# Northern Corridor Improvements

## Assessment of Effects – Corridor Encroachment on Rosedale Landfill

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# Executive summary

## The Project

The Northern Corridor Improvements Project (the Project) covers the area of State Highway (SH) 18 between Albany Highway and Constellation Drive and SH1 between the Upper Harbour Highway (UHH) interchange to just beyond the Oteha Valley Road Interchange.

In summary, the key elements of the project are as follows:

- North and west motorway interchange connections – SH1/SH18;
- SH capacity and safety improvements;
- Northern busway extension from Constellation Station and connection to Albany Station; and
- Shared Use Path (SUP) provision along existing SH1 and SH18 routes for the full extent of the Project corridor.

## Encroachment of the Project on Rosedale Landfill

Auckland Council's Rosedale Landfill (Landfill) is situated east of SH1 and shares a common boundary with SH1. The Landfill is bounded by Greville Road to the North and Rosedale Road to the South. The Busway and SUP elements of the Project will encroach onto the Landfill along the entire 475m length of its western boundary from Busway Chainage 2050m to 2525m. In addition, up to a 250m length of the Project will encroach into the refuse mass. Landfill infrastructure and compliance monitoring stations are located in the western area of the Landfill and will be affected by the Project. The Landfill infrastructure and compliance monitoring infrastructure needs to remain operational during the minimum 30-year aftercare period following closure. The Landfill ceased operation in 2002 and was ultimately closed in 2009.

## Alignment Options in the vicinity of Rosedale Landfill

Alignment options for the Busway and SUP in the vicinity of the Landfill have been developed cognisant of the NZ Transport Agency Safety in Design standard and evaluated using multi-criteria analysis to select a preferred option. The options focussed principally on the vertical alignment in the vicinity of the Landfill as there was negligible opportunity for horizontal re-alignment to the west to avoid the Landfill due to the existing SH1 and development to the west of the existing corridor.

## Landfill Reinstatement Concept

Landfill reinstatement works will be required as the Project will encroach into the Landfill. Construction on closed landfills requires careful consideration of significant hazards including refuse, gas and leachate due to actual or potential adverse effects from these hazards. Hence, the key objectives of the reinstatement concept are to:

- Reduce potential effects on the receiving environment;
- Consider Safety in Design Principles, including Health and Safety for:
  - Project construction workers;
  - Users of the Project (Motorway, Busway, SUP); and

- Personnel responsible for carrying out Landfill aftercare.

The Landfill reinstatement concept developed aims to:

- Minimise excavation into refuse;
- Remove refuse from within/below the Busway and SUP alignment;
- Remove refuse from an area immediately adjacent to the Busway and SUP;
- Provide a new sidewall liner;
- Reinstate the affected Landfill infrastructure and the Landfill monitoring network; and
- Provide a two-tier system for preventing lateral migration of landfill gas.

## Effects of the Project on the Environment

There will be a number of actual and potential effects on the landfill environment arising from the Project's operation and construction activities on and near the Landfill. There will be some short-term adverse effects from construction activities in the vicinity of, and on, the Landfill with some of these effects assessed as being significant if not carefully managed and mitigated. These include effects of odour, Landfill gas, hazardous materials, refuse, leachate, contaminated runoff, and the effects of the works on the stability of the Landfill.

The actual and potential effects of the operation of the Project have been identified as including off-site potential lateral migration of landfill gas and effects on regional groundwater, perched groundwater, and landfill maintenance staff. The effects of operation are assessed as being less than minor.

## Mitigation

Specific measures and controls are required to mitigate the risks of construction activities on construction workers, Landfill aftercare maintenance staff and the receiving environment.

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## Glossary of Abbreviations

| Item | Description |
|---|---|
| AEE | Assessment of Environmental Effects |
| AMP | Rosedale Landfill Aftercare Management Plan |
| AQMP | Rosedale Landfill Air Quality Management Plan |
| ARC | The former Auckland Regional Council (now Auckland Council) |
| AT | Auckland Transport |
| AUP | Auckland Unitary Plan (Operative in Part – 15 November 2016) |
| BoI | Board of Inquiry |
| BPO | Best Practicable Option |
| CEMP | Construction Environmental Management Plan |
| Council | Auckland Council |
| Council CLCLR | Auckland Council Closed Landfill and Contaminated Land Response Team |
| ECBF | East Coast Bays Formation |
| EPA | Environmental Protection Authority |
| ESL | Envirowaste Services Ltd |
| ESRS | Environmental and Social Responsibility Screen |
| HAIL | Hazardous Activities and Industries List |
| LCS | Leachate collection system |
| LFG | Landfill Gas |
| LFGTE | Landfill Gas to Energy |
| LRWP | Landfill Reinstatement Works Plan |
| LHSP | Landfill Health and Safety Plan |
| $NES_{Soil}$ | Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 |
| NMOC | Non-Methane Organic Carbons |
| NSCC | The former North Shore City Council (now Auckland Council) |
| OPW | Outline Plan of Works |
| AUP | Auckland Unitary Plan (Operative in Part – 15 November 2016) |
| PPE | Personal Protective Equipment |
| PGAR | Preliminary Geotechnical Appraisal Report (Opus 2014) |
| PRP | Rosedale Landfill Peer Review Panel |
| PSI | Preliminary Site Investigation |
| RMA | Resource Management Act 1991 |
| SH # (e.g. SH1) | State Highway with number reference |
| Subtitle C | United States Resource Conservation and Recovery Act (RCRA) Subtitle C Hazardous Waste |
| SUP | Shared Use Path |

| | |
|---|---|
| UHH | Upper Harbour Highway |
| USC | Unconfined Compressive Strength |
| USEPA | United States Environmental Protection Agency |

**Terms and Definitions**

| Item | Description |
|---|---|
| Busway | The Northern Busway |
| Constructor | For the purpose of the technical reports, the term 'Constructor' refers to the alliance responsible for delivery (detailed design and construction) of the future stage of the Project |
| Extent of Refuse | The footprint or area of the landfill site within which refuse was deposited |
| Landfill | Auckland Council's Rosedale Landfill |
| Landfill Gas | Gas generated as a result of decomposition processes or biodegradable materials deposited in a landfill. It consists principally of methane and carbon dioxide, but includes minor amounts of other components |
| Landfill Subgrade | For the purpose of the technical reports, the term 'landfill subgrade' means the base of the landfill. For unlined areas of the landfill, refuse was placed directly onto the existing surface or cleared surface. For lined areas of the landfill, liner was constructed on a cleared and prepared subgrade, drainage and separation/protection layers were placed on the liner and then refuse was deposited |
| Leachate | Liquid that has percolated through or emerged from solid waste, and that contains dissolved and/or suspended liquids and/or solids and/or gases |
| NNBSPRP | The New Northern Busway Station and Park and Ride Project. This is an Auckland Transport led project which includes a bus station and Park and Ride facility which is excluded from the Northern Corridor Improvements approvals package |
| Project | The Project refers to the Northern Corridor Improvements Project including the extension to the Northern Busway and the Shared Use Path but excluding the Rosedale Bus Station |
| Project area | The area within the proposed designation(s) corridor for the Northern Corridor Improvements |
| Refuse | For the purpose of the technical reports, the term 'refuse/urban refuse' means the municipal solid waste deposited at the Rosedale Landfill during it operating life. It includes<br>non-hazardous, solid, degradable waste from a combination of domestic, commercial and industrial sources |
| Standard | ZHMS-01 Safety in Design Minimum Standard for Road Projects |
| The Landfill | The Rosedale Closed Landfill site |
| The Project Team | For the purpose of the technical reports, the term "Project Team" means the multidisciplinary team engaged on the Project |
| The NZ Transport Agency | The New Zealand Transport Agency |

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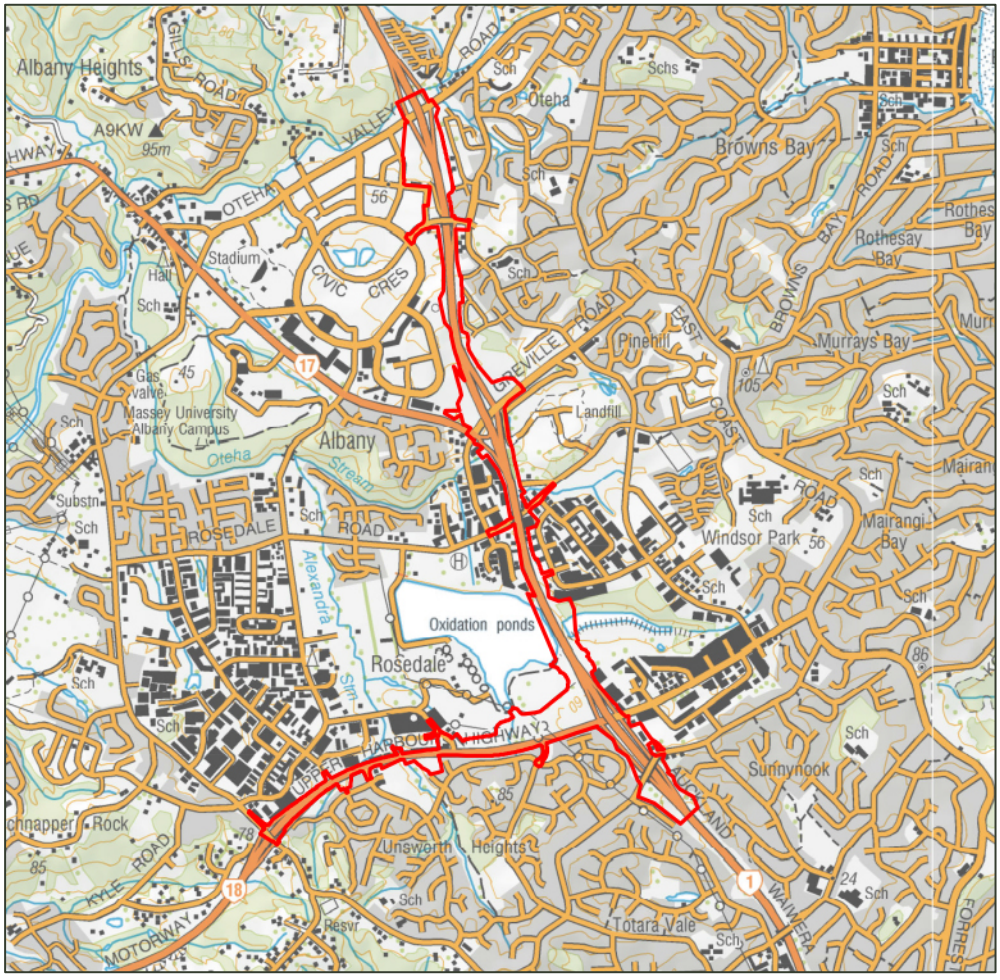
# 1 Description of Project

## 1.1 Overall Project Description

The Northern Corridor Improvements Project (the Project) is an accelerated project. The Project area covers the area of SH18 between Albany Highway and Constellation Drive, and SH1 between Upper Harbour Highway (UHH) interchange to just beyond the Oteha Valley Road Interchange as indicated on **Figure 1** below and confirmed in the suite of plans provided in **Volume 5**.

**Figure 1 Extent of Project area**




*Source: Base Map from LINZ*

The Project proposes to upgrade the existing State highways within the Project area. In summary, the key elements of the Project are as follows:

- North and West Motorway Interchange connections – SH1/SH18;
- State highway capacity and safety improvements;
- Northern busway extension from Constellation Station and connection to Albany Station;
- Reconfiguration of Constellation Station converting it from a terminus station to a dual direction station

- Shared Use Path (SUP) provision along existing SH1 and SH18 routes for the full extent of the Project corridor;
  - Constellation Station to Oteha Valley Road;
  - Constellation Drive to Albany Highway; and
  - Intermediate linkages to local network.

A full description of the Project, including its components and construction, is contained in section 5 of the Assessment of Environmental Effects (AEE).

## 1.2 Landfill Area Project Elements

In summary, the key elements of the Project in the vicinity of the Rosedale Closed Landfill (the Landfill) from Chainage 2050m to Chainage 2525m are (refer Drawing 1 (SKT-2325) in **Appendix A1**):

- The Northern Busway extension; and
- The SUP and intermediate linkages/connections at Greville Road and Rosedale Road.

The current NZ Transport Agency designation boundaries do not encompass the entirety of the works to be located within the Landfill area and therefore it is proposed that the designation be extended further eastward over the Landfill in particular between Busway Chainage 2450m and Chainage 2510m.

