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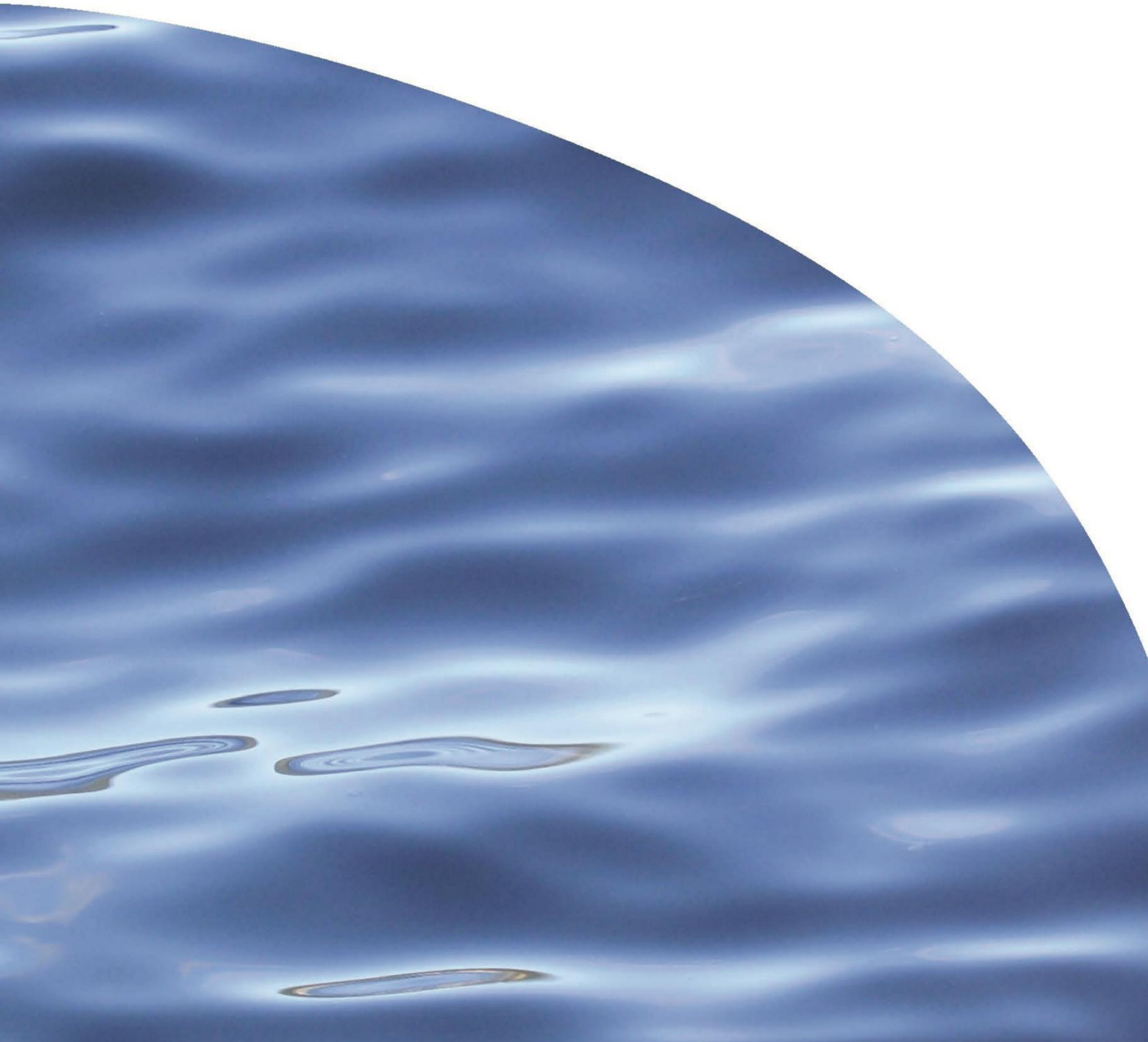
NELSON REGIONAL SEWERAGE BUSINESS UNIT (NRSBU) ABERRATIONAL WASTEWATER OVERFLOWS



NELSON REGIONAL SEWERAGE BUSINESS UNIT (NRSBU) ABERRATIONAL WASTEWATER OVERFLOWS

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1. INTRODUCTION

Cawthron Institute has been contracted by the Nelson Regional Sewerage Business Unit (NRSBU) to provide further information relating to their application for Resource Consent(s) 165114, 165115, 165116 concerning the environmental effects of aberrational wastewater overflows into the Waimea Estuary. The following assessment addresses questions arising from the following reports:

- Cawthron Report No. 2588 (Johnston 2014) Assessment of environmental effects from accidental wastewater overflow on Waimea Estuary receiving environments. Prepared for Nelson Regional Sewerage Business Unit (NRSBU). 31 p. plus appendices.
- Addendum to Cawthron Report 2588: (Johnston 2015) Marine water quality classifications and mixing zone determination. Prepared for the Nelson Regional Sewerage Business Unit. 17 p. plus appendices.
- Cawthron Advice Letter: (Johnston 2016). Request for further information—resource consents 164114, 165115, 165116. Cawthron Advice Letter 1636 to Nelson Regional Sewerage Business Unit dated 10 August 2016. 13 p.

In this report I will discuss the following:

- subsequent literature and data since the original assessment of environmental effects (AEE) was drafted
- the methodology of the original AEE, discharge scenarios and analyses used, and any updates or changes to the methodology (e.g. introducing modelling data)
- the determination of mixing zones and the assimilative capacity of the receiving environment
- the determination of the sensitive and threatened taxa and valued habitats in the receiving environment
- the likelihood of achieving coastal management standards (and where they might not be met)
- overall summary assessment of scale of effects
- recommendations for mitigation, safeguards and monitoring as well as addressing the key ecology related submissions to the overflows application.

1.1. Subsequent literature and data

In addition to the site visits in 2011, 2014 and 2017, numerous effects / impact assessments have been completed relating to the Waimea Estuary: many of these are cited in my report (Johnston 2014). Since my original assessment was completed, the following relevant investigations have also been conducted. I provide a brief precis of information relevant to this report for each investigation.

Unpublished data (2015). Saxton overflow water sampling.

These data were collected by NRSBU following an aberrational discharge at the Saxton Road pump station receiving environment. The overflow occurred on 27 May 2015 and was attributed to the wet well level control failing. The overflow commenced at 12:28pm and continued for 1 to 2 minutes. Water samples were collected at stations 100 m north and south of the outfall, along the high tide mark and from the wet well itself. Sampling at the receiving environment locations was undertaken daily on 27-31 May and 1 June 2015.

Samples were tested for bacteriological indicators (faecal coliforms, *E. coli* and enterococci) and salinity. Results indicated that the edge of plume was situated more to the north than to the south (this result later corroborated by the MOS [2017a] report). No sampling was performed in the tidal channel so this potential area of the plume could not be characterised.

Salinity measure of the discharge was 0.3 ppt and the receiving environment results were typically in the order of 30-32 ppt, with no concentration gradients evident over time at either station. There was a single low salinity measurement (8.9 ppt) occurring on day two after the discharge event, at the northern station, likely due to inputs from a nearby stormwater outfall.

The dilution ratio of each parameter at the northern station after 3.5 tidal cycles was:

- Faecal coliforms: 1:57,143
- *E. coli*: 1:65
- Enterococci 1:200.

New Zealand estuary trophic index screening tools 1 and 2. (Robertson et al. 2015; Robertson et al. 2016).

These two reports describe two Estuary Trophic Index (ETI) tools that have been developed to help to determine the level of stress (in relation to eutrophication) in an estuary. Using the online ETI tool, the Waimea Estuary (Shallow Intertidal Dominated Estuary; SIDE) score was 0.59, band C (moderate stress). When applied to the Saxton site sediment quality results, the score was 0.17 for Saxton, which is described as ‘reflective of minimal eutrophic symptoms’ (using the minimum indicators; 1 primary (macroalgae) and supporting indicators (total nitrogen or TN and total organic carbon or TOC).

Morrisey, D, Johnston O, Newcombe E (2016) Impact of the Nelson (Bell Island) regional sewerage discharge on the coastal environment: Receiving water survey – August 2016.

This investigation had a number of sampling sites throughout the Waimea Estuary. Notably, sites W7, W9 and W11 (adjacent to the Airport outfall site) were in the tidal channels likely to be eventually influenced by wastewater overflows from the pump stations in the eastern arm of the Waimea Estuary. The study concluded the following occurred:

- rapid mixing for low salinity treated wastewater (within the ebb tide)
- nutrient concentrations in 2016 were similar to, or less than in 2011. Results showed adequate dilution down current from the Bell Island wastewater outfall to prevent eutrophication
- ammoniacal-N concentrations were below guideline trigger levels (non-toxic levels) [1, 2]
- phytoplankton characteristics were normal, with no evidence of over-enrichment or undesirable species that might indicate effect of eutrophication by wastewater

Newcombe E, Morrisey D (2016) Advice for the NCC Whakamahere Whakatu Nelson Plan: Coastal indigenous biodiversity

In this assessment the Nelson Resource Management Plan (NRMP) Marine Areas of Significant Conservation (ASCV) was reviewed. The report recommended that it is not appropriate to identify specific areas that are of particular importance to the protection of indigenous biodiversity, and thereby exclude other areas. The report provides tables that describe important habitats and species groupings that should be considered for protection.

McArthur (2016) Nelson freshwater quality. An analysis of state and issues

This report assessed the stream water quality within, and in the vicinity of, the Waimea Estuary. Saxton Creek was identified as having some of the worst water quality in Nelson, exhibiting elevated nutrients, faecal contaminants and sediment, indicative of pastoral land use with unmanaged or unmitigated contaminant losses. Despite this, it was reported that Saxton Creek contains a good diversity of native fish and supports īnanga spawning in its lower reaches. Similarly, other Stoke streams were also home to diverse native fish communities, many of which contained nationally threatened or at risk species.

Streams with lesser degrees of contamination and modification exhibited healthier fish communities, e.g. Poorman Valley and Orphanage streams were healthier compared with Orchard, Jenkins and Saxton creeks. However, all investigated waterways in the Stoke freshwater management unit (FMU) were considered 'good' when compared to national trends.

Beveridge A, McArthur K (2017) Updated aquatic sites of significance document in support of the Nelson Plan Water Management Framework.

This report updated the existing information relating to the potential sites of significance for freshwater values (threatened fish, īnanga spawning, trout habitat and spawning, and threatened birds) for possible inclusion within the Nelson Plan.

[1] ANZECC 2000.
[2] USEPA 1986.

Morrisey D, Webb S (2017) Coastal effect of the Nelson (Bell Island) regional sewerage discharge on the coastal environment: Benthic monitoring survey 2016.

This investigation had a number of sampling sites throughout the Waimea Estuary, two of which were also State of the Environment reference sites (SOE-A and SOE-C). SOE-A, located in the inner middle portion of the estuary, was the closest (2-3 km) sampling site to the pump station outfalls. The study found:

- normally functioning coastal seabed habitats at monitoring sites
- no evidence of abnormal sediment anoxia or other obvious signs of organic enrichment (e.g. fats or oils, sulphide odours, filamentous bacterial growths, or unusual macroalgal abundance, microalgal mat development, etc.)
- reduced coverage of seagrass—likely to be due to habitat change (sediment texture and fauna) or dieback
- total nitrogen (TN), total reactive phosphorus (TRP) and organic matter (OM) content within sediments were typical for the grain size type in a moderately productive estuary. Variation over time represents normal temporal variation
- natural catchment inputs were thought to be the cause of high nickel and chromium concentrations in sediments, and arsenic in cockle tissues
- moderate eutrophication was detected in the estuary, with infauna in the upper parts of the estuary subject to stress from sedimentation.

Morrisey D, Newcombe E (2017) Coastal effects of the Bell Island regional sewerage discharge: April 2017 mussel monitoring survey.

The report describes the monitoring results of the April 2016–2017 survey (following from the Morrisey et al. 2016 investigation described above). The investigation found:

- no suggestion that the phytoplankton community structure is influenced by the Bell Island discharge
- concentrations of enterococci in mussel flesh were elevated in the samples from offshore sites near the eastern estuary mouth (Site 18 430 MPN/100 g; Site 19 230 MPN/100 g) relative to sites near the western mouth (≤ 70 MPN/100 g)
- concentrations of faecal coliforms in mussel flesh were low (≤ 40 MPN/100 g) at all sites, consistent with efficient depuration seen during previous deployment periods
- concentrations of faecal indicator bacteria in seawater samples were at or below laboratory detection limits at all sites (i.e., ≤ 2 or 3 MPN/100 ml for faecal coliforms and E. coli, and < 10 MPN/100 ml for enterococci).

MOS (2017a) Bell Island discharge plume and dilution investigation.

This study characterised the pollutant dispersion and dilution patterns associated with the wastewaters discharged from the Bell Island outfall, within the Waimea Estuary. Results suggest that on the outgoing tides the plume is transported by the ebbing flows to the central Waimea Inlet region, and connects with the flow branching out to the Rabbit Island and Blind channels. The plume propagation suggests possible pollutant loading in shallow areas in close proximity to the discharge source, however the plume concentrations are rapidly diluted (at least 0.001 dilution or 1:1000).

MOS (2017b). Aberrational discharges plume and dilution investigation.
Emergency overflow discharges from Airport, Songer, Saxton and Wakatu pump stations (PS) have been modelled using a calibrated and validated hydrodynamic model of the Waimea Inlet. A range of discharge events was modelled in order to bracket potential discharge characteristics by accounting for:

- different discharge rates from the pump stations
- 'wet' and 'dry' fluvial discharges from 8 nearby rivers/streams/creeks
- different wind forcing events
- ponding of the discharge at the discharge location.

The modelling did not consider the function of wet-well storage capacity at each PS which, in the case of Wakatu and Airport, play a significant role in containing potential overflows (see table 6 in Johnston 2014). Overall, the following findings were made for all PS:

- expected dilution rates (both MHW and MLW) were similar for 'wet' and 'dry' discharges due to the balance between the increased PS discharge rate and increased effective available dilution (due to increased river/stream/creek discharges)
- windy conditions increased dispersion and dilution relative to the no-wind simulation
- the discharge plumes travelled further on the ebbing tide.

Therefore, after 6 hours (assuming 4 hours of discharge), dilutions less than 1:48 are typically confined to tidal channels at all PS sites.

Unpublished data (2017). Aberrational overflow receiving environment sampling.
I performed sediment sampling (8 March 2017) at Saxton initially to validate the findings and site observations of the original ecological assessment of aberrational wastewater overflows into the Waimea Estuary (Johnston 2014). Specifically, trace metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg); grain size (3 fractions): total phosphorus (TP), total nitrogen (TN), ammonium-N; total organic carbon (TOC) and total petroleum hydrocarbons (TPH) were tested for in the receiving environment sediments.

As a result of expert caucusing recommendations (28 June 2017), further sediment quality background information was collected at the remaining pump station outfall locations (Wakatu and Songer on 1 September 2017 and Airport on 4 September 2017). In addition to this, background water quality information was also collected (ref:

meeting minutes) on four occasions (24 August; 7 September; 13 September and 21 September 2017). Test parameters are listed in Appendix 1 and 2.

The sediment and water quality sampling results generally corroborated the findings and calculations in the AEE, with concentrations of metals, organics and nutrients in the main discharge channel (seaward transect; 50–100 m) typically similar to background concentrations recorded for other sites in the estuary (Morrisey & Webb 2016). The exceptions to this (concentrations outside of background or guideline concentration) are presented in Figure 1 and all raw data are presented in Appendix 1 (including previously discussed Saxton results). The results of the water quality analyses are presented in Appendix 2.

Background sediment quality

Sediment-quality (Figure 1) results suggested that outside a localised area surrounding the outfalls (< 10 to 50 m) contaminant concentrations and sediment characteristics were not likely to cause adverse ecological effects attributable to the outfalls. As might be expected, there were some metals/metalloids, organic matter and organic contaminants present in the sediments immediately adjacent to the outfalls. Specifically:

- Phosphorus showed a concentration gradient, reducing with distance from the outfalls (along the channels) at Songer, Saxton and Wakatu.
- Arsenic and mercury were elevated above ISQG-low at the < 10 m stations at Saxton and Songer, respectively.
- Total petroleum hydrocarbons (C15-C36 band; reflecting mineral oils) were detectable, but below trigger values, at both the Songer and Wakatu < 10 m stations (note, this is not presented in Figure 1).
- Concentrations of TN were an order of magnitude higher at Saxton.

The concentrations of TN at Saxton likely reflect natural seasonal variation (Saxton was sampled earlier in summer), particularly as no distinct TN concentration gradients were evident. Also, it is difficult to discount stormwater or road runoff as a causal agent, due to the regular occurrence of stormwater inputs and the presence of nearby stream outlets and road surfaces at these sites.

Background water quality

Water quality was tested in the immediate vicinity the pump station outfalls and at three popular contact recreation sites; Parkers Cove, Tahunanui Beach and Monaco Boat Ramp.

Physical water quality parameters (salinity, dissolved oxygen, pH, temperature and conductivity) were within healthy or typical ranges at all sites (Figure 2). Chemical parameters (listed in Appendix 2, collected +/-2hr from high tide) exhibited variable results between sites and sampling events, with evidence of stormwater and riverine inputs influencing 'background conditions' in close vicinity to the outfalls (notably on 7 September and 21 September 2017, Figures 3 and 4). Overall results (see Appendix 2) show that at the times of testing the background physical and chemical characteristics of the estuarine waters were within healthy or typical ranges. The exceptions to this are discussed in the following paragraphs and are graphed in Figures 3 and 4.

With the exception of copper and zinc, all metals/metalloids were either not detectable or were present at concentrations less than the ANZECC (2000) 95% Level of Protection (LoP). Elevated zinc concentrations coincided with high rainfall events at Songer, Parkers Cove and Tahunanui Beach. Copper concentrations above the 95% LOP (ANZECC 2000) occurred at virtually all sites, with between 80 to 95% of marine species protected. The exception to this was Tahunanui Beach where concentrations were consistently below 95% LoP (ANZECC 2000).

Total suspended solids (TSS) and turbidity (NTU) results suggest that the sites are subject to low water clarity and high turbidity. Notably, TSS and NTU at the Airport and Parkers Cove sites were in the concentration range thought to cause a decline in fish condition, altered foraging strategies and gill deformation (even after short exposures, i.e. 30 mins). On at least one occasion, all sites exhibited turbidity levels that were above, or close to, the ANZECC (2000, table 3.3.3) trigger values (Figure 3). Visual water clarity (estimated using the Munsell scale, 0-10: opaque-clear, Figure 2) at the sites ranged from 2 to 9, water hue varied between brown, green and, on one occasion, black (representative images of water clarity/colour can be provided on request).

Total nitrogen was occasionally above the ANZECC (2000) trigger value at Songer, Wakatu, Airport and Parkers Cove, suggesting potential adverse biological effects due to nitrogen enrichment could occur at those sites. Total phosphorus was also above the trigger value (ANZECC 2000) at all sites apart from Saxton. However, TP values were comparable to typical ranges for New Zealand estuaries (MfE 2013; Figure 4). Nutrient concentrations are often naturally higher in New Zealand than in south-east Australia (where the ANZECC guidance is derived from), and are likely to be heavily influence by rainfall and riverine inputs. For example, quarterly monitoring of nutrient concentrations at locations in western Tasman Bay (Cawthron, unpublished data), recorded TN concentrations in western Tasman Bay in the range 0.2–0.6 g/m^3, compared with ANZECC trigger values for marine and estuarine waters in south-east Australia of 0.12 g/m^3 and 0.30 g/m^3, respectively.

Stevens L, Robertson B (2017). Nelson region estuaries: vulnerability assessment and monitoring recommendations.

This report provides an Estuary Vulnerability Assessment (EVA) designed to be used by experts to represent how coastal ecosystems are likely to react to the effects of potential stressors (e.g. inputs of fine muds, nutrients, pathogens, toxicants, and habitat changes).

