CHAPTER 4
MARINE ECOLOGY

Quality Assurance Statement	
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Reviewed by	Dr Leigh Bull

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Executive Summary

1. As part of the marine ecological assessment of effects, existing data and literature were reviewed and a gap analysis carried out in order to design the surveys required.

2. Assessment of design options was carried out through a multi-criteria analysis process and marine ecology input was provided to the design in order to avoid, remedy or mitigate adverse effects on ecological values where possible.

3. This report includes assessment of permanent habitat loss, habitat disturbance during construction and operation, discharge of earthworks sediment, the discharge of treated stormwater from operation of the road, the discharge of treated stormwater from the catchment, the discharge of contaminants from contaminated land/sediments disturbed by the project construction and direct impacts on marine fauna. The EWL project team worked collaboratively to develop an integrated suite of proposed measures to avoid, mitigate and off-set effects on ecology (Chapter 6 of this report).

4. EIANZ Impact Assessment Guidelines were used as an approach for the assessment of effects.

5. The areas of marine environment affected by the project include the Mangere Inlet (primarily the northern shore and Anns Creek estuarine habitats) and Otahuhu Creek at the existing SH1 crossing.

6. Mangere Inlet is a tidal mudflat that almost entirely empties at low tide, flushing to the Manukau Harbour. The fringes of Mangere Inlet have been highly modified by reclamation in the past. The benthos is dominated by silt and clay sediment, whereas, in general the benthic invertebrate community comprises moderate richness, diversity and abundance. Sediment contaminants are elevated along the northern shore, but are generally below high effects guidelines. Invasive Asian date mussel are present subtidally. Estuarine vegetation provides high habitat values within Anns Creek estuary.

7. Otahuhu Creek, where it is crossed by SH1, comprises a narrow channel fringed by dense mangroves. Whilst the benthic invertebrate assemblage comprises moderate species diversity, richness and abundance, the invasive Asian date mussel is abundant within the channel. Benthic sediment comprises silt and clay and generally has contaminant concentrations below effects thresholds.

8. The marine ecological values within the Mangere Inlet and within Otahuhu Creek were assessed as moderate overall.

9. The main adverse effects of the EWL project on marine ecological values include intertidal habitat loss from reclamation, construction of bridge and boardwalk structures, and location of stormwater treatment devices[20]. The habitat loss adds to the historic high level of reclamation in the Mangere Inlet. Dredging of part of the subtidal habitat within the Inlet is proposed, in order to provide sediment for the mudcrete components of the proposed new landforms that contain the catchment stormwater treatment wetlands. Dredging is proposed primarily in areas where the invasive Asian date mussel beds are dense and have smothered almost all indigenous benthic organisms.

10. Marine ecological benefits of the EWL project are mainly the treatment of catchment stormwater and landfill leachate prior to discharge into the Inlet, with some more minor habitat diversity

[20] Including wetlands and proprietary devices such as stormfilters.

benefits associated with creation of hardshore habitat (i.e. increased habitat diversity). In order to achieve the benefits of treating catchment stormwater through provision of freshwater treatment wetlands along the northern shore of the Mangere Inlet, reclamation is required which is associated with adverse effects on marine ecological values through permanent habitat loss primarily.

11. Mitigation and offset measures are required due to the significant adverse effects associated with reclamation and other permanent effects.

4 Chapter 4 – Marine Ecology

4.1 Introduction

4.1.1 Purpose and scope of this report chapter

This report forms part of a suite of technical reports prepared for the Transport Agency's East West Link project (the Project). Its purpose is to inform the AEE and to support the resource consent applications, new NoR and alterations to existing designations required for the EWL.

This report assesses the marine ecological effects of the proposed Alignment of the Project as shown on the Project Drawings (Drawing numbers AEE-AL-100-116).

The purpose of this report is to:

a) Identify and describe the existing marine ecological values, habitats and environment;

b) Describe the potential effects (positive and adverse), of the Project on the existing marine ecological values;

c) Recommend measures as appropriate to avoid, remedy or mitigate[21] potential adverse effects on marine ecological values (including any conditions/management plan required); and

d) Present an overall conclusion of the level of potential adverse effects of the Project on marine ecological values after recommended measures are implemented.

4.2 Experience

4.2.1 Expertise

Dr De Luca’s qualifications include a Bachelor of Science degree in Zoology (University of Auckland) and a Doctorate in Environmental and Marine Science (University of Auckland). She has more than 16 years’ experience in marine science and a strong background in ecotoxicology. Dr De Luca is a Certified Environmental Practitioner with the Environment Institute of Australia and New Zealand and an Independent Hearings Commissioner.

Over recent years Dr De Luca has worked on a number of infrastructure projects including four Roads of National Significance with the Transport Agency where reclamation and/or discharges to the coastal environment were key issues. She has an in-depth understanding of the effects of earthworks, stormwater, erosion and sediment control and construction on marine ecological values. Dr De Luca has significant experience in assessment of effects on coastal/marine and freshwater ecological values, preparation of aquatic monitoring programmes, habitat surveys, contaminant analyses and restoration plans and preparation and presentation of expert witness evidence.

[21] Including offset mitigation where appropriate.

4.3 Assessment methodology

In preparing this report, several site visits have been undertaken, attendance at a number of workshops and meetings has occurred, numerous discussions and meetings with other experts involved in the project have been undertaken and review of other experts reports.

Our Assessment was undertaken in four phases and included the following:

Phase 1 – Preliminary investigations

- Review of plans and maps and identification of marine ecological values potentially affected by the Project;
- Literature review of existing information on marine ecology in the project area;
- Site visit and preliminary assessment for MCA;
- Gap analysis to assess information gaps and further investigations.

Phase 2 – Existing environment

- Site investigations;
- Assessment of existing marine ecology values.

Phase 3 – Design input and mitigation of adverse effects

- Review of project activities;
- Input to project design to avoid, remedy or mitigate adverse ecological effects;
- Development of specific measures to off-set effects on marine ecology.

Phase 4 – Assessment of Effects

- Assessment of adverse and beneficial effects of the project on marine ecology values, including permanent habitat loss, habitat disturbance during construction and operation, discharge of earthworks sediment, the discharge of treated stormwater from operation of the road, the discharge of treated stormwater from the catchment, and the discharge of contaminants from contaminated land/sediments disturbed by the project construction.
- Conclusion on overall project effects on marine ecology.

In Phase 1, the literature review included review of aerial photography, Auckland Council GIS layers (including Coastal Protection Areas (CPA) and Significant Ecological Areas – Marine (SEA-M), Auckland Council Regional Coastal Plan, Auckland Council marine ecology and sediment data and reports (see references in Section 4.4 of this chapter).

The MCA assessment process involved providing input of the relative ecological effects at project workshops and scoring for MCA analysis as described in Part D: Consideration of Alternatives of the Assessment of Effects Report (Volume 1) and the Report 1: Assessment of Alternatives (Volume 3).

Phase 2 site investigations included characterisation of the benthic marine invertebrate community in subtidal and intertidal habitats. Sites were selected along the proposed alignment where the embankment and stormwater bund are proposed to be located and subtidally where dredging is proposed, In addition, sites in intertidal habitats within the southern and eastern parts of Mangere Inlet were also surveyed to provide context for the values of the Inlet (Map 4-1).

At each site surveyed a 13cm diameter core (approximately 15cm deep) was collected, sieved through a 0.5mm mesh and the retained material and organisms preserved in 70% ethanol.

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Map 4-1 : Marine habitat types

Drawing Number: GIS-AEE-EC-MA-001

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Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-MA-001_T16006_20_Marine_Map1_MarineHabitatTypes.mxd

Macroinvertebrates were extracted from the material, identified and counted by an independent expert taxonomist at a later date. In addition, a 0.25m^2 quadrat was placed on the undisturbed benthic sediment, photographed and all epifauna identified and counted. Data were analysed using descriptive statistics and multivariate analyses (Primer software was used for multi-dimensional scaling and permutational analysis of variance).

A characterisation of the likely fish and marine mammals that may be present occasionally in Mangere Inlet was compiled from the existing literature.

An assessment of water and sediment quality was undertaken by the Project Team. This is reported in Appendix E of Technical Report 15). In particular, intertidal and subtidal sediments were collected (at 10cm for all survey sites and at greater depths for some survey sites) and analysed for sediment contaminants (metals, hydrocarbons, PAHs, and organochlorines) and grain size. Within the upper most 0.1m of sediment is where most of the benthic organisms inhabit and therefore is of most interest with respect to effects on biology. Contaminant concentrations were compared against ANZECC Interim Sediment Quality Guidelines (ANZECC, 2000) and the Auckland Council's Environmental Response Criteria (ERC) for stormwater (ARC, 2004).

The overall value of the marine ecology habitats within the project area was assessed based on the field data collected and literature available using the characteristics in Table 4-1.[22]

Table 4-1: Characteristics of estuarine sites with low, medium and high ecological values.

Ecological Value	Characteristics
LOW	• Benthic invertebrate community degraded with low species richness, diversity and abundance. • Benthic invertebrate community dominated by organic enrichment tolerant and mud tolerant organisms with few/no sensitive taxa present. • Marine sediments dominated by silt and clay grain sizes (>70%). • Surface sediment predominantly anoxic (lacking oxygen). • Elevated contaminant concentrations in surface sediment, above ISQG-high or ERC-red effects threshold concentrations[23]. • Invasive, opportunistic and disturbance tolerant species dominant. • Estuarine vegetation provides minimal/limited habitat for native fauna. • Habitat highly modified.
MEDIUM	• Benthic invertebrate community typically has moderate species richness, diversity and abundance. • Benthic invertebrate community has both (organic enrichment and mud) tolerant and sensitive taxa present.

[22] Currently there are no guidelines for how to assess the ecological values of marine environments in New Zealand. The characteristics of estuarine sites with low, medium and high ecological values have been developed by Dr De Luca to guide valuing estuarine environments, and to provide a transparent approach that can be replicated. The characteristics have been applied in Environment Court and Board of Inquiry hearings, including a number of NZTA projects (Transmission Gully, MacKays to Peka Peka, and Puhoi to Warkworth). The characteristics have been modified over the years as improvements are recognised.

[23] ANZECC (2000) Interim Sediment Quality Guideline (ISQG) High contaminant threshold concentrations and/or the Auckland Council's (former Auckland Regional Council) Environmental Response Criteria (ERC) Red contaminant threshold concentrations (Auckland Regional Council, 2004).

Ecological Value	Characteristics
	• Marine sediments typically comprise less than 50-70% silt and clay grain sizes. • Shallow depth of oxygenated surface sediment. • Contaminant concentrations in surface sediment generally below ISQG-high or ERC-red effects threshold concentrations. • Few invasive opportunistic and disturbance tolerant species present. • Estuarine vegetation provides moderate habitat for native fauna. • Habitat modification limited.
HIGH	• Benthic invertebrate community typically has high diversity, species richness and abundance. • Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and mud. • Marine sediments typically comprise <50% silt and clay grain sizes. • Surface sediment oxygenated. • Contaminant concentrations in surface sediment rarely exceed the respective ISQG-low effects threshold concentrations, nor ERC amber threshold. • Invasive opportunistic and disturbance tolerant species largely absent. • Estuarine vegetation provides significant habitat for native fauna. • Habitat largely unmodified.

Phase 3 included providing advice to the Project Team on design opportunities to avoid and reduce effects where possible, and develop mitigation where significant adverse effects on marine ecological values were identified.

Phase 4 included a detailed assessment of effects of the project on marine ecological values and evaluation of the overall significance of residual effects after mitigation. EIANZ Impact Assessment Guidelines were used as an approach for the assessment of effects.[24]

4.3.1 Magnitude of ecological effect

We assess the magnitude of ecological effects using the following criteria (Table 4-2):

Table 4-2: Criteria for describing effect magnitude (EIANZ 2015).

MAGNITUDE	DESCRIPTION
Very High	Total loss or very major alteration to key elements/ features of the baseline conditions such that the post development character/ composition/ 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 baseline (pre-development) conditions such that post development character/ composition/ attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature.

[24] Noting that the EIANZ Guidelines primarily relate to terrestrial and freshwater ecosystems, as those ecosystems are well covered by ecological literature and have less complex legislative contexts than the coastal environment (Page 3 of the EIANZ Guidelines).

MAGNITUDE	DESCRIPTION
Moderate	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/composition/attributes of baseline 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 baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline condition will be similar to pre-development circumstances/patterns; AND/OR Having a minor effect on the known population or range of the element/feature.
Negligible	Very slight change from 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.

4.3.2 Level of ecological effects

We then assessed the level of ecological effects (Table 4-3) using ecological value (determined in Table 4-1) and effect magnitude (Table 4-2) in general accordance with EIANZ (2015).

The EIANZ impact assessment guidelines state that the purpose of the document is to provide guidance on good practice in environmental management without being prescriptive. Further, the guidelines state that they are not binding, will be revised from time to time with user feedback and evolving good practice, and practitioners are able to deviate from the guidelines where they consider it is ecologically relevant and justifiable to do so.

The EIANZ guidelines were developed for terrestrial and freshwater ecology, but we have made minor modifications and applied them to assessment of effects on marine ecological values. For this Project, modifications have been made to Table 4-3 in order to take a more conservative approach to the assessment, which takes into account that estuaries are a vulnerable ecosystem (Holdaway et al., 2012) and recognising the manner in which reclamation is described within the NZCPS.

The modifications to Table 4-3 result in a more conservative approach to assigning level of effect and are shown in brackets. In addition, the EIANZ guidelines approach to combining values with magnitude of effect only allow for adverse effects. This assessment has also incorporated positive effects of the project within the matrix approach.

Table 4-3: Matrix combining magnitude and value for determining the level of ecological impacts.

EFFECT LEVEL		Ecological &/or Conservation Value			
		Very High	**High**	**Moderate**	**Low**
Magnitude	**Very High**	Very High	Very High	High	Moderate
	High	Very High	Very High	Moderate (High)	Low
	Moderate	Very High	High	Low (Moderate)	Very Low
	Low	Moderate	Moderate	Low	Very Low
	Negligible	Low	Low	Very Low	Very Low

4.4 Existing environment

In this section of the report we summarise the marine ecological values of the Mangere Inlet and the Otahuhu Creek, both of which are potentially affected by the proposed alignment (see photographs in Appendix A). The narrow corridor of land between the Mangere Inlet and the Tamaki River, including Otahuhu Creek, was an historically important portage between these two waterbodies.

4.4.1 Mangere Inlet

The Mangere Inlet is located in the north-eastern corner of the Manukau Harbour. The Manukau Harbour comprises an area of approximately 350km^2, with 226km^2 being intertidal (NIWA, 2007). The Mangere Inlet comprises 5.7km^2 of which 5.37km^2 is intertidal mudflats (Kelly, 2008). Mangere Inlet has a catchment of 34.5km^2, primarily in industrial, commercial and residential landuses. The marine and estuarine habitats within the Project area are shown in Map 4-1.

The northern shore of the Inlet has been extensively modified through reclamation[25], port activities, creation of landfills and roading, resulting in the loss of natural embayments and establishment of a linear shoreline. Along the modified shoreline riprap protects the coastal edge from erosion. In addition, there are numerous stormwater discharge points into the CMA along the northern shore. Anns Creek, in the north-eastern corner of the inlet, comprises a short section of open stream, extensive mangrove stands and some areas of saltmarsh[26] (Map 4-1).

The mangrove stands have been historically severed in a number of locations by the establishment of rail corridors, with remnant mangrove stands physically isolated from the main mangrove area. A small remnant area of mangroves (approximately 400m^2) is located inland of the northern shore of the Inlet, within the Storage King site. We were not permitted access to the site by the landowner and therefore were prevented from carrying out a survey. In addition, adjacent to Galway Street there is an area of saltmarsh that a pedestrian boardwalk traverses through (above the CMA boundary). Estuarine and marine areas both within and adjacent to the existing CMA boundary have been included in this assessment. Within Anns Creek East a new CMA has been surveyed as shown in the General Drawings Plan Set 1.

The eastern shore of Mangere Inlet was also reclaimed to establish the former Westfield freezing works and rail yards, whereas the southern shore is less modified. The Harania and Tararata Creeks remain relatively intact. The Ngarango Otainui Island is located in the south-east of the Inlet. Dense mangroves fringe the eastern and southern shores, whereas the northern shore comprises less dense and patchy areas of mangroves. Along the northern shore, Miami Stream discharges into the main Mangere Inlet via a culvert under the walkway. Review of historic aerial photography shows that the area comprising Miami Stream is a remnant part of the inlet that was not reclaimed in the 1960's. Miami Stream is primarily tidal (though outside of the CMA) with the estuarine portion inhabited by mangroves (over a distance of approximately 210m).

The tidal component of Miami Stream is referred to as Miami Stream Estuary in this chapter. Further upstream, for a short distance (approximately 30m), Miami Stream becomes more freshwater habitat dominated for a short distance prior to becoming culverted (see Chapter 3 of this report for description and assessment of the freshwater part of Miami Stream). In addition, the riparian vegetation along Miami Stream is described and assessed in Chapter 2 of this report.

Historically, a number of industries located adjacent to the Mangere Inlet (e.g. meat works, abattoir, fertiliser works, wool scours, fellmongeries, tannery, woollen mill, wood-pulp works, battery works, soap and candle works and glue works) discharged waste directly into the Inlet. In more recent times, runoff from railway workshops, a steel plant, and septic tank and landfill leachate was discharged to the Inlet. Commissioning, and subsequent upgrading, of the Mangere Wastewater Treatment Plant improved water quality in the Manukau Harbour and Mangere Inlet.

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[25] Approximately 1.9km^2 has been reclaimed within the Mangere Inlet (see 1.1 of Assessment of Coastal Processes report).

[26] Values of, and effects on, Anns Creek is also addressed in the freshwater, avifauna and terrestrial ecology chapters of this report, as only part of Anns Creek is within the CMA.

The Mangere Bridge and Onehunga Wharf constrict water flows between the Inlet and the wider Manukau Harbour. The Inlet is a sediment and contaminant sink, with flood flows having greater suspended sediment compared to ebb flows. Residence time within the Inlet is estimated to be 12.6 days (Williamson et al., 1992). Sediments and contaminants discharged via stormwater to the Inlet will settle out in sheltered intertidal and embayments.

The subtidal area adjacent to the Onehunga wharf is dredged periodically by Ports of Auckland. The area affected is approximately 270m x 15m (4,050m^2) (MHX, 2006).

4.4.2 Significant Ecological Areas (SEA) – Marine

Three SEA M1 areas are recognised in the PAUP within the Mangere Inlet; Anns Creek (21), Ambury (23 - located in the south-west corner of the Inlet) and a small area in the south-east part of the inlet (22). A large SEA M2 (22) area covers most of the remaining CMA within the Inlet, excluding the north-west shore and central areas (Map 4-2). Anns Creek is also recognised as a Coastal Protection Area 1 in Auckland Council's Operative Coastal Plan (CPA1 21).

Anns Creek SEA-M1 is recognised for the ecological sequences and mosaic of vegetation types present, including basalt larva shrubland, freshwater wetland, saltmarsh and mangroves (*Avicennia marina*). Saltmarsh comprises marsh clubrush (*Bolboschoenus flaviatus*), glasswort (*Sarcocornia quinqueflora*), oioi (*Apodasmia similis*), and ribbonwood (*Plagianthus divaricatus*). The freshwater wetland comprises an area of deep aquifer-fed water dominated by raupo, whereas the stream margins are dominated by grasses and sedges. Inanga are known to spawn in this area, and banded rail have been detected. The Anns Creek SEA-M1 vegetation sequence also provides important wading bird habitat for Australasian bittern and banded rail (21w1 - SEA-M2w).

Ambury SEA-M1 is recognised as comprising an important high tide roost area and foraging area for a wide range of international migratory and New Zealand endemic wading birds.

The small SEA-M1 located in the south-east corner of the Inlet comprises a complex of saltmarsh species, including a 0.25ha batchelor's button (*Cotula coronopifolia*) saltmeadow. This area was recognised in the Auckland Council's Regional Plan: Coastal (ARC, 2004) as CPA1 (22b) and with a CPA2 area to the north (CPA2 22a) comprising a high diversity of native saline vegetation.

The SEA-M2 area covering much of the south-east of the inlet (22a) is recognised for saline vegetation on the coastal margins and for the extensive intertidal mudflats containing benthic invertebrate communities that are diverse and dense. The benthic invertebrate assemblages provide important foraging for international and endemic wading birds, some of which are *Threatened*. The Auckland Council Operative Coastal Plan recognised a smaller area as CPA2 (22a) as important foraging habitat for coastal birds.

4.4.2.1 Areas of Significant Conservation Value (ASCV)

The entire Manukau Harbour is recognised by the Department of Conservation (1994) as an ASCV (7), with intertidal mudflats, mangrove and saltmarsh of importance. The harbour is recognised as an internationally important feeding, roosting and breeding area for wading birds.

The Mangere Mountain Foreshore (including Pahoehoe lava flows) is an ASCV (59). Pahoehoe lava flows of national significance are present adjacent to Kiwi Esplanade west of the Mangere Inlet. The ASCV is valued as foraging and roosting habitat for wading birds and seabirds, for the saltmarsh and maritime vegetation as well as the benthic invertebrate assemblages.

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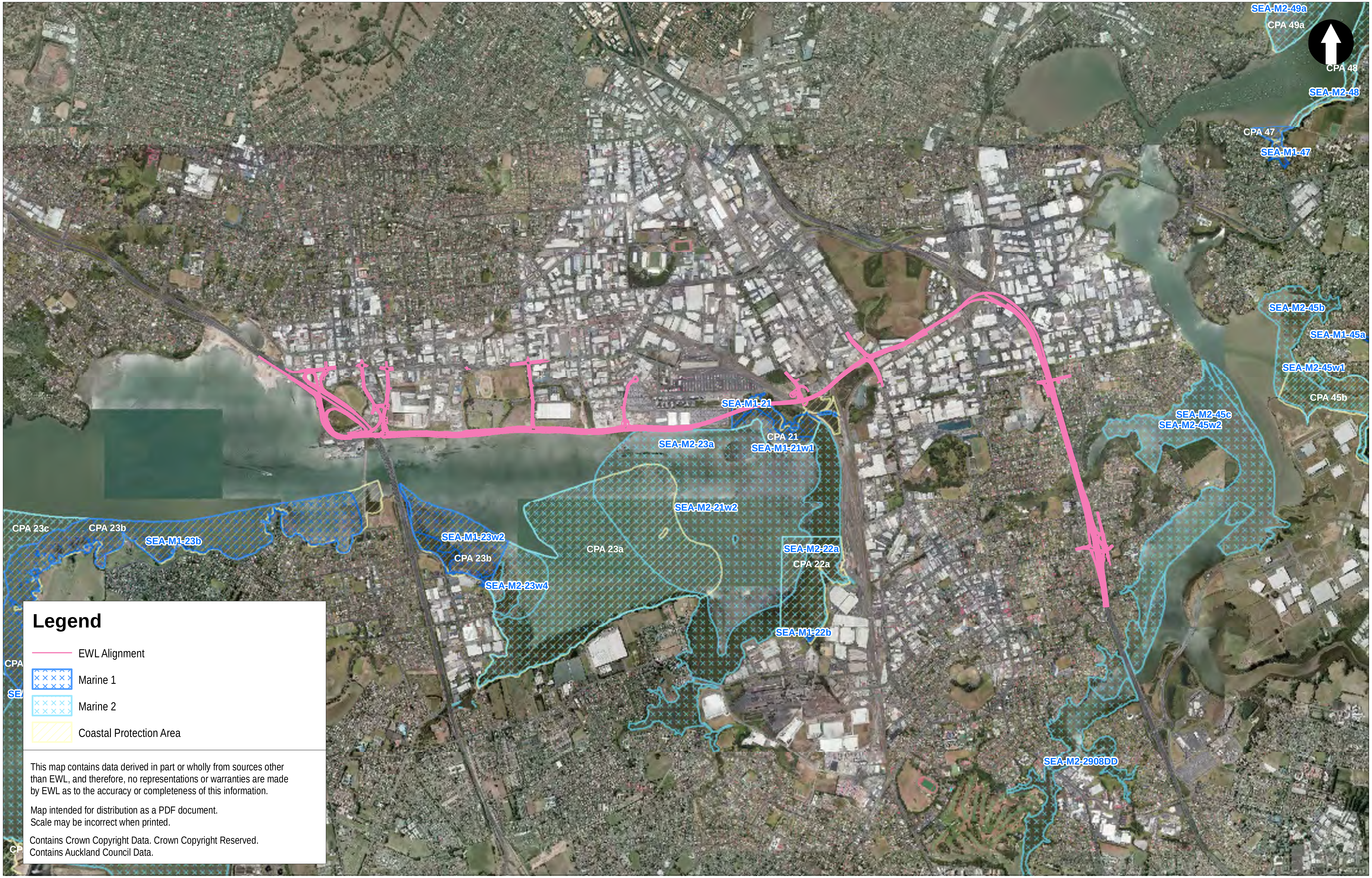

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Drawing Title: ECOLOGY

Map 4-2 : Marine SEA's and CPA's

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4.4.2.2 Water Quality

Water quality within the Mangere Inlet was not surveyed as part of this project for reasons given in Appendix E, Technical Report 15, Coastal Processes Assessment, but primarily because of the variable nature of inputs to the system, the large dilution and water movement within the Inlet and the behaviour of the primary contaminants being that they preferentially sorb to sediment particles. It is noted that the Mangere Inlet is the receiving environment for contaminants arising from discharges to streams from various onsite practices within the adjacent industrial areas, stormwater and groundwater (including landfill leachate and likely wastewater cross contamination at times).

Ammoniacal nitrogen was found to be the primary contaminant in landfill leachate, whilst baseflow of stormwater was found to have overall good water quality and first flush had elevated contaminant concentrations (Appendix E, Technical Report 15, Coastal Processes Assessment)

4.4.2.3 Sediment Quality

Sediment Quality Thresholds / Guidelines

Table 4-4 below presents the ANZECC (2000) ISQG low and high values and the Auckland Council's Environmental Response Criteria (ERC) thresholds.

Table 4-4: Ecological effects contaminant concentration thresholds for marine sediment.

Contaminant (mg/kg dry weight)	AC ERC Green	AC ERC Amber	AC ERC Red	ISQG-Low	ISQG-High
Arsenic	-	-	-	20	70
Chromium	-	-	-	80	370
Copper	<19	19-34	>34	65	270
Lead	<30	30-50	>50	50	220
Nickel	-	-	-	21	52
Zinc	<124	124-150	>150	200	410
HMW PAHs	<0.66	0.66-1.74	>1.74	1.7	9.6
Dieldrin	-	-	-	0.00002	0.008
DDT	-	-	-	0.0016	0.0046

ANZECC ISQG were adopted from Long et al. (1995) and the NOAA[27] sediment quality values which are based on laboratory toxicity tests and field data. These data suggest that if a sediment contaminant is detected between the ISQG-low threshold and the ISQG-high threshold it is possible that adverse effects could occur. Concentrations above the ISQG-high threshold suggest probable adverse effects. However, if a sediment quality threshold is not exceeded there is no surety that adverse ecological effects will not occur. ERC thresholds were developed by AC primarily for the assessment of the environmental quality of coastal marine areas in relation to common contaminants (copper, lead, zinc and high molecular weight polycyclic aromatic hydrocarbons) in stormwater discharges (ARC, 2004). Green indicates low concentrations of contaminants that are unlikely to cause adverse effects on biology, amber indicates that there is the potential for adverse effects on biology, and red indicates likely effects on biology.

[27] National Oceanic and Atmospheric Administration, United States of America.

The Auckland Council ERC thresholds are based on the ANZECC ISQG, plus additional currently available guidelines, which is consistent with development of trigger values associated with local conditions (ARC, 2004). The ERC amber thresholds are set relatively low in order to enable time for a response and further investigation before ecological effects are likely to occur (ERC Red and ISQG-low threshold concentrations).

Existing sediment contaminant data

"Anns Creek"[28] and "Mangere cemetery"[29] are State of the Environment monitoring sites included in Auckland Council's routine marine surface sediment monitoring programme (Mills, 2014a). Data collected in 2013 at Anns Creek indicate zinc exceeds Environmental Response Criteria (ERC) amber (128 mg/kg). Copper, lead and HMW PAHs were below the amber ERC threshold. All contaminant concentrations detected were below ISQG-low. Higher concentrations of contaminants were detected in the late 1990's and early 2000's at this site. At the Mangere cemetery site, contaminant concentrations detected in 2013 were all below the ERC amber threshold. However, concentrations within the amber and red ranges were detected in past years (particularly 1998-2003) (Mills et al., 2012).

Auckland Council surveys in 2010 detected elevated DDT and dieldrin in sediments from Anns Creek and the Mangere cemetery, with dieldrin above ERC red threshold concentration (Auckland Council, 2014). HMW PAHs, OCPs and PCBs were within the ERC green threshold range at the Mangere cemetery site (Mills, 2014b).

Auckland Council's intertidal sediment quality monitoring site at Mangere cemetery is within the permanent footprint of the Project. As such, opportunities to work with Auckland Council to establish a new survey site should be investigated. We understand that the Council is due to re-survey sediment quality at Mangere Inlet in November 2016. As such, there is an opportunity to concurrently survey potential replacement monitoring sites at the same time to provide some temporal overlap in the data set.[30]

EWL Project sediment contaminant data

Surface sediment (top 0.1m of sediment) was collected for the Project within the Mangere Inlet (Map 4-3) along the northern shore (S41-S63, n=22), the eastern shore (S21-S25, n=5), the southern shore (S26-S30, n=5) and the main subtidal channel (S01-S20, n=20). Metals were detected in higher concentration primarily along the northern shore of the Inlet. Other contaminants in surface sediment, for the most part, were below guideline concentrations (Appendix E, Technical Report 15 – Coastal Processes Assessment).

A series of maps have been produced to illustrate the patterns of metal concentrations in surface sediment within the inlet (Maps 4 -15 in Appendix B). Where there are ERC and ISQG thresholds for a single contaminant (e.g. copper, lead and zinc), a comparison against both guidelines concentrations has been mapped.

a) Northern Shore

The highest concentration of arsenic was detected in the southern intertidal area (44 mg/kg), which is double the ISQG-low (Table 4-5). The maximum concentration of arsenic was marginally lower in each of the other areas of the inlet (Table 4-5, Map 4-4, Map 4-5). Approximately 86% of the northern shore samples had arsenic above ISQG-low.

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[28] The survey site is at the mouth of Anns Creek in an area of intertidal mudflat seaward of the mangrove fringe.

[29] The survey site is located intertidally immediately adjacent the centre of the Waikaraka cemetery.

[30] Preliminary discussions have been held with Marcus Cameron at Auckland Council on this matter.

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NZ TRANSPORT AGENCY

East West Link

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Scale: 1:16,000	Original Size: A3	Contract No PA4041	

Drawing Title: ECOLOGY

Map 4-3 : Marine Survey Locations

Drawing Number: GIS-AEE-EC-MA-003

Rev No.: A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-MA-003_T16006_21_Marine_Map3_MarineSurveyLocations.mxd

Chromium was only detected above effects thresholds along the northern shore in surface sediment (Map 4-6, Table 4-5) at one site (S59, 83mg/kg). At sediment depths >0.1m the concentration of chromium exceeded ISQG-Low along three transects (adjacent to S42, S49 and S57) (Map 4-7).

Copper was detected above ISQG-low at one site (S59, 69 mg/kg) and above ISQG-high at two sites within Miami Stream (580 and 600 mg/kg) (Map 4-8, Table 4-5). Ten percent of sites along the northern shore exceeded ISQG-low for copper (Table 4-5). At sediment depths >0.1m copper was detected along the northern shore above ERC-red more frequently than in <0.1m sediment (Map 4-9).

Lead was detected above ISQG-low in seven northern shore samples (Table 4-5), above ERC amber at nine sites and above ERC red at four sites (Map 4-10). The highest concentration of lead was detected in the estuarine part of Miami Stream (210 mg/kg). Similar to copper, lead was detected above ERC-red threshold at more sites along the northern shore in >0.1m depth sediment compared to the <0.1m (Map 4-11).

Along the northern shore, nickel concentration in sediment exceeded ISQG-low at six sites, with the maximum concentration being 51 mg/kg (Table 4-5, Map 4-12, Map 4-13).

Nine sites along the northern shore recorded zinc above ISQG-low and two sites had more approximately three times the ISQG-high concentration (Miami Stream) (Table 4-5,Map 4-14). Within the CMA, the highest concentration detected was 390 mg/kg at site S58 (Map 4-15). With respect to ERC thresholds, 21 sites along the northern shore exceeded ERC red. Similar to the shallow sediment samples, the concentration of zinc at depths >0.1m was detected above ERC-red at a number of locations along the northern foreshore, concentrated around existing stormwater discharge points (Map 4-15).

HMW PAHs in sediment were below ISQG and ERC thresholds.

b) Eastern Shore

Of the samples collected along the eastern shore 40% exceed ISQG-low concentration for arsenic (Table 4-6). Chromium was not detected above ISQG-low in any sample. Three of five sites on the eastern were above ERC amber for copper (Map 4-8). Lead concentration was not above ERC amber or ISQG-low along the eastern shore (Map 4-10). Nickel was below ISQG-low in <0.1m sediment samples along the eastern shore (Map 4-12). Similar to chromium, copper, lead and nickel, zinc was not detected above ISQG-low at eastern shore sites (Map 4-14). HMW PAHs in sediment were below ISQG and ERC thresholds.

c) Southern Shore

Twenty percent of the samples collected from the southern shore had arsenic higher than ISQG-low (Table 4-7). Chromium was not detected above ISQG-low in any sample. Two of five sites on the southern shore were above ERC amber for copper concentration (Map 4-8). Lead concentration was not above ERC amber or ISQG-low along the eastern shore (Map 4-10). Nickel and zinc were below ISQG-low in <0.1m sediment samples along the southern shore (Map 4-12, Map 4-14). HMW PAHs in sediment were below ISQG and ERC thresholds.

d) Subtidal

In subtidal sediments, 45% of samples exceeded ISQG-low for arsenic (Table 4-8). Chromium was not detected above ISQG-low in any sample. Copper was detected above ISQG-low at one site (S59, 69mg/kg) (Map 4-8, Table 4-5), with the ISQG being 65 mg/kg and one in the subtidal area (S16, 86 mg/kg).

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Drawing Title

ECOLOGY

Map 4-4 : Concentration of Arsenic in sediment <0.1m

Drawing Number GIS-AEE-EC-MA-004.1

Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-001_T16006_23_Marine_Map4_Arsenic_Concentrations.mxd

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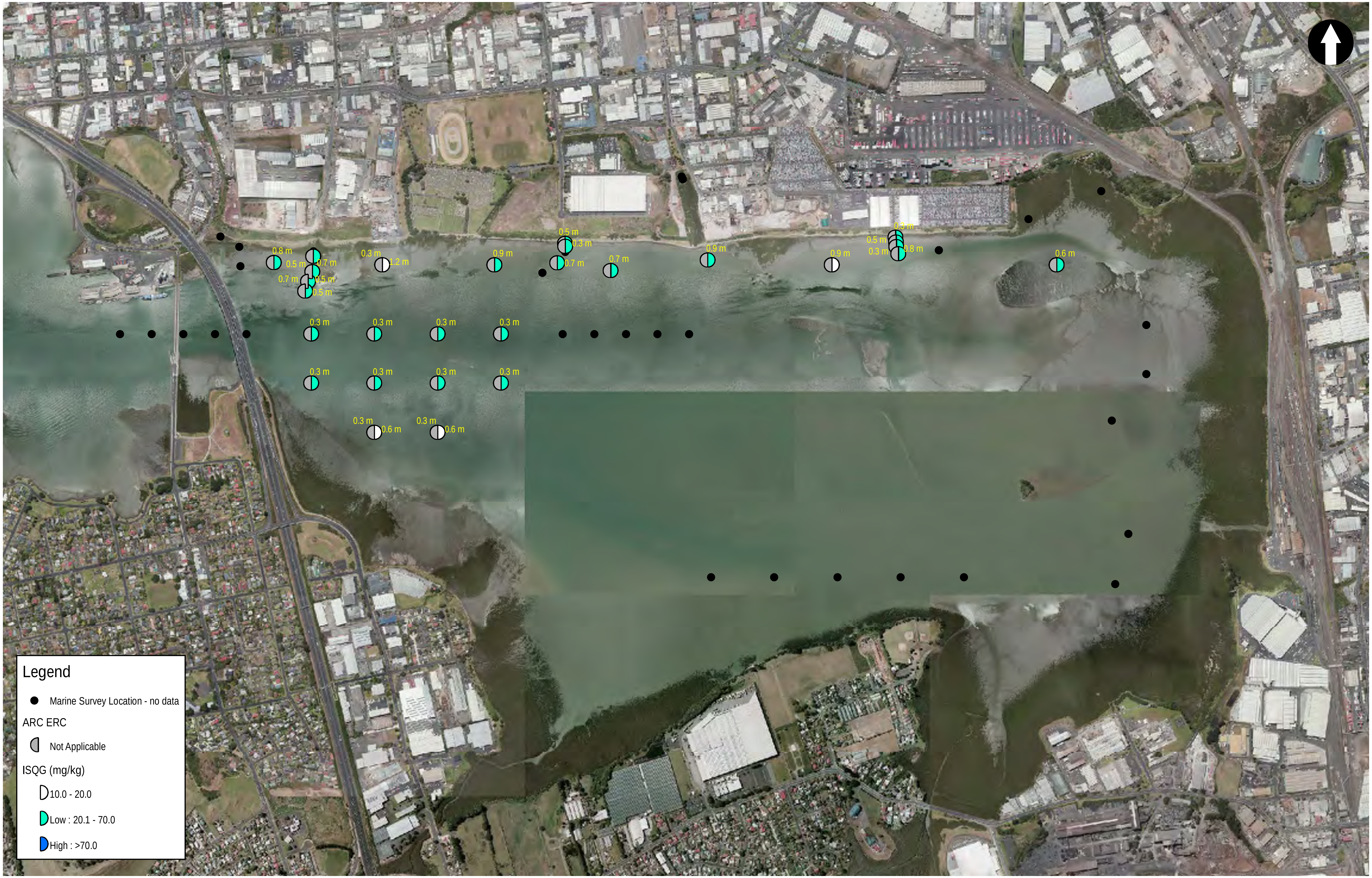

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Drawing Title
ECOLOGY
Map 4-5 : Maximum concentration of Arsenic detected in sediment >0.1m

Drawing Number GIS-AEE-EC-MA-004.7 | Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskell\GIS-EC-AEE-HM-007_T16006_29_Marine_Map4_Arsenic_Deep_Concentrations.mxd

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Drawing Title

ECOLOGY

Map 4-6 : Concentration of Chromium in sediment <0.1m

Drawing Number GIS-AEE-EC-MA-004.2

Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-002_T16006_24_Marine_Map4_Chromium_Concentrations.mxd

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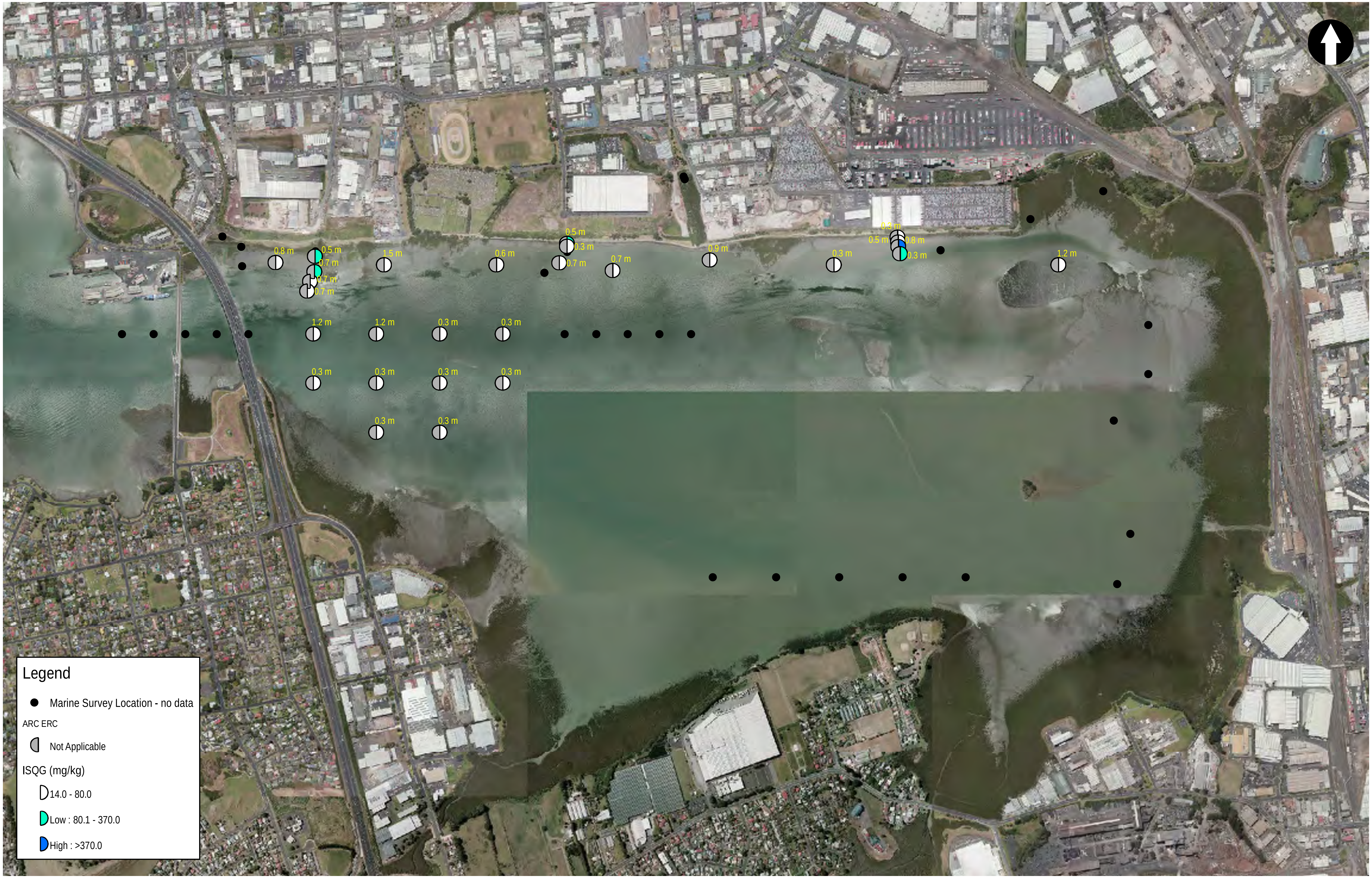