In addition, as the Project encroaches into the Landfill, there will also be Landfill reinstatement works. The works include excavation into the refuse, reinstatement of the Landfill cover and new liner, construction of protection measures to mitigate gas effects, relocation and /or reinstatement of the Landfill's existing operational infrastructure, and relocation and/or reinstatement of the Landfill's existing monitoring network.

## 1.3 Purpose of this Report

This report is one of a suite of technical reports that have been prepared to inform the AEE for the Project.

The particular focus of this report is the assessment of effects of the Project arising from the proximity of the Project to, and its encroachment on, the Landfill.

The features of the Landfill are described, the scale and severity of actual and potential effects of the Project associated with the Landfill are assessed, and measures to minimise or mitigate adverse effects are identified where required.

Matters related to contaminated land in the context of the Landfill are considered in this assessment while the Assessment of Land Contamination Effects (see **Volume 3 – Technical Assessment 6**) considers the remainder of the Project area.

## 1.4 Scope

The scope of this Report includes the following principal components:

Chapter 1: Overview of the Project including overall Project description and elements of the Project in the Landfill area and Landfill infrastructure potentially affected by the Project.

Chapter 2: Description of the main components of the assessment and the assessment methodology framework including sources and review of historical data, gaps in information, and approach adopted to address gaps in information.

Chapter 3: Description of the Landfill existing environment including site description, existing consents, history of the Landfill, its topography and landuse, geology, surface water, groundwater, contaminated land, refuse, leachate, and Landfill gas.

Chapter 4: Description of Landfill Monitoring

Chapter 5: Description of the Landfill reinstatement concept. Issues to be addressed in detailed design, construction management, and health and safety.

Chapter 6: Description of how the operation of the Project will affect the Landfill.

Chapter 7: Description of how the Project construction activities will affect the Landfill.

Chapter 8: Description of mitigation measures.

Chapter 9: Summarises key considerations and conclusions.

## 1.5 Encroachment of the Project into the Landfill Site and Infrastructure Potentially Affected by the Project Works

As outlined in Section 1.2 above, SH1 is on the western boundary of the Landfill. The Busway and SUP will encroach along the entire 500m length of the western boundary of the Landfill and could encroach up to 250m into the Landfill refuse mass itself.

The existing Landfill infrastructure in the western part of the Landfill site and hence in the vicinity of the Project includes:

- Surface and subsurface stormwater infrastructure – pond (Pond 7), swales, perimeter/contour drains, pipes, manholes, subsoil drains and stormwater monitoring stations.
- On-site leachate infrastructure (pipes, manholes, leachate monitoring stations) and off-site leachate infrastructure (leachate disposal pipe under SH 1).
- Gas infrastructure – perimeter migration probes, migration probes, gas ring main, condensate drop-outs, gas extraction wells and pipe network, gas flares and the Landfill gas to energy (LFGTE) plant compound.
- Landfill gas reticulation piped network. This includes internal feeder pipes and a ring main around the edge of the Landfill. The ring main terminates at a flare/electricity generation facility near the south-western corner of the Landfill (within the Project area).
- It is noted that the LFGTE plant ceased operation in February 2016 and the plant has been decommissioned and the plant building demolished. Landfill gas is now extracted and burnt using the existing consented blower system and ground flare located at the south-western corner of the site adjacent to the decommissioned LFGTE plant compound.
- Groundwater monitoring boreholes and groundwater drain outlets.
- Surface water sampling stations.
- The Landfill perimeter access track.

Much of the Landfill infrastructure needs to remain operational during the Landfill aftercare phase and beyond (30 to 50 years).

The Project encroachment will affect the following:

- Approximately 11 to 13 gas migration monitoring probes (gas monitoring wells) on the western, north-western and south-western boundaries.
- Approximately 400m to 450m of gas ring main (and associated valves and sampling points) under or adjacent to the western perimeter track and up to approximately 200m of ring main feeder pipes.
- Two condensate dropouts on the gas reticulation system.
- Approximately 400m to 500m of leachate pipes.

- Two currently monitored groundwater monitoring bores (2007A and 2008).
- Up to three old (not currently monitored) groundwater monitoring bores (2007 old, 2019 and 2020).
- One manhole for groundwater drain monitoring (GW MH1) and up to approximately 50 – 100m of groundwater drainage network pipework in the vicinity of the Greville Road overbridge works.
- Approximately 150 to 200m of stormwater pipe and 200 to 300m of stormwater channel.
- The outlet pipe from the Landfill western stormwater pond and approximately 100 to 150m of the Oteha Stream culvert in the vicinity of the Greville Road overbridge works.
- Potentially part of the existing leachate disposal pipe/sewer under SH1.
- The existing Landfill gas flares (main and auxiliary) located at the south-western corner of the Landfill site.
- Most of the western perimeter access track.

In addition, the Busway/SUP Bridge associated with the crossing of Greville Road may affect existing Landfill infrastructure in the north-western area of the Landfill. In particular, the potential extent of the bridge's southern abutment footprint on the Landfill site north-western corner may affect pipe networks/manholes/etc. for gas, leachate, and stormwater and existing monitoring stations/locations.

# 2 Assessment Methodology

## 2.1 Overview

This Chapter outlines the methodology developed and used by the Project Team to prepare this technical report for the Corridor Encroachment on Rosedale Landfill.

Matters addressed in the objectives and policies of Chapter E13 (Cleanfills, managed fills and landfills) of the AUP are addressed in this report. The actual or potential effects of encroachment into the Landfill during construction of the Project will be minimised or mitigated through appropriate controls, management and monitoring. This will be documented in a Landfill Reinstatement Works Plan (LRWP) that is specific to the Project works occurring within the Landfill and subject to Council certification. The LRWP will form part of the overall Project Construction Environmental Management Plan (CEMP). The LRWP will include measures to protect human health and contain, or appropriately dispose of, contaminants to prevent significant adverse effects to receiving environments. Following construction, the Landfill cover will be reinstated to the same or better standard and the existing Landfill Aftercare Management Plan will be updated as necessary so that the Landfill can continue to be managed appropriately throughout the aftercare period.

The methodology addresses the components identified as related to the Landfill. There are other Project wide components which have been addressed elsewhere in the suite of technical reports.

Key points from this Chapter are:

- There are gaps in historical information.
- Specific site investigations (geotechnical and environmental) are planned for February/March 2017 to address some of the more significant gaps.
- For the purpose of this report, where there is an absence of relevant and/or reliable information, the Project Team has taken a conservative/ precautionary approach and assumed the worst case for analysis, development of solutions and proposed mitigation measures and controls.
- The results of the specific site investigations will be known before detailed design is carried out, and the Constructor will be able to use these results to inform detailed design and the development of management plans for the Project.

## 2.2 Components of the Landfill Assessment

The main components of the Landfill assessment of effects comprise:

- Geology
- Hydrogeology
- Stormwater
- Contaminated land
- Refuse
- Leachate
- Gas
- Odour.

## 2.3 Framework for Assessment Methodology

The methodology framework (steps) adopted in this report for assessing effects of the encroachment of the Project on the Landfill is outlined below:

- Existing environment
- Historic information review and data analysis
- Gap analysis
- Additional monitoring (to address Gaps)
- Updated analysis
- Alignment options and reinstatement concept
- Risk assessment
- Effects of operation
- Effects of construction
- Mitigation measures
- Monitoring considerations.

All of the relevant steps in the framework have been addressed, for each of the Landfill assessment components to assess the effects of the Project associated with the Landfill.

## 2.4 Information Sources

The Landfill data gathered and collated to date has been sourced from the site property file; the site consent file; and information transferred to the Project Team by the Landfill asset owner (the Auckland Council (Council) Closed Landfill and Contaminated Land Response team (Council CLCLR)).

In addition, meetings between the Project Team and Council CLCLR have yielded relevant site information from Envirowaste Services Ltd (ESL) (the former operator of the Landfill) and the Landfill's Peer Review Panel (PRP).

## 2.5 Gaps in Information and Proposed Investigations

In general, information is variable and significant gaps have been identified. Hence, for the purpose of this assessment a conservative or precautionary approach has been adopted in the absence of adequate data. Where data has been absent or inadequate, the Project Team has assumed the worst case applies. Site investigations to be undertaken in February/March 2017 to fill in the gaps (refer Chapter 2, Section 2.6 below) will be used to refine assumptions and inform the detailed design and construction phase of the Project.

### 2.5.1 Gaps in Information

The following specific points are based on information reviewed to date:

#### 2.5.1.1 Monitoring Data

Initial review indicates this data package has gaps in consent related monitoring data and Landfill gas flow rate data (e.g. not all annual reports are available/complete).

#### 2.5.1.2 Gas Migration

There is no measurement of parameters in gas migration wells that would be required to undertake a robust gas risk assessment (e.g. no low atmospheric (<100 kPa) gas monitoring, gas flow or

groundwater levels). These parameters are not required to be monitored under the existing resource consent.

Previous studies indicate limited potential for gas migration across the western Landfill boundary due to the relatively low gas permeability of the soils in this area and reported high groundwater levels. However, Landfill gas migrating from other (more eastern) areas of the Landfill into the Project area and potentially off-site cannot be ruled out.

#### 2.5.1.3 Gas Reticulation

The historical Landfill gas flow rate data supplied has a number of gaps with the latest flow rates provided being from June 2015.

The Landfill gas flow rates have decreased since their peak in 2001.

#### 2.5.1.4 Extent of Refuse Fill

An assessment of the data received to date and historical site investigations by others does not satisfactorily confirm the edge of refuse fill along the western and north western flank of the Landfill. Initial assessment indicates that up to 200 to 250m of the Busway/SUP may encroach into refuse.

#### 2.5.1.5 Hazardous Atmospheric Zones

For work undertaken on the Landfill, the site will be classified as CS3 [under Construction Industrial Research Information Association (CIRIA) 665] and the hazardous atmosphere zones will be designated as shown in Figure C-001 of the Categorisation of Sites for Generic Hazardous Area Classification (Memo prepared for Council by AECOM, dated 5 August 2015).

For work undertaken adjacent to the Landfill, there is insufficient information to assess the potential extent of Landfill gas migration off-site and therefore, it is currently not possible to determine the hazardous zone classification for services within the Project area without further investigation (specific monitoring and analysis).

#### 2.5.1.6 Soil Testing and Foundation Durability

As most of the Landfill in the vicinity of the Project is unlined, leachate seepage/migration may have occurred into soils adjacent to the Landfill. Testing of soils to depth along the alignment of any proposed foundations (piles, pile caps, footings, etc.) is proposed to assess severity of exposure of any subsurface elements of the proposed foundations.

## 2.6 Site Investigation

Non-intrusive and intrusive site investigation will be undertaken to gather additional information on the section of the Landfill that is likely to be affected by the Project.

The first stage of the site investigation works consists of non-intrusive investigations to obtain information regarding the existing infrastructure within the Landfill. This work consists of topographic survey and geophysical survey. The topographic survey will obtain accurate information on the position of all visible Landfill infrastructure relating to the gas reticulation system, the leachate collection system and drainage systems e.g. manhole structures, control systems, monitoring wells/points. The geophysical survey consists of undertaking Electromagnetic Induction (EM) and Ground Penetrating Radar (GPR) to obtain information on the underlying ground profile without penetrating the soil. The relevant information obtained from the non-intrusive survey works has been uploaded into Geographic Information System (GIS) along with the historic data obtained to start to

create a three dimensional model of the existing Landfill and to assist with the next stage of investigation works (intrusive). The first stage of the site investigations is complete.

The second stage of the site investigations is the intrusive investigations, which is split into two phases. The first phase consists of physically locating the existing Landfill infrastructure (gas reticulation system and leachate collection system) within the areas of the planned geotechnical investigations and also components of the system that are going to be directly affected by the Project.

Two types of intrusive investigations will be undertaken, which are as follows:

- Gas reticulation system location: a series of potholing will be undertaken to physically locate the reticulation pipework. Once the pipework has been located, the properties of the pipeline will be recorded and the position of the pipe will be surveyed.
- Leachate collection system inspection: an inspection of the leachate collection pipework will be undertaken using CCTV. The CCTV inspection will allow the pipework to be visually inspected and also allow measurements to be taken of the location of key features as well as the orientation and alignment of the existing pipework. This information will be combined with the survey information obtained as part of the non-intrusive work.

The second phase of the intrusive investigations is to undertake geotechnical investigations to obtain physical samples of the underlying ground and assess relevant soil/Landfill properties. The key focuses of the geotechnical investigations are to obtain information on the thickness of the capping layer, the presence and thickness of any refuse, depth to the base of the Landfill and the composition and strength of natural ground underlying the Landfill. The following geotechnical investigation techniques will be undertaken:

- Cored rotary boreholes.
- Cone Penetration Tests.
- Test pits.
- Hand auger boreholes.