The results of the investigation indicated that Waimea Estuary has a high level of ecological vulnerability. The key contributing stressors are: excessive muddiness, local eutrophication, toxicity, elevated disease risk, habitat loss and climate change. The methods for managing these stressors were described as:

- limit SS inputs to estuary (e.g. mean < 2 mm yr^{-1}, no expansion of existing mud habitat)
- maintain/restore high value seagrass and saltmarsh habitat
- allow saltmarsh to migrate inland as sea level rises
- reduce faecal coliform inputs to meet bathing and shellfish standards
- limit stream specific nutrient, SS, and toxicant inputs
- limit nutrient inputs to 50 mg N m^{-2} d^{-1} (areal loading)
- ensure sediment toxicity guidelines are met 50 m from stormwater outfalls.

Other ongoing / draft investigations

The following studies were not available while this report was being completed and cannot be fully utilised in this assessment:

- Bell Island Wastewater Treatment Plant consent renewal: Assessment of environmental effects. Prepared for Nelson Regional Sewerage Business Unit. (Morrisey D, Berthelsen A In draft).
- Capacity of the marine receiving environment of the Bell Island Wastewater Treatment Plant to assimilate additional nutrients (Gillespie P, Berthelsen A In draft).
- National Objectives Framework. Scientific panel report on estuaries as a receiving environment. Draft. (Lohrer D, Zeldis J, Ellis J, Madarasz-Smith A, Stevens L In draft).

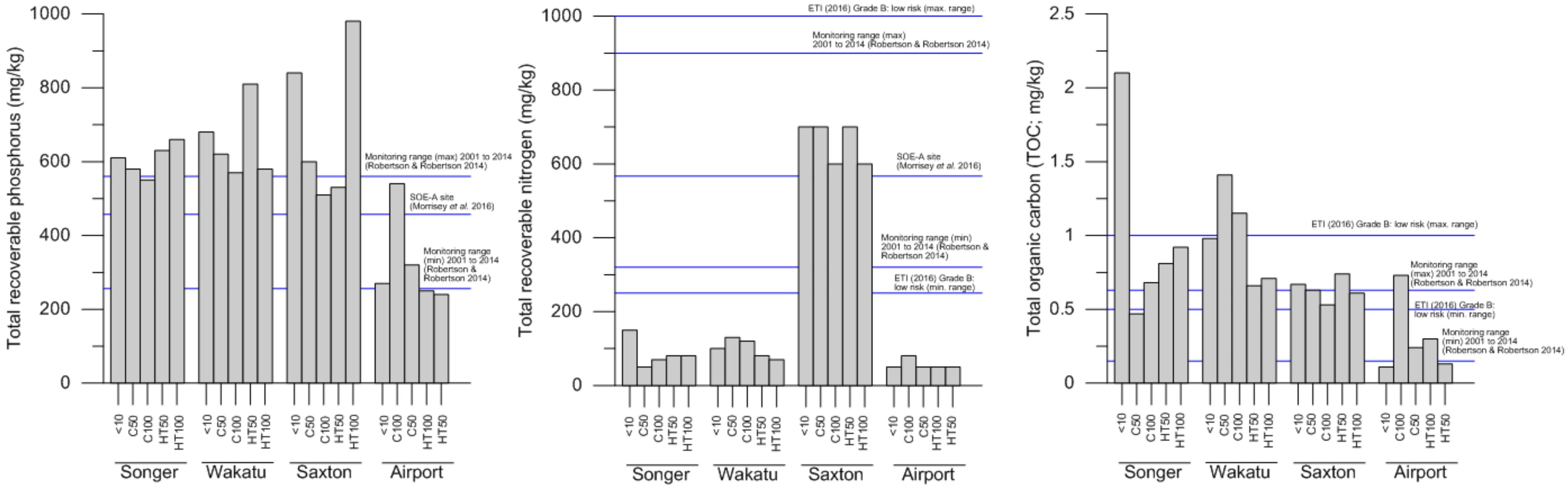

Figure 1. Outfall sediment quality results with comparative guideline values (Sampling dates, Saxton 8 March 2017, Songer and Wakatu: 1 September 2017, Airport: 4 September 2017). Results are tabulated in Appendix 1 (ANZECC 2000; Robertson & Robertson 2014; Robertson et al*.* 2015; Robertson et al*.* 2016; Morrisey & Webb 2017).

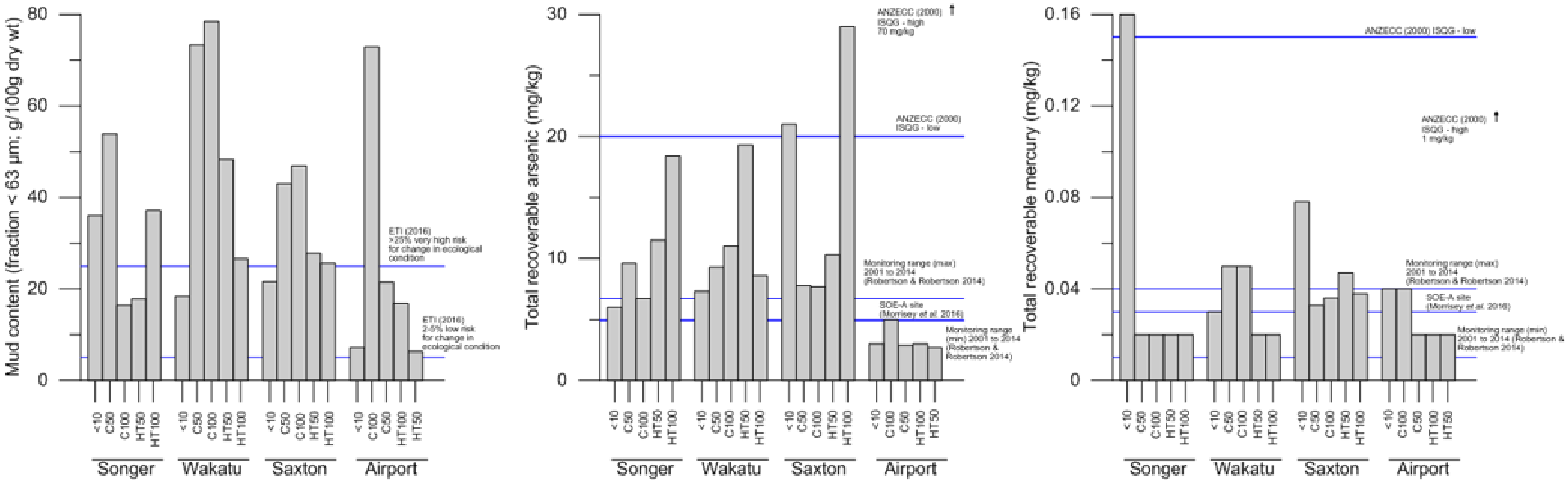

Figure 1, continued

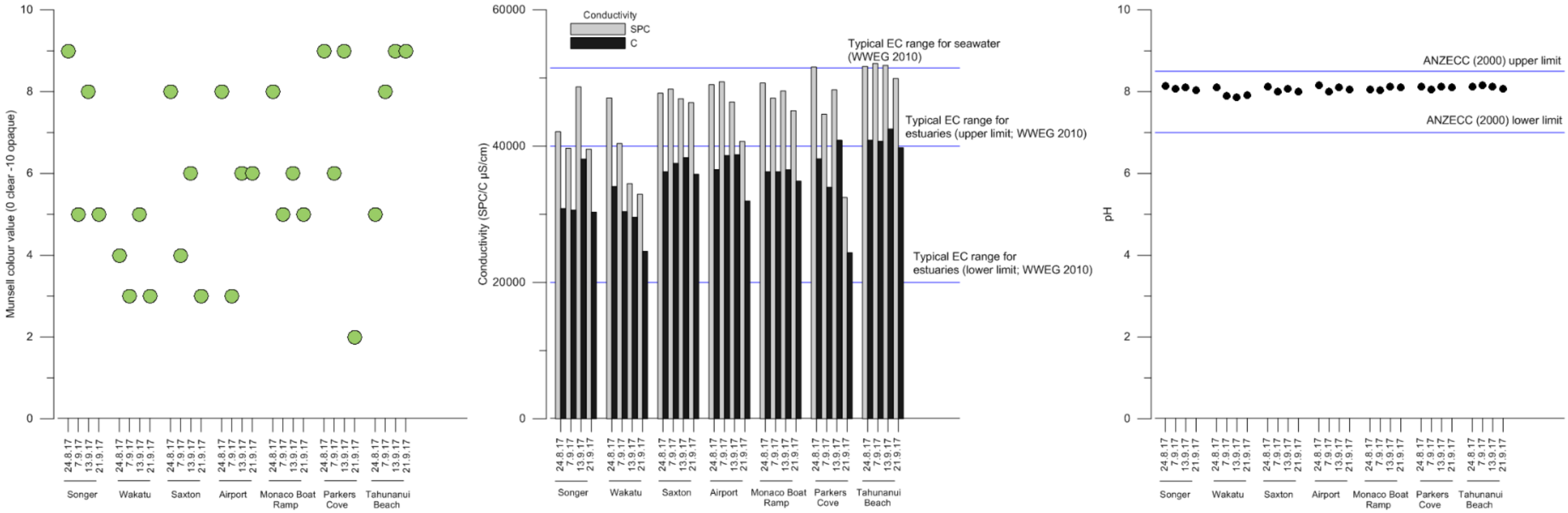

Figure 2. Outfall water quality monitoring results (taken *in situ* using the YSI probe) at outfall locations and Waimea Estuary contact recreation sites. Results are also tabulated in Appendix 2 (ANZECC 2000; USEPA 2006; WWEG 2010).

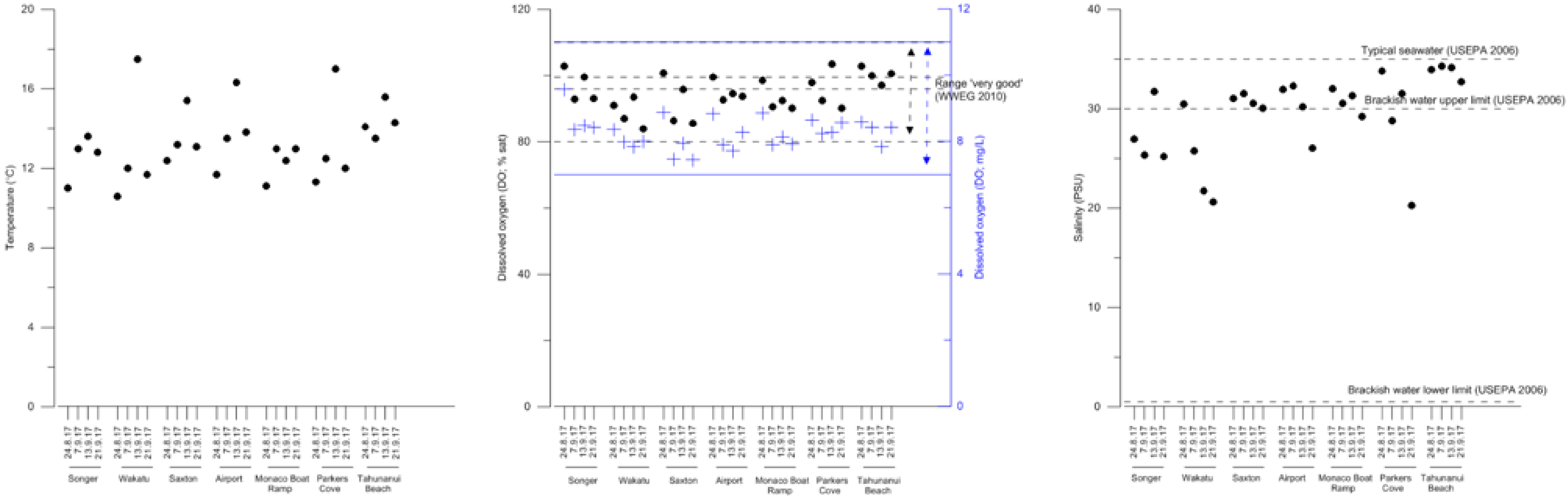

Figure 2, continued

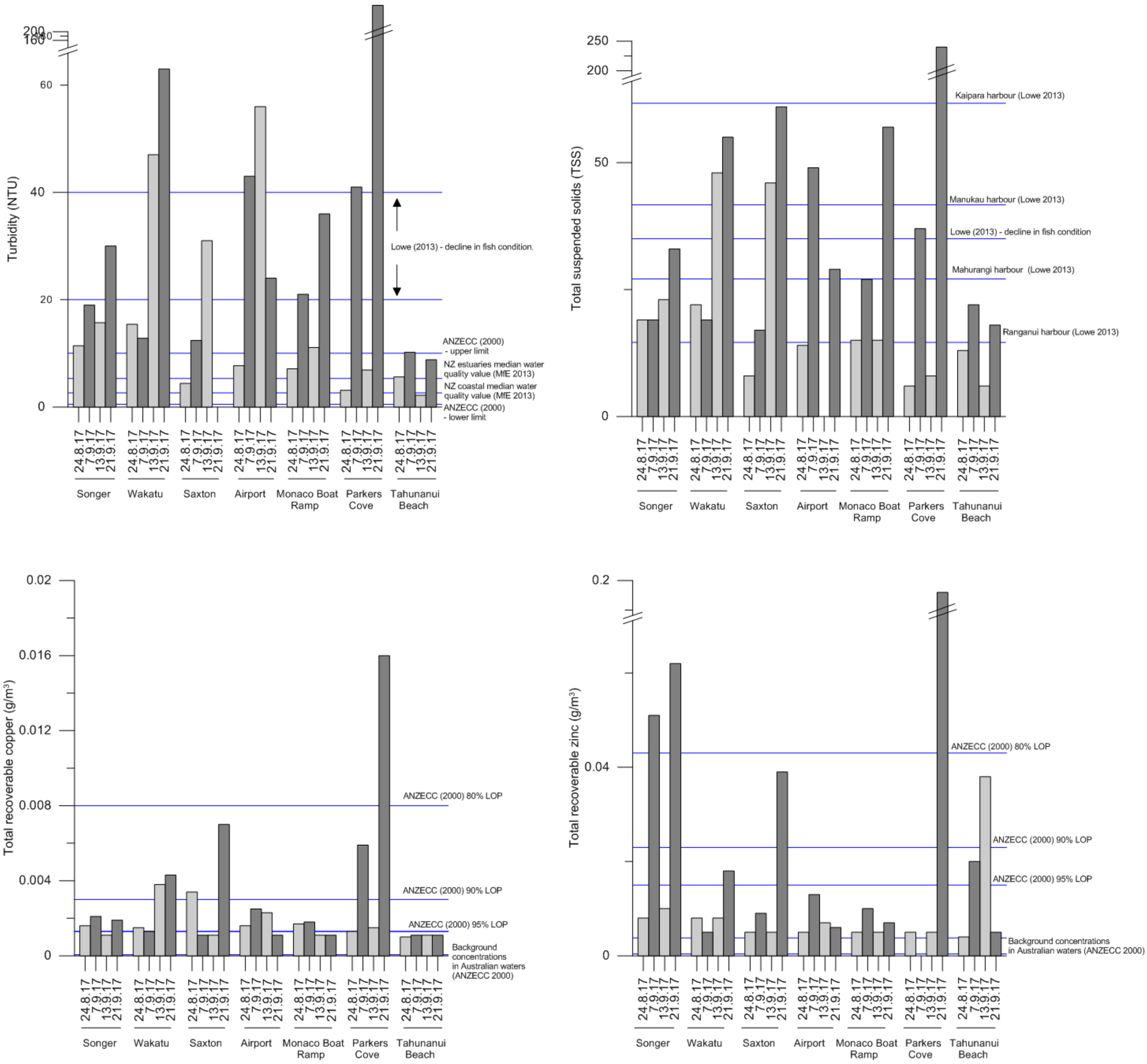

Figure 3. Water quality monitoring results (laboratory results) at outfall locations and Waimea Estuary contact recreation sites. Results are also tabulated in Appendix 2. Dark shading denotes where rainfall has occurred on the day of sampling (ANZECC 2000; Lowe 2013; MfE 2013).

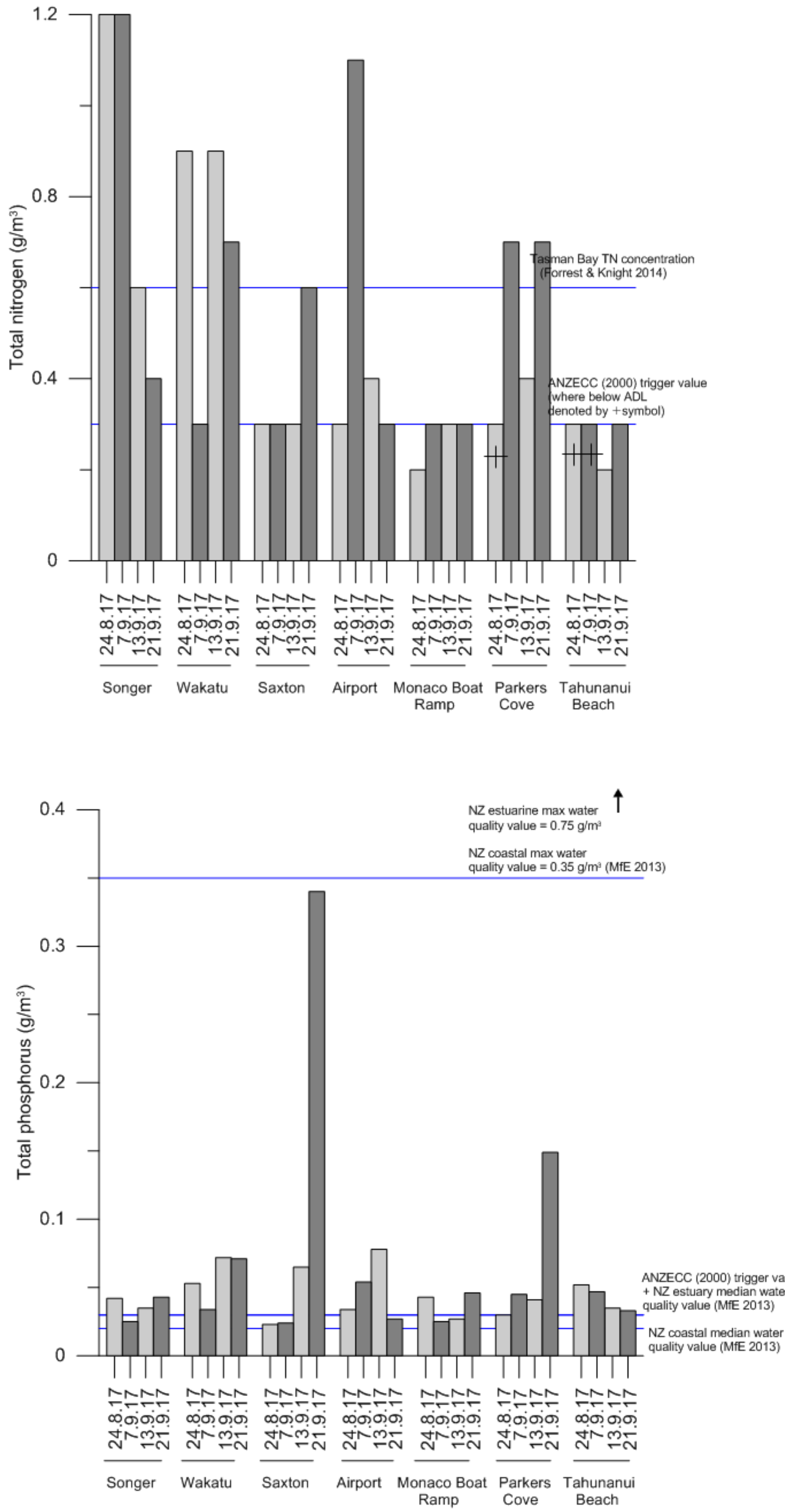

Figure 4. Water quality monitoring results (laboratory results) at outfall locations and Waimea Estuary contact recreation sites. Results are also tabulated in Appendix 2. Dark shading denotes where rainfall has occurred on the day of sampling.

