

Fire Management Plan

Green Island Landfill

Dunedin City Council

13 March 2023

→ **The Power of Commitment**



Project name		GILF Closure Consents					
Document title		Fire Management Plan Green Island Landfill					
Project number		12547621					
File name		12547621_RPT_Green Island Landfill Fire Management Plan					
Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	Rev01	N Karim S Kentwell P De Mar	A Dixon		S Douglas		13/3/2023

GHD Pty Ltd | ABN 39 008 488 373

133 Castlereagh Street, Level 15

Sydney, New South Wales 2000, Australia

T +61 2 9239 7100 | **F** +61 2 9239 7199 | **E** sydmail@ghd.com | **ghd.com**

© GHD 2023

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Project name		GILF Closure Consents					
Document title		Fire Management Plan Green Island Landfill					
Project number		12547621					
File name		12547621_RPT_Green Island Landfill Fire Management Plan					
Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	Rev01	N Karim S Kentwell P De Mar	A Dixon		S Douglas		13/3/2023

GHD Pty Ltd | ABN 39 008 488 373

133 Castlereagh Street, Level 15

Sydney, New South Wales 2000, Australia

T +61 2 9239 7100 | **F** +61 2 9239 7199 | **E** sydmail@ghd.com | **ghd.com**

© GHD 2023

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Contents

1.	Introduction	2
1.1	Current site overview	2
1.2	Purpose of this report	3
1.3	Reliance	3
1.4	Scope and limitations	4
2.	Site setting	5
2.1	Site location and environs	5
2.2	Existing site features	5
2.3	Fire danger days	8
3.	Landfill fires and potential ignition sources	10
3.1	Types of landfill fires	10
3.2	Typical causes of fires in landfill	11
3.3	Fire history records	12
3.4	Potential fire ignition sources	12
4.	Regulatory requirements and key guidelines	13
4.1	Overview	13
4.2	New Zealand documents	13
4.2.1	Resource Management Act 1991	13
4.2.2	Health and Safety at Work Act 2015	14
4.2.3	WasteMINZ Technical Guidelines for Disposal to Land 2018	14
4.3	International documents	14
5.	Proposed development	15
5.1	Overview	15
5.2	Site vegetation and fire hazards on surrounding land	15
5.3	Fire prevention	16
5.4	Fire detection and reporting	18
5.5	Fire notification	19
5.5.1	Operating and after hours	19
5.6	Fire risk mitigation and readiness	19
5.6.1	Overview	19
5.6.2	Site access road network	19
5.6.3	Water sources	19
5.6.4	Landfill cover procedures	19
5.6.5	Perimeter fuel break	20
5.6.6	Onsite evacuation assembly areas	20
5.6.7	Onsite equipment	20
5.6.8	Staff training	20
6.	Fire response	22
6.1	Fire response organisation	Error! Bookmark not defined.
6.2	Operating procedure – Fire response	22
6.2.1	Landfill surface fire response (operational hours)	22
6.2.2	Landfill surface fire response (after hours)	22

6.2.3	Landfill sub-surface fire response	22
6.2.4	Operating procedure – Site safety	23
6.2.5	Personnel evacuation	23
6.2.6	Residual fire risk monitoring	23
7.	Incident reporting and cause investigation protocol	24
7.1	Overview	24
7.2	Incident reporting	24
7.3	Cause investigation protocol	24
8.	Review and evacuation protocol	26
8.1	Checklist and Action Plan	26
8.2	Fire cause review	26
8.3	Process for continuous improvement	26
8.4	Recovery	26
9.	External notification protocols	27
10.	Response and notifications contact details directory	28
11.	Recommendations	29
11.1	Changes to LDMP and LOP	29
12.	References	29
	Fire management action plan	8

Table index

Table 1	Glossary	1
Table 2	Existing site features	5
Table 3	Potential fire ignition sources	12
Table 4	Prevention measures	16
Table 5	Detection measures	18

Figure index

Figure 1	Landfill Location and Layout	2
Figure 2	Annual number of very high and extreme (VH+E) fire danger days (Source: Scion 2011)	9

Attachments

Attachment 1	Fire response form
Attachment 2	Checklist
Attachment 3	Site map

- Attachment 4 Action plan
- Attachment 5 Images of vegetation onsite
- Attachment 6 Locations of fire hydrants

Glossary

Table 1 Glossary

Term	Definition
Council/DCC	Dunedin City Council
ESC	Erosion and Sediment Control
EPA NZ	Environment Protection Authority New Zealand
FENZ	Fire Emergency New Zealand
FMP	Fire Management Plan
Intermediate cover	Intermediate cover covers exposed refuse and is made up of soil material. It has a minimum thickness of 300 mm - 600 mm. Intermediate cover is non-combustible.
LDMP	Landfill Development and Management Plan
LOP	Landfill Operations Management Plan
MfE	Ministry for the Environment
MSW	Municipal Solid Waste
ORC	Otago Regional Council
RRPP	Resource Recovery Park and Precinct
Site	Green Island Landfill, limited to the proposed landfill waste placement footprint detailed in the Waste Futures - Green Island Landfill Closure Design Report (2023)
SRP	Sediment Retention Pond
SWMS	Safe work method statement
PPE	Personal Protective Equipment
TC	Total concentrations
TCLP	Toxicity characteristic leaching procedure
WasteMINZ	Waste Management Institute New Zealand
WM	Waste Management New Zealand Ltd

1. Introduction

Dunedin City Council (Council) engaged GHD to review the Green Island Landfill Development and Management Plan (LDMP) (Stantec 2023) and provide input for the fire management component as an appendix to the Waste Futures - Green Island Landfill Closure Design Report (GHD, 2022).

Landfill fires are manageable at an operational landfill site. Therefore, the key issue is how they can be minimised and best contained so that small occasional fires are promptly identified and extinguished at the source and do not become a large catastrophic fire.