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Drawing Title
ECOLOGY
Map 4-7 : Maximum concentration of Chromium detected in sediment >0.1m

Drawing Number GIS-AEE-EC-MA-004.8
Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-008_T16006_30_Marine_Map4_Chromium_Deep_Concentrations.mxd

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Drawing Title

ECOLOGY

Map 4-8 : Concentration of Copper in sediment <0.1m

Drawing Number GIS-AEE-EC-MA-004.3

Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-003_T16006_25_Marine_Map4_Copper_Concentrations.mxd

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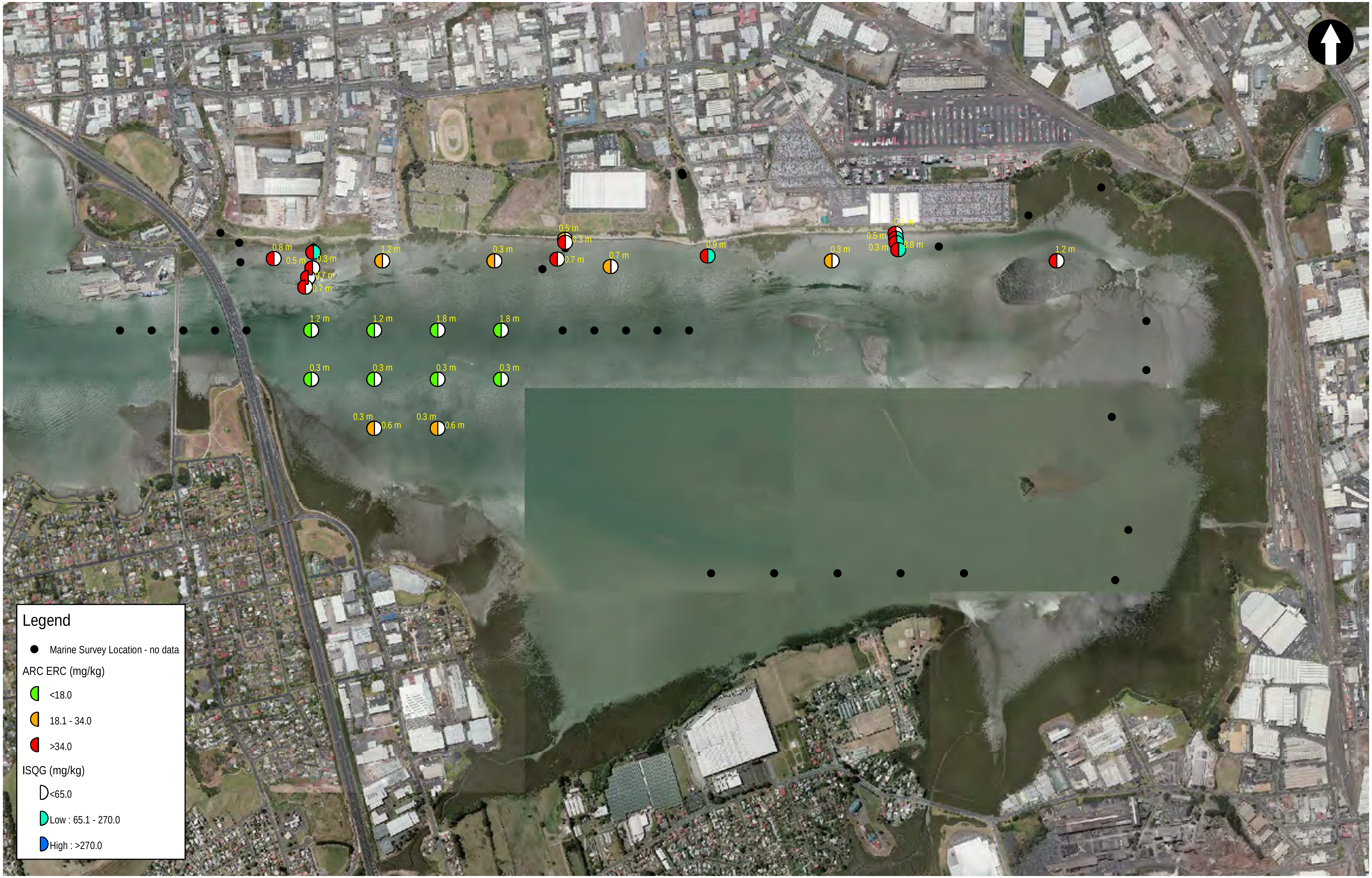

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Drawing Title
ECOLOGY
Map 4-9 : Maximum concentration of Copper detected in sediment >0.1m

Drawing Number GIS-AEE-EC-MA-004.9 | Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TG\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskell\GIS-EC-AEE-HM-009_T16006_31_Marine_Map4_Copper_Deep_Concentrations.mxd

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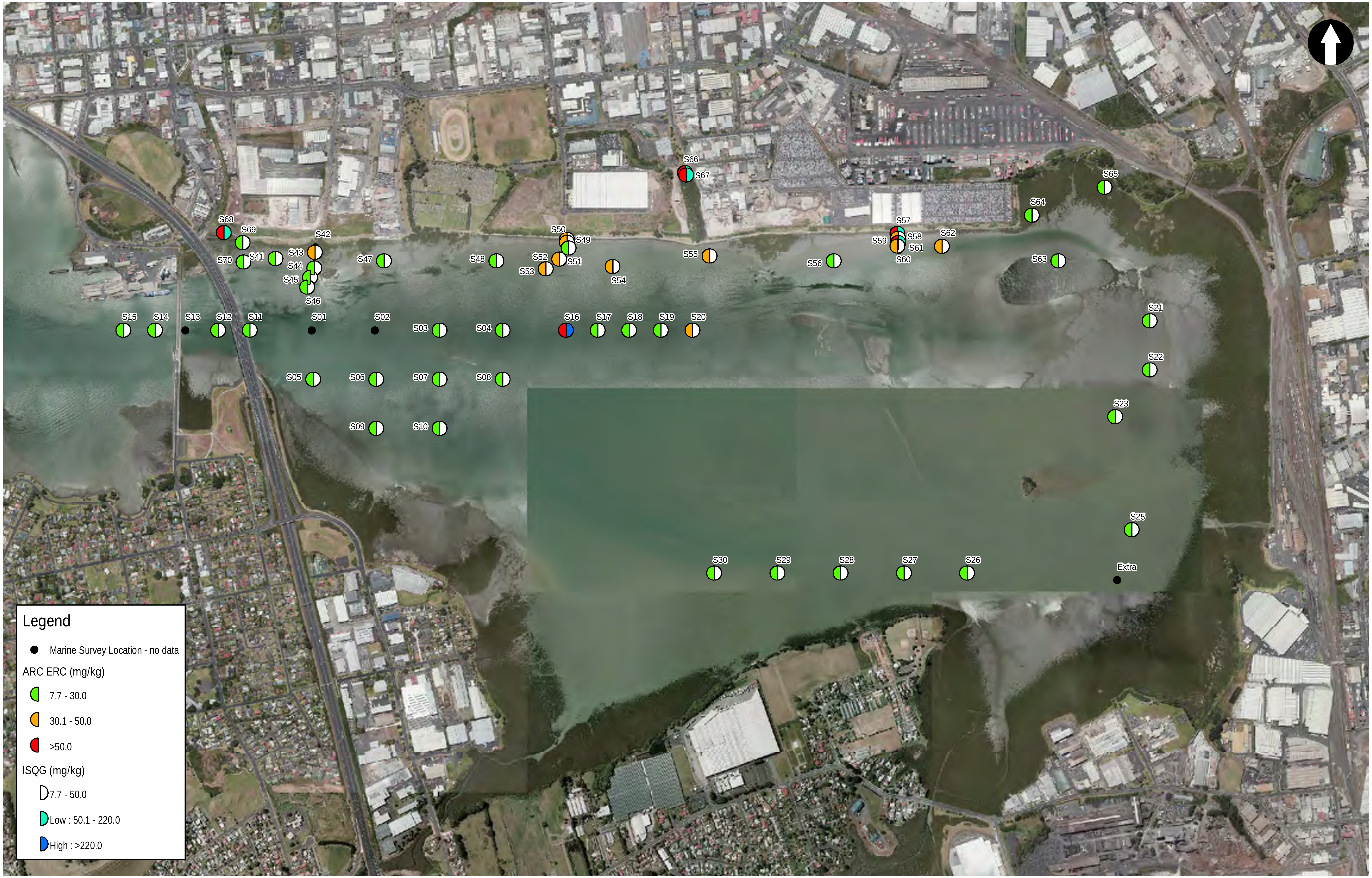

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Drawing Title
ECOLOGY
Map 4-10 : Concentration of Lead in sediment <0.1m

Drawing Number GIS-AEE-EC-MA-004.4

Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-004_T16006_26_Marine_Map4_Lead_Concentrations.mxd

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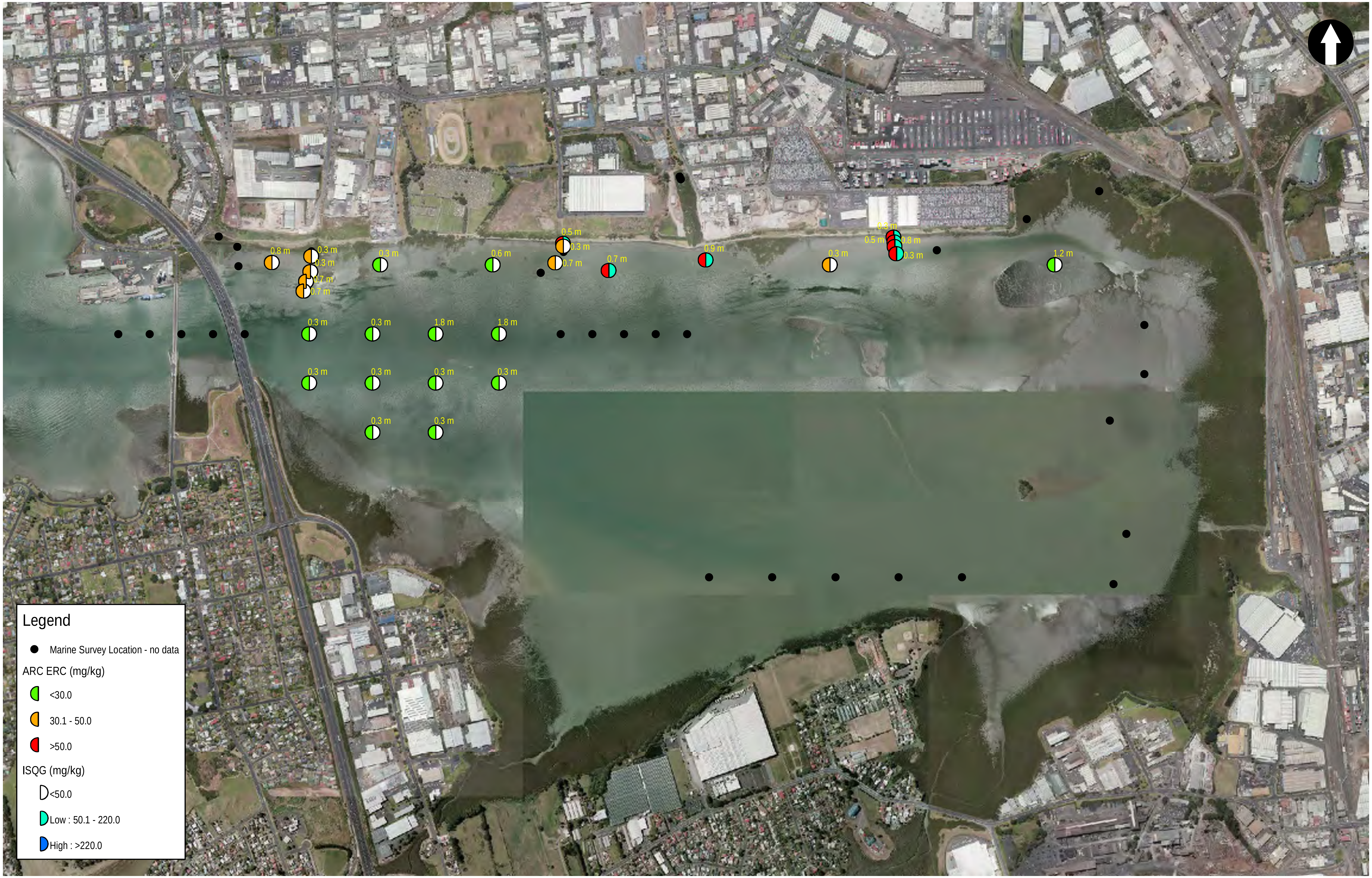

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Drawing Title
ECOLOGY
Map 4-11: Maximum concentration of Lead detected in sediment >0.1m

Drawing Number GISAEE-EC-MA-004.10
Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-010_T16006_32_Marine_Map4_Lead_Deep_Concentrations.mxd

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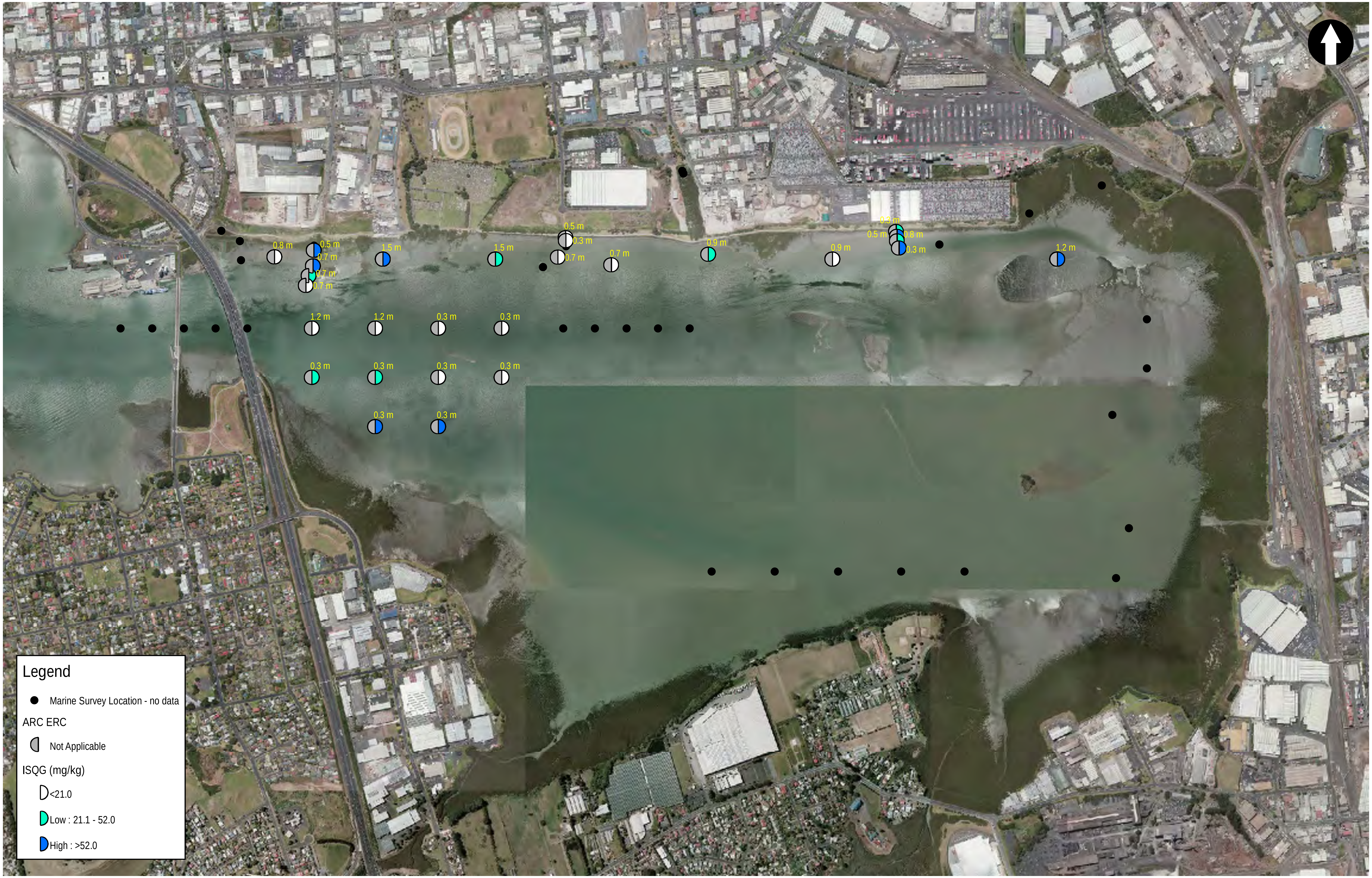
Drawing Title
ECOLOGY
Map 4-12 : Concentration of Nickel in sediment <0.1m

Drawing Number GIS-AEE-EC-MA-004.5 | Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-005_T16006_27_Marine_Map4_Nickel_Concentrations.mxd



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Drawing Title
ECOLOGY
Map 4-13 : Maximum concentration of Nickel detected in sediment >0.1m

Drawing Number GIS-AEE-EC-MA-004.11 | Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-011_T16006_33_Marine_Map4_Nickel_Deep_Concentrations.mxd

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Drawing Title: **ECOLOGY**

Map 4-14 : Concentration of Zinc in sediment <0.1m

Drawing Number: GIS-AEE-EC-MA-004.6 — Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-006_T16006_28_Marine_Map4_Zinc_Concentrations.mxd

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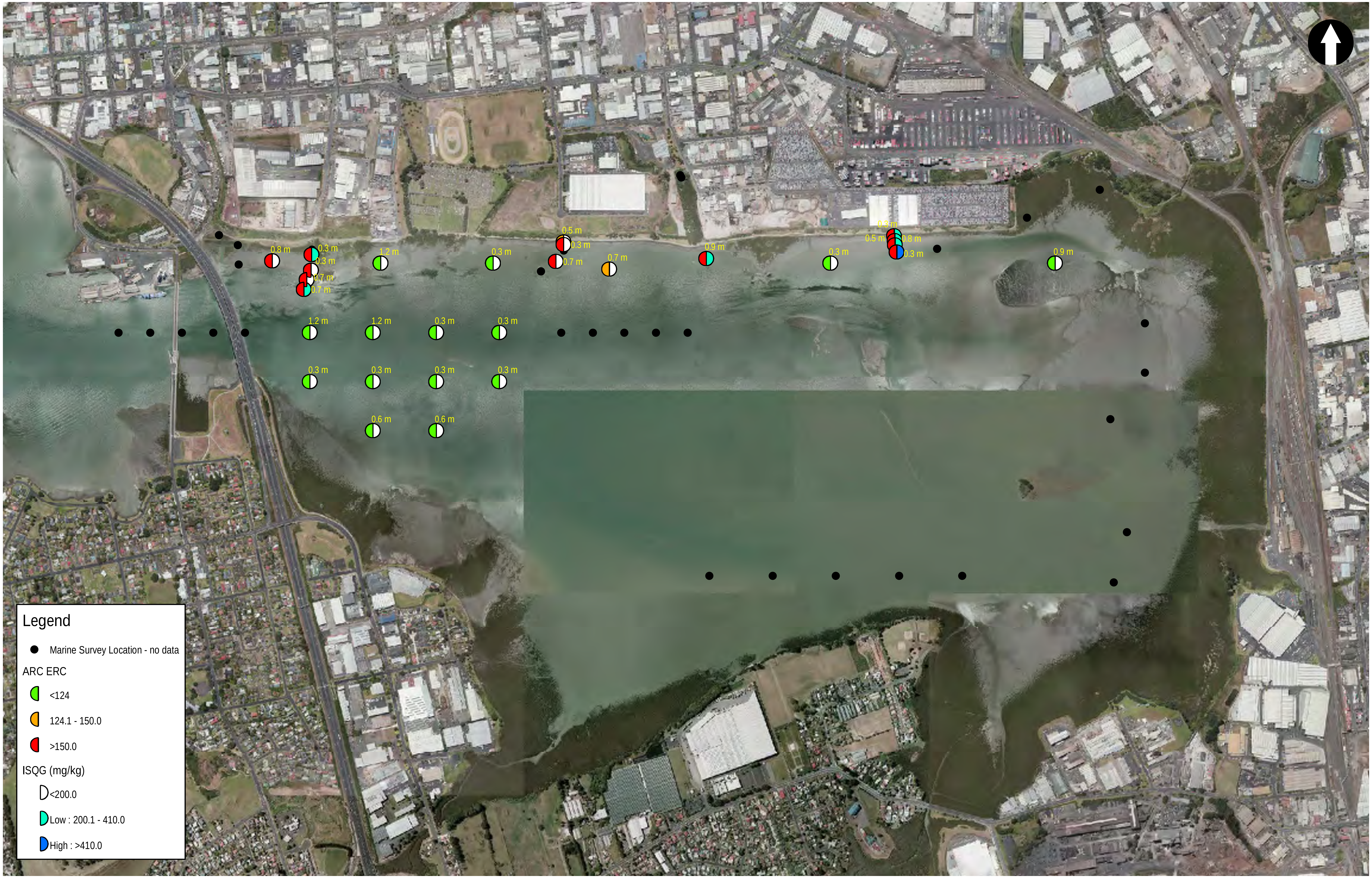

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Drawing Title
ECOLOGY
Map 4-15 : Maximum concentration of Zinc detected in sediment >0.1m

Drawing Number GIS-AEE-EC-MA-004.12 Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-HM-012_T16006_34_Marine_Map4_Zinc_Deep_Concentrations.mxd

Seven sites within subtidal sediment were above ERC amber and 1 site above ERC red threshold for copper (Map 4-8). Lead was detected above ISQG-high at one subtidal site (S16, 410 mg/kg) (Table 4-8, Map 4-10). Nickel concentration in sediment exceeded ISQG-low at three of the subtidal sites, with S15 having the highest concentration of 57 mg/kg (Table 4-8, Map 4-12). Zinc was also below effects thresholds in subtidal sediment Map 4-14). HMW PAHs in sediment were below ISQG and ERC thresholds.

Table 4-5: Northern intertidal sediment heavy metal contaminant summary

Northern Intertidal (including Anns Creek)						
Contaminant	Minimum concentration (mg/kg)	Maximum Concentration (mg/kg)	Number of samples >ISQG-Low	Percentage of samples >ISQG-Low	Number of samples >ISQG-High	Percentage of samples >ISQG-High
Arsenic	10	37	19 of 22	87	0 of 22	0
Chromium	27	83	1 of 22	5	0 of 22	0
Copper	15	69	3 of 29	10	2 of 22	9
Lead	15	74	7 of 29	24	0 of 22	0
Nickel	9.2	51	6 of 22	27	0 of 22	0
Zinc	97	390	11 of 29	38	2 of 22	9

Table 4-6: Eastern intertidal sediment heavy metal contaminant summary

Eastern Intertidal						
Contaminant	Minimum	Maximum	No. of samples >ISQG-Low	%	No. of samples >ISQG-High	%
Arsenic	16	34	2 of 5	40	0 of 5	0
Chromium	21	32	0 of 5	0	0 of 5	0
Copper	6.4	19	0 of 5	0	0 of 5	0
Lead	8.3	21	0 of 5	0	0 of 5	0
Nickel	8.5	14	0 of 5	0	0 of 5	0
Zinc	38	120	0 of 5	0	0 of 5	0

Table 4-7: Southern intertidal sediment heavy metal contaminant summary

Southern Intertidal						
Contaminant	Minimum	Maximum	No. of samples >ISQG-Low	%	No. of samples >ISQG-High	%
Arsenic	11	44	1 of 5	20	0 of 5	0
Chromium	14	31	0 of 5	0	0 of 5	0
Copper	6.1	25	0 of 5	0	0 of 5	0
Lead	10	23	0 of 5	0	0 of 5	0
Nickel	7.6	9.4	0 of 5	0	0 of 5	0
Zinc	39	130	0 of 5	0	0 of 5	0

Table 4-8: Subtidal sediment heavy metal contaminant summary

Subtidal						
Contaminant	**Minimum**	**Maximum**	**No. of samples >ISQG-Low**	**%**	**No. of samples >ISQG-High**	**%**
Arsenic	15	32	9 of 20	45	0 of 20	0
Chromium	22	68	0 of 20	0	0 of 20	0
Copper	6.2	86	1 of 20	5	0 of 20	0
Lead	7.7	410	0 of 20	0	1 of 20	5
Nickel	11	57	3 of 20	15	1 of 20	5
Zinc	38	160	0 of 20	0	0 of 20	0

4.4.2.4 Sediment Grain Size

Sediment grain size in Mangere Inlet is characterised as comprising almost exclusively soft muds (MHX, 2006) dominated by very fine particles i.e. <32µm (Kelly, 2008). Sediment grain size collected for this project at selected sites (53, 54, 55 and 62) also indicated a high proportion of silt and clay fraction (<63µm) sediment (66-84%).

4.4.2.5 Benthic Invertebrate Assemblages

Existing benthic invertebrate data

Auckland Council routinely monitor the benthic invertebrate assemblage within the Mangere Inlet. Along with sediment quality, benthic invertebrate composition assists with the assessment of ecological condition where a score of one is healthy and a score of five is degraded (Anderson et al., 2006). Benthic communities at Anns Creek and Tarata Creek (on the southern shore) scored a health rank of five, whereas Mangere Cemetery and Harania Creek (on the southern shore) scored a health rank of four (Kelly, 2008).

Historically, shellfish are reported to have been diverse and abundant within the Mangere Inlet, including pipi, scallops and mussels (Waitangi Tribunal, 1985).

EWL Project benthic invertebrate data

The abundance of invertebrates within each core sample collected by the EWL Project Team varied significantly among locations within the Mangere Inlet. The northern shore and Miami Stream estuary had the lowest abundance (approximately 20 and 17 individuals per core respectively), with the eastern shore the next most abundant (approximately 60 per core), with the southern shore and subtidal habitats having approximately 100 individuals per core sample. Anns Creek estuary had the highest abundance with approximately 140 individuals per core (Figure 4-1).

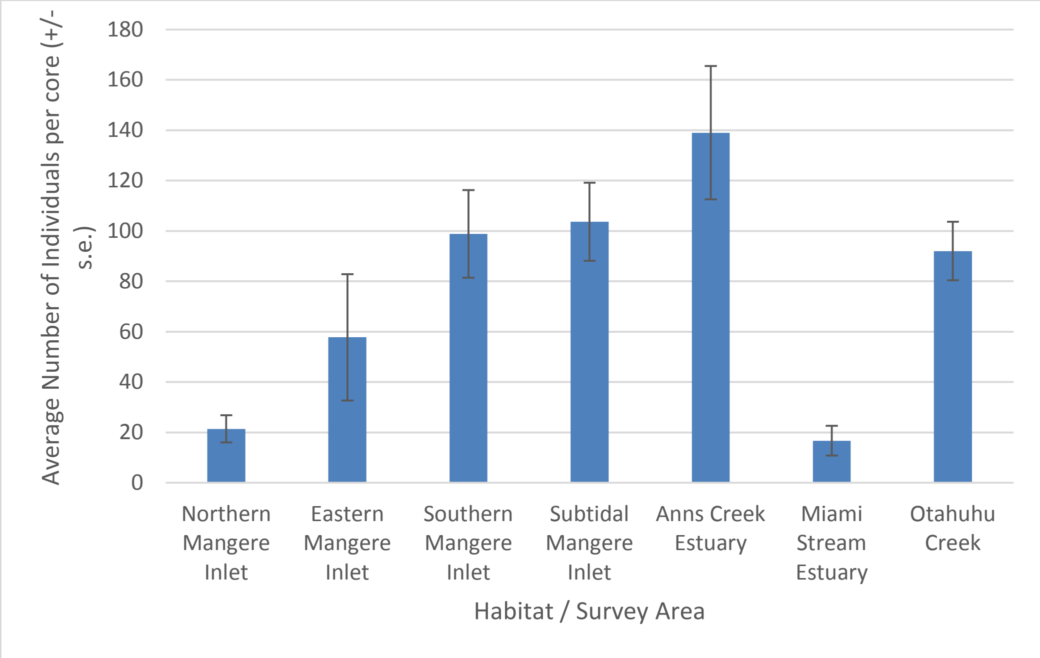

Figure 4-1: Average abundance of benthic invertebrates per core sample

Within the Mangere Inlet, the number of species per core sample was also lowest at sites located along the northern shore and within Miami Stream estuary (approximately 4 and 1 per core respectively), followed by the eastern and southern shores (approximately 7 taxa per core) (Figure 4-2). The subtidal and Anns Creek estuary habitats had the highest number of species per core (approximately 9 and 10 per core respectively) (Figure 4-3).

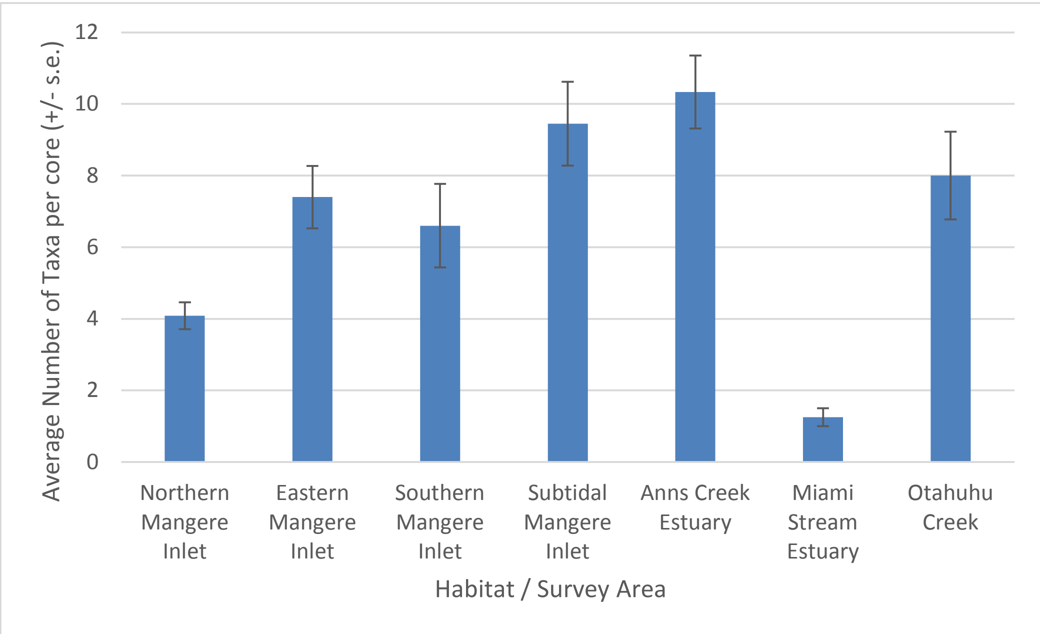

Figure 4-2: Average number of species per core.

Shannon-Wiener Diversity takes into account both number of taxa and evenness (i.e. the spread of individuals across individual taxa). Communities with a large number of species that are evenly distributed are the most diverse and communities with few species that are dominated by one species are the least diverse. In general terms, a diversity index of less than 1 indicates very low to low diversity, between 1 and 1.5 indicates moderate diversity, >1.5 indicates moderate to high diversity and >2 indicates high diversity.

Within the Mangere Inlet, Shannon-Wiener diversity was highest in the subtidal habitat and Anns Creek estuary at approximately 1.3, indicating moderate diversity. Similarly, the invertebrate assemblage on the eastern shore has moderate diversity (1.2), whereas the southern and northern shores have the lowest diversity of around 0.9 (Figure 4-3). Diversity indices for cores collected within Miami Stream could not be calculated due to the very low number of taxa (most sites had only one species present).

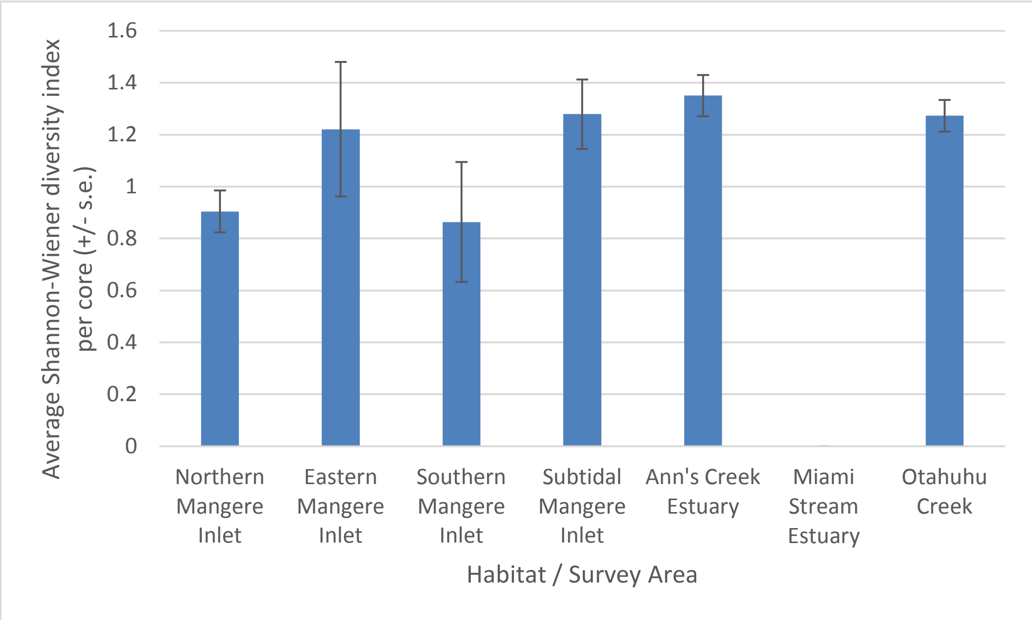

Figure 4-3: Average Shannon-Wiener Diversity Index

The proportion of each main taxa grouping differed among the habitat types. Polychaete worms dominate the subtidal assemblage (c. 80%), with almost 10% amphipods, 8% bivalves and 3-4% gastropods. Some of the subtidal cores had a high abundance of the invasive Asian date mussels (*Musculista senhousia*) and nut shell (*Nucula hartvigiana*) (Figure 4-4). Where Asian date mussels were detected (7 of the 20 subtidal sites), they tend to dominate the assemblage forming between 86% and 98% of the total benthic invertebrate abundance at three sites, and between 22% and 38% at another three sites.

Juvenile snapper have been documented as being associated with Asian date mussels, but only when the date mussel bed has a canopy of red algae, meaning that the fish are choosing to associate where there is algae not the mussels (Morrison et al., 2014). Asian date mussels provide some foraging habitat for fish, but at the expense of native invertebrates that also provide foraging habitat (Creese et al., 2007). A decline in indigenous shellfish has been linked to an increase in Asian date mussels (Morrison et al., 2014) in the Kaipara Harbour. In addition, the dense mats formed by the mussel can create humps up to 1m-1.5m which create navigational hazards. Overall, the presence of this invasive species reduces ecological values.

The assemblage at the eastern shore is also dominated by polychaete worms (c. 85%) with the balance comprising almost entirely bivalves. The southern shore assemblages has the highest proportion of bivalves (approximately 50%), with polychaetes comprising approximately 40% and amphipods, decapods and other taxa collectively forming 10% of the community. The northern shore has approximately 50% polychaetes, 10% oligochaetes, 6-7% decapods and 3-4% bivalves. “Other” taxa in the northern shore core samples make up more than 20% of the assemblage, primarily comprising barnacles and copepods (Figure 4-4). Within Anns Creek estuary, polychaetes comprised approximately 80% of the community, with bivalves forming approximately 20% (Figure 4-4). Bivalves included cockles (*Austrovenus stutchburyi*), wedge shell (*Macomona liliana*), nut shell (*Nucula hartvigiana*) and pipi (*Paphies australis*).

The benthic invertebrate assemblage within estuarine areas of Miami Stream comprised only oligochaete worms, with one sample also containing a single amphipod (Figure 4-4).

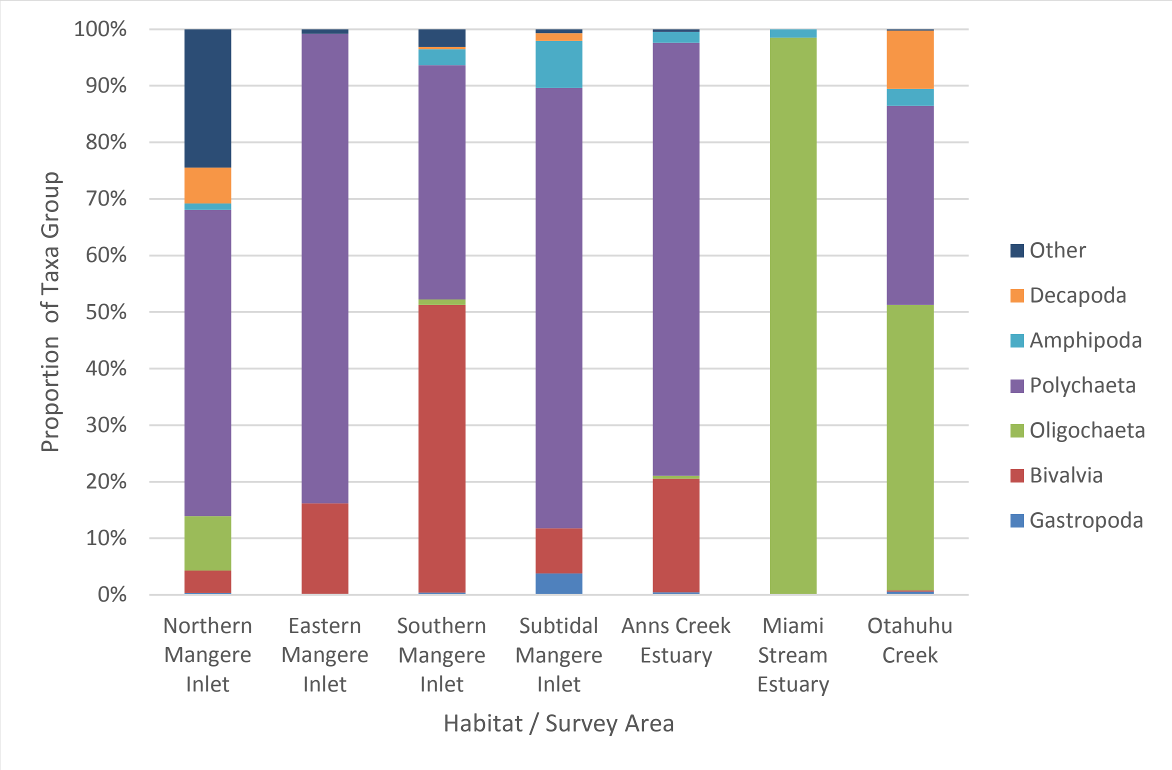

Figure 4-4: Proportion of benthic invertebrate taxa.

Within the polychaete worm taxa grouping, *Heteromastus filiformis* dominates the abundance at all sites i.e. 60% on northern shore, 65% on the eastern shore, 89% on the southern shore and 32% in the subtidal habitat. The spread of abundance within the polychaete worm taxa across species was more even in the subtidal habitat.

The abundance, number of taxa and Shannon-Wiener diversity index indicate that the northern shore has lower values for benthic invertebrates. The community assemblage along that shore also has a relatively high proportion of tolerant organisms, with the lowest abundance of bivalves and gastropods (excluding Miami Stream).

