Marsden Point Refinery: **A Resource Consent Application to Renew 20 Resource Consents from the Northland Regional Council**

Prepared for: **ChanceryGreen on behalf of The New Zealand Refining Company Limited, trading as 'Refining NZ'**

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AEE Environmental Health Effects Assessment

Application by Refining NZ to re-consent discharges and structures at Marsden Point.

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This document is prepared in accordance with a work programme agreed between Refining New Zealand and Environmental Medicine Ltd.

Document information:

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Contents

1 Introduction

1.1 Overview

The New Zealand Refining Company Limited (trading as Refining NZ) owns and operates an oil refinery at Marsden Point, Northland. Refining NZ holds resource consents issued by the Northland Regional Council, that relate to discharges to air and water and associated structures. Details of the existing consents are described in the sections of the Assessment of Effects prepared by Enspire Consulting Limited ('Enspire').

This report is prepared in support of the aforementioned Assessment of Environmental Effects for application for re-consenting of a number of existing activities / structures at the Marsden Point Oil Refinery ('the Refinery') activities, operations and discharges. The reconsenting application is referred to as 'The Proposal'.

For assessment of effects related to human health, discharges are important as sources of potential exposure to pollutants. Routes of exposure that require assessment for The Proposal include:

- Inhalation of pollutants in ambient air.
- Consumption of drinking water impacted by deposition of pollutants from air.
- Consumption of kaimoana exposed to pollutants from coastal discharges.
- Other exposures from human contact with the environment, for example coastal recreation.

1.2 Background

The Refinery is located approximately 17 km southeast of Whangarei City, adjacent to the harbour foreshore at Marsden Point. Details of the site activities and discharges are described in the section 2 of the AEE prepared by Enspire.

The following activities and discharges are relevant as potential sources of hazards to human health:

- Refinery processes: Separation (distillation), conversion (into required products) and purification of crude oil.
- Transport and handling of raw materials and products: crude oil, motor gasoline, Jet fuel A1/ Dual Purpose kerosene, Diesel, Fuel Oil, Bitumen and Sulphur.
- Energy generation.
- Discharge of combustion emissions from eight stacks.

- Fugitive emissions from various site activities
- Management of stormwater.
- Discharge of treated wastewater.
- Discharge through groundwater effects.
- Discharges related to maintenance activities, including sand blasting.
- Discharges (air and water) related to incidents, for example fire-fighting.

1.3 Purpose and Scope of Assessment

The scope of the assessment is in accordance with the requirements of the 4th Schedule to the Resource Management Act 1991.

The Environmental Health Assessment is provided in relation to community exposure from the following:

- Residential and community land use
- Collection of drinking water from roof supply
- Traditional food gathering (kaimoana)
- Coastal Recreation

The potentially affected community for the assessment is evaluated when the likely area of effects from the discharges is assessed.

The assessment of human health risks (and thus human health effects) relies on evidence-based toxicological and epidemiological information contained in various authoritative reports issued by international organisations. It uses approaches recommended by the New Zealand Ministry of Health, and associated guidance documents.

The following New Zealand national agencies (and collaborating Australian agencies) provide sources of criteria or methodologies for use in environmental health assessments:

- Ministry of Health ('MoH')
- Ministry for the Environment ('MfE')
- Ministry of Primary Industries ('MPI')
- Food Standards Australia and New Zealand ('FSANZ')
- National Health and Medical Research Council ('NHMRC') Australia.
- Environmental Health Standing Committee, Canberra ('enHealth')

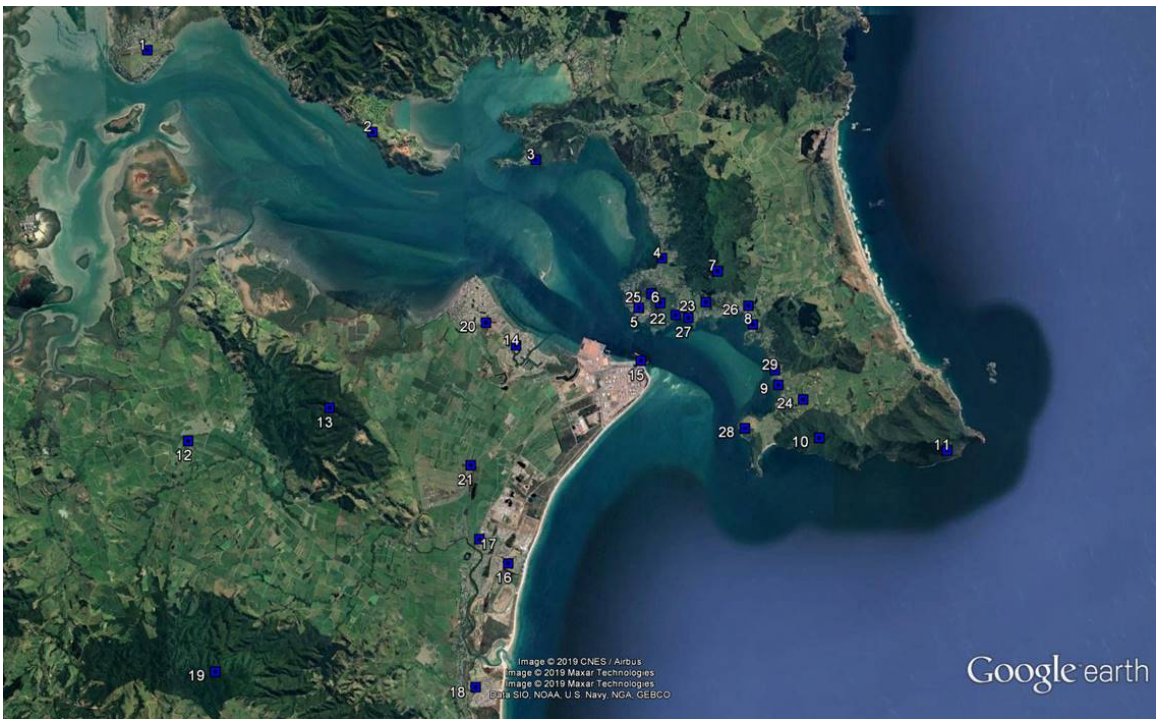
The international sources of peer-reviewed information relied on in this assessment are presented in Table 1, Appendix One.

2 Characterisation of the Community

2.1 Location of the Assessment

The location of the land-based area of interest for the Assessment is shown in the aerial map displayed in Figure 1. This area is determined using the Air Quality Assessment report selection of locations for air discharge modelling.[1] The numbers visible in the Figure are the locations (receptors) assessed for exposure to contaminants in ambient air.

Figure 1: Location of the Environmental Health Effects Assessment (Air)



Several nearby residential communities in proximity to the Site have been identified as sensitive to air quality impacts through location. These have been specifically included in the Air Assessment Report prepared by Tonkin & Taylor Limited ('T&T'):

- Marsden Cove (910 m west-northwest)
- One Tree Point (2.7 km northwest)
- Bream Bay (3.8 km south-southwest)
- The various communities on the opposite of the Whangarei Harbour (Rural Village Residential), including:
    - Whangarei Heads (2 km north-northeast);

[1] Tonkin and Taylor (June 2020) Air Assessment report prepared for NZ Refining Company Limited

- Reotahi Bay (1.25 km north);
- Little Munro Bay (1.3 km north-northwest);
- McKenzie Bay (2.9 km east-northeast); and
- Urquharts Bay (3.3 km east).

The land immediately surrounding the site is industrial in nature and is considered to have a lesser sensitivity to air effects. This includes the Carter Holt Harvey plant immediately west of the site and Northport to the immediate northwest.

The location of the coastal area of interest is identified in the Marine Ecology report prepared by Boffa Miskell Limited ('Boffa Miskell').[2]

2.2 Demographic characteristics

The New Zealand Population Census provides information at intervals about the location and composition of the resident population. The Ministry of Health describes the population of the Northland District Health Board area (2018/19 estimates) as follows[3]: significantly older than the national average, a much higher proportion of Maori and lower proportion of Pacific people living there compared to the national average and with a very high proportion of people in the most deprived section of the population.

This health effects assessment uses health-based guidelines that are intended to be inclusive for a community that might have high health need because of demographic characteristics.

2.3 Health characteristics

The Health Risk Assessment process developed and recommended by the World Health Organisation ('WHO') encompasses a broad range of outcomes consistent with the definition of health. Particular attention is given to the population subgroups that may be more susceptible to exposure to contaminants. The WHO expert review reports for ambient air quality (WHO 2000; 2006) include protection of those who may be more vulnerable to adverse health effects because of age or health difficulties. Likewise, the international expert panels (European Food Safety Authority 'EFSA'; WHO/FAO) for food contamination specifically consider vulnerable consumers, including young children. The NZ Drinking Water Standards (2018) and the documentation in the WHO drinking water guidelines (2017) also

[2] Boffa Miskell (Dec 2019). Assessment of effects on marine ecological values – reconsenting of discharges and structures in the CMA prepared for Refining New Zealand
[3] Ministry of Health My DHB 2019, www.health.govt.nz

relates risk assessments to those who may be vulnerable to health effects, including reproductive risk.

It is assumed in this assessment that there are people with a variety of health characteristics including pregnancy, and that people living in the assessment area experience health problems such as diabetes and cardiovascular disease. It is also assumed that the exposed population includes long-term residents and that some people will have a life-time of exposure to sea foods sourced from the local coast. The adoption of these assumptions is precautionary and ensures that this assessment is appropriately conservative.

Given that this protective approach underpins the guidance for protection against adverse effects relied on in this Assessment, the conclusions can be anticipated to generally apply to the community regardless of individual health status or age.

The following are exceptions to this general approach, relevant to this Assessment:

- Allergy to nickel can be an individual response to minor exposures and this is recognised in recent EFSA health advice about dietary nickel.
- A few people with asthma may have unusual sensitivity to air contaminants and this is recognised by the published information about range of effects observed from ten minute experimental exposure to sulphur dioxide concentrations (refer Table 1 in Appendix Two).

The Whangarei District Health Board have not published detailed localised information about the health characteristics of the population. The Cultural Effects Assessment report (June 2020) ('CEA') also acknowledges the difficulty in obtaining localised data.[4] This assessment assumes that the health characteristics of the residents affected by the Proposal share similarities with the resident population of Whangarei District/Northland/New Zealand.

