TE TAI ŌHANGA
THE TREASURY

Reference: 20210058

15 March 2021

[redacted]

On 15 February 2021, the Ministry for the Environment transferred the following part of your request to the Treasury:

> *"…the latest comprehensive report MFE has (generated from whatever source) on on [sic] either of the above (waste/cleanup)."*

Please find enclosed the following document:

Item	Date	Document Description	Decision
1.	30 October 2020	Project 14 - Identification and Evaluation of Remediation Options	Release in part

I have decided to release the document listed above, subject to information being withheld under one or more of the following sections of the Official Information Act, as applicable:

- personal details, under section 9(2)(a) – to protect the privacy of natural persons, including that of deceased natural persons
- confidential information, under section 9(2)(ba)(i) – to protect information which is subject to an obligation of confidence or which any person has been or could be compelled to provide under the authority of any enactment, where the making available of the information would be likely to prejudice the supply of similar information, or information from the same source, and it is in the public interest that such information should continue to be supplied
- legally privileged information, under section 9(2)(h) – to maintain legal professional privilege
- information to carry on negotiations, under section 9(2)(j) – to carry on negotiations without prejudice or disadvantage

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In making my decision, I have considered the public interest considerations in section 9(1) of the Official Information Act.

Please note that this letter (with your personal details removed) and enclosed documents may be published on the Treasury website.

This reply addresses the information you requested. You have the right to ask the Ombudsman to investigate and review my decision.

Yours sincerely

Jean Le Roux
Manager, Transitions, Regions, and Economic Development

20210058
Information for Release

Project 14

Identification and Evaluation of Remediation Options (Commercial in Confidence)

The Treasury

Reference: 510555

Revision: 0

2020-10-30

aurecon

Bringing ideas to life

Document control record

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Executive Summary

Background

Aurecon has been engaged by Te Tai Ōhanga The Treasury to identify and evaluate remedial options at Rio Tinto's Tiwai Point Aluminium Smelter located at 1427, 1429 and 1530 Tiwai Road, Tiwai Point, Southland ("the Site").

The purpose of the exercise reported here, which represents Aurecon's Phase 2 deliverable to The Treasury, is to:

- Identify available information and strategically assess it to obtain information on the status of the Site
- s9(2)(j) [redacted]
- Provide advice on the state of the Site (e.g. levels of contaminants)
- s9(2)(j) [redacted]
- [redacted]
- Advise on risks to human health and the environment associated with the Site prior to remediation
- s9(2)(j) [redacted]

Treasury has further clarified:

- To the extent practicable, the Phase 2 advice is to describe the risks to human health and the environment posed by each of the elements of the Site for remediation (e.g. the RZAs in the Phase 1B advice).
- The Phase Two advice is to provide an assessment of the risks to human health and the environment that would eventuate for each of the remediation options, to enable assessment of the merits of remediation options relative to costs.

This report builds upon previous advice issued by Aurecon to The Treasury in a series of memos and letters, and all advice should be read together.

Summary of environmental setting

The Site, as well as the conservation area to the east is considered topographically relatively flat, with gently sloping ridges towards Tiwai Point to the south-west. The Site is expected to be underlain by unconsolidated material consisting of sand deposits and gravel along the ridges. There are no permanent water bodies on Site however the Tiwai Peninsula is surrounded by three significant coastal water bodies:

- Foveaux Strait (south);
- Bluff Harbour tidal flats (west); and
- Awarua Bay (north).

Of significance, there is a Ngāi Tahu Statutory Acknowledgement for Rakiura/Te Ara a Kiwa (Rakiura/Foveaux Strait Coastal Marine Area)[1].

The nearest identified ecological receptors from the smelter are:

- Department of Conservation land to the east/adjacent to the site;

[1] http://www.legislation.govt.nz/act/public/1998/0097/7.0/DLM431354.html

- Coastal habitats and vegetation including scrub/forest, estuarine shrub, grassland and duneland immediately surrounding the site and noted areas of significant indigenous biodiversity; and
- Archaeological sites (middens) located approximately along the western coastline.

Strong westerly winds can be expected around Tiwai Peninsula, which will influence deposition and dispersion of emissions from the Site.

Erosion and climate change studies have identified that the landfill and SCL pad may be vulnerable given their proximity to the coastline.

There is a potential tsunami threat from the central westerly coastline which will be a risk to the Site facility and infrastructure.

The groundwater is expected to flow towards the Harbour and Foveaux Strait. A review of readily available data indicates that the groundwater depth can range between 1.83 m and 7 m bgl and the groundwater beneath the Site is considered ‘sensitive’ using the MfE 2011b definition.

Summary of site conditions including current risks

The Site contains infrastructure typical of aluminium smelter sites including a wharf for the unloading of alumina, alumina storage, pot lines, carbon bake, coke store, cast houses, SCL stores, workshops, a fire station, electrical switch gear and at least one landfill. The landfill is unlined and is situated in an environmentally vulnerable location close to the coastline. The most notable environmental incidents that Aurecon is aware of includes an 800,000 litre diesel leak in the industrial precinct area, and a contaminated discharge to ground from SCL storage close to the current SCL pad.

Potential compliance breaches

s9(2)(j) [redacted] s9(2)(h) [redacted]

s9(2)(j) [redacted]

2 Note that the Health and Safety at Work (Hazardous Substances) Regulations 2017 apply to hazardous wastes, including those that may be in the landfill, although the HSNO Act 1996 does not.

s9(2)(j)

s9(2)(j)

s9(2)(j)

s9(2)(j)

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1 Introduction

1.1 Background

Te Tai Ōhanga The Treasury (the client) engaged Aurecon to undertake a Preliminary Site Investigation (PSI) at the New Zealand Aluminium Smelter (NZAS), also known as the Tiwai Point Aluminium Smelter (the 'Site') located at 1427, 1429 and 1530 Tiwai Road, Tiwai Point, Southland 9877. The Site location is shown in and Drawing 510555-0000-DRG-REP-0004-A, Appendix 1.

Aurecon has been requested to provide environmental advice to The Treasury. s9(2)(j) [redacted] This represents part of the deliverables associated with 'Phase 2' of the environmental advice sought by The Treasury.

[redacted]

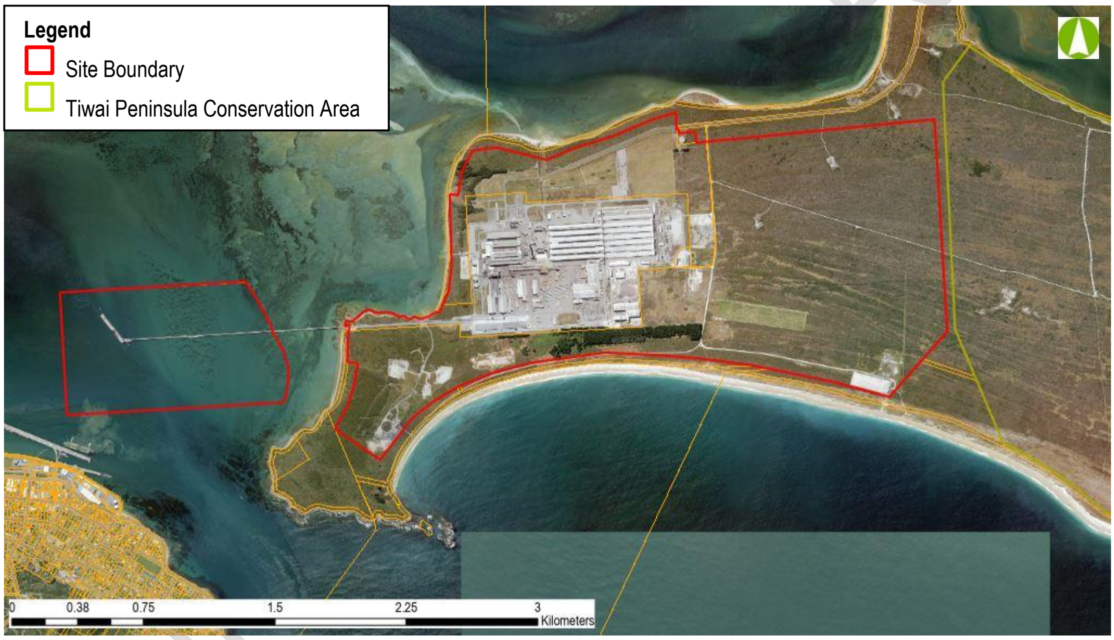

Figure 1 Site Location. Source: LINZ Data Services.

1.2 Objectives

The objectives of the contamination assessment are to:

- Identify all current and historical activities that have involved the delivery, storage, use and disposal of hazardous substances at and beyond the Site (excluding the issue of storage of ouvea premix at Mataura);
- Define the Site conditions such that all receptors of contamination can be identified; and

s9(2)(j) [redacted]

1.3 Scope

The following scope of works was provided by The Treasury:

a) Identify the quantity of available information and strategically assess it to obtain information on the status of the Site

s9(2)(j)

c) Provide advice on the state of the Site (e.g. levels of contaminants)

s9(2)(j)

f) Advice on risks to human health and the environment associated with the Site prior to remediation

s9(2)(j)

Treasury has further clarified:

h) To the extent practicable, the Phase 2 advice is to describe the risks to human health and the environment posed by each of the elements of the Site for remediation (e.g. the RZAs in the Phase 1B advice).

s9(2)(j)

Aurecon has sought to address the above through:

- A description of the Site setting;
- Identification of all activities associated with the aluminium smelter that could lead to contamination of land and water; and
- Identification of remedial options for consideration, including risks.

1.4 Explanatory Statement

1.4.1 Review scope and use

Aurecon has prepared this report for The Treasury, exclusively for its use. It has been prepared in accordance with our scope of services and the instructions given by or on behalf of The Treasury. Data or opinions contained within the report may not be used in other contexts or for any other purposes without Aurecon's prior review and agreement.

Aurecon accepts no responsibility or liability to any third party for the use of, or reliance on, the report by any third party and the use of, or reliance on, the report by any third party is at the risk of that party.

1.4.2 Project Specific Limitations

This report is based entirely upon information provided to Aurecon and publicly available information. No Site visit has been conducted. The limited time available to conduct our assessment makes the conclusions and advice provided in this report necessarily high level. Assumptions, experience or the conclusions of others have been collectively used as the basis of much of the advice provided in this report.

This report has excluded consideration of the ouvea premix waste stored at a disuse paper mill in at Mataura or any other sites owned or used by NZAS.

1.4.3 Limits on Investigation and Information

Soil and rock formations are often variable, and this along with use, storage or disposal of hazardous substances on a Site can result in heterogeneous distribution of contaminants. Contaminant concentrations may be evaluated at chosen sample locations - however, conditions between sample Sites can only be inferred based on geological and hydrological conditions and the nature and the extent of identified contamination. Boundaries between zones of contamination are often indistinct, and therefore interpretation is based on available information and the application of professional judgement.

Only a finite amount of information has been collected to meet the specific technical requirements and timeframe restrictions associated with The Treasury's brief and this report does not purport to completely describe all the Site's characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

This report does not provide a complete assessment of the environmental status of the Site, and it is limited to the scope defined herein. Should further information become available regarding the conditions at the Site, including previously unknown likely sources of contamination, Aurecon reserves the right to review the report in the context of the additional information.

This report has been prepared for The Treasury for its own use and is based on information provided. Aurecon takes no responsibility and disclaims all liability whatsoever for any loss or damage that The Treasury may suffer as a result of using or relying on any such information or recommendations contained in this report, except to the extent Aurecon expressly indicates in this report that it has verified the information to its satisfaction. This report is not to be reproduced either wholly or in part without our prior written permission.

2 Site Description

2.1 Study Area Location

The Tiwai Point Aluminium Smelter is positioned along the southern boundary of the Tiwai Peninsula in Southland, New Zealand. The Site and the adjacent Tiwai Peninsula Conservation Area are located north of Foveaux Strait, east of Bluff Harbour, south of Awarua Bay, and west of Waituna Wetlands Scientific Reserve. The Site is approximately 20 km south of Invercargill and approximately 3.5 km north east of Bluff.

Site identification details are presented in Table 1.

Table 1 Site Identification and Surroundings

	The Site	Conservation Area (Adjacent Site)
Site Name	Tiwai Point Aluminium Smelter	Tiwai Peninsula Conservation Area
Site Location	1427, 1429 and 1530 Tiwai Road, Tiwai Point, Southland	
Legal Descriptions and Title	▪ Lot 1 DP 13987 (SL11B/267), ▪ Lot 1 DP 13988 (SL11B/268), ▪ Section 9 Block XIII Campbelltown HUN (SL3A/93), ▪ Section 6 Block XIII Campbelltown HUN (no title - wharf line which occupies a coastal marine area)	Section 1 Block XIV Campbelltown HUN (SL9C/865)
Site Area	491.271 ha	1757.3104 ha
Site Coordinates	168.38416486, -46.58881095 (New Zealand Geodetic Datum 2000)	
Site Zoning (according to the Invercargill District Plan)	Special Purpose Smelter Zone	Rural
Current Site Use	Aluminium smelter complex and land used for associated smelter activities and landfill Sites.	Conservation Land

2.2 Site Layout

A Site layout plan showing the latest aerial imagery sourced from LINZ Data Services is presented in Drawing 510555-0000-DRG-REP-0004-A, Appendix 1.

Key features of the Site, which have been noted from Google Streetview (accessed on *12 October 2020*) are summarised below:

- The Site can be accessed at 1427 Tiwai Road, north of the industrial precinct (Lot 1 DP 13988);
- A small parcel of land exists immediately south of the 1427 Tiwai Road access point and comprises a silo and large office or storage building (Section 9 Block XIII Campbelltown HUN);
- The smelter is situated within the western portion of the Site boundary and comprises mostly of buildings and storage areas of approximately 92 hectares (ha) of the total Site area;
- A wharf line from Bluff Harbour connects to the west of the smelter into an alumina storage building via a conveyor;
- There are three drainage channels (North, West and South Drains) which flow into Awarua Bay and Bluff Harbour from the smelter fuel tanks and storage areas;
- The Tiwai Landfill (also known as the NZAS Landfill) is located south west of the smelter buildings;
- Scrub / forest can be seen along the southern edge of the smelter 'industrial precinct'; and

- Multiple areas of disturbed land possibly presenting waste disposal areas can be seen across the Site in the form of white patches and / or rectangular disturbed grassed areas.

2.3 Surrounding Land Use

The surrounding land uses are recorded in Table 2.

Table 2 Surrounding Land Use

Direction	Description
North	Tiwai Road is north of the Site, connecting the Awarua Plains to the peninsula from the north. Beyond Tiwai Road is the coastline and Awarua Bay estuary along with Joeys Island and Cow Island. The Awarua Plains are approximately 2 km north across the estuary.
East	Immediately east of the Site is the Tiwai Peninsula Conservation Area, followed by the Waituna Wetlands Scientific Reserve.
South	Immediately south of the Site is the coastline as well as the Invercargill District Boundary. Beyond the coastline is the Harbours' North Channel within Foveaux Strait.
West	The coastline and Bluff Harbour is adjacent to the west of the Site. The wharf line runs from the Site into the Harbour in a west-east alignment. Tiwai Point along with the entrance into the harbour lies south-west of the Site.

2.4 Site Environment

2.4.1 Topography and Land Cover

Topography

The Site is considered topographically relatively flat with an elevation of approximately 5 m above mean sea level (AMSL) Moturiki Datum (refer to Figure 2). The elevation of the Site varies from 4 m to 10 m AMSL. A section of the Tiwai Landfill, as well as the majority of the Tiwai Point area forms low ridges with an elevation of 10 m AMSL.

A review of an Assessment of Effects on the Environment (AEE) Report by NZAS (1995) reported the natural ground elevation of the landfill area (pre-landfill). Land north of the landfill was 8 m (AMSL) and land south of the landfill was between 3 to 4 m AMSL towards the south.

Land Cover

A review of Environment Southland (ES) online data has identified the Site to be situated in an area of "*Lowland Hard Bed*". Indigenous biodiversity and habitat loss are at greatest threat within this lowland environment. Along the southern border of the Site, there is coastal habitat which consists of scrub/forest, estuarine shrub, grassland and duneland. The southern beach consists of firm sand (to the west) and gravel field (to the east until the end of the peninsula).

The 1995 Report detailed grasses, flax, tussock, bracken and small shrubs to dominate coarse sand and gravel dunes between the landfill and southern coast of Tiwai Peninsula.

Figure 2 Site Topography. Source: LINZ Data Services.

2.4.2 Geology

A review of the Institute of Geological and Nuclear Sciences (GNS) 1:250,000 geological map for Murihiku shows that the Site is primarily underlain by Holocene deposits (refer to Figure 3):

- The majority of the Site and immediate surroundings are primarily underlain by Holocene ocean beach (shoreline) deposits which consists of "*gravel in beach ridges on Tiwai peninsula"*;
- The north-western corner of the Site is primarily underlain by Holocene stable dune (windblown) deposits which consists of "*stable longitudinal and parabolic sand dunes with peat in hollows*"; and
- The southern edge of the Site is primarily underlain by Holocene active dune (windblown) deposits which consists of "*sand in active dune fields*".

The surroundings to the south and south-west of the Site, at Tiwai Point, is primarily underlain by Greenhills Group sedimentary rocks which consists of "*volcaniclastic breccia; dolerite; basalt; tuff; sandstone; and impure marble; variably hornfelsed and foliated*".

There is no available investigation data for the Site on the New Zealand Geotechnical Database (NZGD).

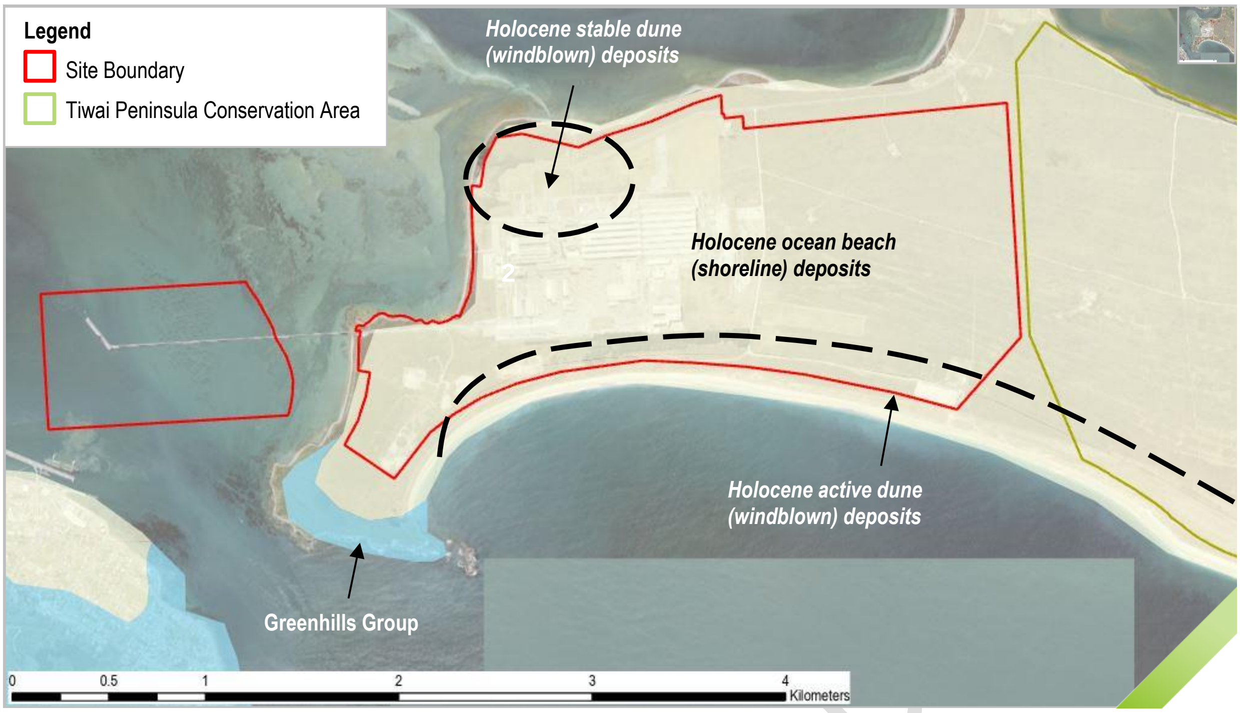

Figure 3 Site Geology. Source: GNS and LINZ data services.