Multi-dimensional scaling provides a means of visualising similarity between samples within a data set using ordination techniques to display information in a distance matrix. A multi-dimensional scaling plot of the community assemblages (Figure 4-5) indicates that the northern and subtidal assemblages are quite disparate. Furthermore, these two assemblages also differ from the eastern and southern assemblages (which are similar to each other). The community composition at Miami Stream estuary and Otahuhu Creek are also distinct to all other assemblages, whereas the Anns Creek assemblage has similarities to the subtidal, northern and southern assemblages (Figure 4-5).

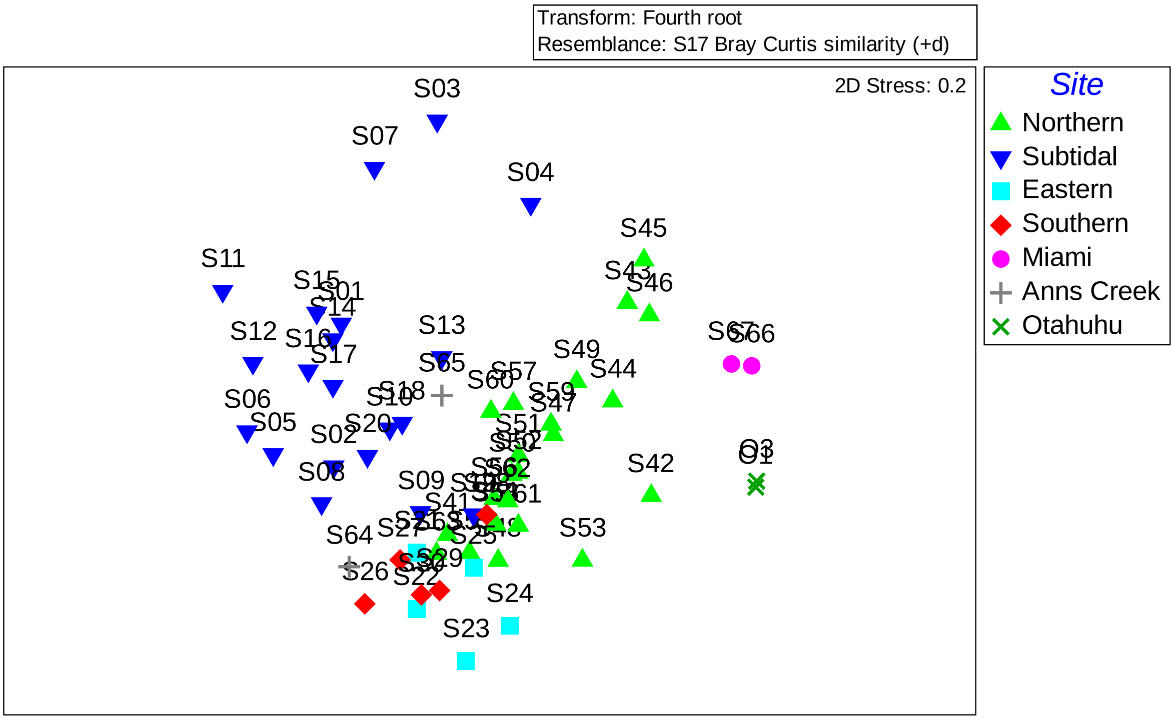

Figure 4-5: MDS plot of benthic invertebrate assemblage in Mangere Inlet[31]

Subtidal sites S03, S04 and S07 appear as outliers at the top of Figure 4-5 because they have high densities of the invasive Asian date mussel. The Asian date mussel forms dense mats bound together by byssal threads that form on top of the benthic sediment smothering infauna beneath them. These three samples have virtually no polychaete worms, which is a stark contrast to the other subtidal sites where a high diversity and abundance of polychaete worms are present. Sites S43, S45 and S46 from the northern shore of the Mangere Inlet appear to have slightly different assemblages to the remainder of the northern shore sites and as such appear as outliers towards the right of the plot (Figure 4-5). Interrogation of the raw data for these sampling sites indicates a lower diversity of polychaete worm taxa and in particular a lack of the commonly detected capitellid polychaete *Heteromastus filiformis*.

The permutational analysis of variance (permanova) statistical test of the community composition supported the MDS plot findings, with the northern assemblage and the subtidal assemblages being significantly different to all other assemblages and to each other. In addition, Miami Creek invertebrate community composition was found to be significantly different[32] to the eastern and southern assemblages, as was the Anns Creek community.

4.4.3 Contaminants in Shellfish

Historically, elevated contaminants have been detected in shellfish within and adjacent to Miami Stream (URS, 2010). Pacific oysters (*Crassostrea gigas*) were collected by the EWL Project Team from the northern shore (S45, S49 and S61) and analysed for body burden of contaminants (Appendix B). Arsenic, cadmium, lead, chromium, copper, nickel, zinc, polycyclic aromatic hydrocarbons, and derivatives of DDT

[31] Data were transformed using fourth root and Bray Curtis similarity multivariate analysis undertaken in order to prepare the multi-dimensional scaling plot (using PRIMER software).

[32] Highly depauperate and degraded.

were detected. Contaminants were present at low concentrations (Appendix B), apart from copper and zinc which were detected at higher concentrations (64-74 mg/kg and 290-430 mg/kg respectively).

The Australia New Zealand Food Standards Code provides maximum allowable levels in shellfish for human consumption, for some of the contaminants analysed in the oysters from Mangere Inlet i.e. cadmium, lead and inorganic arsenic (FSANZ, 2008). The concentration of those contaminants in oysters collected from Mangere Inlet was below the maximum allowable levels. Zinc and copper, whilst detected in elevated concentrations, are essential trace elements in humans, and as such there are no maximum allowable levels for these in food for human consumption.

Notwithstanding the analysis presented here for inorganic contaminants, the stormwater sampling undertaken for the Project (Technical Report 12) has measured elevated levels of indicator bacteria in the existing environment that could present unacceptable risks for consumption of shellfish in the receiving environment, particularly near stormwater outfalls.

In terms of adverse effects of contaminants on marine organisms themselves, it is possible that some contaminants, when present in sediment above effects threshold guideline concentrations[33], may be causing sublethal or lethal adverse effects on sensitive taxa. In addition, there is the possibility that there is some bioaccumulation of contaminants occurring up the food chain i.e. fish and birds that predate upon marine invertebrates with a body burden of contaminants.

4.4.4 Fish

Historically, fish are reported to have been diverse and abundant within Mangere Inlet and the wider Manukau Harbour (Waitangi Tribunal, 1985; Auckland Regional Water Board, 1990), including kahawai, snapper, shark, dogfish, kingfish, gurnard, hapuku, barracouta, flounder, mullet, parore, trevally, terakihi and eel.

While marine fish species and distribution have not been intensively studied in the Mangere Inlet, these ecological features can be inferred from surveys in estuaries nearby on the basis of the dominant habitat types that are present within the Inlet. Given that fish diversity is relatively well understood and the adverse effects of the proposed EWL project upon fish are likely to be negligible, surveys of fish were not included as part of this assessment.

The Mangere Inlet contains large mangrove stands and therefore likely provides habitat for fish species when inundated at high tide. Morrisey et al. (2007) found that the typical fish species that use mangrove habitats included sand and yellow-belly flounder (*Rhombosolea plebeia* and *R. leporina*) and snapper (*Pagrus auratus*).

In 2005, NIWA conducted fish surveys in mangrove and seagrass habitats of Auckland's east coast estuaries. Across all estuaries surveyed, yellow-eyed mullet (*Aldrichetta forsteri*) were found to be the most abundant fish in addition to juvenile short-fin eel (Anguilla australis). Other juvenile fish commonly detected by NIWA in east coast estuaries included parore (*Girella triscuspidata*) and grey mullet (*Mugil cephalus*) (NIWA, 2013a; b). It is likely that these species are also present within the Mangere Inlet at various times.

Recreational fishers commonly catch kahawai (*Arripis trutta*) and Jack mackeral (*Trachurus novaezelandiae*) at the mouth of the Mangere Inlet (Kelly & Sim-Smith, 2015).

Francis et al. (2011) estimated fish richness, occurrence and abundance from intertidal estuaries on the north and south islands of New Zealand. The study found that estuaries in the far north of New Zealand had the highest species richness, which was positively correlated with both the size of the estuary area

[33] Primarily along the northern shore of the Mangere Inlet adjacent to existing catchment stormwater discharge points.

and the area of intertidal habitat. The most abundant species caught included yellow-eye mullet, smelt (*Retropinna retropinna*), anchovy (*Engraulis australis*), NZ sprat (*Sprattus muelleri*), estuarine triplefin (*Grahamina nigripenne*) and exquisite goby (*Favonigobius exquisitus*).

4.4.4.1 Whales, Dolphins and Seals

Pilot and killer whales and dolphins, along with seals have been seen in the Manukau Harbour. It is highly unlikely that whales or dolphin would venture into the upper reaches of the Mangere Inlet. However, seals have been seen near the Mangere Wastewater Treatment Plant and other unusual places around the Manukau Harbour at times. However, it is highly unlikely that seals would swim into the Mangere Inlet for any length of time due to the habitat being primarily intertidal, the shallow depth of water at high tide and the barrier presented by the existing bridges at the mouth of the Mangere Inlet. Surveys of whales, dolphins or seals were not carried out as part of this assessment due to the negligible risk that the project construction and operation presents to these organisms.

4.4.4.2 Saline Vegetation

In 2006, the area within Mangere Inlet covered by mangroves was estimated at 110ha, predominantly at the eastern end of the inlet, and in Harania, Tararata and Anns Creeks. Mangroves form a narrow band along the northern shore adjacent to the rip rap revetment, whereas they extend into the intertidal area extensively along the eastern shore and southern shore. Saltmarsh has reduced in area significantly within the Inlet, with small areas currently present including 0.25ha area of batchelor's button in the south-east corner. Associated with the batchelor's button is the largest area of saltmarsh within the Inlet, comprising patch oioi, wiwi, *Baumea* spp, *Schoenoplectus* spp., needle grass and saltmarsh ribbonwood (MHX, 2006).

Observations of the remnant mangrove area within the Storage King site (Map 4-1) indicates that it receives tidal flows and stormwater discharges, contains rubbish and debris, presumably has elevated contaminant concentrations in sediment, and is likely to provide some low value habitat for marine organisms. Similarly, the isolated areas of mangrove are present in Anns Creek West severed by road and rail (Map 1) that not been surveyed are likely to comprise sediment with elevated contaminants, weed vegetation on the margins, and provide some low to moderate value habitat for marine organisms.

Mangrove removal has been undertaken by Auckland Council in recent years on the south-east and south-western shores of the Inlet, primarily for recreational access.

Saltmarsh vegetation is described in detail in Chapter 2 of this report.

4.4.5 Otahuhu Creek

Otahuhu Creek is a tidal creek which flows east to northeast into the Tamaki Estuary. The Creek is currently crossed by State Highway 1, with three box culverts supporting the alignment. At the location of the proposed widening of SH1, there are deep muds with a narrow incised stream channel on the eastern side of the box culverts;[34] the stream is wider on the western side (see Appendix A for photos). In order to construct SH1 over the Otahuhu Creek there has been historic reclamation over an area of 0.6ha. There are extensive mangroves, with the terrestrial environment bordered by a variety of exotic vegetation, the state highway and residential housing.

Maximum current velocities in the Tamaki Estuary are lowest at Otahuhu Creek (Kelly, 2008). Intertidal mudflats are extensive. Mangroves fringe the low tide channels within Otahuhu Creek and dominate the mudflats (occupying approximately 95% of the CMA west of the existing SH1 alignment), with negligible saltmarsh present between mangroves and land around the SH1 crossing (Kelly, 2008).

[34] Three 2.1m x 2.1m box culverts, approximately 40m long, with invert approximately 0.5m above mean sea level.

The intertidal areas within the Otahuhu Creek are recognised in the PAUP as a significant ecological area as they provide extensive areas of foraging habitat for wading birds (SEA-M2, 45c).

4.4.5.1 Water Quality

The Tamaki Estuary receives discharges from stormwater and at times wastewater. Suspended solids, turbidity, nutrients and faecal bacteria indicators fluctuate within the Tamaki Estuary (Kelly, 2008).

4.4.5.2 Sediment quality

Existing sediment quality data

A sediment quality sampling site at Otahuhu is included in Auckland Council's routine surface sediment monitoring programme. The site is located approximately 700 m downstream of the SH1 crossing. Data collected in 2008 indicate copper and lead above amber ERC thresholds (30 and 36 mg/kg respectively) and zinc above red ERC threshold (180 mg/kg). The concentrations of these three metals have increased since 2004. All contaminant concentrations detected were below ISQG-low.

Sediment at Otahuhu Creek has a high proportion of fine sediment (<63µm) (Kelly, 2008).

EWL sediment quality data

Two sediment samples (10cm deep) were collected immediately in June 2016 downstream of the culverts at Otahuhu Creek (Map 4-3). Sediment quality was similar to that at Mangere Inlet, although the arsenic concentration was significantly lower (average 12.5 mg/kg). Average copper concentration (38 mg/kg) was below ISQG-low, and above ERC red, whereas average lead concentration was above ISQG-low and ARC red (58.5 mg/kg). Zinc concentration was above ERC red but not above ISQG-low at 160 mg/kg. Nickel was detected above ISQG-low (28.5 mg/kg). HMW PAHs[35] (0.16 mg/kg and 0.015 mg/kg) were below ERC amber and ISQG-low guidelines.

4.4.5.3 Benthic ecology

Existing benthic ecology data

Auckland Council's routine benthic invertebrate monitoring, along with sediment quality parameters, combine to indicate a benthic health score of four at Otahuhu. Phoxocephalid amphipods dominated the assemblage at Otahuhu.

EWL benthic ecology data

Surveys carried out for the East West project revealed a moderate average number of individuals (92) (Figure 4-1), number of taxa (8) (Figure 4-2), and Shannon-Wiener diversity (approximately 1.3) (Figure 4-3). While phoxocephalid amphipods were abundant in monitoring carried out by Auckland Council 700m downstream of SH1, they were not detected in the cores collected for the Project at SH1. Oligochaete worms and Polydorid polychaete worms dominated the assemblage. Mud crabs were also common (Figure 4-4). The invasive Asian date mussel was common within pockets of sediment between rocks within the main channel though not abundant on the muddy intertidal banks.

[35] Normalised to 1% total organic carbon.

4.4.5.4 Fish

There is limited data available on the species of fish present in the Tamaki Estuary, particularly near Otahuhu Creek. However, based on Francis et al. (2011) it is likely that speckled sole (*Peltorhamphus novaezeelandiae*), sand flounder (*Rhombosolea plebeia*), grey mullet and short-fin eel are present.

4.4.5.5 Saline Vegetation

Mangroves dominate the saline vegetation within the Tamaki Estuary, with 18ha occurring within the Otahuhu Creek area (Kelly, 2008). Kelly also recorded limited areas of saltmarsh habitat.

4.4.6 Summary of marine ecological values

The marine ecological values in the Mangere Inlet (Table 4-9) and Otahuhu Creek (Table 4-10) can be summarised and assessed with reference to Table 4-1 in the methodology section. In and of themselves, the marine ecological values are assessed as ranging between low and medium (i.e. medium overall) in both the Mangere Inlet (excluding Miami Stream estuary which has very low ecological value) and the Otahuhu Creek. No high value criterion were met at either location.

Table 4-9: Characteristics of Northern shore of Mangere Inlet

Ecological Value	Characteristics
Low	• Marine sediments dominated by silt and clay grain sizes. • Habitat highly modified (in parts).
Medium	• Benthic invertebrate community typically has moderate species richness, diversity and abundance. • Benthic invertebrate community has both (organic enrichment and mud) tolerant and sensitive taxa present. • Shallow depth of oxygenated surface sediment. • Contaminant concentrations in surface sediment generally below ISQG-high or ERC-red effects threshold concentrations. • Few invasive opportunistic and disturbance tolerant species present. • Estuarine vegetation provides moderate habitat for native fauna, excluding Anns Creek which provides high habitat values.

Table 4-10: Characteristics of Otahuhu Creek

Ecological Value	Characteristics
Low	• Benthic invertebrate community dominated by organic enrichment tolerant and mud tolerant organisms with few/no sensitive taxa present. • Marine sediments dominated by silt and clay grain sizes. • Invasive, opportunistic and disturbance tolerant species dominant.
Medium	• Benthic invertebrate community typically has moderate species richness, diversity and abundance. • Shallow depth of oxygenated surface sediment. • Contaminant concentrations in surface sediment generally below ISQG-high or ERC-red effects threshold concentrations. • Estuarine vegetation provides moderate habitat for native fauna. • Habitat modification limited.

The above combined value assessments (Table 4-9 and Table 4-10) indicates that although the sediment quality is compromised and the environment has been modified, it nonetheless supports ecologoically valuable communities of native benthic organisms, saline vegetation and birds.

4.5 Predicted project marine ecology effects

4.5.1 Scope of effects assessment

The proposed works are described in Part D of the AEE.

In the follow sections, the potential adverse effects and benefits of the project on marine ecological values are discussed.

The primary potential adverse effects on marine ecological values are around permanent loss of marine habitat, temporary habitat disturbance during construction, the discharge of runoff from open earthworks during construction and the discharge of treated stormwater during operational phase. For each adverse effect identified, the magnitude of effect is assessed (EIANZ, 2015). Benefits of the project to marine ecological values are also discussed.

4.5.2 Permanent habitat loss

4.5.2.1 Embankment – Sector 2

Construction of the embankment along the northern shore of the Mangere Inlet for the new alignment will involve reclamation and permanent occupation within the CMA over an area of 5.6 ha. This forms 1.2% of the intertidal mudflat habitat within the Mangere Inlet and 0.03% of present intertidal habitat within the Manukau Harbour.

The embankment material is expected to consist of an outer mudcrete barrier with an imported fill core. Effects on marine ecological values relating to production of mudcrete are discussed in Section 4.5.3.2. Ground improvements beneath the embankment are likely to be required. Improvements may involve excavation of marine sediment to be stabilised with cement to form mudcrete, excavation and removal of marine sediments along with placement of imported granular fill or strengthening by insitu mixing. In order to install drains to capture landfill leachate, the imported fill may be excavated in some areas.

The embankment will occupy intertidal mudflat habitat. Mudflat organisms within the embankment area include a low diversity and low abundance of benthic invertebrate taxa and sparse low stature mangroves. In addition, coastal edge vegetation will be removed[36].

The benthic invertebrates present within the embankment footprint are common to mudflat habitats, comprising polychaete and oligochaete worms, mud crabs, bivalve shellfish, barnacles and copepods. Benthic organisms within the embankment area will perish during construction.

In the context of the northern shore of the Mangere Inlet, the magnitude of effect of construction of the embankment on marine ecological values is considered to be High (Table 4-2) due to the major loss of features such that the post-development character will be permanently fundamentally changed.

In the broader context of the entire Mangere Inlet or the entire Manukau Harbour, the magnitude of effect of construction of the embankment is likely reduced to Moderate (Table 4-2), given the scale of the works.

[36] Refer to Chapter 2 of this report

4.5.2.2 Stormwater bund – Sector 2

Construction of the stormwater bund which will contain stormwater treatment wetlands and biofilters, pedestrian / recreational cycling paths, access points to the CMA and gravel intertidal areas will involve the permanent loss of 17.8ha of intertidal mudflat habitat, including low tide channels created by the numerous stormwater discharge points along the northern shore. This forms 3.3%[37] of the present intertidal mudflat habitat within the Mangere Inlet and 0.08% of intertidal habitat within the Manukau Harbour.

The same suite of organisms as described in section 4.5.2.1 will perish beneath the stormwater bund footprint.

Most of the stormwater treatment wetlands will be located immediately seaward of the main alignment. Tidal intrusion into the freshwater wetlands will be controlled through the use of flapgates or duckbill values. The seaward edge of the stormwater bund has been designed to incorporate mudcrete platforms and areas of riprap. The mudcrete platforms have been designed to allow for the establishment of sessile marine invertebrate species, potentially the development of small rock pools and provide a surface suitable for coastal avifauna to roost at high tide. It is not certain at this stage whether hard shore sessile invertebrates will colonise the mudcrete platforms as it is unknown whether suitable larvae will be transported via tidal exchange. There is the potential to experimentally transplant common marine invertebrate species from elsewhere in the Manukau Harbour to the platforms to try to encourage the early development of a self-sustaining hard shore community.

The riprap edges will provide some habitat for a limited range of hard shore species, primarily the small banded periwinkle, *Austrolittorina unifasciata*. This organism is present on the existing riprap and along the newly constructed hard shore edges of the Onehunga Foreshore. It is anticipated that the periwinkle will naturally colonise the area and not require transplanting from elsewhere.

Auckland Council have a sediment quality monitoring location (referred to as Mangere Cemetery) within the footprint of the stormwater bund. A new monitoring site will need to be investigated and established in consultation with Auckland Council as mitigation for this loss.

In the context of the northern shore of the Mangere Inlet, the magnitude of effect of construction of the stormwater bund on marine ecological values is considered to be High (Table 4-2) due to the major loss of features such that the post-development character will be permanently and fundamentally changed.

In the broader context of the entire Mangere Inlet or the entire Manukau Harbour, the magnitude of effect of construction of the stormwater bund is likely reduced to Moderate.

4.5.2.3 Bridge and boardwalk structures in the CMA

At the north-eastern end of the Mangere Inlet the alignment departs from the proposed embankment and is on a bridge structure across Anns Creek Estuary, through Anns Creek West and East, and the existing bridge at Otahuhu Creek will be widened.

Within Sector 3, the bridge structure across Anns Creek Estuary is proposed to be constructed using 35m spans, on 19 1800mm diameter piers supported by 2100mm bored piles below within the CMA. The permanent structure will vary between 24-30m wide. In order to construct the bridge temporary staging is required, requiring the installation of approximately 150 temporary staging piles in the CMA within Anns Creek Estuary. The temporary occupation of the CMA for the staging fingers is considered in section 4.5.3.1.

[37] The current intertidal habitat within Mangere Inlet comprises 537 ha.

The area of permanent occupation within the CMA associated with the bridge structure across Anns Creek estuary comprises 66m^2. The benthic invertebrate organisms (which are abundant and diverse within this area) and estuarine vegetation within the footprint of the piers and piles will perish.

Within Anns Creek West, south-west of the Mighty River Power site, the bridge structure crosses an estuarine remnant with two permanent piers (1800mm pier support by 2100mm pile) in the CMA. Temporary staging does not affect any area of CMA within Anns Creek West. The total area of permanent occupation for the two piers is 7m^2.

Within Sector 5, at Otahuhu Creek, in order to widen SH1, 13 new piers (900mm) will be located within the CMA. The area of permanent occupation will be approximately 8.3m^2. In addition, approximately 100 temporary piers will need to be installed to support the temporary staging (removed upon completion of construction).

The total area of marine environment to be permanently removed due to bridge structures is approximately 73m^2, which is 0.0014% of the intertidal mudflat habitat within Mangere Inlet and 0.00004% of the intertidal habitat within the wider Manukau Harbour. The total area of permanent occupation in the Otahuhu Creek for bridge piers is 8.3m^2.

The coastal processes assessment indicates low velocity tidal currents (less than 0.03m/s),[38] which are unlikely to generate scour around piers in the intertidal deposition habitat.

The landscape design incorporates construction of a network of 4m wide boardwalks through the CMA along the northern shore of the Mangere Inlet. Between the Galway Street area and the Waikaraka Cemetery (chainage 1000 to 1500) the boardwalk involves the removal of some mangroves at a maximum distance from the new CMA boundary of around approximately 25m. A c.110m length of boardwalk adjacent to the cemetery (chainage 1725 to 1850) joins two landscape features and may involve the loss of some mangrove trees, with the boardwalk located 15-20m from the new CMA boundary. In the CMA extending from adjacent to Captain Springs Road to west of Ports Link (chainage 2200 to 3050) the boardwalk is proposed to be located 25-45m from the new CMA boundary and is unlikely to involve the removal of mangroves. Boardwalk within the CMA permanently occupies an area of approximately 0.7 ha.

The magnitude of effect of permanent habitat loss due to installation of permanent bridge and boardwalk piers is considered to be Moderate (Table 4-2) due to partial change to existing features, including occupation of mudflat habitat and changes to coastal processes in the immediate vicinity of the bridge piers.

4.5.2.4 Estuarine habitat at Galway Street

Within Sector 1, the alignment and Galway Street east-bound exit occurs through an area of saltmarsh and salt meadow, comprising primarily glasswort and mangroves (approximately 2,750m^2 in area). The new alignment severs the connection between the estuarine vegetation habitat and the Mangere Inlet and construction of two stormwater treatment wetlands located one to the west and one to the east of Galway Street entirely removes this estuarine feature.

The total area of permanent intertidal habitat loss is incorporated in the calculation of the embankment in section 4.5.2.1.

In the context of the area of saltmarsh / sea meadow, the magnitude of effect of construction of the project is assessed as High, however the area is small and when considered in the context of saltmarsh and sea

[38] Section 7.1, Technical Report 15: Coastal Processes Assessment.

meadow habitat within the wider Mangere Inlet, the magnitude of effect could be considered Moderate (Table 4-2).

4.5.2.5 Miami Stream estuary

Miami Stream estuary is outside of the CMA and occurs upstream of the culvert adjacent to the existing coastal walkway. The mangrove dominated (tidally influenced) area (210m long, 0.5ha), and the freshwater stream dominated area (upstream, approximately 40m long) and surrounding vegetation (approximately 0.8ha) will be removed in order to construct a freshwater stormwater treatment wetland. Loss of freshwater habitat is also considered in chapter 3 of this report.

Permanent loss of tidal / stream habitat approximately 250m in length will be required.

The magnitude of effect of loss of the estuarine components within the Miami Stream is considered to be Very High (Table 4-2).

as total loss will occur in order to accommodate a stormwater treatment wetland. However, in the context of loss of mangrove habitat within the wider Mangere Inlet and Manukau Harbour, the magnitude of effect is considered to be Low (Table 4-2).

4.5.2.6 Cumulative effects on Mangere Inlet

Assessment of cumulative effects requires the consideration of appropriate temporal and spatial boundaries for the assessment, and consideration of the interactions of the ecological effects of the Project along with past and future activities. One type of cumulative effect is incremental habitat loss or degradation which can be difficult to assess on a project-by-project basis. The actual cumulative adverse effect of incremental loss or degradation can be difficult to measure due to the long time frames for measureable effects to manifest themselves and the multiple activities, projects or stressors that, in combination, cause incremental degradation and / or loss.

Incremental loss of marine habitat is the primary cumulative effect on marine ecological values from the Project.

For the EWL Project, in the context of cumulative effects on marine ecological values, we have considered the appropriate temporal scale is prior to all documented historic reclamation (c. 1940). We have determined that the appropriate spatial scale for consideration of cumulative effects is the Mangere Inlet. With respect to future effects, we are not aware of any projects in the Mangere Inlet that may involve reclamation.

It is estimated that approximately 190ha of marine environment has been historically reclaimed in the Mangere Inlet, primarily along the northern shore and around the Manukau Harbour Crossing bridge abutments. The total area of proposed reclamation and permanent occupation of the CMA for the Project within Mangere Inlet is approximately 24.2 ha, which is 4.5%[39] of the current intertidal habitat within the Mangere Inlet. The proposed reclamation and permanent occupation of the CMA is an additional 12.8% of the total already reclaimed in the Inlet. At the Manukau Harbour scale, this represents an increase in in loss of CMA from approximately 2.3% to 2.4% (Section 7.1, Technical Report 15). It is not possible to measure the actual cumulative effect of incremental habitat loss, as it is likely that each action or project that reduces habitat size has very small effects on marine organisms, communities and habitat values. Those very small effects may, in the long term, and in combination with other unrelated stressors, result in adverse effects on individuals, populations or communities e.g. loss of a sensitive species.

[39] Current intertidal area within Mangere Inlet is 537 ha.

Due to the difficulty in clearly demonstrating a measureable cause and effect relationship with incremental habitat loss and ecological value, the magnitude of effect of cumulative reclamation and occupation of estuarine ecosystems within the Mangere Inlet could be assessed as Negligible, but in order to be conservative we have assessed this effect as Low (Table 4-2).

4.5.3 Habitat disturbance

4.5.3.1 Physical disturbance beyond the permanent occupation

The Anns Creek estuary bridge involves temporary bridge staging including staging fingers to be in place for approximately 24 months. It is estimated that 150 temporary piles, each with a diameter of 710mm, are likely to be required within the CMA. The total area of marine habitat occupied by temporary piles will be approximately 60m^2. Within Otahuhu Creek, temporary piles will occupy 40m^2 of CMA. Total temporary occupation due to staging structures is 100m^2.

The temporary piles will be extracted at the end of construction. There is a small risk of some temporary piles becoming stuck in sediment that would need to be cut below the CMA surface in this situation.

The area of additional marine habitat seaward of the embankment and stormwater bund that may be physically disturbed during construction phase (e.g. for access) is estimated to be 11.6ha.

Benthic organisms and estuarine vegetation (primarily mangroves) within the temporary occupation areas will perish. The total area of temporary physical disturbance to benthic habitats will be approximately 11.7ha, which is 2.2% of the intertidal habitat in the Mangere Inlet and 0.05% of the intertidal habitat within the Manukau Harbour.

Due to the low tidal current (<0.3m/s), sediment will not be mobilised around piers and consequently there will be no scour hole created (Section 7.1 of Technical Report 15, Coastal Processes Assessment).

The magnitude of effect of physical habitat disturbance beyond the permanent footprint of the Project is considered to be Moderate (Table 4-2) in the short term and likely to be Low (Table 4-2) in the longer term, as estuarine habitats naturally recover from disturbance over time.

4.5.3.2 Subtidal dredging

In order to create mudcrete required for ground improvement works within the embankment and to create the naturalised platform edges to the stormwater bund, dredging of subtidal sediments is required.

The coastal processes assessment provides detail on how the dredging would be undertaken (Appendix F, Technical Report 15, Coastal Processes Assessment), with the following paragraphs being a summary of the approach.

A barge with specialised mechanical dredging equipment on board will be located in the deep subtidal habitat adjacent to the northern foreshore. An area of 15ha may be dredging to extract 230,000m^3 of marine mud at a sediment depth of 1.5m. In terms of ecological effects, the area of dredging should be minimised. The total subtidal channel area in the Mangere Inlet comprises 33 ha, of which the proposed 15ha is 45%.

Three areas are proposed to be dredged, the largest of which is subtidal and incorporates an area occupied by Asian date mussels (Source 1, Figure F1, Appendix F, Technical Report 15). Source 2 is within an area to be occupied by the new landscape feature and source 3 is at the eastern end of the Project within Anns Creek estuary where a new low tide channel will need to be created.

The area to be dredged should be the lower value subtidal area that is currently dominated by the invasive Asian date mussel, encompassing survey sites S02, S03, S04, S06, S07, S08, S09, and S10. A subtidal survey of the extent of Asian date mussel beds should be carried out prior to dredging works commencing and should inform the precise location of the dredging to maximise removal of Asian date mussels. Given the extensive spread of Asian date mussel within waterways in the Auckland region and its life history characteristics, disturbance to, and removal of, beds of this species is unlikely to facilitate spread to other parts of the marine environment. Removal of fecund adult mussels may reduce the release of gametes to the water column and therefore reduce the spread of this species[40].

If this subtidal area is dredged first to establish the outer bund then all the work behind it would be encapsulated and separated from the tide and would not discharge additional suspended sediment. To achieve this a navigation channel would need to be dredged within the intertidal mudflats between the dredged area and Waikaraka Park construction site where a pug mill would treat the mud with cement to become mudcrete. Construction and operation of the navigation channel in the intertidal mudflats is expected to disturb 1ha. Upon completion of the subtidal dredging, this intertidal navigation channel will be remediated by filling in with marine sediments. From the pug mill the mudcrete could be conveyed (via conveyor belt) to the working face. At that face the mudcrete would be dropped into its final position for later shaping.

Sources of sediment from the dredging/placing operation that could create a sediment plume which would be dispersed around the Inlet/harbour are:

- From the dredger bucket;
- Overflow from the receiving barge; and
- Placement of the mudcrete material,

Dredging with a mechanical dredge will generate sediment material that will fall back into the seawater. One of the benefits of mechanical dredging when compared to other techniques such as suction dredging is that most of that material remains intact and falls back into the dredged area as aggregates or clumps of material. It is estimated, based on previous monitoring and modelling studies (Appendix F of Technical Report 15 Coastal Processes Assessment) that approximately 4% of the silt/clay fraction becomes a passive source of sediment that may be released beyond the dredging area.

Mudcrete tends to bind well and not be dispersed when placing in the tide. In addition, half the volume will be placed above tide level and another half will be behind an outer bund. It is estimated that 0.5% of the mudcrete could be dispersed into the far field.

The fate of sediment and mudcrete during dredging and placement of mudcrete has been modelled using a mixing zone of 200m. The background concentration of suspended sediment (TSS) is an average of c. 26g/m^3, with a range of 10-150 g/m^3. The maximum TSS concentration 200m from any of the dredge source locations is 31 g/m^3. This increase in TSS is expected to occur over a 30 minute period. The increase in TSS is within the range of TSS currently experienced in the Inlet (Appendix F of Technical Report 15 Coastal Processes Assessment). The increase in concentration of TSS predicted through modelling occurring for a short timeframe is unlikely to have more than negligible effects on marine organisms.

Based on a the daily deposition rates generated by 1kg/s of sediment release over 10 hours, the maximum and average sediment deposition rates awary from the dredge source location have been calculated and are presented in Section F2.4 of Appendix F, Technical Report 15. The greatest sediment deposition occurs due to dredging at Source 1, with maximum deposition of 5mm/yr and an average of 3mm/yr. When all of the dredging is considered together the maximum deposition is 6mm/yr and the average deposition is 4mm/yr. Deposition of sediment from dredging will add to the annual deposition occurring currently, but on the basis that 4-6mm does not deposit in a single event and instead occurs

[40] In Australia, dredging is one of the options considered for reducing Asian date mussel populations.

incrementally as would be expected, then adverse effects on marine ecology are expected to be negligible[41].

It is noted that the sediment material is not an introduced source, it is the same as the native material. In addition, the elutriate tests for the native sediment indicate that there are no water quality issues (Section 6.17, Technical Report 13a) with contaminants being below the 80% protection thresholds in the ANZECC marine water quality guidelines.

Overall, sediment plumes and deposition associated with dredging will be to a lesser extent than the ambient levels of TSS, sediment fluxes and deposition (F2.5, Appendix F, Technical Report 15).

Benthic marine invertebrate assemblages are likely to readily recolonise the dredged area over time, particularly where Asian date mussel mats are removed, as those mats tend to smother all other benthic organisms beneath them. Therefore, disruption of the Asian date mussel mats by the dredging operations may have some short term ecological benefits, recognising that this taxa is opportunistic and invasive and likely to recolonise areas disturbed.

The primary effects of the dredging operation include temporary disturbance to intertidal mudflats (and morality of benthic invertebrates within that area) to create navigation channel, removal of and disturbance to subtidal sediment due to the dredging operation itself (involving mortality of benthic invertebrates including an invasive species), temporary increased suspended and deposited sediment due to loss from the dredger bucket and barge. The magnitude of effect of subtidal dredging is considered to be Moderate in the short term and likely to be Low (Table 4-2) in the longer term, as estuarine habitats naturally recover from disturbance over time and recolonisation by benthic invertebrate organisms occurs.

4.5.3.3 Disturbance to sediment contaminants

Contaminant concentrations in marine sediments have been detected above ISQG-high at some sites, primarily along the northern shore of the Mangere Inlet and within Miami Stream estuary (section 4.4.2.3). However, when considering the average concentration of contaminants (see Figure 1, Appendix E of Technical Report 15 Coastal Processes Assessment), only arsenic is above ISQG-low threshold.

The potential for the discharge and release of contaminants from sediment and porewater during excavation within the CMA is considered in Appendix E of Technical Report 15 Coastal Processes Assessment. The primary contaminant of concern is ammoniacal nitrogen, which is present in sediment porewater in concentrations 10 times higher than the ANZECC 90% protection level. Disturbance of sediment may release the ammoniacal nitrogen to the ambient seawater. A 10 times dilution will be required to ensure no observable effects on marine receptors (Appendix E of Technical Report 15 Coastal Processes Assessment).

In addition, copper is present in porewater at a concentration three times higher than the 90% ANZECC protection level threshold, and zinc at two times the 90% ANZECC. A dilution factor of 3 and 2 times for copper and zinc respectively will be required to ensure that water quality is within ecological effects thresholds (Appendix E of Technical Report 15 Coastal Processes Assessment).

The magnitude of effect of disturbance of sediments containing elevated concentrations of contaminants is considered to be Low (Table 4-2), based on the low risk to ecology described in Technical Report 15 Coastal Processes Assessment and temporary nature of the effect.

[41] Based on Lohrer et al., 2004 that suggests that the most sensitive organisms can suffer sublethal stress when >3mm of silt and clay is deposited on top of benthic sediment.

4.5.3.4 Noise and vibration

Noise and vibration may disturb marine organisms and coastal/wading birds. The main source of disturbance noise is likely to occur when temporary staging piles are driven into the sediments within Anns Creek estuary. Section 8 of Technical Report 8 (Construction Noise and Vibration Assessment) states that underwater noise will not have significant adverse effects on marine mammals and fish because the piles are driven into shallow water within the intertidal habitat which minimises sound propagation. In addition, mammals are unlikely to venture into Mangere Inlet and both fish and mammals are able to avoid noisy areas.

The noise assessment states that the worst case for piling of 900mm steel piles in mudflats is a risk of injury to marine mammals and fish within 10m of each pile, with wider behavioural responses extending up to approximately 200m from each pile within intertidal habitat. Piles will also be driven along the northern shore to support the boardwalk. It is estimated that construction of the boardwalk will take approximately three months. We recommend the use of wooden dollys to reduce pile driving noise.

Marine invertebrates within benthic sediment are likely to be adversely affected by noise and vibration during the driving of piles. However, the disturbance will be temporary, the species present are common and ubiquitous in the Mangere Inlet and most marine invertebrates respond to stressors such as noise and vibration by temporarily ceasing feeding and movement while exposed.

Coastal and wading birds may be disturbed during installation of driven piles. This is more of concern within Anns Creek estuary, if *Threatened* and *At-Risk* species are found to breed in this area. These potential effects are addressed in chapter 5 of this report.

Nonetheless, the noise assessment recommends that conservative measures be undertaken, such as "soft starts" for piling and passive visual monitoring of the water with management protocols[42] in place in the unlikely event that a marine mammal is identified during piling (Section 9, Technical Report 8 Construction Noise and Vibration Assessment).

The magnitude of effect of noise and vibration during construction of the project is considered to be Low (Table 4-2) and temporary.

4.5.3.5 Changes to coastal processes

Mangere Inlet

NIWA have modelled the project in terms of tidal currents and sedimentation (Appendix C, Coastal Processes Assessment). NIWA calculated a maximum tidal current change within the new embayments along the northern coastline with a reduction in flow of 0.1m/s. Elsewhere in the Inlet, the change in tidal currents is estimated to be a reduction of 0.05 m/s. These changes are assessed as having negligible effects on coastal processes (Section 7.2, Technical Report 15 Coastal Processes Assessment).

NIWA's modelling indicates that the general circulation of tidal currents will not be changed due to the project but that the average sediment deposition in the Inlet will increase from 9.8mm to 10.5mm annually. Deposition within the new embayments on the northern shore will increase from 25mm/year to 5mm/year (Section 7.2, Technical Report 15 Coastal Processes Assessment).

[42] For example, ceasing piling until the mammal moves away.

Sediment deposition within the inlet is predicted to continue at approximately 10mm/year and the tidal channels have approximately the same level of erosion as the existing situation remaining morphologically stable (Section 7.2, Technical Report 15 Coastal Processes Assessment).

No scouring around piles is expected as the peak tidal velocity is predicted to be less than that required to mobilise marine mud (Section 7.2, Technical Report 15 Coastal Processes Assessment).

The Coastal Processes Assessment (Section 7.3, Technical Report 15) states that design of a new tidal channel at the eastern end of the Project within Anns Creek needs to be carefully designed to mimic the geometry of the channel that will be removed.

The magnitude of effect of changes to coastal processes on marine ecological values in the Mangere Inlet is considered to be Low (Table 4-2) (and permanent) due to the EWL project.

Otahuhu Creek

The works within Otahuhu Creek involve removal of the existing culverts, declamation (0.55ha) of part of the existing southern abutment, re-alignment of the tidal channel to the original location and installation of a new bridge. Under the new bridge abutments, where the environment will be shaded and vegetation growth may be limited, rock armouring is required to provide protection from waves/currents. In addition, the Coastal Processes Assessment (Section 8.1) states that slopes that are not shaded should be planted to provide stabilisation and that a a 10m strip seaward of the base of the new slope be planted in mangroves to aid stability and provide resistance to new stream migration.