1.1 Current site overview

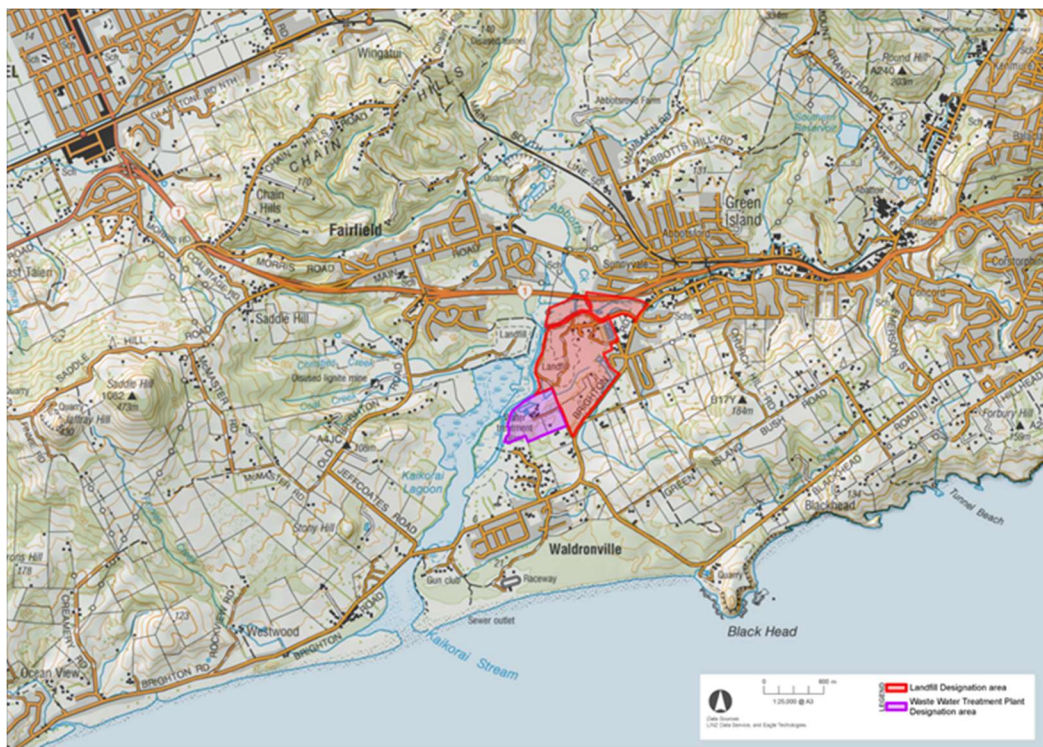
Green Island Landfill (the site, Green Island) is located in Green Island, Dunedin.

Figure 1 shows the site location and the surrounding context. The landfill has been in operation since the 1950s and comprises of a total area of approximately 38 ha owned by Council and currently approved for landfilling. The site is currently operated by Waste Management NZ Ltd (WM).

Existing site operations under the current LDMP includes controls and procedures for access control, stormwater management, leachate management, landfill gas management, green waste mulching and composting, salvage and management of diverted materials, roading and traffic management, waste acceptance and placement, waste cover, and control of nuisances. The current operations are outlined in Section **Error! Reference source not found.** and future operations for the purpose of the landfill expansion are outlined in Section 5.

This report covers the waste placement operations and closure associated with the portion of the site where landfilling is proposed to be continued beyond October 2023. Specifically for the landfill it also includes controls for the landfill gas field, the provision of the water supply for the fire fighting and vegetation setbacks and its management.

Figure 1 Landfill Location and Layout



1.2 Purpose of this report

This fire management assessment report (as an appendix to the design report¹) has been prepared to

- Assess the potential and associated risks of a fire occurring on site during operations and following its closure, including from an external fire entering the site.
- Identify prevention, detection and mitigation techniques.
- Identify the general items to be addressed in the event of an emergency related to a fire, and general protocols to employ following a fire.

The LDMP has recently been re-issued to the Otago Regional Council (February 2023). This report will provide recommendations for further updates to the LDMP which will be incorporated following the approval of any replacement resource consents. These are also summarised in a list of proposed updates to the LDMP appended to the AEE for the Green Island replacement consent application.

1.3 Reliance

The following documents have been considered in this assessment:

- Beca Carter Hollings and Ferner Ltd. (1998). Green Island Landfill perimeter Bund Construction and Staging Report
- Beca Steven. (1992). Environmental Impact Statement of the Extended Green Island Sanitary Landfill
- Boffa Miskell. (2022). Images (3) of the landfill planting and vegetation
- Boffa Miskell. (2021a). Green Island Extension, Closure and RRRP – Open Space
- Boffa Miskell. (2021b). Green Island Extension, Closure and RRRP – Zoning
- Boffa Miskell. (2021c). Green Island Extension, Closure and RRRP – Site overview
- Department of Conservation. (2000). Succession in the Kaimaumau gumland, Northland, New Zealand, following fire
- Dunedin City Council (DDC). (2021). Green Island Resource Recovery & Processing Precinct Park Masterplan Report
- DCC. (2021). Green Island Landfill – Update of Landfill Development Management Plan (LDMP) for 2022 Capping Works
- DCC. (2022). Drone Photogrammetry
- Email correspondence from DCC regarding Green Island LDMP dated 9 December 2022
- Fire Emergency New Zealand (FENZ). (2019). Risk Reduction Strategy 2019 – 2022
- GHD. (2023). Waste Futures - Green Island Landfill Closure Design Report
- Ministry for the Environment (MfE). (2004). Hazardous Waste Guidelines. Landfill Waste Acceptance Criteria and Landfill Classification
- MfE. (2015). Waste Assessments and Waste Management and Minimisation Planning – A guide for territorial authorities.
- MWH New Zealand Limited (2007). Green Island Landfill Development & Management Plan
- Stantec. (2023). Green Island Landfill Development and Management Plan (LDMP).
- Waste Management NZ Ltd (WM). (2018). Green Island Landfill Management Plan (LOP).
- Waste Management Institute New Zealand (WasteMINZ). (2018). Technical Guidelines for Disposal to Land – Appendices.
- WasteMINZ, 2022, Record of fires at Green Island facility between August 2017 and January 2022

¹ Waste Futures - Green Island Landfill Closure Design Report (GHD, 2022)

1.4 Scope and limitations

This report: has been prepared by GHD for Dunedin City Council and may only be used and relied on by Dunedin City Council for the purpose agreed between GHD and Dunedin City Council as set out in Section 1 of this report. GHD otherwise disclaims responsibility to any person other than Dunedin City Council and Council officers, consultants, the hearings panel and submitters associated with the resource consent and notice of requirement process for the Green Island Landfill Closure Project arising in connection with this report.