2.4 Cultural characteristics

The Patuharakeke traditional rohe has been documented as an area that includes the site of the Proposal and other areas south of the Whangarei harbour, affected by the present application. Discussion of the relationship of Patuharakeke with the area is set out in the CEA, and in previous reports prepared for other projects.[5]

[4] Cultural Effects Assessment Report: Refining NZ Reconsenting (PTB, June 2020), at section 5.3.1.
[5] Cultural Effects Assessment Report: Refining NZ Reconsenting (PTB, June 2020), at section 4.1. See also Cultural Effects Assessment Report (PTB 2012) undertaken by the Patuharakeke Te Iwi Trust

Other tangata whenua, in particular Ngatiwai and Te Parawhau, also have a significant relationship with areas affected by the Proposal. As discussion of tangata whenua relationships is set out in the CEA.[6]

For assessment of effects from consumption of coastal shellfish, Marsden and Mair Banks have been identified as areas of significance to tangata whenua[7]. However, currently the gathering of any species of shellfish is affected at these locations by the issuance of a temporary closure notice, issued pursuant to the Fisheries Act 1996.[8]

2.5 Sensitive receptors

Community facilities have been identified as sensitive receptors in the Air Report, including:

- Takahiwai marae (6 km west of the site)
- One Tree Point School (2.4 km northwest of the site)
- Whangarei Heads School (2.3 km northeast of the site)
- Bream Bay College (4 km south-southwest of the site)
- Marsden Playcentre (4 km west of the site)
- Bream Bay kindergarten (4 km south-southwest of the site)

In this assessment of health effects, the above community locations have been specifically assessed for quality of air and any related likelihood of effects from inhaled contaminants or deposition of contaminants affecting drinking water collection from roofs.

The CEA notes that the Mair and Marsden Bank have been used by tangata whenua in the past and up until relatively recently as a source for shellfish harvest. The CEA also notes that tangata whenua intake of shellfish from this location along with other inner harbour locations probably mirrors upper limits of dietary consumption related to elevated levels of contaminants. Further, the CEA records that there is a reliance of Maori coastal communities on kaimoana as a staple part of their diet. With future changes from the present reduction in availability, the aspiration is to return to a state of access to amounts of shellfish that will provide a traditional staple contribution to regular diet.

Board (PTB) for the purposes of an application by Refining NZ to construct a stormwater overflow for the stormwater basin; and Refining NZ Crude Freight Proposal – Tangata Whenua o Whangārei Terenga Paraoa Cultural Effects Assessment.

[6] Cultural Effects Assessment Report: Refining NZ Reconsenting (PTB, June 2020), at section 4.

[7] Proposed Northland Regional Plan

[8] http://www.legislation.govt.nz/regulation/public/2018/0097/latest/whole.html

3 Identification of the Hazards

The Identification of Hazards examines whether a contaminant has the potential to cause harm to human health. Hazard Assessment includes both the presence of a potential exposure route and the potential to cause adverse effects.

The Characterisation of Risk likely from a hazard requires assessments of Dose-Response (numerical relationship between exposure and effects) and Exposure (the frequency, timing and route of contact with a hazard).

3.1 Discharges to Air – Identification of Hazards

Eight tall stacks discharge combustion products associated with the burning of natural gas, refinery generated gas, fuel oil and asphalt. The mix of fuel sources is described by T&T in their Air Quality Assessment. Amounts and proportions of various combustion products are partly determined by the mix of fuels in use, and this is controlled among the conditions of consent to discharge to air. Flaring takes place and these effects have been considered.

The Proposal includes details of proposed future energy sources and associated modelling of effects from emissions.

Hazards among the stack discharges, identified by T&T, include:

a. Sulphur oxides – sulphur dioxide, sulphur trioxide and sulphate.
b. Fine particulate matter less than ten microns and less than 2.5 microns in diameter.
c. Oxides of nitrogen.
d. Carbon monoxide.
e. Various metals – including nickel and vanadium.[9]
f. Trace dioxins and furans.

The hazards among discharges to air primarily give rise to a risk of health effects through inhalation exposure to the ambient air. The likelihood of effects depends on exposure patterns.

Other potential sources of inhaled hazards are the use of abrasive materials for maintenance activities (eg sand blasting) and possible fugitive emissions from sources at the site. The following hazards have been identified:

a. BTEX – benzene, toluene, ethylbenzene and xylene fumes.
b. Silica (respirable quartz) in abrasive materials.

[9] Air Report (Nov 2019) Table 3.8 summarises Aluminium, calcium, iron, sodium, nickel, silicon and vanadium testing results for asphalt and fuel oil. Other metals were below detection.

Some households in the impacted communities use roof water collection for household drinking water supply. An appraisal of the listed hazards among stack discharges has identified nickel and vanadium as warranting risk assessment from exposure through potential presence in household water after roof deposition.

3.2 Groundwater and soil discharges – Identification of Hazards

T&T in their hydrogeological conceptual site model (Dec 2019) identify contaminants in the soil and groundwater with potential to impact the soil, groundwater and coastal water systems. They describe the wastewater processing systems and stormwater containment systems at the site, including groundwater discharging to the coast. Sampling of soils and groundwater and ongoing monitoring of waste water and stormwater discharges provide information about contaminants at the site and this is detailed in their report.

From a perspective of public health effects from the Marsden Point site, the significant matter is to identify hazards that might exert off-site effects through groundwater or stormwater discharges to coastal areas.

The Proposal does not seek land use consents. Accordingly, asbestos-containing materials and waste materials contained at the site are not specifically evaluated in this assessment for public health effects. T&T comment (4.1.5) that chlorinated solvents are not expected to impact the surrounding environment. They also assess that transformer oils are contained (4.1.8).

Hazards to public health among the soil contaminants and discharges to groundwater include:

a. Metals – arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, zinc.[10]
b. Petroleum hydrocarbons
c. Volatile organic compounds
d. Polycyclic aromatic hydrocarbons (PAHs)
e. Phenols
f. Per- and poly-fluoroalkyl substances (PFAS)

The PFAS originate from firefighting foams used at the site (4.1.7).

Hazards from soil and groundwater are considered for health effects through impacts on coastal water and sediments that in turn can potentially expose people through contact recreation and consumption of kaimoana.

[10] T&T hydrogeology report (Dec 2019):
Table 5.1 metal concentrations in water from perimeter wells;
Table 5.2 dissolved metals in groundwater samples Sept 2019;
Table 5.3 dissolved metals in groundwater within Bream Bay foreshore Nov 2019.

3.3 Discharges to ocean – Identification of Hazards

The Marine Ecological Assessment Report prepared by Boffa Miskell (14 Oct 2019) undertakes an assessment of effects from the discharges from the stormwater basin (SWB), including discharge of treated stormwater, wastewater, and groundwater and discharge of uncontaminated seawater. Their report notes the design of the SWB to absorb fluctuations in flows from the site and to accommodate heavy rainfall events.

Information to assess contaminants has been taken from historic sampling, including by the Northland Regional Council ('NRC'), and additional field investigations to fill knowledge gaps. Environmental sampling has included shellfish flesh, benthic invertebrates, sediments, harbour waters and SWB waters.

Contaminants assessed among the coastal discharges include:

a. Heavy metals and aluminium
b. BTEX – benzene, toluene, ethylbenzene and xylene
c. Total petroleum hydrocarbons (TPH)
d. Polycyclic aromatic hydrocarbons (PAHs)
e. Phenols
f. Per- and poly-fluoroalkyl substances (PFAS)
g. sulphide
h. Tributyl tins (TBT and derivatives)
i. Faecal coliforms

A problem was noticed with regard to foreshore degradation following Cyclone Wilma. Stormwater discharge has been subsequently been mitigated with installation of a spillway. This has operated twice since its construction and prevented potential loss of hydrocarbons (TPH) from the site. Additional significant work to reduce contaminants from the site discharging to the harbour and ground is described in the Alternatives Assessment under project Kleenex[11].

[11] Jane Thomson. Refining NZ Reconsenting project Alternatives Assessment. Draft November 2019.

4 Health effects from contaminants (dose response)

The potential to produce health effects from exposure to the identified hazardous contaminants depends on the amount and duration of exposure. Authoritative reviews have been used in this assessment to identify amounts of exposure that represent a level of risk for effects.

4.1 Susceptibility to health effects

Some groups of people are generally recognised to be more vulnerable than others to adverse effects from contaminants in food, water or air. Pregnancy can alter some contaminant effects and some contaminants preferentially cross the placenta. Typically, babies and children during development are more susceptible to toxic effects for a variety of reasons including the vulnerability of organs during growth and development, but also body weight in proportion to food intakes to fuel growth produces a proportionately greater exposure among toddlers. Impairment of lung development among children living near busy roadways has been clearly documented. Some children or adults can be vulnerable because of other health difficulties.

Another possible susceptibility is when exposures to more than one contaminant are at a sufficient concentration to produce effects that might be greater than those appraised for each contaminant alone. Usually combined effects and interactions among contaminants are considered during expert review processes for health-based guidelines. Specific evaluation of combined food, water and inhaled exposures can be added when predicted concentrations exceed health exposure guidelines or food safety standards. Where exposure concentrations are low or below detection, combined effects are unlikely to be a particular issue.

Appendix Two contains further explanation about health effects related to contaminants selected for specific assessment. The information in Appendix Two is selected to have relevance to the reported exposures likely to be associated with the Proposal. It is not a comprehensive review of effects from other, higher or more prolonged exposures.

4.2 Inhalation

New Zealand has regulated standards for air quality under the Resource Management Act– the National Environmental Standards for Air Quality ('NES') – administered by the Ministry for the Environment ('MfE'). These are supplemented by ambient air quality guidelines and other guidance documents issued by the MfE. The intent of these regulations is for consistency to protect the environment and population health. T&T (2019) discuss the NES and other assessment criteria for air quality in their Air Quality report, as these criteria are for use in regulatory assessment for

resource consenting. The use of a stringent 24-hour sulphur dioxide guideline, as proposed in 2005 by the World Health Organisation ('WHO') ambient air quality guidelines global update, has not been adopted in New Zealand. T&T refer to the implementation issues regarding (i) intermittent SO_2 exposures from point sources at locations in New Zealand with mostly clean background air; (ii) evidence that SO_2 may be acting as an indicator for combined harmful contaminants in urban air, in which case addressing harm reduction requires a broader approach; and (iii) uncertainties about applying the use of a guideline for daily average exposure where daily exposures vary widely during any calendar month.

For sulphur dioxide, brief exposures, measured as ten minute or one hour, have been observationally and experimentally associated with acute respiratory effects, including aggravation of asthma. This is the basis for the one hour NES. Table 1 in Appendix Two sets out the dose-response relationship for short term effects from SO_2.