The 1995 NZAS AEE Report described the Site to be underlain by unconsolidated material comprising gravels and sands with some silts and peats followed by Bedrock which is hard, dense, tight, poorly (partially) fractured and fine grained.

The Natural Bioremediation of NZAS Diesel Spill Technical Report by Rio Tinto Technical Services in 2000 described the peninsula to be underlain by glacial outwash gravels. The Site has:

- mostly fine to medium grained quartz pea gravel;
- high soil permeability;
- occasional layers of cemented fine sandy material; and
- gravelly soil with an approximate depth between 10 – 14 m below ground level (bgl) followed by sands and fine silts.

2.4.3 Hydrology

There are no permanent surface water bodies on the Site.

A search of ES and LINZ GIS data services has identified a small lake approximately 1.6 km north-east of the industrial precinct. The lake is connected to a nearby stream which flows into Awarua Bay. The Tiwai Peninsula is surrounded by coastal water bodies, with Bluff Harbour to the west, Awarua Bay along the North and Foveaux Strait south of the peninsula. The closest river is the Mokotua Stream, which is situated within the Awarua Plains approximately 6 km north of the Site. The Bluff Harbour, Awarua Bay and Awarua Plains all form part of the Awarua Wetland Ramsar Site (regionally significant wetlands and sensitive waterbodies).

Refer to Figure 4 below and Drawing 510555-0000-DRG-REP-0004-A, Appendix 1.

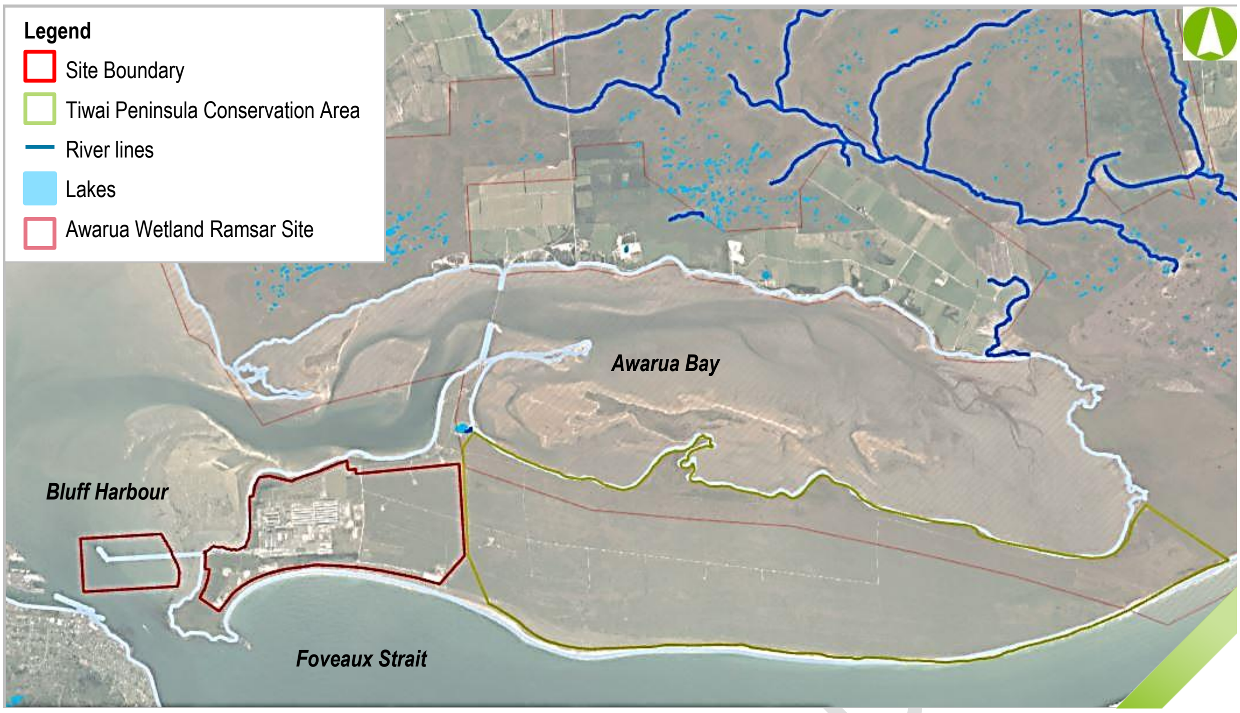

Figure 4 Site Hydrology. Source: ESRC and LINZ Data Services.

2.4.4 Hydrogeology and Well Details

The Site is located in a low-lying area within the Oreti Catchment. Based on our understanding of ground conditions, it may be expected that the water table is likely to be present at a level conversant with nearby surface water features.

Using the regional council mapping software, a search of registered wells was performed on *12 October 2020* and wells identified within the Site and conservation area are detailed in Table 3. Refer to Drawing 510555-0000-DRG-REP-0004-A, Appendix 1 for the location of the wells.

Table 3 Wells within the Site and conservation area

Well No	Date Drilled	Downgradient? (Y/N)	Well Depth (m)	Initial Water Level (m)	Use
The following wells are located within or adjacent to the Site					
E47/0229	24/02/2009	No	6	3.8	Groundwater Quality Monitoring
E47/0230	15/12/2008	No	6	3.6	Groundwater Quality Monitoring
E47/0231	20/12/2008	No	6	3.52	Groundwater Quality Monitoring
E47/0232, E47/0234, E47/0235	15/01/2009, 20/01/2009, 2/02/2009	No	5.7	3.8	Groundwater Quality Monitoring
E47/0233	16/01/2009	No	5.7	3.7	Groundwater Quality Monitoring
E47/0236	5/02/2009	No	5.1	4.6	Groundwater Quality Monitoring
E47/0181, E47/0182, E47/0183, E47/0184, E47/0185, E47/0186, E47/0187	8/12/2008, 9/12/2008, 10/12/2008, 11/12/2008, 12/12/2008	-	6.4	-	Groundwater Quality Monitoring
E47/0118	12/12/2005	No	6	3.17	Groundwater Quality Monitoring
E47/0119	12/12/2005	No	6	3.15	Groundwater Quality Monitoring
E47/0120	13/12/2005	No	6	3.13	Groundwater Quality Monitoring

E47/0121, E47/0122	13/12/2005	No	6	3.28	Groundwater Quality Monitoring
E47/0248	14/06/2011	No	5	2.3	Groundwater Quality Monitoring
E47/0153	1/11/2006	-	8	-	Groundwater Quality Monitoring
E47/0154	1/11/2006	-	22	-	Groundwater Quality Monitoring
E47/0279	18/04/2013	No	14	3.2	Groundwater Quality Monitoring
CG10/0025	19/07/2012	No	5.7	3.93	Groundwater Quality Monitoring
CG10/0024	19/07/2012	No	5.4	3.9	Groundwater Quality Monitoring
The following wells are located within or adjacent to the conservation area					
E47/0016	9/11/1990	No	15	2.5	Commercial / Industrial
E47/0015	8/11/1990	No	15	2	Water Level Observation
E47/0011	13/11/1990	No	25	3.6	Commercial / Industrial
E47/0008	30/10/1990	No	31	3.5	Other (not specified)
E47/0007	9/11/1990	No	25.5	3	Other (not specified)
E47/0014	7/11/1990	No	15	2.9	Water Level Observation
E47/0009	31/10/1990	No	20.7	3.9	Other (not specified)
E47/0006	7/11/1990	No	22	4.2	Other (not specified)
E47/0013	2/11/1990	No	15	2.6	Water Level Observation
E47/0010	1/11/1990	No	21.6	3.7	Commercial / Industrial
E47/0012	6/11/1990	No	15	1.83	Water Level Observation and Commercial / Industrial
E47/0003	-	-	62 (approximate)	-	-
E47/0002	-	-	61.9 (approximate)	-	-
E47/0005	6/11/1990	No	21	4.6	Commercial / Industrial
E47/0004	3/07/1978	No	66	-	-

“ - “ : no information available

A review of the 1995 NZAS AEE Report identified standing levels of groundwater around the landfill area (refer to Figure 5). The groundwater levels were approximately 7 m bgl to the north of the landfill and between 2 to 3.5 m bgl towards the south. This is consistent with the information from regional council provided in Appendix 2. The groundwater flows will be tidally influenced and will be to both the ocean and harbour beaches to the south and west of the site.

A review of the 2000 diesel spill report identified a list of bores across the Site (refer to Figure 6) and groundwater levels measured during an investigation 1999 and 2000 which ranges between 2.9 – 3.5 m bgl. The Natural Bioremediation of NZAS diesel spill 2005 - 2006 Monitoring Report by Rio Tinto Technical Services in 2007 reported groundwater levels to be between 2.7 – 3.5 m bgl.

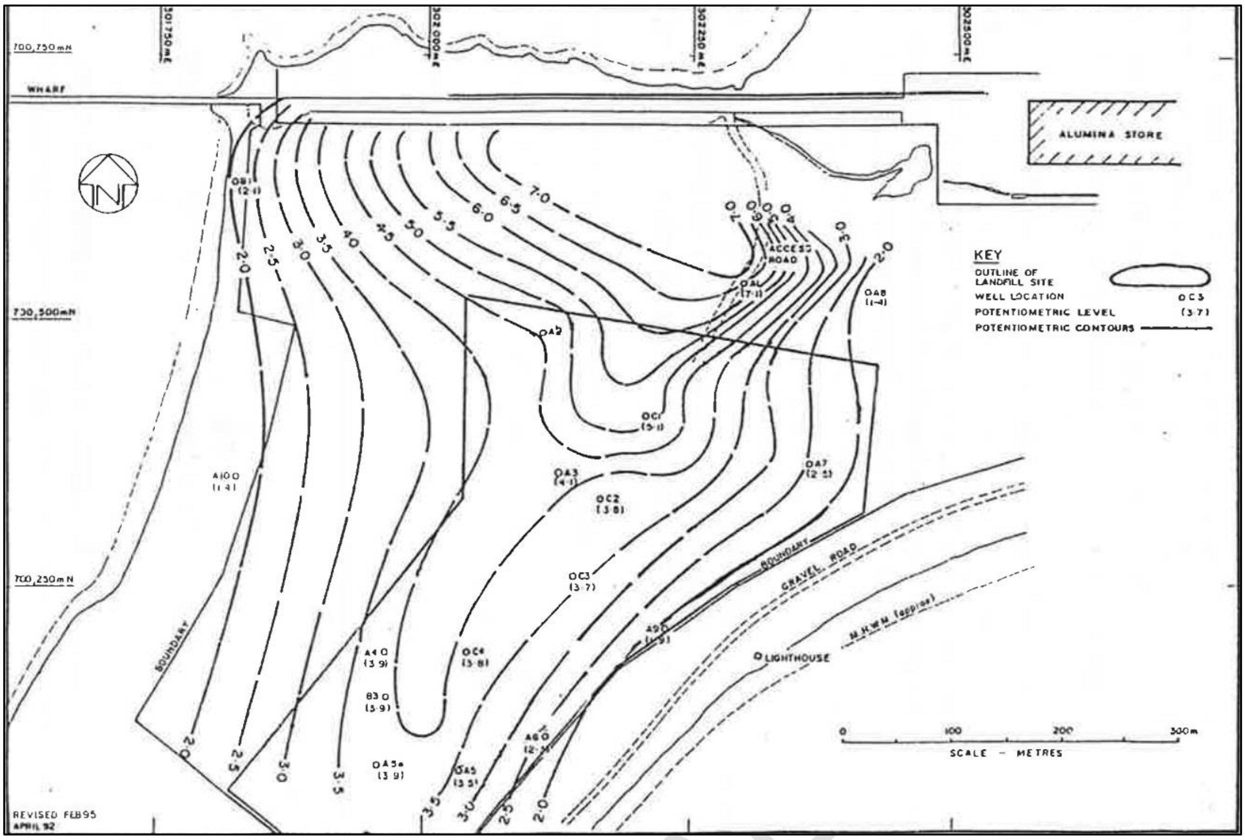

Figure 5 Potentiometric Surface levels of Groundwater. Source: 1995 NZAS Landfill Application Report.

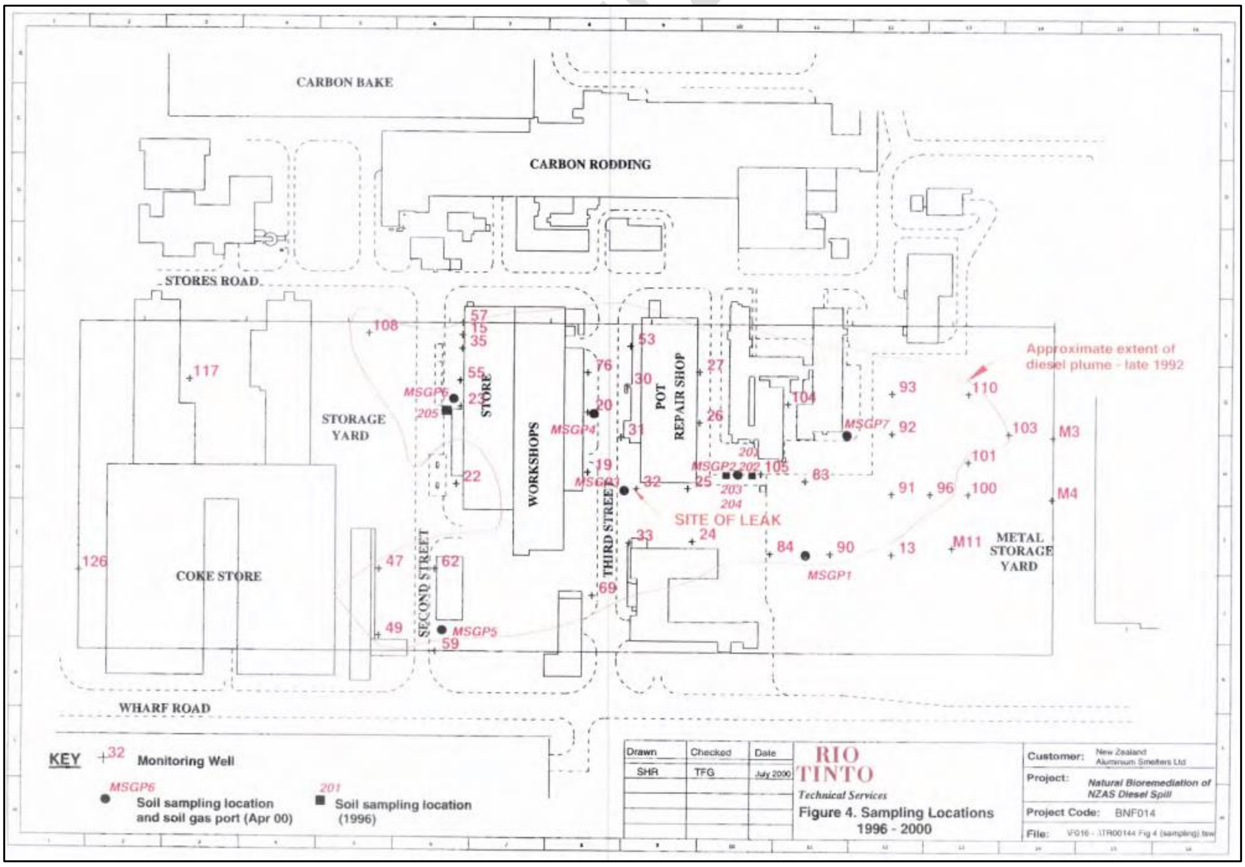

Figure 6 Locations of monitoring wells. Source: 2000 Diesel Spill Bioremediation Report by Rio Tinto.

2.4.1 Meteorological Conditions

Tiwai Peninsula receives a relatively high percentage of strong westerly winds, partly attributed to westerly winds strengthening as they channel through the Foveaux Straight (refer to Figure 7). Meteorological conditions affect the dispersion of discharges into air and are therefore monitored at the Tiwai Point meteorological station. The data includes:

- The distribution of wind strength;
- The distribution of wind direction; and
- Rainfall.

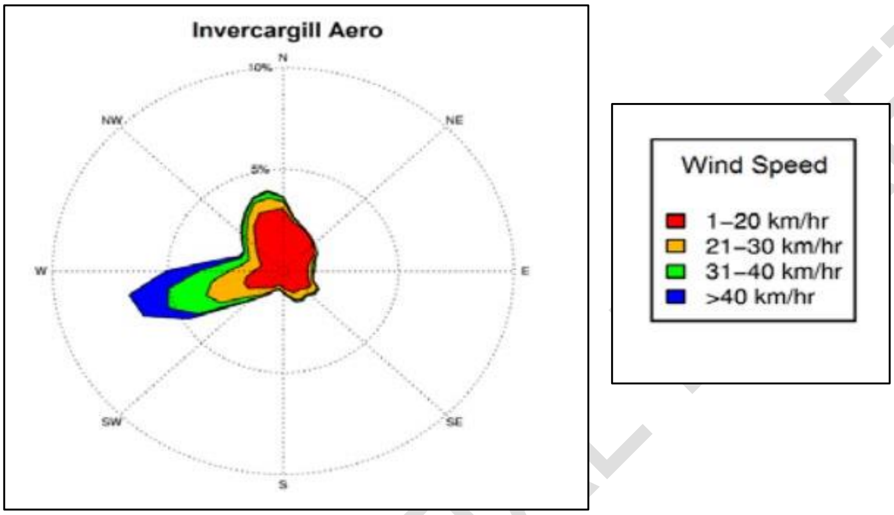

Figure 7 Mean annual wind frequencies (%) of surface wind direction from hourly observations recorded at the nearby Invercargill Airport climate station. The plot shows directions from which the wind blows. Source: NIWA.

2.4.5 Tsunami Risk and Erosion

Tsunami Risk

Geological and Nuclear Sciences Limited (GNS) has undertaken a tsunami inundation assessment[3] for the Site in 2010. GNS used a scenario-based approach divided into two model domains, local and distant, to model potential tsunami risks. The scenarios are defined by the following sources based on available published literature:

- Local earthquake sources of the Alpine Fault system, Fiordland (covers the Southland region):
  - Dusky Sound tsunami and earthquake of magnitude 7.8 (2009)
  - Puysegur Trench earthquake (no tsunami recorded) of magnitude 7.9 (1979)
- Distant earthquake sources (covers the South Pacific region):
  - Peru coast tsunami of magnitude 9.1 and 9.4.
  - Chilean Coast tsunami of magnitude 8.5 and 8.8 (2010)

GNS identified that the Puysegur and Peru scenarios provide moderate to significant risk to both land and marine threat to the Site facility and infrastructure:

- Puysegur scenarios:
  - With a magnitude of 8.6, there is a threat to the central west side of the Site; and

[3] *Tsunami inundation modelling for Tiwai Point, Geological and Nuclear Sciences Limited (ref: 2010/293, November 2010).*

- With magnitudes of 8.3, 8.4, 8.6 and 8.7, there is a threat to the shoreline of Tiwai Point and the harbour entrance.