Effects on coastal processes from the proposed works are considered to be beneficial (Section 9, Technical Report 15). Testuary is expected to remain depositional with minimal erosion risk to the coastline. Removal of the culverts will, however, need to be undertaken in a manner that minimises disturbance to the marine environment.

4.5.4 Structures affecting connectivity of ecological features / habitats

Loss of connectivity of marine / estuarine ecological features occurs at various locations along the proposed alignment including;

- Saltmarsh / sea meadow and the intertidal mudflats adjacent to Galway Street;
- Severing the mangrove stands within the Anns Creek estuary to construct the bridge structure;
- The boardwalk structures within the CMA along the northern shore provide at least a partial barrier to marine organisms, with areas of CMA landward of the boardwalk structures separated by structure, but remaining hydrolically connected;
- Removal of parts of vegetation sequences within the Anns Creek estuary from terrestrial vegetation to mangroves to construct the bridge structure; and
- Increasing the distance from the original northern shoreline to CMA through reclamation to create the embankment and stormwater bund.

The magnitude of effect of disconnecting ecological features is considered to be Moderate (Table 4-2) due to the post-development character and attributes being partially changed.

4.5.4.1 Operational disturbance

During operation of the new alignment there may be some relatively minor new noise and light disturbance to marine organisms due to the proximity of vehicles along parts of the alignment i.e. across Anns Creek estuary and adjacent to the stormwater bund and treatment wetlands. In addition, there may be some disturbance to marine organisms from pedestrian use of the boardwalk features within the CMA. However, the low level of new disturbance to marine ecology is assessed as negligible.

4.5.5 Construction sediment

4.5.5.1 Erosion and sediment control

Excluding the embankment, there are relatively small areas of earthworks that could generate sediment-laden runoff that would discharge directly to the CMA. The majority of earthworks involves placement of structural fill comprising less than 10% fine grain sizes (Technical Report 12: Surface Water Assessment).

Based on USLE calculations the amount of terrigenous sediment entering the CMA from potential open earthworks during a large rainfall event would be relatively small compared to the total contributing catchment of approximately 34 km^2. The runoff from 5ha of open earthwork area would result in approximately 10 tonnes of sediment discharged to the harbour over a year (with erosion and sediment controls in place), compared to 1000 tonnes i.e. 1% of the annual sediment load to the Inlet (Technical Report 12: Surface Water Assessment). As some of the earthworks will occur over historic landfills, it is even more important that potential discharges of sediment and water (and associated contaminants) from these areas are managed and appropriately treated prior to discharge into the CMA. The proposed construction erosion and sediment control management plan will address this risk. The erosion and sediment control proposed will be designed to achieve 75% removal of TSS quality of discharge to the CMA.

During construction of embankment and stormwater bund water within these areas will be pumped into settlement tanks or decanting earth bunds, where treatment will be provided to achieve the same quality as above (Technical Report 12: Surface Water Assessment).

The magnitude of effect of the discharge of treated runoff during open earthworks is considered to be Low (Table 4-2). However, in larger rainfall event, with unstabilised open earthworks, the magnitude of effect could be Moderate, depending on the size of the rainfall event (Table 4-2) due to the potential overflow of untreated runoff depositing sediment on top of benthic invertebrate assemblages.

4.5.6 Discharge of treated road runoff

The design objective for runoff from the proposed alignment is to cater for a 1 in 10 year rainfall event, with treatment in accordance with Auckland Council and the Transport Agency's requirements. In addition, where works occur within and adjacent to areas of existing state highway, runoff from both the new and existing impermeable surfaces will be treated.

A series of stormwater treatment ponds and proprietary devices are proposed along the alignment (see Plan Set 1: Road Alignment), with the annual average treatment being to remove 75% of total suspended solids and associated contaminants prior to discharge to receiving environments (Technical Report 12, Surface Water Assessment).

Within Sector 1, ten stormfilters, one new treatment wetland (S1A) and one existing treatment pond to be converted to a wetland (S1B) will treat runoff prior to discharge to the CMA.

Along the proposed embankment (Sector 2), runoff from the road and part of the structure across the Port land and to the north of Anns Creek estuary will be to the freshwater wetlands to be established within the CMA.

Within Sector 3 there are five stormfilters proposed to treat road runoff. Three storm filters will discharge to the reticulation system, which is turn currently discharges to the estuarine remnant within the Southdown Reserve, one will discharge to Anns Creek East via a new outfall structure on the boundary with TR Group and one will discharge to the reticulation system which discharges to the Anns Creek Reserve Wetland at Great South Road south of the Kiwirail corridor.

In addition, within Sector 3, one stormwater wetland is proposed (S3A), with treated discharges entering the estuarine remnant within the Southdown Reserve.

Sector 4 incorporates seven stormfilters, of which five discharge to the stormwater reticulation system which currently discharges into Anns Creek at Great South Road and two will discharge to the stormwater pipework currently discharging to Clemow Stream at the Mount Wellington interchange.

Within Sector 5 three stormfilters will discharge to the stormwater reticulation system which discharges to Clemow Stream at the Mount Wellington Interchange, and a further four stormfilters will discharge to the CMA at Otahuhu Creek. One wetland (S5E) will replace the existing stormwater treatment pond, which discharges to a small tributary of the Tamaki River in Frank Grey Place.

The magnitude of effect of discharging treated road runoff to the marine environment is considered to be Low (Table 4-2).

4.5.7 Discharge of treated catchment stormwater and landfill leachate

4.5.7.1 Existing stormwater

The key objective of the EWL stormwater design is to treat regional and roadway stormwater runoff along the length of the embankment, with the objective being to improve water quality in the Mangere Inlet. The overall catchment that currently discharges to the CMA along the northern shore is approximately 1300 ha. Survey of the quality of the currently untreated baseflow of stormwater indicates copper and lead concentrations are slightly higher than the Auckland average, and zinc is slightly lower. However, TSS and faecal coliform concentrations are significantly higher than the Auckland average, with the faecal coliform concentration indicating likely cross-connection of stormwater and wastewater systems. The quality of first flush stormwater flows indicated higher concentrations of contaminants (Technical Report 12, Surface Water Assessment).

4.5.7.2 Existing landfill leachate

The existing reclamations along the northern shore of the Mangere Inlet include several closed landfills. The quality of the leachate from the landfills entering the CMA is comparable to other closed landfills in Auckland, other than ammoniacal nitrogen which is present in concentrations 50 times higher than the ANZECC 90% protection concentration for marine organisms (Technical Report 12, Surface Water Assessment).

4.5.7.3 Proposed treatment

In order to achieve 75% removal of total suspended solids and associated contaminants from catchment stormwater and leachate, a series of dual combination wetlands and bio-filtration areas seaward of the road embankment in the CMA are proposed. The treatment comprises gross-pollutant capture, removal of coarse sediment within the vegetated wetlands and then further treatment in vegetated bio-filtration areas. Ammoniacal nitrogen will be converted to nitrate for uptake by plants and microbes in the wetland / biofiltration system. Gaseous nitrogen losses will also occur in anaerobic zones of the treatment system via denitrification. The forebays will also provide an opportunity to detail and remove accidental discharges from surrounding catchment landuse activities before they reach the marine environment.

Some leachate contaminants will be bound in sediments due to the additional distance travelled to enter the CMA. There is also the opportunity for captured leachate to be treated in the stormwater wetlands.

It is estimated that the proposed treatment will prevent approximately 630 tonnes of sediment and 4,700 kg of total nitrogen from entering the Mangere Inlet each year. In addition, the load of metals, hydrocarbons and faecal coliforms discharged will be reduced (Appendix C, Technical Report 12, Surface Water Assessment).

The magnitude of effect of discharge of treated catchment stormwater and treated leachate is considered to be Low (Table 4-2).

4.5.8 Ecological benefits

4.5.8.1 Reduced contaminant load discharged to the CMA

Currently, the main contaminant sources along the northern shore of the Mangere Inlet that discharge to the CMA are:

- Contaminants in groundwater from current and historic land uses including metals, nutrients, petroleum hydrocarbons, PAHs, solvents;
- Landfills and reclamation – nutrients such as ammoniacal nitrogen;
- Stormwater – copper, zinc, lead, nutrients and faecal coliforms; and
- Sewer leakage to ground and/or cross-connection with stormwater yielding faecal coliforms and nutrients.

The proposed EWL design incorporates treatment of runoff from new and existing highway alignment, catchment stormwater and landfill leachate. A reduction in the load of contaminants discharged to the marine environment will reduce the accumulation of contaminants in benthic surface sediment and potentially reduce sublethal stress on marine organisms. In the long term, the reduced contaminant load, may encourage more sensitive marine organisms to inhabit the sediments within the Mangere Inlet, particularly along the northern shore where contaminant concentrations are highest.

The magnitude of positive effect on marine ecological values arising from the reduction of contaminants to the marine environment from a range of sources is considered to be Moderate.

4.5.8.2 Increased habitat diversity

Freshwater stormwater treatment wetlands are likely to provide some different habitat for organisms to colonise, however none of the organisms that may inhabit the wetlands are marine or estuarine, therefore there is no benefit to marine ecological values.

The creation of a more natural hard shore (mudcrete platforms) on the seaward edge of the stormwater bund may encourage colonisation by sessile marine organisms such as limpets, anemones, coralline algae, oysters, mussels and chitons. In addition, gastropods such as oyster borers and periwinkles may establish. However, in order for these organisms to establish there must be a supply of larvae in suspension and the created hardshore surface itself have appropriate characteristics to encourage settlement. Other intertidal mudcrete platforms present in the Waitemata Harbour (e.g. around stormwater outfalls at Kohimarama and St Heliers beaches) have been colonised by a diversity of hardshore organisms which suggests that colonisation should similarly occur naturally on hardshore created in the Mangere Inlet.

If hardshore communities develop on the naturalised edge of the stormwater bund, there is likely to be an increase in biodiversity in the immediate area. In order to increase the likelihood of successful colonisation by hardshore organisms, it is recommended that opportunities to experimentally translocate[43] common sessile organisms (or rocks with sessile organisms attached) from areas of high abundance elsewhere in the Manukau Harbour to the created hard shore areas in the Inlet.

The magnitude of positive effect from increased habitat diversity is considered to be Low (Table 4-2) due to the small scale of different habitats to be created and some uncertainty about colonisation by marine

[43] Permits to translocate organisms would need to be obtained from the Department of Conservation. In addition, permission from iwi would also be required.

organisms within the short term. However, should the hardshore communities develop and be sustained the positive effect in the medium to long term could be Moderate (Table 4-2).

4.6 Assessment of Potential Marine Ecology Effects

In accordance with the EIANZ Impact Assessment Guidelines, the magnitude of each adverse effect combined with the ecological values of the existing environment provides an understanding of the level of the adverse effect. Each of the effects identified in Section 4.5 above is assessed in terms of ecological values, magnitude of effect and level of overall effect is summarised in Table 4-11 below.

EIANZ guidelines state that very high, high and moderate levels of effect require avoidance or mitigation, whereas low and very low levels of effect are normally not of concern, but design, construction and operational care should be taken to minimise adverse effects.

Table 4-11: Assessment of level of effect on marine ecological values[44] at the location of the effect unless stated differently (without mitigation).

Potential Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature
ADVERSE EFFECTS				
Construction of embankment	Moderate	High	High	Permanent
Construction of stormwater bund	Moderate	High	High	Permanent
Loss of Auckland Council sediment quality monitoring site.	Moderate	Negligible	Moderate	Permanent
Construction of permanent bridge structures in the CMA	Moderate	Moderate	Moderate	Permanent
Loss of estuarine vegetation at Galway St	Moderate	Moderate	Moderate	Permanent
Loss of estuarine components of Miami Stream	Very Low	Very High	Low[45]	Permanent
Cumulative effects of permanent loss of CMA (Assessed at Mangere Inlet scale)	Moderate	Low	Low	Permanent
Temporary physical disturbance beyond the permanent occupation / reclamation footprint	Moderate	Moderate Low	Moderate Low	Short term Long term[46]
Subtidal dredging	Moderate	Moderate	Moderate	Short term

[44] Assessment of level of effect on marine ecological values is at the location of the effect unless stated differently in Table 4-11.

[45] EIANZ guidelines do not cover habitats with very low value. The assessment matrix has been modified in this instance to reflect total loss (very high magnitude) of a small habitat with very low ecological values, resulting in a permanent low level of effect.

[46] It is not possible to predict with certainty how rapidly benthic communities will re-establish in disturbed and dredged areas.

Potential Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature
(Assessed at the Mangere Inlet scale)		Low	Low	Long Term
Disturbance to sediment contaminants during construction	Moderate	Low	Low	Short term
Noise and vibration	Moderate	Low	Low	Short term
Changes to coastal processes (Assessed at the Mangere Inlet scale)	Moderate	Low Low	Low Low	Short term Permanent
Structures affecting connectivity of ecological features / habitats	Moderate	Moderate	Moderate	Permanent
Operational phase disturbance	Moderate	Negligible	Very Low	Permanent
Discharges from Erosion and Sediment Control devices	Moderate	Low-Moderate	Moderate	Short term
Discharge of treated road runoff	Moderate	Low	Low	Permanent
Discharge of treated catchment stormwater and landfill leachate	Moderate	Low	Low	Permanent
POSITIVE EFFECTS				
Reduced contaminant load discharged to the CMA (Assessed at the Mangere Inlet scale)	Moderate	Moderate	Moderate	Permanent
Increased habitat diversity from creation of new hard shore habitat (Assessed at the Mangere Inlet scale)	Moderate	Low Moderate	Low Moderate	Short term Permanent

The adverse effects identified in Table 4-11 that have a level of effect which is moderate or higher require mitigation. Those effects are as follows:

High

- Construction of embankment;
- Construction of stormwater bund.

Moderate

- Occupation of the CMA by permanent bridge structures;
- Loss of estuarine vegetation at Galway Street;
- Physical disturbance beyond the permanent occupation / reclamation footprint;
- Loss of Auckland Council sediment quality monitoring site.
- Subtidal dredging;
- Discharge of earthworks sediment during large rainfall event;
- Structures affecting connectivity of ecological features / habitats.

There are no Very High level of effects on marine ecological values from construction or operation of the Project.

The positive effects related to improved catchment stormwater treatment and increased habitat diversity are also acknowledged.

The high and moderate adverse effects identified above inform the suite of ecological mitigation proposed (Chapter 6 of this report).

4.7 Recommendations

The key principles to minimise the effects on marine ecological values that informed the design phase included:

- Minimising reclamation and permanent occupation footprint to decrease the areas of permanent loss of intertidal habitat.
- Longer bridge spans in the CMA to decrease the areas of permanent loss of intertidal habitat.
- Placement of bridge piers to avoid areas of higher ecological values, particularly in relation to Anns Creek estuary and Anns Creek East; and
- Investigate opportunities for declamation.

In order to mitigate and offset for the potential effects of the EWL project on the marine ecological values present, we recommend that the following should be included:

- Work with Auckland Council to establish a new sediment quality monitoring site;
- Add to the current scientific knowledge by carrying out the following research:
    - experimentally transplanting common hard shore organisms to the landward edge of the new landform features in order to determine if there is merit in facilitating colonisation and assist communities becoming self-sustaining;
    - investigate options to increase the abundance of intertidal prey organisms within the Mangere Inlet e.g. seeding of bivalves where sediment grain size is appropriate.
- Establish saltmarsh habitat between terrestrial and mangrove vegetation to replace areas which will be lost under the EWL footprint. Ideally this should be done in a location that may be utilised by banded rail e.g. Anns Creek estuary; and

The following monitoring is also recommended to further minimise potential effects and to determine the success of the proposed mitigation:

- Pre-construction and during-construction – establish adaptive management framework during earthwork / construction for the discharge of suspended sediment and/or sedimentation within the CMA during construction. The adaptive management framework should incorporate monitoring proposed, early warning triggers for potential adverse effects, remedial and mitigation steps to be taken if adverse effects occur, and feedback loop to the earthworks / construction programme;
- Post-construction monitoring of the seaward edge of the new landforms along the northern shore to determine if transplanted or naturally colonised marine organisms inhabit the hard shore. This forms part of the research described above. Addition to the scientific knowledge is the outcome of this recommended monitoring, whether colonisation is considered successful or not. The data gathered will assist with assessing the effects of future projects where artificial hard shores are proposed to be constructed within the marine environment;

- Post-construction monitoring of the quality of the treated stormwater from the treatment wetlands along the northern shore to confirm the performance assumed in the EWL assessments, including the marine ecology assessment. This monitoring will assist with validating the discharge quality assessments and will provide a feedback mechanism to determine if modification to treatment wetlands is required to achieve the required discharge quality.

4.8 References

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Appendix A

Site Photos

Northern shore, showing lava flows in the distance, mudflat and low tide channels.

Northern shore, showing low tide channel created by stormwater discharge.

Miami Stream discharge point to CMA.

Miami Stream estuarine habitat, upstream of the coastal walkway and outside of the CMA.

Miami Stream at pedestrian bridge – downstream.

Mangrove remnant within Storage King site.

Typical intertidal sediments along northern shore of Mangere Inlet.

Otahuhu Creek downstream of SH1.

Box culverts under SH1 within Otahuhu Creek.

Downstream of box culverts in Otahuhu Creek.

Appendix B

Biota Contaminant Survey

East West Link Alliance Memorandum

To:	Sharon DeLuca	**Date:**	12 Aug. 16
From:	Wijnand Udema	**Our Ref:**	
Copy:			
Subject:	Biota Investigation		

1 Biota Contaminant Investigation Methodology

1.1 Rationale for Biota Contaminant Investigation

Biota sampling and testing (chemical analysis of oyster flesh) was undertaken to provide an additional line of evidence for contaminants within the marine receiving environment. Shellfish are known to be good indicators of environmental pollution as their filter feeding tends to accumulate contaminants. They also can provide an indication of chemical toxicity and bioavailability, and as such oysters were selected for analysis.

1.2 Biota / Oyster Contaminant Sampling Methodology

Oysters were selected for the contaminant body burden analysis as they are relatively abundant within the Mangere inlet and are known to accumulate contaminants1,2,3. The Pacific oysters (*Crassostrea gigas*) that were collected for analysis were obtained from discrete locations that roughly coincided with the sediment sampling transects associated with the stormwater outfalls.

The slight variance in location is not considered to be a significant limitation as the oysters are bivalve filter feeders, meaning that they filter food particles (and contaminants) from the water. This means that contaminants in the oysters may vary from what is observed in sediments.

The oyster sampling comprised:

- Collection of approximately 1 kg of shelled oysters from each sample location
- Freezing of samples prior to dispatch to the laboratory to ensure preservation
- Dispatch to RJ Hill Laboratories in Hamilton for analysis
- Preparation of samples including shucking at the laboratory, compositing and homogenising samples for each location
- Selected samples were analysed for trace levels of polycyclic aromatic hydrocarbons, organochlorine pesticides and selected heavy metals.

A number of locations were sampled along the transects, but only the landward sample from each transect was analysed. This approach was considered appropriate as any contaminants were likely highest nearest point source discharge (i.e. end of the stormwater pipe). In the event that appreciable concentrations of contaminants were measured in these samples, then the remainder of the oyster samples along the transect could be analysed.

---

[1] Sericano, J.L., Wade, T.L. and Brooks, J.M., 1996. *Accumulation and depuration of organic contaminants by the American oyster (Crassostrea virginica).* Science of the total environment, 179, pp.149-160.

[2] Meador, J.P., Stein, J.E., Reichert, W.L. and Varanasi, U., 1995. *Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms*. In Reviews of environmental contamination and toxicology (pp. 79-165). Springer New York.

[3] Auckland Council 2014: Marine Water Quality Annual Report 2013, Auckland Council Technical report, TR2014/030, 2014.

Analytical results were compared to other studies on contaminant accumulation of contaminants in oysters for the Manukau Harbour and to New Zealand Food Safety Standards for consumption of shellfish. Whilst these are not environmental standards, they do provide an indication of suitability of shellfish for human consumption which is an important consideration for mana whenua.

Background Data

AC routinely undertakes Shellfish Contaminant Monitoring (SCMP) as part of its marine water quality programme. As shellfish are filter feeders, they process large volumes of water and suspended material in the water and have the capacity to bioaccumulate certain contaminants, such as heavy metals, organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), which may be present in the environment. As such the SCMP uses contaminant levels in oysters and mussels to provide an indirect measure of ambient seawater quality.4

The SCMP indicates that mussels and oysters in Mangere Inlet have elevated concentrations of DDT, chlordane, dieldrin and PCBs relative to the other monitoring sites, and that levels of organic contaminants are relatively high in the Mangere Inlet and Tamaki Estuary compared with other Auckland, and possibly New Zealand sites.5

The AC monitoring found that metal concentrations in Manukau oysters tend to be highly variable and do not provide much differentiation among sites.

A study on the variation of contaminants along a polluted gradient found high concentrations of zinc, copper, chlordane and polynuclear aromatic hydrocarbons in oysters from the more polluted areas and that generally the condition of the oysters improved with distance down the northern Manukau Harbour pollution gradient. towards the sea.

Results

The oyster sampling results show that the concentrations of arsenic, cadmium and lead in the flesh of the oysters were below the shellfish Maximum Allowance Levels for food. Low levels of PAHs and DDT isomers were also observed, however no guidelines were available for considering the significance of these contaminants for uses such as consumption.

Regards

Wijnand Udema
Contaminated Land Lead

Laura Bell
Senior Environmental Scientist

[4] Auckland Council, 2013. Shellfish Contaminant Monitoring Programme Review

[5] Auckland Council, 2004. Contaminant monitoring in shellfish: results of the 2002 shellfish contaminant monitoring programme Technical Publication 231

CHAPTER 5
AVIFAUNA

Quality Assurance Statement	
Prepared by	Dr Leigh Bull
Reviewed by	Dr Sharon De Luca

Executive Summary

1. This chapter of the Ecological Impact Assessment relates specifically to the assessment avifauna values and the potential effects on those values associated with the construction and operation of the EWL.

Existing Environment

2. Information regarding avifauna species and habitats associated with the EWL project and surrounding landscape was obtained through a combination of desktop investigations, literature reviews and field surveys. This information was used to determine the avifauna values present.

Coastal and Marine Avifauna Values

3. The wider Manukau Harbour has been identified as an important site for a number of *Threatened* and *At Risk* national and international migrant wading and shorebirds (Dowding & Moore, 2006; Southey, 2009; Veitch, 1978; Veitch & Habraken, 1999). It is estimated to support more than 20% of the total New Zealand wader population, and is recognised as a national “hotspot” for coastal bird diversity and endangered bird species.

4. The mangroves, saltmarsh and wading bird habitat at the mouth of Anns Creek in Mangere Inlet is identified as SEA-M1 in the PAUP and is contiguous with wading bird habitat. The SEA_M2 wading bird area in the wider Mangere Inlet extends to Pikes Point. Banded rail (*At Risk*) and Australasian bittern (*Threatened*) have been reported in the Anns Creek salt marsh, mangroves and wetlands.

5. As such, Anns Creek wetland (east and west) and estuary was identified as an area of very high avifauna value.

6. The Mangere Inlet is one of the last places in the Manukau to be covered and the first to be exposed, as the tide rises and falls, thus exposing the intertidal mudflats to foraging birds for greater periods of time relative to other parts of the Harbour.

7. The Mangere Inlet has been significantly modified by land reclamation along its northern side, with a highly urbanised catchment and elevated concentrations of sediment contaminants. Nevertheless, a diverse assemblage of species were recorded foraging on the Mangere Inlet intertidal mudflats and included NZ pied oystercatcher (*At Risk*), bar-tailed godwit (*At Risk*), pied stilt (*At Risk*), lesser knot (*Threatened*), wrybill (*Threatened*), northern NZ dotterel (*Threatened*), royal spoonbill (*At Risk*), white-faced heron, red-billed gull (*Threatened*) and black-backed gull.

8. A number of tern and shag species forage in low numbers in the channels and subtidal area of the Mangere Inlet.

9. Overall, the Mangere Inlet was identified as an area of very high avifauna value.

10. High tide roosts within the Mangere Inlet are currently limited but include Pikes Point reef and the large macrocarpa trees on Ngarango Otainui Island; both largely utilised by royal spoonbill. Other shorebirds do not appear to roost along the northern shoreline in significant numbers. Pikes Point reef was identified as an area of high avifauna value.

11. Other important high tide roosts within the wider area include the roofs of several industrial buildings, Ambury Park and Kiwi Esplanade.

12. The Otahuhu Creek, at the location of the proposed SH1 widening for EWL, was identified as having low avifauna values and does not provide the habitat for wading or shorebird as identified elsewhere within the Tamaki Estuary.

Terrestrial Avifauna Values

13. The northern shore of Mangere Inlet has been highly modified due to port activities, infrastructure and coastal reclamation. This is reflected in the terrestrial avifauna assemblage in the area which is dominated by exotic species; this is also the case for the upper Otahuhu Creek. No *Threatened* or *At Risk* land bird species were recorded.

14. Both the Otahuhu Creek and terrestrial component of the northern Mangere Inlet shoreline are considered to have low avifauna values.

Avifauna Assemblages

15. For the purpose of the assessment of effects on the avifauna associated with the EWL project, the overall assemblage values were determined to be as follows:
    - The wading and shorebird assemblage was determined to be Very High value due to the number of *Threatened* and *At Risk* species;
    - The cryptic marshbird assemblage (banded rail and bittern) was determined to be Very High value due the *Threatened* and *At Risk* classifications;
    - The landbird assemblage was determined to be of Low value due to it comprising primarily introduced and also widespread and common native species.

Ecological Effects

16. The Environmental Institute of Australian and New Zealand (EIANZ) Impact Assessment Guidelines were used as a basis for the assessment of effects, whereby the overall level of an effect is derived by using a matrix which combines the level of ecological value present with the magnitude of the effect of the proposed activities without mitigation.

17. The following effects were identified as potentially having a level of effect which is moderate or higher and therefore requiring mitigation:
    - Direct / permanent habitat loss for cryptic marshbirds (very high) and shorebirds (moderate);
    - Cumulative effects of permanent habitat loss for shorebirds (moderate);
    - Construction disturbance for cryptic marshbirds (very high) and shorebirds (moderate);
    - Construction mortalities for cryptic marshbirds, but only if banded rail are found to be breeding within the construction footprint (very high);
    - Indirect effect on food supply during construction for shorebirds (moderate) and cryptic marshbirds (moderate);
    - Operation disturbance, including effective habitat loss, for cryptic marshbirds (very high) and shorebirds (high); and
    - Operation mortalities for cryptic marshbirds (moderate).

18. Potential ecological benefits relevant to avifauna associated with the EWL include reduced containment load discharged into the CMA through improved catchment stormwater treatment and increased habitat diversity.

Recommendations

19. The recommended mitigation and offsetting approach to address the ecological effects of the EWL project is in the form of Proposed Mitigation (Chapter 6 of this report), which includes actions pertaining to avifauna.

5 Chapter 5 - Avifauna

5.1 Introduction

5.1.1 Purpose and Scope of this Report Chapter

This report forms part of a suite of technical reports prepared for the Transport Agency's East West Link project (the Project). Its purpose is to inform the AEE and to support the resource consent applications, new NoR and alterations to existing designation required for the EWL. This report assesses the potential effects on avifauna of the proposed Alignment of the Project as shown on the Project Drawings.

The purpose of this report is to:

- Identify and describe the existing avifauna values, habitats and environment;
- Describe the potential benefits and potential adverse effects of the Project on the existing avifauna values;
- Recommend measures as appropriate to avoid, remedy or mitigate[48] potential adverse effects on existing avifauna values (including any conditions/management plan required); and
- Present an overall conclusion of the level of potential adverse effects of the Project on the existing avifauna values after recommended measures are implemented.

5.2 Experience

5.2.1 Expertise

Dr Bull's qualifications include a Bachelor of Science degree in Zoology (Victoria University of Wellington), Masters of Science (Hons, 1st) in Ecology (Victoria University of Wellington), a Doctorate in Ecology and Biodiversity (Victoria University of Wellington) and a Post-doctorate Research Fellowship (Universite Paris Sud XI). Dr Bull has undertaken and prepared numerous avifauna monitoring programmes, habitat surveys, restoration plans and preparation and presentation of expert witness evidence. She has more than 14 years' experience in biodiversity and ornithology. Dr Bull is a Certified Environmental Practitioner with the Environment Institute of Australia and New Zealand and an Independent Hearings Commissioner.

Dr Bull has significant experience in assessment of effects on terrestrial, freshwater, coastal and oceanic avifauna. She has an in-depth understanding of potential construction and operational effects on avifauna values, having recently worked on a number of infrastructure projects including windfarms (e.g. West Wind, Te Uku, Waverly, Mt Munro), Lyttelton Port Recovery and Roads of National Significance (e.g. Transmission Gully, Mackays to Peka Peka, Puhoi to Warkworth) where impacts on coastal avifauna species have been a key issue.

[48] Including offset mitigation where appropriate.

5.3 Assessment Methodology

In preparing this report, several site visits have been undertaken, attendance at a number of workshops and meetings has occurred, numerous discussions and meetings with other experts involved in the project have been undertaken and review of other experts reports.

Our assessment was undertaken in four phases and included the following:

Phase 1 – Preliminary investigations

- Review of plans and maps and identification of avifauna values potentially affected by the Project;
- Literature and database review of existing information on avifauna in the project area (zone of influence); and
- Gap analysis to assess information gaps and identify the scope of the further investigations required.

Phase 2 – Existing environment

- Site investigations; and
- Determination of existing avifauna values.

Phase 3 – Design input and mitigation of adverse effects

- Review of project activities;
- Input to project design to avoid, remedy or mitigate adverse ecological effects; and
- Development of specific measures to mitigate or offset adverse effects on the avifauna values.

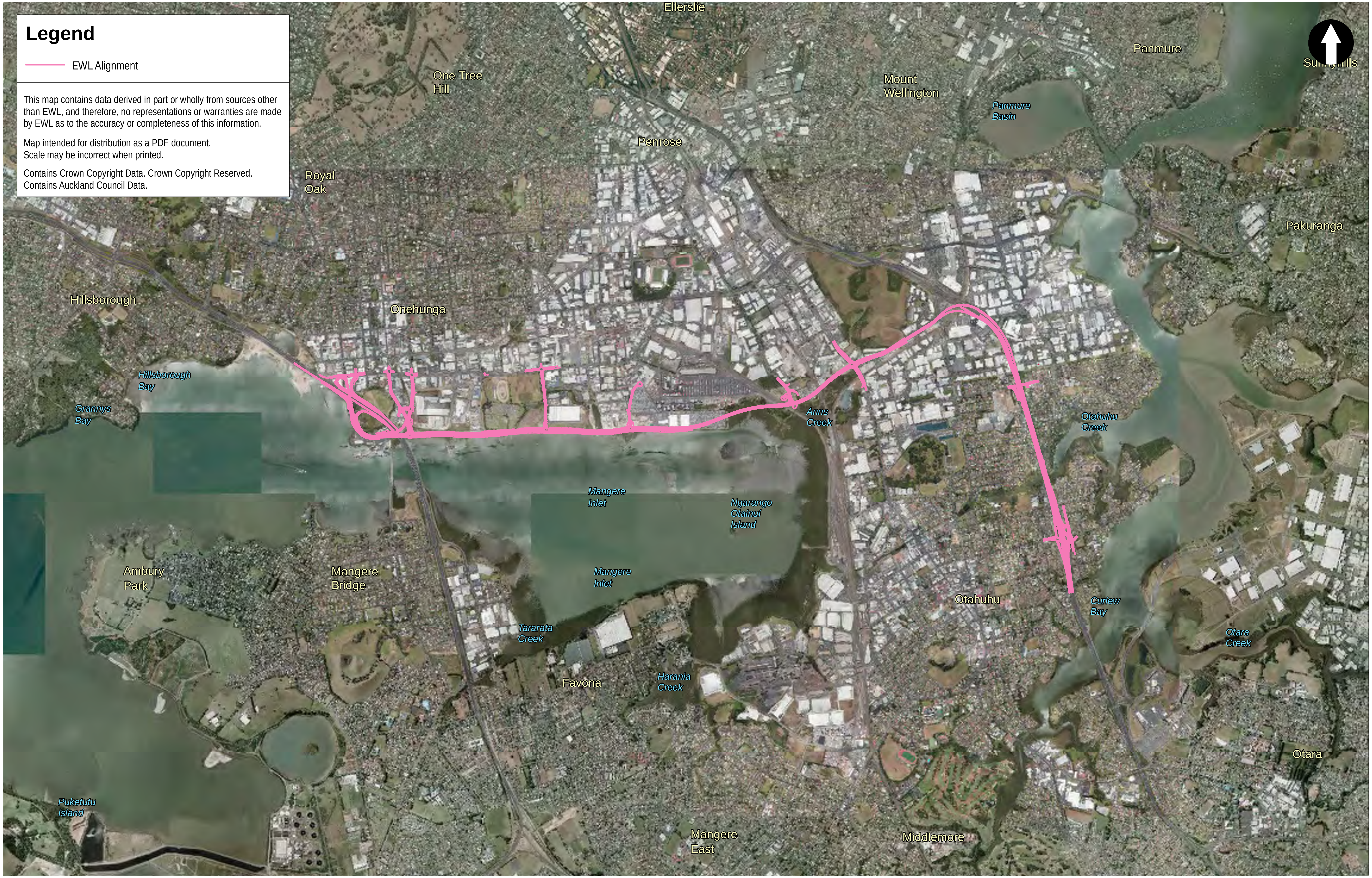
Phase 4 – Assessment of Effects

Assessment of adverse and beneficial effects of the construction and operation of the project on avifauna values, including direct loss of foraging, roosting or breeding habitat (permanent or temporary), and indirect effects on food supply (availability, quality and abundance) through sedimentation and disturbance.

5.3.1 Phase 1 – Preliminary Investigations

In Phase 1, the literature review included a review of aerial photography, Auckland Council GIS layers and preliminary avifauna investigations undertaken by Kessels & Associates (2016) (summer 2016). Further literature (published and unpublished) and website searches were undertaken to obtain additional information regarding avifauna species and habitats known to occur within the wider area.

Data from the Ornithological Society of New Zealand's (OSNZ) atlas (Robertson et al. 2007) was collated from three 10 km x 10 km grid squares (266, 647; 267, 647; 267, 646) which encompass the entire Mangere Inlet, the upper Otahuhu Creek arm and surrounding terrestrial area (refer to Map 5-1 and Map 5-2). Note that the squares include parts of the Manukau Harbour beyond the inlet, as well as the Tamaki River which is part of the upper Waitemata Harbour.



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Drawing Title
ECOLOGY
Map 5-1 : Avifauna - Project Area

Drawing Number GIS-AEE-EC-AV-001

Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskell\GIS-EC-AEE-AV-001_T16006_11_Avifauna_Map1_EnvironmentContext_ProjectAreaREV2.mxd

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ECOLOGY

Map 5-2: Avifauna - OSNZ map grids

Drawing Number GIS-AEE-EC-AV-002

Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-AV-002_T16006_12_Avifauna_Map2_OSNZ_mapgrids.mxd

The primary and secondary habitats[49] for each of the species recorded within these grid squares was obtained from Heather & Robertson (2005), along with each species' New Zealand threat status according to Robertson et al. (2013). The species list obtained from the OSNZ atlas data served as a base list of avifauna species recorded in the wider landscape and therefore potentially present at, or near, the project site.

The MCA assessment process involved providing input of the relative ecological effects for project workshops and scoring for MCA analysis as described in Part D: Consideration of Alternatives of the Assessment of Effects Report (Volume 1) and the Report 1: Assessment of Alternatives (Volume 3).

5.3.2 Phase 2 – Existing Environment

The following avifauna habitat features were identified and site visits undertaken by the project ornithologist (refer to Map 5-1): Onehunga foreshore, Mangere Inlet northern and southern coastal margins, Miami Stream, Anns Creek Estuary, Anns Creek lava flow shrubland and wetlands (Anns Creek West and East), Anns Creek Reserve wetland, upper Otahuhu Creek arm (Tamaki Inlet). Site photos of each of these habitats are provided in Appendix A. The purpose of these visits was to assist in ascertaining the value of these habitats and identify species occurring there.

As described below, more intensive field investigations were undertaken in those habitats that coincided with the EWL main alignment and the area of reclamation and occupation in the coastal marine area (CMA).

5.3.2.1 Shorebirds[50]

Mangere Inlet

Kessels & Associates (2016) established nine count sites (refer to Map 5-3) which were spaced so as to enable full coverage of the Mangere Inlet. The aim of the standardised survey was to assess the utilisation of the intertidal habitats by wading and shorebirds birds, and to identify any roosting areas along the shoreline.

The survey was replicated in both summer[51] and autumn[51] in order to capture both the international and national shorebird activity. Early February was chosen by Kessels & Associates (2016) as the time for the first (summer) survey as arctic waders mostly do not leave New Zealand on their northward migration until March, while many of the South Island migrants (primarily pied oystercatcher and wrybill) have returned to their non-breeding (wintering) areas on northern harbours. By May (autumn), the arctic migrants have returned to the northern hemisphere and the South Island migrants are at their northern New Zealand wintering grounds (e.g. Manukau Harbour, Firth of Thames, Kaipara Harbour etc.).

The survey dates are provided Table 5-1, along with the Mangere Inlet (Onehunga) tidal cycle and weather conditions on those dates. The count sites were visited in different orders to enable utilisation patterns of different parts of the estuary to be assessed at varying stages of the tide. Counts were made using a telescope or binoculars from fixed count stations, and notes were recorded regarding their behaviour (feeding, roosting etc.).

[49] For the purpose of this report, primary habitat refers to the habitat in which the species spends most of its time. Secondary habitats are other habitat types which the species may also utilise.

[50] For the purpose of this report, shorebirds includes long-legged wading species such as pied stilt, royal spoon bill and heron.

[51] All avifauna methodology was developed, and summer surveys conducted, by Kessels & Associates (2016). The autumn replicate surveys were undertaken by Boffa Miskell Ltd following the same methodology.

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ECOLOGY

Map 5-3 : Avifauna - Survey Sites

Drawing Number GIS-AEE-EC-AV-003

Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskell\GIS-EC-AEE-AV-003_T16006_13_Avifauna_Map3_SurveySites_Habitats.mxd

Table 5-1: Times of tides and surveys, Mangere Inlet

Date	High Tide	Low Tide	Survey Start	Survey Finish	Climatic Conditions
02/02/16	17:48	11:34	09:35	16:30	Fine or partly cloudy, high of 26°C, light winds.
03/02/16	18:52	12:42	10:20	16:20	Fine or partly cloudy, high of 26°C, moderate winds for a period.
12/02/16	14:21	20:37	18:10	20:10	Fine or partly cloudy, high of 25°C, light winds.
02/05/16	05:57	12:23	08:00	13:30	Fine or partly cloudy, high of 23°C, light winds.
03/05/16	07:04	13:28	10:30	14:30	Fine or partly cloudy, high of 23°C, light winds.

Tamaki Inlet – Otahuhu Creek

Due to the habitat present, as well as the relatively restricted nature and extent of works associated with the EWL being undertaken at the Otahuhu Creek site, a single site visit was undertaken on 13 May 2016 to the location of the proposed SH1 widening across the Otahuhu Creek arm. The site was visited during a falling tide in order to detect the presence of birds foraging along the stream margins and within the mangroves. All birds seen and heard during the 45 minute site visit were recorded.

5.3.2.2 Landbirds

While walking between the nine count sites (refer to Section 5.3.2.1), a roaming inventory was collated by recording all landbirds seen and heard along the northern shoreline of the Mangere Inlet walkway during the summer and autumn shorebird surveys.

A roaming inventory was collated of all land birds seen and heard at the location of the proposed widening across the Otahuhu Creek arm during the autumn 45 minute site visit (refer to Section 5.3.2.1).

5.3.2.3 Banded rail & Australasian bittern

Banded rail are generally restricted to mangroves and saltmarsh habitats, while Australasian bittern generally inhabit wetlands. Both are cryptic species, typically staying in dense vegetation or near the vegetation edge. This behaviour makes these species difficult to survey. While bittern are very difficult to survey reliably (males can be detected by their booming calls in the early part of the breeding season, roughly August to November), banded rails can more readily be detected visually, usually skulking at the edge of vegetation cover. They also leave distinctive footprints in mud, and respond to recorded calls (Kessels & Associates, 2016).

Banded rail and bittern were searched for by visually scanning mangrove margins through binoculars and telescope, and closer searches were made for footprints during the February survey period (Kessels & Associates, 2016).

Recorded banded rail calls were played during both the February and May site visits in order to try and elicit responses from birds occurring in the area. Playbacks were conducted at three locations considered to be likely habitat (refer to Map 5-3). Ten minute playback sampling sessions were completed at each location.