The geotechnical investigation data obtained will be used to assist the geotechnical design of the retaining measures for the proposed road alignment, determining the extent of the refuse and allowing a more accurate three dimensional model of the Landfill to be developed based on the physical properties encountered.

In addition, soil and groundwater samples will be analysed to provide information for durability requirements of subsurface elements of the Project.

# 3 Landfill Existing Environment

## 3.1 Overview

This chapter summarises the Landfill's existing environment with a focus on those parts of the Landfill in the Project area. The Landfill's existing environment has many elements due to the site being a consented closed Landfill with a range of existing infrastructure and monitoring networks. Additional detail on the elements summarised below is included in **Appendices B, E1, E2 and E3**.

## 3.2 The Landfill

### 3.2.1 Background

The Landfill is situated in the Oteha Valley Catchment (refer Drawing SKT-2325 in **Appendix A1**). The site is bounded by SH1 to the west, Greville Road to the North, Hugh Green Drive to the east, and Rosedale Road to the south. By way of background, a selection of historical drawings showing the development of the Landfill is included at **Appendix A2**. The nearest residential properties are along Rosedale Road and Hugh Green Drive south-east and east of the Landfill. The top of the Landfill is about 45m above SH1. Approximately 23 hectares of the 34.5 hectare site was used for refuse disposal. The Landfill's western boundary is approximately 500m long and the Landfill extends approximately 700m eastwards. The property details and legal description are given in **Tables 1 and 2** below.

Prior to the Landfill development, the land was in pasture. The Oteha Stream and several small tributaries originally flowed through the northern area of the site, but the stream and tributaries were diverted when the Landfill was extended to Greville Road. The historical drawings indicate that the Oteha Stream was raised and diverted to the north side of the Landfill along a concrete lined channel. A tributary from the north side of Greville Road flows through a concrete culvert under the Landfill.

The Landfill accepted general refuse from the 1950s until it ceased operation in October 2002. Historical records indicate that refuse has been disposed of at the Landfill since the latter part of the 1950s. A 1959 aerial photograph for the site sourced from Council's GIS Viewer clearly shows the Landfill was in operation. Approximately 3.3 million tonnes of waste was been deposited into the Landfill, with an average depth of 15m and a maximum depth of 28m.

The capped surface is predominantly grassed, although several areas on the Landfill slopes have established plantings of trees and shrubs. Stormwater ponds are present at the eastern and western boundary of the site. The Landfill is closed to the public.

**Table 1 Property Details**

| Item | Landfill Site |
|---|---|
| Site Address | 101 Rosedale Rd or 62 Greville Road, Albany |
| Landowner | Auckland Council |
| Map Reference | NZMS 271 6495000 2664500 |
| Proposed Auckland Unitary Plan Zoning | Public Open Space – Sport and Recreation |
| Applicable Designations | 417 Rosedale Landfill (Auckland Council)<br>6750 Maintenance, operation, use and improvement to the State Highway Network (NZ Transport Agency) |

The Landfill comprises five separate land parcels, described in **Table 2** below:

**Table 2 Legal Description of Land Parcels**

| Legal Description | Area (ha) |
|---|---|
| Part Allot 171, SO 569332.63 | 2.63 |
| Pt Allot 594, SO39085 | 15.96 |
| Lots 6 and 7 DP 54464 (CT22B/869) | 8.29 |
| Part 5 DP 54464 (CT 17A/352) | 3.82 |
| Lot 1 DP 127427 | 3.52 |
| **Total Land Area** | 34.22 |

### 3.2.2 Existing Resource Consents

Council, the site owner, holds all consents (refer **Table 3**) associated with the ongoing discharges to land, air, and water from the Landfill.

**Table 3 Summary of Current Resource Consents and Permits**

| Consent number | Description | Expiry Date |
|---|---|---|
| 34031 | To divert and discharge stormwater in the vicinity of Rosedale Landfill, from two permanent stormwater detention ponds to be constructed upstream (east) and downstream (west) of the Landfill and two temporary ponds to be constructed downstream during refuse filling. | 31 December 2025 |
| 34032 | Diffuse discharge of contaminants (Landfill leachate) into land and groundwater. | 31 December 2025 |
| 34033 | To divert groundwater into subsoil drains beneath the Landfill and hence keep groundwater from entering the refuse. | 31 December 2025 |
| 41939 | To discharge contaminants into air from a closed Landfill. | 30 August 2048 |
| File No 4037 | Tradewaste Agreement – to authorise the discharge of wastewater arising from Landfill leachate | 30 June 2024 |

Copies of resource consents and the tradewaste agreement are included in **Appendix C1**.

Where the Project will affect the Council's compliance with the conditions of these consents (e.g. the location of monitoring), the NZ Transport Agency will work with the Council CLCLR to change those conditions. Applications to change the consent conditions will be sought separately.

## 3.3 Topography and Land use

### 3.3.1 Topography

The original topography of the Landfill site consisted of gently sloping terrain to the north. A ridge on the southern border of the current Landfill was approximately 60m above sea level, sloping to the north into a valley (previously containing the Oteha Stream) approximately 25m above sea level.

The site contours are indicated on Drawing SKT-2325 in **Appendix A1**.

### 3.3.2 Land use

The land is owned by Council and is designated (Designation Ref 417) as for refuse disposal purposes in the Proposed Auckland Unitary Plan. It is bordered to the south by a mix of business,

residential and recreation zones, to the east by residential zones and the north and west by roads, with residential and business zoning beyond.

## 3.4 Geology

Geology is a key input in the hydrogeological and Landfill gas conceptual models for the Landfill area and the associated effects assessments.

The Landfill was placed on the western slopes of a previous ridge underlain by alternating sandstone and siltstone belonging to the East Coast Bays Formation (ECBF). Bedding in the ECBF in the Landfill area dips at between 15° to 80° to the south-east. The Landfill subgrade typically comprises weathered ECBF soils which are typically silty clay.

The conceptual geological model for the Landfill area in the vicinity of the proposed Project works is illustrated as three parallel east-west cross sections (refer Drawings SKT-2345, SKT-2346 and SKT-2347 in **Appendix A1**).

Additional detail on geology of the Landfill is outlined in **Appendix B**.

## 3.5 Stormwater

Stormwater runoff from the Landfill is captured by open channels and typically directed to detention ponds where the runoff is detained for subsequent discharge to the receiving environment (Oteha Stream) at a controlled rate.

Stormwater from over half of the Landfill (including the western area) flows through a detention pond (Pond 7) in the north-western corner of the Landfill before discharging to the Oteha Stream on the western side of SH1.

Stormwater infrastructure in the general Project area includes channels, pipework, manholes and a detention pond (Pond 7) as shown on Drawings SKT-2327 and SKT-2328 in **Appendix A1**.

Additional detail on stormwater associated with the Landfill is outlined in **Appendix B**.

## 3.6 Groundwater

The regional groundwater level is in the Landfill subgrade (below the base of the refuse) either naturally or due to groundwater drains installed below the northern area of the Landfill during construction (refer Drawings SKT-2345 and SKT-2347 in **Appendix A1**). Regional groundwater flow beneath the Landfill is typically towards the north-west with a localised area of south-west flow in the south-west corner (refer Drawing SKT-2329 in **Appendix A1**). Localised perched groundwater (above the regional groundwater) occurs in the soil between the Landfill and SH1.

Leachate with a head of approximately 5m in refuse is present approximately 15m inside the western boundary of the refuse in the general Project area. The available groundwater quality results indicate negligible influence from leachate.

Registered groundwater users are located greater than 2km from the Landfill.

Groundwater monitoring points and infrastructure in the Project area comprise one manhole for groundwater drain monitoring (GW MH1), groundwater drainage network pipework and two groundwater monitoring bores (refer Drawing SKT-2329 in **Appendix A1**).

Additional detail on groundwater associated with the Landfill is outlined in **Appendix B**.

## 3.7 Contaminated Land

The Hazardous Activities and Industries List (HAIL) activities that apply to the Landfill site are B4 (power stations (power generation plant only)) and G3 (landfill sites). Contaminated and potentially contaminated soils at the site include the refuse, the Landfill sub-grade, the cover layer and the soils associated with the power generation plant. Leachate has the potential to contaminate groundwater beneath the Landfill although the monitoring results to date indicate negligible influence from leachate on groundwater.

Additional detail on contaminated land aspects associated with the Landfill is outlined in **Appendix B**.

## 3.8 Refuse

### 3.8.1 Landfill Stages and Types of Liner

The Landfill stages are shown on Drawing SKT-2325 in **Appendix A1.** The Project encroaches on to the western area of the Landfill (Initial Stage (1950-1984) which is unlined). Further detail on the Landfill stages (including general filling sequence), types of landfill liner and other information pertaining to the development of the Landfill are shown on historical drawings included in **Appendix A2** of this report. Key information relating to Landfill stages and types of liner is summarised in **Appendix B**.

### 3.8.2 Refuse - Source and Categories

The refuse source information is summarised in **Table 4**.

**Table 4 Summary of Sources of Refuse**

| Period (Note 1) | Source (Notes 1, 2) |
|---|---|
| Late 1950s to mid-1960s | Night soil deposition only |
| Mid 1960s to 1991 | Domestic refuse, including public entry (car-loads and trailer-loads of refuse), and industrial refuse accepted directly into the Landfill. |
| 1989 to 1994 | Refuse from Pikes Point Transfer Station directed into Rosedale Landfill. |
| 1991 to September 2002 | Constellation Drive Transfer Station refuse directed to Rosedale Landfill. Public excluded from direct entry and only commercial loads accepted. All car and trailer loads were directed to the Pikes Point and Constellation Drive Transfer Stations |

Notes:

1. Source of Information – Section 3.6 of AMP.
2. The AMP states that of the total tonnage of refuse disposed of at Rosedale by the former Territorial Local Authorities, 75% was by North Shore City, 19% by Auckland City, 3% by Rodney District, 2% by Waitakere City and 1% by Manukau City.

In terms of the categories of waste deposited at the Landfill, the consent granted in 1996 prohibited disposal of hazardous wastes or special wastes apart from those contained in normal household refuse. The consent also required that all controlled wastes (not general refuse) be deposited within 4m of the underside of the final Landfill cap. However, there may be less certainty as to whether hazardous or special wastes were disposed of at Rosedale from the commencement of operation in the 1950s to 1996.

The Project Team has been unable to source any records relating to operations and disposal of refuse prior to 1996 other than general information contained in Management and Operations Plans prepared from 1999 onwards which refer in general terms to the refuse deposited prior to 1996. Based on the lack of information, the Project Team is unable to confirm whether or not hazardous wastes were disposed of at the site prior to 1996. Post 1996, hazardous wastes or special wastes were unlikely to have been disposed of at the Landfill as it would have been a breach of consent conditions. However, mitigation and contingency management measures proposed for the Project assume hazardous and special wastes may be encountered (refer Chapter 8).

## 3.9 Leachate

### 3.9.1 Leachate Infrastructure

The Landfill has been developed in stages, starting in the 1950s and closing in 2002. A description of the leachate collection system for each stage, which was generally constructed during the preparation of the filling area or cell, is described in the Landfill Leachate Collection System Report (ESL, Final Draft, Report No. 2 of 8, 3 September 2008) including drawings of the leachate collection system. The leachate infrastructure is shown on Drawings SKT-2348 and SKT-2330 in **Appendix A1**.

#### 3.9.1.1 Main Leachate Infrastructure

The Main Leachate Collection System (refer Drawing SKT-2348 in **Appendix A1**) comprises a main line (Line A). Line A lies beneath the refuse on the Landfill floor. Line A runs down the low point of the Landfill base and is parallel to and approximately 50m south of Greville Road.

Other leachate lines, Lines B1 to G, branch off the main line (Line A). Leachate within the Landfill flows through the refuse by gravity to the drains which are all interconnected and eventually discharge into the Terminal Leachate Manhole (MH3). There are isolated leachate drains, Lines H and I, in the south and east corners, which are not connected to other drains by gravity. Lines H and I collect leachate from those areas and drain to pump stations and are then pumped to the main drain.

#### 3.9.1.2 Terminal Leachate Manhole & Discharge

Leachate is collected from all sections of the Landfill by a network of gravity drains and rising mains which discharge into the Terminal Leachate Manhole (MH3) located immediately east of Pond 7. The general layout of this area is shown on Drawing SKT-2330 in **Appendix A1**. Refer to the Historical Drawings in **Appendix A2** (Drawings 1251412-148C, 1251412-133C and 1251412-134A) for details.