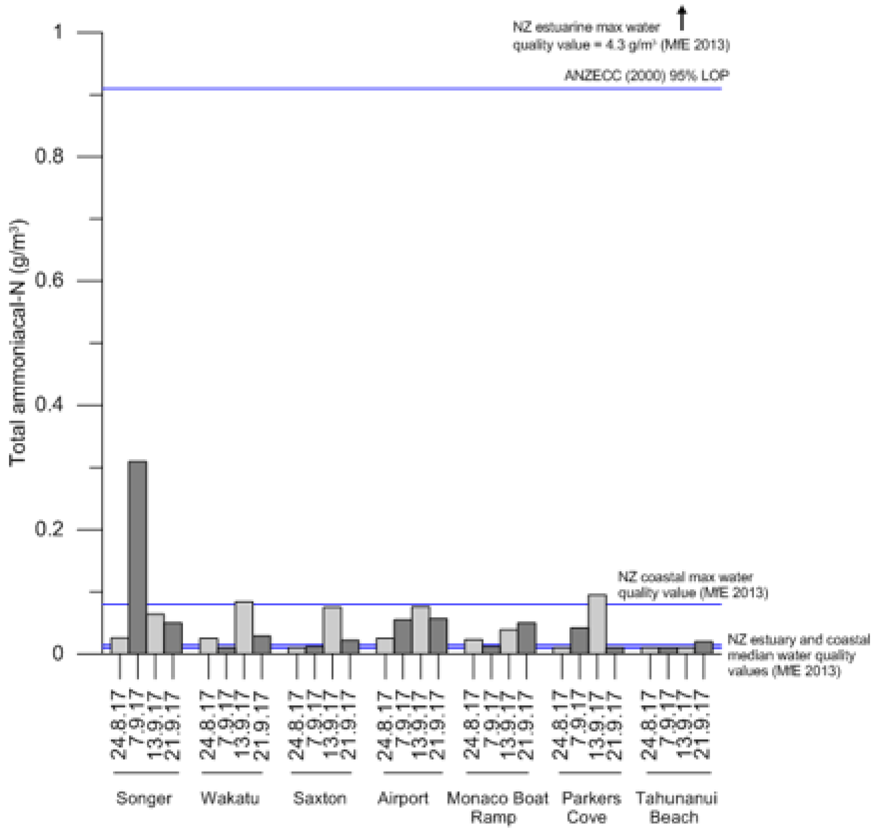

Figure 4, continued.

2. METHODOLOGY FOR ASSESSMENT OF EFFECTS

2.1. Original assessment

In order to evaluate the potential effect of accidental wastewater overflow on the Waimea Estuary receiving environment, information on the discharge and receiving environment were gathered from previous studies. The outfall sites were not within any of the Nelson Resource Management Plan contact recreation overlays (NRMP 2004), however, the recreation values of the outfall sites were discussed and defined with NRSBU (see Table 1, Johnston 2014), outfall sites were visited, photographs and observation notes were taken.

Discharge volumes were defined using scenario-based calculations (flow rate and duration of overflow). In the absence of complete historical records of overflows, conservative, worst-case scenarios were selected, based on discussions with NRSBU (Johnston 2014):

- 2-hrs of discharge – to represent a conservative[3] resolution timeframe
- 24-hrs of discharge (one day) – to represent a worst case overflow scenario.

Median discharge physicochemical characteristics were derived using NRSBU's long-term discharge monitoring dataset (1994 to 2014), which was derived from eight NRSBU wastewater contributors (Figures 3 and 4, Johnston 2014).

Potential discharge volume and concentrations of constituents, and the necessary dilutions to meet appropriate limits[4] and guidelines[5] in the receiving environment, were calculated for each of the discharge scenarios.

Using these results, and the characteristics and composition of the discharge the risk, persistence and likelihood of effects was evaluated for each of the pump stations. Table 8 in Johnston (2014), provides a conceptual overview of this, according to expert opinion based on existing information.

[3] The 2 hr timeframe was a conservative extension of the estimated average resolution timeframe, as agreed during discussions with NRSBU. However, in a priority NRSBU situation (emergency/urgent), the response timeframe is often within 30 minutes.

[4] To put the results into context with other discharges into the same estuary, concentrations were compared against the Bell Island Coastal Permit (CP) limits and the Trade Waste (TW) limits (NCC Bylaw No. 214, 2007).

[5] ANZECC (2000) guideline values for a 95% Level of Protection (LoP). It is noted that ANZECC (2000) guidelines apply to the receiving environment, so are not directly comparable to wastewater concentrations, but are relevant when compared after dilution.

2.2. Updates to the original assessment

2.2.1. Incorporation of historical overflow records

The assessment provided here uses the previously unavailable historical records of overflow from the NRSBU data bundle (NRSBU 2017a), rather than the previously flow-time calculated results (Johnston 2014). Like the findings in the AEE (Johnston 2014), the data bundle shows that Saxton is typically responsible for the majority of the discharges (between the four sites; summarised in Table 1 and Table 2). Since the 2013 upgrades[6], the overall overflow volumes and frequency at each pump station has decreased markedly:

a. **Saxton:** Prior to the system upgrade (2007-2013) the mean overflow volume was 4,128 m^3/event, occurring at a median frequency of two per year (total volume recorded = 70,186 m^3). Since the 2013 upgrade, a total of 3,964 m^3 has been accidentally discharged, over three events (median = 105 m^3; mean = 1,321 m^3). The majority of the discharge (96%) came from a single storm event in March 2016.

b. **Airport:** Prior to the system upgrade, the mean overflow volume was 5,805 m^3 per event (total volume recorded = 40,636 m^3), occurring at a median frequency of one per year. Since the upgrade, zero overflows have been recorded.

c. **Songer:** Since the construction of the Songer pump station (2013), there have been 3 overflows (total volume = 2,225 m^3). Two of these were less than 160 m^3, with one comparatively large overflow (2000 m^3) attributed to a major storm event.

d. **Wakatu:** There have been no recorded overflows from the Wakatu outfall in the last 10 years.

Of these overflow events, 5 have occurred at the same time (each involving two stations at the most), and all of these occurred prior to the system upgrade (NRSBU 2017a). Given they are highly unlikely to occur, simultaneous PS overflows are discussed separately in Section 3.1.

In my previous assessment, Wakatu, Songer and Airport showed low potential for overflow. Similarly, this data bundle shows low / no overflow frequency and volume at these sites. Therefore, I would still consider that any significant[7] adverse effects occurring at these sites as a result of wastewater are highly unlikely.

My previous assessment calculated that a discharge at Saxton could be in the order of 40,000 m^3 (under a high flow scenario, 24 hours of discharge). According the NRSBU data bundle, a discharge of this magnitude has only occurred on one occasion (2011), with the mean discharge volume being in the order of 1,321 m^3

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[6] New pump station upgrades were implemented between April and July 2013. Upgrades included increased pump contingency (additional pumps), alarms and automated generator back up.

[7] So that the results are unlikely to be due to chance e.g. where p= 0.05, the probability of picking up a difference when one doesn't exist must be low.

(since the upgrades occurred). Given this, the available dilution is typically likely to be an order of magnitude greater than originally assumed.

Table 1. Overflow volumes for pump stations. Not all overflows have records of volume associated (so the number of events in Table 1 will not align with Table 2). Wakatu not included as it has no recorded overflows.

	Overflow volume (m^3)		
	Saxton	**Songer**	**Airport**
All recorded overflows - May '07 - June '16			
Mean	3707	742	5805
Median	1146	155	1769
90th percentile	4685	1631	17093
Sum	74149	2225	40636
Before upgrade -Pre April '13			
Mean	4129	0	5805
Median	1146	0	1769
90th percentile	4790	0	17093
Sum	70186	0	40636
After upgrade - Post April '13			
Mean	1321	742	0
Median	105	155	0
90th percentile	3066	1631	0
Sum	3964	2225	0

Table 2. Overflow frequency (events per year) for pump stations from 2005 to 2016. Note that there are more data for frequency than there are for volume, as volume was not always recorded. Prior to 2005, each overflow event was recorded, but no detail was included as to which station it was from, so those data are not included in this summary.

2005-2016	**Wakatu**	**Saxton**	**Songer**	**Airport**	**Total**
Mean	0	2	0	1	3
Median	0	2	0	0	3
90th percentile	0	3	1	2	4
Total	0	22	3	7	31
Pre-2013					
Mean	0	2	0	1	3
Median	0	2	0	1	4
90th percentile	0	4	0	2	5
Total	0	19	0	7	26
Post-2013					
Mean	0	1	1	0	1
Median	0	1	1	0	1
90th percentile	0	2	1	0	3
Total	0	3	3	0	5

2.2.2. Determining sensitive and threatened taxa and valued habitat of Waimea Estuary

In response to caucusing with the other expert scientist, a desktop assessment on the risk to any highly valued taxa or habitat has been performed to identify outstanding, high-value and sensitive substrates/benthic habitats and threatened (and at-risk) marine taxa in the Waimea Estuary with particular emphasis on the outfall sites.

Methods used for this investigation were desk-top based, with specific focus on examination of existing information in the form of databases, regional taxa lists and reports. These information sources were used to assess the sensitive taxa and habitats of the Waimea Estuary, as follows:

- In the first instance, a Waimea Estuary-wide[8] species list (Appendix 3) was obtained, including macrofaunal invertebrate species lists extracted from NPI, NRSBU and NCC monitoring (Cawthron's Caddis database, providing 7000+ taxa records total), Cawthron's sponge garden assessment (Asher et al*.* 2008) historic reports (Davidson & Moffat 1990) and other recent investigations (see Section 1.1).
- The taxa list was primarily compared with available Department of Conservation (DOC) threatened species lists. However, where no threatened species list was available (e.g. for fish) the International Union for Conservation of Nature (IUCN 2017) threatened species lists were compared.
- The presence of protected taxa was also assessed via comparison of the species list with the lists of taxa in the New Zealand Wildlife Act (1953) and the Marine Mammal Protection Act (1978).
- To help better determine marine benthic sensitivity[9] on a local scale, macrofaunal invertebrate taxa records were also assessed against sensitive taxa listed in Robertson & Robertson (2014)[10] and provided by Townsend (2017) [11]. Invertebrate sensitivities results are summarised in Appendix 3 and are described in more detail in Appendix 4 and Appendix 5.
- Habitat types within the Waimea Estuary were compiled (Appendix 6) from recent broad-scale mapping (Stevens & Robertson 2014); the Boffa Miskell Limited reports (BML 2015b; 2015a) and within Newcombe and Morrisey (Newcombe & Morrisey 2016).
- The 'value' of taxa and habitats was determined using the Ecological Impact Assessment New Zealand (EIANZ 2015) value method,Table 3 and Table 4.
- The locations of the sampling sites are provided in the mapping bundle.

[8] The spatial extent of the taxa export is defined as: 1612458.8 – 1620396.3; 5430431.1 – 5424144.6 (NZTM)
[9] It is noted that initial characterisation of the receiving environment using the methods proposed for monitoring (Section 6.2) would have been preferred, but due to funding and time restrictions a database extraction of the likely benthic macrofauna in the vicinity of the outfalls has been provided.
[10] *Mud and organic enrichment sensitivity of macro-invertebrates, Waimea Inlet, 2001-2014.*
[11] *Macrofauna and their sensitivities to nutrients.*

Table 3. Assigning value to species/taxa for assessment purposes (EIANZ 2015).

Determining factors	Value
Nationally threatened – critical or vulnerable	Very high
Nationally at risk – declining	High
Nationally at risk – recovering, relict or naturally uncommon	Moderate–high
Locally uncommon/rare, not nationally threatened or at risk	Moderate
Not threatened nationally, common locally	Low

Table 4. Assigning value to habitat for assessment purposes (EIANZ 2015)
.

Determining factors	Value
Supporting more than one national priority type*	Very high
Supporting one national priority type or naturally uncommon ecosystem	High
Locally rare or threatened, supporting no threatened or at risk species	Moderate
Nationally and locally common, supporting no threatened or at risk species	Low

* *Refer MFE, DOC (MfE 2007) Protecting Our Places. National Priority One: To protect indigenous vegetation associated with land environments (defined by Land Environments of New Zealand at Level IV) that have 20% or less remaining in indigenous cover. National Priority Two: To protect indigenous vegetation associated with sand dunes and wetlands; ecosystem types that have become uncommon due to human activity. National Priority Three: To protect indigenous vegetation associated with 'originally rare' terrestrial ecosystem types not already covered by priorities 1 and 2.*

Values assigned for taxa and habitat were occasionally very high to high (see Appendix 1 for detail). Based on these results, and as mentioned in the initial AEE, habitat critical to seabirds, freshwater fish and marine fish taxa occurs near the pump station outfalls. However, it is emphasised that many of the taxa listed are marine wanderers only likely to visit the estuary occasionally, and only within restricted areas (e.g. marine mammals and sharks will often be restricted to deeper channel areas). The site-specific assessments suggest that taxa and habitats outside of the immediate tidal channels are unlikely to be affected by aberrational discharges. However, in order to be conservative, the precautionary approach was adopted to assign the overall risk rating for the pump stations, and a value rating of very-high for habitat and taxa values was assigned (this is obviously very conservative given the low levels of natural character in the area, BML 2015b).

In order to determine the level of risk of adverse effects to the listed taxa and habitats, the magnitude of the effect must be rated (Table 5). Based on the fact that the likelihood of overflows occurring is low and the timescale of the effects is highly intermittent for all of the stations, and there have been no observable signs of eutrophication or detectable sediment quality effects at any of the outfall locations, one might consider the magnitude of effects to be 'negligible.' However, other experts felt that the simplistic ecological assessment and uncertainty around the discharges required a more precautionary approach. To address these concerns I have instead adopted the low/minor magnitude rating for this assessment (Table 5).

Table 5. Determining magnitude of effects (EIANZ 2015).

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

Using the two ratings of 'very-high value' of the taxa and habitats and 'low/minor magnitude' of effects, the risk assessment criteria from the EIANZ (2015) suggests a 'moderate' risk of having a minor adverse effect on the high value taxa/habitats in Waimea Estuary (Table 6).

Table 6. Level of risk of an adverse effect (EIANZ 2015).

		Ecological Value			
		Very high	**High**	**Moderate**	**Low**
Magnitude	Very high / severe	Very high	Very high	High	Moderate
	High	Very high	Very high	Moderate	Low
	Moderate / medium	Very high	High	Low	Very low
	Low / minor	Moderate	Low	Low	Very low
	Negligible	Low	Very low	Very low	Very low

Burgman (2005), uses an alternative methodology, assessing the 'likelihood' of an effect against its 'consequence' (similar to 'magnitude' in the EIANZ method).

To determine appropriate values for consequence and likelihood, the Burgman (2005) method first considers the spatial scale/extent of effects, and the persistence/duration of the effect (Table 7). In this case, the worst-case spatial scale of effects is considered to be potentially large (1-2 km) and the persistence/duration, to be moderate (within months). Given these scales, the likelihood of an effect (possible, Table 8) multiplied by consequence of an effect (moderate, Table 9) was assigned and then used to determine level of risk (Table 10), e.g. possible (3) x moderate (4) = low-risk (12). See Appendix 7 for summary risk assessment table.

Both the Burgman (2005) and EIANZ (EIANZ 2015) approaches to risk assessment include some measure of confidence in the data used. For this AEE, the rank would be 'medium' to 'high', a combination of existing data, monitoring data and expert judgement (Table 11).

Combining these two methods of risk assessment, it appears that while there is 'moderate' risk to some high valued taxa and habitats, the overall risk (likelihood) of an effect occurring is 'low'.

Table 7. Spatial scale and persistence definitions. Blue-shaded rows illustrate the worse-case effects ratings selected in the Appendix 7 summary risk assessment table.

Spatial scale	Distance from discharge source
Extensive	> 2 km
Large	1km - 2km
Medium	100 - 1km
Localised	10 - 100 m
Immediate vicinity	< 10 m

Persistence/duration	Timeframe
Indefinite recovery, even if stopped (10 years +)	10 years +
Long-term recovery if stopped	Years
Moderate recovery if stopped	Months
Rapid recovery if stopped	Days
Temporary	Hours

Table 8. Likelihood definitions. Blue-shaded rows illustrate the worse-case effects ratings selected in the Appendix 7 summary risk assessment table.

Level	Likelihood category	Likelihood (%)	Description
1	Certain	100%	Will occur
2	Likely	50-99%	Likely to occur
3	Possible	25-50%	Uncommon but possible
4	Unlikely	1-25%	Occurring only in exceptional circumstances
5	Remote	<1%	Highly unlikely to occur

Table 9. Consequence definitions. Blue-shaded rows illustrate the worse-case effects ratings selected in the Appendix 7 summary risk assessment table.

Level	Consequence category	Effects
1	Catastrophic	Local extinction, ecosystem collapse
2	Massive	Regional and long-term adverse impacts
3	Major	Regional medium term adverse impacts
4	Moderate	Local medium term adverse impacts
5	Minor	Local short-term adverse impacts
6	Negligible	No detectable adverse effects

Table 10. Level of risk categories. Blue-shaded rows illustrate the worse-case effects ratings selected in the Appendix 7 summary risk assessment table.

Level	Risk category	Definition
1-2	Extreme risk	Unacceptable
3-4	High risk	Manageable using measures to avoid remedy of mitigate
5-9	Medium risk	Acceptable using measures to avoid remedy of mitigate
10-16	Low risk	Acceptable with less than minor impacts anticipated
17-30	Very low risk	Negligible with no impacts

Table 11. Levels of confidence associated with risk scores. Blue-shaded rows illustrate the worse-case effects ratings selected in the Appendix 7 summary risk assessment table.

Level of confidence	Definition
Low	No data - lack of data, relies on expert judgement
Medium	Combination of existing data and expert judgement
High	Based on monitoring data and expert judgement

2.2.3. Determining reasonable mixing zones

As I could not accurately predict the discharge rate or volume, timing with respect to tidal influences (i.e. flushing and dilution) or composition of an accidental overflow, it was not initially possible to identify an appropriate spatial mixing zone. This was because the area of a mixing zone will vary greatly depending on these factors. Given this, a temporal mixing zone comprising tidal flushing and dilution was considered an appropriate method to assess, monitor and manage any adverse effects of an accidental overflow. At the time, it was suggested to be defined as '1-2 full tidal exchanges' to reach a 95% LoP (ANZECC 2000). For more detail please refer to Johnston 2015, Section 2.2. This suggestion, while simplistic, appears reasonable when considering the new post-discharge dilution ratios of bacteriological indicators (as a proxy for other contaminants) as described in Section 1.1; unpublished data (2015).

As a result of expert caucusing recommendations (26 June 2017), modelling of potential discharge plumes and concentrations was performed in 2017 by MetOcean Solutions Ltd and some sediment and water-quality sampling was performed (see

Section 1.1; unpublished data 2017). These results provided a spatial estimate to help predict a spatial zone of reasonable mixing at each site.

The zones of potential ecological effects could be delineated by estimating the dilution required for typical (median) and worst-case (maximum) discharge concentrations to meet ANZECC (2000) guideline values for protection of biota (Table 12, and in the mapping bundle). This was then compared against the modelled dilution contours to obtain a spatial representation of where adverse ecological effects are likely to occur. (MOS 2017b; NRSBU 2017b):

- Typical/median discharge concentrations: 1:48 and 1:8 would be sufficient to protect 95% and 80% (respectively) of marine species using median copper concentrations (copper was used as a worst-case proxy for all contaminants as it had the highest median concentrations, as described in Johnston 2014).
- Maximum/worst-case discharge concentrations: 1:1692 and 1:275 would be sufficient to protect 95% and 80% level of protection (LoP) respectively using maximum copper concentrations.

Table 12. Median and maximum copper dilutions required to meet the ANZECC (2000) 95 and 80% levels of protection (LoP).

