;

ii. taxa that are listed by the International Union for Conservation of Nature and Natural Resources as threatened;

iii. indigenous ecosystems and vegetation types that are threatened in the coastal environment, or are naturally rare;

iv. habitats of indigenous species where the species are at the limit of their natural range, or are naturally rare;

v. areas containing nationally significant examples of indigenous community types; and

vi. areas set aside for full or partial protection of indigenous biological diversity under other legislation; and

(b) avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on:

i. areas of predominantly indigenous vegetation in the coastal environment;

ii. habitats in the coastal environment that are important during the vulnerable life stages of indigenous species;

iii. indigenous ecosystems and habitats that are only found in the coastal environment and are particularly vulnerable to modification, including estuaries, lagoons, coastal wetlands, dunelands, intertidal zones, rocky reef systems, eelgrass and saltmarsh;

iv. habitats of indigenous species in the coastal environment that are important for recreational, commercial, traditional or cultural purposes;

v. habitats, including areas and routes, important to migratory species; and

vi. ecological corridors, and areas important for linking or maintaining biological values identified under this policy.'

The Project achieves Policy 11, for the reasons set out below.

Policy 11(a)

The taxa and ecosystems relevant to this Policy have been identified and assessed (as in **Table ES1**). The shared path project alternatives assessment (Appendix G) sets out the preferred design option which has been designed by the project team to avoid adverse effects on Threatened and At Risk indigenous taxa and indigenous ecosystems and vegetation types that are threatened in the coastal environment. This includes the avoidance of effects on seagrass in Lowry Bay, on little penguins within or gaining access to breeding sites via the project area, and on a number of other Threatened and At Risk plant and animal species.

Policy 11(b)

The principal mitigation column in **Table ES1** sets out primary measures to ensure the project avoids significant adverse effects and avoids remedies and mitigates other adverse effects of the Project on the matters listed in Policy 11(b), as relevant.

11 ACKNOWLEDGMENTS

Thank you to Mike Rumble (Eastern Bays Little Penguins Group), Sally Bain (ERAT) and locals met during surveys for sharing their local knowledge of little penguins in the field and in other ways. I thank Eastern Bays residents for their little penguin observations posted on the Eastbourne Community Notice Board. Special thanks to property owners who granted access consent for the search for penguins on their properties; Virginia Horrocks and Derek Wilshere for their door-knocking and engagement with property owners in seeking consent; Alastair Judkins, penguin detector dog Mena and Mike Rumble for undertaking the two surveys; and HCC for funding them.

Geoff de Lisle (OSNZ) and Hugh Robertson (DOC) arranged access to the OSNZ Wellington Harbour avifauna surveys data, and Kirsty Brennan and Nick Hempston (EOS Ecology) offered avifauna observations during their surveys. I acknowledge iNaturalist NZ — Mātaki Taiao contributors to plant identification and for little penguin records [Creative Commons licence CC BY-NC], and use of the New Zealand eBird and DOC Bioweb databases. John Van den Hoeven (Upper Hutt) provided information on plants in the Eastern Bays. John Floyd and Brenda MacCormick (HCC) provided HCC GIS data and aerial photographs and Kirsty Brennan arranged for the shared path and seawalls GIS data. Simon Cager (HCC), Wendy Adlam (HCC) and Ali Carew (Historical Society of Eastbourne) sourced literature and information. Janet Lawson (HCC) provided information on HCC plantings. Dr John Cockrem (Kororā Ornithology) assisted with evaluation of potential little penguin restoration sites in the Eastern Bays and other advice; Peter Gaze (Nelson) with information on artificial little penguin breeding sites at Nelson; Dr Philippa Agnew (Oamaru Blue Penguin Colony) shared her knowledge of little penguins and the Oamaru little penguin tunnel; and Rosalie Goldsworthy (Moeraki) provided information on the work of the former Eastern Bays Little Blue Penguin Foundation.

I thank the project team members for their collaborative efforts: Julia Williams (Drakeford Williams), Shelley McMurtrie, Kirsty Brennan and Alex James (EOS Ecology), Dr Michael Allis (NIWA), Jamie Povall, Caroline van Halderen, and Jeremy Walters (Stantec), Virginia Horrocks and Derek Wilshere (current and former Eastbourne Community Board members respectively), and Simon Cager. Simon Cager provided feedback on an earlier report. Shelley McMurtrie peer reviewed an earlier draft. Mike Rumble reviewed the draft penguin report. Caroline van Halderen (Stantec) reviewed the full draft report, and it was peer previewed by Dr John Cockrem.