A summary of health effects associated with longer-term exposures to combustion contaminants is also included in Appendix Two.

4.3 Kaimoana

The suitability of shellfish for consumption depends on standards for safety and contaminant assessment. Mostly, for nutrient and trace contaminant exposure the relevant assessment is for consumption averaged over a period of time.

New Zealand and Australia use a combined approach to food standards, and use guidance from Australasian and the WHO/FAO expert panels. Food Standards Australia and New Zealand ('FSANZ') sets regulated standards, healthful diet guidelines and publishes information about typical dietary intakes. MPI also administers the Food Act 2014 and regulations for food and is responsible for placing warnings about shellfish gathering under adverse conditions such as toxic algal blooms.

Regulatory standards and/or health-based guidance are available, according to the specific trace element under consideration. For nutrient reference values, FSANZ refer to the NHMRC (2006) documentation that is based on exposure and effects assessments. However, non-nutrient contaminants are not included.

Dietary exposure to trace elements is assessed for public health purposes using the context of a standardised diet pattern. The methods for establishing the simulated population diet and for sampling a range of foods for constituent analysis is based on the WHO recommended approach to National Diet Studies.

Appendix Three sets out an assessment of shellfish quality based on Mair Bank samples and explains the methods used.

4.4 Drinking water

New Zealand has regulated Drinking Water Standards (DWS, revised 2018), that apply to both public and private suppliers of drinking water schemes above a specified scale of supply. Regardless of whether the NZ DWS apply through regulation (25 or more people served for 60 plus days in a year), they are an excellent basis for assessing the suitability of water for household consumption.

Generally and historically, NZ sets DWS consistent with the guideline water concentration values (determinands) set by WHO. The purpose of the WHO guidelines is to determine a concentration that will be safe for daily long-term consumption, including by children and people vulnerable for health reasons. The guidelines aim for water to be safe for pregnant women and infants. The latest major update for the WHO Drinking Water Quality Guidelines was in 2017.

The NZDWS are used in this report to assess exposure to metal contaminants through roof drinking water supply.

The Resource Management (National Environmental Standard for Sources of Human Drinking Water) Regulations 2007 ('Drinking Water NES') regulates to reduce the likelihood that water bodies used for community drinking water supply are from contaminated sources. The health-based standards to assess fitness of water for consumption are the NZDWS.

5 Exposure Assessment

5.1 Air contaminant exposure

5.1.1 Exposure information – background sulphur dioxide

The Air Quality Assessment report (T&T vs4, Nov 2019) reports ambient monitoring of sulphur dioxide (2013-2018) summarised for one hour and 24 hour averages. Peak 1-hour concentrations are reported as typically below 150 µg/m^3, but a maximum of around 230 µg/m^3 was recorded at Little Munro Bay. Peak 24-hour concentrations over the 5 year period record maxima on occasional days above 20 µg/m^3 at Little Munro Bay however typical daily exposures are almost always below 10 µg/m.^{3}

The following diagram displays the frequency of concentrations of 24-hour sulphur dioxide data from the three ambient monitoring stations. It can be seen that exposures below 5 µg/m^3 predominate and that the majority of exposures are less than or equal to 3 µg/m.^{3}

Figure 2: Distribution of daily average sulphur dioxide exposures (2013-2018)

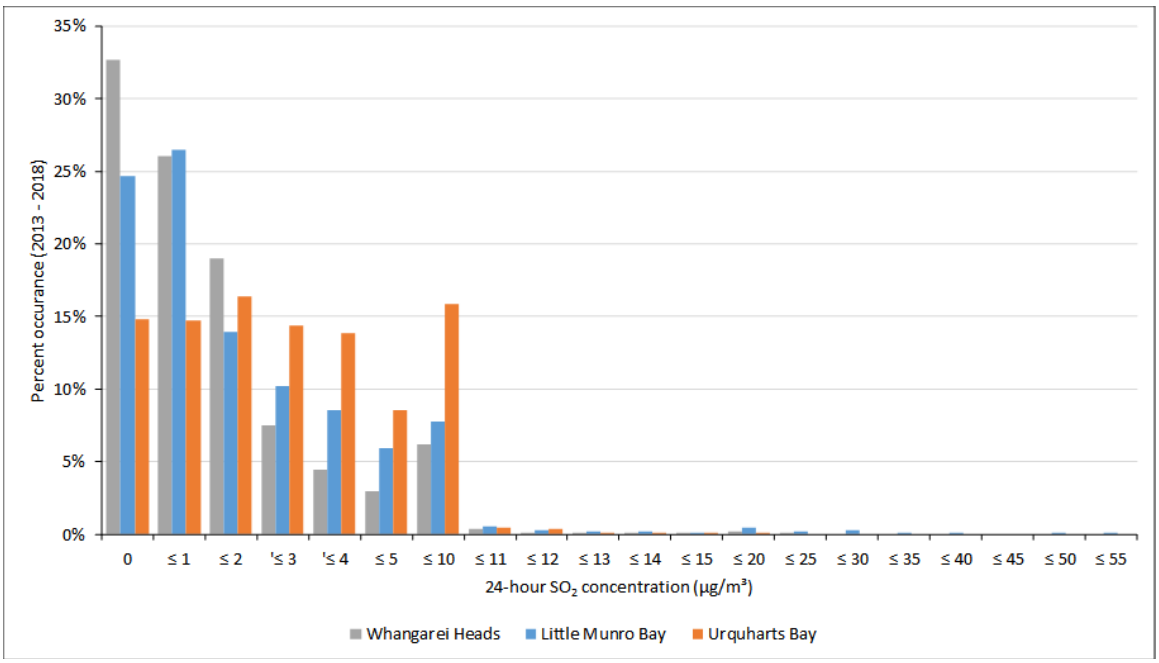


Figure supplied by Tonkin and Taylor, Personal communication 24 Sept 2019.

Note that the ambient monitoring data includes the effects from flaring.

For sulphur dioxide, T&T have derived background concentrations for use in their assessment as follows:

- 1-hour average 25 $\mu g/m^3$ (based on February for Urquharts Bay); and
- 24-hour average of 7 $\mu g/m^3$ (based on January for Little Munro Bay); and
- Annual average of 1 $\mu g/m^3$.

5.1.2 Exposure information – background particulate matter

T&T have assumed a background 24-hour concentration of 30 µg/m^3 for PM_{10}, based on monitoring. They consider that a conservative annual average value is 15 µg/m.[3]

Tonkin and Taylor have adopted an Auckland Council approach to estimating background $PM_{2.5}$, and determined values of:

- 24-hour average of 11 $\mu g/m^3$; and
- Annual average of 5.6 µg/m3.

The methods used by T&T to estimate background exposures for this assessment are conservative, especially the use of Auckland Council data.

5.1.3 Exposure information – background other discharges

There is no ambient monitoring of nitrogen dioxide to inform the site air assessment, therefore T&T have derived background concentrations as follows (4.3.3):

- 1-hour average of 37 $\mu g/m^3$;
- 24-hour average of $\mu g/m^3$; and
- Annual average of $\mu g/m^3$.

There is no ambient monitoring of carbon monoxide to inform the site air assessment, therefore T&T have derived background concentrations as follows (4.3.4):

- 1-hour average of 5 $\mu g/m^3$; and
- 8-hour average of 2 $\mu g/m^3$.

T&T found that the remainder of contaminants are expected to be present at trace amounts in background air. The methods used by T&T to estimate background exposures are conservative.

5.1.4 Exposure information – community effects using modelling

The Air Quality report uses dispersion modelling to estimate contaminant exposures additional to background air quality. The selection of emission parameters and methodologies are described by T&T. As a basis for public health assessment, the predicted concentrations are intended to provide a conservative maximum scenario. The location of community assessment receptors is shown in Figure 5.1 of the Air Quality report. As discussed in the community characteristics section of this report, the modelling receptors include important sensitive locations such as schools, marae and residential areas.

To assess effects associated with modelled predictions, ambient air quality assessment criteria are used. T&T base their evaluation on MfE guidance. The Air Quality report details the assessment approach in 5.1.3. Table 5.3 sets out the dispersion modelling assessment criteria for each of the contaminants included in the assessment.

5.1.5 Exposure information – discharges of sulphur dioxide (modelled)

The model-predicted maximum 1-hour average, 24-hour average and annual average GLCs due to SO_2 emissions from the site's energy plant are summarised in Air report Table 5.4. The areas of greatest impact are immediately west of the site boundary where there is adjoining industrial land, and also on the elevated terrain on the opposite side of the Whangarei Harbour.

The modelling results predict:

- At the western boundary, maximum cumulative offsite ground level concentration:
  - 1-hour 355 µg/m^3
  - 24-hour 80 µg/m^3
  - Annual 4.3 µg/m^3
- At Reotahi Bay, maximum cumulative offsite ground level concentration:
  - 1-hour 255 µg/m^3
  - 24-hour 67 µg/m^3
  - Annual 3.5 µg/m^3

T&T assess the modelling results as meeting the MfE assessment criteria. They note that the elevated 24 hour exposure periods are infrequent and predict that, for sensitive populated areas, 24 hour concentrations that exceed 20 µg/m^3 have an annual frequency of 4 to 16 days a year.

5.1.6 Exposure information – discharges of particulate matter (modelled)

The model-predicted maximum 24-hour average and annual average for PM_{10} are summarised in Air report Table 5.5. The greatest impacts are immediately west of the site boundary where there is adjoining industrial land, and also on the elevated terrain on the opposite side of the Whangarei Harbour.

The modelling results predict:

- At the western boundary, maximum cumulative offsite ground level concentration:
  - 24-hour 42 µg/m^3
  - Annual 15.3 µg/m^3
- At Reotahi Bay, maximum cumulative offsite ground level concentration:
  - 24-hour 41 µg/m^3
  - Annual 15.2 µg/m^3

T&T conclude that the potential adverse effects can be considered less than minor, using the exposure predictions and relevant assessment criteria.

5.1.7 Exposure information – discharges of $PM_{2.5}$ (modelled)

The model-predicted maximum 24-hour average and annual average for $PM_{2.5}$ are summarised in Air report Table 5.6. The greatest impacts are immediately west of the site boundary where there is adjoining industrial land, and also on the elevated terrain on the opposite side of the Whangarei Harbour.