GHD also excludes implied warranties and conditions, to the extent legally permissible. The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report.

GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared. The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Dunedin City Council and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information. The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

2. Site setting

2.1 Site location and environs

The Green Island Landfill site is located approximately 8.8km by road from central Dunedin in the suburb of Green Island. The entire site comprises a total area of approximately 76 hectares, being the total area of the landholding owned by Council and designated in the 2GPI.

In terms of external assistance in the event of a fire at the site, the nearest FENZ station (Lookout Point) is located at 184 Mornington Road, Kenmure which is approximately 4 km from the site or approximately 5 minutes by motor vehicle, subject to traffic conditions. The Lookout Point station is crewed 24 hours a day, seven days a week. Further, there are two other FENZ stations within approximately 10 km of the site.

The surrounding land use, topography and climate are described in Section 2 of the Waste Futures – Green Island Landfill Closure Design Report (GHD 2023).

2.2 Existing site features

Table 2 outlines the existing features and the main fire management procedures currently employed at the site are documented in the LMDP (Stantec 2023) and LOP (WM 2018).

Table 2 Existing site features

<p>Access</p>	<p>Access to the site is via the main entrance on Brighton Road.</p> <p>The site perimeter is securely fenced and gates to the main entrance are locked outside of operational hours.</p> <p>Vehicles delivering waste directly to the landfill are restricted to selected large commercial customers. Members of the public can drop waste at the transfer station, which will be taken to the landfill in consolidated loads.</p> <p>Roads to the tip face are formed with all-weather surfaces from the site entrance and maintained for safe tracking by customer vehicles in all weather conditions.</p>
<p>Scale and type of landfill operation</p>	<p>The quantities and classes of waste received and landfilled at the site are detailed in Section 4 of the Waste Futures – Green Island Landfill Closure Design Report (GHD 2023). The site landfills approximately 120,000 tonnes per annum and roughly 50% of this comprises uncontaminated and contaminated soils. The broad composition of the waste landfilled at the site is as follows:</p> <ul style="list-style-type: none"> – General household municipal waste – Construction and demolition waste – Special and hazardous waste – Asbestos (incl Asbestos in Soils) – Contaminated and uncontaminated soil – Household mattress – Sludges and liquids (including some used oil) – Tyres <p>At this junction, is it worth noting that due to the relatively high proportion of generally non-combustible soil in the landfilled waste it reduces the potential for landfill fires at the site.</p>
<p>Site infrastructure (across the whole facility)</p>	<p>Site infrastructure is described in Section 5.2 of the Waste Futures – Green Island Landfill Closure Design Report (GHD 2023) and it includes:</p> <ul style="list-style-type: none"> – Waste transfer station – Dangerous good store – Weighbridge at the site entrance – Composting area – Site haul roads and paved areas – Wheel wash

	<ul style="list-style-type: none"> – Leachate collection system – Landfill gas collection system – Other
Screening of incoming waste	<p>Waste is screened, by operator visual inspection, at the weighbridge and tipping area to identify waste types not permitted for disposal at the site such as gas cylinders. Further controls include the source of waste is either municipal waste, with all other users of the facility having to declare if they are depositing special or hazardous waste.</p> <p>No waste is received directly from the public at the tipping face and another level of screening takes place at the Green Island Facility's transfer station.</p> <p>On occasion random inspections are undertaken to confirm wastes are permitted to be landfilled at the site.</p>
Landfill operations	<p>The tip face is opened each day by stripping back daily cover. The landfill is developed progressively in accordance with the pre-determined plan agreed with Council to optimise site conditions.</p> <p>Generally, only one tip face is operated at any one time. The width of the active tip face is restricted to 30 m. The area of refuse exposed at the active tip face is kept as no more than 900 m², unless special circumstances prevail that necessitate a maximum of 1200 m².</p> <p>Once the material is placed onto the tip face, it is moved and compacted by heavy mobile plant.</p> <p>Daily cover will comprise natural earth material with a thickness of up to 150mm. A minor organic content from vegetation will be acceptable. A minor amount of contamination (low level contaminated soils) or flagging with waste will be acceptable if the soil has been used previously as cover.</p> <p>Daily cover placement may commence at any time during the day on areas of exposed refuse that will not be receiving more refuse that day.</p> <p>Alternative daily covers are identified as an option, provided they perform as well as a soil cover.</p> <p>Should daily cover areas not have waste placed over them for more than 3 months then another layer of 150mm thick daily cover will be placed or intermediate cover or final capping will be undertaken.</p> <p>Intermediate cover will comprise 300mm to 600mm of soil capping material. Surfaces that will remain exposed for a period exceeding three months will be vegetated or grassed to prevent erosion. The permeability of intermediate cover will be less than 10⁻⁷ m/s after compaction.</p> <p>Final cap will comprise (from top to bottom):</p> <ul style="list-style-type: none"> – 350 mm topsoil and sub – soil – 600 mm low permeability clay (1 x 10⁻⁷ m/s) – 300 mm intermediate cover
Leachate	<p>Green Island Landfill has been retro-fitted with a leachate collection system comprising a perforated cut off drain around the west, north and east sides of the landfill that intercepts groundwater flow moving from beneath the landfill towards the Kaikorai Stream and other wetland areas outside the landfill. Leachate collected in the cut off drain flows into a series of pump stations, where it is pumped into the wastewater pipeline discharging to the Green Island Wastewater Treatment Plant. There is a shallow swale that collects leachate breakouts or surface water that is contaminated by contact with refuse at the active tipping areas and drains it to the leachate collection system. There is also an open leachate ditch along the southern side of the landfill that drains to a pump station. If the replacement consents are granted this southern surface drain will be replaced with a cut off trench.</p>
Landfill gas	<p>A landfill gas collection and treatment system has been established at the site, comprising vertical wells to apply vacuum throughout the waste and horizontal pipes radiating from the vertical wells.</p> <p>The extracted landfill gas is conveyed via network of pipework to the adjacent Green Island Wastewater Treatment Plant where it is used to generate electricity or flared.</p> <p>A mobile solar flare is also available for gas destruction, with the ability to be relocated around the site and connect to up to 5 wells that are not able to be on the main network. The solar flare is typically located close to the active tipping face.</p>
Surface water collection	<p>Stormwater containing sediments is discharged into the existing sediment ponds onsite, prior to discharging into the nearby streams. There are sediments ponds to the east and west for non-contaminated surface water catchments.</p> <p>The stormwater ponds are not generally used for filling the site water cart nor for any other operational purpose but could be used for emergency situations.</p>