Copper	**Effluent concentrations (mg/L)**	**Required dilution for 95% LoP**	**Required dilution for 80% LoP**
Median	0.06	**48**	**8**
Maximum	2.2	**1692**	**275**
n	140		
LoP 95%	0.0013		
LoP 80%	0.008		

During subsequent caucusing on 13 October 2017, it was decided that the maximum required dilution for biological oxygen demand (BOD) in the discharge to reach guideline levels would also be useful as an indicator for short-term effects of organic-rich wastewater. As there are no ANZECC (2000) guideline limits for BOD, aquatic protection limits were approximated from Ryan (1998) and Enderlein et al. (1995)[12]. Effect ranges reported by Ryan (1998) and Enderlein et al. (1995) varied slightly from 3–6 mg/L and background concentrations from the water-quality sampling ranged from < 2 to 7 mg/L. Based on this, a concentration of 5 mg/L BOD was used as a reasonable limit for the purposes of the dilution calculations (Table 13).

As a worst-case example, the required level of dilution to reduce the maximum BOD concentration ever recorded from a pump station contributor (43,380 mg/L from

[12] Previously (Johnston 2014) BOD limits set for other discharges within the same receiving environment were used for comparison (i.e. Bell Island wastewater discharges).

Airport on the 17 January 2007), in the receiving environment to levels considered safe for aquatic life (5 mg/L), would need to be 1:8,676. Using more typical median concentration values for BOD, the required dilution is two orders of magnitude less (1:85).

Table 13. Median and maximum BOD dilutions required for aquatic life protection (Enderlein et al. 1995; Ryan 1998).

	Effluent BOD concentrations	Required dilution
Median	425	**85**
Maximum	43380	**8676**
n	860	
Aquatic protection limit	5	

Defining a reasonable mixing zone:
Based on the 'ecological contour plots'(NRSBU 2017b) [13] derived from the modelling results (MOS 2017b), and considering the above dilution calculations, zones of potential ecological effects can be reasonably delineated for:

- Acute effects (short-term, immediately following an aberrational discharge): represented by the median and maximum BOD dilution isoline contours (see ecological dilution contours illustrated in NRSBU 2017b).
- Persistent effects (longer-term): represented by the median and maximum copper dilution isoline contours (see ecological dilution contours illustrated in NRSBU 2017b).

Outside of these areas it is reasonable to assume that under modelled scenarios, 80-95% of marine species will be protected (copper, Table 12) and/or an adequate level of aquatic protection can be provided (BOD, Table 13).

It is noted that the plume modelling did not account for over flow delays due to wet-well storage, as was done in Johnston (2014), and assumes overflow is immediate (which is unlikely to be the case). Therefore, the plume propagation spatial estimates (MOS 2017b; NRSBU 2017b) can be considered highly conservative (particularly for Airport, which has over 2 hours of storage available before an overflow would occur, even during wet weather flows).

Monitoring results (discussed in Section 1.1; unpublished data 2017) suggest that any persistent sediment and water quality effects appear highly localised (< 10 m) and are difficult to separate from potential stormwater effects.

[13] Ecological contour plots were developed by NIWA (Sanjay Wadhwa) based on the MOS (2017) modelling results. The contours are a composite of the entire modelling time period, and represent all areas < the specified dilutions. Therefore, it does not represent temporal dilution, only spatial distribution.

In order to account for acute (hours to a few days), possible localised persistent effects, and general uncertainty relating to the predicted discharges (size/composition, etc.), it is recommended that the smallest reasonable spatial mixing zones (for more information on mixing zone determination refer to; Johnston 2015) be selected for each site, based on the areas defined in the modelling results (see graphics bundle and Table 14). As the results of the modelling are highly conservative, it is considered reasonable to use the dimensions derived from the median concentration dilutions (grey shading in Table 14) to develop suitable mixing zone areas.

Table 14. Plume dimension estimates based on modelling data from MOS (2017b) and dilution contours illustrated in NRSBU (2017b). Note: grey shading highlights typical (median) discharge concentrations. Note: dis. conc. = discharge concentration; LoP = level of protection, BOD = biological oxygen demand.

	Guideline	Required dilution to meet guideline values	*Plume dimensions*	Plume dimension estimates² (m/m²) Airport	Saxton	Songer	Wakatu
Persistent effects potential	Copper 95% LoP (ANZECC 2000)	Maximum dis. conc. 1:1692	Max. width (m)	200	200	400	200
			Length (m)	1100	3000	1300	900
			Max. area (m²)¹	120000	660750	184625	120475
		Median dis. conc. 1:48	Max. width (m)	200	200	300	100
			Length (m)	500	2000	600	180
			Max. area (m²)¹	45475	146675	55450	7775
	Copper 80% LoP (ANZECC 2000)	Maximum dis. conc. 1:275	Max. width (m)	200	200	300	200
			Length (m)	500	2000	600	380
			Max. area (m²)¹	61900	277300	89650	32900
		Median dis. conc. 1:8	Max. width (m)	200	100	100	50
			Length (m)	450	250	400	100
			Max. area (m²)¹	34100	9650	19650	3100
Acute effects potential	BOD level for aquatic protection (Enderlein et al. 1995; Ryan 1998)	Maximum dis. conc. 1:8676	Max. width (m)	200	2500*	5600***	200
			Length (m)	1200	3500**	2700	2700
			Max. area (m²)¹	145900	2342975	550775	427950
		Median dis. conc. 1:85	Max. width (m)	200	200	450	200
			Length (m)	500	2000	600	250
			Max. area (m²)¹	48125	190775	65475	13100
Notes				Wet MLW southerly and northerly. Plume is highly wind effected and is restricted largely to the tidal channel.	*Dry MHW no wind (plume less channelized, inner estuary), **Dry MLW southerly (plume closer to back beach, more channelised)	Wet and dry MHW northerly. Plume wind effected at high tide. Might expect to see some elevated BOD in the Monaco CR area. ***widest part of plume area in embayment	Wet and dry MHW northerly. Plume is very wind effected at high tide and is restricted largely to the tidal channel.

¹ Plume surface area estimates were calculated by NIWA (Sanjay Wadhwa), who were supplied data from the (MOS 2017) modelling data, available at request.
² Plume modelling did not account for over flow delays due to wet-well storage, and assumes overflow is immediate (which is unlikely to be the case). Therefore, the plume propagation spatial estimates can be considered highly conservative. For this reason, median concentrations (grey shading) are considered more representative of likely plume dimensions.

2.2.4. Determining assimilative capacity

In order to predict the potential effects of one-off accidental wastewater overflow discharges, it is necessary to gain some understanding of the environment's ability to dilute and disperse the discharge; and to break down or sequester its constituents. This is referred to as the assimilative capacity of the receiving environment. Assimilative capacity relies not just on the unique characteristics of the water body, but also on the period of time it takes to renew itself (i.e. dilution and residence time).

Initially, as there were no dilution modelling or studies available on the discharge in the receiving environment, the assimilative capacity was estimated using Waimea Estuary specific tidal and riverine input data obtained from literature (Heath 1976; DOC 2009) and the estimated volumes and concentrations of discharge from the discharge scenarios (2 hrs and 24 hrs). The discharge volume was divided by the total available dilution (volume of the receiving environment) to get the dilution ratio.

Since the recent modelling was completed by MOS (2017b) and the recent background monitoring data became available, the ability of the estuary to assimilate possible future discharges can be better assessed. There is a general agreement in literature that the estuary is nearing its nutrient budget limit and it has been classified recently as having high overall vulnerability to common ecological stressors (Robertson & Robertson 2014; Stevens & Robertson 2017). However, monitoring results and observations at the overflow sites suggest no obvious long-term influences from past discharges, and modelling results suggest any effects will be largely restricted to the tidal channels (as described in Section 2.2.3). Based on these findings it is reasonable to assume that the associated ecological assimilative capacities of the receiving environment have not been adversely effected, and are unlikely to become adversely effected, assuming the current trend continues with reducing discharge volumes and frequencies.

2.2.5. Determining ecological health of outfall receiving environments

Typical estuarine ecological characteristics

Estuaries are dynamic ecological systems, transitioning between fresh water and open coast. They provide a range of ecosystem goods and services for humans, including food production (fish live within or are passing through to spawning in rivers or to the open sea); recreation opportunities, contaminant processing and cultural identity. The ability of estuarine ecosystems to maintain these goods and services is largely reliant on ecosystem processes as well as the diversity and connectivity of habitats within estuaries. Together, the activities of estuarine organisms significantly influence the nature and rate of biogeochemical processes. Despite the fact that (a) it is difficult to isolate underpinning ecosystem processes (due to the interrelationship of these estuarine processes), (b) there is a long list of potential stressors to estuaries and (c) there is a need for habitat restoration in some New Zealand locations, most estuarine ecosystems typically exhibit high biodiversity values (Thrush et al*.* 2013).

There are a number of characteristics of an estuary that can change annually, seasonally, and daily. These include freshwater inputs, tidal inundation, temperature, currents, wave exposure, salinity, depth (tidal height), wind and other hydrological and meteorological factors. The variations in the chemical and physical characteristics and the various habitats (submerged and intertidal) that exist within an estuary require hardy and adaptable species to inhabit them. Therefore, estuarine biota are generally considered amongst the most tolerant and adaptable of species in the marine environment.

Although resilient to fluctuating natural variables, estuaries are not completely resistant and biota will react differently to different stressors. For example:

- **Sedimentation** - in general, the thicker the layer of mud deposited on their habitat, the more animals will be killed and the longer recovery will take. This will affect both the number of species and the number of individuals within each species, but some species are more sensitive than others (Stevens & Robertson 2014).

  In the case of one-off or 'catastrophic' depositions (e.g. riverine flood inputs) with a mud layer greater than 2 cm thick, and remaining for longer than five days, all the resident organisms in that area (with the exception of mobile taxa such as crabs and shrimps) will be killed due to lack of oxygen. Also, a mud thickness of around 0.5 cm, persisting for longer than 10 days, will reduce the number of animals and the number of species, thereby changing the structure of the animal community (Gibbs & Hewitt 2004). Indicators of sedimentation events include high sediment mud content and total suspended solids concentrations.

- **Eutrophication** – is caused when the environment becomes enriched with high levels of nutrients. This can cause problems associated with increased growth of primary producers (phytoplankton and macro algae), loss of seagrass, species changes and water-quality reductions. Indicators of enrichments include increased nutrient concentrations (nitrogen and phosphorus), presence of nuisance algae (opportunistic red and green algae) and chlorophyll-a concentrations (phytoplankton).

- **Disease risk** – Human waste and farm land runoff has the potential to carry disease-causing organisms. Aside from human health risks, there can be economic risks to nearby aquaculture facilities due to closures, however this is not typically considered a major ecological risk. Indicators for disease risk are faecal coliform and enterococci levels.

- **Toxic contamination –** when contaminants derived from discharges and runoff accumulate in an estuary they can collect in sediments and accumulate in fish and shellfish. Decay of organic matter can also contribute to ecotoxic levels of sulphides and ammonia. A common indicator for toxic contamination is sediment contaminant concentrations.

- **Habitat loss** - Estuaries have various high value habitats including shellfish beds, seagrass meadows and saltmarshes. Loss of these habitats effects the continued health and resilience of the estuarine ecosystem. A common indicator habitat loss is habitat identification, condition, level of integrity and change over time (e.g. broad scale mapping).

Ecological health of Waimea Estuary

Waimea Estuary is the endpoint for the accidental wastewater discharges being assessed in the application. The estuary is currently classified as being in a 'moderate' state or condition (Robertson & Robertson 2014). This state has been attributed to:

a. land disturbance and shoreline erosion, causing sedimentation.
b. reclamation, sedimentation, margin modification and human use (habitat disturbance), causing habitat loss.
c. stormwater and runoff from intensive land use, creating disease risk for humans. These factors also restrict bathing in the estuary during periods of high river flow.
d. nutrient runoff from urban areas and sheep, beef and dairy farms causing localised low levels of nuisance macroalgae or phytoplankton blooms, which are largely confined to the mouth of the Waimea River and some small streams that enter the estuary.

Prior to this application, aberrational wastewater discharges have never been considered as a possible threat to estuarine health in any ecological monitoring that I am aware of. This is likely because the discharges are not conspicuous and compared to the state of the estuary prior to the Bell Island upgrade (1983) and the cessation of raw discharges into the estuary, the ecosystem is in a visibly more healthy state (see comparative historical estuary conditions described in Updegraff et al. (1977).

In addition to the wider Waimea Estuary, the localised effects at the outfall receiving environments were also considered. Two of these outfall locations are outer embayments or semi-embayments (Airport and Songer), and the other two are part of the larger inner-eastern arm of the estuary (Saxton and Wakatu). All are on the eastern side of the estuary. The predictions on available dilution in these areas were originally derived using the estuary's morphological characteristics (channels, sand bars, islands, stream inputs, embayments, etc.) and likely tidal directions (at ebbing and flooding tides) for the individual discharge locations (see Johnston 2015 for details), and have subsequently been updated (as follows) using modelling results (MOS 2017a,b):

- Wakatu pump station: expected to have moderate tidal mixing (available dilution), due to the fact that there are large tidal channels adjacent to, and leading from, the discharge point.
- Saxton Road pump station: expected to have moderate-high tidal mixing (available dilution), due to the fact that there are large tidal channels adjacent to, and leading from, the discharge point.
- Songer Street pump station: likely to have comparatively low tidal mixing (available dilution), because this is the outfall with the greatest distance to travel to reach an established tidal channel.
- Airport pump station: Tidal circulation in this embayment is more restricted than previously thought. The observation of macroalgae beds (also noted in Stevens and Robertson 2014) indicative of possible nutrient enrichment, also suggests some restricted flushing ability. In contrast, this area exhibited lower sediment concentrations of organic carbon, nitrogen and phosphorus than any of the other PS. Based on these findings the predicted tidal mixing has been changed from the original AEE (Johnston 2014) to be low-moderate.

When the four outfall locations were visited during 2014 (and also visits to Songer in 2011 and Saxton in 2017), the ecological health of the estuary in the immediate vicinity of these outfall locations appeared stable, with no obvious signs of sedimentation, excessive algal growth, eutrophication or habitat damage.

Sediment chemistry (concentrations of metals, organics and TPH) at the outfall receiving environments was investigated in March 2017 (Saxton in March, as this site was considered to have the highest risk of overflow) and then at the remaining sites during August. All of the parameters tested (refer to Section 1.1; unpublished data 2017) beyond > 10 m from the outfalls were either within background levels, below ANZECC (2000) ISQG-Low thresholds, or were not clearly attributable to waste water overflows (e.g. confounding influences of storm water outfall, and possible particulate contamination/paint chips etc.).

Due to the lack of post-discharge water and sediment monitoring data (immediately following the aberrational overflow) it was not possible to ascertain the exact temporal or spatial trends (impact/recovery timeframes) or existence of the identified potential adverse acute effects (listed in Appendix 7). However, there is no evidence to suggest that previous overflows have caused persistent (long-term) adverse ecological effects at the outfall locations, or within the predicted discharge plume.

3. COASTAL MARINE STANDARDS AND/OR GUIDELINES

3.1. Likelihood of achieving standards and/or guidelines

All of the Nelson coastal marine water quality standards (fisheries, fish spawning, aquatic ecosystem, and aesthetic purposes; FEA standards) were addressed in the AEE addendum (Johnston 2015). In that document each of the standards was described and the overall effects were considered reasonably minor (small scale, temporary / moderately persistent, and tolerable), for the following reasons:

- The required contaminant dilution to reach ANZECC (2000) guideline levels was low (1:48) and the available tidal dilution was still reasonably high (even after 24 hours of overflow; 1:856)[14].
- Peak flow dilution calculations do not consider dilution from rainwater. Rainfall can increase the level of dilution 4–10 fold (URS 2008).
- The frequency of discharge events is low.
- Accidental discharges are not usually simultaneous (i.e. all sites are not discharging at once).

Based on the new literature and data collected over the period of the application, it can now be estimated where standards and/or relevant guidelines might not be met:

In the mixing zone.
As might be expected, standards and/or guidelines are unlikely to be meet in the short-term within the mixing zone areas (Table 14 and Appendix 7). Copper dilution calculations suggest slightly more persistent effects are possible within the specified mixing zones (as defined in Table 14), with, at worst, a moderate rate of recovery (within months) expected. Despite this prediction, there was little evidence for long-term adverse sediment quality effects from discharges (via sediment quality testing) outside of the immediate vicinity of the outfall (< 10 m). Because of this disparity, it is recommended that provision be made for the mixing zone to be further refined based on the results of any future post-discharge monitoring.

Increased volumes and frequency of untreated wastewater discharges.
If the frequency of discharge became chronic, and the discharge volumes increased to a level that could not be diluted to guideline concentrations with the available dilution of the estuary, I would expect the chance of adverse ecological effects to increase. Such effects would be identifiable initially by increased eutrophication in the vicinity of the outfalls, and then potentially becoming estuary wide. Some examples of these effects might be; excessive growth of macroalgae and phytoplankton

[14] Concentration-based limits are considered appropriate when the contaminant is toxic and effects are a consequence of exposure over relatively short periods. Load-based comparisons are often considered appropriate for nutrients (N and P) and organic matter because it is their cumulative effects on the receiving environment that are relevant, however due to the infrequent nature of the proposed discharges I have focussed on receiving environment concentrations to determine ecological risk.

(blooming), depleted oxygen (anoxic conditions), increased biological die-offs and malodorous sediments, as well as increased sedimentation and habitat modification (e.g. increased habitat homogeneity, and loss of salt marsh and seagrass).

Changes to wastewater discharge composition. If discharge chemical concentrations increased to a level that could not be diluted to guideline concentrations with the available dilution of the estuary. I would expect this could result from increased loading on the system or illegal domestic and trade wastes. Such effects would be identifiable by increased sediment contaminant concentrations and reductions in biological diversity.

Additional unrelated discharges. By the same token, if there are discharges to the estuary in the future, additional to those that currently contribute to the state of the environment, this may reduce the estuary's assimilative capacity.

Catastrophic damage to wastewater infrastructure (an earthquake or flood damage etc.). Under such a scenario, one might expect that the estuary would be inundated with untreated wastewater, and that the ecosystem function would suffer adverse effects due to over-enrichment, increased contamination, habitat change and sedimentation. A study by Skilton (2014) concluded that most areas in the Avon Heathcote estuary in Christchurch showed benthic recovery to pre-earthquake abundances and diversity within two years. This shows that estuarine functioning can recover, even under severe nutrient loading fluctuations and physical disturbances. Other international studies, however have found that recovery from eutrophication (without catastrophic causes) for both brackish and marine systems can take between 10–25 years (Jones & Schmitz 2009; Borja et al*.* 2010). Therefore, under this discharge scenario, adverse effects might be expected while discharges persist, with full recovery after cessation of discharges taking somewhere between 2 and 25 years.

4. SUMMARY OF ASSESSMENT OF EFFECTS

In my opinion, the use of basic assimilative capacity (volume and dilution) calculations along with the revised historic discharge volumes from the dataset bundle, the newly acquired sediment and water-quality monitoring data, and modelling information provides a reasonable means to evaluate the potential environmental effects of accidental wastewater discharge. In both this evaluation and the previous assessment, the Airport, Wakatu and Songer sites appear low risk, with little chance of an overflow occurring unless there is a complete pump failure. Relative to Saxton, these stations also exhibited lower concentrations of discharged contaminants, and had lower potential (and historic) volumes of wastewater.

My previous assessment identified Saxton as a high risk pump station, overflowing more frequently, with higher volumes and potentially elevated concentrations of contaminants. This outfall was considered the most likely of the four sites to exhibit negative ecological effects. For the previous assessment I calculated that a discharge at Saxton could be in the order of 40,000 m^3 (under a high flow scenario, 24 hours of discharge), which the available receiving waters diluted 856:1.

According to the NRSBU data bundle, a discharge of this magnitude has only occurred on one occasion (2011), with the mean discharge volume since the upgrades occurred being 1,321 m^3. The available dilution for a ‘typical’ overflow (using mean historical data), since the upgrades occurred, could be expected to be more than an order of magnitude higher than previously estimated.[15]

Given that the available dilution for a typical discharge appears to be much higher than previously thought, my findings from the original assessment remain largely the same. In support of this, the two risk assessments performed to determine the level of risk of adverse ecological effects to valued habitat and taxa suggest that, while there is ‘moderate’ risk of adverse effects to some high-valued taxa and habitats, the overall risk (likelihood/consequence) of an effect occurring is ‘very low’.