Four Department of Conservation (DOC) built acoustic recorders (ARs) were deployed by Kessels & Associates (2016) in and around suitable bittern and banded rail habitat from 2/02/2016 until 12/02/2016 (refer to Map 5-3). The ARs were left to record for 10 nights, recording 4 hours of acoustic data each morning and evening per AR to maximise detection of crepuscular calls of either species. The specific times the ARs were recording on each day was between 0400-0800 hr and 1800-2200 hr NZST.

As noted by Kessels & Associates (2016), the AR units have an effective detection radius of up to 200 m subject to background noise. The ARs record all audible sounds for the period programmed. The sound files were analysed using Raven Lite 1.0 Build 9 Update 22 software, developed by Cornell Lab of Ornithology Bioacoustics Research Programme. Calls were classified on the basis of their audible characteristics and by comparison of spectrograms.

5.3.2.4 Assigning Value

Ecological values have also been assigned to individual species as well as features / habitat. With regard to species, all New Zealand biota have been assessed by DOC against a standard set of criteria (described in Townsend et al. (2008)) and lists published for each taxonomic group.[52] This provides a consistent basis on which to assign ecological value for individual species (see Table 5-2).

Table 5-2: Criteria for assigning ecological value to species (based on Table 10 in EIANZ (2015))

ECOLOGICAL VALUE	SPECIES
Very High	*Nationally Threatened* *(Nationally Critical, Nationally Endangered, Nationally Vulnerable)*
High	*Nationally At Risk – Declining*
Moderate - High	*Nationally At Risk – Recovering, Relict, Naturally Uncommon)*
Moderate	Locally uncommon/rare, not nationally *Threatened* or *At Risk*
Low	*Not Threatened* nationally, common locally

5.3.3 Phase 3 – Design Input and Mitigation of Adverse Effects

Phase 3 included providing advice to the project team on design opportunities to avoid and reduce effects where possible, and develop mitigation where significant adverse effects on avifauna values were identified.

5.3.4 Phase 4 – Assessment of Effects

Phase 4 included a detailed assessment of effects of the project on the avifauna values. Environmental Institute of Australian and New Zealand (EIANZ) Impact Assessment Guidelines were used as a basis for the assessment of effects, whereby the overall level of an effect is derived by using a matrix (Table 5-3) which combines the level of ecological value present (Table 5-2) with the magnitude of the effect (Table 5-4) of the proposed activities without mitigation.

The EIANZ impact assessment guidelines state that the purpose of the document is to provide guidance on good practice in environmental management without being prescriptive. Further, the guidelines state that they are not binding, will be revised from time to time with user feedback and evolving good practice, and practitioners are able to deviate from the guidelines where they consider it is ecologically relevant and justifiable to do so. In addition, the EIANZ guidelines approach to combining values with magnitude of effect only allow for adverse effects. This assessment has also incorporated positive effects of the project within the matrix approach.

[52] Robertson et al.(2013) for birds.

Table 5-3: Matrix combining magnitude and value for determining the level of ecological impacts.

EFFECT LEVEL		Ecological &/or Conservation Value			
		Very High	High	Moderate	Low
Magnitude	Very High	Very High	Very High	High	Moderate
	High	Very High	Very High	Moderate	Low
	Moderate	Very High	High	Low	Very Low
	Low	Moderate	Moderate	Low	Very Low
	Negligible	Low	Low	Very Low	Very Low

Table 5-4: Criteria for describing effect magnitude

MAGNITUDE	DESCRIPTION
Very High	Total loss or very major alteration to key elements/ features of the baseline conditions such that the post development character/ composition/ 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 baseline (pre-development) conditions such that post development character/ composition/ 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 baseline conditions such that post development character/composition/attributes of baseline 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 baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline condition will be similar to pre-development circumstances/patterns; AND/OR Having a minor effect on the known population or range of the element/feature.
Negligible	Very slight change from 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.

5.4 Existing Environment - Avifauna

5.4.1 Habitats

5.4.1.1 Manukau Harbour, Mangere Inlet & terrestrial environment

Manukau Harbour is New Zealand's second largest harbour with a total area of c. 370 km^2 at mean high water spring (Kelly, 2008). Mangere Inlet, in the north-eastern corner of the Manukau harbour has an area of 6.6 km^2 (Kelly, 2008) being roughly rectangular in shape (approximately 3.5 km east to west and 2 km north to south). Refer to Map 5-3 for a broadscale representation of the Mangere Inlet marine habitats (see photos in Appendix A) and avifauna survey locations. The Mangere Inlet is one of the last places in the Manukau to be covered and the first to be exposed, as the tide rises and falls.

The northern shoreline has been extensively reclaimed and is now almost straight, apart from the indentation of Anns Creek in the north-eastern corner. The southern shore is somewhat less modified, and has two creeks (Tararata and Harania creeks) entering into it. As shown in Map 5-3, an extensive mangrove (*Avicennia marina*) fringe extends along the eastern and southern shores of the inner inlet, and parts of the northern shore (Kelly, 2008a, 2008b). We note that consented mangrove clearance operations have recently been undertaken in the south-western corner of the Mangere Inlet.

The inner inlet (above Mangere Bridge) is dominated by extensive areas of intertidal mudflats, much of which are exposed at low tide (Kelly, 2008a, 2008b) (see photos in Appendix A). A small island, Ngarango Otainui, is located at the eastern end, which has an associated small rocky reef. Other reefs, consisting either of volcanic rock or accumulations of Pacific oysters (*Crassostrea gigas*) occur elsewhere in the inlet (refer to Map 5-3), particularly along the northern shoreline, and are used as temporary mid-tide roosts by birds, although most are covered at high tide. There is also a small sandbank towards the western end of the inlet and a longer shellbank towards the eastern end (refer to Map 5-3) which are utilised by birds, though again they are covered on neap high tides.

The assessment of the marine ecology (Chapter 4 of Technical Report 16) for the EWL project found that the sediment grain size within the Mangere Inlet comprises a high proportion of silt and clay. Analysis of sediment contaminants reported metals detected in higher concentration primarily along the northern shore of the Inlet.[53] Benthic invertebrate samples found that the abundance of invertebrates per core collected varied significantly among locations within the Mangere Inlet; the northern shore and Miami Stream estuary had the lowest abundance (approximately 20 and 17 individuals per core respectively), the eastern shore was the next most abundant (approximately 60 per core), followed by the southern shore and subtidal habitats having approximately 100 individuals per core sample. Anns Creek estuary had the highest abundance with approximately 140 individuals per core. The number of species per core sample followed a similar pattern, with the lowest at sites located along the northern shore and within Miami Stream estuary (approximately 4 and 1 per core respectively), followed by the eastern and southern shores (approximately 7 taxa per core). The subtidal and Anns Creek estuary habitats had the highest number of species per core (approximately 9 and 10 per core respectively). Of all the sites sampled, the southern samples were found to have the greatest proportions of bivalves.

The walkway along the northern shoreline passes mostly through a narrow strip of parkland, with mown grass and plantings of exotic and indigenous trees (see photos in Appendix A). At the eastern end the trees are generally larger but less maintained, and there is a rather higher proportion of common indigenous forest species, while the western end has some rougher banks of exotic weeds such as fennel and rank grasses (Kessels & Associates, 2016). There is a small area of saline wetland with *Sarcocornia quinqueflora* and other saltmarsh species at the western end of the walkway near Galway Street.

5.4.1.2 Tamaki Inlet & terrestrial environment

Tamaki Estuary is a ca. 17 km long tidal inlet on the east coast of the Auckland isthmus. The estuary covers an area of approximately 1600 ha, a large proportion of which consists of low relief, intertidal sand/mudflats (Kelly, 2008a). The estuary is utilised by a range of New Zealand resident and migratory shorebirds, with the mid-to-lower reaches being particularly important due to the availability of roosting and feeding areas (see Table 5-5).

Many shorebirds move between the Manukau and Waitemata Harbours, presumably to take advantage of the extended feeding times resulting from the 3-hour tide differential (Dowding & Moore, 2006). As the tide rises in the Manukau Harbour, it is beginning to fall on the other side of the Auckland isthmus (Tamaki and Waitemata), and vice versa. Wading and shorebird flocks work the tidal difference to their advantage,

[53] Refer to Chapter 4 (Marine Ecology) of Technical Report 16 Ecological Impact Assessment for further details regarding the patterns of metal concentrations in surface sediment within the Mangere Inlet.

enabling them to feed for longer, or roost, merely by crossing the narrowest part of the isthmus to the other side, where the rich mudflats or roosting areas are being freshly exposed by the falling tide.[54]

In the upper Otahuhu Creek, at the location of the proposed widening of SH1, there are deep muds with a narrow incised stream channel on the eastern side of the box culverts; the stream is wider on the western side (see Appendix A for photos). There are extensive mangroves, with the terrestrial environment bordered by a variety of exotic vegetation (e.g. bamboo, agapanthus, privet etc), the state highway and residential housing.

Sediment at Otahuhu Creek has a high proportion of fine sediment. The assessment of the marine ecology (Chapter 4 of this report) of the Otahuhu Creek for the EWL project found that sediment quality was similar to that at Mangere Inlet, although the arsenic concentration was significantly lower (average 12.5 mg/kg). In terms of benthic invertebrates, a moderate average number of benthic invertebrate individuals and number of taxa were recorded, with Oligochaete worms and Polydorid polychaete worms dominating the assemblage.

5.4.1.3 Significant Ecological Areas

A number of significant ecological areas, listed in Table 5-5 and shown in Map 5-4, have been identified within the EWL project area and the wider landscape as having values of importance to avifauna species by Auckland Council (Auckland Council, 2004, 2013).

Table 5-5 Significant Ecological and Coastal Protection Areas having values pertaining to avifauna.

FEATURE	
CPA 21	Anns Creek - Mangroves in the intertidal area form part of a unique gradient with the only significant remaining piece of native shrublands on lava flows in the Tamaki ecological district.
CPA 22a-b	South East Mangere Inlet - Small upper intertidal area supporting a high diversity of native saline vegetation…. In the intertidal areas below the vegetated areas are extensive upper intertidal mudflats with dense populations of characteristic species.
CPA 23a-c	Ambury - This modified shoreline (23b) is used as a high tide roost by thousands of international migratory and New Zealand endemic wading birds including a number of *Threatened* species. It is the most important winter roost on the Manukau Harbour for South Island Pied Oystercatchers. The associated intertidal banks (23a, 23c) are a feeding ground for these birds and a variety of other coastal bird species.
CPA 24	Te Tau Bank East - This intertidal sandbank contains large numbers of shellfish, including edible species and species uncommon elsewhere in the Manukau Harbour. It is an important feeding area for wading birds.
CPA 25	Puketutu Island - The island is used as a high tide roost by a variety of wading birds including several *Threatened* species.
CPA 45 a-b	Pakuranga Creek and Roost - Pakuranga Creek roost (45a) is one of the roosting sites used by some of the hundreds of wading birds that feed within the Tamaki Estuary. The whole of the Tamaki Estuary is a regionally important wildlife habitat and has been selected by DOC as an ASCV. This roost is associated with the values of CPAs 47, 48, and 49 and forms an integral part of the wildlife habitat values of the estuary. The mangrove areas of Pakuranga Creek (45b) are regarded as the best example of mangrove habitat in the Tamaki Estuary
CPA 47	Tamaki River East Roost - One of the roosting sites used by some of the hundreds of wading birds that feed within the Tamaki Estuary. This roost is associated with the values of CPAs 45, 48 and 49.

[54] Environment Court evidence of Timothy George Lovegrove in the resource consent hearing between Newbury Holdings Limited (ENV-2006-AKL-000723) and Auckland Council.

FEATURE	
CPA 48	Tamaki East Bank - This intertidal bank is a feeding ground for the hundreds of wading birds that use the Tamaki Estuary. This feeding ground is associated with the values of CPAs 45, 47 and 49. This area also includes part of the Farm Cove ignimbrite, most of which is above MHWS.
CPA 49a-d	Tamaki Estuary West - Large river estuary where considerable areas of intertidal flats have accumulated and a sand-shell spit has built up near the entrance. The spit has been modified to create a variety of freshwater and estuarine habitats. Hundreds of mainly New Zealand endemic wading birds, including a number of *Threatened* species, use the spit and a stretch of coast nearer the entrance (49d) as high tide roosts. The intertidal banks (49a) contain extensive beds of shellfish and are a feeding ground for these birds. The spit and associated northern and southern intertidal banks, together comprise a wildlife habitat of regional importance. This area is associated with the values of CPAs 45, 47 and 48.
SEA-M2-45w2	Wading bird habitat - Extensive areas of feeding habitat for waders along this coastline.
SEA-M 21w1	Anns Creek, South East Mangere Inlet - Mangere Inlet wading bird habitat Wading bird habitat contiguous with ecological sequences from saltmarsh to freshwater wetland in Anns Creek (21) and with mangrove ecosystems along the coastline (23a).

5.4.2 Species

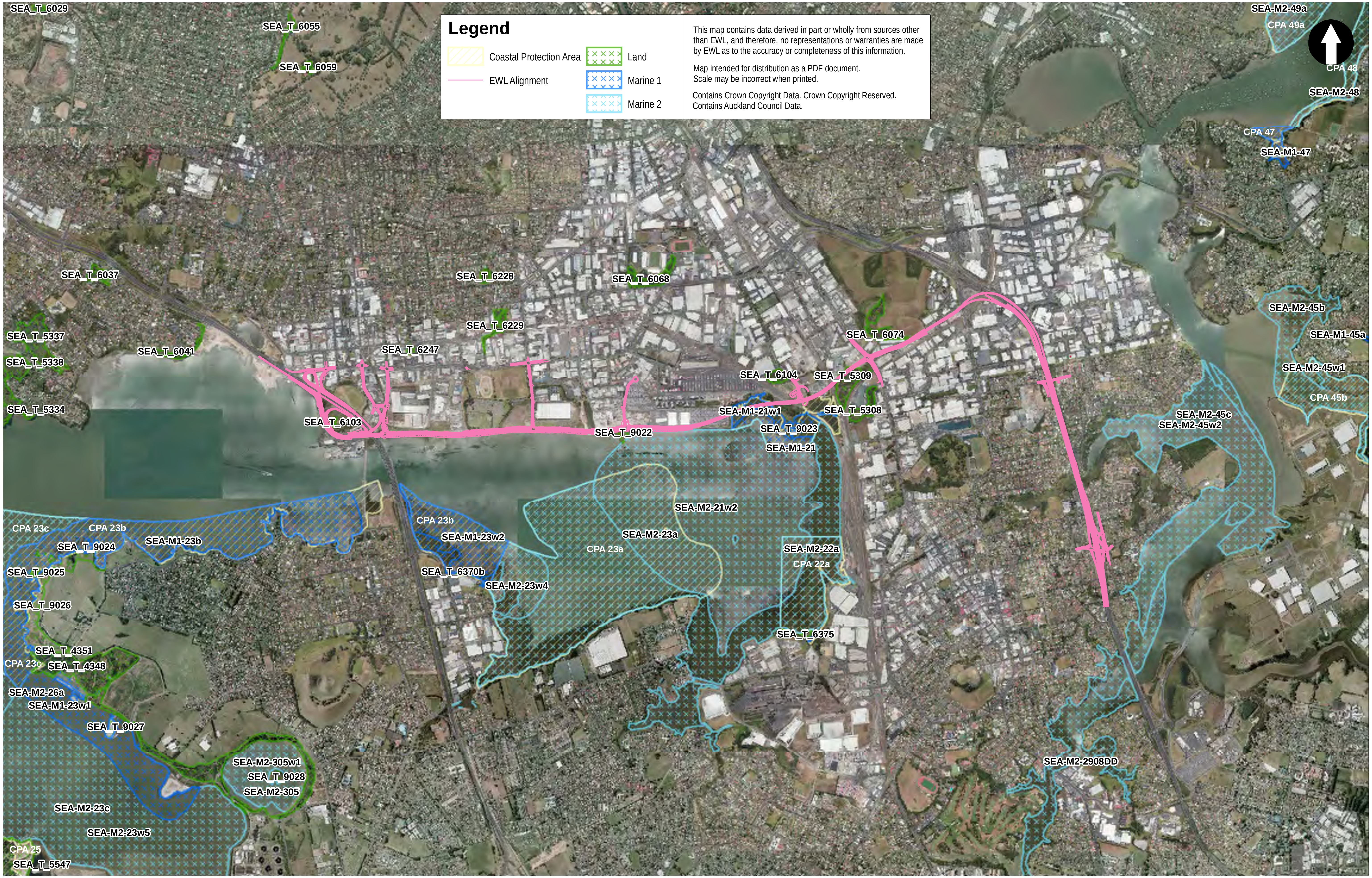
5.4.2.1 Desktop

Eighty-five bird species were recorded in the three 10x10 km OSNZ atlas grid squares covering the Mangere and Tamaki inlets (see Map 5-2) (Robertson et al., 2007). Details of the species recorded are presented in Appendix B. Birds occupying primarily coastal and/or aquatic habitats comprise more than half of the total, although these habitats make up only a small percentage of the area enclosed by the squares. We note that not all the species recorded in the OSNZ data will be present within the project area as it does not provide appropriate habitat for a number of those species. In addition, North Island fernbird (*At Risk -Declining*) are recorded from the north-western mapping square; Kessels & Associates (2016) suggested these may be the birds from the known population at Pollen Island[55] in the Waitemata Harbour, an area which is also included in that atlas square.

The wider Manukau Harbour has been identified as an important site for national and international migrant wading and shorebirds (Dowding & Moore, 2006; Southey, 2009; Veitch, 1978; Veitch & Habraken, 1999). In terms of significance, the Manukau Harbour has been reported to support over 20% of the total New Zealand wader population with potentially more than 60% of all New Zealand waders using the harbour on a temporary basis. As well as being nationally important, the harbour is also an internationally recognised area for a range of Northern Hemisphere waders that use the harbour as a foraging site during summer.

There are important roosts for waders south of Ambury Park, just a few kilometres from the mouth of the Mangere Inlet. Species using this area include eastern bar-tailed godwit, lesser knot, pied oystercatcher, variable oystercatcher, wrybill, New Zealand dotterel, banded dotterel and royal spoonbill. Significant numbers of waders, particularly pied oystercatchers, also roost along the foreshore of Kiwi Esplanade on the south-western shore of the entrance to the inlet (Kessels & Associates, 2016).

[55] http://www.forestandbird.org.nz/what-we-do/projects/motu-manawa



No	Issued Status	Drawn	Check'd	App'd	Date
A	ISSUED FOR INFORMATION ONLY	BAP	AYF	SDL	5/09/2016

DISCLAIMER

The information shown on this drawing is solely for the purpose of supporting application under the RMA for resource consents and/ or designations.
All information shown is subject to final design and review for compliance with any approved consents and/ or designations.
This Drawing must not be used for construction.

NZ TRANSPORT AGENCY

East West Link

Drawn	Drafting Check	Reviewed Design Manager	Approved Alliance Manager
Designed	Design Check		

Scale: 1:27,500 | Original Size: A3 | Contract No PA4041

Drawing Title: ECOLOGY

Map 5-4 : Avifauna - SEA's and CPA's

Drawing Number: GIS-AEE-EC-AV-004 | Rev No. A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\BoffaMiskel\GIS-EC-AEE-AV-004_T16006_14_Avifauna_Map4_PAUP_SEAs_ARC_CPAs.mxd

A number of species have had to adapt to the modified nature of the existing environment. For instance, NZ dotterels have recently been recorded breeding on the Onehunga foreshore reclamation site during construction, bounded by Neilson, Wharangi, Princes and Hill Streets.[56] Similarly, some industrial building rooftops in the area are also used as high tide roosts; some 20% of the global wrybill population at roost on one factory roof in Otahuhu.[57]

Lovegrove[54] noted that the Mangere Inlet is a particularly important site for the wrybill, with up to 1200 birds regularly feeding in the Mangere Inlet.

NatureWatch had one record of a reef heron (*Threatened* - Nationally Endangered) from near the shellbank in the eastern part of the Mangere Inlet, but all other bird records for the inlet are from west of Mangere Bridge. eBird records for the Mangere Inlet were entirely confined to the area west of the Manukau Harbour Crossing SH20 bridge. These do however make clear the importance of roosts along Kiwi Esplanade for the birds of the area, among which recently have been eastern curlew (*Numenius madagascariensis*, a rare migrant listed as Endangered by the International Union for the Conservation of Nature), among others.[58]

According to Appendix 6.1 (Schedule of Significant Ecological Areas – Marine) of the PAUP (Auckland Council, 2013), banded rail (*At Risk - Naturally Uncommon*) and Australasian bittern (*Threatened - Nationally Endangered*) are present around Anns Creek (SEA-M1-211) in the north-eastern corner of the inlet (Auckland Council, 2013). Lovegrove[54] reported both species as present within this area. In terms of Australasian species, it is unlikely that this species nests in the area but rather is a periodic visitor using this wetland as part of a wider habitat network (Tim Lovegrove, *pers. comm.,* 3/8/16). Golder Associates (2009) survey of Anns Creek lava flow shrubland and wetlands did not detect bittern, marsh or spotless crake, but noted that the surveys were conducted outside the period of peak activity.

Lovegrove[7] recorded the following birds in the Anns Creek area:

- Anns Creek and watercourses: black, pied and little shags, mallard duck;
- Salt marsh, mangroves and wetlands: white-faced heron, bittern, paradise shelduck, harrier, pheasant, pukeko, banded rail, pied stilt, spur-winged plover, black-backed gull and kingfisher; and
- Shrublands and open areas: spotted dove, rock pigeon, skylark, welcome swallow, dunnock, song thrush, blackbird, grey warbler, fantail, silvereye, yellowhammer, greenfinch, goldfinch, chaffinch, house sparrow, starling, myna and magpie.

The most common shorebirds within the wider Tamaki Inlet are the pied oystercatcher in autumn and winter, and godwit in summer. Together with pied stilts and knots, these can be seen seasonally on the coastal fringe and spit during high tide or feeding on the mudflats during low tide (Kelly, 2008a). The upper Tamaki River has been identified as an important feeding site for wrybill, often used by >1,000 birds from the upper-Manukau Harbour flock (Dowding & Moore, 2006).

In terms of landbirds, only one *Threatened* or *At Risk* species has been recorded (Robertson et al., 2007), namely New Zealand pipit (*At Risk - Declining*). This is a species of rough open country and therefore unlikely to be present in an industrial suburb of Auckland. However, its presence in low numbers along the coastal fringe of the Mangere Inlet is a possibility.

[56] http://www.birdingnz.net/forum/viewtopic.php?f=9&t=5193

[57] http://www.soulstopsha.org/uploads/5/3/6/6/53663059/talk_10_birds_of_the_manukau_tim_lovegrove.pdf

[58] http://ebird.org/ebird/view/checklist?subID=S25974563

5.4.2.2 Shorebird Observations

Tamaki Inlet

No wading or shorebirds were observed utilising the upper Otahuhu Creek arm of the Tamaki Inlet.

Mangere Inlet

Details of the wading and shorebird counts for each of the nine fixed point sites within the Mangere Inlet are provided in Appendix C. This data has been summarised in Table 5-6 for the summer and autumn surveys. Overall, the most abundant species in the inlet was pied oystercatcher, which were mostly observed foraging on the flats, usually close to the tide line, and also roosting and feeding on the oyster reefs.

Red-billed and black-backed gulls were also common (Table 5-6). Kessels & Associates (2016) reported that during the summer survey, black-backed gulls were particularly common at the eastern end of the inlet, assembling in large numbers on the flats, and particularly at the mouths of creeks, such as Miami Stream, where large numbers roost on the mud with mallards and smaller numbers of other species. At high tide gulls would float on the water in “rafts” of several dozen birds, apparently waiting for the tide to turn. Red-billed gull numbers were higher during the autumn counts. During both seasons this species was observed aggregating higher up the inlet (towards the east). Black-billed gulls were recorded only during the autumn counts and these were in low numbers (Table 5-6).

Pied stilt were observed in relatively low numbers, although 30 birds were recorded in a single count during the autumn survey at Mona Ave. Birds were observed foraging in the open mudflats or along stream channels.

During both seasons, white-faced herons were common. Kessels & Associates (2016) noted that white-faced heron numbers were highest on the falling tide, though significant numbers remained after low tide. As the tide rose herons were the most abundant species on the dry flats at the eastern end of the inlet, where few other birds were found at that time (Kessels & Associates, 2016). Bar-tailed and lesser knots were not recorded during the autumn survey (Table 5-6); as noted earlier, the summer survey was conducted in February to observe arctic migrants before they leave New Zealand in March for their northward migration. During the summer survey, Kessels & Associates (2016) noted considerable changes in bar-tailed godwit numbers between rising and falling tides. Also, godwits (along with pied oystercatchers and a few lesser knots) were recorded flying in from the west, probably from the Tamaki River, where the tide is approximately three hours ahead of Mangere Inlet.

Despite the Manukau Harbour being considered a summer stronghold for lesser knot (Medway, 2000), this species was observed only in low numbers in the Mangere Inlet and only during the summer survey (Kessels & Associates, 2016). Kessels & Associates (2016) speculated that the low numbers may have been due to limited food availability for lesser knots within the inlet. Other small wading species such as wrybill and northern New Zealand dotterel were also scarce (Table 5-6).

Table 5-6: Species recorded during the summer (February) and autumn (May) 2016 fixed point counts within the Mangere Inlet

SPECIES	THREAT CLASSIFICATION (Robertson et al. 2013)	SUMMER (Feb 2016)					AUTUMN (May 2016)					OVERALL				
		No. COUNTS	AVE PER COUNT	MIN	MAX	TOTAL	No. COUNTS	AVE PER COUNT	MIN	MAX	TOTAL	No. COUNTS	AVE PER COUNT	MIN	MAX	TOTAL
Bar-tailed godwit	*At Risk – Declining*	4	118	8	247	472	0		0	0	0	4	118	8	247	472
Black-backed gull	*Not Threatened*	14	61	1	237	852	13	64	2	275	826	27	62	1	275	1678
Black-billed gull	*Threatened - Nationally Critical*	0		0	0	0	3	2	1	2	5	3	2	1	2	5
Black shag	*At Risk - Naturally Uncommon*	0		0	0	0	5	3	1	5	13	5	3	1	5	13
Caspian tern	*Threatened - Nationally Vulnerable*	3	1	1	1	3	2	2	1	2	3	5	1	1	2	6
Grey duck hybrid	-	1	1	1	1	1	0		0	0	0	1	1	1	1	1
Kingfisher	*Not Threatened*	1	1	1	1	1	0		0	0	0	1	1	1	1	1
Lesser knot	*Threatened - Nationally Vulnerable*	1	6	6	6	6	0		0	0	0	1	6	6	6	6
Little black shag	*At Risk - Naturally Uncommon*	2	1	1	1	2	2	2	1	3	4	4	2	1	3	6
Little shag	*Not Threatened*	6	1	1	1	6	0		0	0	0	6	1	1	1	6
Mallard	*Introduced*	7	13	1	29	91	12	7	1	37	84	19	9	1	37	175
NZ dotterel	*Threatened - Nationally Vulnerable*	1	1	1	1	1	0		0	0	0	1	1	1	1	1
NZ pied oystercatcher	*At Risk – Declining*	16	78	4	244	1252	17	73	13	280	1238	33	75	4	280	2490
Paradise shelduck	*Not Threatened*	0		0	0	0	1	2	2	2	2	1	2	2	2	2
Pied shag	*Threatened - Nationally Vulnerable*	10	6	1	19	63	9	6	1	25	54	19	6	1	25	117
Pied stilt	*At Risk – Declining*	9	3	1	10	31	9	8	1	30	72	18	6	1	30	103
Pukeko	*Not Threatened*	1	2	2	2	2	0		0	0	0	1	2	2	2	2
Red-billed gull	*Threatened - Nationally Vulnerable*	11	51	1	208	558	16	84	2	500	1341	27	70	1	500	1899
Reef heron	*Threatened - Nationally Endangered*	0		0	0	0	1	1	1	1	1	1	1	1	1	1
Rock pigeon	*Introduced*	0		0	0	0	1	1	1	1	1	1	1	1	1	1
Royal spoonbill	*At Risk - Naturally Uncommon*	2	5	5	5	10	8	15	3	32	123	10	13	3	32	133
Silvereye	*Not Threatened*	0		0	0	0	1	1	1	1	1	1	1	1	1	1
Spur-winged plover	*Not Threatened*	3	2	2	2	6	0		0	0	0	3	2	2	2	6
Starling	*Introduced*	4	1	1	1	4	1	1	1	1	1	5	1	1	1	5
Variable oystercatcher	*At Risk – Recovering*	3	1	1	1	3	7	3	1	6	19	10	2	1	6	22
Welcome swallow	*Not Threatened*	2	2	1	2	3	0		0	0	0	2	2	1	2	3
White-faced heron	*Not Threatened*	14	15	1	42	210	15	11	1	45	164	29	13	1	45	374
White-fronted tern	*At Risk – Declining*	1	1	1	1	1	3	1	1	2	4	4	1	1	2	5
Wrybill	*Threatened - Nationally Vulnerable*	2	5	4	5	9	0		0	0	0	2	5	4	5	9

Cummings et al. (1997) calculated the summer density of feeding waders on the sandflats around Wiroa Island (south of Auckland International Airport) to be 240 pied oystercatchers per km^2, 168 bar-tailed godwits per km^2, 480 lesser knots per km^2 and 10.4 ruddy turnstone per km^2. In comparison, Kessels & Associates (2016) recorded substantially lower summer densities in the Mangere Inlet, with maximum recorded densities of 165 per km^2 for pied oystercatcher, 119 per km^2 for bar-tailed godwit, 2 per km^2 for lesser knots, and 0 per km^2 for ruddy turnstone.Royal spoonbill were recorded during both seasons, but considerably higher numbers were observed in autumn (Table 5-6); this pattern is as expected as individuals generally disperse away from the breeding colonies in autumn. Birds were recorded roosting on a rocky reef just off the northern shoreline at Pikes Point (see Appendix A for photos), as well as the large exotic trees on the small island, Ngarango Otainui, in the middle of the inlet. During both seasons, royal spoonbill were observed feeding in shallow water just below the tideline or in a small creek (Kessels & Associates, 2016).

Pied shags were reasonably common during both seasons (Table 5-6), either fishing in channels or the subtidal zone, as well as roosting on reefs or sandbanks (Kessels & Associates, 2016). Shag species are generally coastal-inshore pursuit divers (Shealer, 2002). Other shag species were present but only in small numbers (Table 5-6), with most being recorded roosting on the coastal and jetty structures to the west of the Mangere Inlet crossing.

Low numbers of Caspian and white-fronted tern were observed (Table 5-6) in both summer and autumn, traversing the coastline and foraging in the subtidal areas. Both species are visual foragers, feeding on small surface-swimming fish caught by plunge-diving in the first 5-10 m of water (Heather & Robertson, 2005).

Species observed roosting along the northern shoreline of the Mangere Inlet at high tide included royal spoonbill on the reefs, mallards among the mangroves and red-billed gulls on the nearby rooftops of industrial buildings (Kessels & Associates, 2016). Dotterel have also been recorded roosting on these rooftops (Tim Lovegrove, *pers. comm.*).

5.4.2.3 Banded rail / Australasian bittern Survey

Australasian bittern were not recorded at any of the locations surveyed (refer to Map 5-3) during either the summer or autumn surveys for this project.

Kessels & Associates (2016) record banded rail footprints at two locations along the Mangere Inlet northern shoreline (eastern end of the walkway) during the summer surveys (see Map 5-3). Kessels & Associates (2016) noted that at these locations there were narrow bands of mangrove flanked by a retaining wall (see Appendix A for photos), thereby concluding that there would be little if any habitat in the immediate vicinity for birds to retreat to at high tide and as such would probably move up Anns Creek as the tide came in. Though not yet confirmed, the limited area of habitat available at this location during high tide, as well as the high levels of human disturbance, make it unlikely that banded rail are breeding there.

No calls of banded rail or bittern were detected by the static ARs deployed in February 2016 (Kessels & Associates, 2016).

5.4.2.4 Landbirds

Mangere Inlet terrestrial environment

Sixteen species of landbirds were recorded during the summer survey, a subset (12) of which were recorded during the autumn survey (refer to species lists in Appendix B). All were species typical of modified urban and coastal environments. Ten of the species were exotic and six (kingfisher, welcome swallow, grey warbler, fantail, silvereye and tui) were native; all the native species are *Not Threatened*. Native species utilising the mangroves along the northern shoreline included welcome swallow, silvereye, kingfisher and grey warbler. Tui occurred in large eucalypts and wattles at the eastern end of the walkway during the summer survey (Kessels & Associates, 2016).

Fernbird were recorded in the OSNZ atlas square which includes the north-western portion of Mangere Inlet (Robertson et al., 2007). Kessels & Associates (2016) searched the small saline wetland at the western end of the walkway near Galway Street during the summer survey; this area would be at best marginal habitat for the species. No fernbird were detected.

Tamaki Inlet terrestrial environment

Seven avifauna species were recorded during the site visit to the upper Otahuhu Creek arm; these comprised four introduced (barbary dove, blackbird, starling and mallard) and three native *Not Threatened* (welcome swallow, kingfisher and silvereye) species. No *Threatened* or *At Risk* species were recorded.

Anns Creek East and Anns Creek Reserve Wetlands

Four species were recorded within or adjacent to Anns Creek Reserve wetland; these comprised three introduced (blackbird, starling and house sparrow) and one native *Not Threatened* (fantail) species.

Five species were recorded within or adjacent to the Anns Creek East wetland; these comprised three introduced (barbary dove, blackbird and starling) and one native *Not Threatened* (Australasian harrier) species.

No *Threatened* or *At Risk* species were recorded at either site.

5.4.3 Summary of Avifauna Values and Habitats

Table 5-7: provides details regarding the ecological value of the species associated with the project area. The key findings from the avifauna investigation included:

- **Anns Creek East and West wetland and Anns Creek estuary** are areas of **very high** avifauna value. The mangroves in the intertidal area form part of a unique gradient. Wading bird habitat is also contiguous with ecological sequences from saltmarsh to freshwater wetland in Anns Creek and with mangrove ecosystems along the coastline. Banded rail and Australasian bittern have been reported[54] in the Anns Creek salt marsh, mangroves and wetlands;
- **Pikes Point reef** is an area of **high** avifauna value, providing high tide roosting habitat for royal spoonbill. Other shorebirds do not appear to roost along the northern shoreline in significant numbers;
- Pied oystercatcher feed on the intertidal mudflats in the Mangere Inlet in substantial numbers, as do bar-tailed godwits on falling tides, although densities per square km are lower than in less modified parts of the Manukau Harbour;
- Lesser knot, wrybill and other small shorebirds such as banded and northern NZ dotterel use the Mangere Inlet intertidal mudflats in smaller numbers;
- Mangere Inlet is a particularly important site for wrybill, wth up to 1200 birds regurlarly feeding in the inlet, and some 20% of the global population roosting on one factory roof in Otahuhu.
- Tern and shag species forage in low numbers on small fish in the channels and subtidal area of the Mangere Inlet;
- Overall, **Mangere Inlet** is an area of **very high** avifauna value, providing important (and seasonal) foraging and roosting habitat for numerous *Threatened* and *At Risk* wading and shorebird species, including national and international migrants;
- Some of the wading and shorebirds feeding in the Mangere Inlet cross over the Auckland isthmus from the Waitemata Harbour. However, the upper Otahuhu Creek does not provide appropriate foraging habitat for these species;
- The landbird fauna along the northern is shoreline of the Mangere Inlet is dominated by exotic species; this is also the case for the upper Otahuhu Creek. No *Threatened* or *At Risk* land bird species were recorded; and

- Both the Otahuhu Creek and terrestrial component of the northern Mangere Inlet shoreline are considered to have low avifauna values.

Table 5-7: Distribution of *Threatened* or *At Risk* species associated with the proposed alignment

Species	Threat Classification[59]	Ecological Value	Location
Threatened Species			
Black-billed gull	*Nationally Critical*	Very High	Forage (mostly stream mouths) and roost in the Mangere Inlet, likely in wider Tamaki inlet.
Australasian bittern	*Nationally Endangered*	Very High	Identified in the PAUP as present around Anns Creek.
Reef heron	*Nationally Endangered*	Very High	Forage and roost in the Mangere Inlet, likely in the wider Tamaki Inlet too.
Caspian tern	*Nationally Vulnerable*	Very High	Forage (subtidal) and roost (shell and mud-banks) in the Mangere inlet, likely in wider Tamaki inlet.
Lesser knot	*Nationally Vulnerable*	Very High	Forage (intertidal) and roost in the Mangere and wider Tamaki inlet. International migrant, largely present during NZ summer.
Northern NZ dotterel	*Nationally Vulnerable*	Very High	Forage and roost in the Mangere and wider Tamaki inlet.
Pied shag	*Nationally Vulnerable*	Very High	Forage (fishing in channels and subtidal) and roost (reefs and sandbanks) in the Mangere Inlet, likely in wider Tamaki inlet.
Red-billed gull	*Nationally Vulnerable*	Very High	Forage (mostly stream mouths) and roost in the Mangere and wider Tamaki inlet.
Wrybill	*Nationally Vulnerable*	Very High	Forage (intertidal) and roost in the Mangere and wider Tamaki inlet. National migrant, largely present during NZ winter.
At Risk Species			
Banded rail	*Declining*	High	Utilising mangroves along northern shoreline of Mangere Inlet, possibly into Anns Creek.
Eastern bar-tailed godwit	*Declining*	Moderate - High	Forage (intertidal) and roost in the Mangere and Tamaki Inlets. International migrant, largely present during NZ summer.
NZ pied oystercatcher	*Declining*	High	Forage (intertidal) and roost in the Mangere and wider Tamaki inlet. National migrant, largely present during NZ winter.
Pied Stilt	*Declining*	High	Forage (intertidal) and roost in the Mangere and wider Tamaki inlet. National migrant, largely present during NZ winter.

[59] Robertson et al. (2013)

Species	Threat Classification[59]	Ecological Value	Location
White-fronted tern	*Declining*	High	Forage (subtidal) and roost (shell and mud-banks) in the Mangere inlet, likely in wider Tamaki inlet.
Black shag	*Naturally Uncommon*	Moderate - High	Forage (fishing in channels and subtidal) and roost in the Mangere Inlet, likely in wider Tamaki inlet.
Little black shag	*Naturally Uncommon*	Moderate - High	Forage (fishing in channels and subtidal) and roost in the Mangere Inlet, likely in wider Tamaki inlet.
Royal spoonbill	*Naturally Uncommon*	Moderate - High	Forage (shallow water below tideline or stream mouths) and roost in the Mangere Inlet. Favoured roost spots included the rocky reef along northern shoreline and the large exotic trees on the small island (Ngarango Otainui) in the middle of the inlet.
Variable oystercatcher	*Recovering*	Moderate - High	Forage and roost in the Mangere and wider Tamaki inlet.

Overall in terms of species assemblages:

- The wading and shorebird assemblage was determined to be Very High value due to the number of *Threatened* and *At Risk* species and forming part of the wider Manukau Harbour system;
- The cryptic marshbird assemblage (banded rail and Australasian bittern) was determined to be Very High value due to the *Threatened* and *At Risk* classifications; and
- The landbird assemblage was determined to be of Low value due to it comprising primarily introduced and also widespread and common native species.

5.5 Predicted Project Avifauna Effects

5.5.1 Scope of Effects Assessment

Potential adverse ecological effects on birdlife associated with construction of the East West Link include:

- Direct / permenant loss of habitat;
- Mortalities of nesting birds (including eggs and chicks);
- Disturbance; and
- Indirect effect on food supply.

Potential adverse ecological effects on birdlife associated with the operation of the East West Link include:

- Indirect effect on food supply;
- Disturbance, including the effective loss of habitat; and
- Traffic-related mortalities during road operation.

In the follow sections, the magnitude of each of these potential effects on the avifauna values present is assessed (EIANZ, 2015). Potential benefits of the project to the avifauna values are also discussed.

5.5.2 Direct / Permenant Loss of Habitat

A potential direct impact is the loss or degradation of habitat, including feeding, flocking, roosting and nesting sites through construction works.

5.5.2.1 Coastal / Estuarine Environment

Within Sector 1, the alignment and Galway Street east-bound exit occurs through an area of saltmarsh and salt meadow, comprising primarily glasswort and mangroves (approximately 4,900m^2 in area). The new alignment severs the connection between the estuarine vegetation habitat and the Mangere Inlet and construction of two stormwater treatment wetlands located one to the west and one to the east of Galway Street entirely removes this feature.

Construction of the embankment along the northern shore of the Mangere Inlet for the new alignment will involve reclamation within the CMA over an area of 5.6 ha. This forms 1.0% of the intertidal mudflat habitat within the Mangere Inlet and 0.02% of intertidal habitat within the Manukau Harbour. The marine ecology assessment (Chapter 4 of this report) for the project notes that the benthic invertebrates present within the embankment footprint are common to mudflat habitats, comprising polychaete and oligochaete worms, mud crabs, bivalve shellfish, barnacles and copepods.