Environmental monitoring	<p>Environmental monitoring is undertaken on varying frequencies, including:</p> <ul style="list-style-type: none"> – Surface water monitoring – Sedimentation ponds – Groundwater monitoring – Leachate collection trench and pump stations – Landfill gas composition <p>Environmental monitoring is undertaken by external consultants for the purpose of ensuring compliance with the Resource Consent reporting requirements. WM and DCC are advised immediately of any emergency situations.</p> <p>Monthly reports are prepared including a list of all complaints received and actions take, as well as any emergencies that arose.</p> <p>Annual reports are prepared for DCC including a summary of the year’s operation and an annual plan that outlines the next year’s operation. This includes waste quantity summaries, remaining airspace capacities, monitoring results and more.</p>
Operating hours	<p>The landfill operates under the following operational hours:</p> <ul style="list-style-type: none"> – Monday to Saturday: 8:00 to 17:30 – Sunday: 9:00 to 17:30
Normal on-site workforce presence	<p>Typically, two to three people are allocated to and present during operational hours at the tip face. This would reduce to a minimum of one for short periods of the day during lunch and break times as well as at the beginning and ends of the day. Total number of landfill staff onsite is normally between four and six and the distance that those staff are from the tip face is generally no greater than 500m with easy access to vehicles.</p>
After hours arrangements and site security	<p>Wastes are only accepted outside of these operational hours when instructed by DCC. This activity occurs very infrequently.</p> <p>Gates to the site are locked outside of operational hours. CCTV operation in and around the weighbridge, transfer station and resource recovery area is 24hrs, seven days per week, but not actively monitored.</p>
Plant and equipment	<p>During waste placement, the following equipment is readily available onsite:</p> <ul style="list-style-type: none"> – 1 x reuse compactor (minimum 24 tonnes, 180 kW, “816” size) – 1 x bulldozer (minimum 16 tonnes, 110 kW, “D6” size) – 2 x hydraulic excavators (minimum 12 tonnes, 60 kW) – 1 x water truck – 3 x 4WD utility vehicle (various configurations) – 1 x 6W truck <p>Additional equipment is periodically employed onsite, including:</p> <ul style="list-style-type: none"> – Additional compaction – Additional hydraulic excavator – Additional dump truck(s) – Tractor – Re-fuelling truck – Motor-grader – Wheel loader – Roller
Fire water supply	<p>Potable water enters the site along main entry road services the workshop, main office, rummage store and transfer station. There are two hydrants located at the site, with one at the exist of wheel wash and the other one is adjacent the fenced compound. The location for these hydrants is depicted in Error! Reference source not found..</p>
Fire management procedures	<ul style="list-style-type: none"> • Prohibition on all forms of deliberate burning. • No smoking on site. • Screening of wastes by visual inspection during operations. • Close control of waste deposition. • Good compaction and cover. <p>Fire extinguishers are held on site and in all mobile plant and the operator’s vehicles on the site. Operations staff are trained in the use of such equipment and in techniques for dealing</p>

	with surface fires and deep-seated fires. The Fire Service will be called to deal with large fires and are understood to have been consulted regarding training and establishment of on-site fire-fighting procedures. Further details are provided in the Site Emergency Management Procedure (Stantec 2023).
Final landform	The final cover placed to date comprises no less than: <ul style="list-style-type: none"> – 350 mm topsoil (grassed) and sub-soil – 600 mm low permeability clay (with a permeability of $< 10^{-7}$ m/s) – 300 mm intermediate cover

2.3 Fire danger days

The National Institute of Water & Atmospheric Research Ltd prepared a Fire Risk Assessment report in 2017 for the Ministry for the Environment which provides a measure to quantify bush fire risk for New Zealand locations. The guidance document utilises the New Zealand Fire Danger Rating system which relies on:

- Daily rainfall;
- Temperature;
- Relative humidity; and
- Wind speed.

Due to Green Island's coastal influenced climate and high latitude (45.9 degrees south) toward the southern end of the South Island, it experiences much milder fire weather conditions than areas further north along the east coast. Nevertheless, during drought-affected seasons, hot days and windy conditions, fire conditions may be exacerbated and can elevate the fire danger. Research published in 2012 found that on average, the Dunedin region experiences 6 – 9 very high and extreme fire danger days per year, expected to increase to 12 – 16 days per year by 2040 (Scion, 2012)**Error! Reference source not found..**

FENZ reports the daily fire rating and provides a short-term fire rating forecasts for New Zealand including for the Dunedin region (FENZ, 2023).