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Appendix A: EIANZ tables for assigning ecological value and describing magnitude of effect and level of effects

The following tables are from the EIANZ guidelines for ecological impact assessment in New Zealand (Roper-Lindsay et al. 2018).

Table 4: Attributes to be considered when assigning ecological value or importance to a site or area of vegetation/habitat/community

Matters	Attributes to be considered
Representativeness	Criteria for representative vegetation and aquatic habitats: • Typical structure and composition • Indigenous species dominate • Expected species and tiers are present • Thresholds may need to be lowered where all examples of a type are strongly modified Criteria for representative species and species assemblages: • Species assemblages that are typical of the habitat • Indigenous species that occur in most of the guilds expected for the habitat type
Rarity/distinctiveness	Criteria for rare/distinctive vegetation and habitats: • Naturally uncommon, or induced scarcity • Amount of habitat or vegetation remaining • Distinctive ecological features • National priority for protection Criteria for rare/distinctive species or species assemblages: • Habitat supporting nationally Threatened or At Risk species, or locally uncommon species • Regional or national distribution limits of species or communities • Unusual species or assemblages • Endemism
Diversity and pattern	• Level of natural diversity, abundance and distribution • Biodiversity reflecting underlying diversity • Biogeographical considerations - pattern, complexity • Temporal considerations, considerations of lifecycles, daily or seasonal cycles of habitat availability and utilisation
Ecological context	• Site history, and local environmental conditions which have influenced the development of habitats and communities

	• The essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience (from "intrinsic value" as defined in RMA) • Size, shape and buffering • Condition and sensitivity to change • Contribution of the site to ecological networks, linkages, pathways and the protection and exchange of genetic material • Species role in ecosystem functioning - high level, key species identification, habitat as proxy

Table 5: Factors to consider in assigning value to terrestrial species for Ecological Impact Assessment

Determining factors	
Nationally Threatened species, found in the ZOI either permanently or seasonally	Very High
Species listed as At Risk — Declining, found in the ZOI, either permanently or seasonally	High
Species listed as any other category of At Risk, found in the ZOI either permanently or seasonally	Moderate
Locally (ED) uncommon or distinctive species	Moderate
Nationally and locally common indigenous species	Low
Exotic species, including pests, species having recreational value	Negligible

Table 8: Criteria for describing magnitude of effect

Magnitude	**Description**
Very high	Total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or

	attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature

Table 10: Criteria for describing level of effects

Ecological Value	**Very high**	**High**	**Moderate**	**Low**	**Negligible**
Magnitude					
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very Low	Very low	Very low	Very low
Positive	Net gain	Net gain	Net gain	Net gain	Net gain

Appendix B: Vascular flora survey data

Vascular flora survey data, Eastern Bays, May 2016 and May 2017. Records from other sources as cited. Some species identified to genus or family only. Species primarily recorded at first occurrence only (beginning at Sunshine Bay in May 2016). CR = Claphams Rock (York Bay-Mahina Bay headland).

Scientific Name	Common Name	Indigenous / Introduced	Point Howard-Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Notes / Source
Acaena sp.		N/A		✓					
Achillea millefolium	Yarrow	Introduced					✓		
Aciphylla squarrosa var. squarrosa	Cook Strait speargrass	Indigenous				CR		✓	(Freegard & Weeber 1986); HCC landscape plantings at Windy Point
Agapanthus praecox ssp. orientalis	African lily	Introduced				CR	✓		
Ammophila arenaria	Marram grass	Introduced						✓	
Apium prostratum subsp. prostratum var. filiforme	New Zealand celery	Indigenous			✓	✓			
Apodasmia similis	Jointed rush	Indigenous						✓	HCC landscape plantings at Windy Point