- Peru scenarios:
  - With magnitude 9.1, there is a threat to the central west part of the Site, along with the creek extending more inland; and
  - With a magnitude of 9.4, the threat is similar to that of magnitude 9.1, except the build-up is less.

The Fiordland scenarios only provide a threat to the beachfront areas, with less threat to Tiwai Point. Sand dunes along the Foveaux Strait are high enough, thus no major tsunami threat, except for where there is a creep extending inland.

Erosion

MetOcean Solutions Ltd (MSL) carried out a coastal erosion assessment[4] of the Tiwai Peninsula (see Figure 8). This was undertaken close to the SCL pad located south-east of the Site using historical wave data over a period of 37 years (1979 to 2015). The assessment by MSL concludes the following:

- Tiwai Peninsula suffers erosion due to relative instability
- Latest data of the assessment undertaken at the time (approximately between 2010 to 2016) identified that retreat of the dune line has not exceeded more than approximately 10 m which they concluded won't represent an immediate risk of the Site located 120 m from the shoreline
- There was a general decrease of storminess during 1996 and 2007

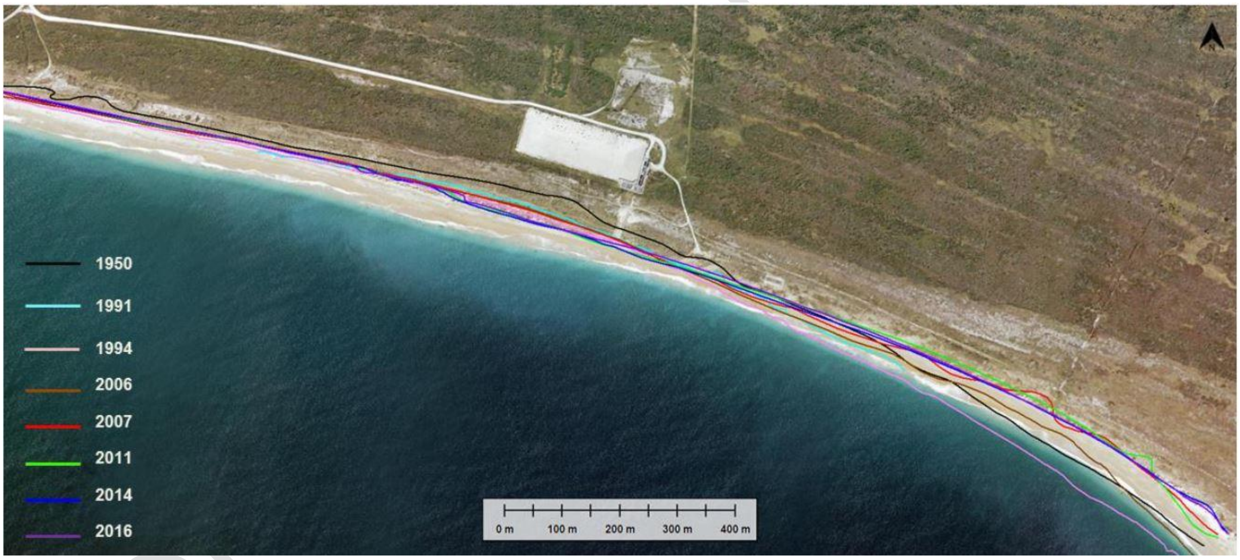

Figure 8 Historical beach erosion (dune lines between 1950 and 2016) at the shoreline opposite to the Site's SCL pad. Source: MSL.

2.4.6 Sensitive Aquifer Assessment

Shallow groundwater from the Tiwai Aquifer is encountered at approximately 3 m bgl. The aquifer is located between 20 to 30 m of gravelly sands beneath the Tiwai Point peninsula. The aquifer has variable permeabilities due to the lensitic and linear nature of the gravel and sand deposits. The aquifer is recharged from rainfall and acts as a large reservoir for stored groundwater.

Water take from the aquifer on Tiwai Peninsula is covered by consent number 202958 issued by ES on 12 September 2005. Total abstraction rate is not to exceed 4,654 m^3/day.

[4] *Coastal Dynamics Study, Coastal erosion assessment along Tiwai Peninsula, MetOcean Solution Ltd (ref: P0324-01 Rev0, May 2017)*

An assessment to establish whether the shallow groundwater beneath the Site is a 'sensitive aquifer' is presented in Table 4.

Table 4 Sensitive Aquifer Assessment per MfE 2011b

Criteria	Assessment
The aquifer is not artesian or confined; and	**No** - The aquifer is **not artesian** or confined.
The aquifer is expected to be less than 10 metres below the source or suspected source of contamination; and	**Yes** – Shallow groundwater from the Tiwai aquifer is encountered at approximately 3 m bgl, likely due the proximity to sea and permeable ground conditions. Shallow groundwater can be considered sensitive as it can readily transfer contaminants into the sea.
The aquifer is of a quality appropriate for use, can yield water at a useful rate and is in an area where extraction and use of groundwater may be reasonably foreseen; or	**Yes** – Up to 4,654 m^3/day of groundwater is abstracted from the Tiwai aquifer and used at the smelter for the aluminium production process, as potable water supply and, when needed, emergency firefighting. The abstraction well field comprises six production wells located to the east of the smelter on adjacent Crown land (administered by DOC). Wells are spaced at approximately 1 km intervals along the Tiwai peninsula.
The source of contamination is less than 100 metres from a sensitive surface water body.	**Yes** – Although the industrial precinct is more than 100 m away from any water body, the closest sensitive water body, the Foveaux Strait is approximately 100 m south of the SCL pad.

Groundwater from the Tiwai Aquifer is abstracted and used for smelter activities. The Tiwai aquifer has to be managed carefully in that if the water take is too large, there is a risk of saltwater incursion – which would destroy the integrity of the supply.

The Tiwai aquifer is therefore considered **sensitive**.

2.4.7 Ecology

Under the Resource Management Act (Section 30), regional councils and unitary authorities have responsibilities to safeguard the life-supporting capacity of soil and ecosystems and ensure any adverse effects on the environment are avoided or mitigated.

Any Site remediation may result in a change of land use to a more sensitive land use, which is relevant to the ecological assessment of the site. The presence of on and off-Site ecological receptors was investigated, and the results are presented in Table 5.

Table 5 Ecological assessment checklist[1]

Ecological receptor	On Site	Off-Site	Comments
Marshes, swamps, tidal flats or other ecologically sensitive wetlands near[2] the Site?	No	Yes	The regionally significant Awarua Wetland Ramsar Site (Regionally Significant Wetlands and Sensitive Waterbodies according to ES) is located north of the Site and covers the northern part of the Tiwai Peninsula, covering most of the Awarua Bay estuary and Awarua Plains (refer to Figure 4).
Are other aquatic habitats such as rivers, lakes or streams near the Site?	No	Yes	There is a small lake with a river linked to the nearby coast north-east of the Site, right of Tiwai Road entering the peninsula from the north.
Are ecologically important marine or estuarine environments near the Site?	No	Yes	The Awarua Bay estuary is located north of the Site and Tiwai Peninsula. The estuary is regionally a significant wetland.
Are ecologically important or sensitive environments such as national parks or nature reserves located near the Site?	No	Yes	The conservation area, adjacent to the east of the Site, covers approximately 1757.3104 ha of the peninsula.

Are habitats for rare, threatened or endangered species near the Site?	No	Yes	Tiwai Point, south-west of the Site and immediately adjacent to the south of Tiwai Landfill, is home to Foveaux shags, important bird life, and the critically endangered Foveaux looper moth.
Are culturally important ecological receptors located near the Site (including areas identified on regional council GIS mapping)?	Yes	Yes	Archaeological Sites (middens) are located along the western coastline, and western side of the Site. The grave of Bluff Pioneer William Stirling is located along the southern coast on adjacent land to the southwest of the smelter complex.
Are commercially or recreationally important ecological receptors located near the Site?	No	Yes	Areas used for recreational and commercial purposes e.g. oyster farming and watersports.
Are forested, grassland or other habitats of significance located near the Site	Yes	Yes	Scrub/forest, estuarine shrub, grassland and duneland are located along the southern areas of the Site and Tiwai Peninsula. Areas of Significant Indigenous Biodiversity is located in the north-eastern part of the Site, areas along the north and west boundary of the Site and the majority of the conservation area.
Is the Site used for food production (arable or livestock)?	No	No	None.
Summary: Based on the information collected, the Site **is** considered ecologically sensitive, and data **should** include assessment using guidelines relevant to the assessment of ecological impact			

1: Table adapted from Appendix 4I, MfE 2011c.
2: Near is judged on a Site-specific basis given the contaminant's potential for transport by wind, surface run-off, groundwater transport or preferential pathways from service lines etc and should include positive factors such as reticulation of stormwater away from the Site.

2.4.8 Summary of Environmental Conditions

The Site, as well as the Adjacent Site (conservation area to the east), is considered topographically relatively flat, with gently sloping ridges towards Tiwai Point to the south-west. The Site is expected to be underlain by unconsolidated material consisting of sand deposits and gravel along the ridges. There are no permanent water bodies on Site however, the Tiwai Peninsula is surrounded by three significant coastal water bodies:

- Foveaux Strait (south);
- Bluff Harbour tidal flats (west); and
- Awarua Bay (north).

The nearest identified ecological receptors from the smelter are:

- The conservation area adjacent to the east of the Site;
- Coastal habitats and vegetation including scrub/forest, estuarine shrub, grassland and duneland immediately surrounding the site and noted areas of significant indigenous biodiversity; and
- Archaeological Sites (middens) located approximately along the western coastline.

Strong westerly winds can be expected around Tiwai Peninsula, which will influence deposition and dispersion of emissions from the Site.

Erosion and climate change studies have identified that the landfill and SCL pad may be vulnerable given their proximity to the coastline.

There is a potential tsunami threat from the central westerly coastline which will be a risk to the Site facility and infrastructure.

The groundwater is expected to flow towards the Harbour and Foveaux Strait. A review of readily available data indicates that the groundwater depth can be between 1.83 m and 7 m bgl and the groundwater beneath the Site is considered sensitive using the MfE 2011b definition.

3 Site History and Current Use

3.1 Introduction

A search of readily available information sources was conducted with the objective of identification of past or present activities with the potential to contaminate land or other media such as sediment, surface water and groundwater. The nature and extent of any identified activities has also been assessed, where information was available.

3.2 Regional Council Register of HAIL Sites

Environment Southland holds a database of sites that have, or have had in the past, an activity or industry that is detailed in the Hazardous Activities and Industries List (HAIL) (MfE 2012). The web-based database was queried on *12 October 2020*. HAIL activities identified at Tiwai Peninsula are listed in Table 6.

Table 6 Regional Council Register of HAIL Activities at Tiwai Peninsula, Southland

Selected Land Use Sites ID	Classification	Address	Legal Description	HAIL Categories
SLUS-00000305	Verified – HAIL	1429-1530 Tiwai Road, Awarua, Invercargill	Lot 1 DP 13987; Lot 1 DP 13988; Section 6 Block XIII Campbelltown HUN	**A17:** Storage tanks or drums for fuel, chemicals or liquid waste; **D4:** Metalliferous ore processing **G3:** Landfill Sites

Note that the register is incomplete as not all HAIL activities in the region have been identified. The details listed in Table 6 are not considered to be comprehensive, and further HAIL activities are reported in this section.

For confidentiality reasons, property statements and local authority property files were not requested from the Regional Council.

3.3 Regional Council Consents

NZAS holds various consents from ES associated with the operation of the smelter. An assessment of the consenting arrangements for the Site is provided in an Authorisations and Non-Compliances table in Appendix 2.

3.4 Records of Title

Records of title have been obtained for land located at Tiwai Peninsula from Land Information New Zealand (LINZ). Record of title information is summarised in Table 7 and detailed information is provided in Appendix 4.

s9(2)(h)

[redacted]

s9(2)(h)

Table 7 Records of Title

Reference	Year	Owner	Comments
SL3A/93	24 November 1972	New Zealand Aluminium Smelters Limited	■ The property is an estate in fee simple of 7,105 square metres more or less and is more particularly described as Section 9 Block XIII Campbelltown Hundred. ■ The title is subject to (now repealed) s59 of the Land Act 1948 which reserves minerals to the Crown.
SL11B/267	09 September 1998	New Zealand Aluminium Smelters Limited	■ The property is an estate fee simple of 91.8628 hectares more or less and is more particularly described as Lot 1-2 Deposited Plan 13987. ■ The title is subject to a number of interests including a lease to Transpower Limited contained in a record of title 644313 over Lot 2 Deposited Plan 13987.
SL11B/268	09 September 1998	Pacific Aluminium (New Zealand) Limited	■ The property is an estate in fee simple of 312.7181 hectares more or less and is more particularly described as Lot 1 Deposited Plan 13988. ■ The title is subject to a number of interests.
SL9C/865 (Leasehold)	21 September 1990	Comalco New Zealand Limited	■ The property is an estate in leasehold pursuant to a lease under s67(2) of the Land Act 1948 between Her Majesty the Queen as lessor and Comalco New Zealand Limited (now Pacific Aluminium (New Zealand) Limited) as lessee (Lease) of 1667.3048 hectares more or less and more particularly described as Section 1 Block XIV Campbelltown Hundred. ■ The land contained in records of title SL9C/865 is Crown land managed by the Department of Conservation subject to an expired lease to Comalco New Zealand Limited (now Pacific Aluminium (New Zealand) Limited). It is unclear from the records registered with LINZ whether Pacific Aluminium (New Zealand) Limited continues to have an interest in or rights and obligations in relation to this parcel of land. ■ While it appears that the SCL pad and landfill are not located on this title (and information supplied by the Ministry for the Environment suggests it was not), it is noted that clause 6 of the Lease requires the lessee, at its own expense to *make such property sanitary arrangements as may be required by the Director-General [of Conservation] or any other competent authority and will at reasonable periods remove and destroy rubbish on the said land*.

3.5 National Library of New Zealand Catalogue

A search of the Site was conducted using the National Library of New Zealand Catalogue on *12 October 2020*. The environmental resources listed in Table 8 are available upon request at the Alexander Turnbull Library, the National Library of New Zealand and the Invercargill City Library and Archives.

Table 8 National Library of New Zealand Catalogue Information

Title	Publication Type	Creator	Year	Available	Notes
Expansion of the Tiwai Point Aluminium smelter to three potlines: environmental statement	Environmental Statement	Creator: New Zealand Aluminium Smelters Ltd Contributor: Interdepartmental Committee on Environmental Effects of the Tiwai Aluminium Smelter	1980	Available at the National Library of New Zealand, Wellington, New Zealand Pacific	This book is for reference only and may not be borrowed. Source: NLNZ ALMA 99557553502836
The people & the power: the history of the Tiwai Point Aluminium Smelter	Book	Creator: Clive A Lind Contributor: New Zealand Aluminium Smelters Limited	1996	Available to read at the National Library of New Zealand, Wellington, New Zealand Pacific	This book is for reference only and may not be borrowed. Source: NLNZ ALMA 992965323502836 Book scans provided – history and timeline of Tiwai Smelter operations up until 1996.
The vegetation of Awarua and the control of air pollution at the N.Z.A.S aluminium smelter on Tiwai Port, Bluff, New Zealand	Book	Creator: Gavin Thomas Daly Contributor: New Zealand Aluminium Smelters Limited	1971	Available at The Alexander Turnbull Library New Zealand Pacific	This book is for reference only and may not be borrowed. Source: NLNZ ALMA 9912481473502836
Tiwai Peninsula: a groundwater research report	Report	Creator: Bruce W Hunt Contributor: University of Canterbury, Department of Civil Engineering	1978	Available at The Alexander Turnbull Library New Zealand Pacific	This book is for reference only and may not be borrowed. Source: NLNZ ALMA 9913606803502836 Mathematical model of aquifer.
Groundwaters of Tiwai Peninsula: environmental study, New Zealand Aluminium Smelters Limited	Book	Prepared by Woodward-Clyde (N.Z.) Ltd.	1995	Available at The Alexander Turnbull Library New Zealand Pacific	This book is for reference only and may not be borrowed. Source: NLNZ ALMA 9910006033502836 Report describes the results of investigation into the effects which the operation of the New Zealand Aluminium Smelters Limited's plant on Tiwai Peninsula has on groundwaters at the Site and on groundwater beneath the remainder of Tiwai Peninsula.
Aluminium Smelting in New Zealand: Summary of Negotiations with Government since 1959	Book	Comalco Limited	1976?	Invercargill City Library and Archives	This book is for reference only and may not be borrowed. Book scans have been provided.

3.6 Review of Historical Aerial Photography

Historical aerial photographs of the Site were reviewed, and a summary is presented in Table 9 below:

Table 9 Historical Aerial Photograph Summaries

Year and Source	Site	Adjacent area
1951 - Retrolens	- An unoccupied coastal plain predominantly covered by coastal vegetation, grassland and scrub. - Surface water is ponding in an area where the landscape appears to have been shaped by an old wetland or estuary. - A navigation peak exists along the southern coast. A track from this leads to areas of cleared land - possibly used for agricultural purposes.	- A small wharf to the north of the peninsula extends into Bluff Harbour. Nearby structures (including one larger tower building and two smaller structures) are present near the wharf. - A farmhouse and small sheds are visible on Section1 Block XIV Campbelltown Hundred block of land. - The Awarua Bay coastline east of the wharf appears to be eroding and receding inland.
1962 - Retrolens	- There is evidence of an unusual excavation near the navigation peak on the southern coast and earthworks near areas of cleared land (noted above).	- Farmhouse has been removed, but sheds remain. - Large building near the wharf has also been removed but two smaller nearby structures also remain. - Erosion along the northern coast appears to have been remediated and vegetated.
1969 - Retrolens	- Much of the coastal vegetation and scrub within the Site area and to the east of the Site has been cleared. - Significant earthworks appear to be taking place, including construction of Tiwai Road, Tiwai Wharf Road, Loop Road and other small access roads. - Earthwork areas noted above (1962) appear larger in size. - Some earthworks are observed where the current wharfline meets the coastline.	- Newly constructed access roads and earthworks observed.
1978 - Retrolens	- The aluminium smelter has been constructed, roading has been extended and upgraded. - The Tiwai wharf has relocated northeast and extends further into the Bluff Harbour (although the older smaller wharf further west remains). - The Tiwai Landfill and waste oil pit can be observed. - SCL stockpiling appears to be taking place on the SCL pads to the east of the smelter, near the southern coast. - The north, west and south drains are visible.	- A bridge has been built across the neck of Awarau Bay, connecting the peninsula to the mainland. - Small areas of disturbance across the adjacent Site. - A pit or pond (visually similar to the waste oil pit at Tiwai Landfill) is apparent adjacent Tiwai Road, near the peninsula's northern arm. Land around this appears to be particularly disturbed.
1985 - Retrolens	- Smelter upgrades and extensions including (but not limited to) additional warehouses to the east of the alumina store, coke store extensions, additional carbon bake sheds, construction of a third reduction line (Reduction Line 3) and other new and/or relocated buildings (cross-referenced with current site layout). - The Tiwai landfill and waste oil pit are much larger in size. - Vegetation (small trees/scrub) exist south of the smelter.	- SCL pad has been covered. Effluent treatment plant evident.