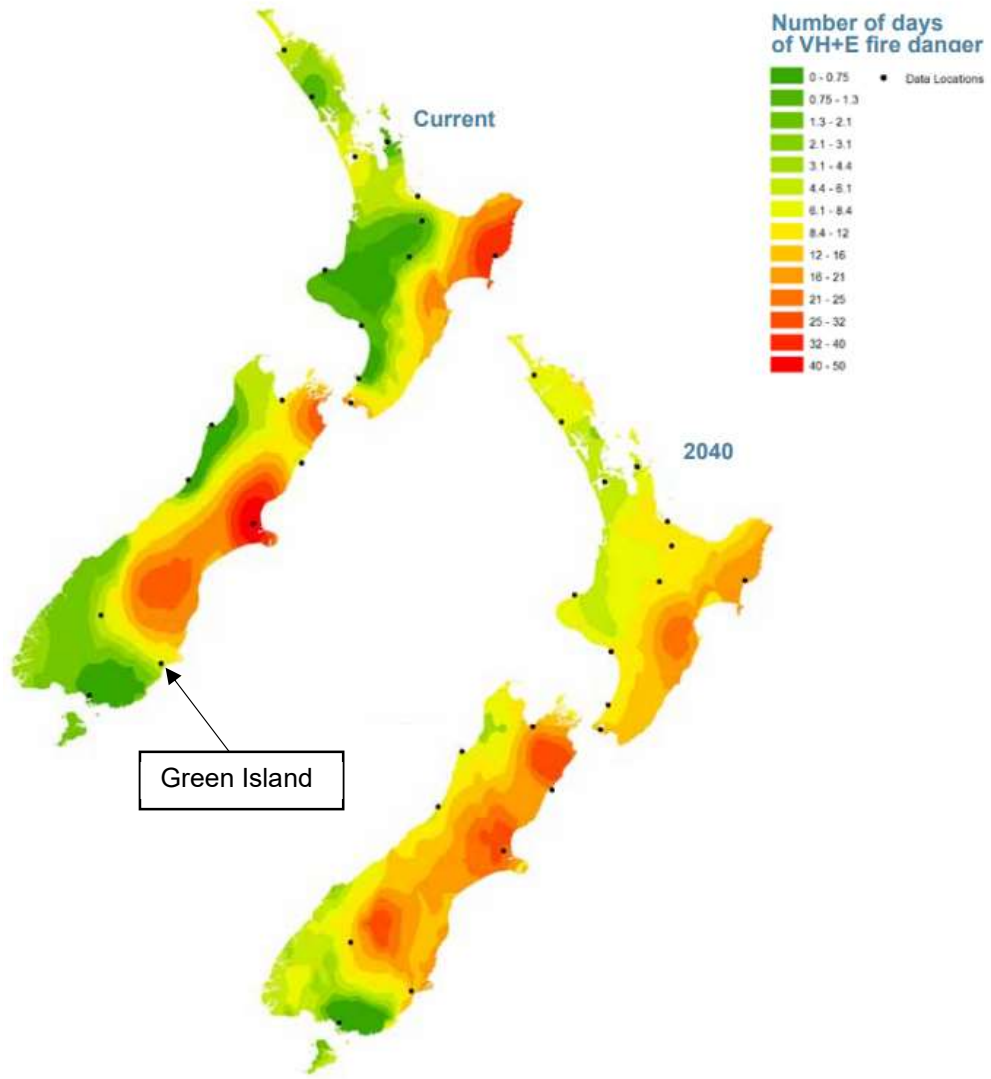


Figure 2 Annual number of very high and extreme (VH+E) fire danger days (Source: Scion 2011)

3. Landfill fires and potential ignition sources

3.1 Types of landfill fires

The International Solid Waste Association Landfill Operational Guidelines (2010) describes the necessary components for a fire to occur as:

- Heat or ignition source;
- Fuel; and
- Oxygen

All three elements must be present for a fire to occur and removal of one of the elements will result in the fire being extinguished. The relationship between the elements is shown in **Error! Reference source not found.** Figure 3 below.

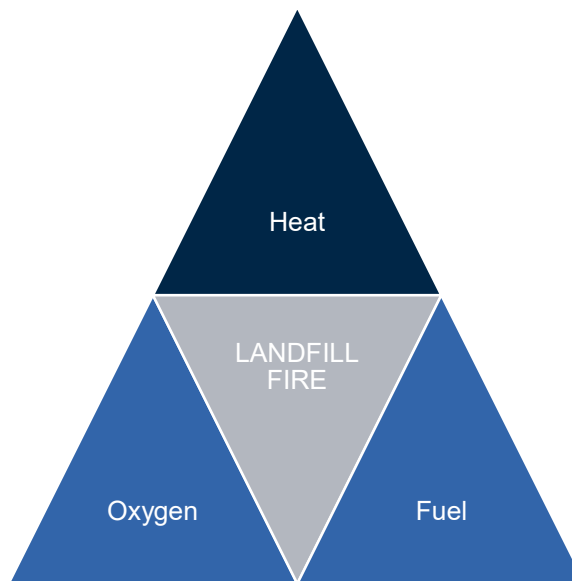


Figure 3 Fire Triangle (ISWA 2010)

Landfill fires are not uncommon at an operational landfill site. There are two main types of fires that occur at landfills.

- Surface fires at a landfill can occur in recently placed and/or exposed waste.
- Subsurface fires (sometimes referred to as deep seated fires or 'hot spots') are caused by exothermic reactions that occur below the surface of the landfill or from a surface fire not being extinguished and extending into the waste. Subsurface fires tend to travel slower than surface fires and would be limited to the extent of the landfill.

A further fire possibility is a forest or grass fire extending onto the site and damaging plant, equipment, infrastructure and potentially causing surface waste to ignite.

The natural biological decomposition of waste generally results in the temperature of landfilled waste below the surface in the range of generally between 40 – 60 degrees Celsius.

3.2 Typical causes of fires in landfill

Surface fires at a landfill can occur in recently placed and/or uncovered waste. Based on a literature review of relevant guidance documents (Fattal et al 2016, Environment Agency 2007, FEMA 2002, Environmental Services and Regulation 2020), and GHD experience, some causes of landfill surface fires where they can be identified are as follows.

- Dumping of hot materials;
- Pilot ignition from engines and exhaust systems of vehicles;
- Deliberate ignition from arson or mixing of reactive materials;
- Extreme weather conditions such as extended dry and hot weather;
- Large area of exposed waste at the surface of the landfill;
- Over extraction of landfill gas from landfill gas collection systems;
- Air ingress into landfilled waste other than due to landfill gas collection systems operations;
- Poorly designed leachate re-circulation system;
- Embers from another fire;
- Hot works;
- Lightning;
- Poorly maintained equipment or faulty electrical wiring;
- Spontaneous combustion of materials;
- Combustion of lithium-ion batteries; or
- A combination of the above.

Hot spots are exothermic reactions that occur below the surface of the landfill. Some of the causes identified in literature (Fattal et al 2016, Environment Agency 2007, FEMA 2002) include.