Modelling (MOS 2017a) illustrated that at all outfalls any potential for adverse effects is largely restricted to the tidal channel, with the exceptions of Songer and Saxton, which appear more likely to have wider-reaching, acute effects. However, I would still expect some moderately persistent edge effects where tidal circulation is limited (e.g. the high tidal zone) in the immediate vicinity of the outfall. These effects are likely to be mainly litter and odour, but there is also some potential for short-term smothering (from suspended solids), as well slightly increased concentrations of nutrients, contaminants and organics in these localised areas (see Appendix 5 for a summary of potential effects and risk assessment).

[15] Assuming tidal compartment and riverine inputs = 31,848,160 m^3, as used in Table 7, Johnston 2014.

Given that the monitoring results showed a lack of enrichment and/or toxicity indicators in the associated outfall channel sediments, and the risk assessments (Section 2.2.2) suggest low risk of adverse effects, I would still expect that after reasonable tidal mixing following an accidental discharge (of typical size and composition), that any wastewater-derived physico-chemical parameters should be at levels representative of background, and/or below guideline values and standards (plan rules), and the overall adverse ecological effects would be low/minor.

My conclusions are based on the following rationale/findings:

a) The required contaminant dilution to reach guideline levels is low (1:48–1:85) and the available tidal dilution is reasonably high.
b) Peak flow dilution calculations do not consider in-pipe dilution from rainwater (which in another study had increased the level of dilution 4–10 fold).
c) The frequency of discharge events is low and is generally following a decreasing trend.
d) Accidental discharges are not usually simultaneous (i.e. all sites are not discharging at once).
e) The water residence time in the Waimea Estuary is short (0.6-11.6 days[16]), with massive tidal exchange, in the order of 30–50 billion litres.
f) Modelling shows that under most conditions, the discharge plume is likely to be restricted to the tidal channels associated with each pump station.
g) When the sediment and water quality at the PS receiving environments was investigated further, there was no evidence to suggest persistent adverse ecological effects (visible effects and changes to sediment chemistry). Results indicate dominant influences from stormwater, road run off and riverine inputs.
h) The estuarine species in the Waimea Estuary are generally considered adaptable and hardy. Their resilience to the naturally dynamic nature of the estuarine ecosystem makes them reasonably well suited to withstand short-term discrete events such as accidental wastewater discharges. Long lasting adverse ecological effects from such an event are considered unlikely and any impact will be reduced with each subsequent tidal exchange.

If accidental discharges became more frequent, the volumes increased, contaminant concentrations increased, or if all sites discharged simultaneously, then the assimilative capacity of the estuary could be compromised and unable to dilute and disperse the discharge adequately. Under such unlikely circumstances, measurable negative ecological effects could be expected at an estuary-wide scale, and could take from 2 to 25 years to fully recover.

[16] Residence time (see Johnston 2014 and references therein) - 0.6 days (assuming complete tidal mixing and exchange each tide) and 11.6 days (based on input volume with the Estuary low-water volume).

5. RECOMMENDATIONS

5.1. Mitigation and safeguards

The principal safeguard against negative ecological effects from accidental overflows is to reduce the frequency and volume of contaminant concentrations in the discharge. The improvements from such safeguards are evident from the last system upgrade, and can be further built on in the future. Examples of such improvements include; more back-up pump contingency, better management of control systems to stay ahead of peak flow, reducing stormwater infiltration into the system, reducing contaminant concentrations in the waste water discharges (including illegal waste into the system), and construction of longer outfall pipes, to reduce high-tide edge effects (although it is noted that any construction activities for a pipeline will undoubtedly have adverse disturbance related effects associated with them).

If an overflow occurs, the best option to mitigate negative ecological effects is to remove large visible waste/debris/litter, and allow the discharge to be assimilated by the estuary. In residential and commercial areas where odour and visual effects may be more of an issue (i.e. Songer discharge site), it may be necessary to flush the area with brackish water using a portable pump. If this is unachievable, then fresh water may be used as estuarine systems are adapted to coping with regular fresh water inputs. If the flushing method is considered necessary, it is recommended to do so at a low flow rate, so as not to physically disturb existing habitat and biota.

While it is not recommended as an ecological safeguard, it may be necessary to use biodegradable disinfectants to mitigate the risk to public health in extreme (high risk) circumstances. However, we strongly caution against using such products as, by their nature, they have deleterious biological effects.

In order to more accurately assess the spatial/temporal scale of effects from accidental wastewater discharges, particularly from Saxton, environmental monitoring of the receiving environment is suggested. The collection of quantitative macrofaunal and sediment contaminant and characteristics data from the outfall receiving environment after an accidental discharge event, would provide a better understanding of actual ecological effects, as well as outlining their potential spatial scale and duration (community recovery). This is particularly important to ensure the area off effects (mixing zone) remains as small as practicable. Therefore, it is recommended any monitoring plans and/or consent conditions should allow flexibility and review for incorporating new information and monitoring tools.

5.2. Ecological monitoring recommendations

When an outfall location overflows (Songer, Saxton, Wakatu and Airport) the receiving environment should be monitored individually for both water and sediment quality.

Design: Transect sampling stations should follow a transect/distance graded method of sampling, as typical for assessing point source discharges. The recommended transects are the main flow channel leading from the outfall (channel) and the soft sediments parallel the high tide mark (shoreline).

A combination of background sampling, a reference site and distance based sampling, are suggested for detecting water quality and ecological changes when discharges occur. Interpretation of background sample results must be treated with caution as the outfall station may already be impacted.

Water quality sampling: Estuarine water samples can be used to determine changes to water quality. *In situ* field measurements (e.g. pH, turbidity, temperature and salinity) can be obtained along with collection of samples for laboratory analyses, at the same locations.

Compositional data should be obtained from the pump-station specific raw discharge (end of pipe), as well as at sampling station distances selected based on the site specific modelling results from the outfall along both transects (e.g. < 10 m, 100 m, 500 m). Additionally, a reference station outside of the predicted influence of aberrational and stormwater discharges and with a similar depth/sediment and tidal circulation type should be incorporated (it may be possible to use the data from an existing monitoring site, e.g. State of the Environment monitoring). Sampling should occur during the next high tide while the discharge is occurring, and during the following 1-2 tidal cycles, on a similar tidal state after the discharge has ceased. Repeat samplings would be required only if test results indicate significant ongoing or residual adverse discharge effects.

Three replicate water samples should be analysed initially for each site. However, the numbers of replicates may be revised for subsequent samplings, if necessary, based on variability of results. The analysis suite for water quality samples should include:

- Total suspended solids (TSS),
- Metal/metalloid suite (Cd, Cr, As, Pb, Ni ,Hg, Zn, Cu),
- Semi volatile organic compounds (e.g. PCB/OCP/ dioxins),
- Nutrients (TP/TN/ Ammonia-N/ Nitrate-N/ Nitrite-N),
- Total oils and grease, and BOD/COD.

Water quality field measurements:

- Black disk /Secchi water clarity measurements,
- Visual observations (photos of undesirable biological growths, water hue and reflectance),
- *In situ* sampling of turbidity, conductivity, pH, temperature and dissolved oxygen.

Sediment quality sampling: Samples can be collected along transects, at low-tide to determine the effects of the wastewater discharge on sediment physico-chemical characteristics, contaminant status, and macrofaunal community composition. Similar monitoring techniques have been used at a local scale to assess the effects of sewage and sewage overflows in Sydney (ANZECC 2000), for monitoring the effects of sludge disposal at Rabbit Island in Waimea Inlet (Gillespie & Asher 2004) and for monitoring the effects of the Bell Island outfall.

Sediment sample should be obtained at distances from the outfall derived from the site specific modelling data (e.g. < 10 m, 100 m and 500 m) along both transects, as well as from a reference station away from the influence of stormwater discharges and with a similar depth/sediment and tidal circulation type (it may be possible to use the data from an existing monitoring site, e.g. State of the Environment monitoring). Sediment sampling should occur at the next low tide (after the discharge event) when the sites are exposed. Repeat samplings would be required only if test results indicate significant ongoing or residual adverse discharge effects.

Three replicate sediment and three macrofauna samples should be analysed for each site initially. However the numbers of replicates may be revised for subsequent samplings, if necessary, based on variability of results. The analysis suite for sediment samples is comprised of typical sediment quality parameters:

a) Visual observations of sediment cores, collected using 63 mm Pespex™ push cores (inserted c. 100 mm), should include descriptions of sediment profile, colour and odour. The cores can then be photographed and subsampled for laboratory analyses[17][4] of:
    - grain size
    - organic content (TOC)
    - nutrients (TP/TN/ Ammoniacal-N)
    - metal/metalloids (Cd, Cr, As, Pb, Ni, Hg, Zn, Cu)
    - semi-volatile organic compounds (e.g. PCB/OCP/ dioxins)
    - TPH (oils and grease).

b) Infaunal samples: can be collected using standard infaunal sediment push cores (130 mm diameter by 100 mm depth, 0.0135 m^2) and sieving (through 0.5 mm mesh) the subsequent sediments to obtain infauna. The residual sample would then need to be processed by an experienced taxonomist for macrofaunal identification and enumeration.

c) Epifaunal counts: abundance of conspicuous macroinvertebrate species and biogenic features; e.g. crab holes, shellfish and surface animals, can be counted *in situ*, using replicate 0.1m^2 quadrats (as described in Gillespie and Asher 2004).

[17] We recommend Hill Laboratories for analyses: http://www.hilllaboratories.com/file/fileid/48279

d) Algal species and % coverage: Where a significant algal cover exists, the percent coverage of the sediment habitat can be estimated using replicates of a randomly placed 0.25 m^2 quadrat containing gridlines (Gillespie & Asher 2004).

To aid in the assessment of the potential for adverse ecological effects, physico-chemical results can be compared to ANZECC (2000) guidelines (where available). Also significant deviations from background conditions/communities can also be determined by analysing variance in the results.

NOTE: As the dataset develops over time, further stations/transects/parameters may need to be added/taken away to better determine the extent of the discharges' health/ecological effects in different areas of the estuary. For example, once the receiving environment dataset is considered robust, it may be possible to infer the potential for adverse ecological effects based on ecotoxicity testing (either series dilutions or in-situ receiving environment toxicity testing). This sort of testing would also aid in validating the hydrodynamic-modelling and mixing zone predications. Any monitoring plans and/or consent conditions should allow flexibility for these changes.

5.3. Responses to ecology-related submissions

Submissions that focused on ecology, and my response to those concerns, are discussed below.

Five submitters (Judy Crowe, Connie Winslow, Caroline Etches, Tahuna Beach Camp and Raewyn Scott) mentioned a general concern about the safety of, and damage to, the environment/estuarine ecosystems. To address their concerns these submitters are referred to my summary evidence (paragraph 14) and the original AEE (Johnston 2014).

One submitter (Joanna Plows) was concerned about adverse effects on seabirds and marine mammals. While I am not a marine mammal or seabird expert, there are records of bottlenose dolphin, Hector's dolphin, orca, dusky dolphin, common dolphin and fur seals occasionally visiting the Waimea Estuary and wider surrounds (see Appendix 3 and the NRSBU 2017 graphics bundle). To the best of my knowledge, marine mammals generally have extensive foraging areas, and are not perturbed by increases in turbidity, any localised impacts around the discharge point can be expected to be of extremely low significance to overall foraging efficiency.

As with marine mammals, I would consider it highly unlikely that seabirds (information on seabirds; Appendices 1 of AEE) would directly ingest contaminated suspended or benthic sediment, although it is possible that small amounts could be consumed through foraging (e.g. larger debris and cockles which have sequestered contaminants). Foraging taxa are already subject to ingestion of contaminated shellfish in the Waimea Estuary (see Morrisey & Webb 2016), and it would therefore be very difficult to determine whether the source of effects was wastewater. It is unlikely that any contaminants would be absorbed through contact with contaminated water as both seabirds and whales have low susceptibility to absorption through these pathways. Potential contamination pathways are further reduced due to the generally low concentrations of chemicals in the discharge after reasonable mixing in the receiving environment, as described earlier in this evidence. Overall, as seabirds and marine mammals are highly mobile and able to avoid stressors, any aberrational discharge overflows are only likely to have less than minor and/or temporary effects.

Two submitters (Joanna Plows and Friends of the Haven) expressed concern over climate change effects increasing the potential risk associated with the overflows. The submitters are referred to the last heading in one of my previous letters (response to a request for further information, Johnston 2016) and to the original AEE (Section 4.1). Overall, I would expect that for infrequent/intermittent discharges the ecological risk from overflows would be lower, due to the increase in available dilution and dispersion mechanisms (increased storm events, winds and rainfall). While I am not really qualified to comment (perhaps a question for engineers), I would expect that the inundation, and subsequent inoperability of the pump stations/outfalls due to the predicted sea level rise would become an issue before any increases in the frequency of overflow become a problem.

Three submitters (Joanna Plows, Friends of the Haven and Thomas Taylor) showed concern over the lack of environmental monitoring. I believe that my evidence (paragraphs 25 to 36; ecological monitoring recommendations) addresses these concerns adequately.

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APPENDICES

Appendix 1. Raw sediment quality results.

								Metals/metalliods								Grain size fractions							Petroleum hydrocarbons			
Pumpstation	Sample_ID	Location, Immediate outfall (IO), channel (C), high-tide mark (HT)	Distance from source	Total Recoverable Phosphorus mg/kg dry wt	Total Nitrogen mg/100g dry wt	Ammonium-N mg/kg dry wt	Total Organic Carbon g/100g dry wt	Total Recoverable Arsenic mg/kg dry wt	Total Recoverable Cadmium mg/kg dry wt	Total Recoverable Chromium mg/kg dry wt	Total Recoverable Copper mg/kg dry wt	Total Recoverable Lead mg/kg dry wt	Total Recoverable Mercury mg/kg dry wt	Total Recoverable Nickel mg/kg dry wt	Total Recoverable Zinc mg/kg dry wt	Fraction >/= 2 mm g/100g dry wt	Fraction < 2 mm, >/= 1 mm g/100g dry wt	Fraction < 1 mm, >/= 500 µm g/100g dry wt	Fraction < 500 µm, >/= 250 µm g/100g dry wt	Fraction < 250 µm, >/= 125 µm g/100g dry wt	Fraction < 125 µm, >/= 63 µm g/100g dry wt	Fraction < 63 µm g/100g dry wt	C7 - C9 mg/kg dry wt	C10 - C14 mg/kg dry wt	C15 - C36 mg/kg dry wt	Total hydrocarbons (C7 - C36) mg/kg dry wt
Songer	Song <10	IO	<10	610	150	< 5	2.1	6	0.05	48	40	16.2	0.16	49	129	36.6	6.9	5.3	4.9	5.1	5.2	36.1	< 10	< 20	108	108
	Song C50	C	50	580	50	< 5	0.47	9.6	0.021	48	14.1	15.8	< 0.02	58	80	4	2.4	2.2	3.2	16.4	17.8	53.9	< 8	< 20	< 40	< 70
	Song C100	C	100	550	70	< 5	0.68	6.7	0.039	52	23	14.3	0.02	55	182	56.2	10.6	5.3	4.4	4.1	2.9	16.5	< 8	< 20	< 40	< 70
	Song HT50	HT	50	630	80	< 5	0.81	11.5	0.024	41	19.4	21	< 0.02	42	105	49.3	6.7	5.7	6.1	8.3	6.1	17.8	< 8	< 20	< 40	< 70
	Song HT100	HT	100	660	80	< 5	0.92	18.4	0.017	41	13.5	15	< 0.02	41	74	20.8	6.9	5.3	6.1	12.5	11.2	37.1	< 9	< 20	< 40	< 70
Wakatu	Waka <10	IO	<10	680	100	< 5	0.98	7.3	0.034	51	25	10.8	0.03	51	89	51.8	11	6.1	4.8	4.7	3.1	18.4	< 8	< 20	68	68
	Waka C50	C	50	620	130	< 5	1.41	9.3	0.047	69	24	15.6	0.05	83	96	3.4	2.9	2.9	2.7	7.1	7.8	73.3	< 11	< 30	< 50	< 80
	Waka C100	C	100	570	120	< 5	1.15	11	0.059	63	23	16.1	0.05	76	86	5.6	2.9	1.7	6	3.7	1.5	78.4	< 11	< 30	< 50	< 80
	Waka HT50	HT	50	810	80	< 5	0.66	19.3	0.032	54	18.7	23	< 0.02	61	90	8	8.1	8.3	7.4	11.5	8.2	48.3	< 9	< 20	< 40	< 70
	Waka HT100	HT	100	580	70	< 5	0.71	8.6	0.047	42	19	13.8	0.02	46	89	28.2	10.6	5.8	6.1	12.9	9.7	26.6	< 8	< 20	< 40	< 70
Saxton	Sax <10m	IO	<10	840	700	< 5	0.67	21	0.043	54	22	11.7	0.078	62	78	46.4	7.4	2.9	1.7	10.9	9.1	21.6	< 9	< 20	< 40	< 70
	SaxC50m	C	50	600	700	< 5	0.63	7.8	0.028	59	15.2	10	0.033	78	60	25.1	3.2	1.4	1.5	15.8	10.1	43	< 9	< 20	< 40	< 70
	SaxC100m	C	100	510	600	< 5	0.53	7.7	0.033	52	12.6	8.2	0.036	73	53	6.2	2.7	2.1	2.1	22.8	17.2	46.9	< 10	< 20	< 40	< 70
	SaxHT50m	HT	50	530	700	< 5	0.74	10.3	0.075	74	25	11.1	0.047	72	112	34.6	6.2	3.8	4.4	12.5	10.8	27.8	< 9	< 20	< 40	< 70
	SaxHT100m	HT	100	980	600	< 5	0.61	29	0.035	53	19.4	16.1	0.038	64	84	41.4	4.8	3.1	2.2	14.2	8.7	25.6	< 9	< 20	< 40	< 70
Airport	Air <10	IO	<10	270	< 50	< 5	0.11	3	0.016	15.1	6.6	4.9	0.04	18.9	22	0.4	0.4	0.4	1.9	68.6	21	7.2	< 9	< 20	< 40	< 70
	Air C100	C	100	540	80	40	0.73	5	0.035	60	15.6	9.8	0.04	79	61	0.1	0.1	< 0.1	0.2	11.7	15.1	72.8	< 10	< 20	68	< 70
	Air C50	C	50	320	< 50	< 5	0.24	2.9	0.018	26	7.9	5.9	< 0.02	33	33	0.9	< 0.1	< 0.1	0.4	50.6	26.5	21.5	< 8	< 20	< 40	< 70
	Air HT100	HT	100	250	< 50	< 5	0.3	3	0.012	21	6.2	4.9	< 0.02	25	26	0.6	0.2	0.2	0.8	66.8	14.6	16.9	< 8	< 20	< 40	< 70
	Air HT50	HT	50	240	< 50	< 5	0.13	2.7	0.013	14.8	5.2	4.7	< 0.02	17.7	21	0.4	< 0.1	< 0.1	1.4	65.1	26.7	6.3	< 8	< 20	< 40	< 70

Appendix 2. Raw water quality results. Further details (e.g. notes) available in electronic format from the author.