Scientific Name	Common Name	Indigenous / Introduced	Point Howard-Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Notes / Source
Asplenium appendiculatum ssp. maritimum	Coastal spleenwort	Indigenous				CR			
Atriplex prostrata	Orache	Introduced		✓			✓	✓	
Astelia chathamica	Chatham Islands kakaha	Indigenous						✓	HCC landscape plantings at Windy Point
Beta vulgaris	Beet	Introduced		✓					
Brachyglottis compacta		Indigenous						✓	HCC landscape plantings at Windy Point
Brachyglottis monroi	Monro's groundsel	Indigenous						✓	HCC landscape plantings at Windy Point
Calystegia soldanella	Shore bindweed	Indigenous					✓	✓	Windy Point, (Freegard & Weeber 1986)
Calystegia tuguriorum	Climbing convolvulus	Indigenous				CR			(Freegard & Weeber 1986)
Cardamine debilis agg.	New Zealand bitter cress	Indigenous			✓				
Cenchrus clandestinus	Kikuyu grass	Introduced					✓		

Scientific Name	Common Name	Indigenous / Introduced	Point Howard-Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Notes / Source
Chenopodium triandrum	Berry saltbush, poipapa	Indigenous				CR			http://inaturalist.nz/observations/1307106
Chrysanthemoides monilifera	Boneseed	Introduced					✓		
Clematis vitalba	Old man's beard	Introduced					✓		
Coprosma repens	Taupata	Indigenous	✓	✓	✓	✓	✓	✓	
Crassula sieberiana		Indigenous				CR			http://inaturalist.nz/observations/2497684
Crepis capillaris	Hawksbeard	Introduced				✓	✓	✓	
Daucus carota	Wild carrot	Introduced			✓				
Dichondra repens	Creeping dichondra	Indigenous				CR	✓	✓	
Digitaria sanguinalis	Hairy crabgrass	Introduced		✓			✓		
Disphyma australe	Ice plant	Indigenous				CR			
Echium cf. candicans	Pride of Madeira	Introduced						✓	http://inaturalist.nz/observations/9041408
Ehrharta erecta	Veldt grass	Introduced					✓		
Euphorbia glauca	Waiūatua, shore spurge	Indigenous						✓	HCC landscape plantings at Windy Point
Euphorbia helioscopia	Sun spurge	Introduced					✓		

Scientific Name	Common Name	Indigenous / Introduced	Point Howard-Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Notes / Source
Ficinia nodosa	Knobby clubrush	Indigenous				CR		✓	
Ficinia spiralis	Pīngao	Indigenous		✓					Two sites, planted?
Foeniculum vulgare	Fennel	Introduced						✓	(Freegard & Weeber 1986)
Fumaria muralis subsp. muralis	Smoking fumitory	Introduced					✓		At rock riprap and north
Galium aparine	Cleavers	Introduced			✓				
Geranium sp.		N/A		✓					
Gramineae		Introduced		✓				✓	
Helminthotheca echioides	Bristly ox-tongue	Introduced		✓					
Hypochaeris radicata	Catsear	Introduced					✓	✓	
Lupinus arboreus	Tree lupin	Introduced					✓		
Luzula banksiana	Coastal woodrush	Indigenous				CR			http://inaturalist.nz/observations/1307099
Malva arborea	Tree mallow	Introduced					✓	✓	
Medicago lupulina	Black medick	Introduced					✓		
Melicytus crassifolius	Thick-leaved porcupine plant	Indigenous						✓	HCC landscape plantings at Windy Point

Scientific Name	Common Name	Indigenous / Introduced	Point Howard-Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Notes / Source
Metrosideros excelsa	Pohutukawa	Indigenous (not native to Wellington)	✓		✓	✓	✓	✓	
Metrosideros perforata	Small white rata	Indigenous				CR			(Freegard & Weeber 1986)
Muehlenbeckia complexa	Scrambling pohuehue	Indigenous						✓	HCC landscape plantings at Windy Point
Myoporum laetum	Ngaio	Indigenous				✓		✓	HCC landscape plantings at Windy Point
Olearia paniculata	Golden akeake, akiraho	Indigenous				CR			
Oxalis sp.		N/A					✓		
Ozothamnus leptophyllus	Tauhinu	Indigenous					✓		
Pachystegia insignis	Marlborough rock daisy	Indigenous						✓	HCC landscape plantings at Windy Point
Paraserianthes lophantha	Brush wattle	Introduced		✓					Seedling