- Burying of surface fires;
- Over extraction of landfill gas collection systems;
- Air ingress other than due to landfill gas collection system operations;
- Poorly designed leachate re-circulation system;
- Spontaneous combustion of materials;
- Combustion of lithium ion batteries; or
- A combination of the above.

However, quite often the cause of a landfill fire whether it be a surface fire or hot spot below the landfill surface is unknown. The review by the Australian Institute of Sustainable Futures (ISF 2016) from data provided by the New South Wales Environmental Protection Authority for landfill fires between the start of 2014 and April 2016 indicated that the cause for the majority of these fires in New South Wales Australia was recorded as unknown. This is also supported by international studies by FEMA (2002) that concluded more than half of fires at landfills have no known cause.

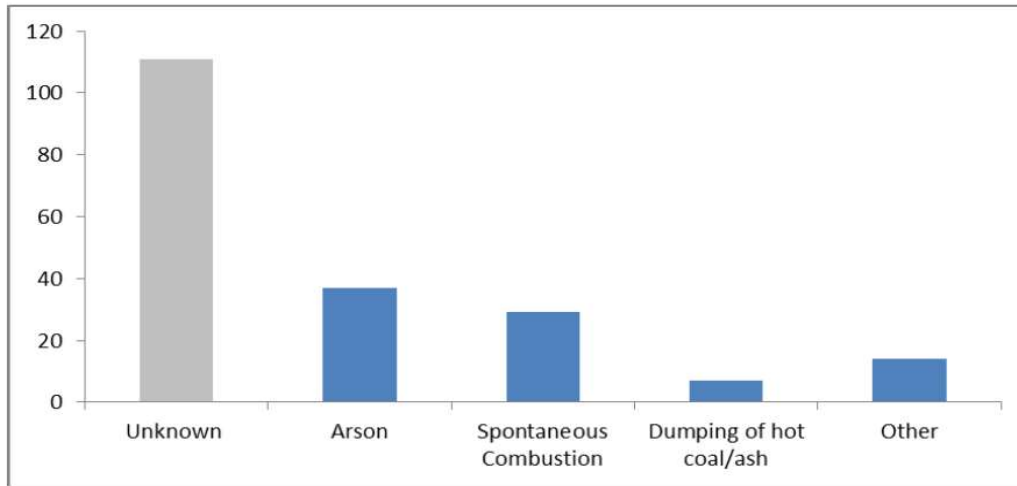


Figure 4 Causes of fires in New South Wales (ISF, 2016)

Similarly, the UK Environment Agency (2007) reviewed 78 incidents at landfills to identify the main causes and contributing factors for hot spots which in some cases can cause a surface fire. Air ingress to the waste as a result of active gas extraction system management was suspected to be the primary contributing factor for the majority of sites (62%).

3.3 Fire history records

Based on review of the fire history information provided for the Green Island landfill between April 2016 and January 2023, the following findings were identified:

- Seven fires occurred at the landfill active filling area, suspected causes included:
 - Chemical reaction from hydrated lime delivered to the landfill
 - Three battery fires
 - Hot loads received at the landfill on two occasions
 - Fire started by heated debris that had built up under the axle guard of the compactor

These fires were detected by visual observations by site staff of smoke and flames. The fires detected at the tipping face were extinguished by digging out of the hot spot and either or both extinguishing with water and placement and compaction of clay material. In two out of the seven landfill fires which were not able to be rapidly extinguished by site staff, FENZ was called to assist control the fire.

3.4 Potential fire ignition sources

Key potential fire ignition sources at the site have been identified in Table 3.

Table 3 Potential fire ignition sources

Potential fire ignition sources	Description
Batteries	The most recurrent cause of landfill fires reported at the site is combustion of batteries.
Hot waste materials	Dumping of hot waste materials on the landfill face can provide an ignition source to start a fire.
Vehicle engines	Pilot ignition from engines of vehicles. Diesel engines reduce particulate and soot emissions by trapping the particles in the filter. Once they reach a certain saturation level, the engine increases the temperature inside the exhaust to 'burn off' the particles. The heat dissipating from the exhaust may be a potential fire ignition source.
Active tipping face	Landfill fires with a large area of exposed waste at the surface of the landfill have an increased risk of spreading and are more difficult to extinguish.

Potential fire ignition sources	Description
	Spontaneous combustion of materials or sub-surface fire migration to surface.
Air ingress	Air ingress into the landfilled waste, particularly on batters where it is more difficult to compact waste and place cover.
Arson	Deliberate ignition from arson.
Landfill gas collection	Over extraction of the landfill gas collection system and introducing air and facilitating spontaneous combustion of the waste.
Electrical wiring	Poorly maintained equipment or faulty electrical wiring sparking ignition.
Leachate system	Air ingress from the leachate extraction system.
Fuel ignition	<p>Areas close to gas sources are classified as hazardous with reference to NZS 2430.3.7:1997. These include:</p> <ul style="list-style-type: none"> – Points within 0.25 m around a point of potential gas leakage such as a wellhead, valve, blower, and flanged pipe joint. – Any area within 3 m of a venting duct such as vents on leachate tanks. – Any enclosed or inadequately vented area within the gas system such as a condensate pump shed. – Inside any tank (Waste Management NZ Ltd (WM), 2018).
A combination of the above.	

4. Regulatory requirements and key guidelines

4.1 Overview

The site's regulatory requirements were reviewed with regard to fire management. Also considered in this section are relevant guidelines (both national and international) in relation to the management of fires at landfill sites.

4.2 New Zealand documents

4.2.1 Resource Management Act 1991

The Resource Management Act 1991 is a key legislative guide for the development and operation of landfills in New Zealand. The purpose of the Resource Management Act is to promote sustainable management of natural resources. The Act outlines controls on the environmental effects of waste management facilities through local policies, plans and resource consent procedures. The Act requires land use consent for the development of new landfill sites.