Description	Airport				Monaco Boat Ramp (CR)				Parkers Cove (CR)				Saxton				Songer				Tahunanui beach (CR)				Wakatu			
Lat	-41.300422	-41.300422	-41.300422	-41.300422	-41.307686	-41.307686	-41.307686	-41.307686	-41.286262	-41.286262	-41.286262	-41.286262	-41.320126	-41.320126	-41.320126	-41.320126	-41.306403	-41.306403	-41.306599	-41.306403	-41.278859	-41.278859	-41.278859	-41.278859	-41.3262	-41.3262	-41.3262	-41.3262
Long	173.217135	173.217135	173.217135	173.217135	173.206562	173.206562	173.206562	173.206562	173.231481	173.231481	173.231481	173.231481	173.210449	173.210449	173.210449	173.210449	173.219447	173.219447	173.219454	173.219447	173.245245	173.245245	173.245245	173.245245	173.209101	173.209101	173.209101	173.209101
Date	24.8.17	7.9.17	13.9.17	21.9.17	24.8.17	7.9.17	13.9.17	21.9.17	24.8.17	7.9.17	13.9.17	21.9.17	24.8.17	7.9.17	13.9.17	21.9.17	24.8.17	7.9.17	13.9.17	21.9.17	24.8.17	7.9.17	13.9.17	21.9.17	24.8.17	7.9.17	13.9.17	21.9.17
Sampling time	11:18:00	10:38:00	14:57:00	10:46:00	09:43:00	08:10:00	11:59:00	08:30:00	10:32:00	08:48:00	13:02:00	09:02:00	13:43:00	09:46:00	14:14:00	09:56:00	12:11:00	11:15:00	15:29:00	11:16:00	14:43:00	11:47:00	16:01:00	11:47:00	13:15:00	09:25:00	13:51:00	09:36:00
High tide time	11:22:00	10:22:00	14:46:00	10:20:00	11:22:00	10:22:00	14:46:00	10:20:00	11:22:00	10:22:00	14:46:00	10:20:00	11:22:00	10:22:00	14:46:00	10:20:00	11:22:00	10:22:00	14:46:00	10:20:00	11:22:00	10:22:00	14:46:00	10:20:00	11:22:00	10:22:00	14:46:00	10:20:00
Tidal state	Slack	Slack	Slack	Slack	Incoming	Incoming	Incoming	Incoming	Incoming	Incoming	Incoming	Incoming	Outgoing	Incoming	Incoming	Incoming	Slack - outg	Outgoing	Outgoing	Outgoing	Outgoing	Outgoing	Outgoing	Incoming	Outgoing	Incoming	Incoming	Incoming
Tidal range (m)	3.75	3.52	2.61	3.7	3.75	3.52	2.61	3.7	3.75	3.52	2.61	3.7	3.75	3.52	2.61	3.7	3.75	3.52	2.61	3.7	3.75	3.52	2.61	3.7	3.75	3.52	2.61	3.7
Tide height (m)	1.84	1.75	1.26	1.81	1.84	1.75	1.26	1.81	1.84	1.75	1.26	1.81	1.84	1.75	1.26	1.81	1.84	1.75	1.26	1.81	1.84	1.75	1.26	1.81	1.84	1.75	1.26	1.81
Sampling sequence	3	5	5	5	1	1	1	1	2	2	2	2	6	4	4	4	4	6	6	6	7	7	7	7	5	3	3	3
Last rain event?	1.5mm (19th	5.5mm(that	2mm (10th S	16mm (21.9	1.5mm (19th	5.5mm(that	2mm (10th S	16mm (21.9	1.5mm (19th	5.5mm(that	2mm (10th S	16mm (21.9	1.5mm (19th	5.5mm(that	2mm (10th S	16mm (21.9	1.5mm (19th	5.5mm(that	2mm (10th S	16mm (21.9	1.5mm (19th	5.5mm(that	2mm (10th S	16mm (21.9	1.5mm (19th	5.5mm(that	2mm (10th S	16mm (21.9.
Approx water depth (m)	0.5	0.4	0.4	0.4	0.5	0.3	0.3	0.5	0.5	0.3	0.3	0.5	0.5	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.5	0.4	0.4	0.5	0.5	0.4	0.4	0.5
BacT (1 bottle)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
WQ (8 bottles)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Water sample photo (x1 representative p	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site photo?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Water colour/hue	Green, clea	grey brown	Green brow	Green grey	Green (8)	Green grey	Green grey	Green grey	Green (9)	Yellow, bro	Green yello	Brown	Brown - gre	Green grey	Green grey	Black	Brown - gre	Tree debris	Green grey	Green brow	Brown - gre	Clear, suspe	Green	Green	Brown - gre	Oily sheen,	Green grey	Green brow
Munsell colour system value	8	3	6	6	8	5	6	5	9	6	9	2	8	4	6	3	9	5	8	5	5	8	9	9	4	3	5	3
Water clarity (secchi depth, m)	+0.5	0.3	0.15	0.3	1	0.2	+0.5	0.3	+0.5	0.2	+0.5	<0.1	+0.5	0.3	0.2	<0.1	+0.5	+0.3	0.4	0.2	+0.5 (lower	+0.5	+0.5	1	=/- 0.5m, co	<0.2	0.1	<0.1
Air temp/ conditions	Fine, warm,	Been rainin	Still slight b	Sun and clo	Fine, warm,	Been rainin	N wind, clo	Raining cold	Fine, warm,	Been rainin	Light N bree	Cloudy and	Fine, warm,	Been rainin	NW wind cl	Cloud & sun	Fine, warm,	Been rainin	Still cloudy	Sun	Fine, warm,	Been rainin	Breeze clou	Cloud & sun	Fine, warm,	Been rainin	NW breeze,	Cloud & sun
Notes	High tide, fi	Slack tide, v	Tide lower t	-	Incoming ti	Tide incomi	-	Cloudy turb	Incoming ti	Tide incomi	Lots of dogs	Muddy wate	Outgoing ti	Tide incomi	-	Black water	High tide tu	Outgoing ti	Tide lower t	Full tidal co	Outgoing ti	Outgoing ti	Suspended	-	Outgoing hi	Tide incomi	Poor viz, pa	-
Conductivity (SPC_µS/cm)	49036	49454	46489	40711	49270	47061	48102	45222	51617	44684	48277	32470	47781	48385	46965	46401	42131	39694	48691	39561	51702	52148	51867	49930	47086	40388	34513	32946
Conductivity (C_µS/cm)	36577	38638	38754	31969	36259	36258	36540	34863	38145	33992	40882	24379	36264	37488	38351	35898	30855	30625	38115	30329	40894	40729	42537	39761	34102	30390	29596	24587
pH	8.16	8.01	8.11	8.05	8.05	8.04	8.13	8.1	8.12	8.06	8.12	8.1	8.13	8.01	8.08	8.01	8.14	8.08	8.11	8.04	8.13	8.15	8.13	8.07	8.1	7.89	7.87	7.92
Water temperature	11.7	13.5	16.3	13.8	11.1	13	12.4	13	11.3	12.5	17	12	12.4	13.2	15.4	13.1	11	13	13.6	12.8	14.1	13.5	15.6	14.3	10.6	12	17.5	11.7
Salinity (PSU)	31.94	32.32	30.23	26.05	31.98	30.56	31.29	29.24	33.79	28.84	31.53	20.27	31.06	31.53	30.56	30.09	26.96	25.31	31.76	25.21	33.98	34.29	34.14	32.69	30.47	25.77	21.75	20.59
DO (% sat)	99.5	92.7	94.6	93.8	98.5	90.6	92.5	90.1	97.8	92.5	103.6	90.2	100.9	86.5	95.8	85.6	102.9	92.8	99.5	93.1	102.9	100	97	100.7	91	87.1	93.5	84
DO	8.83	7.9	7.72	8.27	8.85	7.89	8.12	7.91	8.64	8.23	8.28	8.57	8.88	7.46	7.94	7.45	9.56	8.35	8.49	8.42	8.59	8.41	7.84	8.42	8.35	7.98	7.84	8
Turbidity-NTU	7.7	43	56	24	7.1	21	11.1	36	3.1	41	6.9	320	4.4	12.4	31	97	11.4	19	15.7	30	5.6	10.2	2.2	8.8	15.4	12.8	47	63
Total Suspended Solids-g/m3	14	49	66	29	15	27	15	57	6	37	8	240	8	17	46	61	19	19	23	33	13	22	6	18	22	19	48	55
Total Recoverable Arsenic-g/m3	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	0.019	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Total Recoverable Cadmium-g/m3	< 0.0003	< 0.0003	< 0.0003	0.0002	< 0.0003	< 0.0003	0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	0.0003	< 0.0003	< 0.0003
Total Recoverable Chromium-g/m3	0.0017	0.0041	0.0057	0.0022	0.0014	0.0045	0.0013	0.0046	< 0.0011	0.0044	< 0.0011	0.0106	< 0.0011	0.0024	0.0033	0.01	0.0017	0.0021	0.0015	0.0023	0.0027	0.0019	0.017	0.002	0.0041	0.0024	0.0044	0.0033
Total Recoverable Copper-g/m3	0.0016	0.0025	0.0023	< 0.0011	0.0017	0.0018	< 0.0011	< 0.0011	0.0013	0.0059	0.0015	0.016	0.0034	0.0011	< 0.0011	0.007	0.0016	0.0021	< 0.0011	0.0019	0.001	< 0.0011	< 0.0011	< 0.0011	0.0015	0.0013	0.0038	0.0043
Total Recoverable Lead-g/m3	< 0.0011	< 0.0011	0.0014	< 0.0011	< 0.0011	< 0.0011	< 0.0011	0.001	< 0.0011	0.0012	< 0.0011	0.0075	< 0.0011	< 0.0011	< 0.0011	0.0027	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	0.001	0.0014
Total Recoverable Mercury-g/m3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Total Recoverable Nickel-g/m3	< 0.007	< 0.007	0.009	< 0.007	< 0.007	< 0.007	< 0.007	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.008	< 0.007	< 0.007	< 0.007
Total Recoverable Zinc-g/m3	< 0.005	0.013	0.007	0.006	< 0.005	0.01	< 0.005	0.007	< 0.005	0.117	< 0.005	0.192	< 0.005	0.009	0.005	0.039	0.008	0.051	0.01	0.062	0.004	0.02	0.038	0.005	0.008	< 0.005	0.008	0.018
Total Cyanide-g/m3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Fluoride-g/m3	1	0.7	1.1	0.8	1.1	1.1	1.1	0.8	1.1	0.5	1.1	< 0.3	1	1.1	1.1	0.4	0.8	0.6	1.1	0.6	1.1	1.2	1.2	0.9	0.7	1.2	0.8	< 0.3
Total Nitrogen-g/m3	0.3	1.1	0.4	< 0.3	0.2	0.3	0.3	< 0.3	< 0.3	0.7	0.4	0.7	0.3	0.3	0.3	0.6	1.2	1.2	0.6	0.4	< 0.3	< 0.3	0.2	0.3	0.9	0.3	0.9	0.7
Total Ammoniacal-N-g/m3	0.025	0.055	0.076	0.057	0.023	0.012	0.039	0.05	< 0.010	0.042	0.095	< 0.010	< 0.010	0.012	0.075	0.022	0.026	0.31 #1	0.064	0.05	< 0.010	< 0.010	< 0.010	0.02	0.025	< 0.010	0.084	0.029
Nitrite-N-g/m3	0.002	0.007	0.003	0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.006	0.005	0.004	0.002	0.002	0.002	0.004	0.004	0.005	0.003	0.003	< 0.002	< 0.002	< 0.002	< 0.002	0.004	< 0.002	0.006	0.004
Nitrate-N-g/m3	0.081	0.46	0.122	0.096	0.066	0.145	0.116	0.082	0.019	0.25	0.161	0.149	0.16	0.147	0.114	0.173	1.02	0.93	0.38	0.26	0.009	0.01	< 0.002	0.024	0.67	0.085	0.48	0.4
Nitrate-N + Nitrite-N-g/m3	0.083	0.47	0.124	0.098	0.068	0.147	0.117	0.084	0.021	0.26	0.166	0.153	0.162	0.149	0.116	0.178	1.02	0.94	0.39	0.26	0.01	0.01	< 0.002	0.025	0.67	0.086	0.48	0.41
Total Kjeldahl Nitrogen (TKN)-g/m3	< 0.2	0.6	0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.4	0.2	0.6	< 0.2	< 0.2	< 0.2	0.5	< 0.2	0.3	0.2	< 0.2	< 0.2	< 0.2	0.2	0.3	0.2	< 0.2	0.4	0.3
Total Phosphorus-g/m3	0.034	0.054	0.078	0.027	0.043	0.025	0.027	0.046	0.03	0.045	0.041	0.149	0.023	0.024	0.065	0.34	0.042	0.025	0.035	0.043	0.052	0.047	0.035	0.033	0.053	0.034	0.072	0.071
Total Sulphide-g/m3	< 0.002	< 0.003	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Sulphate-g/m3	2500	1330	2400	2400	2600	2300	2,400	2600	2700	880	2,200	260	2400	2300	2,400	660	1840	1060	2,300	1400	2600	2700	2,700	3000	1620	2400	1,520	230
Dissolved Total Biochemical Oxygen Dem	< 2	< 2	< 2	< 2	< 2	< 2	< 2	2	< 2	< 2	< 2	3	< 2	< 2	< 2	7	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Chlorophyll a-g/m3	0.0012	0.001	0.001	0.0004	0.0015	0.0009	0.0006	0.0009	0.0025	0.0012	0.0012	0.001	0.0009	0.0006	0.0006	0.002	0.0011	0.0008	0.0012	0.0006	0.0039	0.0019	0.0014	0.001	0.0009	0.0023	0.0008	0.0006
Acetylated Phenols in Water samples by Liq/liq-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-		-	-	-
4-Chloro-2-methylphenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
4-Chloro-3-methylphenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
2-Chlorophenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
2,4-Dichlorophenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
2,6-Dichlorophenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
2,4-Dimethylphenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
3-Methylphenol (m-cresol)-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
2-Methylphenol (o-Cresol)-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
4-Methylphenol (p-Cresol)-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
2-Nitrophenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
Pentachlorophenol (PCP)-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
Phenol-g/m3	< 0.0005	-	-	-	< 0.0005	-	-	-	< 0.0005	-	-	-	< 0.0005	-	-	-	< 0.0005	-	-	-	< 0.0005	-	-	-	< 0.0005	-	-	-
2,3,4,6-Tetrachlorophenol (TCP)-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
2,4,5-Trichlorophenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
2,4,6-Trichlorophenol-g/m3	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-	< 0.00005	-	-	-
Total oil and grease -g/m3	-	-	< 4	< 4	-	-	< 4	< 4	-	-	< 4	< 4	-	-	< 4	< 4	-	-	< 4	< 4	-	-	< 4	< 4	-		< 4	< 4

Appendix 3. Taxa values / ecological risk assessment for the aberrational overflow receiving environments. Value definitions derived from (EIANZ 2015) guidance.