Scientific Name	Common Name	Indigenous / Introduced	Point Howard-Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Notes / Source
Petroselinum crispum	Wild parsley	Introduced			✓				
Phormium cookianum subsp. hookeri	Mountain flax, wharariki	Indigenous			✓	CR	✓	✓	HCC landscape plantings at Windy Point
Pinus sp.		Introduced					✓		Seedling
Pittosporum crassifolium	Karo	Indigenous (not native to Wellington)					✓		1-2 m shrubs
Plantago coronopus	Buck's-horn plantain	Introduced			✓		✓	✓	
Plantago lanceolata	Narrow-leaved plantain	Introduced			✓				
Plantago major	Broad-leaved plantain	Introduced		✓					
Poa annua	Annual poa	Introduced					✓		a
Poa cita	silver tussock	Indigenous						✓	HCC landscape plantings at Windy Point
Polycarpon tetraphyllum	Allseed	Introduced					✓	✓	

Scientific Name	Common Name	Indigenous / Introduced	Point Howard-Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Notes / Source
Polygonum aviculare	Common knotgrass, wireweed	Introduced			✓				
Prunella vulgaris	Self-heal	Introduced			✓				
Pseudognaphalium luteoalbum	Jersey cudweed	Indigenous			✓		✓		
Pyrrosia elaeagnifolia	Leather-leaf fern	Indigenous				CR			
Raphanus raphanistrum ssp. maritimus	Sea radish	Introduced	✓	✓			✓		
Rumex crispus	Curly dock	Introduced		✓					
Sarcocornia quinqueflora	Glasswort	Indigenous	✓		✓	CR			http://inaturalist.nz/observations/1307112
Senecio lautus	Shore groundsel	Indigenous				CR			http://inaturalist.nz/observations/2497701
Senecio skirrhodon	Gravel groundsel	Introduced						✓	
Senecio vulgaris	Common groundsel	Introduced		✓				✓	
Solanum nigrum	Black nightshade	Introduced		✓			✓		At rock riprap and north

Scientific Name	Common Name	Indigenous / Introduced	Point Howard-Sorrento Bays	Lowry Bay	York Bay	Mahina Bay	Sunshine Bay	Windy Point	Notes / Source
Sonchus oleraceus	Common sow thistle	Introduced				✓	✓	✓	
Sophora sp.	Kowhai	Indigenous			✓				Seedling
Spinifex sericeus	Kowhangatara, silvery sand grass	Indigenous		✓					Planted?
Stellaria media subsp. media	Chickweed	Introduced					✓		At rock riprap
Trifolium repens	White clover	Introduced					✓		
Tropaeolum majus	Nasturtium	Introduced					✓		
Ulex europaeus	Gorse	Introduced						✓	
Veronica speciosa	Tītīrangi	Indigenous						✓	HCC landscape plantings at Windy Point
Veronica stricta	Koromiko	Indigenous						✓	HCC landscape plantings at Windy Point
Veronica (Hebe) sp.		Indigenous			✓				Seedling
Vicia sativa	Common vetch	Introduced		✓					
Zostera muelleri subsp. novazelandica	Seagrass	Indigenous		✓					

Appendix C: Avifauna survey data

Avifauna survey data, Eastern Bays, May 2016 (Point Howard to Days Bay) and May 2017 (Windy Point). Includes three records from the afternoon of 2017-05-17 not part of formal survey. Numbers in large flocks are estimates. Four records (in *italics*) may be birds previously seen flying forward of the observer and are not counted in survey totals.

Date	Time	Species	Number	Location	Habitat	Activity
2016-05-02	815	Little black shag	40	Point Howard-Sorrento Bays	Sea	Swimming, flying, feeding
2016-05-02	815	Red-billed gull	30	Point Howard-Sorrento Bays	Sandy beach, near shoreline and on water	Roosting
2016-05-02		Little shag	1	Point Howard-Sorrento Bays	Rock	Roosting
2016-05-02		Southern black-backed gull	2	Point Howard-Sorrento Bays	Sea, between rocky islets	Swimming
2016-05-02		Little shag	1	Point Howard-Sorrento Bays	Rock at shoreline	Roosting
2016-05-02		Southern black-backed gull	5	Point Howard-Sorrento Bays	Shoreline or in water	Roosting
2016-05-02		Variable oystercatcher	2	Point Howard-Sorrento Bays	Rocks	One bird roosting, flew south to mate
2016-05-02		Variable oystercatcher	1	Point Howard-Sorrento Bays	Shoreline	Feeding
2016-05-02		Southern black-backed gull	26	Point Howard-Sorrento Bays	Rocks, islets and water	Roosting, a few roosting on water
2016-05-02		Little shag	3	Point Howard-Sorrento Bays	Rocky islet	Roosting
2016-05-02		Little black shag	2	Point Howard-Sorrento Bays	Rocky islet	Roosting, flew off south
2016-05-02		Red-billed gull	1	Point Howard-Sorrento Bays	Sandy beach	Roosting
2016-05-02		Southern black-backed gull	2	Point Howard-Sorrento Bays	Sandy beach	Roosting
2016-05-02		Southern black-backed gull	21	Point Howard-Sorrento Bays	Sea	Roosting
2016-05-02		Little shag	1	Point Howard-Sorrento Bays		Flew south
2016-05-02		Southern black-backed gull	2	Point Howard-Sorrento Bays		
2016-05-02		Little shag	1	York Bay	Islet, near Whiorau reserve	Roosting