The modelling results predict:

- At the western boundary, maximum cumulative offsite ground level concentration:
  - 24-hour 23 µg/m^3
  - Annual 5.9 µg/m^3
- At Reotahi Bay, maximum cumulative offsite ground level concentration:
  - 24-hour 22 µg/m^3
  - Annual 5.8 µg/m^3

T&T conclude that the potential for adverse effects can be considered less than minor, using the exposure predictions and relevant assessment criteria. For the purposes of health effects assessment the methods used by T&T for particulate assessment are conservative.

5.1.8 Exposure information – discharges of other combustion products

Predicted nitrogen dioxide exposures are summarised in table 5.7 in the Air report and the potential for adverse effects can be considered less than minor for the most impacted residential locations.

The following contaminants discharged to air are considered by T&T to have negligible potential for adverse effects:

a. Carbon monoxide.
b. Trace dioxins and furans.

Given the expected level of impact, these contaminants are not considered further in the Health Assessment Report.

5.1.9 Exposure information – discharges of metals (modelled)

The following metals are discharged to air[12] and are considered by T&T to have less than minor potential for adverse effects (Table 5.10):

a. Aluminium
b. Other metals- silver
c. Lead
d. Vanadium

Nickel modelling predicts 1-hour and annual average maximal exposures below assessment criteria, but at the most impacted locations the modelled worst 8 hour average exceeds the California OEHHA guidelines. At Reotahi Bay predicted concentrations go above 0.06 $\mu g/m^3$ on an average of five 8-hour occasions per year. The 8 hour guideline selected in the Air Report is intended to protect against lung inflammation from repeated daily inhaled exposures.

T&T have modelled an 8-hour rolling average analysis[13] to determine the frequency and persistence of the maximal modelled values for nickel as an 8 hour average. The rolling average distribution indicates that the concentration is not sustained throughout the 8 hours, does not extend into a second consecutive 8 hours and is not predicted to repeat.

The distribution pattern for the modelled exposures for nickel are detailed in Appendix Two: Table 2. This shows that the exposure pattern does not correspond to a health effect.

[12] Air Report (Nov 2019) Table 3.8 summarises Aluminium, calcium, iron, sodium, nickel, silicon and vanadium testing results for asphalt and fuel oil. Other metals were below detection.
[13] Tonkin and Taylor, email communication 3 February 2020 and update March 2020.

5.1.10 Exposure information – Fugitive Emissions

Fugitive emissions have been assessed based on monitoring information rather than modelling (Air report 6.1). The fugitive emissions under assessment are the key indicator contaminants for volatile organic compound losses. These are collectively known as BTEX – benzene, toluene, ethylbenzene and xylene.

T&T present results from the 2019 monitoring programme (6.3.2 and table 6.4). They report all measurements below detection, except for detection of toluene at the Northport boundary. The maximum monthly toluene concentration was 8 µg/m^3 assessed against a criteria of 300 µg/m.^{3}

5.1.11 Exposure information – Dust Emissions

Dust emissions can arise from abrasive blasting associated with maintenance activities. These have been assessed in the Air report on the basis of FIDOL characteristics (Frequency/Intensity/Duration/Offensiveness/Location) rather than health based guidelines. It is considered that the potential for dust nuisances is very low, as abrasive blasting is separated from residential land use. Good practice management is recommended, including the use of low silica blasting media.

5.2 Exposure to contaminants through shellfish consumption

An important exposure for public health effects is through consumption of kaimoana that might be affected by contaminants. Shellfish represent a greater dietary risk than pelagic (free-swimming) fish because they remain in an exposed location and tend to ingest and accumulate contaminants due to their feeding behaviour. The most important data to assess is the quality of sampled flesh from representative shellfish at selected locations. Information about presence of contaminants in waters and sediments contributes to the assessment by identifying contaminants that warrant measurement in shellfish.

5.2.1 Exposure information – groundwater perimeter wells

T&T (Hydrogeological conceptual site model, 2019) report contaminant levels in groundwater perimeter wells (5.1). In Table 5.2 the analysis is for dissolved metals concentrations in groundwater, potentially outside of site containment. The range of recorded concentrations is compared with NZ Drinking Water Standards (2018).

For arsenic, chromium, manganese and nickel some measurements are above DWS. This data indicates that it is important to include these metals in analyses of kaimoana; such assessment considers the effects of groundwater.

For total petroleum hydrocarbons ('TPH'), concentrations in wells outside of hydraulic containment were below the limits of reporting in the most recent monitoring undertaken in 2018 and 2019, with the exception of 0.14 mg/L C15-C20 reported for P8 in April 2019. This was not replicated in the monitoring round undertaken two weeks later (5.2.1). TPH are a relevant substance to include in shellfish flesh analyses.

Phenols were not detected in any of the perimeter well samples (5.2.4). PAHs did not exceed the relevant criteria (5.2.3).

5.2.2 Exposure information – harbour water quality and sediments

The Marine Ecological Assessment Report prepared by Boffa Miskell (June 2020) concluded (Water Quality 2.2) that metals and metalloids were largely below detection limits except for arsenic in 2015 at two sites; phenols and sulphide were below detection limits at all sites and TPH were generally very low and below detection limits at all sites.

Surface sediment samples collected in May 2019 at subtidal sites beneath and adjacent to the RNZ jetty revealed very low concentrations of contaminants, all significantly below default guideline values (DGV, ANZ 2018). Only aluminium, arsenic, chromium, copper, lead, nickel and zinc were present at concentrations above laboratory detection limits. All other contaminants including total petroleum hydrocarbons analysed were either absent or present at concentrations at/below laboratory detection limits. (Sediment Quality 3.2).

5.2.3 Exposure information – shellfish flesh

The Marine Ecological Assessment Report prepared by Boffa Miskell (Dec 2019) assessed the quality of sampled shellfish from various sites and several species (Shellfish Contaminant Body Burden 3.4). This information is directly relevant to an assessment of human exposure through kaimoana.

The following contaminants were measurable in oyster flesh and with higher concentrations recorded at Northport rocks and/or the Refining NZ jetty sites, compared to comparison sites at Urquhart's Bay, Little Munroe Bay and Manganese Point:

I. 2-methylphenol
II. Phenol
III. Phenanthrene
IV. Benzo(a)pyrene

Historic (2005) PAH measurements for sentinel mussels at the jetty were higher than current shellfish quality.

The following contaminants were below laboratory detection limits in all samples from Northport rocks and/or the Refining NZ jetty sites, and the comparison sites at Urquhart's Bay, Little Munroe Bay and Manganese Point:

I. TPHs
II. Chlorophenols
III. Dichlorophenols
IV. Trichlorophenols
V. Tetrachlorophenols
VI. Pentachlorophenol
VII. Dimethylphenol

Boffa Miskell report (p 39): "Analysis of fire-fighting foam contaminants (per- and polyfluoroalkyl substances (PFAS)) in oyster flesh samples collected from three locations beneath the RNZ jetty (RNZ 4, 5 and 7 – Figure 2) in July 2019 revealed concentrations of contaminants were all below laboratory detection limits. This result is similar to the shellfish tests carried out on organisms from Mair Bank on 14 June 2018 i.e. below laboratory detection limits."

5.2.4 Exposure information – shellfish flesh metals

The Marine Ecological Assessment Report prepared by Boffa Miskell (Dec 2019) presents results in Figures 20 - 27 for aluminium, arsenic, chromium, copper, lead, nickel, mercury and zinc. A survey in late 2019 provided results for mussels and pipi at Mair Bank. The Mair Bank mussels and pipi differed from other sample locations as follows: higher in aluminium; higher in chromium; higher in nickel; lower in zinc.[14] Note that Mair Bank is currently subject to a closure notice issued pursuant to the Fisheries Act 1996, intended to prevent shellfish gathering at this location. The CEA sets out the aspiration for tangata whenua to once again eat shellfish from this bank.

Nickel was selected for a specific exposure assessment from shellfish consumption. T&T identified that amounts of nickel in air discharges warranted specific exposure assessment and for a conservative health effects assessment, a combined exposure approach has been chosen for nickel.

5.2.5 Exposure information – dietary patterns

There is no specific detailed inclusion of important kaimoana species in the methodologies used by the Food Standards Australia and New Zealand (FSANZ) organisation, when conducting population diet studies. An overall

[14] Sharon de Luca Email communication 7 November 2019.

approach is taken to fish consumption (fish, cakes/fish, battered/fish, canned/fish, fresh/fish fingers) and shellfish do not feature as a dietary component in the 2016 NZ Total Diet Study (NZTDS).

The 2009 NZ Total Diet Study included oysters to represent shellfish consumption, additional to forms of fish. The information from that survey (including oysters) indicated that the average annual consumption of fish is about 10 kg for adult females and 15 kg for adult males.

It is important to determine representative diet patterns, including traditional harvested wild food consumption. In the absence of specific locally surveyed information, there is general diet characterisation available from the FAO for Pacific people living with traditional reliance on seafood. A current market survey for the Pacific Region ("FAO Survey") found that on average the coastal people of Pacific Islands, consumed 10 to 50 kg fish per person per year.[15]

To account for the potential consumption of seafood in amounts greater than anticipated by international food safety guidelines, a "high consumption" scenario is proposed. For the purposes of this assessment this high consumption scenario is selected as being four times the amount of fish compared to typical population consumptions from the simulated NZ population diet. A multiplier of four was adopted unanimously by the Health Expert Joint Witness Statement for the assessment of dietary effects during the consenting for the presence of the MV Rena. This high consumption model was selected by the expert witness group for consistency with the FAO Survey and after consideration of information about diet patterns among Te Arawa[16].

[15] Food and Agriculture Organisation (FAO). A Regional Survey of Aquaculture in the Pacific – Consumption of fish and shellfish in the regional market.
http://www.fao.org/docrep/t5816e/t5816e03.htm

[16] Phillips N, Stewart M, Olsen G et al (2011). Risk Assessment of contaminants in kai from within the Te Arawa rohe. Te Arawa Lakes trust and NIWA.
http://www.niwa.co.nz/sites/niwa.co.nz/files/te_arawa__summary_report_kai_contamination.pdf

5.3 Exposure to contaminants through drinking water (roof supply)

Community water supplies are available in parts but not all of the area under assessment for effects from discharges to air. Also, some households may use roof collection for personal reasons where there might be access to piped water at their boundary. T&T have provided data to assess exposure to contaminants through drinking water from roof supply.[17] The exposure data is taken from their dispersion modelling and is based on estimated deposition impacts on a roof surface.

Appendix Four includes the following detailed information:

> The roof water exposure assessment by T&T for nickel, vanadium, arsenic, barium, cadmium, chromium, copper, lead, mercury, molybdenum. This is for the highest impact near-site receptor from the air modelling and will overestimate most of the potentially affected residential areas.