					Within possible ZOI?						
Taxa group	**Associated taxa**	**Species name**	**Status**	**Value**	**Airport**	**Songer**	**Saxton**	**Wakatu**	**Associated habitats of significance**	**Ref**	**Notes:**
Birds	Banded dotterel	*Charadrius bicinctus bicinctus*	Threatened: Nationally vulnerable	Very-high	Likely	Likely	Likely	Likely	Eastern Waimea estuary-(Estuary) Bell Island shellbanks, Rabbi	N&M 2016 + Pauls evidence; DOC 2015	Waimea Inlet host an average of about 12,000 birds (maximum 15,000) in summer (February). The highest numbers in Tasman Bay in summer were recorded from Motueka Sandspit (about 5,000 on average; maximum of 7,500) and East Waimea Inlet (about 4,100 birds on average; maximum of 6,000). No site hosted more than 10,000 shorebirds. (Pauls evidence). On 'king' tides the majority of the Waimea Inlet birds are forced to Motueka Sandspit as this is the last remaining site as the others become inundated.(Pauls evidence). Tasman Bay (including the Waimea estuary) is also part of the Cook Strait Important Bird Area6, which comprises a number of internationally important seabird species, including the Black-fronted tern, Black-billed gull and an assemblage of mainly pelagic seabirds. The IBA recognises the linkeages between estuarine, coastal and offshore habitats that are utilised by seabirds at various stages of their lives..(Pauls evidence).
	Eastern bar-tailed godwit	*Limosa lapponica baueri*	At risk: Declining	High	Likely	Likely	Likely	Likely	Eastern Waimea estuary-(Estuary) No Mans Island, Bell Island s	N&M 2016 + Pauls evidence; DOC 2015	
	Lesser knot	*Calidris canutus*	Threatened: Nationally vulnerable	Very-high	Likely	Likely	Likely	Likely	Eastern Waimea estuary (red knot)-(Estuary) Bell Island shellba	N&M 2016 + Pauls evidence; DOC 2015	
	Reef heron	*Egretta sacra*	Threatened: Nationally endangered	Very-high	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Pauls evidence	
	Royal spoonbills	*Platalea regia*	At risk: Naturally uncommon	Moderate–high	Likely	Likely	Likely	Likely	Waimea Estuary (whole)-(Estuary) No Mans Island, off Bronte F	N&M 2016 + Pauls evidence; DOC 2015, Paul Fisher pers. comm. 16.10.17	
	South Island pied oystercatche	*Haematopus finschi*	At risk: Declining	High	Likely	Likely	Likely	Likely	Eastern Waimea estuary + seagrass meadows-(Estuary, islets) E	N&M 2016 + Pauls evidence; DOC 2015	
	Variable oystercatcher	*Haematopus unicolor*	At risk: Recovering	Moderate–high	Likely	Likely	Likely	Likely	Eastern Waimea estuary + seagrass meadows-(Estuary, islets) N	N&M 2016 + Pauls evidence; DOC 2015	
	White heron	*Ardea modesta*	Threatened: Nationally critical	Very-high	Possible	Possible	Possible	Possible	Waimea Estuary (whole). Feed in the estuary and roost on vege	N&M 2016 + Pauls evidence	
	Wrybill	*Anarhynchus frontalis*	Threatened: Nationally vulnerable	Very-high	Likely	Likely	Likely	Likely	Waimea Estuary (whole)-(Estuary) Rabbit Island- Wrybill regula	N&M 2016 + Pauls evidence; DOC 2015, Paul Fisher pers. comm. 16.10.17	
	Caspian tern	*Hydroprogne caspia*	Threatened: Nationally vulnerable	Very-high	Likely	Likely	Likely	Likely	Waimea Estuary (whole)-(Estuary, islets) Bell Island shellbanks	N&M 2016 + Pauls evidence; DOC 2015, Paul Fisher pers. comm. 16.10.17	
	Little blue penguin	*Eudyptula minor*	At risk: Declining	High	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Pauls evidence	
	Pied shag	*Phalacrocorax varius*	Threatened: Nationally vulnerable	Very-high	Likely	Likely	Likely	Likely	Waimea Estuary (whole)-(Estuary): feeds in the estuary at high	N&M 2016 + Pauls evidence; DOC 2015, Paul Fisher pers. comm. 16.10.17	
	Little black shag	*Phalacrocorax sulcirostris*	At risk: Naturally uncommon	Moderate–high	Possible	Possible	Possible	Possible	Waimea Estuary (whole) - feed in the estuary and associates w	Pauls evidence	
	Red-billed gull	*Larus novaehollandiae (scopulinus)*	Threatened: Nationally vulnerable	Very-high	Likely	Likely	Likely	Likely	Waimea Estuary (whole) + seagrass meadows? Ocassionally occ	N&M 2016 + Pauls evidence, Paul Fisher pers. comm. 16.10.17	
	Black-billed gull	*Larus bulleri*	Threatened: Nationally critical	Very-high	Possible	Possible	Possible	Possible	Post-breeding individuals occasionally recorded foraging in the	Pauls evidence	
	Sooty shearwater	*Puffinus griseus*	At risk: Declining	High	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Pauls evidence	
	White-fronted tern	*Sterna striata*	At risk: Declining	High	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Pauls evidence	
	Banded rail	*Gallirallus philippensis assimilis*	At risk: Declining	High	Likely	Likely	Likely	Likely	Waimea Estuary (whole)-(Margins), Waimea/pearl creek, O'cor	N&M 2016 + Pauls evidence; DOC 2015, Paul Fisher pers. comm. 16.10.17	
	Marsh crake	*Porzana pusilla affinis*	At risk: Relict	Moderate–high	Possible	Possible	Possible	Possible	Waimea Estuary (whole)-(Margins), Waimea/pearl creek, Neim	N&M 2016 + Pauls evidence; DOC 2015	
	South Island fernbird	*Bowdleria punctata punctata*	At risk: Declining	High	Possible	Possible	Possible	Possible	Waimea Estuary (whole)-(Margins), Waimea/pearl creek, O'cor	N&M 2016 + Pauls evidence; DOC 2015	
	Pied stilt	*Himantopus himantopus leucocephalus*	At risk: Declining	High	Likely	Likely	Likely	Likely	(Estuary, Islets) No Mans Island, Rabbit Island east, Bell Island s	N&M 2016 + Pauls evidence; DOC 2015, Paul Fisher pers. comm. 16.10.17	
	Black shag	*Phalacrocorax carbo novaehollandiae (Phalacrocorax carbo)*	At risk: Naturally uncommon	Moderate–high	Possible	Possible	Possible	Possible	(Estuary)- feed in the estuary and associates with the Pied shag	N&M 2016 + Pauls evidence; DOC 2015	
	Black-fronted tern	*Chlidonias albostriatus*	Threatened: Nationally endangered	Very-high	Likely	Likely	Likely	Likely	(Estuary) Bell Island east- breeds in the braided Waimea river c	N&M 2016 + Pauls evidence; DOC 2015	
	Grey teal	*Anas gracilis*	Not threatened	Low	Possible	Possible	Possible	Possible	(Estuary)	N&M 2016 + Pauls evidence; DOC 2015	
	Little shag	*Phalacrocorax melanoleucos brevirostris*	Not threatened	Low	Possible	Possible	Possible	Possible	(Estuary)	N&M 2016 + Pauls evidence; DOC 2015	
	Pukeko	*Porphyrio melanotus*	Not threatened	Low	Possible	Possible	Possible	Possible	(Estuary)	N&M 2016 + Pauls evidence; DOC 2015	
	Ruddy turnstone	*Arenaria interpres*	Migrant	Moderate	Likely	Likely	Likely	Likely	(Estuary) Bell Island shellbanks, Rabbit Island East-	N&M 2016 + Pauls evidence; DOC 2015	
	Northern shoveler	*Anas clypeata*	Vagrant	Low	Possible	Possible	Possible	Possible	(Estuary)	N&M 2016 + Pauls evidence; DOC 2015	
	Australian bittern	*Botaurus poiciloptilus*	Threatened: Nationally endangered	Very-high	Possible	Possible	Possible	Possible	(Margins), Waimea/pearl creek, O'conner creek delta, Neimans	N&M 2016 + Pauls evidence; DOC 2015	
	Southern black backed gull	*Larus dominicanus*	Not threatened	Low	Likely	Likely	Likely	Likely	Congregates and feeds in channels close to discharge points of	Paul Fisher Pers. Comm. 16.10.17	
	Australian harrier	*Circus approximans*	Not threatened	Low	Possible	Possible	Possible	Possible	(Margins)	N&M 2016 + Pauls evidence; DOC 2015	
	Kingfisher	*Todiramphus sanctus vagans*	Not threatened	Low	Possible	Possible	Possible	Possible	(Margins)	N&M 2016 + Pauls evidence; DOC 2015	
	Spotless crake	*Porzana tabuensis tabuensis*	Relict (small population stabilised after declining)	Moderate	Possible	Possible	Possible	Possible	(Margins). Occur in the marshland of the estuary.	N&M 2016 + Pauls evidence; DOC 2015	
Freshwater fish	Longfin eel	*Anguilla dieffenbachii*	At risk: Declining	High	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole) + subtidal channels and lagoons--	N&M 2016 + Kates evidence	Migrate to sea as adults to spawn - migrate to freshwater as juveniles
	Shortfin eel	*Anguilla australis*	Not threatened nationally, common locally	Low	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Migrate to sea as adults to spawn - migrate to freshwater as juveniles
	Lamprey	*Geotria australis*	Threatened: Nationally vulnerable	Very-high	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Juveniles go to sea at 4-5 years and stay there for 3-4 years before
	Torrentfish	*Cheimarricthys fosteri*	At risk: Declining	High	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to sea, migrate to freshwater as juveniles
	Giant kokopu	*Galaxias argenteus*	At risk: Declining	High	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to sea, migrate to freshwater as juveniles
	Banded kokopu	*Galaxias fasciatus*	Not threatened nationally, common locally	Low	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to sea, migrate to freshwater as juveniles
	Koaro	*Galaxias brevipinnis*	At risk: Declining	High	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to sea, migrate to freshwater as juveniles
	Inanga	*Galaxias maculatus*	At risk: Declining	High	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Adults spawn in tidally indudated vegetation. Juveniles migrate into
	Shortjaw kokopu	*Galaxias postvectis*	Threatened: Nationally vulnerable	Very-high	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to sea, migrate to freshwater as juveniles
	Black flounder	*Rhombosolea retiaria*	Not threatened nationally, common locally	Low	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Largely esturine dwelling although some adults penetrate far into
	Upland bully	*Gobiomorphus breviceps*	Not threatened nationally, common locally	Low	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Non-migratory
	Common bully	*Gobiomorphus cotidianus*	Not threatened nationally, common locally	Low	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to coast, juveniles return to freshwater
	Giant bully	*Gobiomorphus gobioides*	Not threatened nationally, common locally	Low	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to coast, juveniles return to freshwater
	Bluegill bully	*Gobiomorphus hubbsi*	At risk: Declining	High	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to coast, juveniles return to freshwater
	Redfin bully	*Gobiomorphus huttoni*	At risk: Declining	High	Unlikely	Unlikely	Possible	Possible	Waimea Estuary (whole)	N&M 2016 + Kates evidence	Larvae washed out to coast, juveniles return to freshwater
Marine fish	Snapper*	*Chrysophrys pagrus / Pagrus auratus*	Least Concern	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole) + seagrass meadows (Hallaw waters se	Mentioned in N&M 2016, Davidson & Moffat 1990 (pg 53); Davidson et al 1993.	
	Yellow-bellied flounder*	*Rhombosolea leporina*	Not evaluated	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole). Common species.	Davidson & Moffat 1990 (pg 53)	Common species: (Flat fish) Diet of YBF = mudcrabs helice crassa
	Sand flounder*	*Rhombosolea plebeia*	Least Concern	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole). Most common in inlet 1990	Davidson & Moffat 1990 (pg 53)	Common species: (Flat fish) Most common in inlet 1990
	Common sole*	*Peltorhamphus novaezealandiae*	Not evaluated	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole). Common species.	Davidson & Moffat 1990	Common species: (Flat fish)
	Witch	*Arnoglossus scapha*	Not evaluated	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole). Common species	Davidson & Moffat 1990	Common species: (Flat fish)
	Yellow-eyed mullet	*Aldrichetta forsteri*	Least Concern	Low	Likely	Likely	Likely	Likely	In the estuary all seasons, large shoals pentrate the estuary cor	Mentioned in BML 2015b, Davidson & Moffat 1990 (pg 53)	Common species: In the estuary all seasons, large shoals pentrate the e
	Grey Mullet	*Mugil cephalus*	Least Concern	Low	Likely	Likely	Likely	Likely	Recreational fisherman commonly net these fish in the Travers	Davidson & Moffat 1990 (pg 54)	Common species: Grey mullet enter the estuary to feed (detritus and a
	Rig*	*Mustelus lenticulatus*	Least Concern	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole). Shallow water to breed.	Davidson & Moffat 1990	Common species: Female rig enter shallow water to breed. Adults use e
	Kahawai	*Arripis trutta*	Not evaluated	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole)	Mentioned in BML 2015b, Davidson & Moffat 1990	Common species: Spawn and spend most their lifes at sea, then enter t
	Stargazer*	*Leptoscopus macropygus*	Not evaluated	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole)	Davidson & Moffat 1990	Uses Waimea as a nursery for young.
	Tarakihi*	*Nemadactylus macropterus*	Not evaluated	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Blue shark	*Prionace glauca*	Near Threatened (NT)	Moderate	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Bronze whaler	*Carcharhinus brachyurus*	Near Threatened (NT)	Moderate	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Hammerhead shark	*Sphyrna zygaena*	Vulnerable (VU)	High	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Spiny dogfish	*Squalus sp./ Squalus acanthias*	Vulnerable (VU)	High	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Eagle ray	*Myliobatis tenuicaudatis*	Least Concern; Rajiformes (skates and rays) - n	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990; Mentioned in N&M 2016	Ray feeding grounds
	Pilchard*	*Sardinops neopilchardus / Sardinops sagax*	Least Concern	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Anchovy*	*Engraulis australis*	Not evaluated	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Red cod*	*Pseudophycis bacchus*	Not evaluated	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Garfish	*Reporhamphus ihi / Hyporhamphus ihi*	Not evaluated	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Seahorse	*Hippocampus abdominalis*	Data Deficient	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Gurnard*	*Chelidonichthys kumu*	Least Concern	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Rockfish	*Acanthoclinus fuscus*	Not evaluated	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Trevally*	*Caranx lutescens*	Least Concern	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Kingfish*	*Seriola grandis*	Least Concern	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Barracouta*	*Thyrsites atun*	Not evaluated	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Spotty	*Pseudolabrus celidotus*	Least Concern	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Cockabully	*Tripterygion sp. / Forsterygion nigripenne*	Least Concern	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Jack mackerel*	*Trachurus novaezelandiae*	Not evaluated	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Blue mackerel*	*Scomber australasicus*	Least Concern	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	
	Pufferfish	*Contusus richei*	Least Concern	Low	Possible	Possible	Possible	Possible	Waimea Estuary (whole)	Davidson & Moffat 1990	

Appendix 3, continued.

MM	Bottlenose dolphin	*Tursiops truncatus*	Threatened: Nationally endangered	Very-high	Possible	Possible	Possible	Possible	Subtidal channels	NABIS database 2016, N&M 2016	Coastal waters, bays, fiords
	Hector's dolphin	*Cephalorhynchus hectori*	Threatened: Nationally endangered	Very-high	Possible	Possible	Possible	Possible	Subtidal channels. Estuary mouth	NABIS database 2016, N&M 2016	Shallow inshore coastal waters, harbours (within 15 nm from shore)
	Killer whale	*Orcinus orca*	Threatened: Nationally critical	Very-high	Possible	Possible	Possible	Possible	Subtidal channels	NABIS database 2016, N&M 2016	Coastal waters, bays, estuaries
	Dusky dolphin	*Lagenorhynchus obscurus*	Not threatened, but protected under MMP Act. 1978	Moderate	Possible	Possible	Possible	Possible	Subtidal channels	NABIS database 2016, N&M 2016	Coastal waters, bays, fiords
	Common dolphin	*Delphinus delphis*	Not threatened, but protected under MMP Act. 1978	Moderate	Possible	Possible	Possible	Possible	Subtidal channels	NABIS database 2016, N&M 2016	Continental shelf waters and seasonal movements between inshore an
	Fur seals	*Arctocephalus forsteri*	Not threatened, but protected under MMP Act. 1978	Moderate	Possible	Possible	Possible	Possible	Subtidal channels & haul out areas	NABIS database 2016, N&M 2016	Rocky coastline, continental shelf waters
Invertebrates	Back beach beetle - terrestrial margin	*Bembidion (Zecillenus) tillyardi)*	Threatened: Nationally critical	Very-high	Unlikely	Unlikely	Unlikely	Unlikely	Back beach, terrestrial margin		
	Marine macrofauna - see attached spreadsheet for lists, and Appendices 4 and 5 for indicator taxa.	Amphipoda present. Potentially nutrient sensitive. Nemertea, Glyceridae, Oligochaeta and Paraonidae present. Tolerant to excess mud and organic enrichment, indicative of 'slight unbalance/enrichment.' Aonides sp. present. Very sensitive to mud and organic enrichment, indicative of 'initial /natural state'.	Not threatened nationally, common locally.	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole)	Freeman et al 2013 threatened species list, Robertson &Robertson 2014 (also see Appendix 5), and review by Townsend 2017 (also see Appendix 4).	
	Sponge gardens	69 species of plant and animals associated	Locally uncommon/rare, not nationally threate	Moderate	Unlikely	Unlikley	Likely	Possible	Saxton - Monaco channel	Gillespie (2008) as refered to in Johnston (2014, section 2.1.2)	Species listed in separate spread sheet
	Mud snails	*Amphibola crenata*	Not threatened nationally, common locally	Low	Likely	Likely	Likely	Likely	Intertidal		
	Mud crabs	*Austrohelice crassa*	Not threatened nationally, common locally	Low	Likely	Likely	Likely	Likely	Intertidal	Burrow holes observed only	
	Shellfish	Bivalves	Not threatened nationally, common locally	Low	Likely	Likely	Likely	Likely	Waimea Estuary (whole) - Bell Island (Figure 4, Stevens & Robe	Currently not recommended for consumption (by DHB)	
	Tube worm (fields)	Sabellids	Locally uncommon/rare, not nationally threate	Moderate	Possible	Possible	Possible	Possible	Waimea Estuary (whole) - Narrow reefs on channel banks, mostly in the lower eastern arm of the estuary.--		
Plants	**Saltmarsh species:**								--	Stevens and Robertson 2014	
	Glasswort (Herbfield)	*Sarcocornia quinqueflora*	Locally uncommon/rare, not nationally threate	Moderate	Likely	Likely	Likely	Likely	See mapping package--	Stevens and Robertson 2014	The loss of saltmarsh habitat has been attributed primarily to reclamation and drainage around margin areas, with shoreline modification (e.g. seawalls, bunds, roads) now greatly limiting natural saltmarsh expansion and restricting its capacity to migrate inland in response to predicted sea level rise. Consequently, future saltmarsh loss is highly likely (Stevens and Robertson 2014).
	Sea blite (Herbfield)	*Suaeda novae-zelandiae*	Locally uncommon/rare, not nationally threate	Moderate	Likely	Likely	Likely	Likely	--	Stevens and Robertson 2014	
	Ice plant (Herbfield)	*Carpobrotus edulis*	Not listed, locally uncommon/rare (decrease	Moderate	Likely	Likely	Likely	Likely	--	Stevens and Robertson 2014	
	Remuremu (Herbfield)	*Selliera radicans*	Locally uncommon/rare, not nationally threate	Moderate	Likely	Likely	Likely	Likely	--	Stevens and Robertson 2014	
	Primrose (Herbfield)	*Samolus repens*	Locally uncommon/rare, not nationally threate	Moderate	Likely	Likely	Likely	Likely	--	Stevens and Robertson 2014	
	Raupo (Reedland)	*Typha orientalis*	Locally uncommon/rare, not nationally threate	Moderate	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Searush (Rushland)	*Juncus kraussii*	Locally uncommon/rare, not nationally threate	Moderate	Likely	Likely	Possible	Likely	--	Stevens and Robertson 2014	
	Jointed wirerush (Rushland)	*Apodasmia similis*	Locally uncommon/rare, not nationally threate	Moderate	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Marram grass (Duneland)	*Ammophila arenaria*	Not listed, locally uncommon/rare(decrease ir	Moderate	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Tall fescue (Grassland)	*Festuca arundinacea*	Not listed, locally uncommon/rare(decrease ir	Moderate	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Umbrella sedge (Sedgeland)	*Cyperus eragrostis*	Not listed, locally uncommon/rare(decrease ir	Moderate	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Three square (Sedgeland)	*Schoenoplectus pungens*	Locally uncommon/rare, not nationally threate	Moderate	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Buggar grass (Tussockland)	*Austrostipa stipoides*	Locally uncommon/rare, not nationally threate	Moderate	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Saltmarsh ribbonwood (Estuari	*Plagianthus divaricatus*	Locally uncommon/rare, not nationally threate	Moderate	Possible	Possible	Likely	Possible	--	Stevens and Robertson 2014	
	Seagrass	*Zostera muelleri*	At risk: Declining (have declined considerably since 1990)	High	Possible	Possible	Possible	Possible	Eastern Waimea estuary + seagrass meadows--	Stevens and Robertson 2014	The cause of the seagrass loss is likely attributable to the unusually large extent of soft mud in the estuary (see later sections of this
	Agar weed	*Gracilaria*	Not threatened nationally, common locally	Low	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Sea sedge	*Carex litorosa*	At risk: Declining	High	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	NZ spinach 1	*Tetragonia tetragonioides*	At risk: Naturally uncommon	Moderate-high	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	NZ spinach 2	*Atriplex buchananii*	Threatened: Nationally vulnerable	Very-high	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Native musk	*Thyridia repens*	At risk: Naturally uncommon	Moderate-high	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Pingao	*Ficinia spiralis*	At risk: Declining	High	Possible	Possible	Possible	Possible	--Rabbit Island	Stevens and Robertson 2014	
	Coastal peppercress	*Lepidium banksii*	Threatened: Nationally critical	Very-high	Possible	Possible	Possible	Possible	--	Stevens and Robertson 2014	
	Grey salt bush	*Atriplex cinerea*	Threatened: Nationally critical	Very-high	Possible	Possible	Possible	Possible	--Only remaining NZ population	Stevens and Robertson 2014	

*commercial fish species (as per Davidson and Moffat 1990)

Appendix 4. Invertebrate taxa with nutrient sensitivities and their presence/absence (yes/no) in the Waimea Estuary marine invertebrate Caddis database export (7000+ taxa records). In order to ascertain the potential for effects to similar taxonomic groups, and for varying taxonomic classifications between the two datasets, the cross-reference between the sensitive taxa and the database taxa was performed at the species, genus, family and order levels. Note, the database matches (grey highlight) were from the order Amphipoda (a group of diverse, abundant and widespread crustaceans). The presence of the order Amphipoda suggests there may be nutrient-sensitive species in the Waimea Estuary receiving environment. See mapping bundle for sample station distribution/locations. For references please refer to Townsend (2017).

									Classification ranks present in Caddis Database export			
Indicator taxa	**Genus**	**Family**	**Order**	**Nutrient**	**Dose (mgL^{-1})**	**Time (hrs)**	**Response**	**Reference**	**Species**	**Genus**	**Family**	**Order**
Corophium voltator	Corophium	Corophiidae	Amphipoda	NH_3	3.1	72	LC_{50}	Kater et al. (2006)	No	No	No	Yes
Leptocheirus plumulosus	Leptocheirus	Corophiidae	Amphipoda	NH_3	0.7	96	LC_{50}	Moore et al. (1997)	No	No	No	Yes
Ampelisca abdita	Ampelisca	Ampeliscidae	Amphipoda	NH_3	0.83	96	LC_{50}	Moore et al. (1997)	No	No	No	Yes
Rhepoxynius abronius	Rhepoxynius	Phoxocephalidae	Amphipoda	NH_3	1.59	96	LC_{50}	Moore et al. (1997)	No	No	No	Yes
Eohaustorius estuarius	Eohaustorius	Haustoriidae	Amphipoda	NH_3	2.52	96	LC_{50}	Moore et al. (1997)	No	No	No	Yes
Grandidierella japonica	Grandidierella	Aoridae	Amphipoda	NH_3	3.48	96	LC_{50}	Moore et al. (1997)	No	No	No	Yes
Penaeus japonicus	Penaeus	Penaeidae	Decapoda	NH_3	3.1	96	LC_{50}	Lin et al. (1993)	No	No	No	No
Penaeus semisulcatus	Penaeus	Penaeidae	Decapoda	NH_3	1.43	96	LC_{50}	Wasjbrot et al.(1990)	No	No	No	No
Homarus americanus	Homarus	Nephropidae	Decapoda	NH_3	5.12	96	LC_{50}	Yong-Lai et al. (1991)	No	No	No	No
Streblospio benedicti	Streblospio	Spionidae	Polychaeta	NO_3- & PO_4	70 μM NO3-, 4 μM PO4	Every flood tide May-Oct (150 days)	Positive effect on taxa	Johnson et al. (2009)	No	No	No	No
Manayunkia aestuarina	Manayunkia	Fabriciidae	Polychaeta	NO_3- & PO_4			Positive effect on taxa	Johnson et al. (2009)	No	No	No	No
Paranais litoralis	Paranais	Tubificidae	Oligochaeta	NO_3- & PO_4			Positive effect on taxa	Johnson et al. (2009)	No	No	No	No
Fabricia sabella	Fabricia	Fabriciidae	Polychaeta	NO_3- & PO_4			Positive effect on taxa	Johnson et al. (2009)	No	No	No	No
Cernosvitoviella immota	Cernosvitoviella	Enchytraeidae	Oligochaeta	NO_3- & PO_4			Positive effect on taxa	Johnson et al. (2009)	No	No	No	No

Appendix 5. Invertebrate taxa with mud and organic enrichment sensitivities and their abundances) in the Waimea Estuary marine invertebrate Caddis database export (7000+ taxa records). Note, four of the top five most abundant taxa × database matches (grey highlight) represent taxa that are tolerant to excess mud and organic enrichment, indicative of 'slight unbalance'. However, it is noted that sensitive taxa were also present. See mapping bundle for sample station distribution/locations. Please note the sampling/monitoring intensity varied yearly.