A gravity drain connects to the Leachate Monitoring Manhole (west of MH3) where samples are taken for quality analysis by Council. That manhole is also used for leachate flow measurement when required. A short pipe connects that manhole to the Council sewer manhole (NSCC Sewer Manhole) and from there it flows to the Watercare Services Ltd North Shore Wastewater Treatment Plant.

#### 3.9.1.3 Leachate infrastructure in the Western Area

The Initial Stage of the Landfill (which includes the area filled from 1979 to 1984, refer **Appendix A2**, Drawing 1251412-144A) is in the vicinity of the Project (refer Drawing SKT-2330 in **Appendix A1**). Leachate Lines E, F and D are in the western area.

Additional detail on leachate infrastructure is outlined in **Appendix B**.

## 3.10 Landfill Gas

Landfill gas aspects are provided in detail in **Appendix E**. Key aspects relevant to existing environment are outlined below.

Landfill gas is produced by the bacterial decomposition of organic waste within the Landfill and comprises mainly 45% to 60% methane, 40% to 60% carbon dioxide and various trace gases. Peak Landfill gas production for the site occurred in 2001 to 2002 and has been decreasing since that time. Refuse near the Project area is approximately 30 to 40 years old and is only generating very low volumes of gas.

Gas from the Landfill is removed via extraction wells spread across the Landfill and flows through a pipe network to the gas flare in the compound in the south-western corner of the Landfill. Gas was previously provided to the gas to electricity plant but declining gas volumes, as the Landfill has aged, has resulted in the plant being closed and currently all gas is flared. Gas extraction wells in the general Project area are currently closed (are not connected to the gas extraction system) as gas generation in this old part of the Landfill is minimal.

Currently most of the Landfill gas being an abstraction from the Landfill is occurring within gas abstraction wells along the northern side. It is from the northern side of the Landfill that the greatest pressure and LFG concentration gradients exist to generate lateral migration of Landfill gas.

The Landfill gas conceptual site model for the existing conditions is provided in **Appendix E6**, and key elements are outlined below:

- Surrounding the Landfill there is typically low permeability silty clay and clayey sands soils. The clayey sandy soils are more permeable than the silty clay soils and may act as a slightly more permeable gas/water migration pathway.
- Preliminary hydrogeological data suggests that there may be perched water-tables within elevated clayey sandy layers acting as a partial barrier to lateral gas migration as methane is only slightly soluble in the water.
- High water tables encountered and potentially steeply dipping strata along the southern boundary of the Landfill will act as a barrier to lateral migration of Landfill gas. As can be seen in Drawing SKT-2331 in **Appendix A1** the nearest receptors to the west of the Landfill are commercial buildings (Miro Street) which are significantly lower (approximately 10 m) than the base of the refuse. The high regional groundwater table and the existing motorway cut will be effective barriers to prevent sub-surface gas migration to off-site receptors to the west of the Project area.
- ESL has installed a vent on the leachate line near the western boundary of the Landfill to minimise the volume of Landfill gas migrating off-site in this area.

Monitoring of the Landfill gas migration monitoring probes indicates that, with the exception of two probes (2140 and 2141) on the north-western boundary, no evidence of methane, Landfill gas or elevated carbon dioxide has been detected at the Landfill boundary.

## 3.11 Gas Infrastructure

Landfill gas infrastructure in the general Project area includes the western part of the gas ring main, ring main feeder pipes, valves, sampling points and condensate dropout points. Landfill gas monitoring in the general Project area includes gas migration monitoring probes on the western, north-western and south-western Landfill property boundaries. This infrastructure is shown on Drawings SKT-2348 and SKT-2330 in **Appendix A1**.

Additional detail on gas infrastructure associated with the Landfill is outlined in **Appendix E3**.

# 4 Landfill Monitoring

## 4.1 Landfill Aftercare and Monitoring

The aftercare management of the Landfill is the responsibility of the Council CLCLR.

Aftercare Management and monitoring of the Landfill is documented in two management plans:

- Rosedale Landfill Aftercare Management Plan (AMP), March 2010, prepared by ESL.
- Rosedale Closed Landfill Air Quality Management Plan (AQMP), July 2015, prepared by URS New Zealand Ltd.

The AMP was prepared pursuant to condition 1 of resource consents 34031, 34032 and 34033. The AMP contains the monitoring, management and operational procedures, methodologies and contingency plans required to comply with the discharge consents. The AMP includes descriptions of the Landfill infrastructure including the leachate collection system, Landfill gas collection system, groundwater collection system, stormwater system and the Landfill cover.

The AQMP was prepared pursuant to condition 27 of resource consent 41939. The AQMP records the monitoring, management and operational procedures, methodologies and contingency plans required to comply with the air discharge consent.

## 4.2 Landfill Monitoring Programme and Results

A summary of the current consent monitoring programme for visual inspections, groundwater sampling, surface water sampling, and leachate sampling at the site is presented in **Table 5**.

**Table 5 Summary of Inspections and Water Quality Monitoring**

| Activity | Month each year |
|---|---|
| Visual Inspections | May, Nov |
| Groundwater Sampling from manholes | Feb, Apr, Jun, Aug, Oct, Dec |
| Groundwater bore sampling | Jun, Dec |
| Surface water sampling | Feb, May, Aug, Nov |
| Leachate Sampling | Nov |
| Reporting (Water Quality) | Apr |
| Visual Inspections | May, Nov |

A summary of the inspections and air quality monitoring activity and frequency required under the AQMP prepared in accordance with Condition 27 of the relevant resource consent is presented in **Table 6.**

Table 6 Summary of Inspections and Air Quality Monitoring

| Monitoring | Frequency of monitoring | Duration |
|---|---|---|
| Visual Inspection | 6 monthly | 5 years following the closure of the gas collection system |
| Surface Emissions | Annually | 3 years of annual monitoring following closure of the gas collection system + 2 consecutive compliant monitoring rounds |
| Monitoring Gas Migration Probes | 6 monthly | 2 years following the closure of the gas collection system + 3 consecutive compliant monitoring rounds |
| Gas Extraction Wellheads | 6 monthly | While gas collection system is in operation |
| Flares | Annually | While gas collection system is in operation |
| General Inspection of Extraction System and Safety Equipment | Monthly | While gas collection system is in operation |
| Building Monitoring | 6 monthly | If applicable, buildings within the footprint to be monitored for the extent of the consent |

### 4.2.1 Landfill Historic Monitoring

Monitoring results for leachate, groundwater and surface water are compared against trigger levels, as defined in the monitoring and contingency section of the AMP for the Landfill. The historic monitoring results for leachate, groundwater and surface water and associated trigger levels are provided in **Appendix D1**. Monitoring results to date indicate negligible influence of leachate on groundwater, which suggests the existing leachate collection and disposal system is effective.

Historic monitoring results and overview comments relating to Landfill gas are provided in **Appendix E4.**

### 4.2.2 Landfill Project Monitoring

Project specific monitoring has been carried out for gas, leachate and groundwater. The results for leachate and groundwater monitoring are provided in **Appendix D2**. The results of the Landfill gas monitoring and associated overview comments are provided in **Appendix E5.**

### 4.2.3 Landfill gas Migration Monitoring Results Evaluation

Gas migration monitoring results are a key input for the gas migration risk assessment in this report. A summarised evaluation of the results from this monitoring is therefore provided below.

Historical Landfill gas monitoring has been undertaken by ESL on behalf of Council and records are available from March 1998 to May 2016. Monitoring of gas flows and water levels were not undertaken as part of this monitoring programme.

However, methane concentrations in most of the monitoring probes are below the detection limit of the instrument which indicates that monitoring of these two parameters is not critical because Landfill gas does not appear to be migrating into these wells.

From 1998, there have been 55 monitoring events on Auckland Council records and 9 undertaken by the Project team. These monitoring events have been taken under a range of barometric pressures including 11 monitoring events when the barometric pressure was less than 1000 hectopascals (hPa).

The current monitoring data is considered to be sufficient to characterise the Landfill gas regime and it does cover the worst case scenario (falling barometric pressure and either high or low water

table). The current monitoring data would meet the requirements to undertake a CIRIA C665 Landfill gas risk assessment with respect to the number and duration of the monitoring events.

The historical and current monitoring shows that there is negligible Landfill gas migration along with the western boundary of the Landfill. However, it does indicate that there is the potential for low level (less than 0.07 litres of methane per hour) in the north-western corner of the Landfill (near gas migration monitoring probe 2141). There is also historical evidence and current monitoring data which suggests that the leachate lines may be acting as a preferential pathway for the migration of Landfill gas.

# 5 Alignment in the Vicinity of the Landfill and Reinstatement Concept

## 5.1 Overview

As the Busway/SUP encroaches onto the western area of the Landfill, it will affect the existing operational Landfill infrastructure and the compliance monitoring network and will require excavation into refuse. Hence, this chapter focuses on the reinstatement of the Landfill and issues that need to be addressed for the next phase of the Project (detailed design and construction).

Construction on closed landfills requires careful consideration of hazards (refuse, gas, leachate, etc.). To address these hazards this chapter details design, construction management and health and safety risk to construction workers, Landfill maintenance staff and the receiving environment. Specific measures and controls to mitigate the risk are detailed in Chapter 8.

Alignment options have been developed cognisant of NZTA's Safety in Design Standard and evaluated using multi criteria analysis to select a preferred option. The authors of this report had input to the process and the outcome of the process is reported separately in Chapter 7 of the AEE.

This chapter focuses on the preferred alignment option (Option 3) for the Busway/SUP between Chainage 2050m and Chainage 2525m. The preferred alignment option is illustrated in plan, long section and cross sections in Drawings SKT-2350, 2351, 2352 and 2353 **in Appendix A1.**

Key points from this Chapter are:

- It is common practice to adopt the concept of multiple gas protecting measures. The gas characteristic situation calculated from the Landfill gas migration risk assessment indicates that between 1 to 2 levels of gas protection are required.
- The Landfill reinstatement concept aims to:
  - Minimise excavation into refuse.
  - Remove refuse from within/below the Busway/SUP footprint.
  - Remove refuse from the area (5.5m to 6m nominal width) immediately east of the Busway/SUP.
  - Provide a new sidewall liner.
  - Provide a two-tier system for preventing lateral migration of landfill gas (refer **Appendix E6** Assessment of Landfill Gas Migration Risk during Operation).
  - Reinstate Landfill infrastructure and the Landfill monitoring network.
- Detailed design and construction of the Project will need to demonstrate that the issues identified for design, construction management and health and safety have been addressed.

## 5.2 Safety in Design

Safety in Design (SiD) workshops were undertaken in accordance with the NZ Transport Agency's Safety in Design Minimum Standard for Road Projects (NZTA ZHMS-01) and the process and outcome (SiD Register) is reported separately in this suite of technical reports.

With respect to the Landfill the identified hazards during construction are landfill gas, leachate, refuse, hazardous substances, instability of Landfill (refuse mass), odour, and electrical services (lighting, etc.) along Busway/SUP in the vicinity of the Landfill. Hazards during operation have also been identified. The issues associated with each of these hazards are detailed in the SiD register.

## 5.3 Landfill Reinstatement Concept

### 5.3.1 Objective

The key objectives of the reinstatement concept are to:

- Reduce potential effects on the receiving environment.
- Consider Safety in Design Principles, including Health and Safety for:
  - Project construction workers.
  - Users of the Project (Motorway, Busway, SUP).
  - Personnel responsible for carrying out Landfill aftercare.

### 5.3.2 Design Basis

The design of the Landfill reinstatement is based on Council CLCLR information and the following industry standards/guidelines:

- Consideration of the overarching principles for Council CLCLR as Closed Landfill Asset Owner (**Appendix C2**).
- For working on the Landfill, the site will be classified as a CS3 site under Construction Industry and Research Information Association CIRIA C665D.
- For the Landfill liner, the relevant Ministry for the Environment (MfE) endorsed guidelines current at the time of detailed design or the Technical Guidelines for Disposal to Land (April 2016).
- For hazardous atmospheric zones, the Council Categorisation of Sites for Generic Hazardous Area Classification (5 August 2015).
- General guidance for design and construction on Auckland Closed Landfills, the Auckland Council Code of Practice for Design and Construction on Refuse Landfills.
- For the gas interception trench the following guidance documents have been referred to:
  - BRE 414 (2001) Protective measures for housing on-gas contaminated land
  - DEPT/PIT (1997) Passive Venting of Soil Gases beneath Building research Report. Volume 1: Guide for Design,
  - US Army Corps of Engineers (2013) EM200-1-22. Landfill Gas Collection and Treatment Systems.
  - BS 8485:2015. Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings.
- For structures in the vicinity of the existing Landfill gas flares the following guidance documents have been referred to:
  - Guideline for Determination of Good Engineering Practice Stack Height (USEPA, 1985, EPA-450/4-80-023R)
  - Resource Management (National Environmental Standards for Air Quality) Regulations 2004
  - Good practice guide for atmospheric dispersion modelling (MfE, 2004)
  - ERCB Flare software - A Model for Temporary Flaring Permits, Non-Routine Flaring and Routine Flaring Air Dispersion Modelling for Source Gas Facilities.