As shown in Appendix Four, only nickel and vanadium emissions are assessed to have concentrations above the limit of detection (LOD). All other metal analyses are estimated using an assumption that they are present at half the value of the LOD.

For nickel, at the nearest location with maximal air concentrations, drinking water concentrations from a roof supply were estimated at 2.9% of the NZDWS.

The Drinking Water NES requires regional councils and territorial authorities to consider risks to drinking water sources in applicable RMA planning and consenting decisions. The intent of these regulations is to reduce the likelihood that water bodies used for community drinking water supply contain contaminants adversely affecting the safety and wholesomeness of the drinking water after it has undergone a 'treatment process'.

The discharges to air and water associated with the Proposal do not include concentrations of contaminants at locations with an effect on sources of community supply.

5.4 Exposure to contaminants through coastal water (recreation)

In this section, quality of coastal water for recreational activities including swimming, boating and kaimoana gathering is considered.

The background seawater quality is discussed in 5.4.2. Because that is based on sample data it potentially includes discharges added to background at

[17] Tonkin and Taylor. Email communication 16 December 2019 and update March 2020.

some locations. 5.4.1 infers the quality of discharges using sampling from the stormwater basin. As such it is a conservative way to infer risk associated with foreshore and harbour quality.

5.4.1 Exposure information – discharges from Refining NZ

Streamlined Environmental (Dec 2019) provide a Water Quality Assessment report ('the Water Quality report') that includes appraisal of the receiving environment water and sediment quality.[18] The exposure evidence is from various sampling sites and it provides a basis for a health assessment of safety for contact recreation.

The Water Quality report presents selected parameters in Table 7 and compares results with surface water quality guidelines (SWQG), chosen for restrictive ecological values (2.1.3). The assessment criteria chosen for ecological protection will conservatively provide for human safety through contact recreation.

The analyses are based on samples from the site SWB and are therefore not diluted into the receiving environment. Among metals included in Table 7, median and maximum copper and zinc exceed the SWQG. Arsenic, cadmium, chromium, lead, mercury, and nickel do not.

Median and maximum faecal coliform (FC) concentrations are 11-fold and 378-fold above the applicable SWQG. The maximal measurements are reported as due to a nesting colony of red-billed gulls.

5.4.2 Exposure information – harbour water

NRC monitor water quality sites in the Whangarei harbour, including inner harbour, edge of the mixing zone and outer harbour.

Table 18 in the Water Quality report displays results for metals from sampling 2015-2019. Measurements are mostly low or not detectable except for occasional samples for arsenic or copper. Table 20 displays the annual maximum TPH concentrations from 2014 to 2018. Apart from 2016, results have been very low and below detection limits.

All refinery café, laboratory, domestic and ablutions wastewater goes to the Ruakaka reticulated wastewater system operated by the Whangarei District

[18] Streamlined Environmental (December 2019). Water Quality Assessment at Marsden Point oil refinery to inform resource consent renewal applications.

Council.[19] The Regional Council currently conducts monthly harbour water sampling at coastal locations and includes enterococci and faecal coliform measurements. The results for One Tree Point show a lack of contamination – refer to Appendix Five for details.

5.4.3 Exposure information – foreshore groundwater

T&T (Hydrogeological conceptual site model, 2019) report contaminant levels in foreshore groundwater from Bream Bay, analysed from temporary wells (5.2.6). The range of recorded concentrations is compared with NZ Drinking Water Standards (2018).

Among the analytes in Table 5.3, arsenic has a highest recorded concentration of 0.013 mg/L – above the DWS of 0.01 mg/L. Grab samples of seawater were collected downgradient and arsenic was not detected above the limit of reporting (0.004 mg/L).

6 Characterisation of Potential for Health Effects

6.1 Summary of assessed exposures

6.1.1 Air

For ambient air exposures the contaminants that require detailed assessment are sulphur dioxide and nickel.

Particulate PM_{10} and $PM_{2.5}$ from the discharges are predicted to add low amounts to background concentrations, and cumulatively present a low potential for effects to human health. The use of the conservative method for background estimation assessment by T&T adds conservatism to the health effects assessment. Nitrogen dioxide predictions are all below corresponding assessment criteria.

All other contaminants among discharges to air are present in very low or non-detectable amounts and are not specifically assessed.

6.1.2 Shellfish

For dietary exposure assessment, trace elements concentrations vary among species at some locations and sampling occasions. The elements (metals) that have been assessed include both nutrients and

[19] Whangarei District Council. Consent renewal TW0004. 9 April 2019.

non-nutrient contaminants. In particular, nickel warrants specific assessment (refer Appendix Three).

Arsenic was detected in some environmental samples but has not been selected for specific assessment. Arsenic in seafood is typically present as sugar compounds such as arsenobetaine and these compounds are non-toxic to humans. As such it is not considered necessary to further assess arsenic. Varying amounts of copper and zinc, while of ecological importance for the shellfish, have very low public health significance when consumed in variable amounts in a mixed diet.

PAH concentrations from recent samples are below relevant assessment criteria for health from the European Food Safety Authority.

Other compounds including BTEX, phenols and TPH are present in amounts that are either low or below detection and are therefore not assessed specifically.

6.1.3 Drinking water

Deposited metals were assessed for potential to impact roof collection for drinking water. The highest presence was for nickel and concentrations were predicted to be 2.9% of the relevant drinking water standard at the most affected location.

6.1.4 Coastal contact recreation

Quality of coastal water was assessed and found to not contain any potential for contact recreation effects from contaminant metals or compounds from the discharges. The Regional Council monthly enterococci and faecal coliform measurements at One Tree Point indicate a very low potential for microbiological health effects through contact recreation (refer Appendix Five).

6.2 Comparison with assessment criteria

6.2.1 Air - Nickel

T&T have assessed the discharges to air using current MfE recommended assessment criteria. The only potential exceedance they identified was for an 8-hour averaging period criterion for nickel. The criterion adopted was from the California Office of Environmental Hazard ('OEHHA') and relates to an inflammatory lung health effect from repeated exposures. The criterion does not have systemic

uptake as a concern and their documentation notes that typical dietary intakes for nickel will be far greater than the amounts of nickel inhaled if the air criterion is exceeded.

T&T have provided a more detailed assessment for nickel with a frequency analysis for rolling average 8-hour concentrations at each community receptor (refer Appendix 2). This demonstrates that there is not an inhaled effect of the type that the criterion seeks to address.

6.2.2 Air – Sulphur dioxide

T&T have assessed the discharges to air using current MfE recommended assessment criteria. They found that for one-hour SO_2 predictions the most impacted off-site location had a combined estimated concentration from background assessment plus modelled worst occasion that was above the NES reference concentration of 355 µg/m^3. The maximum was located at the immediate western boundary. Locations identified as sensitive receiving environments for health effects are below the NES reference concentration.

T&T provided a detailed assessment showing predicted frequency of 24-hour average daily patterns for sulphur dioxide. This demonstrates that the majority of days and locations have low or negligible exposure to sulphur dioxide. The predicted pattern has also been confirmed in the ambient monitoring data at 3 community locations.

6.2.3 Shellfish

There is observed variation in metal contaminant concentrations in the flesh of shellfish (body burden analysis). A detailed dietary intake analysis was prepared using 2019 data for nickel from Mair Bank mussels and pipi. This shows that if a consumer of kaimoana harvested these shellfish on an ongoing basis as their exclusive source of dietary fish and shellfish the intake for nickel would potentially exceed typical dietary intakes for Australia/NZ (refer Appendix Three).

6.2.4 Drinking Water (roof collection)

There are no exceedances of the NZ drinking water standards for metals or other contaminants expected from the air discharges.

6.2.5 Coastal contact recreation

There are no exceedances of safety criteria for contact recreation, because of contaminants discharged from the site. The assessment includes treated groundwater, surface water and stormwater.

6.3 Effects from combined exposures

Potential combined effects have not been identified. There is not any contaminant with systematic excess exposure from combined routes, nor assessable contaminants that are recognised for potential effects via combined action.

6.5 Overall characterisation of effects

The assessment of potential for adverse human health effects from the discharges is to characterise overall health effects as less than minor.

7 Mitigations and Monitoring

7.1 Air discharges

The outcomes from the present assessment do not indicate a necessity for sulphur removal technologies. This is primarily because elevated ambient concentrations for sulphur dioxide arise sporadically and this lowers the potential for effects.

Historic ambient monitoring at community locations has provided useful information to confirm the modelling for sulphur dioxide exposures. It will be useful to continue selected community ambient monitoring on a voluntary basis. There is no necessity for ambient monitoring as a consent condition.

Exposure to nickel in ambient air is not important as a source of health effects. There are no mitigations necessary for nickel, nor any specific monitoring of air concentrations.

7.2 Water discharges

There is a variation in metal concentrations in shellfish at locations that are significant for traditional food sources. The Boffa Miskell report found that the refinery is unlikely to be a significant contributor of chromium and nickel. The potential for health effects from the discharges is less than minor and no specific mitigations nor monitoring have been identified in relation to health effects.

8 Conclusions about Health Effects

8.1 Health effects through air

The health effects are less than minor for sulphur dioxide acute exposure.

At most locations, the health effects are less than minor for chronic exposure to sulphur dioxide because exposure is negligible on most days. At elevated locations across the harbour from the site infrequent days have 24-hour concentrations for sulphur dioxide predicted to be higher than other locations. The potential for effects may be minor on occasional days but the overall health effects are less than minor based on the pattern throughout the year.

The health effects are less than minor for inhaled nickel and other metallic contaminants.

The health effects from the discharges are less than minor for particulate matter because the additional exposures from the Refining NZ discharges are very low. The conservative assessment for predicted background (based on urban and transport assessments from elsewhere) gives rise to a prediction of measurable exposures, albeit below the assessment criteria. This assessment notes that $PM_{2.5}$ is a non-threshold toxicant.

The health effects are less than minor for: fugitive emissions of BTEX, dioxins and furans, petroleum hydrocarbons, nitrogen dioxide and carbon monoxide.

8.2 Health effects through kaimoana

The potential for health effects from the discharges are less than minor.

8.3 Health effects through drinking water

The assessed health effects are negligible.

8.4 Health effects through coastal recreation

The assessed health effects are negligible.