1998 - Retrolens	- Smelter upgrades and extensions including (but not limited to), additional CBF sheds, additional fuel tanks and a smaller fourth reduction line (Reduction Line 4) – cross referenced with reports and current site layout. - Smelter gardens have been cleared to the northeast of the smelter Site. - Land disturbance and stockpiling to the east of the Site area. - Parts of the Tiwai Landfill have been capped and vegetated, including the waste oil pit. Possible stockpile of unknown material adjacent filled burn pit.	- Land disturbance behind the SCL pad – possible stockpiling and/or vehicle disturbance. - Pit and/or pond resembling waste oil pit north east of the Site has been filled and/or vegetated. - DOC land is being disturbed east of the Site, likely for subsurface drip irrigation.
2013 – 2014 – LINZ	- Evidence of the landfill extension for Haysom's Dross disposal. - The Dross Recycling Building is now on-Site. - Obvious stockpiling to the east of the Site – refractory bricks?	- A subsurface discharge field for treated (effluent from the on-site wastewater treatment plant) has been developed across approximately 6 hectares of Department of Conservation land.

Historical Aerial Images are provided in Appendix 5.

3.7 Historical and Current Layout of the Site

This section identifies all current and historical activities that have involved the delivery, storage, use and disposal of hazardous substances at and beyond the Site.

3.7.1 Overview of the Aluminium Production: The Hall-Heroult Process

NZAS's website (https://www.nzas.co.nz/) provides an online overview of the aluminium smelting process carried out at Tiwai Point. This process is summarised as follows:

The Hall-Heroult process is used to reduce alumina to aluminium metal at NZAS. The basic inputs required for this process are:

a) Alumina (Al_2O_3);

b) Electricity; and

c) Carbon (C).

The equation for the basic reaction is: $\mathbf{2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2}$

During this process, alumina undergoes an electro-chemical reaction in individual reduction cells. Reduction cells are long steel shells lined with refractory bricks and carbon and are connected electrically in series. The carbon lining of the cell forms the cathode – the negatively charged electrode by which electrons enter the cell.

A hopper located above the reduction cells feeds alumina into the cells at regular intervals, where it is dissolved in a bath of molten cryolite (sodium aluminium fluoride) at 960^{0}C.

Reduction cells at NZAS are laid out in four reduction lines. Reduction lines 1,2 and 3 are approximately 600 m long and each contain 208 individual cells. Reduction line 4 (installed more recently) is 300 m long and contains 48 reduction cells.

A very high electrical direct current of approximately 196,000 amps for Lines 1, 2, 3 and 225,000 amps for Line 4 flows into the reduction cells through carbon anodes which are suspended above the cell on cast iron yokes. Anodes form the positive electrode also supply the carbon for the reduction reaction. The electrical current passing through the alumina bath solution reduces the alumina to aluminium and oxygen. The aluminium is deposited at the cathode while the oxygen is attracted to the carbon anode as shown in Figure 9.

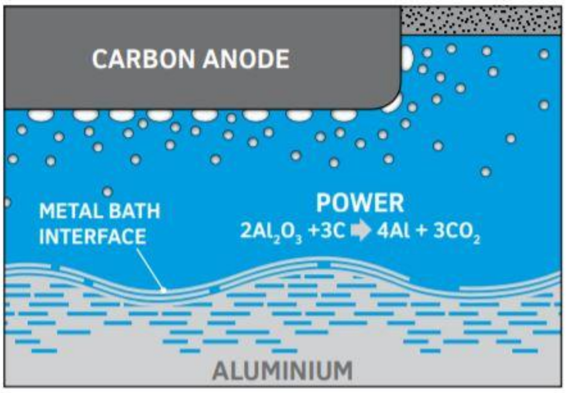

Figure 9 Electro-chemical reaction in a reduction cell. Source: NZAS website (https://www.nzas.co.nz/)

The carbon anode blocks (18 in Reduction Lines 1,2, and 3 cells, and 20 in Reduction Line 4 cells) gradually reduce in size over a period of approximately 26 days. When a block becomes too small, it is replaced by a new block. Used anodes (butts) are crushed and used to produce new anodes which are manufactured using petroleum coke, liquid pitch and recycled carbon material.

As the aluminium is produced it sinks to the bottom of the cell. Each day approximately 1,450 kg of molten aluminium is produced in each of Reduction Lines 1, 2 and 3 and approximately 1,730 kg in Reduction Line 4 (newer technology). Aluminium is tapped from the cell into a crucible (a large steel bucket lined with refractory bricks) by vacuum siphoning. Each crucible can tap the aluminium from three cells.

Once each crucible is filled with aluminium (always from the same tapping bay), it is transported from the reduction lines to furnaces in the Metal Products Division from where it is cast into finished products in the form of billet, rolling block and T-bar. After casting, billet is placed in a homogenising furnace for reheating and cooling under controlled conditions. This ensures a uniform crystalline structure throughout. NZAS produces over 300,000 tonnes of aluminium every year. Around 90% of the aluminium produced is exported overseas to Japan, South Korea, North America and Europe.

An overview of the aluminium smelting process from delivery of raw materials to the final aluminium product is shown in Figure 10.

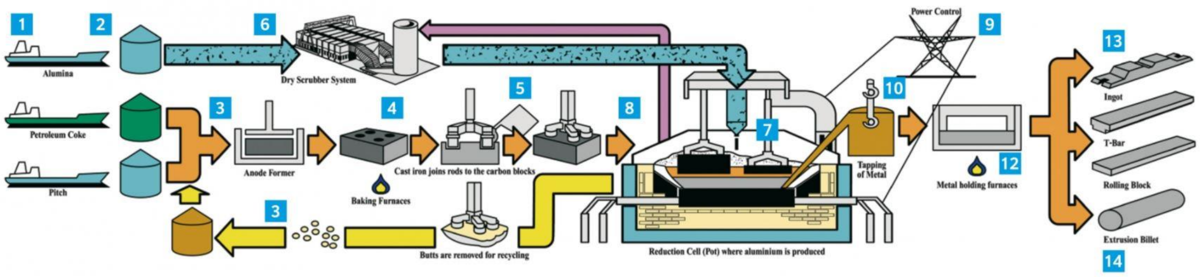

Figure 10 **Aluminium smelting process at New Zealand Aluminium Smelter - Tiwai. Source: NZAS website (https://www.nzas.co.nz/)**

3.7.2 Industrial Precinct Activities and Associated Contamination

The Tiwai smelter complex/industrial precinct is shown in Figure 11. A foundation to understanding of Site contamination and environmental incidents that have occurred within the industrial precinct has been summarised in Table 10.

Aurecon has been provided with limited information and data for the Site. Given the limitations in information and time available to complete this report, the extent of contamination and all environmental incidents that have occurred on-site since smelting operations commenced cannot be given at this stage**.**

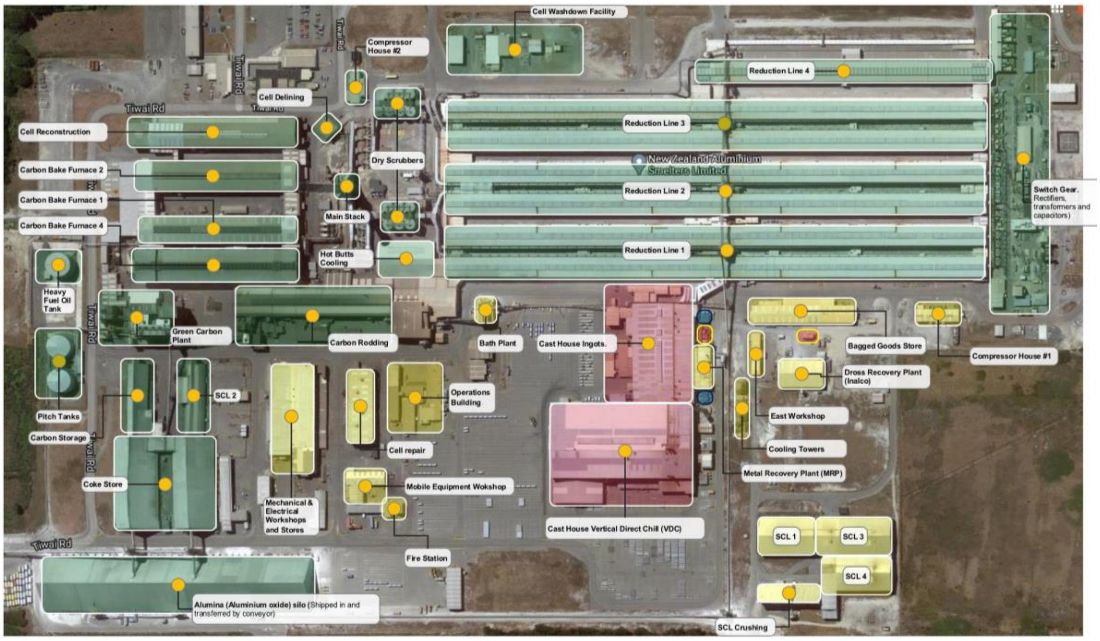

Figure 11 **New Zealand Aluminium Smelter Industrial Precinct.**

Table 10 Summary of Industrial Precinct Contamination – Activities and Environmental Incidents

Land Use/Activity	Associated Contaminants (not limited to the following)	Contaminating Processes and/or Incidents	Potential Environmental Risks
Wharf Line and Ship Unloader Delivery of alumina, petroleum coke and pitch via conventional bulk carrier ships.	Hydrocarbons (particularly PAHs), heavy metals, alumina dust	Incidental contamination associated with wharf operations including (but not limited to) delivery and unloading of alumina and raw materials. **Reported Incidents:** - Community complaints of visible wharf dusting during alumina discharge (frequently observed from Bluff). - Alumina discharged into sea and air during discharge and conveyor repairs. - Heavy fuel oil and pitch spilt into sea during discharge and unloading operations (10+ litres reported at a time). - Debris (e.g. metal planks, bars and poles) on the seabed from wharf operations (2019).	- Polluted marine sediments. - Sediment accretion. - Ecological disturbance. - Debris on seabed from wharf operations.
Hazardous Storage Sheds and Warehouses Alumina store/silo, coke store, SCL stores, carbon storage and other buildings used to store hazardous materials**.**	Hydrocarbons, heavy metals, residual dusting SCL is of concern as it is corrosive and reacts with water releasing toxic and explosive gases. It can also generate cyanide and fluoride in leachate leading to adverse environmental impacts.	Incidental contamination associated with storage of hazardous substances in sheds and warehouses within the smelter complex. **Reported Incidents:** - Alumina dusting around the alumina store, visible in historical aerial photographs and satellite imagery. - Since 1992, SCL has been stored in buildings designed for the purpose of SCL storage. Leachate from wet SCL has been known to leak through the floor of the storage shed. Wet SCL is no longer placed in SCL stores.	- Contaminated soil/groundwater under/in the vicinity of buildings warehouses and storage sheds to be demolished and removed. s9(2)(j)
Hazardous Storage Tanks Pitch tanks, heavy fuel oil tanks, diesel tanks and others.	Hydrocarbons, heavy metals and a wide variety of chemicals.	Incidental contamination associated with storage of hazardous substances in above and underground storage tanks. **Reported Incident:** In 1991, an 800,000 L diesel leak occurred on-Site due to a transfer pipe failure. Most of the diesel free product on groundwater, 520,000 L, was recovered in 1992. However, a plume of free product, estimated at 140,000L remained. In addition, a large volume of subsurface soil remained contaminated with diesel range petroleum hydrocarbons, with concentrations measured up to 14,000 mg/kg in 1994. In 1996, natural bioremediation was selected as the most appropriate remediation approach as there was clear evidence that natural attenuation processes were active. It was predicted that natural attenuation could take up to 25 years to remove the remaining diesel in free, residual and the dissolved phases. NZAS agreed to monitor TPH in four bores each year and review the process after 5 years. In 1999, ES advised NZAS that continuation of annual monitoring was not required. In 2000, NZAS provided the Council with a comprehensive Diesel Spill Bioremediation Report and in 2006 a	- Contaminated soil/groundwater under/in the vicinity of storage tanks. - Contaminated soil/groundwater in the vicinity of diesel spill and plume.

Land Use/Activity	Associated Contaminants (not limited to the following)	Contaminating Processes and/or Incidents	Potential Environmental Risks
		final review of the diesel plume remediation was issued. By November 2006, it was calculated that well over 85%, and potentially up to ~99% of the diesel had been removed, principally by biodegradation.	
Reduction Lines/Potlines	Discharges to air: Particulate matter, fluoride, sulphur dioxide, alumina dust, perfluorinated chemicals (PFCs), cyanide, carbon dioxide, carbon monoxide, nitrogen dioxide, carbon dust, PAHS, TPHs.	Incidental contamination associated with potline processes, waste and discharges to air via main stack extraction, potline roof ventilation, and baghouse filtration. **Reported Incidents:** - Minor violations of permit concentrations. - Elevated concentrations of fluoride levels in ungrazed grass. - Increasing carbon dioxide discharge due to aluminium process instability.	- Contaminated soil/groundwater under/in the vicinity of potlines/reduction lines. - Fluoride in vegetation, soils and marine sediment (including parts within the adjacent conservation estate). - Deposited dust and particulate emissions.
SCL Processing	Residual contamination – fluoride and cyanide. SCL is of concern as it is corrosive and reacts with water releasing toxic and explosive gases. It can also generate cyanide and fluorine in leachate leading to adverse environmental impacts.	Incidental contamination associated with cell washdown, cell delining, SCL crushing facilities and any other associated facility.	- Contaminated soil/groundwater in the vicinity. s9(2)(j) - Deposited dust and particulate emissions.
Carbon Baking Furnaces	During formation of anodes and cathodes, a variety of solid wastes, liquid effluent and gaseous emissions (e.g. products of combustion from heavy fuel oil furnaces (NO_x, SO_2, CO particulate), PAH, condensable hydrocarbons) are produced. Oils and tars, fluorides, metals (in particular, aluminium, antimony, nickel).	Incidental contamination associated with carbon baking processes, waste and discharges to air via main stack. - Baking furnaces are typically maintained by either continuous flue wall replacement or multi-sectional re-builds. - Refractory brick stockpiles on-site.	- Contaminated soil/groundwater under/in the vicinity of the carbon baking furnaces. - Deposited dust and particulate emissions.
Hot Butts Cooling	Particulate and gaseous fluoride, sulphur dioxide, PAHs.	Incidental contamination associated with carbon anode processes, waste and discharges to air via main stack.	- Contaminated soil/groundwater under/in the vicinity of buildings. - Deposited dust and particulate emissions.
Green Carbon Plant	Products of combustion from heavy fuel oil furnaces (NO_x, SO_2, CO particulate), pitch fume (PAH	Incidental contamination associated with green carbon plant processes, waste and discharges to air via furnace stacks (3), pitch fume scrubber, dust collectors and dust collectors.	- Contaminated soil/groundwater under/in the vicinity of the green carbon plant.

Land Use/Activity	Associated Contaminants (not limited to the following)	Contaminating Processes and/or Incidents	Potential Environmental Risks
	particulate), particulate.		- Deposited dust and particulate emissions.
Carbon Rodding and Spent Anode Recycling	Products of combustion from diesel and LPG, particulate, welding fume. Anode Butts	- Incidental contamination associated with green carbon plant processes, waste and discharges to air via furnace stacks (3), pitch fume scrubber, dust collectors and forced ventilation. **-** Anode butts stockpiled and stored on-Site.	- Contaminated soil/groundwater under/in the vicinity of the carbon rodding buildings. - Deposited dust and particulate emissions.
Dross Recovery Plant and Metal Recovery Plant Aluminium dross recycled into mineral fertiliser. Two buildings within the smelter complex: Metal Recovery Plant Annex and Dross Recycling Building.	Products of combustion from heavy fuel oil furnaces (NO_x, SO_2, CO particulate), gaseous fluorides, chlorides and HCl from aluminium degassing, particulate, fume from dross pressing (dust and particulate), products of combustion from LPG, particulate and trace gases from reaction of dross with water (ammonia, methane, acetylene)	Incidental contamination associated with dross recycling processes including (but not limited to) discharge to air from the Metal Recovery Plant (MRP) fuel oil fired furnace, fume extraction from hot dross pots in the MRP, MRP ventilation, the gas-fired rotary drier and drying and mechanical processing of aluminium dross in the Dross Recycling Building.	- Contaminated soil/groundwater under/in the vicinity of buildings to be demolished (including dust and particulate emissions). - Remaining dross and aluminium waste by-product on-site to be disposed of appropriately. - Fluoride discharges affecting vegetation in the immediate area.
Electrical Switch Gear and Transformers	Polychlorinated biphenyls (PCBs), TPHs, heavy metals (in particular, mercury), asbestos.	Incidental contamination associated with electrical switch gear, substations and transformers. **Reported Incident** 1990 – lightning caused power surge wiping computer control of half of the 612 cells.	- Contaminated soil in the vicinity of electrical equipment. - Risk of transformer fire and/or explosion due to electricity overload following smelter closure.
Cast House Operations	Hydrocarbons, heavy metals (mainly copper, magnesium, manganese, silicon, tin and zinc), dross/aluminium waste and impurities.	- Incidental contamination associated with cast house operations e.g. degassing, refining, skimming, casting and stacking. **Reported Incident:** - Frequent community complaints reporting black smoke from furnaces.	- Contaminated soil/groundwater under/in the vicinity of the cast house buildings and operations area. - Deposited dust and particulate emissions.
Fire Station	PFAS and other chemicals.	- PFAS possibly used in fire-fighting foam used for training and fire control. **Reported Incident:** - First major fire at Tiwai smelter in 1976 – little damage. - In 2018, a fire broke out in early hours of the morning, destroying a building situated between two potlines that was used as a smoko and canteen room. It took seven fire crews from the Tiwai Fire Brigade an hour and a half to control the fire. The cause of fire is unknown.	- PFAS in soil and groundwater. - Soil contamination following fires.
Workshops	Hydrocarbons, heavy metals,	- Incidental contamination associated with workshop activities.	- Contaminated soil/groundwater under/in

Land Use/Activity	Associated Contaminants (not limited to the following)	Contaminating Processes and/or Incidents	Potential Environmental Risks
Mechanical, electrical and other.			the vicinity of buildings and structures.
Buildings, Structures and Other Precinct Infrastructure	Asbestos, heavy Metals, fluoride, cyanide, hydrocarbons, sulphur compounds and a variety of solid wastes, liquid effluents, gaseous emissions and fugitive dusts.	- Asbestos in current and historical buildings. - Hazardous bulk dusts in buildings. - Incidental contamination from other smelter activities.	- Asbestos in buildings and soil. - Buildings and structures which contain hazardous bulk dusts e.g. heavy metals. - Contaminated soil/groundwater.

Contamination associated with the Tiwai Landfill/s and the Spent Cathode Lining (SCL) pad is detailed in Section 3.7.4.

3.7.3 Drain Discharges and Treated Sewage

Table 11 below summarises precinct drain discharges and treated sewage discharges onto land and into water.