Construction of the stormwater bund which will contain stormwater treatment wetlands and biofilters, pedestrian / recreational cycling paths, access points to the CMA and small sandy beach areas will involve the permanent loss of 17.1ha of intertidal mudflat habitat, including low tide channels created by the numerous stormwater discharge points along the northern shore. This forms 3.2% of the intertidal mudflat habitat within the Mangere Inlet and 0.08% of intertidal habitat within the Manukau Harbour.

As outlined in Section 4.5.2.3, the landscape design incorporates construction of a network of 4m wide boardwalks through the CMA along the northern shore of the Mangere Inlet. In total, the boardwalk within the CMA will result in the permanent loss of approximately 0.7 ha of intertidal mudflat habitat.

At the north-eastern end of the Mangere Inlet the alignment departs from the proposed embankment and is on a bridge structure across Anns Creek Estuary, through Anns Creek West and East, and the existing bridge at Otahuhu Creek will be widened. The total area of marine environment to be permanently removed due to bridge structures is approximately 73m^2, which is 0.0014% of the intertidal mudflat habitat within Mangere Inlet and 0.00004% of the intertidal habitat within the wider Manukau Harbour. The total area of permanent occupation in the Otahuhu Creek for bridge piers is 8.3m^2.

Threatened and *At Risk* avifauna species recorded in association with Anns Creek complex include banded rail within the intertidal mangrove stand (and possibly the estuarine rushes) and bittern (including the raupo wetland in Anns Creek East). Thus, removal of vegetation associated with this vegetation sequence will result in the direct loss of habitat for these species. Historically, these species have been greatly impacted through the loss of habitat in the Auckland region.

At a local level, the magnitude of the effect of permanent habitat loss due to the construction of the EWL are considered to be low on shorebirds and of a permanent nature. However, in the wider context, and at a population level, the magnitude of the effect of permanent habitat loss due to the construction of the EW will be negligible on the shorebird populations.

At a local level, the magnitude of effect of permanent habitat loss due to the construction of the EWL is considered to be moderate on banded rail and bittern. In the wider context, and at a population level, the magnitude of the effect of permanent habitat loss due to the construction of the EW will be moderate on banded rail and bittern populations.

5.5.2.2 Cumulative Effects

Assessment of cumulative effects requires the consideration of appropriate temporal and spatial boundaries for the assessment, and consideration of the interactions of the ecological effects of the

Project along with past and future activities. One type of cumulative effect is incremental habitat loss or degradation which can be difficult to assess on a project-by-project basis. The actual cumulative adverse effect of incremental loss or degradation can be difficult to measure due to the long time frames for measureable effects to manifest themselves and the multiple activities, projects or stressors that, in combination, cause incremental degradation and / or loss.

Incremental loss of shorebird foraging habitat is the primary cumulative effect on avifauna values from the Project.

Migrating shorebirds are exposed to threats at their summer breeding sites, migration pathways and wintering sites. International migrants (such as bar-tailed godwit) in particular, have been suffered population declines as a consequence of reclamations at multiple locations along the East Asian-Australasian flyway (Moores, Rogers, Rogers, & Hansbro, 2016). Thus, further reclamation of intertidal foraging habitats adds to the cumulative effects of habitat loss for shorebird species.

For the EWL Project, in the context of cumulative effects on shorebirds, we have considered the appropriate temporal scale is prior to all documented historic reclamation (c. 1940). We have determined that the appropriate spatial scale for consideration of cumulative effects is the Mangere Inlet. With respect to future effects, we are not aware of any projects in the Mangere Inlet that may involve reclamation.

It is estimated that approximately 190ha of marine environment has been historically reclaimed in the Mangere Inlet, primarily along the northern shore and around the Manukau Harbour Crossing bridge abutments. The area of proposed reclamation and permanent occupation of the CMA within the Mangere Inlet for the Project is 24.2 ha, which is 4.5% of the current intertidal habitat within the Mangere Inlet. The proposed reclamation and permanent occupation of the CMA is an additional 12.8% of the total already reclaimed in the Inlet. It is not possible to measure the actual cumulative effect of incremental habitat loss, as it is likely that each action or project that reduces habitat size has very small effects on shorebird values. Those very small effects may, in the long term, and in combination with other unrelated stressors, result in adverse effects on individuals or populations.

Due to the difficulty in clearly demonstrating a measureable cause and effect relationship with incremental habitat loss and ecological value, the magnitude of effect of cumulative reclamation and occupation of estuarine ecosystems within the Mangere Inlet could be assessed as Negligible, but in order to be conservative we have assessed the magnitude as Low.

Migrating shorebirds are exposed to threats at their summer breeding sites, migration pathways and wintering sites. International migrants (such as bar-tailed godwit) in particular, have been suffered population declines as a consequence of reclamations at multiple locations along the East Asian-Australasian flyway (Moores, Rogers, Rogers, & Hansbro, 2016). Thus, further reclamation of intertidal foraging habitats adds to the cumulative effects of habitat loss for shorebird species.

The magnitude of effect of cumulative reclamation and occupation of estuarine ecosystems within the Mangere Inlet and the Manukau Harbour is considered to be Moderate for shorebirds.

5.5.2.3 Terrestrial Environments

Chapter 2 of this report describes the terrestrial vegetation communities associated with each of the EWL sectors. The terrestrial vegetation communities impacted by the construction of the EWL are of low value to native avifauna, being largely fragmented and comprising mostly exotic species.

Thus, the magnitude of effect of permanent terrestrial habitat loss due to the construction of the EWL are considered to be negligible on landbirds at both the local and population level.

5.5.3 Disturbance

5.5.3.1 Construction

Indirect disturbance to avifauna is a potential adverse effect that may arise by way of effective loss of habitat as a result of construction activities such as noise, vibration and plant movement. *Threatened* and *At Risk* species are generally considered to be more vulnerable to the potential impacts of disturbance due to their small population sizes and / or declining numbers. Construction activities will occur both within the CMA and on land, thus exposing a range of avifauna species to the potential effects of disturbance.

In terms of activities in the CMA, the one of the main sources of disturbance noise is likely to occur when temporary staging piles are driven into the sediments within Anns Creek Estuary, Anns Creek West and East wetland (Sector 3), as well as during the subtidal dredging operation (which is expected to take about 300 days) (refer to Technical Report 15, Coastal Processes Assessment, Appendix F).

In addition, the construction of the boardwalk in the CMA may cause further disturbance. It is estimated that construction of the boardwalk will take approximately three months. We recommend the use of wooden dollys to reduce pile driving noise associated with this activity.

Shorebirds will likely forage and roost elsewhere in the Mangere Inlet or wider Manukau Harbour during the period of these activities. Thus, at a local level the magnitude of the effect of construction disturbance due to the EWL project is considered to be low on shorebirds and of a temporary nature. However, in the wider context and at a population level, the magnitude of the effect of construction disturbance due to the EWL project will be negligible on the shorebird populations.

Construction activities occurring in the Anns Creek portion of Sector 3 are also likely to disturb banded rail and bittern. Though unlikely, if banded rail are breeding along the coastal margin, the potential disturbance from the construction activities may result in these birds abandoning the nesting habitat. As such, the magnitude of effect of construction disturbance on banded rail and bittern is considered to be high at a local level, but of a temporary nature. In the wider context, and at a population level, the magnitude of the effect of construction disturbance due to the EWL will be moderate on banded rail and bittern populations.

In terms of activities on land (all Sectors), the main source of disturbance noise will be that associated with earthworks and plant movement. The species exposed to these activities will be common native and introduced landbirds; there have been no *Threatened* or *At Risk* landbird species recorded associated with the EWL proposal. As such, the magnitude of effect of construction disturbance on landbirds is considered to be negligible and of a temporary nature, both at a local and population level.

5.5.3.2 Operation

Operational disturbance to avifauna is a potential adverse effect that may arise by way of an effective loss of habitat (both terrestrial and intertidal) as a result of noise (e.g. traffic), lighting or increased activities (e.g. recreational users, including the presence of dogs).

The existing environment associated with the wider Mangere Inlet and adjacent land uses is one which is highly modified with industrial, recreational and roading activities. Thus, the current avifauna assemblages are already exposed to a level of "operational" disturbance.

Light-induced mortalities have been recorded for a number of seabirds, particularly petrels, whereby they are attracted to artificial light sources and either collide with structures or are vulnerable to predation when on land (Black, 2005; Matthieu Le Corre, Ghestemme, Salamolard, & Couzi, 2003; M. Le Corre, Ollivier, Ribes, & Jouventin, 2002; Montevecchi, Rich, & Longcore, 2006; Rodriguez & Rodriguez, 2009). Cook's petrel (*Pterodroma cookii*) is an *At Risk (Relict)* oceanic seabird breeding only on Little Barrier, Great Barrier and Codfish islands. Birds from Little Barrier Island are known to forage in the North Tasman Sea, traversing the Auckland Isthmus (Rayner et al., 2008). Given the extensive lighting in the existing environment across the isthmus, the EWL project will not increase the risk of light-attraction to any traversing birds.

An increase in artificial lighting associated with the EWL is unlikely to impact on the nocturnal foraging of waders. In fact, Santos et al. (2010) found that artificial illumination from urban areas and roads had a positive effect on nocturnal foraging of waders whereby visual foragers increased their foraging effort in illuminated areas, and mixed foragers changed to more efficient visual foraging strategies. These behavioural shifts improved prey intake rate by an average of 83% in visual and mixed foragers (Santos et al., 2010).

Currently, shorebirds readily forage in close proximity to the Mangere Bridge; the presence of a busy operating state highway not deterring the birds from foraging or roosting in that location. As such, there is no reason to expect this would not be the case for the EWL. However, it is the presence of recreational users (including pedestrians, cyclists and dogs) in close proximity that may result in the disturbance to both foraging and roosting shorebirds.

Numerous studies have reported various distances at which shorebird species are disturbed by human activities (including walking, running and dogs) (Glover, Weston, Maguire, Miller, & Christie, 2011; Goss-Custard, Triplet, Sueur, & West, 2006; Rodgers & Schwikert, 2002; Rodgers & Smith, 1995; Thomas, Kvitek, & Bretz, 2003). Glover et al. (2011) researched the distance at which 28 of Australia's regularly occurring shorebird species responded (i.e., flight initiation distance [FID]) when presented with an approaching human. They found that species differed in their FID, with species with higher body masses having longer FIDs. Mean FIDs for species ranged from 18.6–126.1, with bar-tailed godwit exhibiting a mean FID of 59.50m (Glover et al 2011). It is important to note that depending on the species, FID was significantly influenced by a number of factors including the starting distance of the human approach, flock size, previous exposure to humans and stimulus type (walker, jogger, walker with dog) (Glover et al 2011). Thomas et al. (2003) reported that 100% of the shorebirds they studied responded to humans within 30m, and as such recommend this as a minimum distance of 30m for people away from areas where shorebirds concentrate.

Given these findings, we have calculated the area of effective habitat loss of intertidal habitat based on a 30 m and 50 m buffer zone from the boardwalk edge[60] (refer to Map 5-5). Based on a 30 m buffer zone, approximately 10.7 ha of intertidal habitat will be effectively lost as a result of the EWL project (refer to Map 5-5) due to disturbance associated with the operation of the road and location of the boardwalk. If a more conservative buffer zone of 50 m is applied, this will result in the effective loss of approximately 15.1 ha of intertidal habitat. These area include a large portion of Pikes Point, which is currently used as a roosting site by a number of species.

As such, the magnitude of the effect of operational disturbance on shorebirds at a local level is considered to be moderate and ongoing. This is based on the fact that the disturbance, especially in regards to effective habitat loss, will result in the "l*oss 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*" (EIANZ 2015). At a wider context, the magnitude of the effect of operational disturbance associated with the EWL will be negligible on the shorebird populations.

[60] These areas have been calculated based on the assumption that pedestrians and dogs remain on the boardwalk and do not access the coastal edges of the landforms.

This map contains data derived in part or wholly from sources other than EWL, and therefore, no representations or warranties are made by EWL as to the accuracy or completeness of this information.

Map intended for distribution as a PDF document. Scale may be incorrect when printed.

No	Issued Status	Drawn	Check'd	App'd	Date

DISCLAIMER

The information shown on this drawing is solely for the purpose of supporting application under the RMA for resource consents and/ or designations.
All information shown is subject to final design and review for compliance with any approved consents and/ or designations.
This Drawing must not be used for construction.

NZ TRANSPORT AGENCY

East West Link

Drawn	Drafting Check	Reviewed Design Manager	Approved Alliance Manager
Designed	Design Check		

Scale: 1:8,311 | Original Size: A3 | Contract No PA4041

Drawing Title

ECOLOGY
Map 5-5: Potential area of disturbance to shorebird foraging due to boardwalk

Drawing Number: GIS-AEE-EC-001-5-5 | Rev No. A

Plot Date: 8/11/2016 Plotted by: Ben Peyton File: U:\2016\T16006_SDE_East-West_Connection_Ecology\GIS\T16006_39_BoardwalkAreas.mxd

Though unlikely, if banded rail are breeding along the coastal margin of Anns Creek estuary, disturbance may result in birds abandoning the nesting habitat permanently. Historically this species has been greatly impacted through the loss of habitat in the Auckland region. As such, the magnitude of the effect of operational disturbance on banded rail, if breeding at this location, is considered at a local level to be High and ongoing. In the wider context, and at a population level, the magnitude of the effect of operational disturbance due to the EWL will be moderate on the banded rail population.

Despite the current land uses surrounding Anns Creek, Australasian bittern have still been recorded present. However, traffic traversing this section of EWL will be an additional disturbance to these birds. Historically this species has been greatly impacted through the loss of habitat both in the Auckland region and nationally. As such, the magnitude of the effect of operational disturbance (an effective loss of habitat) on bittern, at a local level, is considered to be High and ongoing. In the wider context, and at a population level, the magnitude of the effect of operational disturbance due to the EWL will be moderate on the Australasian bittern population.

For landbirds, the species exposed to operational disturbances will be common native and introduced landbirds; there have been no *Threatened* or *At Risk* landbird species recorded associated with the EWL proposal. Due to the widespread and mobile nature of these species, the magnitude of the effect of operational disturbance on landbirds are considered to be negligible at both the local and population levels.

5.5.4 Indirect Effect on Food Supply & Foraging Ability

Impacts on food supply or the ability of visual foragers to locate prey items can have flow-on effects to avifauna through reduced foraging resources.

5.5.4.1 Construction

If, during construction, runoff from the site is untreated prior to discharge to the receiving environment, there is the potential for adverse effects on marine water quality through increased suspended sediment and on marine invertebrates from the clogging of fine structures (such as gills) and smothering from deposited sediment.

The marine ecology assessment (Chapter 4 of this report) noted that marine invertebrates within benthic sediment are likely to be adversely affected by noise and vibration during the driving of piles. However, it was noted that this disturbance will be temporary and that the species present are common and ubiquitous in the Mangere Inlet.

The marine ecology assessment (Chapter 4 of this report) determined low levels of effects on the marine ecology during construction associated with discharges from erosion and sediment control devices, disturbance to sediment contaminants, increased sedimentation associated with dredging, noise and vibration.

The potential exists for the discharge and release of contaminants from sediment and porewater during excavation within the CMA (Technical Report 15 Coastal Processes Assessment). The marine ecology assessment (Chapter 4 of this report) considered that the magnitude of this effect on the marine ecology values to be Low and of a temporary nature.

The Construction Noise and Vibration Assessment (Technical Report 8) states that underwater noise will not have significant adverse effects fish because the piles are driven into shallow water within the intertidal habitat which minimises sound propagation.

Thus, based on those findings, we consider that the magnitude of the indirect effect on food supply for shorebirds and cryptic marshbirds, at a local level, will be Low, and of a temporary nature. In the wider context, and at a population level, the magnitude of the indirect effect on food supply due to the EWL will be negligible for all species.

The proposed subtidal dredging and placement of mudcrete will result in sediment release and plumes. These activities will result in increased TSS levels which will reduce the visibility levels for avian species such as tern and shags foraging in these waters. NIWA's modelling of the maximum release of sediment back to the CMA to assess its final fate and the change in water column concentrations away from the dredger indicates within a 200m mixing zone, a worst case of $20g/m^3$ to the west of the dredge area and $5g/m^3$ to the east. When placing material at the eastern most end of the northern shore of the Mangere Inlet, TSS could increase to $50g/m^3$. It is noted that the existing TSS concentration in the Manukau Harbour is an average of $30g/m^3$, but the range if 10-150 g/m^3 (Appendix F, Coastal Processes Assessment). The marine ecology assessment (Chapter 4 of this report) considered that the magnitude of effect of subtidal dredging on the marine values present to be Moderate in the short term and likely Low in the longer term.

Given the relatively low numbers of tern and shags foraging in the Mangere Inlet, the availability of extensive similar foraging habitat elsewhere in the Manukau Harbour, and the short term and confined nature of the elevated TSS levels, we consider the magnitude of the effect of dredging on terns and shags will be Low in the context of the local environment. The magnitude of this effect will be negligible at a population level.

5.5.4.2 Operational

If operational stormwater is not treated to a high standard there is the potential to directly impact on marine invertebrates, and thereby indirectly on coastal avifauna through a reduction in food availability or quality.

The marine ecology assessment (Chapter 4 of this report) determined a low level of effect on the marine ecology associated with discharging treated road run off to the marine environment. Therefore, based on those findings, we consider that the magnitude of the indirect effect on food supply for shorebirds and banded rail will be negligible at both the local and population levels.

5.5.5 Mortalities

5.5.5.1 Construction

The mobile nature of most avifauna species means that the potential for direct mortalities associated with construction activities are likely to be confined to birds that may be breeding within the project footprint, if construction activities occur during the breeding season.

There is no shorebird nesting habitat along the EWL alignment. As such, there should be no direct mortalities to these species due to the construction of the EWL project.

However, while not presently nesting along the EWL main alignment, banded and northern New Zealand dotterel may take up residence during the construction of the project. Both species, but particularly northern New Zealand dotterel, opportunistically take advantage of recently cleared or earthworked areas to nest in. Given the presence of these species in the wider area, including nesting on the Onehunga foreshore development, it is likely that these birds may take advantage of earthworked areas associated with the EWL project during the breeding season. As has been done for other projects, including the North Shore busway development, such situations can be managed in a way to minimise impacts on nesting birds through the construction phase as outlined in the draft guidelines prepared by NZTA.[61]

Though unlikely, there is the potential for banded rail to be nesting along the coastal margin associated with Anns Creek estuary. Historically this species has been greatly impacted through the loss of habitat in the Auckland region. As such, the magnitude of the effect of construction mortalities on banded rail, at

[61] NZTA (2014). Draft Guidance in relation to NZ dotterels on NZTA land. Revision C prepared 15/5/14.

a local level, is considered to be Very High if they are nesting in this location. At a wider context, the magnitude of such an effect at a population level is considered to be Low.

The majority of species that may be breeding within the construction footprint include common native and introduced landbirds nesting in trees and scrub. There have been no *Threatened* or *At Risk* landbird species recorded associated with the EWL proposal. Due to the widespread and mobile nature of these species, the magnitude of the effect of construction mortalities on these landbirds populations is considered to be negligible.

5.5.5.2 Operation

Avifauna crossing the pathway of traffic may be at risk of mortalities. Based on the avifauna assemblage present, those species most likely to suffer traffic mortalities will be common native and introduced birds such as pukeko, blackbird, kingfisher and tui. Due to the widespread nature of these species, the magnitude of the effect of operation mortalities on these landbird populations is considered to be Negligible.

Shorebirds currently entering the Mangere Inlet, from either east or west, already traverse the existing roading network without any known mortalities. Given the location of the EWL, it is unlikely that shorebird mortalities will occur as a result of the operation of the road. As such, the magnitude of the effect of operation mortalities on shorebirds is considered to be Negligible.

Similarly, banded rail and bittern currently utilising Anns Creek and the associated coastal margin already traverse the existing roading network. However, the close proximity of the EWL to their Anns Creek habitat means that traffic mortalities are more likely to occur as they arrive and depart, than under the current situation. Thus, the magnitude of this potential impact will depend, in part, on the species flight patterns. We consider the magnitude of the effect of operation mortalities on banded rail and bittern would be Low at both a local and population level.

5.5.6 Ecological Benefits

5.5.6.1 Reduced contaminant load discharged to the CMA

Currently, the main contaminant sources along the northern shore of the Mangere Inlet that discharge to the CMA are:

- Contaminants in groundwater from current and historic land uses including metals, nutrients, petroleum hydrocarbons, PAHs, solvents;
- Landfills and reclamation – nutrients such as ammoniacal nitrogen;
- Stormwater – copper, zinc, lead, PAHs, nutrients and faecal coliforms; and
- Sewer leakage to ground and/or cross-connection with stormwater yielding faecal coliforms and nutrients.

The proposed EW design incorporates treatment of runoff from new and existing highway alignment, catchment stormwater and landfill leachate. A reduction in the load of contaminants discharged to the marine environment will reduce the accumulation of contaminants in benthic surface sediment and potentially reduce sublethal stress on marine organisms. In the long term, the reduced contaminant load may encourage more sensitive marine organisms to inhabit the sediments within the Mangere Inlet, particularly along the northern shore where contaminant concentrations are highest.

A number of studies have reported the avian susceptibility to bioaccumulation of pollutants through ingestion of contaminated food sources (Becker & Cifuentes, 2004; Braune & Noble, 2009; Joanna Burger, Schreiber, & Gochfeld, 1992; Cooke, Bell, & Prestt, 1976; De Luca-Abbott et al., 2001; Dirksen et al., 1995; Fox, Yonge, & Sealy, 1980; Roodbergen, 2010). Pollutants have been shown to impact population stability of avian species through impacts on reproduction and survival (J. Burger & Gochfeld, 2001).

Though only reflective of relatively short term exposures, Thompson & Dowding's (1999) study of heavy metal concentrations in blood samples of NZ pied oystercatcher foraging in the Mangere Inlet reported low levels of mercury concentrations (unlikely to result in deleterious toxicological effects), but higher concentrations of lead (particularly in juveniles), including levels above the threshold generally considered to define the concentration at and above which there is potential for toxicological effects.

Thus, the EWL project may have a potential positive effect on the quality of the Mangere Inlet shorebird foraging habitat and food resource through reducing contaminant load within the Inlet. The magnitude of positive effect on shorebird values arising from the reduction of contaminants to the marine environment from a range of sources is considered to be Low.

5.5.6.2 Increased habitat diversity

Freshwater stormwater treatment wetlands are likely to provide some different habitat for common native and introduced bird species such as pukeko and waterfowl.

The creation of a more natural hard shore (mudcrete platforms) on the seaward edge of the stormwater bund may encourage colonisation by sessile marine organisms. If hardshore communities develop on the naturalised edge of the stormwater bund, there is likely to be an increase in biodiversity and food source for avifauna species such as variable oystercatcher.

The magnitude of positive effect from increased habitat diversity is considered to be Low due to the small scale of different habitats to be created and some uncertainty about colonisation by marine organisms within the short term, and therefore additional food resource.

5.6 Assessment of Potential Avifauna Effects

In accordance with the EIANZ (2015) Impact Assessment Guidelines, the magnitude of each adverse effect combined with the ecological values of the existing environment provides an understanding of the level of the adverse effect. Each of the effects identified in Section 5.5 is assessed in terms of ecological values, magnitude of effect and level of overall effect in Table 5-8 below.

EIANZ guidelines state that very high, high and moderate levels of effect require avoidance or mitigation, whereas low and very low levels of effect are normally not of concern, but design, construction and operational care should be taken to minimise adverse effects.

Table 5-8: Assessment of level of effect (without mitigation) on avifauna at the local scale (without mitigation).

Potential Effect	Avifauna assemblage	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature
ADVERSE EFFECTS					
Direct habitat loss	Shorebirds	Very High	Low	Moderate	Permanent
	Cryptic marshbirds	Very High	Moderate	Very High	Permanent
	Landbirds	Low	Negligible	Very Low	Permanent
Cumulative effects of permanent loss of CMA (Assessed at Mangere Inlet scale)	Shorebirds	Very High	Low	Moderate	Permanent
Disturbance – Construction	Shorebirds	Very High	Low	Moderate	Temporary

Potential Effect	Avifauna assemblage	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature
	Cryptic marshbirds	Very High	High	Very High	Temporary
	Landbirds	Low	Negligible	Very Low	Temporary
Disturbance – Operation	Shorebirds	Very High	Moderate	High[62]	Permanent
	Cryptic marshbirds	Very High	High	Very High	Permanent
	Landbirds	Low	Negligible	Very Low	Permanent
Food supply – Construction	Shorebirds	Very High	Low	Moderate	Temporary
	Cryptic marshbirds (banded rail)	Very High	Low	Moderate	Temporary
Food supply – Operation	Shorebirds	Very High	Negligible	Low	Permanent
	Cryptic marshbirds (banded rail)	Very High	Negligible	Low	Permanent
Mortalities – Construction	Cryptic marshbirds	Very High	Very High[63]	Very High	Temporary
	Landbirds	Low	Negligible	Very Low	Temporary
Mortalities – Operation	Shorebirds	Very High	Negligible	Low	Permanent
	Cryptic marshbirds	Very High	Low	Moderate	Permanent
	Landbirds	Low	Negligible	Very Low	Permanent
POSITIVE EFFECTS					
Reduced contaminant load discharged to the CMA	Mangere Inlet shorebirds	Very High	Low	Low[64]	Permanent
Increased habitat diversity	Mangere Inlet avifauna	Moderate	Low	Low	Permanent

[62] EIANZ (2015) guidelines states that practitioners are able to deviate from the guidelines where they consider it is ecologically relevant and justifiable to do so. In this case, it was determined that a High overall level of effect was more appropriate than Very High given it is being driven by effective habitat loss (whereby some individuals **may** still utilise the area).

[63] If banded rail are found to be breeding, otherwise a negligible magnitude of effect

[64] EIANZ (2015) guidelines states that practitioners are able to deviate from the guidelines where they consider it is ecologically relevant and justifiable to do so. In this case, it was determined that a Low positive effect was more appropriate than Moderate given the high usage of the area even in its current condition.

The adverse effects identified in Table 5-8 that have a level of effect which is moderate or higher require mitigation. Those effects are as follows:

Very High

- Permanent habitat loss for cryptic marshbirds;
- Construction disturbance for cryptic marshbirds;
- Operation disturbance for cryptic marshbirds; and
- Construction mortalities for cryptic marshbirds (but only if banded rail are found to be breeding within the construction footprint).

High

- Operational disturbance (and effective habitat loss) for shorebirds;

Moderate

- Cumulative effects of permanent habitat loss for shorebirds;
- Permanent habitat loss for shorebirds;
- Construction disturbance for shorebirds;
- Indirect effect on food supply for shorebirds;
- Indirect effect on food supply for cryptic marshbirds; and
- Operation mortalities for cryptic marshbirds.

The positive effects related to improved catchment stormwater treatment and increased habitat diversity (Section 5.5.6) are also acknowledged, whilst noting that these benefits do not relate directly to the adverse effects identified above.

As such, the very high and moderate adverse effects identified above inform the suite of mitigation proposed in Chapter 6 of this report.

5.7 Recommendations

The following principles were recommended during the design phase to minimise the effects on avifauna:

- Minimising reclamation footprint to decrease the areas of permanent loss of foraging habitat;
- Height of bridges to reduce risk of avifauna collision;
- Longer bridge spans to decrease the areas of permanent loss of habitat; and
- Placement of bridge piers and boardwalk to avoid areas higher ecological values, particularly in relation to Anns Creek estuary, Anns Creek east wetland and Pikes Point.

In order to mitigate and offset for the potential effects of the EWL project on the avifauna values present, we recommend that the following should be included in the suite of actions forming the recommended mitigation and offsets package (Chapter 6 of this report):

- Investigate options for protection of Ngarango Otainui Island, particularly the macrocarpa trees which provide roosting habitat for royal spoonbill. Given macrocarpa have a limited lifespan, more suitable trees (not necessarily native species) should be planted as future roosting habitat for this species. Erosion protection should be provided to the island, which has been eroding over time. Such erosion protection measures should preferably be soft engineering solutions, with hard engineering solutions considered as a last resort[65]. In addition, high tide roosts should be incorporated into any erosion protection created for the island;
- Engage with the owners of industrial buildings which are currently used as high tide roosts around the Mangere Inlet to inform them of the characteristics and threat status of the species using their roof tops, the value of their roof tops to those species and if they were to replace their roof or building in the long term the type of roof design that would suit those avifauna species. The aim of this non-binding engagement would be to inform building owners/managers and to get their “buy-in” to protection of the species and their roost sites;
- Planting of saltmarsh to replace areas which will be lost under the EWL footprint. Ideally this should be done in a location that may be utilised by banded rail;
- Recreate the Anns Creek East raupo wetland, currently utilised by Australasian bittern, in an appropriate location. In addition, investigate opportunities to transplant raupo to be removed from Anns Creek East to the new raupo wetland location; and
- Given that the proposed reclamation will reduce the quantity of intertidal foraging habitat in the Mangere Inlet, options should be investigated to increase the abundance of intertidal prey items within the Mangere Inlet. This research could involve transplanting hard shore organisms to the new landscape feature and / or translocating soft shore organisms to areas disturbed or lacking in large macrofauna. The aim of is recommendation is to increase scientific knowledge and inform projects of a similar nature in the future. If the conclusion of the research is that it is not feasible to significantly increse the quantity of foraging prey, then that data is useful in itself and there is no need to develop further mitigation.
- In order to offset the direct and effective loss of foraging (and to a lesser extent, roosting) habitat for shorebirds in the Mangere Inlet arising from the embankment, the landform/stormwater features and the ongoing disturbance from people and dogs using the boardwalk within the CMA and on the landforms, the EWL project team avifauna expert shall collaborate with the Department of Conservation to identify potential sites (i.e. staging, roosting or breeding sites) for some of the *Threatened* or *At Risk* species that forage within the Inlet and to develop an appropriate package of offset that will provide sufficient quantum of benefit to those species. Such offset could include long term pest control at appropriate sites and/or working with DOC on other programmes that benefit those avifauna species.

The following monitoring is also recommended to further minimise potential effects and to determine the success of the proposed mitigation:

- Prior to construction, monitoring to determine if banded rail and Australasian bittern are breeding in areas of potential nesting habitat within the proposed EWL designation; and
- The proposed monitoring (recommended in Chapter 4, Section 4.7) of sediment quality and benthic invertebrate assemblage adjacent to the stormwater treatment wetland discharge points can be used to detect any changes in food supply for foraging shorebirds around that area.

[65] It is recommended that the erosion protection measures be developed with a coastal engineer, avifauna expert and representative from the Department of Conservation.

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Appendix A

Site photos

Terrestrial vegetation along pedestrian pathway and northern coastal edge of Mangere Inlet

Terrestrial vegetation along walkway by Anns Creek

Dense mangrove stand along the lower Anns Creek channel (Anns Creek Estuary).

Narrow rush edge along pedestrian path at Anns Creek Estuary.

Reef outcrops and mud banks within the Mangere Inlet used by roosting birds.

Red-billed gull, pied stilt and spoonbill foraging around stream channel edge during a falling tide.

Mangrove stand on the eastern side of Mangere Bridge.

Intertidal mudflats in the Onehunga estuary.

Recently created beach at Onehunga foreshore.

Recently created rip-rap edged associated with Onehunga foreshore development.

Mangere Inlet intertidal mudflat along southern shoreline, view from Mona Ave count site.

Mangere Inlet intertidal mudflat along southern shoreline, view from Norana Park count site.

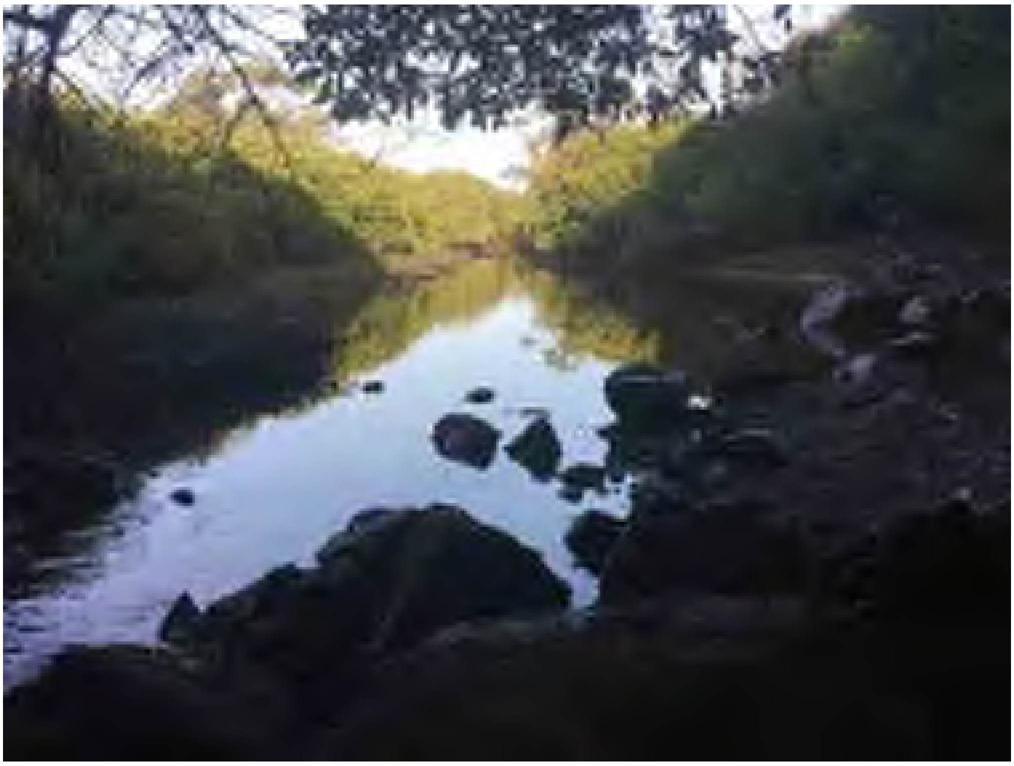
Miami Stream (Mangere Inlet) riparian edge.

Upper Otahuhu Creek (Tamaki Inlet) channel and mangrove at low tide.

Upper Otahuhu Creek channel (adjacent to SH1) at low tide.

Terrestrial vegetation on eastern side adjacent to SH1, upper Otahuhu Creek.

Box culverts under SH1, upper Otahuhu Creek.



Upper Otahuhu Creek on the western side of the box culverts and SH1.

Open water component of the Anns Creek Reserve wetland

***Bolboschoneus* field within Anns Creek Reserve wetland.**

Bolboschoneus **field within Anns Creek East wetland.**

Mixed shrubland component of Anns Creek East wetland.

Appendix B

Avifauna species and habitat summary

The following table lists species recorded within the OSNZ atlas from three 10 km x 10 km grid squares (266, 647; 267, 647; 267, 646), as well as those recorded through the project avifauna field investigations. The primary (dark green) and secondary (light green) habitats[66] for each of the species recorded was obtained from Heather & Robertson (2005), along with each species' New Zealand threat status according to Robertson et al. (2013).

SPECIES (Robertson et al. 2007)		**CONSERVATION STATUS (Robertson et al. 2013)**	**HABITAT**								**SOURCE**				
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open country	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	OSNZ atlas squares	MANGERE INLET - Summer	MANGERE INLET - Autumn	LANDBIRDS - Summer	LANDBIRDS - Autumn
Kereru	*Hemiphaga novaeseelandiae*	Not Threatened[CD Inc]									✓				
Kingfisher	*Todiramphus sanctus vagans*	Not Threatened									✓	✓		✓	✓
Morepork	*Ninox n. novaeseelandiae*	Not Threatened									✓				
North Island fantail	*Rhipidura fuliginosa placabilis*	Not Threatened[EF]									✓			✓	
Shining cuckoo	*Chrysococcyx l. lucidus*	Not Threatened[DP]									✓				
Tui	*Prosthemadera n. novaeseelandiae*	Not Threatened[OL St]									✓			✓	
Blackbird	*Turdus merula*	Introduced & Naturalised[SO]									✓			✓	✓
Brown quail	*Coturnix ypsilophora australis*	Introduced & Naturalised[SO]									✓				
California quail	*Callipepla californica*	Introduced & Naturalised[SO]									✓				
Eastern rosella	*Platycercus eximius*	Introduced & Naturalised[SO]									✓				
Grey warbler	*Gerygone igata*	Not Threatened									✓			✓	✓
Pheasant	*Phasianus colchicus*	Introduced & Naturalised[SO]									✓				

[66] For the purpose of this report, primary habitat refers to the habitat in which the species spends most of its time. Secondary habitats are other habitat types which the species may also utilise.