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APPENDICES: ONE to FIVE

Appendix One

Table 1 International Sources of background information

International information source	Comment	Resource location
Agency for Toxic Substances and Disease Registry (ATSDR)	An agency of the US Dept of Health and Human Services – takes responsive public health actions and provides health information to prevent harmful exposure and disease related to toxic substances.	www.atsdr.cdc.gov
ACGIH	The American Conference of Governmental Industrial Hygienists is a leading source of scientific guidelines	www.acgih.org
CONTAM	Expert Panel on Food Contaminants - a joint process of FAO and WHO	www.fao.org
EFSA	European Food Safety Authority – funded by the European Union to assess risk throughout the foodchain and provide scientific advice	www.efsa.europa.eu
Food and Agriculture Organisation (FAO)	The UN specialised agency for Agriculture. Joint processes for food safety and standards for food traded for human use are established by FAO and WHO.	www.fao.org
FSANZ	Food Standards Australia and New Zealand, formerly ANZFSA	www.foodstandards.govt.nz
Hazardous Substances Data Bank	HSDB is a comprehensive, scientifically reviewed, factual database with records for more than 4,500 toxic or potentially toxic chemicals	US National Library of Medicine
International Agency for Research on Cancer	IARC, part of the WHO, co-ordinates and conducts research on the causes of human cancer, the mechanisms of carcinogenesis, and develops scientific strategies for cancer control.	www.iarc.fr

International information source	Comment	Resource location
JECFA	Joint Expert Committee on Food Additives - a joint process of FAO and WHO	www.fao.org
MEDLINE	Database of more than 10m references to articles published in 4,300 refereed biomedical journals – maintained by NLM.	MEDLINE online access
NICNAS	Australian National Industrial Chemicals Notification and Assessment Scheme helps protect the Australian People and the environment by assessing the risks of industrial chemicals and providing information to promote their safe use.	Nicnas.gov.au
OEHHA	California Office of Environmental Health Hazard Assessment Our mission is to protect and enhance the health of Californians and our state's environment through scientific evaluations that inform, support and guide regulatory and other actions.	0ehha.ca.gov
REACH	European Programme for Assessment of Chemicals, a regulation of the European Union	Echa.europa.eu
US Environmental Protection Agency (EPA)	Government environment agency of the United States, EPA provides leadership in the nation's environmental science, research, education and assessment efforts and aims to protect human health and safeguard the natural environment.	www.epa.gov
World Health Organisation (WHO)	WHO, a United Nations specialised agency for health, established April 7 1948, includes 192 Member States. It gives worldwide guidance in the field of health; sets global standards; co-operates with governments in strengthening national health programmes; and assists in developing and transferring appropriate health technology, information and standards.	www.who.org

Toxicological and epidemiological information

Assessment as to the likelihood of adverse health effects from environmental exposure relies on both epidemiological and toxicological information. Epidemiological information comes from studies of outcomes or risk factors among groups of people and uses a variety of statistical methods. Toxicological information comes from studies of people, animals, tissues or cells and uses direct experimental methods. These varied types of information need to be used together, and placed in a context of the characteristics of the people exposed to the risk, in order to adequately assess likelihood of effects. The associations that can be determined through epidemiological analysis require concomitant toxicological and medical research to determine biological mechanisms in order to determine likely causation. An associated methodological matter is to identify uncertainties in the key information, as this clarifies the reliability of an assessment.

Acute and chronic health effects and exposure times

Generally, health effects associated with a contaminant can be either or both acute and chronic. Acute effects are those that arise rapidly at the time of exposure, and short-term guidelines are usually determined to prevent exposure amounts that might give rise to acute effects.

Chronic effects are those that develop over time or with a delayed onset, usually after repeated or ongoing exposures. An example of chronic effects is the development of kidney or blood pressure problems from exposure to heavy metals. For some contaminants it is possible for chronic effects to develop at ambient concentrations below those at which acute effects arise, but the averaging period of relevance will be longer. For the assessment of long-term risks, the pattern of daily averages is useful rather than a worst-case day in an annual period. This especially applies to assessment of intakes over time through food.

Appendix Two – Basis for health assessment Air Effects

Exposure to combustion contaminants and health effects

The NES relies on a one-hour average assessment to protect against short-term effects from sulphur dioxide. The original experimental assessments used a briefer exposure period and clearly established that, for some people with asthma, exposure to SO_2 aggravates breathing difficulties (refer Table 1).

Table 1, Appendix 2: Summary of health outcomes from acute exposure to sulfur dioxide*

SO_2 concentration in air, $\mu g/m^3$ [duration of exposure]		*Health risk on inhalation*
≥260µg/m³	[10 minutes]	Some extremely sensitive to SO_2 exposure people with asthma may experience bronchoconstriction during exercise
<650µg/m³	[short term]	No effect of sulfur dioxide is seen on the airways of sensitive individuals in the general population who take exercise [IARC, 1992]
700µg/m³	[5 -10 minutes]	People with asthma may experience bronchospasms during exercise as an immediate response without delayed or prolonged effects beyond 4 hours
>700µg/m³	[short term]	People with asthma may experience increased frequency or duration of attacks, depending on amount of exposure
700 - 1,400µg/m³	[short term]	People with asthma may develop symptoms and a decrease in lung function
790 - 2,600µg/m³		Concentrations of SO_2 that could possibly be detected by taste or smell
2,6200µg/m³	[1 to 6 hours]	Constriction of upper airways in young, healthy (20-28 years of age) adult males
<2,600µg/m³	[short term]	No effects have been reported for healthy adults
2,600µg/m³	[40 minutes]	A slight increase in subjective, mild, upper respiratory symptoms, such as sore throat and ability to taste and smell sulfur dioxide with no effects on lung function parameters, have been reported in healthy adults
2,800µg/m³	[short term]	Older adults at increased risk of respiratory disease. Some people may experience worsening of chronic bronchitis

* Information was generated from ATSDR, 1998a; Patty's Industrial Hygiene and Toxicology: Chapter by Bingham et al, 2001; American Conference of Governmental Industrial Hygienist, Inc, 1991; IARC, 1992

Note that this historically published toxicological information for acute exposure to sulphur dioxide has not been replaced and remains a current reference.

From a public health perspective, since 2005 a very large body of literature has been published about health effects associated with exposure to contaminants in air. Of importance are consensus expert reviews (including the American Cardiology Association) and significant multicentre epidemiological studies. It is clear that compromised air quality harms health and causes premature death. Since the WHO global update air guidelines (2006), research attention has focussed on clarifying the relationship among contaminant exposures and adverse outcomes. Exposure to traffic and urban combustion products is associated with adverse cardiovascular outcomes; lung cancers; respiratory disease including loss of lung function in adults and reduced lung development in childhood; haemorrhagic stroke; possibly other chronic and inflammatory diseases and probably reproductive harm. It is now established that ultrafine constituents in diesel exhaust are a source of harm. Note that $PM_{2.5}$ and ultrafine particles can penetrate lung tissue and soluble contaminants can undergo gas exchange in the lung and enter the bloodstream.

Given the significance of air quality to health it is important to evaluate details of the exposure patterns associated with discharges.

Exposure to inhaled nickel and health effects

Table 2, Appendix 2: Distribution of ambient nickel concentrations (8 hour rolling average)

ID	1	2	3	4	5	6
Name	Whangarei airport	Manganese Point	The Nook	McLeod Bay	Reotahi	Mt Aubrey
Maximum	0.009	0.021	0.015	0.032	0.072	0.055
99th percentile	0.007	0.014	0.010	0.023	0.040	0.046
90th Percentile	0.001	0.002	0.000	0.000	0.000	0.001
Average	0.000	0.001	0.000	0.001	0.001	0.002
UTM_X(km)	1723.300	1728.803	1732.804	1735.888	1735.312	1735.811
UTM_Y(km)	6040.700	6038.714	6038.024	6035.648	6034.432	6034.533
>0.08 - 0.1 µg/m³	0.00%	0.00%	0.00%	0.00%	**0.11%**	0.01%
>0.06 - 0.08 µg/m³	0.00%	0.00%	0.00%	0.00%	**0.35%**	**0.25%**
>0.055 - 0.06 µg/m³	0.00%	0.00%	0.00%	0.00%	**0.10%**	**0.10%**
>0.05 - 0.055 µg/m³	0.00%	0.00%	0.00%	0.00%	0.09%	0.17%
>0.045 - 0.05 µg/m³	0.00%	0.00%	0.00%	0.00%	0.23%	0.19%
>0.04 - 0.045 µg/m³	0.00%	0.00%	0.01%	0.03%	0.21%	0.29%
>0.035 - 0.04 µg/m³	0.00%	0.00%	0.02%	0.06%	0.29%	0.23%
>0.03 - 0.035 µg/m³	0.00%	0.00%	0.01%	0.20%	0.39%	0.45%
>0.025 - 0.03 µg/m³	0.00%	0.00%	0.03%	0.34%	0.35%	0.50%
>0.02 - 0.025 µg/m³	0.00%	0.01%	0.03%	0.40%	0.42%	0.71%
>0.015 - 0.02 µg/m³	0.05%	0.14%	0.21%	0.58%	0.43%	0.80%
>0.01 - 0.015 µg/m³	0.11%	0.28%	0.36%	0.92%	0.72%	0.96%
>0.005 - 0.01 µg/m³	0.85%	1.21%	0.89%	1.55%	0.95%	1.49%
>0.004 - 0.005 µg/m³	0.51%	0.59%	0.37%	0.46%	0.50%	0.45%
>0.003 - 0.004 µg/m³	0.69%	0.59%	0.54%	0.68%	0.51%	0.57%
>0.002 - 0.003 µg/m³	0.98%	0.89%	0.65%	0.76%	0.90%	0.74%
>0.001 - 0.002 µg/m³	1.58%	1.42%	1.10%	1.33%	1.30%	1.31%
>0 - 0.001 µg/m³	10.20%	9.77%	10.30%	11.64%	11.36%	11.35%
0 µg/m³	85.03%	85.10%	85.49%	81.04%	80.75%	79.44%
Check	100.00%	100.00%	100.00%	100.00%	99.95%	100.00%