Table 11 Liquid Discharges to Land and into Coastal Marine Areas

Land Use/Activity	Associated Contaminants	Contaminating Processes and/or Incidents	Potential Environmental Risks
Treated Sewage Discharges of treated sewage into water and land.	Organic and inorganic compounds, faecal coliforms, total phosphorous, total ammonia, nitrate, total nitrogen, chlorinated aliphatic hydrocarbons, Bacteria, viruses, heavy metal, nutrients, chlorinated phenols, PAHs, fluoride.	The wastewater from the smelter facilities (sanitary sewer from toilets, showers, laboratories, kitchens, canteens) was treated via an on-site wastewater treatment plant and had historically been discharged to Awarua Bay via a submerged outfall pipe. Consent was sought to discharge treated wastewater to an infiltration Site on land east of the smelter plant in 1995. Maximum daily discharge of 295 m^3/day to water and onto land. **Reported Incidents:** - Minor violations of excess suspended solids and contaminants onto land and into the coastal marine environments.	- Contaminated marine sediments and ecological disturbance (Awarua Bay). - Contaminated vegetation, soil and groundwater. - Migration of sewage components in groundwater into Foveaux Strait.
Stormwater Drain Discharge Onto land and into the coastal marine area (north drain, south drain and west drain).	Suspended solids, fluoride, hydrocarbons, heavy metals, phosphorous	Since 1996, NZAS has held discharge and coastal permits to discharge water including contaminants into the coastal marine areas of Awarua Bay and Bluff Harbour, including surface water (unspecified amount) and cooling, washing and flushing waters. **Reported Incidents:** - NZAS personnel contacted ES with a concern of diesel from bowser reaching sea via Site storm water drain. - Fluoride discharge via drains exceeding permit levels following heavy rainfall.	- Contaminated marine sediments and ecological disturbance. - Contaminated soil/groundwater.
SCL leachate and related discharge	Suspended solids, free cyanide, fluoride.	SCL leachate and water from cell superstructure and shell washing, cathode bar and handling equipment washings, burn-off washings, recovered groundwater and	- Contaminated marine sediments and ecological disturbance.

Land Use/Activity	Associated Contaminants	Contaminating Processes and/or Incidents	Potential Environmental Risks
Discharge of treated process water and leachate via a diffuser to Foveaux Straight		drain cleaning washings are transferred to the treatment plant adjacent to the SCL pad. The treatment plant consists of holding tanks, settling tanks, mixing tanks for treatment chemical addition, associated pumps, piping etc., chemical storage and a field laboratory. Treatment focuses on reducing cyanide, fluoride, and solids concentrations in the discharge to Foveaux Strait. Periodically, settling basins are cleared and the solids removed are added to the material stockpiled in the spent cathode lining storage building. **Reported Incidents:** - Violations of fluoride and cyanide discharge limits into the Foveaux Strait.	

Discharge locations are shown in Figure 12 below.

Figure 12 Smelter and Auxiliary Services at Tiwai Peninsula.

3.7.4 Landfills / waste stockpiles

One main landfill has been identified on the Site, known as “Tiwai Landfill” or “NZAS Landfill”. Available information for this landfill is summarised in this section. The main Spent Cathode Liner (SCL) waste stockpile is also included in this section as a significant waste deposit on the Site. Multiple discrete smaller waste areas, both waste pits (in ground) and waste stockpiles (above ground) are likely to be present on the Site, however records for these have not been included in the information made available.

The following documents have been reviewed for this section:

- CRA Advanced Technical Development 1993, Remediation of SPL Leachate Contaminated Groundwater at NZAS

- NZAS 1995a, Application for resource consent (Discharge permit): Discharges onto and into land NZAS Landfill
- NZAS 1995b, Assessment of effects on the environment: Discharges onto and into land NZAS Landfill
- NZAS 1995c, Landfill Management Plan
- AquaFirma Ltd 1995, Technical Review of NZAS Cathode Pad Contaminant Plume Report.
- Southland Regional Council 1995a, NZAS landfill staff report
- Southland Regional Council 1995b, Cathode Pad Contaminant Plume, Options for Remediation
- Southland Regional Council 1996a, NZAS leachate and sewage discharge staff report
- Southland Regional Council 1996b, Discharge permit (landfill)
- NZAS 2003a, Application and assessment of effects on the environment: Discharges onto and into land NZAS Landfill
- NZAS 2003b, Landfill Management Plan
- Southland Regional Council 2003, NZAS landfill staff report
- NZAS 2005, Assessment of effects on the environment: Discharge of treated effluent into Foveaux Straight and occupation and disturbance of the foreshore and seabed
- Southland Regional Council 2006a, Hearing decision NZAS consents
- Southland Regional Council 2006b, Hearing report NZAS consents
- NZAS 2009, Landfill Management Plan
- NZAS 2018, Annual Environmental Monitoring Report 2018
- NZAS 2019, Annual Environmental Monitoring Report 2019
- 'Tiwai Erosion Risk" – no date or author listed
- NZAS 2020 Quarterly Resource Consent Report: Quarter 2 2020

Tiwai Landfill

A brief description of the landfill is as follows: Tiwai Landfill is located at the western end of the Tiwai Peninsula, southwest of Pt Lot 1 DP 7529. The landfill is approximately 70 m from the coastline to the east, 180 – 230 from the coast to the west and north, and 600 m from Tiwai Point to the south. The topography of the area around the landfill comprises low ridges to the north, east and south. To the west, natural swamp lies between the landfill and the coast. Natural ground beneath the landfill is given as 3 – 4 m above sea level in the south and 8 m above sea level in the north. The landfill is unlined, and does not have a leachate collection system. The landfill has been formed through a combination of excavation below natural ground level (approximately 0.5 – 1 m excavation typically) and backfilling of the excavation, and placement of waste above the former ground level (building-up). Multiple layers of waste have been placed in some areas. This landfill area has been in operation at least since the smelter started operation (1972) and may have started during smelter construction (1970). The landfill is still in use.

Over its history, the landfill has accepted a wide variety of wastes from smelter operations, construction and demolition activities on the Site, and miscellaneous waste from the Site. Older sections / layers of the landfill are likely to comprise mixed waste deposits; from the early 1990s onwards, waste has been segregated and disposed of in specified areas for different waste types. Some areas are likely to therefore contain bulk deposits of lower risk materials while other areas contain largely high-risk materials.

Types of waste reported as deposited in the landfill include:

Aluminium dross	MMMF (man-made mineral fibres)
Alumina	MRP (metal recovery process) fines
Aluminium	Miscellaneous materials

- Asbestos (reported to be deposited in a segregated cell at the landfill.)
- Ash / clinker residue
- Building waste
- Carbon dusts
- Copper wire
- Cryolite
- Dust collector bags
- Concrete
- Floor sweepings
- Glass
- Paint tins
- Petroleum coke and metallurgical coke (contains pitch and iron)
- Plastics
- Refractory bricks
- Rubber
- Steel strapping
- Timber
- Tree and garden material
- Waste oil and grease
- Water-based liquids

A timeline of reported events, activities and investigations concerning the landfill is included in Table 12. Landfill maps available over different years are included as Figure 13 to Figure 16. Different wastes included in different areas and closure dates for each area are detailed in the Landfill Management Plans.

Table 12 Tiwai Landfill timeline

Year	Description
1970 – 1972	Landfilling began, associated with smelter construction and commissioning
1970s – 1980s	Construction material was deposited at the landfill in the early 1970s, mid 1970s, and early 1980s (coinciding with major construction and upgrades at the smelter).
Pre mid-1980s	Management consisted of covering completed areas
1984	Health department approved the landfill as an asbestos disposal site
1986 – 1987	Reduction in working face length completed as an additional management strategy
1991 – 1994	A series of landfill investigations were carried out. (NZAS 1991, Woodward-Clyde 1992 and NZAS 1994). These have not been made available, however information from these reports has been referenced in the documents reviewed.
1990 - 1992	Recovery of aluminium dross and MRP fines stored up to this time for offsite processing ‘Cleaning up’ and re-contouring of the landfill Clearer separation of wastes into different disposal areas and signage to support this
1991	A site walkover referenced in NZAS 1995b was undertaken 1991: ▪ Dust from MRP fines storage was affecting plants over an area extending approximately 200 m north east of the landfill ▪ Carbon rodding dust was visible up to 30 m from the landfill but impacts to plants only noted 2 - 3 m from landfill ▪ 20 x 30 m area visibly impacted by wind-blown oil ▪ Wind-blown plastic was distributed surrounding the landfill Prior to 1991, MRP fines were being stored in the landfill then recovered for recycling by another industry, involving screening and stockpiling of the MRP material on Site. Since 1991, MRP fines have been stored in cells, and covered with gravel and revegetated on completion.
1992	1992 landfill map (from NZAS 1995b) presented as Figure 13
1991 – 1992	Recovery of oil from waste oil pond for offsite reprocessing

1992	Oil contaminated bottom sediments and soil was excavated from the waste oil pit and relocated to a “bioremediation” area on the western side of the landfill (9,880 m^2, oil contaminated soil depth varying from 30 cm to 1 m) where biostimulation consisting of nutrient addition, pH monitoring and adjustment, tillage and deep ripping and monitoring were carried out. Start of landfill surface profiling
1993	Start of revegetation programme
1994	Small fire east of the landfill recorded
1994	Open burning as a landfill management practice was carried out up until 31 December 1994. At this time, the burning pit was closed and a small pit was formed in case burning for border control purposes was required
1994	Landfill assessment referenced in NZAS 1995b (undertaken in 1994 by Woodward-Clyde) indicates: ■ Approximate area 88,000 m^2 ■ Assumed average depth 5 m ■ Assessed volume 440,000 m^3 ■ Possible range of materials: – Refractory materials >50% – Timber and construction materials 10 – 20% – Other 5 – 15% – Metals 3 – 7 % – Carbon <5% – MRP fines <5% – Paper <1%

1995	**Consent application submitted to ES for landfill discharge** ■ The activity was described as "…discharge contaminants onto and into land (including in circumstances where the contaminants may enter water) at the NZAS Landfill". ■ **Estimated waste volumes:** – Approximately 5,000 tonnes per year waste material from smelter operations. – Approximately 8,000 – 10,000 tonnes of refractory material from Carbon Baking Furnace No 3 demolition anticipated in 1997 – 1998 period. – Refractory and other construction or demolition material if other Carbon Baking Furnaces or smelter facilities require rebuilding or substantial repairs. – Approximately 12,000 – 16,000 tonnes per year "COMTOR" product if other uses for this product were not established. COMTOR was described as a process to treat Spent Cathode Lining (SCL) via 1) removal of iron and grinding to reduce particle size, 2) thermal destruction of cyanide, and 3) ash treatment / stabilisation. This process was intended to treat both newly generated SCL and stored SCL from earlier production, and result in a product which could be used in offsite applications. If no offsite applications were viable, the COMTOR product would be landfilled. It is unclear whether the COMTOR process was commissioned on the Site or if this process was never installed. ■ **Wastes reported as disposed of or recycled offsite:** cardboard, facsimile rolls, ferrous metals, food waste, soda-glass from laboratories, liquids containing oils, medical wastes, non-ferrous metals, wood, plastics, non-process aluminium, oils, packaging paper, office materials, paper, ledger, PCBs, printer cartridges, refractory bricks. ■ **Wastes reported as stored onsite for future use or recycling:** chemicals, ESP tars, MRP (metal recovery process) fines, SCL. ■ **Groundwater investigation**: noted fluoride, ammonia, phosphorus, and oil and grease exceeding the criteria values which were used as a basis of comparison on the Site at the time. ■ The assessment notes that consideration was given to leachate collection and treatment, but this was not thought to be required. ■ Community complaints reporting dust blowing from NZAS landfill ■ Leaching as a pathway for contaminant migration is noted, via direct percolation of rainwater through the landfill profile to groundwater underlying the Site, and via surface water runoff. ■ **Landfill gases**: the assessment notes that the putrescible content of wastes is low so landfill gas generation from decay is insignificant. It also notes MRP fines may generate gas when wet. ■ **Landfill management plan:** states that areas are prepared for landfilling by removing vegetation, removing small mounds, and removing uncompacted surface pea gravel up to a depth of approximately 1 m. Soil, sand and pea gravel to be stockpiled for use as cover material.
1996	Consent granted for landfill discharge 1996 landfill map (NZAS 1995c) excerpted as Figure 14
1996	Removal of ESP tar
2002	Significant reduction in quantities of Dross Waste Product going to landfill

2003	**Consent application for landfill discharge and assessment of effects on the environment** This application was in part due to the impending expiry of the previous consent for the activity, and partially due to issues with the disposal of the material known as 'Haysom's Dross'. 'Haysom's Dross' was a waste product which originated at the smelter which was on-sold for processing to Haysom's Industries Limited. Processing did not take place, and the material had been the subject of over 10 years of dispute regarding disposal. The application sought consent to dispose of the dross at the NZAS landfill. The consent application included extending the landfill footprint to provide for disposal of the dross, in addition to continuing the existing disposal activities within the previously agreed landfill boundaries. ■ Filling has raised the ground to 7.1 – 10.5 m above sea level and evened out the surface. ■ A second and third layer of materials has been placed in some parts of the landfill. ■ Estimates of 50,000 tonnes of material landfilled between 1995 – 2003. ■ Groundwater quality is being impacted by the landfill. A number of contaminants are detected in the groundwater, attributed to landfill influence. Groundwater quality monitoring data and trends are included in the AEE ■ Haysom's dross has the following leachate contaminants of concern: ammonia, aluminium, fluoride and vanadium Mitigation measures (Section 9, AEE): *"In the unlikely event that an adverse effect on the environment occurs as a result of the discharge of contaminants onto or into land at the extended NZAS landfill that is significantly greater than the effects predicted in this AEE, then NZAS will either:* • *Remove some or all of the material(s) causing the adverse effects for another suitable location for disposal, and/or* • *Change the landfill management practices to reduce the adverse effects caused by the material(s)"* 2003 landfill map (NZAS 2003a) excerpted as Figure 15
2003	Landfill management plan (NZAS 2003b) ■ Notes that pitch tar has been excavated and boxed prior to relocation (unclear whether relocation within landfill or taken offsite) ■ Current Closure Plan provisions for the landfill are to cover, shape and revegetate the area ■ Bunding of cells is mentioned – cells to be prepared using waste materials for bund walls with outer walls to be covered with about 300 mm of soil, sand, or pea gravel and revegetated ■ An approximately 600 m^2 area is noted as a bioremediation area for oil contaminated materials ■ An approximately 9880 m^2 area was formerly used for bioremediation of oil contaminated soil. Oil content in soil in this area has been reduced to 'acceptable' levels and the areas closed and sown with grass.
2003 - 2004	Landfilling of Haysom's DWP was carried out in the extension of the landfill which had been approved for this purpose.
2009	Landfill management plan (2009 version) states that the bioremediation area will be permanently closed by the end of 2009 and oil contaminated material will be disposed of offsite

2018	2018 landfill map (NZAS 2018) excerpted as Figure 16 One complaint was received in 2018 from a member of the public related to landfill operations. The complaint was regarding excessive dust generated during high winds. NZAS responded by wetting down the source area. A small landfill fire also occurred in September 2018, in the general waste cell. Metal reclamation plant stockpile: dross was not mined from the old MRP area during 2018. Inalco (independent company) processed newly produced dross and also processed some containerised dross which had been stored onsite during 2018. The planned approach is for Inalco the process both the containerised dross and the landfilled MRP stockpile. Aerial drone survey and photogrammetry were carried out to determine volume increases of various stockpiles within the landfill area (general waste, cleanfill, carbon, MRP dross and Haysom's Dross (control site). Groundwater monitoring results from wells around the landfill show landfill-associated nitrogen, fluoride, sulfate, sulfite present in groundwater, with varying contaminants decreasing, increasing, or plateauing in different monitoring locations over recent years.
2019	2019 monitoring report states that in 2020 a new cell for Carbon Bake Furnace brick disposal will be created. Inalco processed newly produced dross and some containerised dross which had been stored on site during 2019. No dross was mined from the old MRP area during 2019. Groundwater monitoring results were generally similar to 2018.
2020	Quarter 2 results show groundwater monitoring results were generally similar to 2019 for this quarter.

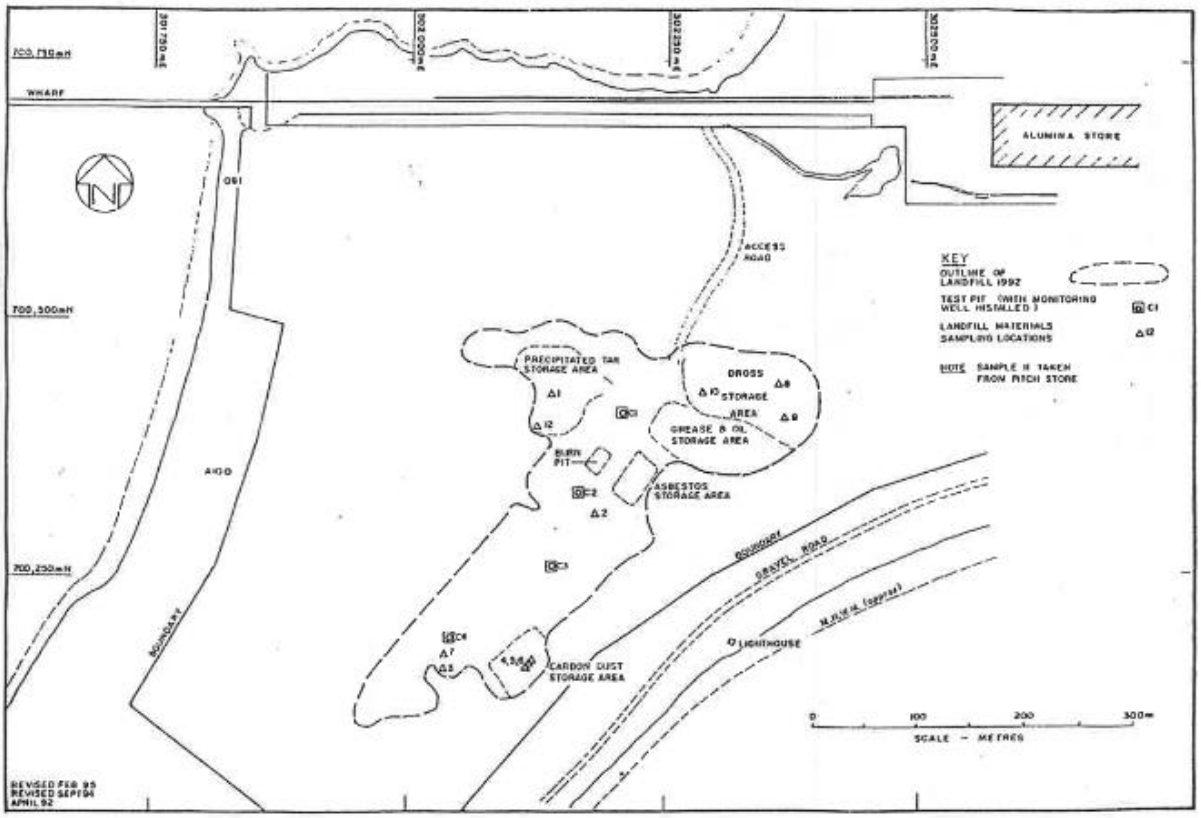

Figure 13 Landfill Map, 1992 (NZAS 1995b)