Date	Time	Species	Number	Location	Habitat	Activity
2016-05-02		Red-billed gull	2	York Bay	Sea	Roosting
2016-05-02	1108	Variable oystercatcher	2	York Bay		Roosting
2016-05-02		Little shag	2	Mahina Bay		Flying close by, north
2016-05-02		Little shag	1	Mahina Bay		Flying close by
2016-05-02		Southern black-backed gull	1	Sunshine Bay		
2016-05-02	1220	Southern black-backed gull	1	Sunshine Bay		
2016-05-03	740	Southern black-backed gull	50	Point Howard-Sorrento Bays	Offshore water, rocks	Roosting
2016-05-03		Red-billed gull	2	Point Howard-Sorrento Bays		Roosting
2016-05-03		Variable oystercatcher	3	Point Howard-Sorrento Bays		Feeding
2016-05-03		Red-billed gull	1	Point Howard-Sorrento Bays		Roosting
2016-05-03		Southern black-backed gull	1	Point Howard-Sorrento Bays		Flying
2016-05-03		Red-billed gull	1	Point Howard-Sorrento Bays		Roosting
2016-05-03		Southern black-backed gull	1	Point Howard-Sorrento Bays	High tide roost	
2016-05-03		Little shag	1	Point Howard-Sorrento Bays	High tide roost islet	
2016-05-03		Southern black-backed gull	2	Point Howard-Sorrento Bays	High tide roost	
2016-05-03		Southern black-backed gull	1	Point Howard-Sorrento Bays	High tide roost	Roosting
2016-05-03		Little shag	1	Point Howard-Sorrento Bays		
2016-05-03		Southern black-backed gull	1	Lowry Bay		Roosting
2016-05-03		Red-billed gull	1	Lowry Bay		
2016-05-03		Southern black-backed gull	2	Lowry Bay		Roosting
2016-05-03		Red-billed gull	1	Lowry Bay		Roosting
2016-05-03		Southern black-backed gull	1	Lowry Bay		Roosting
2016-05-03		Red-billed gull	1	York Bay	Islet	Roosting

Date	Time	Species	Number	Location	Habitat	Activity
2016-05-03		Southern black-backed gull	1	York Bay		Flying
2016-05-03		Southern black-backed gull	1	York Bay	Sea	Roosting
2016-05-03		Southern black-backed gull	1	York Bay		
2016-05-03		Red-billed gull	2	York Bay		
2016-05-03		Red-billed gull	1	York Bay	Rocks	Feeding, low tide line
2016-05-03		Little shag	1	Mahina Bay	South side of large rock	Roosting
2016-05-03	1000	Little black shag	2	Mahina Bay		Flying high, south
2016-05-03		Southern black-backed gull	1	Mahina Bay		
2016-05-03		Southern black-backed gull	1	Mahina Bay		
2016-05-03		Red-billed gull	2	Mahina Bay		
2016-05-03		Variable oystercatcher	1	Mahina Bay		Flying north
2016-05-03	1010	Little black shag	1	Mahina Bay		Flying south and north
2016-05-03	1300	Variable oystercatcher	1	Sunshine Bay	Beach gravels	Sitting, injured left foot
2017-05-14	1413	Red-billed gull	27	Days Bay	Intertidal, gravel beach	Roosting
2017-05-14	1419	Southern black-backed gull	15	Days Bay	Sea (0-20 m offshore)	Roosting
2017-05-14	1448	Variable oystercatcher	2	Windy Point	Intertidal cobblefield	Roosting
2017-05-14	1452	Southern black-backed gull	2	Windy Point	Sea (20-100 m offshore)	Flying
2017-05-14	1515	Little shag	2	Windy Point	Sea (20-100 m offshore)	Flying
2017-05-14	1531	Little shag	1	Windy Point	Intertidal rocky shore	Roosting
2017-05-14	1538	Black shag	1	Windy Point	High rocks	Roosting
2017-05-17	1020	Southern black-backed gull	1	Windy Point	Emergent rock	Roosting
2017-05-17	1051	Variable oystercatcher	2	Windy Point	Sea (20-100 m offshore)	Flying
2017-05-17	1120	Variable oystercatcher	4	Windy Point	Sea (0-20 m offshore)	Flying