ID	7	8	9	10	11	12
Name	Mt Manaia	Taurikura Bay	Urqhuarts Bay	Moint Lion	Te Whara	Mata Hall
Maximum	0.042	0.022	0.025	0.012	0.006	0.008
99th percentile	0.031	0.012	0.013	0.008	0.004	0.005
90th Percentile	0.006	0.001	0.000	0.000	0.000	0.001
Average	0.002	0.001	0.000	0.000	0.000	0.000
UTM_X(km)	1737.109	1738.112	1738.732	1739.518	1742.518	1724.323
UTM_Y(km)	6035.236	6034.039	6032.569	6031.343	6031.050	6031.206
>0.08 - 0.1 µg/m³	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%
>0.06 - 0.08 µg/m³	0.04%	**0.27%**	**0.03%**	0.00%	0.00%	0.00%
>0.055 - 0.06 µg/m³	**0.07%**	**0.09%**	**0.06%**	0.00%	0.00%	0.00%
>0.05 - 0.055 µg/m³	0.06%	0.19%	0.02%	0.00%	0.00%	0.00%
>0.045 - 0.05 µg/m³	0.15%	0.26%	0.12%	0.00%	0.00%	0.00%
>0.04 - 0.045 µg/m³	0.19%	0.30%	0.13%	0.03%	0.00%	0.00%
>0.035 - 0.04 µg/m³	0.33%	0.43%	0.19%	0.10%	0.00%	0.00%
>0.03 - 0.035 µg/m³	0.47%	0.48%	0.31%	0.21%	0.03%	0.00%
>0.025 - 0.03 µg/m³	0.79%	0.50%	0.42%	0.23%	0.07%	0.00%
>0.02 - 0.025 µg/m³	0.88%	1.01%	0.64%	0.36%	0.20%	0.00%
>0.015 - 0.02 µg/m³	1.41%	0.79%	0.87%	0.92%	0.38%	0.00%
>0.01 - 0.015 µg/m³	2.07%	1.36%	1.28%	1.53%	0.72%	0.36%
>0.005 - 0.01 µg/m³	3.45%	1.95%	1.89%	3.29%	2.92%	2.20%
>0.004 - 0.005 µg/m³	0.66%	0.66%	0.46%	1.06%	1.39%	0.90%
>0.003 - 0.004 µg/m³	0.63%	0.66%	0.54%	1.23%	1.51%	1.18%
>0.002 - 0.003 µg/m³	0.96%	1.04%	0.74%	1.19%	1.70%	1.72%
>0.001 - 0.002 µg/m³	1.36%	1.41%	1.28%	1.56%	2.17%	1.76%
>0 - 0.001 µg/m³	8.60%	14.91%	13.69%	9.15%	9.56%	11.47%
0 µg/m³	77.88%	73.65%	77.33%	79.16%	79.34%	80.40%
Check	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

ID	13	14	15	16	17	18
Name	Takahiwai Dam	Marsden Bay	Jetty	Ruakaka	Ruakaka School	Ruakaka South
Maximum	0.010	0.039	0.023	0.031	0.037	0.016
99th percentile	0.007	0.036	0.018	0.019	0.024	0.011
90th Percentile	0.001	0.017	0.004	0.006	0.008	0.002
Average	0.000	0.004	0.001	0.002	0.002	0.001
UTM_X(km)	1727.820	1732.315	1735.373	1732.128	1731.427	1731.335
UTM_Y(km)	6032.014	6033.525	6033.153	6028.226	6028.824	6025.225
>0.08 - 0.1 µg/m³	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
>0.06 - 0.08 µg/m³	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
>0.055 - 0.06 µg/m³	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
>0.05 - 0.055 µg/m³	0.00%	0.02%	0.01%	0.00%	0.00%	0.00%
>0.045 - 0.05 µg/m³	0.00%	0.02%	0.01%	0.00%	0.00%	0.00%
>0.04 - 0.045 µg/m³	0.00%	0.05%	0.03%	0.00%	0.00%	0.00%
>0.035 - 0.04 µg/m³	0.00%	0.15%	0.04%	0.02%	0.01%	0.00%
>0.03 - 0.035 µg/m³	0.00%	0.26%	0.07%	0.07%	0.03%	0.00%
>0.025 - 0.03 µg/m³	0.01%	0.43%	0.07%	0.14%	0.10%	0.01%
>0.02 - 0.025 µg/m³	0.23%	0.83%	0.18%	0.33%	0.54%	0.06%
>0.015 - 0.02 µg/m³	0.48%	1.05%	0.40%	0.73%	1.11%	0.13%
>0.01 - 0.015 µg/m³	1.25%	1.71%	0.79%	1.52%	1.44%	0.58%
>0.005 - 0.01 µg/m³	3.01%	2.04%	1.68%	2.08%	2.39%	2.02%
>0.004 - 0.005 µg/m³	0.77%	0.49%	0.82%	0.70%	0.73%	0.63%
>0.003 - 0.004 µg/m³	1.20%	0.70%	0.85%	0.79%	0.74%	0.87%
>0.002 - 0.003 µg/m³	1.18%	0.84%	1.38%	0.81%	0.62%	0.95%
>0.001 - 0.002 µg/m³	1.66%	1.42%	2.29%	1.70%	1.65%	1.54%
>0 - 0.001 µg/m³	11.30%	11.60%	23.80%	8.90%	9.15%	9.36%
0 µg/m³	78.92%	78.38%	67.57%	82.21%	81.49%	83.84%
Check	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

ID	19	20	21	22	23	24
Name	Kukunui	One Tree Point	Marsden Centre	Little Munro Bay	Whangarie Heads School	Urquarts Monitor
Maximum	0.011	0.040	0.027	0.066	0.063	0.016
99th percentile	0.009	0.034	0.022	0.034	0.052	0.011
90th Percentile	0.003	0.014	0.006	0.007	0.004	0.000
Average	0.001	0.003	0.002	0.002	0.003	0.000
UTM_X(km)	1725.236	1731.581	1731.214	1736.214	1736.944	1739.302
UTM_Y(km)	6025.810	6034.079	6030.611	6034.260	6034.570	6032.217
>0.08 - 0.1 µg/m³	0.00%	0.00%	0.00%	0.03%	0.00%	**0.03%**
>0.06 - 0.08 µg/m³	0.00%	0.00%	0.00%	**0.23%**	0.09%	**0.10%**
>0.055 - 0.06 µg/m³	0.00%	0.00%	0.00%	**0.06%**	**0.08%**	**0.06%**
>0.05 - 0.055 µg/m³	0.00%	0.01%	0.00%	0.22%	0.16%	0.10%
>0.045 - 0.05 µg/m³	0.00%	0.01%	0.00%	0.23%	0.18%	0.13%
>0.04 - 0.045 µg/m³	0.01%	0.05%	0.00%	0.22%	0.23%	0.18%
>0.035 - 0.04 µg/m³	0.02%	0.11%	0.06%	0.29%	0.36%	0.21%
>0.03 - 0.035 µg/m³	0.05%	0.18%	0.09%	0.36%	0.37%	0.23%
>0.025 - 0.03 µg/m³	0.07%	0.37%	0.43%	0.50%	0.56%	0.42%
>0.02 - 0.025 µg/m³	0.09%	0.58%	0.88%	0.66%	0.67%	0.59%
>0.015 - 0.02 µg/m³	0.22%	0.88%	1.29%	0.87%	0.97%	0.88%
>0.01 - 0.015 µg/m³	0.46%	1.39%	1.66%	1.05%	1.24%	1.16%
>0.005 - 0.01 µg/m³	1.43%	2.19%	2.41%	1.71%	1.75%	1.62%
>0.004 - 0.005 µg/m³	0.66%	0.62%	0.49%	0.37%	0.53%	0.58%
>0.003 - 0.004 µg/m³	0.93%	0.62%	0.78%	0.48%	0.65%	0.58%
>0.002 - 0.003 µg/m³	1.29%	0.83%	0.83%	0.74%	1.13%	0.89%
>0.001 - 0.002 µg/m³	1.76%	1.19%	1.82%	1.23%	1.58%	1.13%
>0 - 0.001 µg/m³	9.50%	10.66%	11.58%	12.47%	13.11%	13.25%
0 µg/m³	83.52%	80.33%	77.68%	78.27%	76.35%	77.83%
Check	100.00%	100.00%	100.00%	100.00%	100.00%	99.99%

ID	25	26	27	28	29
Name	Mt Aubrey	Ody Road	Castle Rock	Home Point	Ocean Road
Maximum	0.054	0.024	0.074	0.011	0.038
99th percentile	0.038	0.020	0.052	0.007	0.020
90th Percentile	0.001	0.001	0.005	0.000	0.000
Average	0.001	0.001	0.003	0.000	0.001
UTM_X(km)	1735.610	1737.994	1736.523	1737.889	1738.641
UTM_Y(km)	6034.762	6034.487	6034.196	6031.521	6032.927
>0.08 - 0.1 µg/m³	0.00%	0.01%	0.05%	0.00%	**0.01%**
>0.06 - 0.08 µg/m³	**0.11%**	**0.11%**	**0.23%**	**0.02%**	**0.10%**
>0.055 - 0.06 µg/m³	**0.17%**	**0.05%**	**0.13%**	**0.00%**	**0.08%**
>0.05 - 0.055 µg/m³	0.17%	0.07%	0.16%	0.03%	0.14%
>0.045 - 0.05 µg/m³	0.18%	0.15%	0.13%	0.02%	0.19%
>0.04 - 0.045 µg/m³	0.19%	0.24%	0.20%	0.03%	0.15%
>0.035 - 0.04 µg/m³	0.31%	0.36%	0.27%	0.13%	0.37%
>0.03 - 0.035 µg/m³	0.24%	0.37%	0.37%	0.13%	0.29%
>0.025 - 0.03 µg/m³	0.38%	0.61%	0.43%	0.21%	0.49%
>0.02 - 0.025 µg/m³	0.68%	0.78%	0.63%	0.22%	0.79%
>0.015 - 0.02 µg/m³	0.49%	0.97%	0.70%	0.32%	0.84%
>0.01 - 0.015 µg/m³	0.83%	1.35%	1.06%	0.70%	1.43%
>0.005 - 0.01 µg/m³	1.65%	1.96%	1.68%	1.58%	1.70%
>0.004 - 0.005 µg/m³	0.34%	0.61%	0.55%	0.71%	0.44%
>0.003 - 0.004 µg/m³	0.66%	0.71%	0.62%	0.55%	0.80%
>0.002 - 0.003 µg/m³	0.76%	0.98%	0.84%	1.03%	0.83%
>0.001 - 0.002 µg/m³	1.14%	1.62%	1.56%	1.27%	1.30%
>0 - 0.001 µg/m³	11.27%	15.23%	13.72%	13.83%	14.20%
0 µg/m³	80.43%	73.84%	76.67%	79.22%	75.83%
Check	100.00%	100.00%	100.00%	100.00%	99.98%

Appendix Three – Basis for health assessment Kaimoana Effects

New Zealand and Australia use a combined approach to food standards, and use guidance from the WHO/FAO expert panels. Food Standards Australia and New Zealand (FSANZ) sets regulated standards, healthful diet guidelines and publishes information about typical dietary intakes. The Ministry of Primary Industries also administers regulations for food and is responsible for placing warnings about shellfish gathering under adverse conditions.