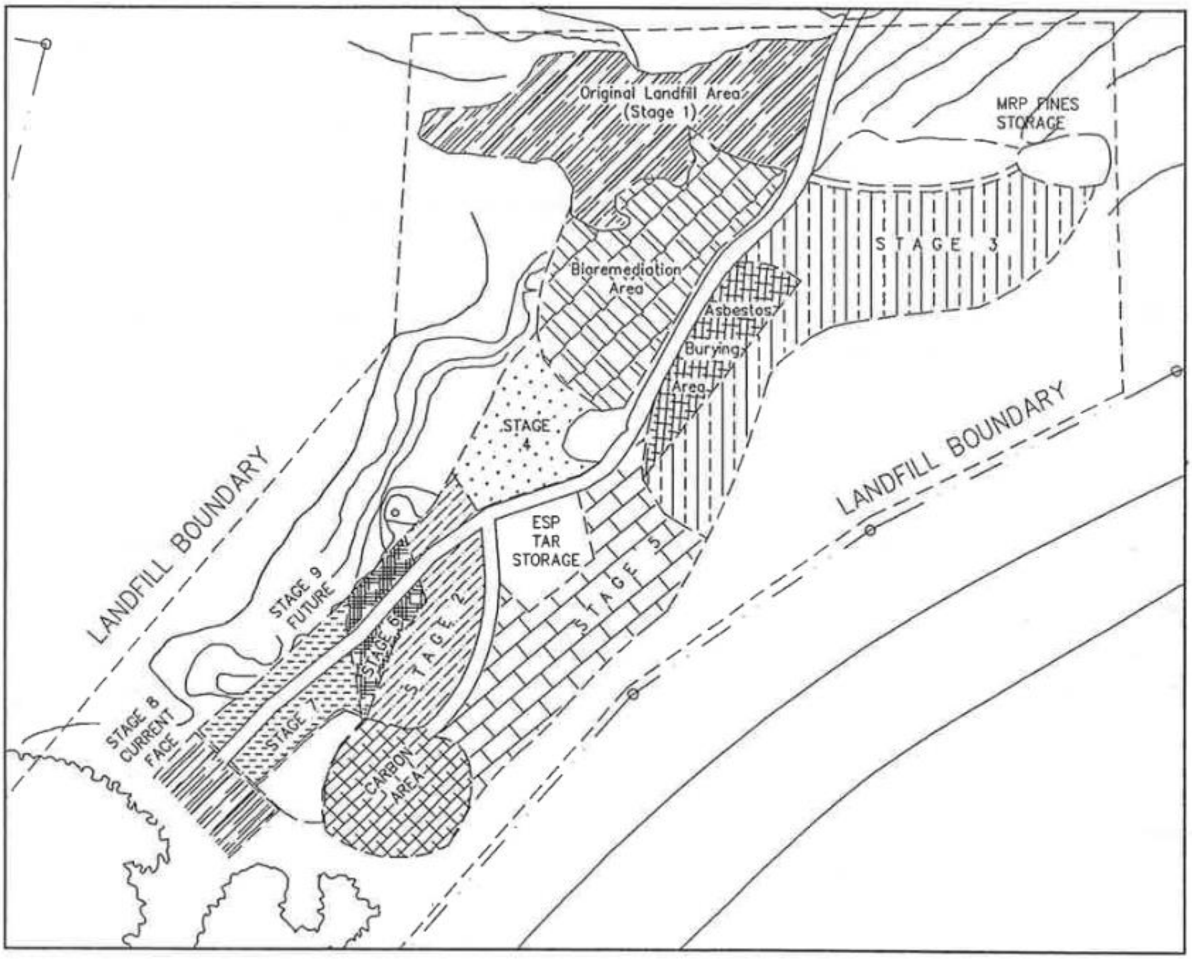

Figure 14 Landfill Map, 1995 (NZAS 1995c)

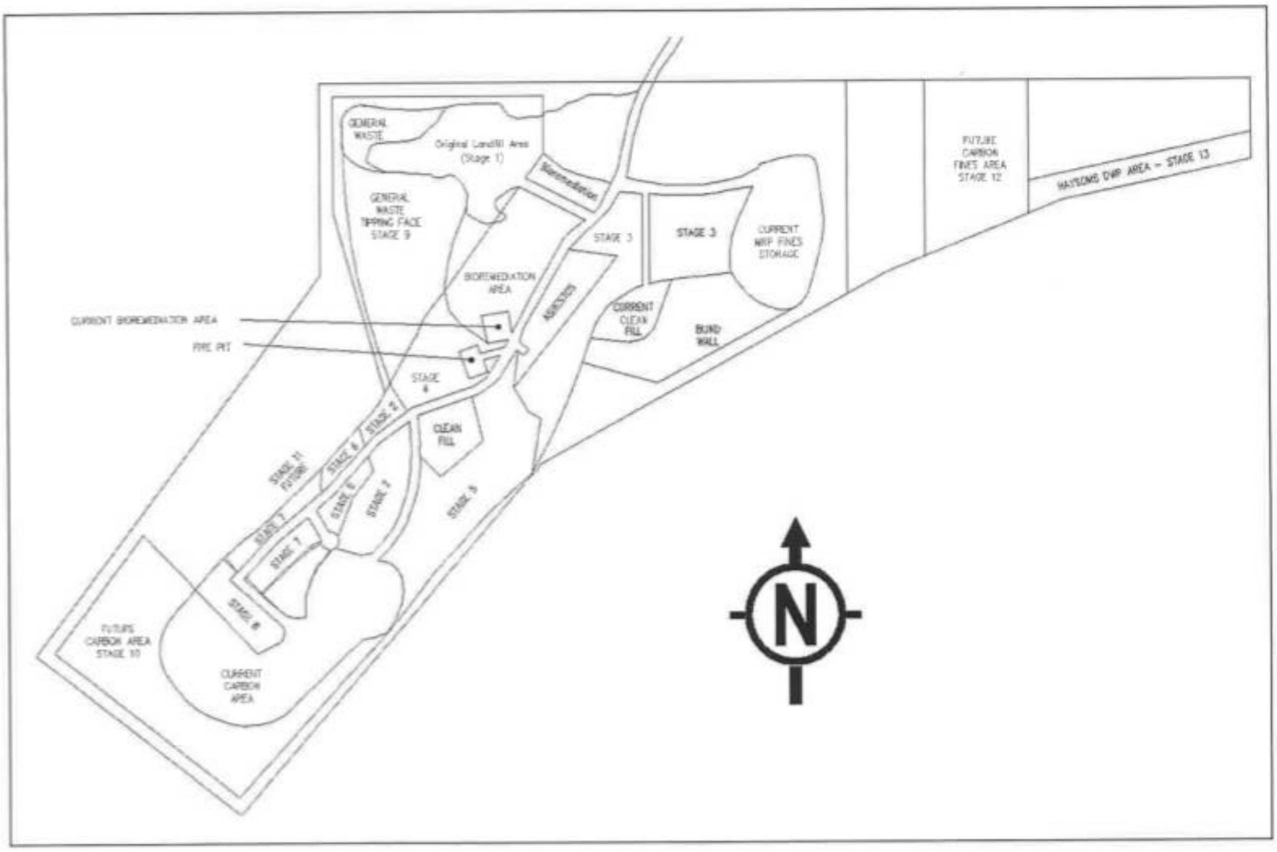

Figure 15 Landfill Map, 2003 (NZAS 2003a)

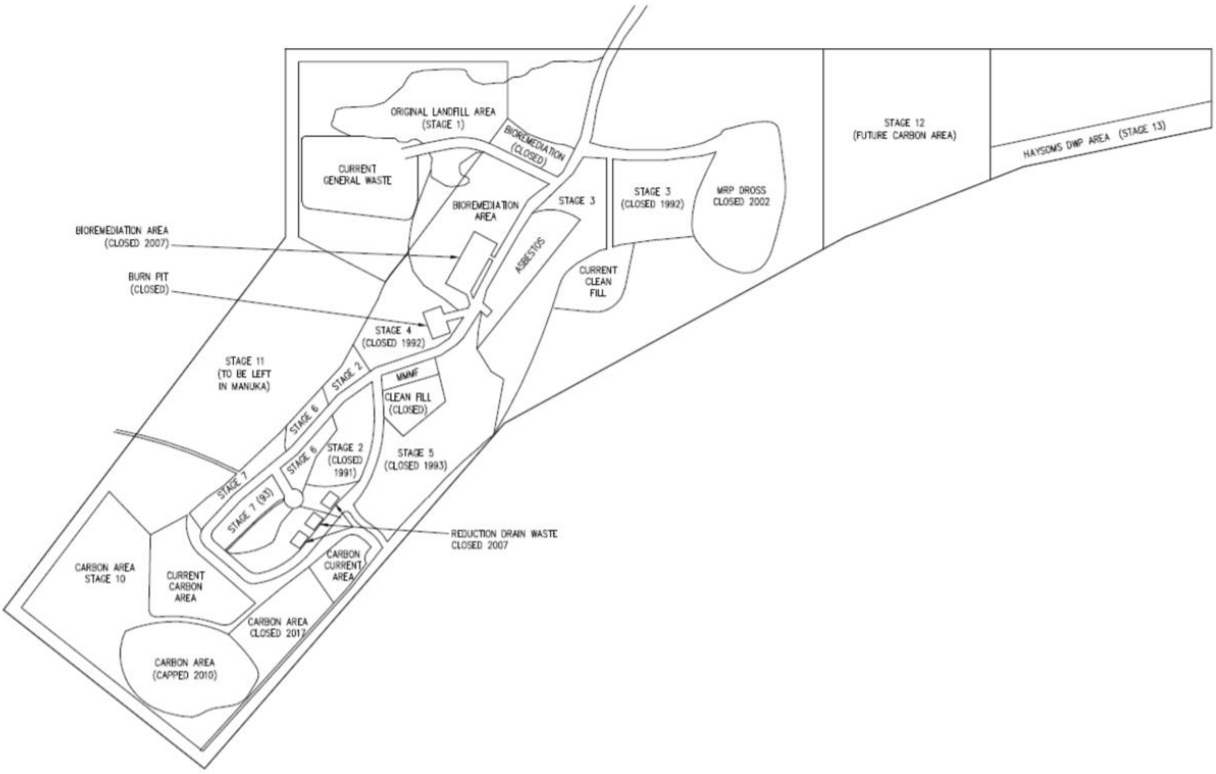

Figure 16 Landfill Map, 2018 (NZAS 2018)

Landfill volume estimate

Estimates of the current volume of the landfill are based on broad assumptions and should be considered a 'best guess'. Two approaches to estimating the landfill volume are included here, which provides a cross-check opportunity, although some underlying assumptions are carried across both approaches, limiting the independence of the methods. Multiple sources of information have been combined to make estimate, each with inherent uncertainty. The first approach presented is to roughly estimate the total waste volume based on observed soil disturbance areas and reported waste depths, and calculate the total volume based on these parameters (geometry approach). The second approach presented is to tally up recorded waste disposal volumes on a year-by-year basis to generate a total, which also has the benefit of providing a break-down of waste types included in the landfill.

1) Total volume based on area and depth

The extent of ground disturbance observed in historical aerial images within the landfill boundaries is approximately 15.5 Ha for the main landfill body and approximately 1.6 Ha for the Haysom's Dross extension. The average waste depth is assumed to be 5 m thick in the main landfill body, based on reported waste depths up to 7 m thick balanced against the likelihood that some areas have shallower waste depths. The depth of waste in the Haysom's Dross extension is assumed to be 1 m thick based on its reported construction. This equates to a volume of 775,000 m^3 in the main landfill and 16,000 m^3 in the Haysom's Dross extension. Note that the true landfill volumes may be larger or smaller than these estimates.

As a preliminary cross-check, the main landfill was estimated at 440,000 m^3 waste volume in 1992. This was approximately 25 years after the smelter commenced operation. Extrapolating out the waste deposition over the intervening 25 years to today, the waste volume estimate presented of 775,000 m^3 is broadly consistent with the 1992 estimate (waste disposal of approximately 400,000 m^3 per 25 years). The Haysom's Dross extension estimate of 16,000 m^3 is broadly consistent with news articles at the time of the Haysom's Dross issue, which reported approximately 16,000 tons of Haysom's Dross.

2) Volume based on recorded waste deposition

A table presenting year-by-year totals of recorded waste deposited in the landfill, and assumptions made in this estimate, is presented in Appendix 6.

In summary, estimated total volumes by waste type and the overall total estimated volume are included in Table 13.

Table 13 Estimated volumes of waste in landfill

Waste type	Volume (m^3)
Refractory materials	233,125
Timber and construction materials	68,436
Other	74,148
Metals	25,371
Carbon	135,211
MRP fines	43,385
Paper	4,928
ESTIMATED TOTAL	**624,205**

The total volume estimated by this method is approximately 624,000 m^3. This is generally consistent (~20% difference) with the estimate based on assumed area and depth of the landfill.

Note that both of these methods rely on the 1992 estimate of 440,000 m^3 as a baseline for estimating landfill volume; the uncertainty in this original estimate is unknown. Comparisons of our estimates of volumes added to the landfill from 1992 – 2019 are presented in Table 14. This shows approximately 60% difference in the estimates for waste disposal post 1992, which is more indicative of the uncertainty in these estimates.

Table 14 Post 1994 landfill volume estimates

Method of estimation	Volume added 1992 - 2019
Method 1) Volume based on area and assumed depth	335,000 m^3
Method 2) Volume added based on waste disposal records	184,000 m^3

An additional method to estimate the landfill volume would be via totalling up waste generated by the smelter and associated activities each year, and factoring in waste disposal / recycling offsite and landfill re-working activities, however insufficient information is available to fully explore this method.

Spent Cathode Liner stockpile

The Spent Cathode Liner stockpile is a large stockpile of waste material located on a purpose-built pad, sometimes referred to as a landfill, present to the east of the smelter plant, adjacent to the south coast. Spent Cathode Liners (SCL, also referred to as Spent Cell Liners, Spent Pot Liners, Spent Cathode Waste) is a waste product of the aluminium smelting process. This comprises the carbon cathode lining used in the smelter cells. Cathode linings generally have a useable lifespan of approximately 6 - 7 years prior to disposal. At the end of their useful life, cells are processed. The superstructure is removed, electrolyte bath contents and aluminium are removed from the cell cavity and the SCL is broken up and removed. The cell superstructure and shell are then washed prior to refurbishment and return to service.

The SCL is a hazardous waste product. During active service, cyanide complexes are formed in the cathode material. It also adsorbs fluorides from the cryolite solution. Cyanide and fluoride can leach from the SCL along with other contaminants, including heavy metals. SCL can also react with water to form toxic and explosive gases (ammonia, hydrogen cyanide, hydrogen, methane). NZAS considers the leachable components make the SCL unsuitable for conventional landfilling (NZAS 2005).

A timeline of reported events and activities concerning the SCL stockpile is included in Table 15.

Table 15 SCL stockpile timeline of events and reports

Year	Details
1970s - 1992	SCL generated at the smelter was stored uncovered on concrete pads with leachate collection systems until 1992. The concrete pad containing rain water leachate from the SCL stockpile was confirmed to have failed in 1992. This containment failure and resultant contamination is expected to have been ongoing since cathode storage began in the mid-1970s. Infiltration of leachate to groundwater resulted in what was described as “severe” groundwater contamination beneath and downgradient from the spent cathode pad. The zone of contamination is described as <1 Ha. Groundwater abstraction and use in the contaminated area is unlikely. Treatment technologies for remediating the contaminant plume were not available at the time of the report (CRA Advanced Technical Development 1993). The two former stockpiles were combined and covered with an impervious liner (high density polyethylene material with welded joins) following this detection to prevent ongoing leachate discharge to groundwater. Water which was present in the SCL prior to covering gradually drained to the collection system or evaporated through the cover ventilation system. The SCL pile is understood to be drier than when it was placed. The water in the collection system was transferred to the treatment plant, which also treats water from cell superstructure and shell washing, cathode bar and handling equipment washings, burn-off washings, recovered groundwater and drain cleaning washings. The treatment plant is adjacent to the SCL stockpile.

Post-1992	Since 1992, newly generated SCL has been stored in several buildings designed for the purpose of SCL storage. The assessment (NZAS 2005) notes that NZAS "…has always stored the spent lining so it could be treated when suitable technology became available." Wet SCL material used to be placed in one of the SCL sheds. At one time this resulted in water leaking through the floor, which was captured by the underfloor membrane and treated through the treatment plant. Wet SCL material is no longer placed in SCL sheds.
1995	Southland Regional Council agreed to allow the cathode pad contaminant plume to disperse without active remediation efforts. The plume was identified to contain fluorine, cyanide, and ammonia.
1996	Consent application report notes that treated cathode pad effluent was being discharged to the costal marine environment, via a submerged diffuser in Foveaux Straight. The consent application sought for this discharge to continue.
2005	Application for resource consent and an assessment of environmental effects in regard to treated effluent from the Cathode Stockpile. This documentation states that NZAS held existing consents for this activity which were due to expire 2006 Discharge is listed as comprising: – Leachate from the spent cell stockpile – Cell superstructure and shell washings – Cathode bar and handling equipment washings – Burn-off washings – Recovered groundwater – Drain cleaning washings Effluent sources are transferred to the treatment plant adjacent to the spent cathode lining stockpile. The treatment plant consists of holding tanks, settling tanks, mixing tanks for treatment chemical addition, associated pumps, piping etc., chemical storage and a field laboratory. Treatment focuses on reducing cyanide, fluoride, and solids concentrations in the discharge. Periodically, settling basins are cleared and the solids removed are added to the material stockpiled in the spent cathode lining storage building. Analytical results from groundwater monitoring downgradient of the pad indicates that over 2002 – 2005 the contaminant plume was recovering
2018	Discharges were within consented limits
2019	One exceedance of the permitted cyanide concentration in discharge from this area (discharge 24 g/m^3, limit 20 g/m^3, volume 80 m^3)
2020	Documents provided refer to the SCL stockpile area as being at risk of erosion. Site inspection notes dated 17/03/2020 note that erosion is evident, limited to an area east of the smelter, in front of the SCL stockpile. Significant erosion of the beach dune has resulted in the beach losing more than 20 m of land in the last decade, projected to continue at 3 – 5 m per year loss. The notes indicate that the SCL stockpile is vulnerable to erosion and the current estimate is that it will be approximately 10 years before the stockpile will be at risk. No formal assessment is included, and the supplied documents were not attributed to an author / organisation. This contradicts MetOcean Solutions Ltd's 2017 assessment, which is summarised in Section 2.4.5.
2020	Quarter 2 results show all discharges were within permitted limits for this quarter.

Estimated SCL Waste (Generated and Stored On-Site)

No site visit or site investigations have been conducted by Aurecon and the work presented here is based on information made available to Aurecon. The exact volumes of SCL waste generated and stored at the site is unknown.

Estimates for the average mass of SCL generated per tonne of aluminium produced at smelters is expected to vary between 7 and 50 kg, but an average of approximately 25 kg is frequently given. The known values of aluminium produced (tonnes) since operations commenced and the estimated average of ~25 kg of SCL per tonne of aluminium produced at Tiwai Aluminium Smelter has been used to estimate the volume of SCL waste generated since 1971. These indicative values are presented in Table 16.

Table 16 Estimated Volumes of SCL Waste Generated at Tiwai Point Aluminium Smelter since 1971.