	Year																		
Indicator taxa	**1991**	**1996**	**1997**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2014**	**2016**	**Total**	**Description**
Nemertea	36	3	11	63	4	3	5	1	18	4	6	2	2	17	1	3	28	207	3. Tolerant to excess mud and organic enrichment (slight unbalanced situations)
Glyceridae	26	23	4	32					13		2	1		25		4	20	150	3. Tolerant to excess mud and organic enrichment (slight unbalanced situations)
Oligochaeta	7		37	9	1		6	3	5	4	6	6	2	22	1	4	19	132	3. Tolerant to excess mud and organic enrichment (slight unbalanced situations)
Aonides sp.				51					8								12	71	I. Very sensitive to mud and organic enrichment (initial state)
Paraonidae	7	3		16					6		1			6			13	52	3. Tolerant to excess mud and organic enrichment (slight unbalanced situations)
Cumacea	1	9		8					15		2			5		1	9	50	I. Very sensitive to mud and organic enrichment (initial state)
Nematoda	7	5	4				1			1				8			17	43	2. Indifferent to mud and organic enrichment
Sipuncula	7	8	6	17					1					1				40	2. Indifferent to mud and organic enrichment
Phoxocephalidae														10	2	4	13	29	2. Indifferent to mud and organic enrichment
Copepoda		2	1		1		2	3	3	3	1			6		1	4	27	2. Indifferent to mud and organic enrichment
Mysidacea	2	6	4					1	1					2			11	27	I. Very sensitive to mud and organic enrichment (initial state)
Aonides trifida														6		1		7	I. Very sensitive to mud and organic enrichment (initial state)
Chironomidae																	2	2	Uncertain mud and organic enrichment
Amphibola crenata				1														1	3. Tolerant to excess mud and organic enrichment (slight unbalanced situations)
Total	93	59	67	197	6	3	14	8	70	12	18	9	4	108	4	18	148	838	

Appendix 6. Habitat values/ecological risk assessment for the aberrational overflow receiving environments.

		Within possible ZOI?					
Ecosystem / habitats*	**Value****	**Wakatu**	**Saxton**	**Songer**	**Airport**	**Notes**	**References**
1. Terrestrial margins							
Terrestrial margins	Very-high	Possible - nearby Saxton Creek	Possible - nearby Orphanage Creek	Likely - embayment provides shelter, but no nearby freshwater influences other than stormwater.	Possible - Poorman & Jenkins stream outlet 200 + m to the south west, behind penenisula	Marginal freshwater wetlands (Gahnia wetland, reedland, rushland and sedgeland communities. Threatened or At Risk birds, fish and plants.	Newcombe & Morrisey 2016 -
2. High intertidal vegetation							
Back Beach beetle habitat	Very-high	Unlikely	Unlikely	Unlikely	Unlikely	Vulnerable endemic beetle habitat. Back beach intertidal hummocks slightly above MHW	
Salt marsh (includes rushland, herbfield etc)	Very-high	Likely - 60m from outfall	Likely - 200m from outfall	Likely <10m from outfall, ID'd and wriggle	Likely <10m from outfall, ID'd and wriggle	Saltmarsh patches in the eastern arm (declining locally) . The most extensive saltmarsh areas were located in therelatively narrow armseither sideof the Waimea River. Nearby saltmarsh at Airport and Songer Wakatu and Saxton. i.e. saltmarsh, brackish or saltwater rushland and sedgeland. Bird foraging habitat, including fernbird, marsh crake, banded rail, South Island pied and variable oystercatchers. Fish foraging, breeding and migration pathways, including galaxiids, lampreys, eels and other native fish. East Waimea Inlet of national or international importance for several wader species.	
3. Intertidal flats							
Mud flats	Very-high	Likely	Likely	Likely	Likely	Bird and fish foraging habitat, including banded dotterel, South Island pied and variable oystercatchers, red-billed gulls and royal spoonbills. East Waimea Inlet of national or international importance for several wader species. Cockles, ray feeding grounds. Highest demand for food resources on todal flats during summer for shorebirds (species composition changes seasonally) Habitat more extensive in estuaries than prior to human settlement due to increased sedimentation.	Newcombe & Morrisey 2016 Stevens & Robertson 2014
Artificial habitat	Low	Likely - roading & stormwater	Likely - roading & stormwater	Replanted and modified. Stormwater outfalls nearby	Historic sewage outfall. Stormwater outfalls nearby	Hard substrate, such as reclaimed rock wall found at Saxton/Wakatu. Low indigenous biodiversity values. Stormwater outfalls immediately adjacent macroalgae beds.	
Cobble field	Low	Likely (man-made)	Likely (man-made)	Unlikely	Unlikely	Extensive throughout upper reaches and near river and stream deltas	
Gravel field	Low	Likely	Likely	Likely	Unlikely	As above, also common adjacent reclaimed shorelines	
Oyster reef	Moderate	Unlikely	Unlikely	Unlikely	Unlikely	Most extensive near estuary entrances and along muddy channel margins	
Sabellid field	Moderate	Unlikely, nearest sabellid field is >1.9km NNW (wriggle)	Unlikely, nearest sabellid field is >1.3km NW (wriggle)	Unlikely, nearest sabellid field is >1.2km W (wriggle)	Unlikely, nearest sabellid field is >1.2km SW (wriggle)	Narrow reefs on channels banks, mostly in the lower eastern arm of estuary.	
Shell bank	Moderate	Unlikely, nearest shell bank is >1.6km NNE from outfall (wriggle)	Unlikely, nearest shell bank is 1.1 km NE from outfall (wriggle)	Unlikely, nearest shell bank is 1.5 km SW from outfall (wriggle)	Unlikely, nearest shell bank is 2km SW the S via nearest channel (wriggle)	Predominantly in upper tidal reaches near established cockle beds	
Cockle bed	Moderate	Unlikely, nearest cockle bed is >1km NNE from outfall (wriggle)	Possible, Cockle shells ID'd, and nearest cockle bed is 500 -700 m NE from outfall (wriggle)	Unlikely, nearest cockle bed is >1.5km SW from outfall (wriggle)	Unlikely, nearest cockle bed is >2km SW then S, via nearst channel (wriggle)	Most extensive in the eastern arm, in sandy habitat near well flushed tidal channels (Cockles, ray feeding grounds)	
Mobile sand	Low	Unlikely	Unlikely	Unlikely	Unlikely	Most common near channel margins by estuary entrances	
Mobile mud/sand	Low	Unlikely	Unlikely	Unlikely	Unlikely	Most common near channel margins by estuary entrances	
Firm sand	Low	Unlikely	Unlikely	Unlikely	Likely	Predominantly in the upper intertidal zone by the eastern estuary entrance	
Soft sand	Low	Unlikely	Unlikely	Unlikely	Unlikely	Predominantly in theupper intertidal zoneby theeastern estuaryentrance	
Firm mud/sand	Moderate	Unlikely	Likely	Likely	Likely	Commonly raised, well flushed, mid-intertidal tidal flats,and among saltmarsh.	
Soft mud/sand	Low	Likely	Likely	Likely	Likely	Most common as tidal flats in the mid-upper tidal reaches of the estuary.	
Very soft mud/sand	Low	Likely	Likely	Likely	Likely	Concentrated in deposition zones in the mid-upper tidal reaches and channel margins.	
Seagrass	Very-high	Unlikely 1.9km from outfall	Unlikely 1.7km from outfall	Unlikely1.6km from outfall	Unlikely 1.4 km from outfall	1% of habitat in estuary (2014). Bird foraging habitat, including South Island pied and variable oystercatchers, and red-billed gulls. Fish breeding and juvenile habitat (including snapper), foraging and migration pathways. East Waimea Inlet of national or international importance for several wader species.	
Macroalgae beds (& eutrophic areas)	Low	Unlikely >3km from outfall	Unlikely >3km from outfall	Unlikely >3km from outfall	Possible, 130 m from outfall + eutrophic zone	2% of habitat in estuary, predominantly in the easter arm (2014). Poor condition (100% smothering anoxic sediments toxic to biota) - nusiance conditions (undesirable). Nelson Airport and MDF plant are the closest beds to the outfalls. Stormwater outfalls immediately adjacent Airport macroalgae beds.	
4. Subtidal estuarine areas							
Channels and lagoons	Very-high	Possible, >1km closest subtidal channel, but intertidal channels adjacent	Possible, >1km closest subtidal channel, but intertidal channels adjacent	Possible, >1.2 km closest large subtidal channel	Possible, >850 m to closest large subtidal channel	Feeding areas for fish and birds. Possible nursery areas for fish species. Migratory pathways for fish species such as galaxiids, lampreys, eels and other native fish. Likely degraded as a result of sediment input. Historically may have included biogenic habitat, including tubeworm mounds, shellfish reefs and more extensive sponge gardens.	Newcombe & Morrisey 2016
Estuarine sponge garden	Very-high	Possible, Monaco-Saxton channel >2km NNW from outfall	Likely-ID in area, Monaco-Saxton channel >1.5km W of outfall	Possible, Monaco-Saxton channel approx. 1.5km NW from outfall	Possible, Monaco-Saxton channel approx. 1.5km SW from outfall	Provides biogenic habitat, filtering. Monaco-Saxton channel most established estuarine sponge gardens in Waimea Inlet. 69 species of plant and animals thought to be associated at Monanco-Saxton garden, but pockets of similar habitat in other parts of the estuary, that are thought to 'seed' off this main garden. Described as being able to fluctuate high turbidity, reduced salinities and high current flows. None of the taxa listed in the sponge gardens are in the threatened invertebrate list (DOC) - note: *Notoacmea helmsi (eel grass limpet)* was matched in the list but it is now considered 'not threatened' (was previously described as range-restricted).	Gillespie 2008 Newcombe & Morrisey 2016
Shellfish reef	High	Unlikely/unknown	Unlikely/unknown	Unlikely/unknown	Unlikely/unknown	Original extent unknown, currently rare/absent - thought to have once been much more widespread. For example, shellfish reefs were observed in the entrance to Delaware Estuary in the late 1970s or early 1980s (Paul Gillespie, pers. comm), but it is not known whether these persist. Sediment characteristics were broadly mapped by Mitchell (1986).	Newcombe & Morrisey 2016
5. Sea surface and water column							
Sea surface and water column	Moderate	Likely	Likely	Likely	Likely	Planktonic productivity, seabird (including penguin) passage, resting and foraging. Marine mammal resting and foraging habitat and passage. Benthic and pelagic fish.	Newcombe & Morrisey 2016

*Broad scale features (numbered headings) in Waimea Inlet taken from Wriggle (Stevens and Robertson 2014) report (Table 5), subcatagories derived from other references and Wriggle report (Stevens and Robertson 2014).

**Assigning value to vegetation or habitat for assessment purposes, see table below and Refer MFE, DOC (2007a & 2007b) Protecting Our Places and Chapter 5.

Appendix 7. Ecological risk assessment for potential effects (derived from Burgman 2005) for the aberrational overflow receiving environments. Note, spatial scales were derived from the maximum dilution required for discharge concentrations to meet either, 95% LoP (ANZECC 2000) for copper and/or background BOD levels (which ever was highest), as described in Table 14. See Section 2.2.2 for an explanation of the table headings.

		Potential effects	Maximum spatial scale	Persistence	Consequence	Likelihood	Overall risk score	Overall risk level	Confidence level
Airport	Water colomn / quality	Temperature change	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Salinity change	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Decreased DO	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Colour changes, increased suspended solids (SS), reduced water clarity, and turbidity	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unrefined pollutants / litter - visually unattractive	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unpleasant odour	Medium (100-1km)	Rapid recovery	Negligible (6)	Possible (3)	**18**	**Low risk**	Medium to high
		Nutrient enrichment (algal blooms from increase N and P)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity to water column organisms (primary productivity)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Sediment quality	Increased SS causing smothering (smothering of seagrass meadows?) - sedimentation rate <1mm/y	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Organic enrichment and sediment hypoxia	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Unpleasant odour	Localised (50-100m)	Moderate recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unrefined pollutants / litter - visually unattractive	Localised (50-100m)	Moderate recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification to macrofauna	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Fish	Chemicals in fish tissues	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Changes in fish behaviour (e.g. migration)	Medium (100-1km)	Rapid recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Bioaccumulations of contaminats in fish tissue	Medium (100-1km)	Moderate recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification	Medium (100-1km)	Moderate recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
	Marine mammals	Reduced foraging efficacy from increased turbidity	Medium (100-1km)	Rapid recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Reduced prey avaliability	Medium (100-1km)	Rapid recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Habitat displacement	Medium (100-1km)	Long-term recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Unlikely (4)	**24**	**Very low risk**	Medium to high
	Birds	Reduced foraging efficacy from increased turbidity	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Reduced prey avaliability	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Habitat displacement	Medium (100-1km)	Long-term recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Plants	Reduced photsynthesis from increased turbidity	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Smothering causing dieooff, anoxia/eutrophication from SS deposits	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Unpleasant odour at plants dieoff.	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Habitat/substrate loss	Medium (100-1km)	Long-term recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
Songer	Water colomn / quality	Temperature change	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Salinity change	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Decreased DO	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Colour changes, increased suspended solids (SS), reduced water clarity, and turbidity	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unrefined pollutants / litter - visually unattractive	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unpleasant odour	Medium (100-1km)	Rapid recovery	Negligible (6)	Possible (3)	**18**	**Low risk**	Medium to high
		Nutrient enrichment (algal blooms from increase N and P)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity to water column organisms (primary productivity)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Sediment quality	Increased SS causing smothering (smothering of seagrass meadows?) - sedimentation rate <1mm/y	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Organic enrichment and sediment hypoxia	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Unpleasant odour	Localised (50-100m)	Moderate recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unrefined pollutants / litter - visually unattractive	Localised (50-100m)	Moderate recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification to macrofauna	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Fish	Chemicals in fish tissues	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Changes in fish behaviour (e.g. migration)	Medium (100-1km)	Rapid recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Bioaccumulations of contaminats in fish tissue	Medium (100-1km)	Moderate recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification	Medium (100-1km)	Moderate recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
	Marine mammals	Reduced foraging efficacy from increased turbidity	Medium (100-1km)	Rapid recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Reduced prey avaliability	Medium (100-1km)	Rapid recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Habitat displacement	Medium (100-1km)	Long-term recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Unlikely (4)	**24**	**Very low risk**	Medium to high
	Birds	Reduced foraging efficacy from increased turbidity	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Reduced prey avaliability	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Habitat displacement	Medium (100-1km)	Long-term recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Plants	Reduced photsynthesis from increased turbidity	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Smothering causing dieooff, anoxia/eutrophication from SS deposits	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Unpleasant odour at plants dieoff.	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Habitat/substrate loss	Medium (100-1km)	Long-term recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
Saxton	Water colomn / quality	Temperature change	Large (1km-2km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Salinity change	Large (1km-2km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Decreased DO	Large (1km-2km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Colour changes, increased suspended solids (SS), reduced water clarity, and turbidity	Large (1km-2km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unrefined pollutants / litter - visually unattractive	Large (1km-2km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unpleasant odour	Large (1km-2km)	Rapid recovery	Negligible (6)	Possible (3)	**18**	**Low risk**	Medium to high
		Nutrient enrichment (algal blooms from increase N and P)	Large (1km-2km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity to water column organisms (primary productivity)	Large (1km-2km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Sediment quality	Increased SS causing smothering (smothering of seagrass meadows?) - sedimentation rate <1mm/y	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Organic enrichment and sediment hypoxia	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Unpleasant odour	Localised (50-100m)	Moderate recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unrefined pollutants / litter - visually unattractive	Localised (50-100m)	Moderate recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification to macrofauna	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Fish	Chemicals in fish tissues	Large (1km-2km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Changes in fish behaviour (e.g. migration)	Large (1km-2km)	Rapid recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Bioaccumulations of contaminats in fish tissue	Large (1km-2km)	Moderate recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification	Large (1km-2km)	Moderate recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
	Marine mammals	Reduced foraging efficacy from increased turbidity	Large (1km-2km)	Rapid recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Reduced prey avaliability	Large (1km-2km)	Rapid recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Habitat displacement	Large (1km-2km)	Long-term recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Large (1km-2km)	Moderate recovery	Moderate (4)	Unlikely (4)	**24**	**Very low risk**	Medium to high
	Birds	Reduced foraging efficacy from increased turbidity	Large (1km-2km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Reduced prey avaliability	Large (1km-2km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Habitat displacement	Large (1km-2km)	Long-term recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Large (1km-2km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Plants	Reduced photsynthesis from increased turbidity	Large (1km-2km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Smothering causing dieooff, anoxia/eutrophication from SS deposits	Large (1km-2km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Unpleasant odour at plants dieoff.	Large (1km-2km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Habitat/substrate loss	Large (1km-2km)	Long-term recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Large (1km-2km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
Wakatu	Water colomn / quality	Temperature change	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Salinity change	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Decreased DO	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Colour changes, increased suspended solids (SS), reduced water clarity, and turbidity	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unrefined pollutants / litter - visually unattractive	Medium (100-1km)	Rapid recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unpleasant odour	Medium (100-1km)	Rapid recovery	Negligible (6)	Possible (3)	**18**	**Low risk**	Medium to high
		Nutrient enrichment (algal blooms from increase N and P)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity to water column organisms (primary productivity)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Sediment quality	Increased SS causing smothering (smothering of seagrass meadows?) - sedimentation rate <1mm/y	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Organic enrichment and sediment hypoxia	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Unpleasant odour	Localised (50-100m)	Moderate recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Unrefined pollutants / litter - visually unattractive	Localised (50-100m)	Moderate recovery	Minor (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification to macrofauna	Localised (50-100m)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Fish	Chemicals in fish tissues	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Changes in fish behaviour (e.g. migration)	Medium (100-1km)	Rapid recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Bioaccumulations of contaminats in fish tissue	Medium (100-1km)	Moderate recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification	Medium (100-1km)	Moderate recovery	Major (5)	Possible (3)	**15**	**Low risk**	Medium to high
	Marine mammals	Reduced foraging efficacy from increased turbidity	Medium (100-1km)	Rapid recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Reduced prey avaliability	Medium (100-1km)	Rapid recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Habitat displacement	Medium (100-1km)	Long-term recovery	Negligible (6)	Unlikely (4)	**24**	**Very low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Unlikely (4)	**24**	**Very low risk**	Medium to high
	Birds	Reduced foraging efficacy from increased turbidity	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Reduced prey avaliability	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Habitat displacement	Medium (100-1km)	Long-term recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
	Plants	Reduced photsynthesis from increased turbidity	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Smothering causing dieooff, anoxia/eutrophication from SS deposits	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Unpleasant odour at plants dieoff.	Medium (100-1km)	Rapid recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Habitat/substrate loss	Medium (100-1km)	Long-term recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high
		Toxicity and bioaccumulation/magnification (direct absorption/ingestion)	Medium (100-1km)	Moderate recovery	Moderate (4)	Possible (3)	**12**	**Low risk**	Medium to high