The history of resource consents is summarised in the Waste Futures - Green Island Landfill Closure Design Report (GHD 2023) with the relevant specific conditions relating to fire management stating:

- the consent holder shall not disposal of any material in the landfill by burning it. Should any fire arise in the landfill it shall be extinguished immediately upon being detected
- the intentional burning of rubbish is not allowed. Any unintentional fires must be extinguished as soon as possible. Fires lit on the landfill site specifically for training exercises will be allowed so long as all precautions are taken to avoid the fire spreading to the refuse and the amount of smoke generated is minimised

4.2.2 Health and Safety at Work Act 2015

The Health and Safety at Work Act 2015 aims to provide a framework to ensure the health and safety and workers and workplaces. The Act outlines the duties of employers to provide a safe workplace for any individuals undertaking works at the site. There are a number of responsibilities that include provision of safe work systems, provision and maintenance of safe plant, and training programs to allow for a work environment that is without risk to health and safety, as far as reasonably practicable.

4.2.3 WasteMINZ Technical Guidelines for Disposal to Land 2018

The Waste Management Institute New Zealand (WasteMINZ) prepared technical guidelines for the siting, design, operation and monitoring of landfills in New Zealand. Management measures prescribed in the guidelines are focused on the potential effects of new landfills or landfill cells on the environment and communities. The guidelines do not cover initial emergency response to natural disasters however do outline the following relevant pre-planning measures for fire management in section 7.11:

- *Construction of fire breaks around landfill cells*
- *Prohibition of all forms of deliberate burning at the site*
- *No smoking allowed at the site by personnel or visitors*
- *Adequate screening of incoming waste loads*
- *Close control/supervision of waste deposition*
- *Good compaction of waste and placement of suitable cover material*
- *Maintenance of fire-fighting equipment at the site*
- *Training of operational staff in fire management in consultation with the Fire Service and development of fire-fighting procedures.*
- *Provision of the following equipment:*
 - *Adequate permanent water supply that can be delivered to any area of the landfill*
 - *Fire extinguishers*
 - *Protective clothing and breathing gear*
 - *A water cart fitted with high pressure hose system*
 - *Specialist chemical spill agents and foams*

The guidelines outline some key fire fighting approaches for fires at landfills in section 7.11 as follows:

- *Extinguishment of surface fires before they become established by dousing with large volumes of water or smoother with large volumes of wet or damp soil*
- *Extinguishment of deep-seated fires by surcharging with large volumes of clay or similar material and visual monitoring for heat, smoke, cracking and subsidence*
- *Monitoring of landfill gas wells (temperature and carbon monoxide levels) and isolating any wells located near the vicinity of the fire and sealing any nearby landfill gas vents.*
- *If practicable, trenches backfilled with clay may be constructed to contain deep-seated fires*

4.3 International documents

International documents also provide relevant guidance for the best practice management of fires at landfills and these are included in the references section of this report.

5. Proposed Development

5.1 Overview

The Waste Futures - Green Island Landfill Closure Design Report (GHD, 2022) describes the proposed development which in summary involves increasing the capacity of the landfill by raising its height.

There are no changes proposed to the landfill's design, operations and closure which would significantly alter from the current approved situation the site's fire risks and associated hazards.

However, as outlined below there are a number of additional leading industry measures which would be implemented by DCC and the site operator. These additional measures would reduce the potential for an uncontrolled fire to occur at the site or extend off-site.

5.2 Site vegetation and fire hazards on surrounding land

The Green Island landfill site is located on low lying land on flats adjacent to the Kaikorai Stream and Estuary. Managed agricultural lands lie south of the landfill, and further waterbodies lie to the east (then flanked by residential areas) and north adjacent to New Zealand State Highway 1. Low lying waterlogged areas are mostly too wet to be managed (or support a significant fire) and near level agricultural flats are managed. Refer to Figure 5 and Attachment 5 for images of the vegetation on site.