### 5.3.3 Rationale

Key rationale statements for the Landfill reinstatement are:

- Minimising excavation into refuse.
- Encroachment of the Project into refuse:
- Remove any refuse from within/below the Busway and SUP footprint alignment.
- In addition, remove any refuse from the area immediately east of the eastern edge of the SUP (5.5m to 6m nominal width).
- Provide an engineered barrier (low permeability compacted clay or similar) and backup gas interception measures (gas interceptor and venting trench) between the refuse mass and the eastern edge of the Project where the eastern edge borders or encroaches into the refuse mass.
- Removing all refuse from within the Busway and SUP alignment and up to 6m immediately east of the SUP minimises long-term risk by providing a physical barrier between the refuse and the Busway and SUP.
- Reinstating (including repositioning) all affected leachate, gas and stormwater infrastructure and affected monitoring stations/parts of the network to areas within the Landfill site (i.e. within Council land for ease of access for monitoring and maintenance).
- Providing access for operation and maintenance of existing Landfill infrastructure located outside the Landfill site (i.e. to the west within NZTA land)

### 5.3.4 Key Components

The key components of the Landfill reinstatement works are:

- Temporary works including temporary reconfiguration of leachate and gas infrastructure, stormwater controls.
- Temporary leachate control drain at western edge of refuse excavation to capture perched leachate and contaminated runoff etc.
- Excavation and removal of refuse allowing for temporary support of the excavated refuse profile and undercut of areas previously covered by refuse.
- Reinstatement of the Landfill sidewall using an engineered barrier (low permeability compacted clay liner or similar) with tie-ins at the north and south ends and tie-ins to the Landfill cover layer and base. Installation of ground retention piles and wall construction would be required for the preferred option.
- Reinstatement (including repositioning) of the existing landfill operational infrastructure (western infrastructure, including stormwater drainage).
- Reinstatement (including repositioning) of the Landfill monitoring network (western network).
- Construction of protection measures to mitigate Landfill gas effects (back-up gas interception trench).
- Commissioning of works.

The concept developed, based on the above, is shown on Drawing SKT-2342 **in Appendix A1**.

With respect to the source and accuracy of information used to develop the Landfill reinstatement concept plan and section the following points are noted:

1. Landfill Surface - the existing ground profile and cadastral boundary location is based on Council GIS data.
2. The fill/refuse profile within the Landfill including the extent of refuse (western edge of refuse fill), the base of the Landfill, the depth of refuse and thickness of cover/fill layers have been inferred based on:

a. Geological information in historical exploratory drillholes.

b. Digitising information from scanned PDF copies of historical drawings contained in the Rosedale Landfill Aftercare Management Plan, ESL (Final Draft, March 2010). This digitised information is based on scanned drawings that have been subject to distortion and hence there is uncertainty as to its accuracy.

The following summarises the preliminary estimate of quantities based on the concept shown on Drawing SKT-2342 in **Appendix A1**:

- Volume of Refuse – approximately 7,000m³ to 10,000m³ for the nominal 6m wide strip and under the Busway/SUP
- Volume of undercut below base of refuse – approximately 1,500m³ to 2,000m³ for the nominal 1m undercut
- Area – approximately 1,500m² to 2,000m² (plan area).

The estimate does not include:

- Additional excavation/benching into refuse for temporary stability
- Additional undercut below base of Landfill
- Earthworks for Landfill infrastructure reinstatement
- Earthworks for access (temporary/permanent)
- Earthworks for Greville Road Overbridge
- Bulk earthworks for the Busway/SUP.

## 5.4 Design Considerations

The Constructor will need to consider and address the following items during preparation of their temporary and permanent works designs. This is not an exhaustive list but is intended to assist the Constructor in assessing the risks associated with various temporary works design and construction methodologies:

- Sidewall Liner: It is essential that the sidewall liner (nominal 5.5m to 6m wide compacted clay) has a sufficiently low permeability ($k < 1 \times 10\text{-}9$ m/s) so as to prevent leachate migration through the liner. If the moisture content of the sidewall liner is sufficiently low there is a risk of desiccation and cracks forming. Such cracks could form preferential drainage paths for leachate and landfill gas through the sidewall liner. This could be mitigated through the addition of bentonite in the clay. However, the suitability of this approach would need to be specifically assessed by the Constructor.
- Stability: Temporary stability of the Landfill and works will need to be maintained. The Constructor will need to consider the stability risks associated with its chosen construction methodology and the effect that this could have on the stability of the Landfill. The temporary and permanent works should be designed to achieve the Factors of Safety against instability prescribed in the relevant codes and standards.
- Design Parameters: The design parameters have been assessed by the Project Team and these are presented elsewhere in the suite of technical reports. The design parameters have been based on information available at the time and further consideration of the parameters will need to be given following completion of the proposed site investigations (refer Chapter 2, Section 2.6). The Constructor should consider the risk of variation of material parameters on the suitability of their designs.
- Durability: In accordance with durability requirements of Australian Standard (AS2159) for Piling – Design and Installation, the preliminary corrosion classification is assessed to be 'severe to very severe'. Further investigations are proposed (refer Chapter 2, Section 2.6) to provide information on the aggressivity of the soil adjacent to the western area of the Landfill, refuse, leachate and groundwater. The Constructor will need to carry out their own assessment of the appropriate

corrosion classification using the investigation data and any other relevant guidelines and standards.

- Landfill Gas Flares - Area of wake influence and downwash effects: Both the main and auxiliary flares may be within the area of wake influence which extends out to a distance of five times the height of built structures in the vicinity of the flares and downwash effects may affect the dispersion of emissions from the two flares. The main and auxiliary landfill gas flares are located 35m east of the edge of the Busway/SUP at it nearest point (refer Drawing SKT-2354 in **Appendix A1**). Hence if the Busway/SUP embankment is less than 7m high, it will be outside the area of wake influence and downwash effects are unlikely. Therefore, for detailed design, if the height of the Busway/SUP is greater than 7m at its closest point to the existing flares, a suitable air dispersion model which incorporates building downwash effects in complex terrain will need to be prepared.

## 5.5 Construction Management and Health and Safety

Construction management aspects and health and safety issues need to be considered and addressed during detailed design and/or the construction of the Landfill reinstatement works.

The key construction activities include:

- Access for earthworks, piling, retaining wall construction, Greville Road Overbridge construction, and Landfill reinstatement.
- Earthworks – Busway/SUP - excavation (cut to fill, cut to waste, disposal off-site, importing fill, engineered fill).
- Earthworks – Landfill reinstatement (refuse excavation and disposal off-site, excavation for undercut and disposal off-site, importing fill, sidewall liner construction, etc.).
- Earthworks – stormwater diversion and contaminated run-off containment.
- Retaining walls – Piling, wall construction, drainage.
- Greville Road Overbridge – piling, embankment, etc.
- Landfill infrastructure – surface structures and reticulated pipework for leachate, gas, stormwater and new monitoring stations (groundwater, gas probes, etc.).

The key issues are management of refuse, landfill gas, leachate, odour, hazardous materials, dust, asbestos, contaminated run-off and contaminated materials.

Chapter 8 details specific measures and controls to address these issues and mitigate risks.

# 6 Effects Assessment: Operation of the Project on the Landfill

## 6.1 Overview

There will be a number of actual and potential effects arising from the Project's proximity to the Landfill site. This chapter addresses the effects of the Project's operation. The next chapter (Chapter 7) addresses the effects of the Project's construction activities.

## 6.2 Effects of Operation of the Project

Actual and potential effects of the operation of the Project have been identified as including:

- Effects on off-site lateral migration of landfill gas.
- Effects on regional groundwater.
- Effects on perched groundwater.
- Effects on Landfill maintenance staff.

### 6.2.1 Effects on Off-Site Lateral Migration of Landfill Gas

The long-term operational effects on off-site lateral migration of landfill gas are outlined below.

A landfill gas risk assessment was undertaken to determine potential effects of lateral gas migration and to inform design of appropriate mitigation measures, as required. The landfill gas risk assessment is presented in **Appendix E7**.

The conceptual gas migration site model (refer Drawing SKT-2331 in **Appendix A1**) indicates that there is a possible migration pathway to the lighting and underground services infrastructure within the Project area (Busway/SUP). However, the likelihood of this pathway is considered to be low. In addition, the consequences of a build-up of methane (fire and damage to lighting infra-structure) is considered to be minor (easily repairable damage to infrastructure) to mild (significant damage to services). Adopting these inputs, the risk assessment framework indicates that the associated risk is very low to low.

This gas migration/risk scenario requires one to two levels of gas protection. Conservatively, two levels of protection are recommended for this area of the Project to reduce the potential for lateral migration of gas from the Landfill off-site to the west towards the Busway/SUP. Control of gas migration is typically accomplished by breaking the migration pathway between the source and the receptor. Installing a 2-tier gas migration barrier system comprising a low permeability barrier (e.g. engineering clay) and a passive venting trench (i.e. gas interception trench) behind the barrier is proposed as the Landfill reinstatement concept (refer Drawing SKT2342 **Appendix A1**).

By adopting the 2-tier gas migration barrier system, the effects of potential lateral gas migration to the west will be less than minor.

### 6.2.2 Effects on Groundwater

The long-term operational effects on groundwater are outlined in the sub-sections below.

A numerical 2D groundwater model (SEEPW) was developed to assess the potential effects to both perched and regional groundwater. The model was calibrated to replicate the regional groundwater levels produced by Earthtech (1995) and confirmed by recent groundwater level monitoring bore data.

The modelled perched groundwater included two separate bodies of perched groundwater within the residual ECBF soil, completely weathered ECBF, and highly weathered ECBF soil:

- Perched 1 (shallowest zone) approximately 1m depth below ground level and approximately 1m saturated thickness.
- Perched 2 (deeper) – beginning approximately 2m beneath the base of Perched 1, with approximately 1.5m saturated thickness.

The modelled perched systems are based on a conceptualisation, and are deemed realistic within the available unsaturated zone. Drawing SKT-2343 in **Appendix A1** displays the modelled perched and regional groundwater profile within the zone of interest. Drawing SKT-2344 in **Appendix A1** displays the groundwater profile during long-term operation. Technical details on the model construction are presented in **Appendix F**.

#### 6.2.2.1 Effects on Regional Groundwater

The lowest elevation of motorway drainage is at least approximately 1 m above the average regional groundwater level which ranges between approximately RL 27.0m and RL 30.0m within the area of the Project (refer Drawing SKT-2344 in **Appendix A1**). At times of higher than average groundwater level, small quantities of groundwater (i.e. < 10 $m^3$/day) may drain into motorway subgrade drains.

The addition of paved surfaces will reduce recharge to the regional system however the effect of this to regional groundwater level will be negligible given the overall small area compared to the total catchment.

Consequently, predicted effects of operation of the Project on the regional groundwater system and third party users of regional groundwater are negligible.

#### 6.2.2.2 Effects on Perched Groundwater

The relatively localised perched groundwater system located between the Landfill and the existing SH1 will be removed during construction. In addition, the majority of the land cover directly above this perched system will be replaced with paved surfaces so it is unlikely that any zones of notable perched groundwater would reform.

There are no beneficial users of the perched groundwater system in this area. There are no groundwater dependant ecological systems associated with the perched groundwater in question.

Consequently, predicted effects of the operation of the Project on the localised perched groundwater system are negligible.

### 6.2.3 Effects on Landfill maintenance staff

With the exception of the area around Pond 7 at the north-western corner of the Landfill area, Landfill maintenance staff will not need to access the operational Project area. The Landfill will be separated from the operational Project by a security fence.

Landfill maintenance staff will need to access the area in the vicinity of Pond 7 for monitoring and maintenance purposes. This area is located under the proposed Greville Road overbridge and therefore is effectively isolated from the operational Project area. Landfill maintenance staff would access the area in the vicinity of Pond 7 from the Landfill without having to traverse the operational Project.

The effects from operation of the Project on Landfill maintenance staff are therefore negligible.

# 7 Effects Assessment: Construction Activities

## 7.1 Overview

This chapter addresses the effects of the Project's construction activities arising from Project works on, and in the vicinity of, the Landfill. The previous chapter (Chapter 6) addresses the effects of the operation of the Project.