Date	Time	Species	Number	Location	Habitat	Activity
2017-05-17	1125	Australasian gannet	1	Windy Point	Sea (0-20 m offshore)	Flying
2017-05-17	1128	Variable oystercatcher	1	Windy Point	Sea (100-200 m offshore)	Flying
2017-05-17	1433	Variable oystercatcher	3	Windy Point	Rocky islet	Roosting
2017-05-17	1551	Little black shag	40	Windy Point	Sea (0-20 m, 20-200 m offshore)	Sequentially flying and feeding
2017-05-17	1555	Red-billed gull	2	Windy Point	Intertidal cobblefield	Flying north

Appendix D: Guidelines for little penguin breeding habitat in rock seawalls

The following guidelines are adapted from Woehler (2015).

- The engineering requirements will largely determine the overall revetment design characteristics to achieve protection from erosion through wave attack. Covering rock dimensions needed will vary with the strength of waves. High thermal mass (volcanic) rocks help penguins remain relatively warm in winter and cool in summer (Earthcare St Kilda 2018).

- The roof offered by rock is critical for little penguins as dry, well-drained sites that provide shelter from rain and direct sunshine to eggs and chicks; rain and seawater otherwise will chill them rapidly and result in deaths from hypothermia. The rock also reduces the visibility of the nesting effort to predators, and relatively tight and small entrances further reduce the opportunity for predators to take eggs, chicks and adults from breeding sites.

- Voids need to be located so they are not washed over by waves during high tides, storm surges and wave splash. Location also needs to recognise sea-level rise and the possibility of increased wave heights from climate change (Gorman et al. 2006).

- Key little penguin dimensions are *c.* 40 cm height (Heather, Robertson & Onley 2015) while standing just over 25 cm tall (Houston 2007). The internal dimensions for little penguin nest boxes provide a guide for the sizes of voids for little penguin nest sites: 450 mm long x 350 mm wide x 250 mm high (Houston 1999). The entrance dimensions (150 mm x 150 mm) provide the minimum size for a void to be accessible, but walking height is preferable.

- Sizing, layering and interlocking of rocks to offer nesting voids and accesses down to these dimensions will maximise their value for little penguin habitat. The role of smaller rocks in providing suitable nesting platforms within the voids is a critical aspect. Design access in voids with bends for protection from the elements and to reduce exposure to predators.

- What seems to work best is rocks that are compacted together (interlocked) to form a flat surface where the water breaks (at varied tidal levels) as landing places, and above that along the top of the wall, rocks are loosely sitting to allow the penguins to nest amongst them.

- Penguins need to be able to walk out of the sea and require places on the rocks to be able to do so. Concrete ramps may be used to facilitate access to breeding sites.

- Where rock riprap is also used as access by penguins breeding further inland, the seawall design needs to consider facilitating penguin access through the rock riprap, while considering other risks e.g. roadkill on adjoining road. Fencing or other barrier 30-40 cm high on top of the seawall may be used to guide access to least risk locations, while also reducing light spill from vehicles onto the seawall and foreshore.

- Some fine materials are important to provide a base for nesting in the voids. These could be provided in several ways: by inclusion of geotextile or granular filters in the design; or through the placement of soil or fine gravels where these can move into voids (while not introducing soil into the coastal marine area). In the Eastern Bays, the backfill level could be raised amongst the top double layer of large rocks using surplus broken-down greywacke rock excavated during curved seawall construction. Nest boxes may offer better shelter from wave splash.

- If feasible, retention or planting of native shrubs and ground-covering vegetation (e.g. taupata, flax, cabbage tree) may reduce erosion (particularly of finer grade fill) and provide shelter for penguins.