Dietary exposure to trace elements is assessed for public health purposes using the context of a standardised diet pattern. Regulatory standards and/or health-based guidance are available, according to the specific trace element under consideration.

Mair Bank mussels and pipi (2019) effects from nickel

The documents selected for relevant use in this asessment include:

- NHMRC (2006) Nutrient Reference Values for Australia and New Zealand, including recommended dietary intakes. Includes trace nutrients.[20]
- The 22nd Australian Total Diet Study (ATDS), Appendix 9 (2008) Estimated population based age-gender intakes for nickel.[21]
- The 2009 New Zealand Total Diet Study (MPI, 2011) provides simulated diet parameters. The NZTDS systematically samples representative foods for sale and analyses for constituents present in a typical diet.[22]
- Food consumption information was based on 14-day simulated diets to match the 2009 NZTDS. [23]
- Estimated intake for NZ High consumers of fish/shellfish, including traditional wild harvesting, used for Environment Court evidence for the Rena consenting. (Joint Witness Statement, May 2015).

Note that the 2009 NZTDS has been used for guidance for fish and shellfish consumption, rather than the more recent 2016 NZTDS. This is because the 2009 Study (but not the 2016) specifically included a representation of mollusc consumption (oysters) as well as types of fish.

For the purposes of this assessment it is assumed that the sample is also

[20] Updated since 2006 for some nutrients, but not chromium or nickel
[21] Includes nickel. Includes fish fillets and canned tuna but not shellfish, any age groups. Used dietary patterns from the Australian 1995 National Nutrition Survey.
[22] Includes nickel and chromium. Includes oysters as well as fish fillets/canned tuna. The (latest) 2016 New Zealand Total Diet Study did not include nickel or chromium in food.
[23] The 2008/9 NZ Adult National Nutrition Survey was not available in time for the 2009 NZTDS. The most recent NZ Children's Nutrition Survey was conducted in 2002 (MOH 2003)

representative of additional collections of pipi and mussels from the same source sample and that consumption is ongoing over at least weeks if not longer. This is conservative, as the concentrations of nickel in shellfish at other sampling locations are lower than the concentrations used in these calculations.[24]

The current FSANZ documentation includes nickel with an assessed presence in food referred to in mg/day, as an average intake over long periods (months/year). Their estimated daily dietary intakes for nickel (95th percentile) are presented below for age and gender groups. They note that generally most nickel exposure is from food rather than amounts in water or inhaled.

An international expert panel (EFSA)[25] has assessed dietary nickel and derived a TDI of 2.8 μgNi/kg bw per day. This was based on chronic exposure and developmental risk. They concluded that exposure to dietary amounts close to or higher than the TDI was frequent, especially among children. They also found that current intake could be a risk for dermatitis among people with nickel allergy.

Table1, Appendix 3: Male Nickel intake in μg/day from a Mair's bank shellfish meal compared to Middle Bound Intake in μg/day for Nickel (ATDS 2008)

Age	Male MBI (95th percentile) μg/day	Male Mair pipi μg/day	Male Mair mussels μg/day	Male Mair pipi HIGH μg/day	Male Mair mussels HIGH μg/day
2-3 years	170	23.2	36	92.8	144
4-8 years	168	34.8	54	139.2	216
9-13 years	192	58	90	232	360
14-18 years	211				
19-24 years	228	81.2	126	324.8	504
30-49 years	254	87	135	348	540
50-69 years	247	87	135	348	540
70+ years	259				

Nickel (mean estimate)
Mair Mussels (reported Nov 19) approx. 4.5 mg/kg
Mair Pipi (reported Nov 19) approx. 2.9 mg/kg

[24] Boffa Miskell (2019) Marine Ecological Assessment Report Appendix 4: Oyster body burden graphs.

25 EFSA Panel on contaminants in the food chain (2015). Scientific Opinion on the risks to public health related to the presence of nickel in food and drinking water. EFSA Journal 2015; 13(2):4002.

Table 2, Appendix 3: Female Nickel intake in μg/day from a Mair's bank shellfish meal compared to Middle Bound Intake in μg/day for Nickel (ATDS 2008)

Age	Female MBI (95th percentile) μg/day	Female Mair Pipi μg/day	Female Mair mussels μg/day	Female Mair pipi HIGH μg/day	Female Mair mussels HIGH μg/day
2-3 years	114	23.2	36	92.8	144
4-8 years	128	34.8	54	139.2	216
9-13 years	130	31.9	49.5	127.6	198
14-18 years	175				
19-29 years	174	58	90	232	360
30-49 years	190	58	90	232	360
50-69 years	194	58	90	232	360

Nickel (mean estimate)
Mair Mussels (reported Nov 19) approx. 4.5 mg/kg
Mair Pipi (reported Nov 19) approx. 2.9 mg/kg

The additional nickel consumed from other parts of the meal such as vegetables are not estimated. For fish/shellfish consumption the estimation uses daily meal content averaging based on the NZTDS (2009).

Conclusions :

For nickel, average female consumers have a meal intake from kaimoana within the average range. The intake for females who consume four times average NZ intake for fish, and source all that fish only from mussels or pipi, potentially have elevated nickel intake if the shellfish are consumed repeatedly in those high amounts over time.

For nickel, average male consumers have a meal intake from kaimoana within the average range. The intake for males who consume four times average NZ intake for fish, and source all that fish only from mussels or pipi, potentially have elevated nickel intake if the shellfish are consumed repeatedly in those high amounts over time.

Appendix Four – Basis for health assessment Drinking Water Effects

Appendix Four includes the following detailed information:

Table 1: The roof water exposure assessment by Tonkin and Taylor[26] for nickel, vanadium, arsenic, barium, cadmium, chromium, copper, lead, mercury, molybdenum. This is for the highest impact near-site receptor from the air modelling and will overestimate most of the residential areas.

Note that only nickel and vanadium had emissions concentrations above the limit of detection (LOD). All other metal analyses are estimated using an assumption that they are present at half the value of the LOD.

Exposures are very low compared to NZ Drinking Water Standards (2018)

Table 1 Appendix 4: Estimated roof water concentrations

Metal Concentration in tank water	**Unit**	**Nickel**	**Vanadium**
Max off-site deposition rate	µg/m²/s	**1.07E-04**	**7.50E-05**
Annual rate	g/m²/yr	0.003362368	0.0023652
Accumulation on roof (no losses)	g/year	0.72189	0.508518
Concentration in water	g/m3	0.0023	0.0016
Concentration in water	g/L	0.00000228	0.00000161
Concentration in water	**mg/L**	**0.0023**	**N/A**
NZ Drinking water standard	mg/L	0.08	N/A
Percentage of standard	%	2.9%	N/A

[26] Tonkin and Taylor. Email communication 16 December 2019 and updated data for Ni March 2020.

		Emissions data based on 1/2 LOD value			
		<LOD	<LOD	<LOD	<LOD
Metal Concentration in tank water	**Unit**	**Arsenic**	**Barium**	**Cadmium**	**Chromium**
Max off-site deposition rate	µg/m²/s	**5.00E-07**	**5.00E-07**	**5.00E-07**	**5.00E-07**
Annual rate	g/m²/yr	1.5768E-05	1.5768E-05	1.5768E-05	1.5768E-05
Accumulation on roof (no losses)	g/year	0.00339012	0.00339012	0.00339012	0.00339012
Concentration in water	g/m3	0.00001	0.00001	0.00001	0.00001
Concentration in water	g/L	0.00000001	0.00000001	0.00000001	0.00000001
Concentration in water	**mg/L**	**0.00001**	**0.00001**	**0.00001**	**0.00001**
NZ Drinking water standard	mg/L	0.01	0.1	0.004	0.05
Percentage of standard	%	0.11%	0.01%	0.27%	0.02%

		Emissions data based on 1/2 LOD value			
		<LOD	<LOD	<LOD	<LOD
Metal Concentration in tank water	**Unit**	**Copper**	**Lead**	**Mercury**	**Molybdenum**
Max off-site deposition rate	µg/m²/s	**5.00E-07**	**5.00E-07**	**5.00E-07**	**5.00E-07**
Annual rate	g/m²/yr	1.5768E-05	1.5768E-05	1.5768E-05	1.5768E-05
Accumulation on roof (no losses)	g/year	0.00339012	0.00339012	0.00339012	0.00339012
Concentration in water	g/m3	0.00001	0.00001	0.00001	0.00001
Concentration in water	g/L	0.00000001	0.00000001	0.00000001	0.00000001
Concentration in water	**mg/L**	**0.00001**	**0.00001**	**0.00001**	**0.00001**
NZ Drinking water standard	mg/L	2	0.01	0.007	0.07
Percentage of standard	%	0.00%	0.11%	0.15%	0.02%

Appendix Five – Basis for health assessment contact recreation effects

The following summary information comes from a data spreadsheet provided by the Northland Regional Council (NRC)[27]:

- Location Whangarei Harbour at One Tree Point
- Monthly measurements 20/07/2017 – 4/07/2019
- Bimonthly measurements 16/01/2014 – 20/07/2017
- Enterococci below detection on all occasions except
  - 22/09/2016 – 20 MPN/100ml
  - 27/06/2018 -10 MPN/100ml
- Faecal coliforms below detection on all occasions except:
  - 22/05/2014 – 60 CFU/100ml
  - 22/09/2016 – 40 CFU/100ml
  - 20/09/2018 – 17 CFU/100ml

The Ministry for the Environment (MfE) publishes microbiological water quality guidelines for marine recreational areas.[28] The NRC monitoring data has not been collected for direct comparison purposes with the guidelines. However the guideline values are presented here for information.

The recreational shellfish gathering guideline refers to faecal coliforms and states that:

- The median faecal coliform content of samples taken over a shellfish gathering season shall not exceed a Most Probable Number (MPN) of 14 CFU/100 ml
- And not more than 10% samples exceed MPN 43/100ml

The contact recreation guideline for bathing uses enterococci, as an indicator for risk from pathogens. The highest grade assessment category refers to enterococci below 40/100ml, but also includes a sanitary inspection.

[27] Northland Regional Council. Monitoring Data. Email 20 August 2019.
[28] www.mfe.govt.nz