There will be some short-term adverse effects as a result of construction activities. Some of these effects are assessed as being significant if not appropriately managed. As a result, specific construction management aspects and health and safety issues will need to be considered and addressed during detailed design and construction of the elements of the Project in the vicinity of the Landfill and the Landfill reinstatement works. These have been detailed in Chapter 8, Section 8.2 and include:

- Preparation and certification of a LRWP for the elements of the Project in the vicinity of the Landfill and the Landfill reinstatement works. The LRWP shall include a specific Landfill Health and Safety Plan (LHSP) prepared in consultation with Council CLCLR. These documents will form part of the overall Project CEMP.
- Preparation and certification of Construction Method Statements for all Landfill reinstatement works.
- Supervision of Landfill reinstatement works by appropriately qualified and experienced persons.

## 7.2 Effects of Construction Activities of the Project

Actual and potential effects of the construction activities have been identified as including:

- Effects of odour from excavation into refuse.
- Effects of Landfill gas on construction workers and Landfill maintenance staff as a result of excavation into refuse.
- Effects of refuse on construction workers as a result of skin contact, ingestion or inhalation.
- Effects of potentially hazardous materials (e.g. asbestos) on construction workers as a result of excavation into the refuse.
- Effects of dust from excavation into refuse and other earthworks.
- Effects of erosion and sediment generated during earthworks, excavation and reinstatement on surface water.
- Effects of contaminated runoff/leachate on surface water as a result of excavation into the Landfill.
- Effects of discharges to land from excavated refuse.
- Effects on regional groundwater.
- Effects on perched groundwater.
- Effects of the works on the stability of the Landfill.
- Effects of contruction traffic which are addressed in the Assessment of Transport Effects report.

### 7.2.1 Effects of Odour on Offsite Receptors from Excavation into Refuse

The effects of odour on offsite receptors from excavation into refuse are potentially significant (refer Odour Assessment in **Appendix G**).

The closest receptors are a number of commercial buildings located in Miro Place approximately 120m to 160m west across the motorway from the Project area. The nearest residential receptors are located over 400 m east of the Project area. People using the existing SH1 will be approximately 20m from the Landfill works, although these receptors will be transitory.

Specific hazard minimisation controls and procedures are detailed in Chapter 8. The effects of odour from excavation into refuse should be minor if these control measures are utilised (e.g. odour fences and the use of daily cover).

### 7.2.2 Effects of Landfill Gas on Construction Workers and Landfill Maintenance Staff as a result of Excavation into Refuse

The effects of landfill gas on construction workers and Landfill maintenance staff as a result of excavation into refuse are significant.

In areas where refuse materials have been exposed it is likely that elevated levels of carbon dioxide ($CO_2$) and methane may be present. In addition, $CO_2$ and methane levels at the ground surface may be temporarily elevated due to exposure of refuse materials. The main dangers from Landfill gas are adverse health effects and explosion hazards.

Specific hazard minimisation controls and procedures are detailed in Chapter 8, Sections 8.3.3.1 and 8.3.6. The effects of landfill gas on construction workers and Landfill maintenance staff as a result of excavation into refuse should be minor if these control measures are utilised (e.g. gas monitoring and PPE).

### 7.2.3 Effects of Potentially Hazardous Materials (e.g. asbestos) on Construction Workers as a result of Excavation into the Refuse

The effects of hazardous materials (e.g. asbestos) on construction workers as a result of excavation into the refuse are significant. Specific hazard minimisation controls and procedures are detailed in Chapter 8. The effects of potentially hazardous materials (e.g. asbestos) on construction workers as a result of excavation into the refuse should be minor if these control measures are utilised (i.e. minimising/preventing exposure to hazardous materials).

### 7.2.4 Effects of Refuse on Construction Workers as a Result of Skin Contact, Ingestion or Inhalation

The effects of refuse on construction workers as a result of skin contact, ingestion or inhalation during excavation into refuse and reconstruction of leachate infrastructure is potentially significant.

Refuse may contain material which may contain human pathogens and would represent a biological hazard to staff. Refuse may contain the following materials which may represent a biological hazard:

- Medical waste (e.g. wastes from Hospitals, vets and tattooists). These can contain needles and blood products.
- Sanitary products and nappies.
- Soil microbes such as tetanus and legionella.

Construction workers could potentially be exposed to pathogens including hepatitis A, B and C, gastro-enteritis and tetanus, legionella, respiratory and skin diseases.

Specific hazard minimisation controls and procedures are detailed in Chapter 8, Section 8.3.7. The effects of refuse on construction workers as a result of skin contact, ingestion or inhalation should be minor if these control measures are utilised (e.g. minimising exposure to hazardous materials).

### 7.2.5 Effects of Leachate on Construction Workers as a Result Of Excavation into Refuse and Reconstructing Leachate Infrastructure

The effects of leachate on construction workers as a result of excavation into refuse and reconstruction of leachate infrastructure is potentially significant if not appropriately managed.

Construction workers could potentially be exposed to leachate principally through skin contact and/or ingestion.

Specific hazard minimisation procedures are detailed in Chapter 8, Sections 8.3.3.2, 8.3.3.3, 8.3.5 and 8.3.7.

### 7.2.6 Effects of Dust from Excavation into Refuse and Other Earthworks

The proposed earthworks, excavations into refuse and plant and machinery used for construction will generate dust. The effects of dust are potentially significant if not appropriately managed.

Dust generated during excavation and general site work may result in adverse health effects. As the content of the Landfill will vary, so therefore will the level and type of contaminants in the dust.

Ways in which on-site personnel may become exposed to dust include the following:-

- Inhalation of dust which may contain heavy metals and other contaminants.
- Dermal contact with contaminated solids and liquids on the ground, equipment or clothing.
- Ingestion of contaminants from eating, drinking or smoking within the work zone or before passing through decontamination.

In addition to nuisance dust issues, there is also the issue of exposure to hazardous chemicals in the contaminated dust from the Landfill.

The effects of dust from construction activities will be minor if the control measures described in Chapter 8, Sections 8.3.2.4 and 8.3.3.4 are utilised.

### 7.2.7 Effects of Contaminated Runoff/Leachate on Surface Water as a result of Excavation into the Landfill

The effect of contaminated runoff and leachate on surface water as result of excavation into the Landfill is potentially significant if not appropriately managed.

Leachate is currently collected via the leachate collection system and discharged as trade waste to sewer. Contaminated runoff from minor seepages through the Landfill cover is intercepted via perimeter drains and conveyed to Pond 7 for treatment prior to discharge.

Excavation into refuse will result in perched leachate being released into the excavation. In addition contaminated runoff could be generated from surface water coming into contact with refuse. More information about the quantity of leachate and its rate of release during construction will be known once the site investigations planned for February/March are complete.

Specific hazard minimisation controls and procedures are detailed in Chapter 8, Sections 8.3.1, 8.3.2.2, and 8.3.5 and Drawing SKT-2342 in **Appendix A1**. The effects of contaminated runoff and leachate on surface water as a result of excavation into the Landfill should be minor if these control measures are utilised.

### 7.2.8 Effects of Erosion and Sediment Generated During Earthworks, Excavation and Reinstatement on Surface Water

The effects of erosion and sediment on surface water during earthworks excavation and reinstatement not covered by Section 7.2.7 have been addressed separately in the suite of technical reports.

### 7.2.9 Effects of Discharges to Land from Excavated Refuse

The effects of discharges to land are potentially significant.

Excavated refuse has the potential to contaminate surrounding/adjacent areas of the site and cross-contaminate uncontaminated material if it is not managed appropriately.

Specific hazard minimisation controls and procedures are detailed in Chapter 8, Sections 8.3.1 and 8.3.2.1. The effects of discharges to land from excavated refuse should be minor if these control measures are utilised.

### 7.2.10 Effects on Groundwater

The effects of construction on groundwater are outlined in the sub-sections below.

As outlined in Chapter 6, Section 6.2.3, a numerical 2D groundwater model (SEEPW) was developed to assess the potential effects to both perched and regional groundwater. Drawing SKT-2344 in **Appendix A1** displays the modelled perched and regional groundwater profile. Technical details on the model construction and details are presented in **Appendix F**.

#### 7.2.10.1 Effects on Regional Groundwater

The lowest elevation of excavation for the Project is at least approximately 1 m above the average regional groundwater level which ranges between approximately RL 27.0m and RL 30.0m within the area of proposed construction (Drawing SKT-2343 in **Appendix A1**). At times of higher than average groundwater level, small quantities of groundwater (i.e. < 10 $m^3$/day) may drain into excavation. Consequently predicted effects of construction activities to the regional groundwater system and to third party users of regional groundwater are negligible.

#### 7.2.10.2 Effects on Perched Groundwater

The proposed excavations are likely to intersect zones of perched groundwater between the Landfill and existing SH1. The two zones of perched groundwater (Perched 1 and Perched 2) are conservatively assessed to be present across the entire excavation; however this continuity is unlikely to occur in reality.

The effects to perched groundwater during construction can be summarised as follows:

- The majority of perched groundwater/soil water will be removed via direct excavation of the soil and rock i.e. physical removal of material which contains perched water.
- Very low rates of seepage through the cut face can be expected during the excavation phase. Maximum seepage rates are estimated at up to 10$m^3$/day.
- Total maximum expected volume of perched groundwater, removed via direct excavation or seepage, is estimated at approximately 9750$m^3$ (based on an area of 13,000$m^2$, a 2.5m total saturated thickness and 30% porosity).

There are no beneficial users or groundwater dependant ecological systems associated with the perched groundwater system in this area. Consequently predicted effects of construction activities on the localised perched groundwater system are negligible.

### 7.2.11 Effects of Works on Stability of Landfill

The effects of works on the stability of the Landfill are assessed as being significant. Instability could result in potentially severe harm to construction workers and discharges to land, air and surface water.

Hence the Constructor will need to address the stability risks associated with its chosen construction methodology and the effect that this could have on the stability of the Landfill. The Constructor shall prepare Construction Method Statements for all Landfill reinstatement works for certification.

The effects of works on the stability of the Landfill should be minor if the temporary and permanent works are designed to achieve the Factors of Safety against instability prescribed in the relevant codes and standards (refer Chapter 5, Section 5.4), Contractor Construction Method Statements for all reinstatement works are certified by Council and works are supervised by appropriately qualified and experienced persons.

# 8 Mitigation Measures

## 8.1 General

Mitigation measures have been discussed throughout this report and detailed in Chapter 5. These are summarised in the **Table 7** and detailed in Section 8.2 below.

Overall, specific construction management aspects and health and safety issues will need to be considered and addressed during detailed design and construction of the elements of the Project in the vicinity of the Landfill and the Landfill reinstatement works. These include:

- Preparation and certification of a LRWP for the elements of the Project in the vicinity of the Landfill and the Landfill reinstatement works. As a minimum, this overarching plan shall include specific management/monitoring plans to address the following:
  - Landfill site specific health and safety
  - Odour – off-site
  - Landfill gas – exposure
  - Dust
  - Hazardous materials – exposure
  - Refuse - exposure and discharges to land
  - Leachate – exposure and discharges to surface water
  - Contaminated run-off
  - Stormwater
  - Disturbance of contaminated soil
  - Stability
  - Asbestos management and removal.
- Preparation and certification of Construction Method Statements for all Landfill reinstatement works.
- Supervision of the Landfill reinstatement works by appropriately qualified and experienced personnel.

In addition, where the NCI Project will affect the Council's compliance with the conditions of these consents (e.g. the location of monitoring), the NZ Transport Agency will work with the Council CLCLR to change those conditions. Applications to change the consent conditions will be sought separately.