Year	Aluminium Produced (tonnes of saleable metal)	Estimated SCL Waste Generated (tonnes) Calculated using average estimate of ~25kg of SCL per tonne of Aluminium)	Notes
Nov 1971 – Jan 1985	2,000,000	~50,000	- Majority of the SCL generated during this time period is likely to have been stockpiled on the SCL pad - covered in 1992. - Annual aluminium production from 1992 has been included in the total estimate.
Jan 1985 – Jan 1989	1,000,000	~25,000	
Jan 1989 – Jan 1993	1,000,000	~25,000	
1971 - 1993 Estimated Total	**4,000,000**	**~100,000**	
Jan 1993 - Sep 1995	1,000,000	~25,000	- Majority of the SCL waste generated during this time period is likely to have been stored in designated SCL buildings within the smelter precinct.
Sep 1995 – Dec 2011	5,000,000	~125,000	
Dec 2011 – Dec 2019	3,038,364	~76,000	
Dec 2019 – Current	~330,000 (estimated)	~8,250	
1993 - 2020 Estimated Total	**~9,368,364**	**~234,250**	
Total	**~13,368,364**	**~334,250**	

The estimated volumes of SCL waste stored on-site have been refined and are estimated as follows:

- SCL Pad: approximately 42,500 m^3
- SCL Store Buildings:
  - SCL 1 8800 m^3
  - SCL 2 16,500 m^3
  - SCL 3 12,500 m^3
  - SCL 4 8,800 m^3
- Total waste volume in SCL Store Buildings: approximately 46,700 m^3

Volumes have been calculated using SCL pad and building measurements acquired from satellite imagery, and assumptions around SCL pile height within the sheds. Estimated dimensions and calculated volumes are presented in Appendix 6. These values do not take into account any SCL waste stored in any other buildings on-site or SCL waste that may have been deposited into the Tiwai Landfill recycled and/or taken off-site. It also does not include the Cathode Linings currently in the potlines.

4 Preliminary Conceptual Site Model

4.1 Introduction

The CSM outlines the potential source-pathway-receptor linkages that may be present. The CSM defines what contamination could be present at a site, how it may travel and what receptors they could affect by doing so. Establishing these factors is essential to guide the preparation of an investigation plan. Refer to Table 17.

Table 17 Conceptual Site Model

Sources	Pathways	Receptors
NZAS Industrial Precinct Contaminants associated with smelter operations and processes (refer to Table 9 for associated contaminants).	Pathways for contaminant exposure and migration of contaminants generally include the transport of contaminants via air, solid phase, and water. The potential pathways identified from the desk information are: ▪ *Direct contact (dermal and ingestion)* ▪ *Inhalation of contaminated dust and vapours* ▪ *Overland transport of contaminated sediment in surface water* ▪ *Migration of contaminants to coastal waters via precinct drainage points and groundwater* ▪ *Dispersion and deposition of contaminants from precinct emission discharges to air.*	*Receptors include people and the environment (for example surface water ecosystems) that are or may be adversely affected by the identified contaminants. The potential receptors identified in the assessment include:* ▪ *Current and future site users at Tiwai Peninsula* ▪ *Adjacent land (including conservation land and archaeological sites)* ▪ *Maintenance and construction/excavation workers* ▪ *Ecology including coastal vegetation, coastal/marine habitats and important biodiversity (e.g. endangered Looper Moth and Foveaux Shag)* ▪ *Underground infrastructure* ▪ *Groundwater and the 'sensitive' Tiwai aquifer* ▪ *Coastal marine areas (including Bluff Harbour, Foveaux Strait and Awarua Bay) and associated commercial and recreational activities.*
NZAS/Tiwai Landfill Contaminants associated with landfilling operations and disposal of on-site waste Contaminants associated with the Tiwai landfill (as well as volumes and types of waste) are detailed in Section 3.7.4.	The potential pathways identified from the desk information are: ▪ *Direct contact (dermal and ingestion)* ▪ *Inhalation of contaminated dust, and vapours* ▪ *Overland transport of contaminated sediment in surface water* ▪ *Migration of contaminants to coastal waters via groundwater.* ▪ *Coastal erosion*	As above.
Spent Cathode Lining (SCL) Pad Contaminants associated with SCL stockpiling. SCL is of particular concern as it is corrosive and reacts with water releasing toxic and explosive gases. It can also generate cyanide and fluorine in leachate leading to adverse environmental impacts.	Pathways for contaminant exposure and migration of contaminants generally include the transport of contaminants via air, solid phase, and water. The potential pathways identified from the desk information are: ▪ *Direct contact (dermal and ingestion)* ▪ *Inhalation of contaminated dust, leachate and vapours* ▪ *Overland transport of contaminated sediment in surface water* ▪ *Migration of contaminants to coastal waters via effluent drainage point and groundwater* ▪ *Coastal erosion*	As above.

5 Current Risks

The Treasury has asked Aurecon to identify current risks to human health and the environment associated with the Site prior to remediation.

Based on the Conceptual Site Model the potential current risks are to:

- Ecological receptors in the coastal marine area
- Humans and livestock on the Site or in the wider area
- Groundwater

The theoretical risks are presented by:

- Solid and liquid hazardous substances and hazardous waste currently stored on the site associated with the industrial precinct, the landfill/s and the SCL pad;
- Contaminated land and groundwater at the site;
- Discharges of contaminated stormwater and SCL treatment plant waste into the coastal marine area;
- Discharges of contaminants (primarily fluoride) into air via the stack;
- There are potential fire or explosion risks presented by carbon dust and flammable hazardous substances.

Current occupational risks to workers presented by contamination include exposure to PAHs in dust originating from incomplete combustion as well as asbestos containing dust. Other potential exposures in include: sulphur dioxide and fluorides; aluminium fluoride; fibrous sodium aluminium tetrafluoride particles; fluorspar; alumina; carbon monoxide; carbon dioxide; various trace metals, such as vanadium, chromium and nickel; asbestos; extreme heat; and high static magnetic fields (cited from: *Chemical Agents and Related Occupations* 2012. IARC Working Group on the Evaluation of Carcinogenic Risk to humans ISBN-13: 978-9283213239)

As an active industrial plant, the smelter is legally required to meet the requirements of the Health and Safety at Work Act 2015.

6 Future effects of climate change

The Site is located on a low-lying peninsula and is subject to coastal erosion. Climate change predictions suggest that coastal inundation will occur in the future.

The future effects of climate change are addressed in Aurecon letter 510555-0000-LET-KF-0001 Rev1 which is provided in Appendix 3.

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9 Reference List

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New Zealand Aluminium Smelters Limited (NZAS). (1995). *Assessment of Effects on the Environment: Discharges onto and into Land, NZAS Landfill*. Tiwai Point, New Zealand: New Zealand Aluminium Smelters Limited.

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1

Drawings

Appendix 1

Drawings

NOTES:

AREAS OF RZA'S ARE APPROXIMATE AND THE INFORMATION IN THIS DRAWING IS FOR HIGH LEVEL DECISION MAKING ONLY. BOUNDARIES ARE APPROXIMATE AND SHOULD BE SET OUT BY A LICENSED CADASTRAL SURVEYOR. AERIAL IMAGERY SOURCED FROM INVERCARGILL CITY COUNCIL, ENVIRONMENT SOUTHLAND REGIONAL COUNCIL AND LINZ DATA SERVICES AND REPRODUCED UNDER THE CREATIVE COMMONS ATTRIBUTION 3.0 NEW ZEALAND LICENSE.

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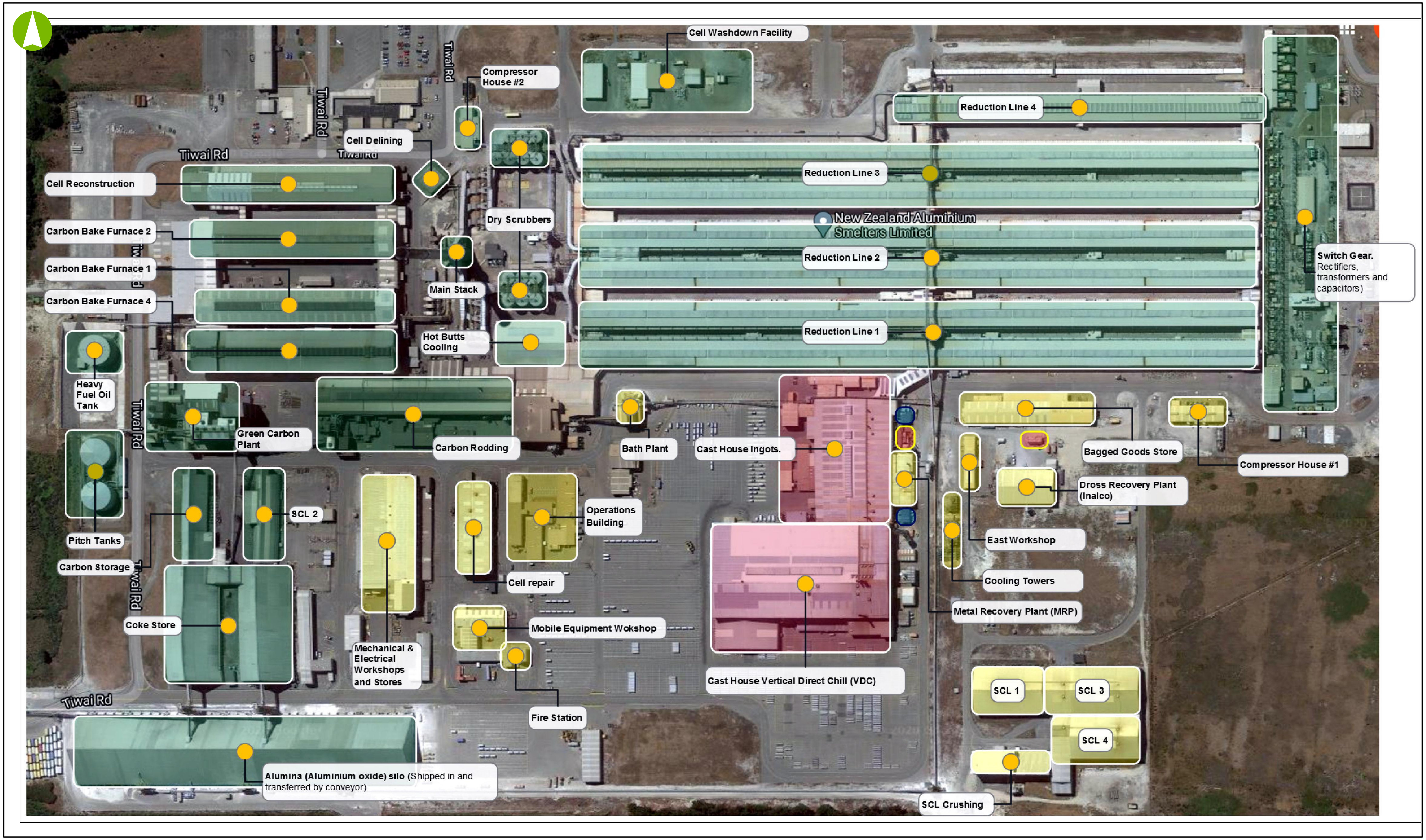
SHEET 1 OF 3

DOCUMENT	PROJECT No.	WBS	TYPE	DISC	NUMBER	REVISION
	510555	0000	DRG	KF	0001	A



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PROJECT	PROJECT 14 - IDENTIFICATION OF REMEDIATION OPTIONS
TITLE	SITE LOCATION PLAN - INDUSTRIAL PRECINCT SHEET 2 OF 3

DOCUMENT	PROJECT No.	WBS	TYPE	DISC	NUMBER	REVISION
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SHEET 3 OF 3

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3

Climate Change

Appendix 3
Climate Change

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2020-10-30

Daniel Lawrey
Senior Analyst, Natural Resources
Te Tai Ōhanga, The Treasury

Delivered by upload to The Treasury secure site

Dear Daniel

Project 14, Tiwai Point Landfill Climate Change Risk Assessment

1 Background

Treasury has requested that Aurecon provide initial advice on the risks of the Tiwai Point landfill being exposed by erosion or subject to coastal inundation. If there are material risks, Treasury has requested advice on potential actions that may be necessary to manage risks (e.g. removal of waste, coastal defences).

Aurecon has addressed the above request by conducting a high-level assessment of the impact of erosion on the landfill and the impact of climate change on coastal inundation of the landfill. Essentially, the impact of erosion and the impact of climate change have been considered as the same risk. Material risks have been defined as any significant change to the current discharges from the site. Potential actions are limited to conceptual information on management options for the landfill.

2 Climate Change Risk

2.1 Background

The initial climate change risk assessment (screening) of the site, has identified the following coastal climate change risks:

1. Sea level rise combined with erosion generating storm surge events will cause an inland movement of the coastline within 100 years that may erode any landfill “berms” and is thus likely to expose and release contaminants in several landfill areas and contaminated sites.
2. Sea level rise induced saltwater intrusion into several landfill and contaminated sites would occur before any erosion exposed the contaminants. Saltwater intrusion may increase the flushing of contaminants into the environment and may chemically react with some of the wastes resulting in the release of secondary reaction products.

2.2 Site sensitivity:

- Tiwai Spit is generally only 6 – 7m above sea level
- The landfill is located within the south-western portion of the site, approximately 50-100 meters from the existing coastline.
- The landfill is unlined and contains a variety of commercial wastes including carbon, timber, clean fill, asbestos, MMMF, general wastes and historic deposits of aluminium dross.

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2.3 Sea level Rise projections and coastal processes:

The Ministry for Environment's (MfE) Coastal Hazards and Climate Change guidance provides four scenarios of future sea-level rise to use in conducting hazard and risk assessments.

It also provides minimum transitional sea-level rise values for use in planning processes for two out of four broad categories of development. In applying this risk assessment, Category C – Existing coastal development and asset planning, is the most appropriate category. Category C requires:

For planning and decision timeframes out to 2120, councils should use a minimum transitional value for sea level rise of 1 metre relative to the 1986-2005 baseline.

New Zealand-wide sea-level rise projections recommended in the Ministry for the Environment's 2017 coastal guidance, based on the IPCC 5th Assessment Report. Sea level height is relative to the average mean sea level over the recent period 1986-2005, which IPCC use as a zero baseline for projections. The collapse of parts of the Antarctic ice sheets could substantially increase the upper end of this range. New Zealand's offshore sea-level rise (SLR) may be up to 0.05 m more than global average sea level rise (Ackerley et al, 2013)

The Bruun Rule[1] applied to the sandy coastline from Tiwai point, extending eastward, indicates 1.0 m SLR would migrate the coastline inland by about 100 m through erosion and new equilibrium of coastal processes.

Coastal Erosion Assessment along Tiwai Peninsula 2017 indicates that, 'the South coast of the South Island receives far-field wave energy originating from frequent storms in the Southern Ocean. This large amount of incident energy in a micro-tidal system predominantly contributes to influence the coastal dynamics over years, generating alternating areas of accretion and erosion driven by the longshore sediment transport patterns. It is likely that the combined effect of the interannual variability of the wave climate influenced by large-scale processes such as the Southern Oscillation or global warming are therefore susceptible to significantly modify the coastal sediment budget at different time scales.' With sea level rise the inland migration of the coastline will be a pre-dominant driver of change over time. The change in climate will also influence the scale and extent of the Southern Oscillation.

The storm surge events are when substantial changes will occur. It is likely that climate change will increase in magnitude and frequency of storm surge events in the region, generating greater beach erosion events and new coastline equilibrium. The assessment of vertical land movement trends for the site has not been included i.e. is the land sinking over time that would accelerate the impact.

2.4 Coastal Climate Change Risk Assessment

A risk management framework has been used to assess the climate change risks to the landfill. This framework is based on the Australia New Zealand Standard ISO 31000 (AS/NZS ISO 31000: 2009), Risk management – Principles and Guidelines. This Standard is a globally accepted standard for managing all forms of risk. The climate risk assessment is also aligned to the Australian Standard AS 5334: 2013 Climate Change Adaptation for Settlements and Infrastructure. To ensure the risk assessment was relevant to the marine/coastal context and New Zealand risk thresholds, the MfE guidance on risk management for Aquaculture Risk Management Options 2007[2] was used.

Timeframes were selected in accordance with the NZ Coastal Policy Statement 2010, 'to plan ahead for "at least 100 years" and for use in developing and stress-testing options in dynamic adaptive pathways to plan ahead for adaptation in coastal lowland areas.'

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[1] The Bruun Rule is a formula for estimating the magnitude of the retreat of the shoreline of a sandy shore in response to changes in sea level.
[2] https://www.mfe.govt.nz/publications/marine/aquaculture-risk-management-options/4-risk-management-frameworks

The following risk assessment table highlights the risk, it's rating and the residual risk after mitigation solutions are implemented. The likelihood, consequence and risk rating are derived from the risk assessment framework in Appendix 1.

Table 1. Risk Assessment of Tiwai Point Landfill

Risk	Risk Description	Likelihood	Consequence	Risk Rating	Existing Controls	Confidence in rating
1. Coastal erosion of landfill	Sea level rise of 1m combined with erosion generating storm surge events will cause an inland movement of the coastline by 100 metres within 100 years eroding landfill "berms" and releasing contaminants causing extensive irreversible environmental damage and health impacts with the potential to cause fatalities	Almost Certain	Catastrophic	Extreme	None	Moderate to high
2. Saltwater intrusion into landfill	Sea level rise of 1m induces saltwater intrusion into the landfill within 100 years. This will cause flushing of contaminants into the environment causing extensive irreversible environmental damage and potential health impacts to humans with the potential to cause loss of life	Almost Certain	Catastrophic	Extreme	None	Moderate to high

The risks assessed are both Extreme risks. The suggested response in the risk framework is to 'Avoid or eliminate threat'.

Existing controls for both risks are minimal as only moderate sea level rise has occurred to date.

The confidence rating for likelihood is moderate to high as the direction of sea level rise is certain and the rate of acceleration of sea level rise by the end of the century is conservative.

The risk mitigation options and residual risks are assessed in Table 2 below.

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Appendix 1 Risk Assessment Framework

The risks have been assessed using the following three MfE risk assessment tables whereby:
Consequence x Likelihood = Risk Rating

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3 Risk assessment

Table 3: Risk assessment matrix and mitigation treatment

	Minor (1)	**Moderate (2)**	**Major (3)**	**Severe (4)**	**Catastrophe (5)**
Almost Certain (5)	**Low risk** Enhance systems to minimise potential Accept Repair	**Moderate risk** Enhance systems to minimise potential	**Very high risk** Immediate action Avoid Enhance systems to minimise potential	**Extreme risk** Immediate action Cease activity Avoid or eliminate threat	**Extreme risk** Immediate action Cease activity Avoid or eliminate threat
Likely (4)	**Low risk** Enhance systems to minimise potential Accept Repair	**Moderate risk** Enhance systems to minimise potential Insure	**Very high risk** Immediate action Enhance systems to minimise potential	**Very high risk** Immediate action Avoid Contingency plans	**Extreme risk** Immediate action Cease activity Avoid or eliminate threat
Possible (3)	**Negligible risk** Accept Repair	**Moderate risk** Enhance systems to minimise potential Insure Contingency plans	**Very high risk** Immediate action Insure Contingency plans	**Very high risk** Immediate action Avoid Contingency plans	**Very high risk** Immediate action Avoid Contingency plans
Unlikely (2)	**Negligible risk** Accept Repair	**Low risk** Accept Repair	**High risk** Monitor Insure Contingency plans	**High risk** Monitor Insure Contingency and disaster plans	**Very high risk** Monitor Insure Contingency and disaster plans
Rare (1)	**Negligible risk** Accept Repair	**Low risk** Accept Repair	**Moderate risk** Monitor Insure Contingency plans	**High risk** Monitor Insure Contingency and disaster plans	**High risk** Monitor Insure Contingency and disaster plans

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Records of Title

Appendix 4
Records of Title

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Historical Aerial Photographs

Appendix 5
Historical Aerial Photographs

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Appendix 5 – Historical Aerial Images

Figure 1 Tiwai Peninsula 1951 Aerial Image (sourced from Retrolens

Figure 2 Tiwai Peninsula 1962 Aerial Image (sourced from Retrolens)


Figure 3 Tiwai Peninsula 1969 Aerial Image (sourced from Retrolens)


Figure 4 Tiwai Peninsula 1978 Aerial Image (sourced from Retrolens)

Figure 5 Tiwai Peninsula 1985 Aerial Image (sourced from Retrolens)

Figure 6 Tiwai Peninsula 1998 Aerial Image (sourced from Retrolens)

Figure 7 Tiwai Peninsula 2013-2014 Aerial Image (sourced from Land Information New Zealand (LINZ))

Figure 8 Tiwai Peninsula 2020 Aerial Image (sourced from Land Information New Zealand (LINZ))

Figure 9 Tiwai Peninsula 2020 (Adjacent Site) Aerial Image (sourced from LINZ).