SPECIES (Robertson et al. 2007)		**CONSERVATION STATUS (Robertson et al. 2013)**	**HABITAT**								**SOURCE**				
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open country	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	OSNZ atlas squares	MANGERE INLET - Summer	MANGERE INLET - Autumn	LANDBIRDS - Summer	LANDBIRDS - Autumn
Silvereye	*Zosterops lateralis lateralis*	Not Threatened[SO]									✓		✓	✓	✓
Canada goose	*Branta canadensis*	Introduced & Naturalised[SO]									✓				
Cattle egret	*Ardea ibis coromanda*	Migrant[SO]									✓				
Chaffinch	*Fringilla coelebs*	Introduced & Naturalised[SO]									✓			✓	✓
Goldfinch	*Carduelis carduelis*	Introduced & Naturalised[SO]									✓			✓	
Greenfinch	*Carduelis chloris*	Introduced & Naturalised[SO]									✓			✓	✓
House sparrow	*Passer domesticus*	Introduced & Naturalised[SO]									✓			✓	✓
Kookaburra	*Dacelo novaeguineae*	Introduced and Naturalised[SO RR]									✓				
Magpie	*Gymnorhina tibicen*	Introduced & Naturalised[SO]									✓				
NZ pipit	*Anthus n. novaeseelandiae*	At Risk - Declining									✓				
Peafowl	*Pavo cristatus*	Introduced & Naturalised[SO]									✓				
Redpoll	*Carduelis flammea*	Introduced & Naturalised[SO]									✓				
Rook	*Corvus frugilegus*	Introduced & Naturalised[SO]									✓				
Skylark	*Alauda arvensis*	Introduced & Naturalised[SO]									✓				
Song thrush	*Turdus philomelos*	Introduced & Naturalised[SO]									✓			✓	✓
Spur-winged plover	*Vanellus miles novaehollandiae*	Not Threatened[SO]									✓	✓			
Starling	*Sturnus vulgaris*	Introduced & Naturalised[SO]									✓	✓	✓	✓	✓
Tufted guineafowl	*Numida meleagris*	Introduced & Naturalised[SO]									✓				
Swamp harrier	*Circus approximans*	Not Threatened[SO]									✓				
Welcome swallow	*Hirundo n. neoxena*	Not Threatened[Inc SO]									✓	✓		✓	✓

SPECIES (Robertson et al. 2007)		CONSERVATION STATUS (Robertson et al. 2013)	HABITAT								SOURCE				
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open country	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	OSNZ atlas squares	MANGERE INLET - Summer	MANGERE INLET - Autumn	LANDBIRDS - Summer	LANDBIRDS - Autumn
Wild turkey	*Meleagris gallopavo*	Introduced & Naturalised[SO]									✓				
Yellowhammer	*Emberiza citrinella*	Introduced & Naturalised[SO]									✓				
Australasian bittern	*Botaurus poiciloptilus*	Threatened - Nationally Endangered[DP Sp TO]													
Australasian little grebe	*Tachybaptus n. novaehollandiae*	Coloniser[SO]									✓				
Black shag	*Phalacrocorax carbo novaehollandiae*	At Risk - Naturally Uncommon[SO Sp]									✓		✓		
Black stilt	*Himantopus novaezelandiae*	Threatened - Nationally Critical[CD RR]									✓				
Black swan	*Cygnus atratus*	Not Threatened[SO]									✓				
Black-billed gull	*Larus bulleri*	Threatened - Nationally Critical[RF]									✓		✓		
Black-fronted dotterel	*Charadrius melanops*	Coloniser[SO Sp]									✓				
Brown teal	*Anas chlorotis*	At Risk - Recovering[CD RR]									✓				
Feral (greylag) goose	*Anser anser*	Introduced & Naturalised[SO]									✓				
Grey duck	*Anas s. superciliosa*	Threatened - Nationally Critical[SO]									✓				
Grey teal	*Anas gracilis*	Not Threatened[Inc SO]									✓				
Little black shag	*Phalacrocorax sulcirostris*	At Risk - Naturally Uncommon[RR]									✓	✓	✓		
Little shag	*Phalacrocorax melanoleucos brevirostris*	Not Threatened[Inc]									✓	✓			
Mallard	*Anas platyrhynchos*	Introduced & Naturalised[SO]									✓	✓	✓		
North Island fernbird	*Bowdleria punctata vealeae*	At Risk - Declining[DP]									✓				
NZ dabchick	*Poliocephalus rufopectus*	Threatened - Nationally Vulnerable[St]									✓				
NZ pied oystercatcher	*Haematopus finschi*	At Risk - Declining									✓	✓	✓		

SPECIES (Robertson et al. 2007)		CONSERVATION STATUS (Robertson et al. 2013)	HABITAT								SOURCE				
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open country	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	OSNZ atlas squares	MANGERE INLET - Summer	MANGERE INLET - Autumn	LANDBIRDS - Summer	LANDBIRDS - Autumn
NZ scaup	*Aythya novaeseelandiae*	Not Threatened[Inc]									✓				
NZ shoveler	*Anas rhynchotis variegata*	Not Threatened									✓				
Paradise shelduck	*Tadorna variegata*	Not Threatened									✓		✓		
Pied shag	*Phalacrocorax varius varius*	Threatened - Nationally Vulnerable									✓	✓	✓		
Pied stilt	*Himantopus h. leucocephalus*	At Risk - Declining[SO]									✓	✓	✓		
Pukeko	*Porphyrio m. melanotus*	Not Threatened[Inc SO]									✓	✓			
Asiatic black-tailed godwit	*Limosa limosa melanuroides*	Vagrant[SO]									✓				
Banded dotterel	*Charadrius bicinctus bicinctus*	Threatened - Nationally Vulnerable[DP]									✓				
Banded rail	*Gallirallus philippensis assimilis*	At Risk - Declining[DP RR]													
Black-backed gull	*Larus d. dominicanus*	Not Threatened[SO]									✓	✓	✓		
Caspian tern	*Hydroprogne caspia*	Threatened - Nationally Vulnerable[SO Sp]									✓	✓	✓		
Eastern bar-tailed godwit	*Limosa lapponica baueri*	At Risk - Declining[TO]									✓	✓			
Eastern curlew	*Numenius madagascariensis*	Migrant[SO]									✓				
Lesser knot	*Calidris canutus rogersi*	Threatened - Nationally Vulnerable[TO]									✓	✓			
Northern NZ dotterel	*Charadrius obscurus aquilonius*	Threatened - Nationally Vulnerable[CD Inc]									✓	✓			
Pacific golden plover	*Pluvialis fulva*	Migrant[SO]									✓				
Pectoral sandpiper	*Calidris melanotos*	Vagrant[SO]									✓				
Red-billed gull	*Larus novaehollandiae scopulinus*	Threatened - Nationally Vulnerable									✓	✓	✓		
Red-necked stint	*Calidris ruficollis*	Migrant[SO]									✓				

SPECIES (Robertson et al. 2007)		CONSERVATION STATUS (Robertson et al. 2013)	HABITAT								SOURCE				
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open country	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	OSNZ atlas squares	MANGERE INLET - Summer	MANGERE INLET - Autumn	LANDBIRDS - Summer	LANDBIRDS - Autumn
Reef heron	*Egretta sacra sacra*	Threatened - Nationally Endangered[DP SO Sp St]									✓		✓		
Royal spoonbill	*Platalea regia*	At Risk - Naturally Uncommon[Inc RR SO Sp]									✓	✓	✓		
Sharp-tailed sandpiper	*Calidris acuminata*	Migrant[SO]									✓				
Siberian (grey-tailed) tattler	*Tringa brevipes*	Vagrant[SO]									✓				
Spotted shag	*Stictocarbo p. punctatus*	Not Threatened									✓				
Turnstone	*Arenaria interpres*	Migrant[SO]									✓				
Variable oystercatcher	*Haematopus unicolor*	At Risk - Recovering[Inc]									✓	✓	✓		
White-faced heron	*Egretta novaehollandiae*	Not Threatened[SO]									✓	✓	✓		
White-fronted tern	*Sterna s. striata*	At Risk - Declining[DP]									✓	✓	✓		
Wrybill	*Anarhynchus frontalis*	Threatened - Nationally Vulnerable[RR]									✓	✓			
Australasian gannet	*Morus serrator*	Not Threatened[De Inc SO]									✓				
Fluttering shearwater	*Puffinus gavia*	At Risk - Relict[RR]									✓				
Northern blue penguin	*Eudyptula minor iredalei*	At Risk - Declining[DP EF]									✓				
Sooty shearwater	*Puffinus griseus*	At Risk - Declining[SO]									✓				
Rock pigeon	*Columba livia*	Introduced & Naturalised[SO]									✓		✓	✓	
Barbary dove	*Streptopelia risoria*	Introduced & Naturalised[SO Sp]									✓				
Spotted dove	*Streptopelia chinensis tigrina*	Introduced & Naturalised[SO]									✓			✓	✓
Myna	*Acridotheres tristis*	Introduced & Naturalised[SO]									✓			✓	✓

Appendix C

Mangere Inlet shorebird count data

The table below provides data regarding species recorded during the summer (February) and winter (May) 2016 fixed point counts within the Mangere Inlet

SPECIES	Mona Ave				Norana Park				CS1				CS2				CS3			CS4			CS5				CS6				CS7		
	2-Feb	3-Feb	2-May	3-May	2-Feb	3-Feb	2-May	3-May	2-Feb	3-Feb	12-Feb	3-May	2-Feb	12-Feb	2-May	3-May	2-Feb	2-May	3-May	3-Feb	2-May	3-May	2-Feb	3-Feb	2-May	3-May	3-Feb	12-Feb	2-May	3-May	3-Feb	2-May	3-May
Bar-tailed godwit						71					247																8	146					
Black-backed gull	31	22		2	15	62		3	1	1		9		28		12	155	150	180	19		3	115	137	150	21	24	237	3	275	5	10	8
Black-billed gull							2												2			1											
Black shag																		5	1						5	1				1			
Caspian tern	1			2									1									1					1						
Grey duck hybrid											1																						
Kingfisher									1																								
Lesser knot											6																						
Little black shag															1		1			1												3	
Little shag	1					1			1				1				1			1													
Mallard	23		4			1	4	4		2	2	1				2	29	12	37					8	12	2		26	2	2			2
NZ dotterel										1																							
NZ pied oystercatcher	98	41	40	50	20	80	50	202	80	4	93	35	108	160	32	85	8	13	60	46	30	20	16	18	13	26	223	244	32	280	13	230	40
Paradise shelduck																			2														
Pied shag	13	19			1	1		3	1				2			1	1		1	18	25	1		6		8	1		4	10			1
Pied stilt				30			10		1	1	1					1	6	1		4		9	5	1	1		2	10	10	8		2	
Pukeko	2																																

SPECIES	Mona Ave				Norana Park				CS1				CS2				CS3			CS4			CS5				CS6				CS7		
	2-Feb	3-Feb	2-May	3-May	2-Feb	3-Feb	2-May	3-May	2-Feb	3-Feb	12-Feb	3-May	2-Feb	12-Feb	2-May	3-May	2-Feb	2-May	3-May	3-Feb	2-May	3-May	2-Feb	3-Feb	2-May	3-May	3-Feb	12-Feb	2-May	3-May	3-Feb	2-May	3-May
Red-billed gull		3		6	208	152	150	110				2	1	1	20	500	8	20	10	36	6	2	32	35	20	20		43	15	270	39	80	110
Reef heron																																1	
Rock pigeon			1																														
Royal spoonbill															30	3	5	16	9						16	7		5		10		32	
Silvereye															1																		
Spur-winged plover					2						2																	2					
Starling			1						1	1			1							1													
Variable oystercatcher				2								1			5					1	1	2				2	1	1				6	
Welcome swallow										2	1																						
White-faced heron	15	4	6	10	42	37	6	28	18	7	15	3	3	39	6	6		1		10	12	12	1	1	1	2		17		45	1	25	1
White-fronted tern								2	1																	1						1	
Wrybill					5						4																						
TOTAL BIRDS	184	89	52	102	293	405	222	352	105	19	372	51	117	228	95	610	214	218	302	137	74	51	169	206	218	90	260	731	66	901	58	390	162
SPECIES COUNT	8	5	5	7	7	8	6	7	9	8	10	6	7	4	7	8	9	8	9	10	5	9	5	7	8	10	7	10	6	9	4	10	6

CHAPTER 6

PROPOSED MITIGATION AND OFFSET

Quality Assurance Statement	
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Reviewed by	Stephen Fuller

6 Chapter 6 – Proposed Mitigation and Offset

6.1 Introduction

6.1.1 Purpose and scope

This report forms part of a suite of technical reports prepared for the Transport Agency's East West Link project (the Project). Its purpose is to inform the AEE and to support the resource consent applications, new NoR and alterations to existing designation required for the EWL.

This report provides an integrated approach to mitigation and offset of significant adverse effects[67] on the existing ecological values, bringing all aspects of ecology together to ensure holistic ecological outcomes that maximise benefits. This chapter has been prepared based on the information presented in Chapters 2-5 and, as a package, recommends mitigation and offset to balance[68] potential adverse effects on ecological values identified in each of the preceding ecological assessment chapters.

Application of the mitigation hierarchy involved avoidance and minimisation of adverse effects on ecological values early on in the Project design to inform the scale, location and construction methodology for the Project.

6.1.2 Ecological design principles

The following set of simple ecological principles were used to help guide the Project design as well as the mitigation outcomes:

- Minimise permanent habitat loss;
- Avoid and minimise loss of rare ecosystem types and habitats for *Threatened* and *At Risk* species;
- Avoid habitat fragmentation / barriers;
- Avoid loss of, enhance or create habitat connectivity;
- Enhance existing habitats and ecosystems – particularly habitat sequences;
- Create safe habitats, especially for *Threatened* or *At Risk* species;
- Improve water and sediment quality;
- Recreate habitats no longer present and ecosystem that were types unique to the area;
- Increase biodiversity – may including investigating options for re-introducing locally extinct species;
- Measure mitigation success for an ecologically relevant period and in a manner that is practicable to implement.

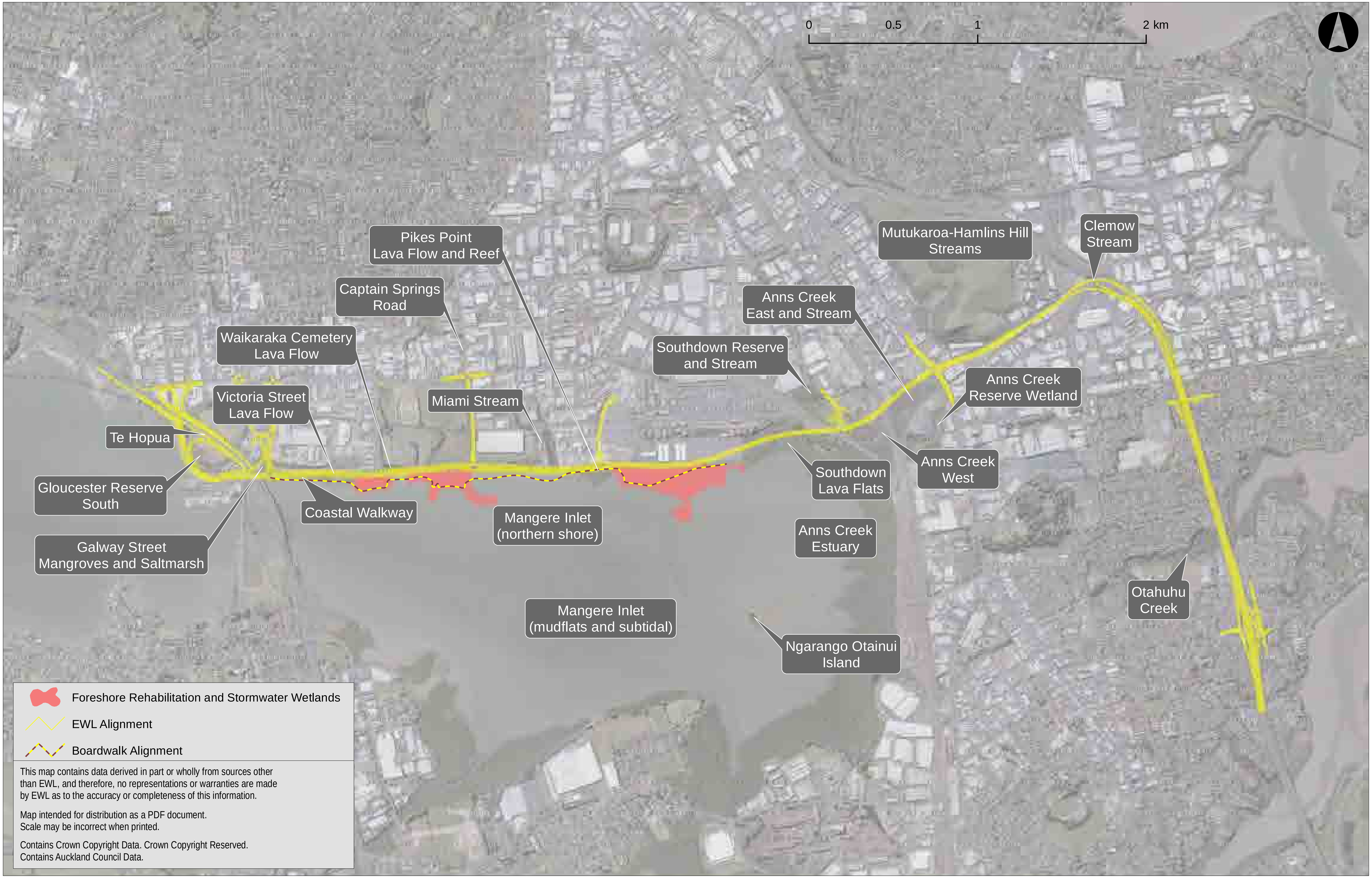
6.1.3 Summary of ecological features

A series of maps have been produced that summarise the main ecological values identified in Chapters 2-5 and other ecological areas related to the Project (Map 6-1 to Map 6-7).

---

[67] Those effects identified in chapters 2-5 as medium or higher.

[68] Acknowledging that some of the measures identified are reliant on third party agreements, but nevertheless are critical to achieving the balace required.



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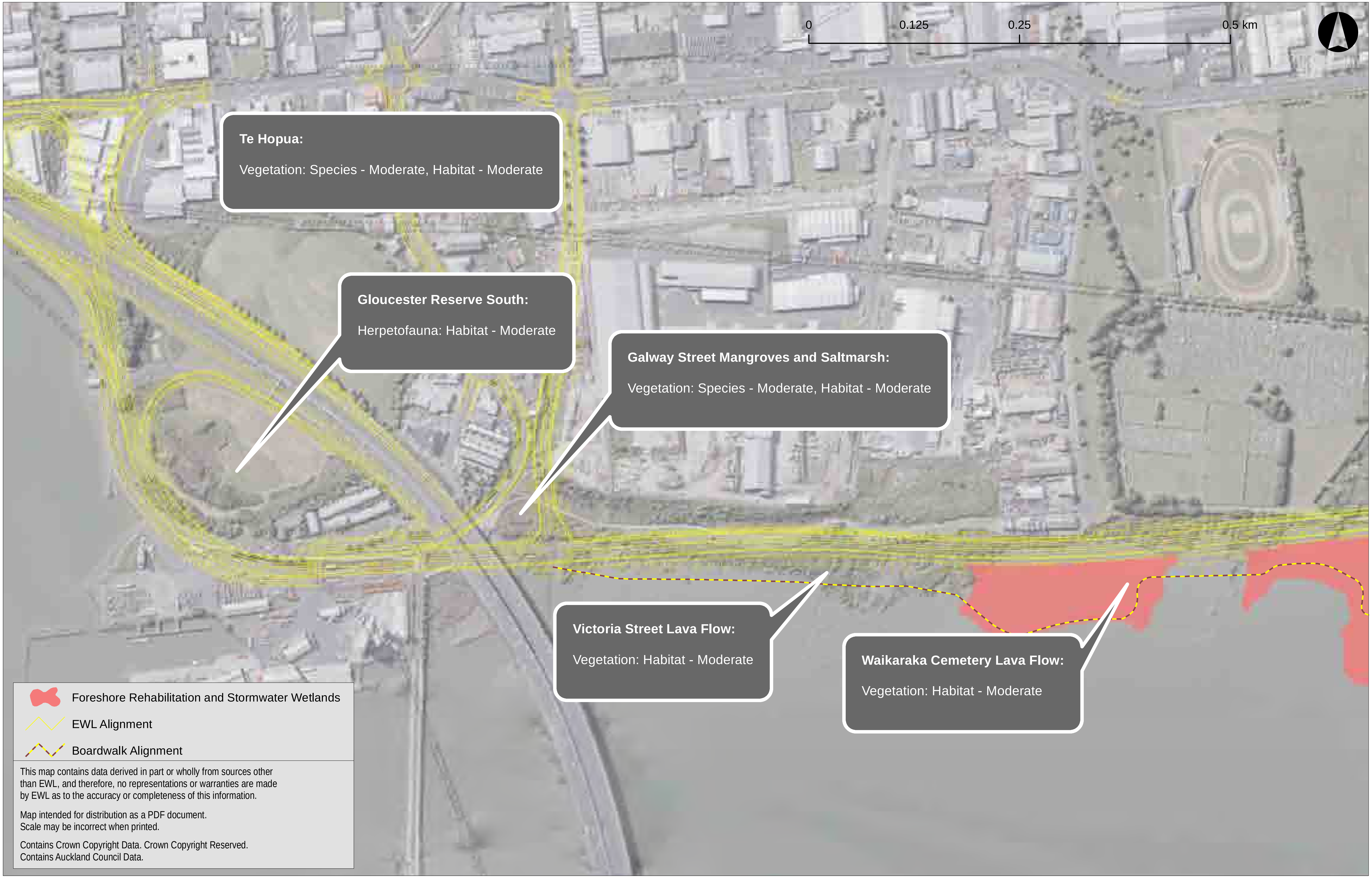
Drawing Title
ECOLOGY
Map 6-1: Ecological Value

Drawing Number GIS-AEE-EC-001-6-1
Rev No. A

Plot Date: 17/11/2016 Plotted by: Ben Peyton File: U:\2016\T16006_SDE_East-West_Connection_Ecology\GIS\T16006_37_EcologyValues_DDP.mxd



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Drawing Title: ECOLOGY
Map 6-2: Ecological Value Sheet 1

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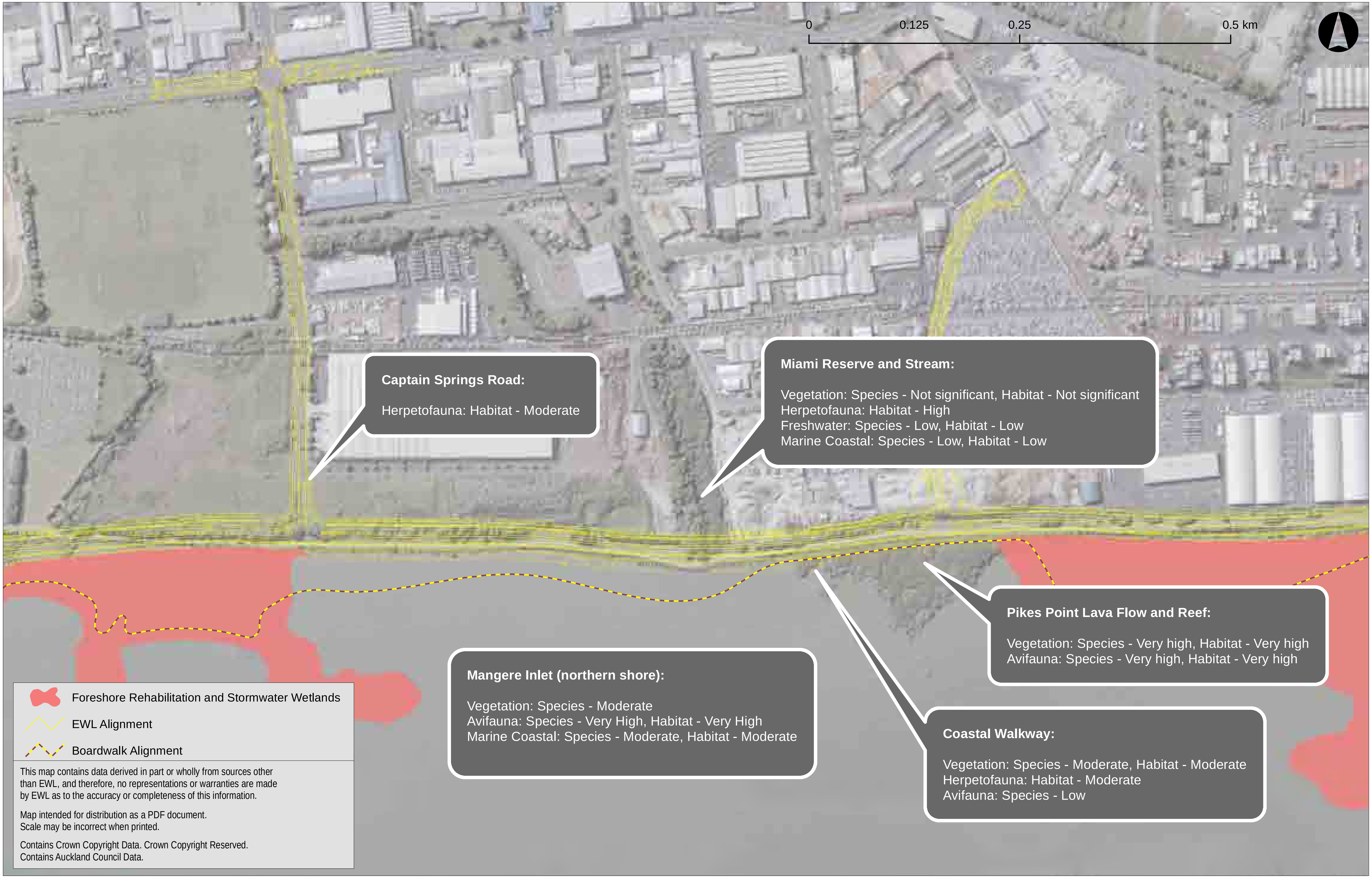

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Map 6-3: Ecological Value Sheet 2

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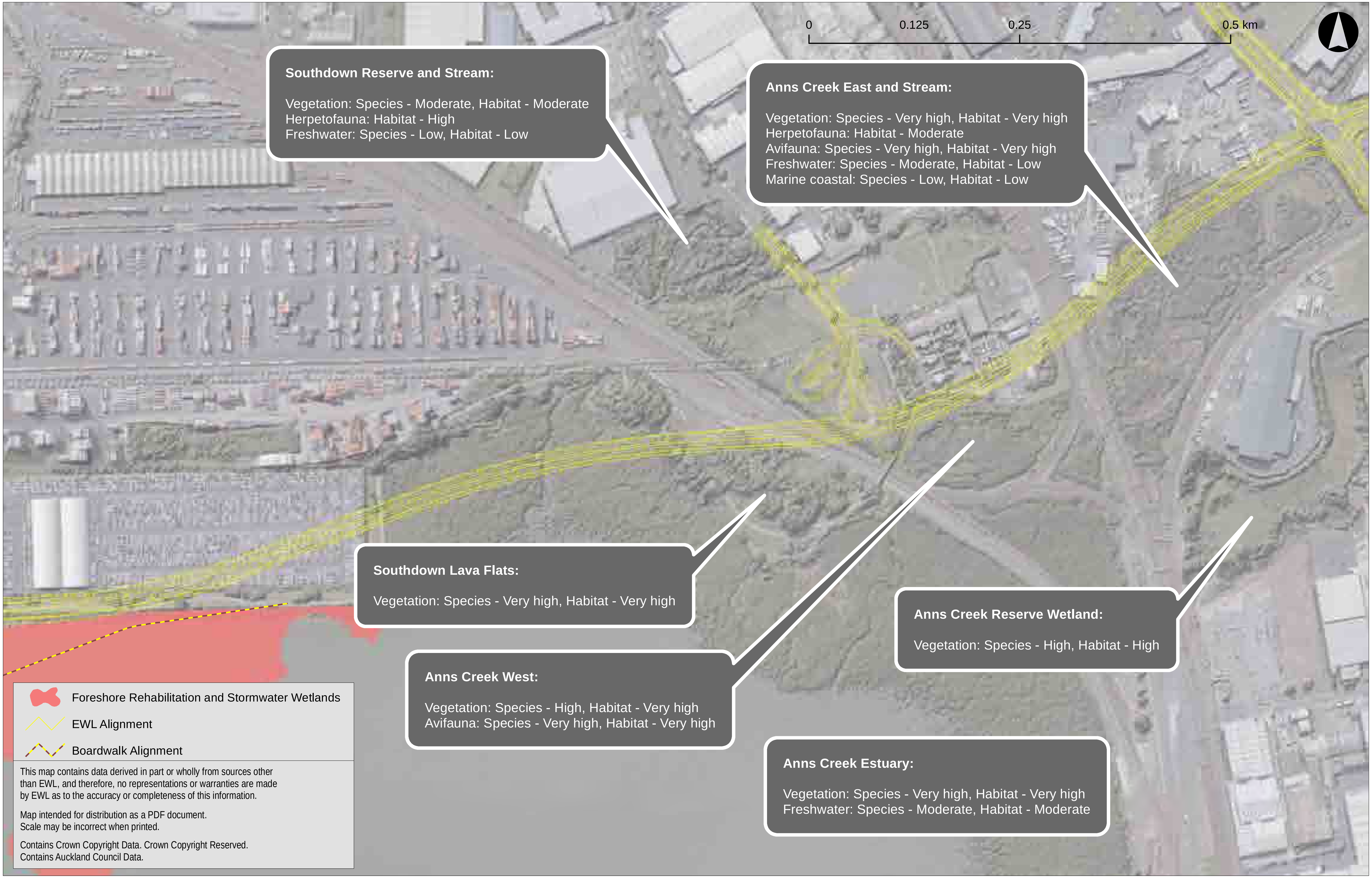

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Map 6-4: Ecological Value Sheet 3

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Map 6-5: Ecological Value Sheet 4

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Map 6-6: Ecological Value Sheet 5

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Original Size: A3
Contract No PA4041

Drawing Title
ECOLOGY
Map 6-7: Ecological Value Sheet 6

Drawing Number GIS-AEE-EC-001-6-7
Rev No. A

Plot Date: 17/11/2016 Plotted by: Ben Peyton File: U:\2016\T16006_SDE_East-West_Connection_Ecology\GIS\T16006_37_EcologyValues_DDP.mxd

6.1.4 Summary of Positive and Potential Adverse Effects

6.1.4.1 Positive effects

The positive effects of the Project on ecological values are identified and summarised in Table 6-1.

Table 6-1: Positive effects of the EWL Project on ecology values

Positive Effects	Ecological Value	Magnitude of Effect	Level of Effect
MARINE			
Reduced contaminant load discharged to the CMA (Assessed at the Mangere Inlet scale)	Moderate	Moderate	Moderate
Increased habitat diversity (provision of hard shore) (Assessed at the Mangere Inlet scale)	Moderate	Moderate	Moderate
AVIFAUNA			
Reduced contaminant load discharged to CMA (foraging habitat) benefits to Mangere Inlet shorebirds	Very High	Low	Low
Increased habitat diversity for Mangere Inlet avifauna on edge of stormwater landscape features and provision of stormwater wetlands	Moderate	Low	Low

6.1.4.2 Potential adverse effects

According to the EIANZ (2015) guidelines, the level of potential effect can be used as a guide to the extent and nature of ecological response required (including the need for biodiversity offsetting) as follows:

- Very High and High represent a high level of effect on ecological or conservation values and warrant avoidance and/or extremely high intensity mitigation and remediation actions. Biodiversity offsetting should be considered where these adverse effects cannot be avoided;
- Moderate represents a level of effect that requires careful assessment and analysis of the individual case. Such an effect could be mitigated through avoidance, design, or extensive appropriate mitigation actions;
- Low and Very low should not normally be of concern, although normal design, construction and operational care should be exercised to minimise adverse effects. If effects are assessed taking mitigation into consideration, then it is essential that prescribed mitigation is carried out to ensure Low or Very low level effects; and
- Very low level effects can generally be considered to be classed as 'not more than minor' effects.

Outlined in Table 6-2 is a summary of all of the potential adverse effects on the ecological values which have been identified as being of moderate, high or very high level, and thereby requiring some form of mitigation or offset (as identified in the right-most column of Table 6-2).

Table 6-2: Summary of potential moderate, high and very high level adverse effects on ecological values

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset
TE HOPUA / GLOUCESTER PARK				
There are no significant potential adverse effects on ecological values in this area				
GALLWAY STREET MANGROVE AND SALTMARSH				
Loss of saltmarsh/mangrove habitat at Onehunga / Mangere Bridge (Assessed at Mangere Inlet scale)	Moderate	High	Moderate	Mitigate
NORTHERN SHORE				
Loss of and disturbance to Pikes Point lava flow vegetation	High	High	Very High	Mitigate
Loss of lava flow vegetation and ecosystem at Waikaraka Cemetery and west	Moderate	High	Moderate	Mitigate
Loss of part of lava flow ecosystem at Victoria Street	Moderate	High	Moderate	Mitigate
Loss of vegetation within and adjacent to Miami Stream and estuary	Moderate	High	Moderate	Mitigate
Permanent stream habitat loss in Miami Stream (25m)	Low	Very High	Moderate	Mitigate
Loss of Auckland Council long term monitoring site (Mangere cemetery)	Moderate	Negligible	Moderate[69]	Mitigate
Loss of CMA - Construction of road embankment	Moderate	High	High	Offset
Loss of CMA - Construction of rehabilitated coastal edge and stormwater bund	Moderate	High	High	Offset
Loss of Auckland Council sediment quality survey site	Moderate	Negligible	Moderate	Mitigate
Physical disturbance in CMA beyond the permanent occupation / reclamation footprint	Moderate	Moderate	Moderate	Mitigate
Subtidal dredging (Assessed at the Mangere Inlet scale)	Moderate	Moderate	Moderate	Mitigate

[69] The level of effect has to be moderate, which is a departure from EIANZ guidelines, because there is scientific value in the long term data set held by Auckland which will be disrupted by the Project. Mitigation required is to locate and survey at a new location concurrently with the existing location prior to construction.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset
Cumulative effect of permanent loss of CMA on shorebird populations (Assessed at Mangere Inlet scale)	Very High	Low	Moderate	Offset and Mitigate
Permenant habitat loss for shorebirds	Very High	Low	Moderate	Offset and Mitigate
Disturbance (and effective habitat loss) during operational phase to shorebirds	Very High	Moderate	High	Offset
Reduced food supply for shorebirds through potential sedimentation in CMA during construction	Very High	Low	Moderate	Offset if sedimentation event in CMA occurs[2]
ANNS CREEK ESTUARY				
Occupation of the CMA by permanent bridge structures	Moderate	Moderate	Moderate	Offset
Loss of and disturbance to Anns Creek Estuary vegetation	Very High	High	Very High	Mitigate
Structures affecting connectivity of ecological features / habitats (Anns Creek Estuary primarily)	Moderate	Moderate	Moderate	Mitigate
Habitat loss for cryptic marshbirds	Very High	Moderate	Very High	Offset and Mitigate
Disturbance during construction to cryptic marshbirds	Very High	Low/High	Very High	Avoided as far as practicable
Disturbance during operational phase to cryptic marshbirds	Very High	High	Very High	Unable to mitigate
Reduced food supply for cryptic marshbirds through potential sedimentation in CMA during construction	Very High	Low	Moderate	Offset if sedimentation event in CMA occurs[59]
Mortality of cryptic marshbirds during construction	Very High	Very High	Very High	Avoided as far as practicable
Mortality of cryptic marshbirds during operational phase	Very High	Low	Moderate	Unable to mitigate
ANNS CREEK EAST				
Loss of and disturbance to Anns Creek East vegetation	Very High	High	Very High	Avoid where possible and mitigate where cannot be avoided
Permanent freshwater habitat loss in Anns Creek East (10m long)	High	Moderate	Moderate	Mitigate

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset
Loss of raupo wetland	High	Very High	Very High	Offset
SOUTHDOWN RESERVE AND SOUTHDOWN STREAM				
There are no significant potential adverse effects on ecological values in this area				
ANNS CREEK RESERVE WETLAND				
There are no significant potential adverse effects on ecological values in this area				
CLEMOW STREAM				
There are no significant potential adverse effects on ecological values in this area				
OTAHUHU CREEK				
There are no significant potential adverse effects on ecological values in this area				
PROJECT WIDE EFFECTS				
Loss of herpetofauna habitat and displacement of *At Risk* and *Threatened* organisms	Moderate/High	High	Moderate/High	Mitigate
Fragmentation of herpetofauna habitat for *Threatened* and *At Risk* species	High	Moderate	High	Mitigate
Injury or death of *Threatened* or *At Risk* native herpetofauna	Moderate/High	Very High	Very High	Avoided as far as practicable
Discharges from Erosion and Sediment Control devices to streams and CMA	Moderate	Low-Moderate	Moderate	Offset if sedimentation event in CMA occurs[70]

6.1.5 Interpretation of Mitigation and Offset

The Project team have reviewed the relevant sections of the Auckland Unitary Plan for guidance on mitigation hierarchy and offsetting. The Unitary Plan contains policies that describe a mitigation hierarchy around managing effects of activities on indigenous biodiversity values that are identified as significant ecological areas (Policy D9.3). The policy describes the mitigation hierarchy as firstly avoid, then remedy, then mitigate and then consider the appropriateness of offsetting[71] any residual adverse effects that are significant and where they have not been able to be mitigated, through protection, restoration and enhancement measures.

The Unitary Plan also sets out a framework for biodiversity offsetting (Appendix 8, Auckland Unitary Plan), which is to be read in conjunction with the New Zealand government Guidance on Good Practice Biodiversity Offsetting in New Zealand document[72]. The framework states:

[70] This effect may or may not occur, depending on size of rainfall events during open earthworks and erosion and sediment control design capacity before overflow to CMA.

[71] The Project team has relied on the following definition for offset: "to provide a positive effect to compensate for an adverse effect on the environment".

[72] New Zealand Government, 2014.

1. Restoration, enhancement and protection actions will only be considered a biodiversity offset where it is used to offset the significant residual effects of activities after the adverse effects have been avoided, remedied or mitigated.

2. Restoration, enhancement and protection actions undertaken as a biodiversity offset are demonstrably additional to what otherwise would occur, including that they are additional to any avoidance, remediation or mitigation undertaken in relation to the adverse effects of the activity.

3. Offset actions should be undertaken close to the location of development, where this will result in the best ecological outcome.

4. The values to be lost through the activity to which the offset applies are counterbalanced by the proposed offsetting activity, which is at least commensurate with the adverse effects on indigenous biodiversity. Where possible the overall result should be no net loss, and preferably a net gain in ecological values.

5. The offset is applied so that the ecological values being achieved through the offset are the same or similar to those being lost.

6.2 Proposed Mitigation and Offset

In terms of potential offsets for the permanent loss of the CMA, a like-for-like approach was investigated whereby the Mangere Inlet and wider Manukau Harbour were searched for areas that could possibly be declaimed. However, no such areas were identified as being available and therefore a like-for-like offset approach could not be achieved. Consequently, the offset for this effect has had to take a different form (i.e. not like-for-like). Nevertheless, as stated earlier, the approach taken to the ecological mitigation and offsetting for the EWL Project has been to seek overall biodiversity gains.

Based on the integrated nature of the approach taken towards the ecological mitigation and offsetting requirements for the EWL project, the suite of proposed actions are presented below on a sector basis incorporating the requirements for all the different ecology specialist areas (i.e. terrestrial vegetation, herpetofauna, freshwater, marine and avifauna) (Map 6-8).

Mitigation and offset proposed on land that is not owned by the Transport Agency wil be subject to the agreement of the landowner. Initial discussions have taken place with most landowners (especially Auckland Council) and will continue as the Project progresses.

Mitigation and offset should be detailed in and guided by an Ecological Management Plan.

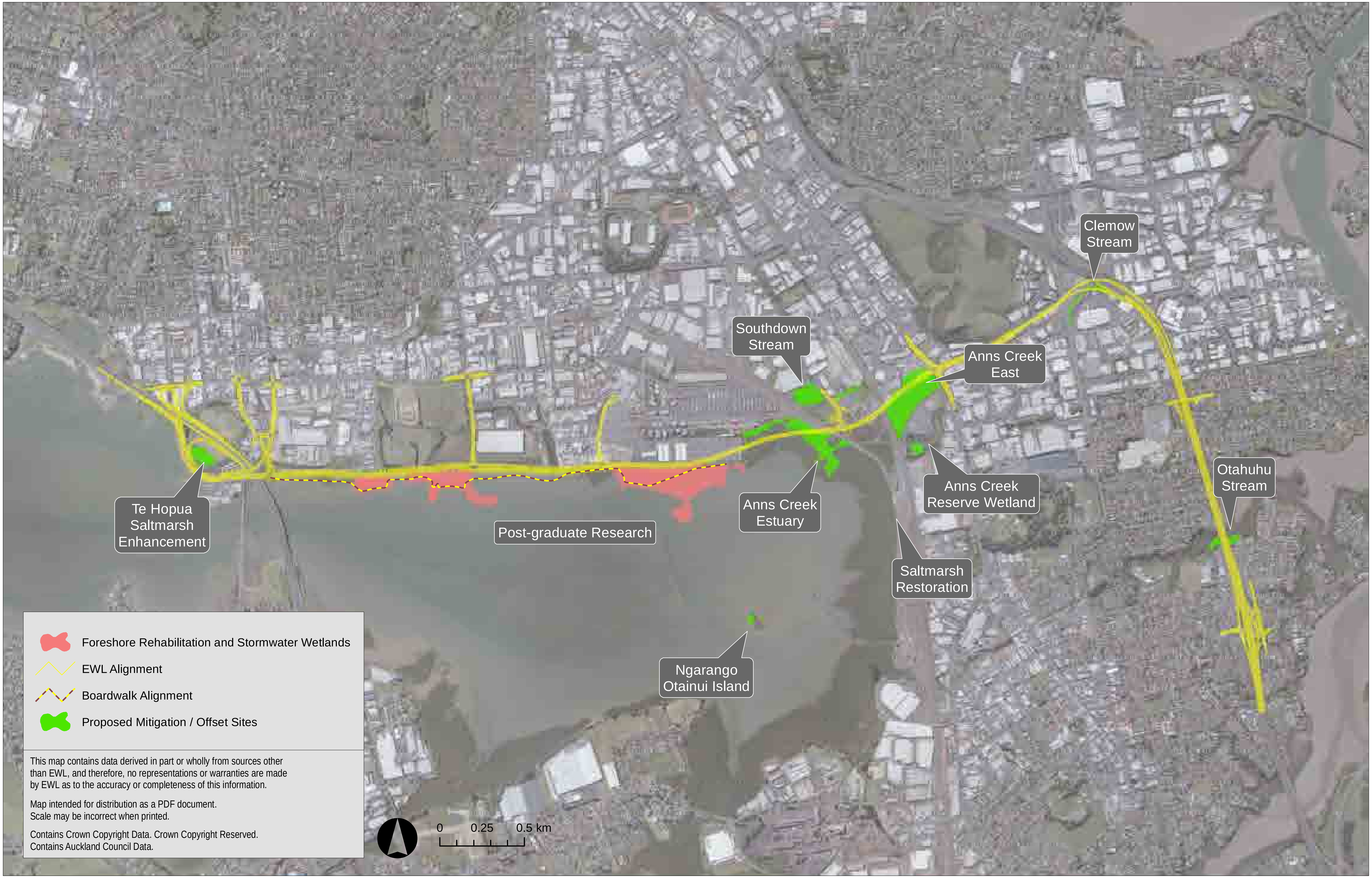
6.2.1 Sector 1 – Neilson Street Interchange

6.2.1.1 Te Hopua / Gloucester Park South

The existing saltmarsh wetland in Te Hopua (Gloucester Park South) should be enhanced through weed control, edge/buffer planting of appropriate native species (e.g. harakeke, manuka, taupata, ti kouka) and enhancement planting within the saltmarsh wetland itself (e.g. oioi, sea rush, glasswort, salt marsh ribbonwood) (Map 6-9).

There is an opportunity to increase the area of wetland in the crater by planting additional saltmarsh to further enhance the ecological values and functions.

The area of saltmarsh enhancement and creation is approximately 1.1ha.



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Drawing Title
ECOLOGY
Map 6-8: Proposed Mitigation / Offset Sites

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Plot Date: 17/11/2016 Plotted by: Ben Peyton File: U:\2016\T16006_SDE_East-West_Connection_Ecology\GIS\T16006_34_East_West_Mitigation_DDP.mxd

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Drawing Title	ECOLOGY Map 6-9: Te Hopua Saltmarsh Restoration	
Drawing Number	GIS-AEE-EC-001-6-9	Rev No. A

Plot Date: 17/11/2016 Plotted by: Ben Peyton File: U:\2016\T16006_SDE_East-West_Connection_Ecology\GIS\T16006_34_East_West_Mitigation_DDP.mxd

6.2.1.2 Galway Street mangrove and saltmarsh

The loss of glasswort and mangrove dominated saltmeadow / saltmarsh located to the east of SH20 bridge (referred to as Galway Street mangrove and saltmarsh) should be mitigated by the establishment of a similar vegetation feature / habitat along the eastern edge of the Mangere Inlet (see saltmarsh restoration area identified on Map 6-12). The new area of saltmarsh is approximately 1ha.