**Table 7 Summary of Actual or Potential Adverse Effects and Proposed Mitigation**

| Actual or Potential Adverse Effect - Operation | Proposed Mitigation |
|---|---|
| Off-site lateral migration of landfill gas | Two tier system comprising a sidewall liner (compacted clay, permeability < 1 x $10^{-9}$ m/s) and a vented gas interception trench). Gas migration probes on boundary. |
| | |
| **Actual or Potential Adverse Effect – Construction Activities** | **Proposed Mitigation** |
| Odour from excavation into refuse | Odour managed through the LRWP.<br>Odour suppression.<br>Limiting areas of exposed refuse.<br>Removing refuse from site as soon as practicable.<br>Periodic walkover surveys of site boundary.<br>No excavated refuse to remain on site for more than eight hours. |
| Stormwater Management – Landfill | Regular inspections and maintenance of the Landfill's western stormwater infrastructure. |
| Landfill gas on construction workers and Landfill maintenance staff from excavation into refuse | LHSP.<br>Gas Monitoring.<br>Monitoring of leachate lines being a preferential pathway for LFG.<br>Warning /hazard notices.<br>Specific health and safety requirements for excavation into refuse.<br>Training and supervision.<br>Person Protective Equipment.<br>No smoking.<br>No naked flames or hot work in excavations or while refuse excavation is being undertaken.<br>Use of intrinsically safe electrical devices.<br>Spark arrestors on all vehicles, plant and machinery. |
| Potentially hazardous materials (e.g. asbestos) on construction workers | LHSP.<br>Contingency Management.<br>Screening of refuse.<br>Asbestos Management and Removal (managed through LRWP). |

| | |
|---|---|
| Refuse on construction workers from skin contact, ingestion or inhalation | LHSP.<br>Hazard minimisation procedures.<br>Specific health and safety requirements for excavation into refuse.<br>Screening of refuse.<br>Training and supervision.<br>Person Protective Equipment including chemical resistant overalls and gloves.<br>Shower and boot wash facilities onsite.<br>All work clothes washed at commercial cleaners not at home.<br>Clean work clothes provided at the beginning of every shift.<br>No food or drink consumed within the construction area.<br>Breaks in skin (cuts and abrasions) disinfected immediately and covered.<br>Emergency contacts and procedures. |
| Leachate on construction workers from excavation into refuse | LHSP.<br>Hazard minimisation procedures.<br>Specific health and safety requirements for excavation into refuse.<br>Monitoring of leachate lines being a preferential pathway for LFG.<br>Training and supervision.<br>Person Protective Equipment including chemical resistant overalls and gloves.<br>Shower and boot wash facilities on-site.<br>All work clothes washed at commercial cleaners not at home.<br>Clean work clothes provided at the beginning of every shift.<br>No food or drink consumed within the construction area.<br>Breaks in skin (cuts and abrasions) disinfected immediately and covered.<br>Emergency contacts and procedures. |
| Dust from excavation into refuse and other earthworks | Dust control measures (in the LRWP).<br>Provision for control of asbestos fibres and monitoring of asbestos fibres. |
| Erosion and sediment on surface water | Addressed elsewhere in the suite of technical reports. |

| | |
|---|---|
| Contaminated runoff/leachate on surface water from excavation into refuse | Separation of clean runoff and contaminated runoff/leachate.<br>Stormwater from the Landfill will be diverted via temporary clean water diversion and discharged to the north western pond (Pond 7).<br>Leachate and contaminated runoff will be contained within the excavation and intercepted by a drain initially at the toe/perimeter of the excavation.<br>The leachate and contaminated runoff will be directed to a treatment device or discharged to sewer as trade waste. |
| Discharges to land from excavation into refuse | Management of Refuse – appropriate handling and approved disposal offsite.<br>Intercept and contain leachate/contaminated runoff within excavation.<br>Tradewaste consent for leachate/contaminated runoff disposal to sewer.<br>Approved disposal and handling of refuse. |
| Works on stability of landfill | Temporary and permanent works to be designed to achieve the Factors of Safety against instability in the relevant codes and standards.<br>Specific Construction Method statements to be prepared for approval.<br>Monitoring for land instability during construction.<br>Works to be supervised by a Chartered Professional Engineer with experience in geotechnical engineering and landfill engineering. |
| Disturbance of contaminated soil | The LRWP will address the requirements of a Remediation Action Plan/Contaminated Soil Management Plan. |
| Construction stormwater management – surface drains – blockage and overflow onto the Northern Motorway | Regular inspections and maintenance. |

## 8.2 Landfill Reinstatement Works Plan and Health and Safety Plan

A LRWP will need to be prepared by the Constructor for the works. The LRWP will require independent review by an appropriately qualified and experienced chartered professional geotechnical engineer and an appropriately qualified and experienced chartered professional landfill engineer and certification by Council prior to works commencing on-site.

The purpose of this LRWP is to address specific issues principally associated with refuse, leachate, and landfill gas management during construction (refer to Section 8.3 below for details). The works within the refuse are of a specialist nature and will require a specific LHSP, for approval by Council CLCLR as the Landfill asset owner, in addition to any overall LHSP for the works. The LHSP shall, as a minimum, address the issues outlined in Section 8.3 below.

## 8.3 Refuse, Leachate and Landfill Gas Management during Construction

### 8.3.1 General

The following sections address:

- Contingency management for refuse, leachate and odour.
- Hazard minimisation procedures for explosive gases, skin contact with potentially contaminated materials, and ingestion of toxic materials.
- Training and supervision.
- Personal protective equipment.
- Landfill gas monitoring for methane, low explosive limit, carbon dioxide, carbon monoxide, hydrogen sulphide, oxygen and photo-ionisable organic compounds.
- Specific health and safety requirements for excavations into the refuse layer (termed refuse intrusive works).
- Appropriate disposal of contaminated soil and refuse.

Other matters that shall be addressed by the Constructor in the LRWP and LHSP include:

- Preparation of Construction Method Statements for all Landfill reinstatement works.
- Ensuring the use of plant and equipment appropriately rated and protected for use in a Hazardous Atmospheric Zone.
- Ensuring compliance with requirements for excavations and works in confined spaces.
- Emergency contacts.
- Landfill gas and leachate system. There are significant hazards associated with the operation and maintenance of the leachate and gas systems and hence procedures detailed for maintenance of either or both of the systems must be strictly adhered to. Prior to opening any part of the systems, clearance must be obtained from the Gas Technician in charge of the gas extraction system. Currently, the technician is Mr Martin Ward (mobile number +64 274 796 847) of ESL.

In general the contingency management and hazard minimisation procedures aim to ensure that:

- Works do not compromise the requirements of the existing resource consents held by Council. If the Project makes it difficult or impossible for Council to comply with the conditions of existing

resource consents, the NZ Transport Agency and Constructor must work with the Council to change those conditions.

- The existing Landfill cap/barrier is maintained or reinstated to current best practice.
- Off-site disposal of contaminated material/refuse is to a licenced landfill.
- Contaminated groundwater (leachate) and surface water in contact with refuse is controlled during excavation and disposed off-site by a licenced contractor.
- Landfill gas risk is mitigated during construction and longer term.
- No open fires on-site and hot work permit system will be in place to prevent accidental ignition of any flammable vapours.
- All confined spaces be identified and a confined space entry system prepared in accordance with AS 2865:1995.
- No workers or machinery shall enter the landfill flare exclusion zone.
- No temporary site offices, buildings or enclosed structures are to be erected over landfill gas generating areas of the Landfill.
- Asbestos containing materials are identified and asbestos are controlled in accordance with Health and Safety at Work (Asbestos Regulations).

### 8.3.2 Contingency Management

#### 8.3.2.1 Refuse

In general:

- Refuse that needs to be removed will be disposed of at an off-site licenced waste disposal facility. Receipts for any material disposed of off-site will be retained for site validation reporting.
- Removal of refuse material from the site will take place as soon as possible after excavation (depending on gas levels in the works area – see chapter on landfill gas monitoring for details of stop-work limits). The excavated material storage container (e.g. skip), will be covered at all times when it is not in use to prevent odour.
- Any excavated cover material containing refuse will be treated as refuse and disposed of off-site at a licenced landfill (e.g. Redvale Landfill located at Dairy Flat).
- Any undercut material in areas previously covered by refuse shall be treated as contaminated by leachate and disposed of off-site at a licenced landfill (e.g. Redvale Landfill).
- Works in refuse material (refuse intrusive works) shall be closed/covered overnight.
- No stockpiling of excavated refuse on-site overnight.
- Odour control
- Safety fences shall be erected around open work areas.
- Health and safety procedures shall be followed should any refuse be exposed.
- Should any material with potentially higher hazard levels than municipal refuse be identified (e.g. drums, identifiable hydrocarbon/fuel or solvent odour) work shall cease immediately. A suitably qualified environmental scientist shall be engaged to investigate the new hazard and the Council Resource Consenting and Compliance team shall be informed immediately.

#### 8.3.2.2 Leachate

Leachate that accumulates in any excavations will not be suitable for discharge to the stormwater system. Any surface water or groundwater that has come into contact with refuse should be treated as contaminated and, therefore contained, collected, and removed by sucker truck for discharge at a

licenced facility or trade waste discharge to sewer. Receipts for any leachate disposed of off-site must be retained for site validation reporting.

#### 8.3.2.3 Odour

Exposed refuse is likely to release some odour. Exposed refuse shall be managed to minimise potential odour effects. The following methods as a minimum shall be employed by the Constructor responsible for refuse excavation and by other contractors should refuse be exposed during the works:

- Areas of exposed refuse shall be limited so far as practicable.
- Works areas shall be closed at the end of each working day and no refuse shall remain exposed overnight.
- Refuse shall be removed from the work site as soon as practicable after excavation (dependent on landfill gas monitoring levels in the immediate area – see Section 8.3.6 Table 8 on landfill gas monitoring for details of stop-work limits).
- No excavated refuse shall remain on-site for more than eight hours.
- Odour suppressant sprays and heavy tarpaulins shall be available on site and, if necessary, shall be used on exposed refuse.
- Periodic walkover survey shall be made of the site boundary to check for offensive or objectionable odours. If odours are offensive or objectionable, works will stop until odour can be reduced.

#### 8.3.2.4 Dust

Site specific dust control measures will need to be included in the LRWP to control dust emissions during construction and potential effects on on-site and off-site receptors. Dust monitoring will need to include provision for control of the release of asbestos fibers and monitoring of asbestos fibers).

#### 8.3.2.5 Asbestos

Prior to the disturbance of the Landfill capping material asbestos management and removal measures will need to be prepared by the Contractor to deal with the risks associated with actual or potential presence of asbestos on the site. These measures will be included in the LRWP which is to be submitted for certification to the Council Team Leader, Northern Monitoring, Resource Consenting and Compliance.
The asbestos management and removal measures will include the following:

a) Details of how the asbestos removal will be carried out, including the method of work used and the tools, equipment, and personal protective equipment used.

b) Details of the asbestos to be removed, including the location, type, and condition of asbestos.

c) A detailed description of the asbestos removal work area for the work and any air monitoring points.

d) Details of the means of transport and disposal of asbestos waste.

If during the earthworks unforeseen discovery of asbestos or any asbestos containing material (ACM) occurs, the contractor will have to meet the Health and Safety at Work (Asbestos) Regulations 2016 and the measures in the LRWP may need to be updated and the proposed new approach agreed with Team Leader Northern Monitoring.

Work involving the removal of asbestos and/or ACM material will be carried out under the control of a person holding a WorkSafe NZ Class A Certificate of Competence (CoC) for restricted works.

### 8.3.3 Hazard Minimisation Procedures

The following section sets out procedures to minimise site hazards in relation to refuse materials, leachate, and landfill gas.

#### 8.3.3.1 Explosive Gases

Potentially explosive concentrations of methane may be encountered within the works area, therefore:

- No naked flames or hot work shall be undertaken on-site while intrusive works are being undertaken.
- No naked flames or hot work in open excavations.
- No smoking on-site.
- Post prominent warning notices in appropriate positions, e.g., at the site entrance and around the site fence to advise persons of the possible hazards.
- The site should be kept tidy and free of obvious fire hazards and fuel sources.
- Any fire which may occur on the site shall be treated as an emergency i.e. reported to the fire services, and if possible extinguished immediately.
- Dry powder chemical or CO2 type fire extinguishers shall be available on-site.
- Intrinsically safe electrical device should be used where there is the potential for hazardous concentration of landfill gas to be present. Instruments must comply with a minimum of either NEC500 (US) Class 1 Division 1 Group D T1 rating or EEx ibd iiA T1 or equivalent.
- Spark arrestors should be fitted to vehicles working in potentially gas affected areas.
- Vehicles should not be parked overnight or for prolonged periods on top of/within 100m of gas contaminated land. This is to prevent gas ingression and accumulation within the vehicle overnight or any time when the vehicle is not being used for prolonged periods (greater than eight hours). If vehicles are being parked over gas contaminated land then they should be adequately ventilated (open windows or doors).

In addition, landfill gas and contingency responses are set out in the sub-sections below.

#### 8.3.3.2 Skin Contact with Potentially Contaminated Materials

Should refuse materials be encountered, all personnel in the works area shall wear chemical resistant gloves and overalls until the refuse is removed, to reduce dermal or oral contact during all potential contact with contaminated materials.

All personnel excavating refuse and laying pipes where refuse has been exposed shall wear chemical resistant gloves and overalls during works.

Care shall be exercised when using equipment to avoid splashing of liquids. If water has pooled/ponded in an area it is to be pumped from the site for disposal at an approved facility or trade waste discharge to sewer. If leachate is encountered in trenches and excavations it shall be pumped for disposal at an approved facility or trade waste discharge to sewer.