6

Landfill And SCL Waste Calculations

Appendix 6
Landfill and SCL Waste Calculations

Note: The landfill has been subject to re-working processes over its history, including significant work in the early - mid 1990s to recover and recycle / remove from site previously deposited waste including aluminium dross and MPR fines, ESP tar, oil, and a bioremediation programme for oil contaminated soil / sediment. This history of re-working previously deposited wastes adds to the uncertainties in the following estimates.

Table 1: Estimated disposal to landfill per year

Year	Notes	Waste (m3)								
		Refractory materials	Timber and construction materials	Other	Metals	Carbon	MRP fines	Paper	**Increase per period**	**Running total**
Pre-1992	No detailed records have been made available for waste disposal prior to 1992. In 1992, an assement was made of the waste volume by Woodward-Clyde. This document has not been reveiwed first-hand, however it is referenced in NZAS 1995b. Estimated total landfill volume and waste type by percent (not stated whether by volume or mass; assumed to be by volume) from this report is included here as our 'baseline' for landfill contents. Where a range has been given for a waste type, the mid-point has been used in this estimate.	220000	66000	44000	22000	22000	22000	4400	-	440000
1993	NZAS 1995b referenced waste surveys undertaken in 1993 which indicated an average of 21,170 tonnes per year (with an unusually high amount of 14,200 tonnes bricks per year at the time due to site upgrade works). Assuming a bulk density of 2.2 T/m3 for bricks, 0.6 T/m3 for carbon and 1.5 T/m3 for other waste types, and assuming the relative proportions of waste types excluding bricks was consistent with the 1992 estimate, volumes have been estimated.	6455	1394	929	465	1162	465	46	10915	450915
1994	NZAS 1995b referenced waste surveys undertaken in 1994 with a waste type breakdown, in tonnes per year. Assuming a bulk density of 2.2 T/m3 for bricks, 0.6 T/m3 for carbon and 1.5 T/m3 for other waste types, volumes have been estimated. Note that the NZAS 1995b report estimates that ~18,000 m3 of material was landfilled in 1994 year, which is inconsistent with their estimate of the mass disposed of (4,800 T).	335	14	1594	-	-	1101	-	3043	453959
1995	NZAS 1995b provides estimates of the predicted disposal of waste to landfill in future years, this has been used for 1995 as actual disposal information has not been made available for this year. Assuming a bulk density of 2.2 T/m3 for bricks, 0.6 T/m3 for carbon and 1.5 T/m3 for other waste types, volumes have been estimated.	455	100	613	-	3333	1333	-	5835	459793
1996	NZAS 2003a includes total tonnes of waste	624	36	1814	245	2780	1353	0	6851	466645
1997	disposed of from 1996 - 2002. Assuming a bulk	468	25	1456	161	4915	1218	3	8246	474891
1998	density of 2.2 T/m3 for bricks, 0.6 T/m3 for carbon	164	0	1163	147	3973	1440	0	6887	481778
1999	and 1.5 T/m3 for other waste types, volumes have	110	77	1053	62	4393	953	13	6662	488440
2000	been estimated. Where waste types do not align	271	26	861	18	4968	899	13	7055	495495
2001	precisely with categories used in previous years,	152	63	843	193	5332	0	19	6601	502096
2002	these are included in the most appropriate	83	67	410	99	5598	0	106	6364	508460
2003 - 2017	Gap of information, reports on waste deposited over this time have not been made available. As an estimate, the average volume per year for each type of waste for the 1996 - 2002 period has been calculated and prorated for the 15 year period without data (2003 - 2017)	4010	633	16286	1981	68486	12561	329	104286	612746
2018	increase in volumes of various waste piles; these are attributed to the most appropriate categories here.	-	-	936	-	4771	-58	-	5649	618395
2019	increase in volumes of various waste piles; these are attributed to the most appropriate categories here.	-	-	2190	-	3499	121	-	5810	**624205**
Total per category		**233125**	**68436**	**74148**	**25371**	**135211**	**43385**	**4928**		

Table 2a: Estimated volumes of SCL waste in SCL storage sheds

Parameter	SCL storage shed			
	SCL 1	SCL 2	SCL 3	SCL 4
Estimated length (m)	60	100	85	60
Estimated width (m)	40	45	40	40
Assumed height (m)	5	5	5	5
Area of base (m2)	2400	4500	3400	2400
Assumed area of top 50% less than area of base (m2)	1200	2250	1700	1200
Volume of waste (m3)	8828	16553	12507	8828
Total				46717

Table 2b: Estimated volume of SCL waste on SCL pad

Parameter	SCL pad
Estimated length 1 (base) (m)	215
Estimated width 1 (base) (m)	80
Assumed height (m)	5
Area of base (m2)	17200
Estimated length 2 (top) (m)	145
Estimated width 2 (top) (m)	15
Area of top (m2)	2175
Volume of waste (m3)	42486

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Appendix 7

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Memorandum

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Copy		Reference	**510555**
Date	**2020-10-30**	Pages (including this page)	**9**
Subject	s9(2)(j) [redacted]		

Dear Daniel

s9(2)(j) [redacted]

The nature and extent of contamination across the site will obviously be the foundation to understanding what remedial scopes would be appropriate. At this stage we have been provided with only limited site data and thus we have made some preliminary estimates of how the site might be zoned, with each zone having a particulate characteristic that would then guide remedial activities. Aurecon has termed these Remedial Zone Areas (RZAs) and they are shown in Drawing 510555-0000-DWG-KF-0003, which is attached. s9(2)(j) [redacted]

2 Remediation Zone Areas

Only after an appropriate level of intrusive investigation at the site will remediation zone areas be able to be defined. We have made some very broad assumptions on the basis of our review of information provided by Treasury and our experience and general understanding of the contaminant profile typically found at aluminium smelters.

The remediation zone areas (RZA) are shown in Drawing 510555-0000-DWG-KF-0003 (attached) and are:

- RZA1 - Spent cathode lining (housed in the SCL pad and various sheds around the site).
- RZA2 – the landfill
- RZA3 – the industrial precinct associated with aluminium smelting:
  – RZA3a – carbon bake
  – RZA3b – SCL processing
  – RZA3c – electrical switch gear
  – RZA3d – cast house
  – RZA3e – rest of the industrial precinct

The general character of these RZAs are summarised in Table 1 (locations are shown in the drawing provided in Attachment 1).

Table 1 Remedial Zone Area Characteristics

RZA	Description	Typical contaminants	Location
RZA1	Spent Cathode Lining	Spent cathode pot linings are physically removed from the pot cradle using a variety of techniques as chunks, fragments and dusts. SCL contains carbon, complex hydrocarbons, aluminium, aluminium nitrides, cyanides and fluorides.	Main SCL pad and SCL sheds 1 to 4 (within the precinct) [Note: volume estimate is SCL pad only]
RZA2	Landfill	A wide range of materials appear to have been deposited in the landfill; it is likely that the landfill could contain all the waste streams likely produced over the operational life of the facility. A definitive inventory of contaminants is difficult to define.	Identified landfill to the west and south of the main industrial precinct
RZA3a	Carbon bake	During the formation of anodes and cathodes a variety of solid wastes, liquid effluents and gaseous emissions are produced. PAHs, oils and tars, fluorides, metals (in particular, aluminium, antimony, nickel)	The majority of the western portion of the industrial precinct comprising the coke store, carbon storage, pitch and heavy fuel oil tanks, the green anode plant, carbon bake furnaces and carbon rodding room
RZA3b	SCL processing	As RZA 1, but residual contamination will likely be characterised as “finer particles”.	Various locations comprising cell washdown, cell delining SCL crushing
RZA3c	Electrical switch gear	Mercury (from older rectifiers), PCBs (from older switch gear).	Main electrical switch gear area to the east of the industrial precinct comprising rectifiers, transformers, capacitors and the like.

RZA	Description	Typical contaminants	Location
RZA3d	Cast house	Molten aluminium is poured into moulds or is cast using a variety of techniques. The ingot or billet is cooled and then sent off site. Impurities are removed which results in a dross being formed which comprises a high percentage of water-soluble salts and a liquid effluent containing oil and grease. A variety of metals (mainly copper, magnesium, manganese, silicon, tin and zinc) at up to around 15% by weight can be added to the molten aluminium to make speciality alloys. Metals can be recovered from the dross.	Comprises the cast house and the vertical direct chill cast house, associated dross treatment / recovery plant.
RZA3e	Rest of the industrial precinct	Variety of solid wastes; liquid effluents and gaseous emissions and fugitive dusts. Fluorides, cyanides, PAHs, metals, sulphur compounds, fluorocarbons, diesel / petrol and PFAS.	The remainder of the industrial precinct which will have the main reduction lines, and a variety of ancillary facilities such as the fire station, compressors, cooling towers, water treatment, air emission scrubbers, mechanical and electrical workshops, transformers and above and below ground storage tanks.

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NOTES:

AREAS OF RZA'S ARE APPROXIMATE AND THE INFORMATION IN THIS DRAWING IS FOR HIGH LEVEL DECISION MAKING ONLY. BOUNDARIES ARE APPROXIMATE AND SHOULD BE SET OUT BY A LICENSED CADASTRAL SURVEYOR. AERIAL IMAGERY SOURCED FROM INVERCARGILL CITY COUNCIL, ENVIRONMENT SOUTHLAND REGIONAL COUNCIL AND LINZ DATA SERVICES AND REPRODUCED UNDER THE CREATIVE COMMONS ATTRIBUTION 3.0 NEW ZEALAND LICENSE.

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PROJECT: PROJECT 14 - IDENTIFICATION OF REMEDIATION OPTIONS

TITLE: SITE LOCATION PLAN - RZA
SHEET 3 OF 3

DOCUMENT	PROJECT No.	WBS	TYPE	DISC	NUMBER	REVISION
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References

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Attachments

- Attachment 1. Drawings 510555-0000-DRG-KF-0001, Drawings 510555-0000-DRG-KF-0002 and 510555-0000-DRG-KF-0003
- Attachment 2: Project 14, Hazardous Building Materials Management – Technical Advisory Note

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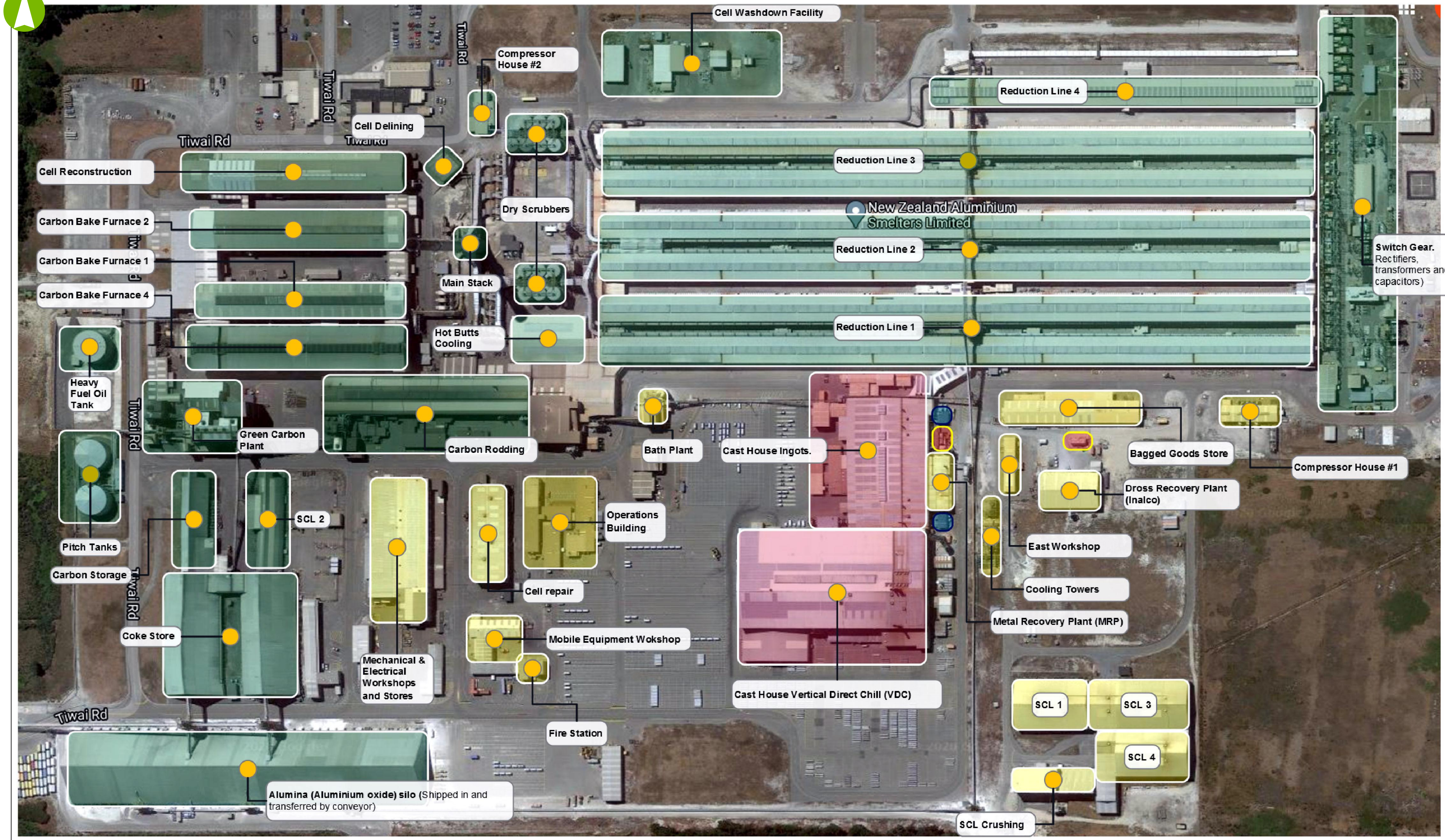

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SHEET 2 OF 3

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Memorandum

To	**Daniel Lawrey** Senior Analyst, Natural Resources Te Tai Ōhanga The Treasury	From	s9(2)(a) [redacted]
Copy		Reference	**510555**
Date	**2020-10-16**	Pages (including this page)	**11**
Subject	**Project 14, Hazardous Building Materials Management – Technical Advisory Note (Commercial in Confidence)**		

1 Project Background

Te Tai Ōhanga (The Treasury) has requested Aurecon to provide high-level asbestos and hazardous building materials remediation advice for the potential demolition and disposal of structures located on the smelter site located in Tiwai Point.

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3 Common types of Hazardous Building Materials that are encountered within Smelters

Hazardous materials such as asbestos, lead (Pb) containing materials, heavy metal contaminated bulk dusts, synthetic mineral fibres (SMF), and polychlorinated biphenyls (PCBs) are commonly found in assets and infrastructure within aluminium smelters.

3.1 Asbestos

Asbestos is a term used for a number of naturally occurring minerals, which have an acicular crystal habit. The fibres have high tensile strength, and chemical, electrical and heat resistance, and were widely used for these properties; either raw (e.g. asbestos textiles and insulation packings), or more often, combined with other materials (fire-proofings, insulation, boards, asbestos cement sheets etc.).

Due to its excellent engineering and chemical inert properties, asbestos was used in a wide variety of insulating products and building materials mainly from the 1930's to the 1980's. Asbestos content varies dependant on application and date of manufacture, some materials can contain up to 100% asbestos fibre (e.g. woven textile) while in others the asbestos fibre content can be as low as 2-5% (e.g. vinyl floor tiles).

In New Zealand today, asbestos containing materials are commonly found within industrial sites such as smelters.

- Industrial facilities and workplaces installed as:
  - Asbestos containing refractory "fire brick" (Friable)
  - asbestos cement roof sheeting, wall and ceiling linings (Non-friable)
  - thermal insulation on pipes, boilers, ovens, structural steel components etc. (Friable)
  - low density asbestos sheets in oven/furnaces insulation to electrical heaters, electrical backing boards (Both Friable and Non-friable)
  - fire-retarding boards (Friable)
  - textured paints (Friable)
  - other coating materials (acoustic)
  - floor coverings (Non-friable)
- Gaskets to plant and pipework (Friable)
- Friction plates and brake pads (Non-friable)
- Air and chemical filters (Friable)
- Mastics and waterproofing material (Non-friable)

3.2 Hazardous Paints including Lead-based Paints (Pb)

Hazardous paints are often used on industrial sites such as smelters due to their durable properties. A hazardous paint is defined in *AS/NZS 4361.1 2017 Guide to Hazardous Paint Management Part 1:*

Lead and other Hazardous Metallic Pigments in Industrial Applications is a dry paint containing ingredients that has the potential to create a human health risk, toxic workplace atmospheres, hazardous wastes and pollution if disturbed and eroded. Toxic ingredients include **lead, chromates, arsenic, cadmium, arsenic, asbestos and coal tar derivatives such as phenols or PAHs**.

Industrial assets built before the 1980's may contain painted surfaces with hazardous ingredients. Generally pre-1980 white lead paint was used largely on exterior surfaces, interior doors and architraves. Undercoats and primers frequently contained as much as 20% lead by weight. If the asset was built post 1980 the painted surfaces are less likely to contain these levels of lead, possibly below 1%.

3.3 Bulk heavy metal contaminated dusts

Heavy metals bulk dusts are commonly found with smelters as they are often used in the processing of the metals and are also found in degrading hazardous paints.

It is recommended that the following surface dust lead loadings guidelines be applied to technical reports in the absence of, or in consideration of, any local regulatory guidance:

Industrial, Construction and Specialist Sites with lead controls measures ^

Location	Surface Dust Lead Loadings (mg/m^2)
Operational areas using lead	50 mg/m^2
Exterior surfaces	8 mg/m^2
Interior surfaces	5 mg/m^2
Floors	2.2 mg/m^2
Staff amenities	2.2 mg/m^2

^ These suggested levels are based on the US Department of Energy (Brookhaven National Laboratory). Applies to locations such as operational and containment areas of laboratories, workshops, heavy industrial sites and firing ranges. These guideline levels should only be applied following consultation with a suitably qualified occupational hygienist.

3.4 Synthetic Mineral Fibres (SMF)

The risk in normal day to day activities remains relatively low. The risk of exposure to respirable SMF increases when materials containing SMF are disturbed. Although there is limited evidence to indicate exposure to SMF could lead to disease as with asbestos. Older type SMF products prior to 1990, are potentially carcinogenic.

To a lesser extent the following substances are also encountered during hazardous materials investigation/assessments.

SMF is likely to be identified on a smelter include fibreglass corrugated sheeting, insulation to pipework, ovens, machinery and plant.

3.1 Polychlorinated Biphenyls (PCBs)

PCBs are described as highly persistent, bio accumulative chemicals. Generally used as coolants and lubricants in electrical equipment, hydraulic fluids, and additives in paint, carbonless copy paper, plasticisers and dye carriers. PCBs were used mainly because they do not burn easily and are good insulators.

PCBs are likely to be found on site in the form of PCB oil within capacitors to fluorescent lighting or transformer units to substations.

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Yours sincerely

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