6.2.2 Sector 2 – Mangere Inlet Northern Shoreline

6.2.2.1 Northern shore

The remaining basalt lava flows and lava shrubland habitats at Pikes Point and Victoria Street should be protected (during and post-construction) and enhanced through weed control and revegetation (Map 6-10).

Salvage and relocation of remnant basalt lava flow features and rocks and associated native organisms, which will be destroyed as part of reclamation, should be investigated. These could be re-used as part of the re-creation of lava field habitat within the coastal foreshore.

Rehabilitation of lava shrubland species should be undertaken through planting on the new coastal edge, using eco-sourced local genetic stock e.g. *Coprosma crassifolia*, ngaio, akeake, saltmarsh ribbonwood, oioi, *Austrostipa stipoides*, *Puccinellia stricta* (salt grass). Planting of *Threatened* coastal species such as *Mimulus repens* could be undertaken. Propagating from existing lava shrubland vegetation should be investigated as a plant source.

There is significant opportunity for restoration of indigenous coastal plant assemblages to be undertaken as part of the proposed stormwater wetlands, landscape planting along the coastal foreshore edge and on natural islands to enhance vegetation values themselves and also to provide habitat for indigenous organisms.

The EWL Project team should work with Auckland Council to establish a new sediment quality monitoring site to replace the “Mangere Cemetery” survey site that sits within the proposed stormwater bund footprint. This monitoring site is due to be surveyed in November 2016 and there is an opportunity at that time to concurrently survey potential replacement sites which will provide overlap in the data set. Discussions with Auckland Council on this matter have been had during October/November 2016.

The treatment of catchment stormwater and landfill leachate, within freshwater wetlands along the proposed northern shoreline landscape features, prior to discharge to the CMA will have benefits on water quality at the discharge points, and sediment quality and benthic invertebrate health in the longer term (Map 6-10). If contaminant concentrations in surface sediment are reduced over time to below effects thresholds, sub-lethal stress on benthic invertebrate taxa may be reduced (at least for the most sensitive species) which may have positive effects on growth and reproduction. If such benefits on marine invertebrate assemblages occur, increases in abundance and diversity of organisms is likely to have benefit to those organisms that predate upon benthic invertebrates e.g. shorebirds. We recommend that a monitoring programme be established within the vicinity of the stormwater treatment wetland discharge points (and at control locations) designed to detect improvements in benthic invertebrate community composition and sediment quality in order to determine if benefits to ecological values from the Project are measureable. Such a monitoring programme should be undertaken for a period of at least five years.

As the proposed reclamation will reduce the quantity of intertidal foraging habitat for avifauna in the Mangere Inlet, options should be investigated to increase the abundance of intertidal prey items within the Mangere Inlet including provision of a post-graduate research scholarship to investigate potential to facilitate enhancement of the benthic invertebrate assemblage e.g. potentially transplanting large invertebrates that are uncommon in the northern part of the Inlet, such as bivalves. The value of this research is to extend current scientific knowledge and inform future projects of a similar nature.

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ECOLOGY

Map 6-10: Northern Shore and Inlet

Drawing Number GIS-AEE-EC-001-6-10

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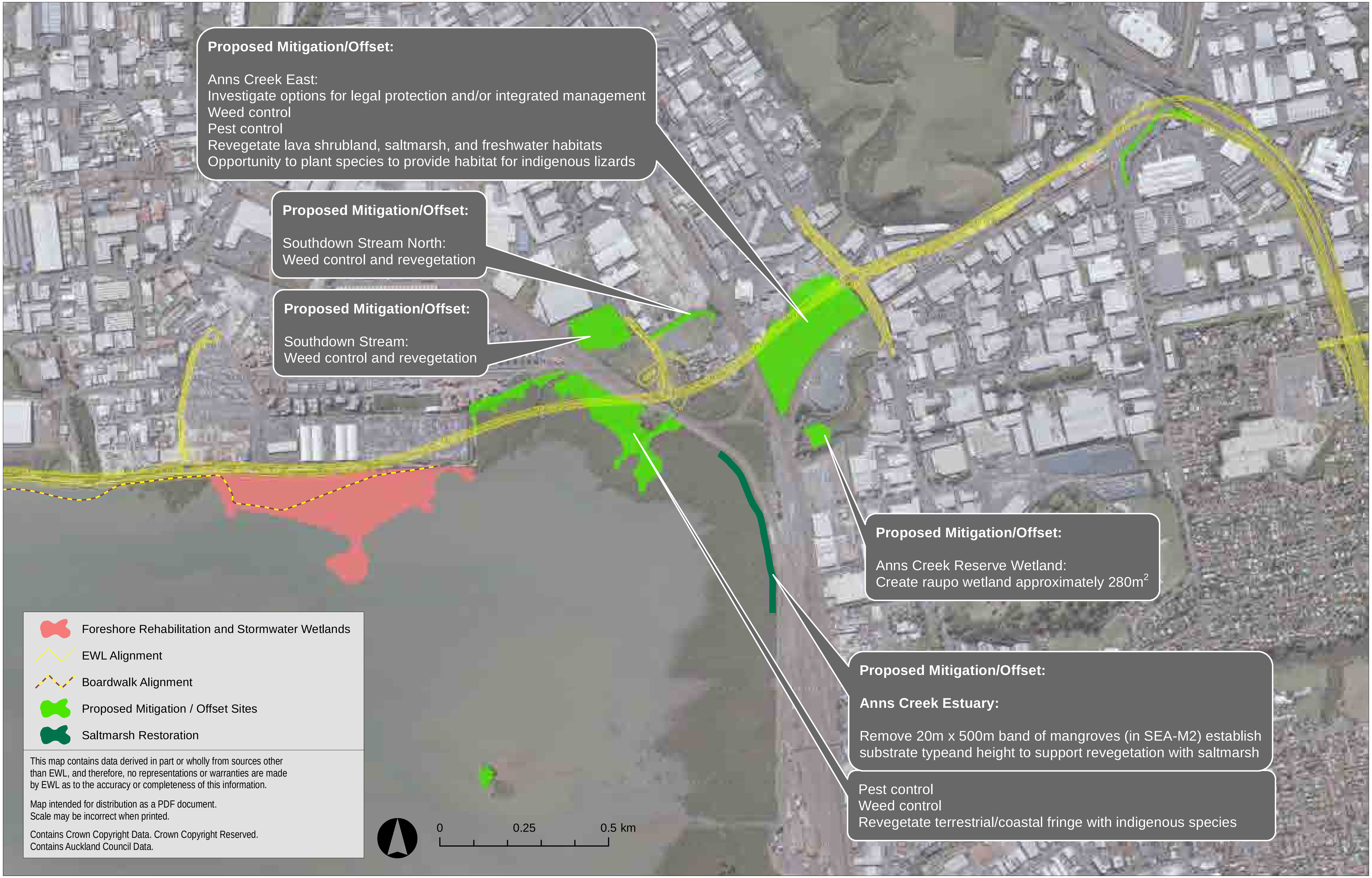

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Drawing Title: ECOLOGY
Map 6-11: Anns Creek

Drawing Number: GIS-AEE-EC-001-6-11 | Rev No. A

Plot Date: 17/11/2016 Plotted by: Ben Peyton File: U:\2016\T16006_SDE_East-West_Connection_Ecology\GIS\T16006_34_East_West_Mitigation_DDP.mxd

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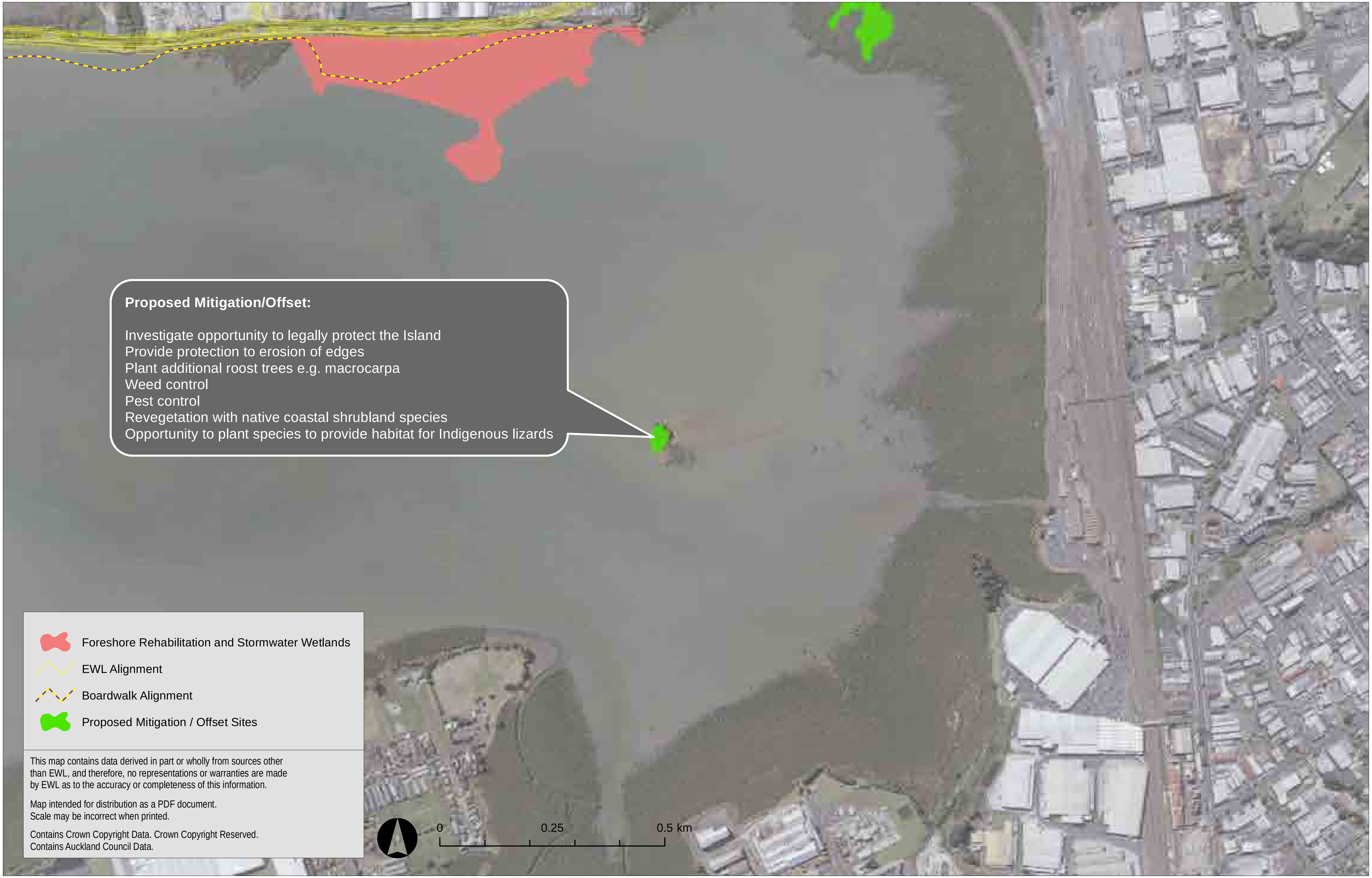

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Map 6-12: Ngarango Otainui Island

Drawing Number: GIS-AEE-EC-001-6-12

Rev No.: A

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ECOLOGY
Map 6-13: Clemow Stream and Hamlins Hill Streams

Drawing Number GIS-AEE-EC-001-6-13
Rev No. A

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A form of offset, not yet developed, will be required due to the significant adverse effect associated with both the direct and effective loss of foraging (and to a lesser extent, roosting) habitat for shorebirds in the Mangere Inlet arising from the embankment, the landform/stormwater features and the ongoing disturbance from people and dogs using the boardwalk within the CMA and on the landforms. This offset will require collaboration with DOC to identify potential sites (i.e. staging, roosting or breeding sites) for some of the *Threatened* or *At Risk* species that forage within the Inlet and to develop an appropriate package of offset that will provide sufficient quantum of benefit to those species. Such offset could include long term pest control at appropriate sites and/or working with DOC on other programmes that benefit those avifauna species.

Options for legal protection of Ngarango Otainui Island should be investigated, including the macrocarpa trees which provide roosting habitat for royal spoonbill (Map 6-12). Given macrocarpa have a limited lifespan, more suitable trees should be planted (not necessarily native species) as future roosting habitat for this species. Revegetation of this island with coastal species should be undertaken, along with weed control and pest control. The coastal fringe of this island is currently being eroded. We recommend coastal erosion mitigation measures are undertaken to provide protection to these edges, with soft options being preferred over hard engineering solutions such as rip rap or mudcrete.

The works should incorporate additional types of high tide roosts into these erosion protection measures. It is recommended that the erosion solution for the island be developed in consultation with a coastal engineer, avifauna expert and a coastal ecologist from the Department of Conservation.

There is an opportunity to provide a post-graduate research scholarship to investigate invertebrate and macroalgal colonisation of new hard shores provided along the rehabilitated northern shore and erosion protection to Ngarango Otainui Island[73]. Such research may also investigate transplanting common hard shore marine invertebrates from elsewhere in the Manukau Harbour to new areas of hard shore with an aim to facilitating colonisation.

Engagement should be undertaken with the owners of industrial buildings which are currently used as high tide roosts around the Mangere Inlet to provide the owners with information about the important species that use their roof tops, the value of the roost sites to those species, what it is about the design of the roof that the birds like (to inform any future rebuilding). Such non-binding engagement with the building owners may result in enhanced understnding and “buy-in” to protection of the roof top roost sites.

We recommend that there is requirement in the consent conditions of a minimum setback distance of 10m between the coastal edge of the reclamation/landscape feature and any landward path or cycleway, in order to minimise disturbance to foraging and roosting birds. From an ecological perspective, the greater the distance people (and potentially dogs) are from areas used by birds for foraging and roosting, the less likely adverse effects on birds will occur.

6.2.3 Sector 3 – Mangere Inlet and Anns Creek

6.2.3.1 Anns Creek Estuary

Historically, the coastal fringe within Anns Creek Estuary has been modified, causing the loss of terrestrial-saltmarsh-estuarine vegetation sequences; in the most part, mangroves are now abutting the reclaimed coastal edge with no saltmarsh or terrestrial vegetation present. It is recommended that the feasibility of removing a 20m wide strip of the landward-most mangroves and replacement with planted saltmarsh (e.g. *Juncus krausii* or oioi) habitat be investigated.[74] In order to ensure appropriate positive

[73] Current research indicates that colonisation rate and abundance of organisms is higher when the new hard shore material has high roughness (Cacabelos et al., 2016)

[74] At the same time, making sure that replanting does not affect any lava features of *Threatened* plants which may be present.

ecological outcomes, removal of mangroves and establishment of bed height to sustain saltmarsh species should be undertaken in a staged approach or involve a trial. Establishment of saltmarsh would restore part of the indigenous vegetation sequence and may provide nesting habitat for cryptic marshbirds such as banded rail. Planting of saltmarsh should be undertaken (in the area identified on Map 6-11) to replace areas which will be lost under the EWL footprint.

In addition we recommend that an appropriate location for the creation of salt marsh habitat is located along the eastern shoreline of the Mangere Inlet (Map 39) and propose that a 500m x 20m strip (1ha) of mangroves be removed and revegetated with salt marsh species. This will serve to replace areas of salt marsh lost due to the EWL project (e.g. 2,750 m^2 at Galway Street) and to create habitat for banded rail in an area that is not accessible to pedestrians. Removal of mangroves and establishment of saltmarsh is somewhat experimental, but should be achievable with location of saltmarsh plants at the appropriate height above MHWS. It is recommended that a staged, adaptive approach be taken to this restoration work, guided by the Ecology Management Plan.

6.2.3.2 Anns Creek East

Construction effects should be minimised and avoided within the lava flow shrublands and saltmarsh habitats in Anns Creek. Construction of the Anns Creek East viaduct should be located as close as practicable to the degraded northern edges of the lava flow, with bridge piers not to be located on existing lava habitat and associated shrubland vegetation.

Weed control and revegetation should be undertaken in Anns Creek East in order to enhance and protect the unique combinations of threatened plant communities associated with lava shrubland[75] (unique combination of shrub, grass, fern, herb species), saltmarsh and freshwater and wetland values (including wetland bird habitat) (Map 6-11). Management practices around weed hygiene will need to form part of the ecological managmeent in this area in order to avoid further spread of weeds and control at source. Irrigation may need to be provided to vegetation under the proposed bridge structure. It is recommended that a restoration management plan be prepared for Anns Creek East to guide this work (as part of the Ecological Management Plan) and that legal protection of the area is explored; this would need to be permanent and enduring. Mammalian pests, such as rats and cats, should be controlled within Anns Creek East, whilst revegetation is maturing. Monitoring of the efficacy of pest control should be undertaken. Opportunities for a community group, local business or Auckland Council to continue ongoing management and long term animal pest and weed control should be explored.

Within Anns Creek East, riparian planting has already been undertaken along the southern part of the stream, but could be extended along the north part. This would benefit about 150 m of stream length. This area is potential inanga spawning habitat, with existing grasses likely to provide good spawning substrate. As such, potential improvement to inanga spawning value may be limited for freshwater values, but vegetation values could be enhanced through replacement of exotic species with indigenous species.

The raupo wetland (approximately 140m^2) within Anns Creek East, currently providing habitat for *Threatened* Australasian bitten, will be impacted by the EWL Project. As such, it is recommended similar habitat be recreated. An area of approximately 280m^2 has been identified within south-western corner of Anns Creek Reserve Wetland (refer to Map 39) (approximately 400m to the south) which would provide an appropriate location of that habitat re-creation (further details are provided in section 6.2.3.5). The proposed new location is appropriate because cryptic marshbird species are very mobile and use a network of sites. There is an opportunity to potentially transplant raupo to be removed from Anns Creek East to the new raupo wetland location. Following construction, attempts should be made to restore any area of the raupo wetland remaining within Anns Creek East.

[75] An adaptive approach to establishment of lava shrubland vegetation may need to be taken, whereby small areas are initially trialled.

It is recommended that further opportunities to relocate the proposed construction yard within Anns Creek East (currently to be in the area where a consent exists for reclamation) be explored further. In addition, discussions with the consent holder should be undertaken to determine if there are opportunities for the consent to be surrendered and the area purchased by NZTA for long term enhancement and protection.

6.2.3.3 Southdown Reserve enhancement

It is recommended that estuarine and freshwater habitats within Southdown Reserve should be enhanced. There is approximately 80m of freshwater stream with riparian vegetation that could be enhanced. Any enhancement would have to consider the management of *Threatened* plant species that may be present, weed control, riparian revegetation and inanga spawning requirements (refer to Map 6-11). Enhancement should be guided by a restoration management plan.

6.2.3.4 Southdown Stream (north)

This section of open channel (about 140 m in length) runs near the property boundary within a corridor about 15 m in width. Riparian vegetation could be planted here to provide shade and enhance stream values (refer to Map 6-10).

6.2.3.5 Anns Creek Reserve Wetland enhancement

The large area (approximately 280m^2) of kikuyu grass located in the south-western corner of Anns Creek Reserve wetland should be removed and revegetated with raupo. This would serve to extend and enhance the existing wetland values as well as provide similar habitat for bittern which will be lost in Anns Creek East (refer to section 6.2.3.2) (refer to Map 6-11).

In addition, areas of exotic *Glyceria* could be restored with native species, and animal pest control could be undertaken to improve habitat for wetland birds.

6.2.4 Sector 4 – Tiptop Corner

6.2.4.1 Clemow Stream

The current Clemow Stream channel is about 90m in length and has a concrete base (refer to Map 6-13). As the section of stream will be realigned as part of the project, there is potential to re-establish a more natural channel with a mud or rocky substrate and native riparian vegetation. The enhancement of this channel would improve stream values in the medium and long term.

6.2.5 Sector 5 – Otahuhu Creek

6.2.5.1 Upper Otahuhu Creek

Terrestrial vegetation values on the floodplain and adjacent hillslopes could be enhanced by weed control and riparian planting.

6.2.5.2 Otahuhu Creek at SH1

There are significant opportunities for restoration of coastal ecosystems in Otahuhu Creek through declamation and restoration of fringing saltmarsh and riparian vegetation (Map 6-14).

Removal of the existing box culverts beneath SH1 and removal of the southern reclamation for the existing bridge abutments are likely to have positive effects on ecological values. The new structure and

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Drawing Title: ECOLOGY
Map 6-14: Otahuhu Creek

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removal of the culverts will enable the natural creek bed to re-establish, and the channel morphology to develop over time.

There are significant opportunities for weed control and revegetation along the estuarine and freshwater dominated margins of Otahuhu Creek.

6.2.5.3 Project wide

With lizard surveys needing to be carried out over the summer period and with the Auckland Council's standard conditions regarding lizard management, at this stage mitigation for lizards across the Project involves avoidance of effects on individuals through careful and supervised vegetation removal, translocation of lizards from works areas prior to works commencing, and restoration and enhancement incorporating species that provide habitat and food for native lizards. General recommendations include further survey work to inform preparation of a native lizard plan in accordance with Auckland Council standard conditions. As such, there are no specific mitigation measures proposed in Table 6-3.

6.3 Conclusion

The approach that we have taken to mitigation and offsetting for this project is an integrated solution for ecology. By that we mean that we have assessed all the adverse effects and benefits across all areas of ecology and developed mitigation and offset that, as a package, is appropriate. Table 6-3 identifies for each sector of the project the adverse effects, ecological benefits, and the mitigation and offsets proposed. It is important to note that for some parts of the project where there are no significant adverse effects restoration works are proposed as offset for adverse effects in other parts of the project.

We consider that if all the proposed mitigation and offset described in this chapter is implemented, including the offset for loss of foraging habitat yet to be developed with DOC and other offsets requiring third party approvals, it is possible for the potential moderate, high and very high ecological effects identified in Chapters 2-5 to be sufficiently addressed.

6.4 Summary of proposed mitigation

- Protection of remnant lava flow on northern shore and of lava shrubland in Anns Creek East (including areas outside of the Project footprint);
- Revegetation along the rehabilitated shoreline to be incorporate lava shrubland species;
- Investigate options for protection and enhancement of Ngarango Otainui Island and its coastal margins with the objective of creating and enhancing high tide roost habitat;
- Collaboration with DOC to identify potential sites (i.e. staging, roosting or breeding sites) for some of the *Threatened* or *At Risk* species that forage within the Inlet and to develop an appropriate package of offset that will provide sufficient quantum of benefit to those species. Such offset could include long term pest control at appropriate sites and/or working with DOC on other programmes that benefit those avifauna species;
- Work with Auckland Council to identify and establish a new long term sediment quality monitoring site to replace the "Mangere Cemetery" site which will be lost due to the project footprint;
- Construction of the Anns Creek East viaduct should be located as close as practicable to the degraded northern edges of the lava flow, with bridge piers not to be located on existing lava habitat and associated shrubland vegetation;
- Enhancement of Anns Creek East should be undertaken through weed control and revegetation;
- Removal of culverts beneath SH1 at Otahuhu Creek and declaim existing southern bridge abutment.
- Weed control and pest control proposed as part of the mitigation package covers a total area of approximately 10ha.

- Investigate options for legal protection and / or integrated management of Anns Creek East, including the area consented for reclamation (TR Group consent);
- Use results from planned lizard surveys (to be carried out in the summer of 2016/2017) to inform the development of a native Lizard Management Plan in accordance with Auckland Council's proposed draft standard conditions;
- Engage and develop relationships with the owners of industrial buildings which are currently used as high tide roosts around the Mangere Inlet to inform them of the valuable species that use their roof tops with the objective of achieving awareness and "buy-in" from the building owners regarding the value of the roof tops to *Threatened* and *At Risk* avifauna;
- The Lizard Management Plan objectives should include:
  - The population of each species of native lizard present on the site at which vegetation clearance is to occur shall be maintained or enhanced, either on the same site or at an appropriate alternative site; and
  - The habitat(s) that lizards are transferred to (either on site or at an alternative site, as the case may be) will support viable native lizard populations for all species present pre-development.
- Where revegetation is carried out as remedial work or mitigation, species that are suitable for native herpofauna should be included where appropriate;
- Avoid streamworks during freshwater fish spawning periods (relating to *Threatened* and *At Risk* species). Translocate native fish out of works area to avoid adverse effects where practicable;
- Provision of post-graduate research scholarships for assessing the success of translocating hard shore species to created islands and soft shore species to northern shore mudflats;
- Monitoring of sediment quality and benthic invertebrate assemblage adjacent to the stormwater treatment wetland discharge points for an appropriate length of time, being no less than 5 years;
- Removal of mangroves and creation of saltmarsh habitat (and monitoring its success) within Anns Creek Estuary between existing mangroves and the shoreline;
- Declamation of Otahuhu Creek bridge abutments and removal of existing culverts;
- Prior to construction of the proposed bridge across Anns Creek estuary and Anns Creek East, monitoring to determine if banded rail and Australasian bittern are breeding in areas of potential nesting habitat within the proposed EWL designation;
- Creation of raupo wetland habitat for Australasian bittern to replace that which will be lost or impacted due to the EWL Project;
- Creation of salt marsh habitat to offset for the loss of this vegetation community and banded rail habitat; and
- The preparation of an integrated ecological management plan (or plans) outlining the proposed work above and the enhancement and restoration packages.

Table 6-3: Effects, Mitigation and Offset Summary

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
TE HOPUA / GLOUCESTER PARK					
There are no significant potential adverse effects on ecological values in this area					• Enhance (and potentially expand) the existing saltmarsh wetland in Te Hopua (Gloucester Park South) through weed control, edge/buffer planting of appropriate native species and enhancement planting within the saltmarsh wetland itself. Area of saltmarsh enhancement and creation approximately 1.1 ha. • Weed control and revegetation across the entire project will occur over approximately 10ha, including the northern shoreline, Anns Creek estuary margins, Anns Creek East, Southdown Stream, Te Hopua, and Otahuhu Creek.
GALWAY STREET MANGROVE AND SALTMARSH					
Loss of saltmarsh/mangrove habitat at Onehunga / Mangere Bridge	Moderate	High	Moderate	Mitigate	• Mitigate by the establishment of a similar vegetation feature / habitat along the eastern edge of the Mangere Inlet. Area of saltmarsh/mangrove feature to be lost approximately 0.3 ha. Area of mangrove to be removed and replaced with saltmarsh along the eastern shore of the Inlet approximately 1 ha.
NORTHERN SHORE					
Loss of and disturbance to Pikes Point lava flow vegetation	High	High	Very High	Mitigate	• Protect and enhanced (through weed control) the remaining basalt lava flows and lava shrubland habitats at Pikes Point. • Investigate the possibility to salvage and relocation of remnant basalt lava flow features and rocks and associated native organisms. These could be re-used as part of the re-creation of lava field habitat within the coastal foreshore. • Rehabilitation of lava shrubland species should be undertaken through planting on the new coastal edge.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
					• Weed control and revegetation across the entire project will occur over approximately 10 ha, including the northern shoreline, Anns Creek estuary margins, Anns Creek East, Southdown Stream, Te Hopua, and Otahuhu Creek.
Loss of lava flow vegetation and ecosystem at Waikaraka Cemetery and west	Moderate	High	Moderate	Mitigate	• Investigate the possibility to salvage and relocation of remnant basalt lava flow features and rocks and associated native organisms. These could be re-used as part of the re-creation of lava field habitat within the coastal foreshore. • Rehabilitation of lava shrubland species should be undertaken through planting on the new coastal edge.
Loss of part of lava flow ecosystem at Victoria Street	Moderate	High	Moderate	Mitigate	• Protect and enhanced (through weed control) the remaining basalt lava flows and lava shrubland habitats at Victoria St. • Investigate the possibility to salvage and relocation of remnant basalt lava flow features and rocks and associated native organisms. These could be re-used as part of the re-creation of lava field habitat within the coastal foreshore. • Rehabilitation of lava shrubland species should be undertaken through planting on the new coastal edge. • Weed control and revegetation across the entire project will occur over approximately 10 ha, including the northern shoreline, Anns Creek estuary margins, Anns Creek East, Southdown Stream, Te Hopua, and Otahuhu Creek.
Loss of vegetation within and adjacent to Miami Stream and estuary	Moderate	High	Moderate	Mitigate	• See mitigation within Te Hopua above.
Permanent stream habitat loss in Miami Stream (25m)	Low	Very High	Moderate	Offset	• See mitigation at Southdown Stream and Otahuhu Creek below.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
Loss of CMA - Construction of road embankment	Moderate	High	High	Partial Offset	• Post-graduate research scholarship to investigate potential to facilitate enhancement of the benthic invertebrate assemblage e.g. potentially transplanting large invertebrates that are uncommon in the northern part of the Inlet, such as bivalves. • Declamation at Otahuhu Creek and estuarine fringe revegetation provides additional offset (see below). • The benefits of treating catchment stormwater and leachate prior to discharge into the CMA counter-balance some of this effect.
Loss of CMA - Construction of rehabilitated coastal edge and stormwater bund	Moderate	High	High	Partial Offset	• Post-graduate research scholarship to investigate potential to facilitate enhancement of the benthic invertebrate assemblage e.g. potentially transplanting large invertebrates that are uncommon in the northern part of the Inlet, such as bivalves. • Post-graduate research scholarship to investigate invertebrate and macroalgal colonisation of new hard shores provided along the rehabilitated northern shore and erosion protection to Ngarango Otainui Island. • The benefits of treating catchment stormwater and leachate prior to discharge into the CMA counter-balance some of this effect.
Physical disturbance in CMA beyond the permanent occupation / reclamation footprint	Moderate	Moderate	Moderate	Mitigate	• Will naturally recover in the long-term.
Subtidal dredging	Moderate	Moderate	Moderate	Mitigate	• Will naturally recover in the long-term.
Cumulative effect of permanent loss of CMA on shorebird populations (Assessed at Mangere Inlet scale)	Very High	Low	Moderate	Offset and Mitigate	• Post-graduate research scholarship to investigate potential to facilitate enhancement of the benthic invertebrate assemblage e.g. potentially transplanting large invertebrates that are uncommon in the northern part of the Inlet, such as bivalves.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
Habitat loss for shorebirds	Very High	Low	Moderate	Offset and Mitigate	• Investigate opportunities for legal protection of Ngarango Otainui Island, particularly the macrocarpa trees which provide roosting habitat for royal spoonbill. Given macrocarpa have a limited lifespan, more trees should be planted as future roosting habitat for this species. Revegetation of this island with coastal species should be undertaken, along with weed control and pest control. The coastal fringe of this island is currently being eroded. We recommend coastal erosion mitigation measures are undertaken to provide protection to these edges which could also be tailored to provide roosting habitat for shorebirds. Soft engineering solutions to the erosion problem are preferred over hard engineering solutions such as rip rap and rock walls. • Engagement should be undertaken with the owners of industrial buildings which are currently used as high tide roosts around the Mangere Inlet to inform building owners of the value of the species using their roof tops and to discuss maintaining the roofs as roost sites.
Disturbance and effective habitat loss during operational phase to shorebirds	Very High	Moderate	High	Offset	• Work with DOC to identify potential sites (i.e. staging, roosting or breeding sites) for some of the *Threatened* or *At Risk* species that forage within the Inlet and to develop an appropriate package of offset that will provide sufficient quantum of benefit to those species. Such offset could include long term pest control at appropriate sites and/or working with DOC on other programmes that benefit those avifauna species.
Reduced food supply for shorebirds through potential sedimentation in CMA during construction	Very High	Low	Moderate	Offset if sedimentation event in CMA occurs	• Post-graduate research scholarship to investigate potential to facilitate enhancement of the benthic invertebrate assemblage e.g. potentially transplanting large invertebrates that are uncommon in the northern part of the Inlet, such as bivalves.
Loss of Auckland Council long term sediment quality monitoring site.	Moderate	Moderate	Moderate	Mitigate	• Work with Auckland Council to identify and establish a new long term sediment quality monitoring site to replace the existing “Mangere Cemetery” site. Survey of potential new sites and the existing site will be required prior to construction.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
ANNS CREEK ESTUARY					
Occupation of the CMA by permanent bridge structures	Moderate	Moderate	Moderate	Partial Offset	• Creation of salt marsh habitat along the eastern boundary of the Mangere Inlet (Anns Creek Estuary). • Protect and enhance marine intertidal habitat around Ngarango Otainui Island.
Loss of and disturbance to Anns Creek Estuary vegetation	Very High	High	Very High	Mitigate	• Creation of salt marsh habitat along the eastern boundary of the Mangere Inlet (Anns Creek Estuary). • Revegetation with Anns Creek East and Pikes Point lava flows with appropriate native lava shrubland species.
Structures affecting connectivity of ecological features / habitats (Anns Creek Estuary primarily)	Moderate	Moderate	Moderate	Mitigate	• Creation of salt marsh habitat along the eastern boundary of the Mangere Inlet (Anns Creek Estuary).
Habitat loss for cryptic marshbirds	Very High	Moderate	Very High	Offset and Mitigate	• Creation of salt marsh habitat along the eastern boundary of the Mangere Inlet (Anns Creek Estuary).
Disturbance during construction to cryptic marshbirds	Very High	Low/High[76]	Very High	Avoided as far as practicable	• Avoided as far as practicable[77].
Disturbance during operational phase to cryptic marshbirds	Very High	High	Very High	Unable to mitigate	• Unable to mitigate.

[76] Low magnitude of effect if cryptic marshbirds are not breeding in Anns Creek Estuary, High if they are.

[77] A consent condition will be developed to state that if cryptic marshbirds are breeding in Anns Creek Estuary then construction of the bridge across Anns Creek Estuary and any other construction or restoration works will need to be undertaken outside of main breeding season.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
Reduced food supply for cryptic marshbirds through potential sedimentation in CMA during construction	Very High	Low	Moderate	Offset if sedimentation event in CMA occurs	• Offset only needed if significant sedimentation event occurs in CMA during construction.
Mortality of cryptic marshbirds during construction (assessed at the individual bird scale)	Very High	Very High	Very High	Avoided as far as practicable	• Avoided as far as practicable.
Mortality of cryptic marshbirds during operational phase	Very High	Low	Moderate	Unable to mitigate	• Unable to mitigate.
ANNS CREEK EAST					
Loss of and disturbance to Anns Creek East vegetation	Very High	High	Very High	Avoid where possible and mitigate where cannot be avoided	• Investigate opportunities to relocate the proposed construction yard[78] within Anns Creek East (currently to be in the area where a consent exists for reclamation) be explored further. In addition, discussions with the consent holder should be undertaken to determine if there are opportunities for the consent to be surrendered and the area purchased by NZTA for long term enhancement and protection. • Construction effects should be avoided within the lava flow shrublands and minimised within saltmarsh habitats in Anns Creek. Construction of the Anns Creek East viaduct should be located as close as practicable to the degraded northern edges of the lava flow, with bridge piers not to be located on existing lava habitat and associated shrubland vegetation. Pier

[78] Whilst noting that TR Group have an existing consent for reclamation in the northern part of Anns Creek East.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
					placement will be informed by an exclusion area plan that shows where piers cannot be located due to the presence of lava flows. • Weed control and revegetation should be undertaken in Anns Creek East. It is recommended that a restoration management plan be prepared for Anns Creek East to guide this work and that legal protection of the area is explored; this would need to be permanent and enduring. Mammalian pests, such as rats and cats, should be controlled within Anns Creek East, whilst revegetation is maturing. Monitoring of the efficacy of pest control should be undertaken.[79] • Weed control and revegetation across the entire project will occur over approximately 10 ha, including the northern shoreline, Anns Creek estuary margins, Anns Creek East, Southdown Stream, Te Hopua, and Otahuhu Creek.
Permanent freshwater habitat loss in Anns Creek East (10m long)	High	Moderate	Moderate	Mitigate	• Investigate opportunities to relocate the proposed construction yard within Anns Creek East (currently to be in the area where a consent exists for reclamation) be explored further. In addition, discussions with the consent holder should be undertaken to determine if there are opportunities for the consent to be surrendered and the area purchased by NZTA for long term enhancement and protection. • Within Anns Creek East, riparian planting has already been undertaken along the southern part of the stream, but could be extended along the north part. This would benefit about 150 m of stream length. This area is potential inanga spawning habitat, with existing grasses likely to provide good spawning substrate. As such, potential improvement to inanga spawning value may

[79] The existing consents held by TR Group require some ecological restoration within Anns Creek East as part of the reclamation of the northern part of the site.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
					be limited for freshwater values, but vegetation values could be enhanced through replacement of exotic species with indigenous species.
Loss of raupo wetland	High	Very High	Very High	Offset	• The large area (approximately 280m^2) of kikuyu grass located in the south-western corner of Anns Creek Reserve wetland should be removed and revegetated with raupo. In addition, areas of exotic Glyceria within Anns Creek Reserve wetland could be restored with native species, and animal pest control could be undertaken to improve habitat for wetland birds.
SOUTHDOWN RESERVE AND SOUTHDOWN STREAM					
There are no significant potential adverse effects on ecological values in this area					• Enhancement of estuarine and freshwater habitats within Southdown Reserve should be undertaken. There is approximately 80 m of freshwater stream with riparian vegetation that could be enhanced. Any enhancement would have to consider the current asbestos issue on site, the management of *Threatened* plant species that may be present, weed control, riparian revegetation and inanga spawning requirements. Enhancement should be guided by a restoration management plan. • The Southdown Stream north section of open channel (about 140 m in length) runs near the property boundary within a corridor about 15 m in width. Riparian vegetation could be planted here to provide shade and enhance stream values. • Weed control and revegetation across the entire project will occur over approximately 10ha, including the northern shoreline, Anns Creek estuary margins, Anns Creek East, Southdown Stream, Te Hopua, and Otahuhu Creek.
ANNS CREEK RESERVE WETLAND					

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
There are no significant potential adverse effects on ecological values in this area					• Areas of exotic Glyceria within Anns Creek Reserve wetland could be restored with native species, and animal pest control could be undertaken to improve habitat for wetland birds.
CLEMOW STREAM					
There are no significant potential adverse effects on ecological values in this area					• The current Clemow Stream channel is about 90 m in length and has a concrete base. As the section of stream will be realigned as part of the project, there is potential to re-establish a more natural channel with a mud or rocky substrate and native riparian vegetation. The enhancement of this channel would improve stream values in the medium and long term.
OTAHUHU CREEK					
There are no significant potential adverse effects on ecological values in this area					• Terrestrial vegetation values on the floodplain and adjacent hillslopes could be enhanced by weed control and riparian planting. • There are significant opportunities for restoration of coastal ecosystems in Otahuhu Creek through declamation and restoration of fringing saltmarsh and riparian vegetation. • Removal of the existing box culverts beneath SH1, removal of the southern reclamation for the existing bridge abutments are likely to have positive effects on ecological values. The new structure and removal of the culverts will enable the natural creek bed to re-establish, and the channel morphology to develop over time. • There are significant opportunities for weed control and revegetation along the estuarine and freshwater dominated margins of Otahuhu Creek. • Weed control and revegetation across the entire project will occur over approximately 10ha, including the northern shoreline, Anns Creek estuary margins, Anns Creek East, Southdown Stream, Te Hopua, and Otahuhu Creek.

Potential Adverse Effects	Ecological Value	Magnitude of Effect	Level of Effect	Avoid, Mitigate or Offset	
PROJECT-WIDE EFFECTS					
Loss of herpetofauna habitat and displacement of *At Risk* and *Threatened* organisms	Moderate/High	High	Moderate/ High	Mitigate	• With lizard surveys needing to be carried out over the summer period and with the Auckland Council's standard conditions regarding lizard management, at this stage mitigation for lizards across the Project involves avoidance of effects on individuals through careful and supervised vegetation removal, translocation of lizards from works areas prior to works commencing, and restoration and enhancement incorporating species that provide habitat and food for native lizards. General recommendations include further survey work to inform preparation of a native lizard management plan in accordance with Auckland Council standard conditions.
Fragmentation of herpetofauna habitat for *Threatened* and *At Risk* species	High	Moderate	High	Mitigate	
Injury or death of *Threatened* or *At Risk* native herpetofauna	Moderate/High	Very High	Very High	Avoided as far as practicable	
Discharges from erosion and sediment control devices to streams and CMA	Moderate	Low-Moderate	Moderate	Offset if sedimentation event in CMA occurs[80]	• Offset required if significant sedimentation event occurs during construction and results in significant adverse effect on ecology.

[80] This effect may or may not occur, depending on size of rainfall events during open earthworks and erosion and sediment control design capacity before overflow to CMA.

6.5 References

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