Breaks in skin (cuts or abrasions) shall be disinfected immediately and covered.

#### 8.3.3.3 Ingestion of Toxic Materials

No food or drink shall be consumed within the construction area. All personnel are to remove protective clothing and wash hands prior to eating or drinking.

#### 8.3.3.4 Inhalation of Contaminated Dust

Dust generated during excavation and general site work may result in adverse health effects. As the content of the Landfill will vary, so therefore will the level and type of contaminants in the dust.

Ways in which onsite personnel may become exposed to dust include the following:-

- Inhalation of dust which may contain heavy metals and other contaminants.
- Dermal contact with contaminated solids and liquids on the ground, equipment or clothing.
- Ingestion of contaminants from eating, drinking or smoking within the work zone or before passing through decontamination.

In addition to nuisance dust issues, there is also the issue of exposure to hazardous chemicals in the contaminated dust from the Landfill. It is important that shower and boot wash facilities are provided to workers to allow them to decontaminate before leaving the work area. All work clothes shall be washed at commercial drycleaners and **NOT** washed at home. Clean overalls shall be provided to all workers at the beginning of each shift.

### 8.3.4 Training and Supervision

The Constructor responsible for the refuse intrusive works shall prepare a site specific LHSP for the works. The Constructor shall be responsible for providing hazard details to all personnel working at the site.

The Landfill reinstatement works should be carried out under the supervision of a NZ Chartered Professional Engineer (NZCPEng) with experience in landfill engineering.

### 8.3.5 Personal Protective Equipment

All personnel within the active works area shall use the following minimum level of personal protective equipment (PPE):

- Chemically resistant gloves (latex or nitrile).
- Chemically resistant overalls.
- Eye protection (if required).
- Respiratory protection (if required).
- Dust protection measures.

PPE requirements shall be routinely assessed cognisant of the prevailing conditions. PPE should be replaced as appropriate.

### 8.3.6 Landfill Gas Monitoring

In areas where refuse materials have been exposed it is likely that elevated levels of carbon dioxide ($CO_2$) and methane may be present. In addition, $CO_2$ and methane levels at the ground surface may be temporarily elevated due to exposure of refuse materials.

Continuous gas monitoring shall be undertaken at the ground surface in the intrusive works area (not within the excavations) during works.

Explosivity (%LEL) and oxygen (%$O_2$) deficiency should be monitored during all site activities. The multi-gas meter should be equipped with a sensor to monitor hydrogen sulphide ($H_2S$) and the sensor should have a detection limit of approximately 1 ppm (v/v) or less. A minimum of one gas monitor should be available at all times. The instrument should have been fully serviced and calibrated within the last six months. It is the responsibility of the contractor staff to ensure that the equipment is in correct working order, and is used effectively. Batteries shall be routinely charged overnight.

The main danger from landfill gas is an explosion. The gas monitors measure the percentage of the lower explosive level (LEL) of flammable gases and vapours present. The monitors shall be calibrated to methane and so, assuming no other flammable gases are present in significant amounts, the reading can be converted to a methane concentration. For the purpose of minimising the hazards, the alarm levels provided in **Table 8** are to be followed:

**Table 8 Action Levels**

| Location | %LEL | %$O_2$ | $H_2S$ (ppm) | PID (ppm) | Action |
|---|---|---|---|---|---|
| **Confined Space** | <5% | >19.5 % | <10 ppm | <5 | Enter and work with constant monitoring |
| | 5% to 10% | | 10 ppm to 15 ppm | | Enter only when necessary and work with extreme care, only when necessary. Remove all sources of ignition and monitor constantly |
| | 10% to 15% | <19.5% | >15 ppm | >5 | Evacuate space. Cordon off and ventilate area |
| **General site work** | <5% | >19.5 % | <10 ppm | <5 ppm | Normal work activities with monitoring regularly or when conditions change |
| | 5% to 10% | | <10 ppm | 5 pm to 250 ppm | Work activities can be continued with constant monitoring, within 3m of any source of ignition. Respirator must be worn at all times. |
| | 10% to 15% | <19.5% | >15 ppm | 250 ppm to 1000 ppm | Evacuate immediate work area. Cordon off and ventilate area. |
| **All areas** | ≥15% | | 100 ppm | >1000 ppm | Evacuate all work areas. |

Re-entry into areas can only be made when monitoring shows that the hazardous gas levels have fallen below the appropriate action level(s).

If explosive gas levels are found to be regularly in excess of 5% LEL, improved engineering controls shall be used to minimise the explosion hazard. In particular, ventilation of confined spaces shall be used to help ensure that landfill gas levels are kept non-hazardous.

Any landfill gas monitoring equipment should be intrinsically safe and meet as a minimum either NEC500 (US) Class 1 Division 1 Group D T1 rating or EEx ibd iiA T1 rating or equivalent.

### 8.3.7 Specific Health and Safety Requirements for Excavations into the Refuse Layer

Where excavations extend into the refuse (refuse intrusive works), additional health and safety measures may be required. If, during works, refuse is encountered, concentrations of landfill gas shall be measured in the relevant sections of the works area.

The measures outlined below shall be implemented while the refuse remains exposed:

- A minimum of two workers are required to be in the works area with full PPE, one to carry out the work and one to observe/act as backup.
- Continual active landfill gas monitoring shall be carried out in the works area (i.e. in the area outside the intrusive works area). If concentrations exceed the criteria in the landfill gas monitoring sub-section (above), work in the area shall cease and advice shall be sought from a suitably qualified landfill gas specialist.
- Personnel shall not enter excavations unless the following respiratory protection measures are implemented:
  - The person working within the excavation shall wear a full-face respirator with supplied air at positive pressure.
  - An observer shall remain outside the excavation and shall have available a full-face respirator with supplied air in case recovery in the works area is required.
  - Continuous landfill gas monitoring shall be carried out.
  - Respiratory protection procedures may be reassessed and altered as required based on continuous gas monitoring results.

If methane concentrations within the works area exceed 0.5%, work in the area shall cease and advice shall be sought from a suitably qualified landfill gas specialist.

Refuse may contain material which may contain human pathogens and would represent a biological hazard to staff. Refuse may contain the following materials which may represent a biological hazard:

- Medical waste (e.g. wastes from Hospitals, vets and tattooists). These can contain needles and blood products.
- Sanitary products and nappies.
- Soil microbes such as tetanus and legionella.

Potential pathogens that workers could be exposed to include hepatitis A, B and C, gastro-enteritis and tetanus, legionella, respiratory and skin diseases.

To minimise risk of being infected, all workers should:

- Use good hygiene practices such as hand washing and drying.
- Not eat or smoke around the Landfill.
- Use PPE provided including gloves, mask (or respirators), safety glasses and disposable tyvek suits.
- Use procedures for when hand-washing facilities are not available (i.e. antibacterial hand wipes).
- Have frequent changes of tyveks and gloves.
- Use disinfectant of sampling equipment at end of shift.
- Avoid touching face with hands.
- Disinfectant any cuts or grazes that occur on-site.
- Report all illness.

# 9 Summary and Conclusions

The key elements of the Project in the vicinity of the Landfill from Chainage 2050m to Chainage 2525m are the Northern Busway extension and Shared Use Path (SUP). As the Busway/SUP encroaches onto the western area of the Landfill, it will affect existing operational infrastructure for the Landfill and the compliance monitoring network and will require excavation into refuse.

Council, the Landfill site owner, holds all consents associated with the ongoing discharges to land, air, and water. The aftercare management and monitoring of the Landfill is the responsibility of the Council CLCLR team.

For the purpose of this report where there is an absence of relevant and/or reliable information, the Project Team has taken a conservative/precautionary approach and assumed the worst case for analysis, developing solutions and proposed mitigation measures and controls. Specific site investigations (geotechnical and environmental) are planned for February/March 2017 to address the key information gaps. The output of these investigations should be used to refine assumptions, risks and mitigation measures outlined in this report and to inform the detailed design and construction phase of the Project.

Construction on closed landfills requires careful consideration of hazards (refuse, gas, leachate, etc.). Construction management and health and safety measures and controls to mitigate risk to construction workers, Landfill maintenance staff, and the receiving environment are required to address the hazards.

Key aspects/considerations are:

- The Landfill is a closed Landfill that accepted general refuse from the 1950s until October 2002 and cleanfill until 2008. Refuse placed in the western area (in the vicinity of the Project) pre-dates 1984 other than for a small part in the north-west where refuse was placed from 2000 to 2002. The western area of the Landfill is unlined.
- The Landfill was placed on the western slopes of a previous ridge underlain by alternating sandstone and siltstone belonging to the East Coast Bays Formation (ECBF). Bedding in the ECBF in the Landfill area dips at between 15° to 80° to the south-east. The Landfill subgrade comprises weathered ECBF soils, which are typically silty clay.
- The regional groundwater level is below the base of the refuse either naturally or due to groundwater drains installed in the northern area during Landfill construction. Regional groundwater flow beneath the Landfill is typically towards the north-west with a localised area of south-west flow in the south-western corner. Localised perched groundwater (above the regional groundwater) occurs in the soil between the Landfill and SH1. The available groundwater quality results indicate negligible influence from leachate. Registered groundwater users are >2km from the Landfill.
- Groundwater monitoring points and infrastructure in the Project area comprise one manhole for groundwater drain monitoring (GW MH1), groundwater drainage network pipework, and two groundwater monitoring bores.
- Stormwater runoff from the Landfill is captured by open channels and typically directed to detention ponds where the runoff is detained for subsequent discharge to the receiving environment (Oteha Stream) at a controlled rate. Stormwater from over half of the Landfill area (including the western area) flows through a detention pond (Pond 7) in the north-western corner of the Landfill before discharging to the Oteha Stream on the western side of SH1. Stormwater infrastructure in the Project area includes channels, pipework, manholes, and stormwater Pond 7.

- For the most part, leachate within the Landfill flows through the refuse by gravity to leachate collection drains, which are interconnected and eventually drain into a terminal leachate manhole. Leachate lines that branch off the main line, the terminal manhole, monitoring manhole, and Council discharge manhole are all located in the western area in the vicinity of the Project.
- Landfill gas infrastructure in the Project area includes the western part of the gas ring main, ring main feeder pipes, valves, sampling points and condensate dropout points. Landfill gas monitoring in the Project area includes gas migration monitoring probes on the western, north-western, and south-western Landfill property boundaries.
- A Landfill infrastructure and monitoring network needs to remain operational during the Landfill aftercare period (minimum 30 years).
- The Hazardous Activities and Industries List (HAIL) activities that apply to the Landfill site are B4 (power stations (power generation plant only)) and G3 (landfill sites). Contaminated and potentially contaminated soils at the site include the refuse, the landfill sub-grade, the cover layer and the soils associated with the decommissioned power generation plant. The Landfill leachate is a contaminant. Leachate has the potential to contaminate groundwater beneath the Landfill. Monitoring results to date indicate negligible influence from leachate on groundwater, which suggests that the leachate collection and disposal system is effective.
- The gas migration risk assessment indicates that between one and two levels of gas protection are required. It is common practice to adopt the concept of multiple gas protection measures. Two levels of protection are recommended.
- The Landfill reinstatement concept aims to:
  - Minimise excavation into refuse.
  - Remove refuse from within/below the Busway/SUP footprint.
  - Remove refuse from the area (5.5m to 6m nominal width) immediately east of the Busway/SUP.
  - Provide a new sidewall liner.
  - Provide a two-tier system to act as a barrier to lateral migration of landfill gas.
  - Reinstate Landfill infrastructure and the Landfill monitoring network.
- There are significant actual and potential adverse effects associated with the construction activities in the vicinity of, and on, the Landfill.
- Specific measures and controls must be implemented to mitigate the risks of construction activities on construction workers, Landfill maintenance staff, and the receiving environment.

The effects of operation of the Project on the Landfill are assessed to be negligible or less than minor with mitigation measures implemented.

There will be some short-term adverse effects as a result of construction activities and some of these effects are assessed as being significant, if not mitigated. These risks should be minor (or lower) with the implementation of appropriate mitigation measures. The mitigation measures will need to include consideration of specific construction management aspects and health and safety issues and be addressed during detailed design, construction and reinstatement in the vicinity of the Landfill. Implementation documentation/actions must include:

- Preparation and certification of a LRWP for the elements of the Project in the vicinity of the Landfill and the Landfill reinstatement works. The LRWP shall include a site specific LHSP prepared in consultation with Council CLCLR.
- Preparation and certification of Construction Method Statements for all Landfill reinstatement works.
- Supervision of the Landfill reinstatement works by appropriately qualified and experienced personnel.

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