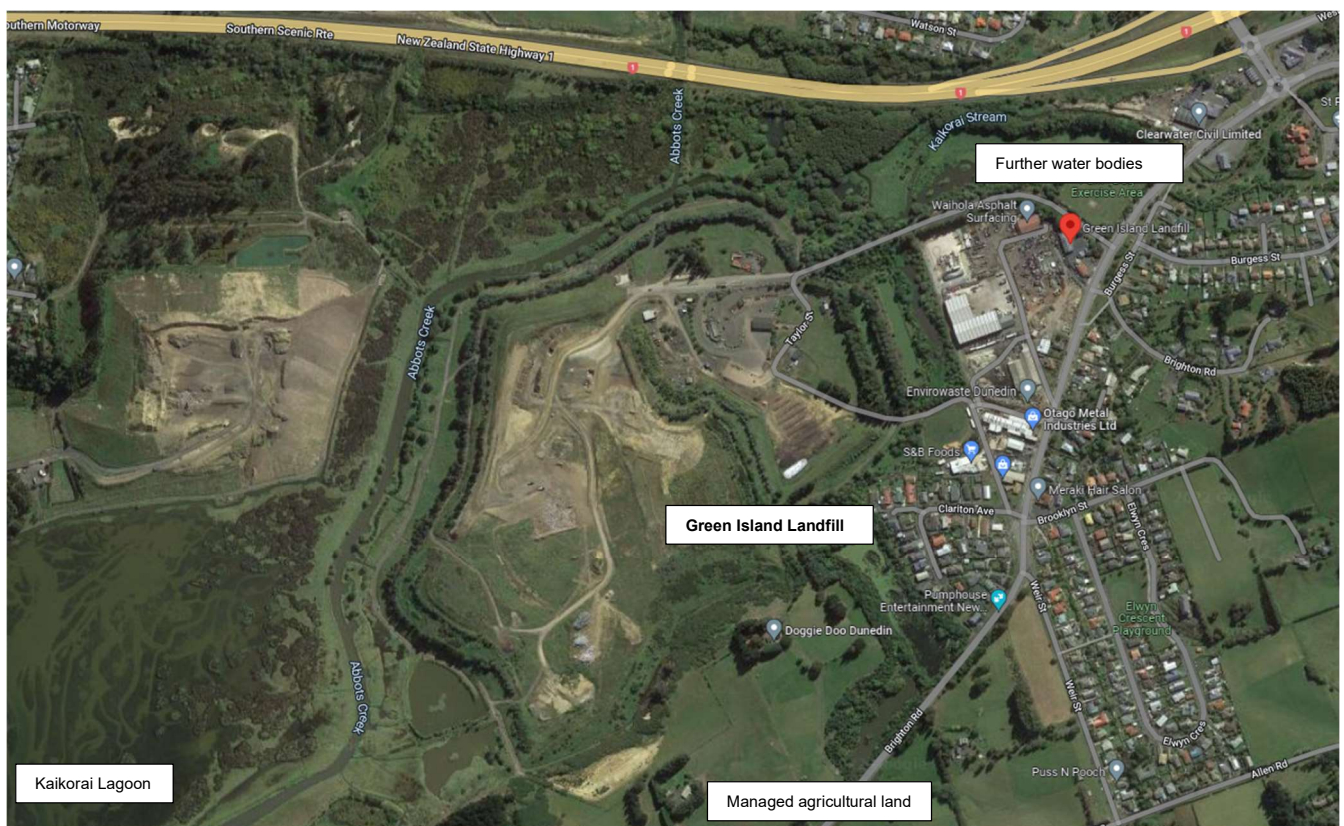


Figure 5 Surrounding land Green Island

Accordingly, there is no opportunity for a large-scale vegetation fire on the site surrounds as any vegetation fire would be constrained to burning in isolated pockets, restricted from spreading by waterbodies, managed paddocks, and built areas such as roads, highways and residential properties. Within the landfill site, vegetation cover is in a highly modified form. Working areas are devoid of vegetation or have very sparse cover which would not sustain a spreading vegetation fire. Capped areas retain a managed cover of grass. Around the perimeter of

the site, single or double rows of trees have been planted, to screen views into the landfill from surrounding areas. These single or double rows of screen tree plantings are of insufficient extent to constitute a significant fire hazard.

Noting that historically, no landfill fire is known to have ever spread off-site via vegetation internal or external to the site, the highly modified and fragmented nature of vegetation cover within and surrounding the site provides a relatively low risk of any landfill fire spreading from the site. As a further layer of risk control the presence of a perimeter track, accessible to FENZ fire appliances, will provide opportunity for fire responders to contain and extinguish and vegetation fire burning in fragmented patches of vegetation cover at the site.

5.3 Fire prevention

There are a number of fire prevention measures that will be adopted in addition to those detailed in the LDMP (Stantec 2023) and LOP (WM 2018) to further reduce the risk of landfill fires occurring or becoming extensive and severe at the site. These are outlined in Table 4 .

Table 4 Prevention measures

Measure	Implementation
Cover materials that do not comprise combustible materials that could sustain a fire	Should any alternative daily or intermediate covers be proposed to be utilised, they are to comprise inert materials and not capable of sustaining a significant fire. For example only the inert fraction of construction and demolition waste may be utilised, such as brick, tile and concrete.
Screening of incoming waste loads for combustible materials and hot waste	Before 31 October 2023 a review will be conducted of the site's waste screening procedures to lower the potential for prohibited and higher risk flammable wastes to be landfilled at the site, including waste such as marine flares, gas bottles, pool chlorine and hot loads). The recommendations of this review will be considered by Council and where practical implemented by 1 January 2024.
Maintain a compact tipping area during landfill operations (with all other landfilled surfaces covered with either daily, intermediate or final cover)	The active tipping area (being all exposed waste in the landfill area) will be limited in area to no greater than 1,200 m ² at any time and for the majority of time should be no greater than 500 m ² . During filling operations (when the active area is not covered) it should be under constant observation for signs of fire and smoke.
Plant and equipment	All plant and equipment are to be properly inspected, maintained and cleaned by operational staff regularly to prevent accumulation of wastes or other materials. Operators will consistently monitor plant throughout the day. Retrofit the site's water cart with a firewater cannon that has capacity to spray water at least 50 m or further if possible, or alternatively a portable pump kept and maintained on site that could be deployed to the water-cart and can similarly spray water at least 50 m. Install water tanks with a capacity of 60 kL in close proximity to the active landfilling area. Confirm each year with the three closest FENZ stations that their appliances can couple and gain full access to the water at the site's two fire hydrants, water tanks, and sediment ponds.
Active tipping area during very high and extreme fire danger days	As per section 2.3, fire danger days range in 2012 from 6 – 9 very high and extreme fire and is expected to increase to 12 – 16 days by 2040, noting that the site is proposed to be closed by 2030 based on current annual waste volumes. If the general fire rating is very high or extreme the active tipping face will be limited to no greater than 300 m ² . All site personnel are to be notified of the fire danger risk at the commencement of each day and have heightened alert for the identification and management of fires when the rating is high or greater. On very high and extreme fire danger days, the site water cart is to be moved to the immediate vicinity of the active tipping area to provide immediate response if required. Fire water tanks and the water cart will be checked daily to confirm they are full and maintained.
Appropriately managing the landfill gas extraction and leachate management systems so that they do not result in sub-surface or surface fires due to ingress of oxygen	Inappropriate management of landfill gas extraction and leachate systems can result in air ingress into landfilled waste which can result in a sub-surface (or potentially) a surface landfill fire. The landfill gas and leachate collection systems will therefore be managed as follows:

Measure	Implementation
	<p>– The landfill gas collection system be operated, monitored and maintained in accordance with appropriate industry guidance that includes the monitoring of oxygen (as an indicator of air ingress into the waste) and carbon monoxide (as an indicator of potential combustion) in the collected gas. Guidance to be considered from a number of the documents listed in the references and outlined in Table 11.</p> <p>The potential for air ingress into the landfilled waste including via these systems should be minimised.</p>
Stockpiling of combustible materials	Combustible materials will not be stockpiled in the landfill area.
Set back of vegetation from the landfill area.	Any vegetated intermediate cover, final capping or other areas surrounding the active landfill area will not be revegetated within 10 m of the active landfilling area.
Vehicle engines	Vehicles should be stored off the active landfill face when not in use.
Weekly review of landfill surface for combustible material	A review every two weeks using the checklist (Attachment 2) should be undertaken to ensure that the only exposed flammable material (other than dispersed wind blown litter) within the landfill footprint is in the active landfill area or revegetated intermediate cover and/or final cap. Any other exposed waste must be covered by the end of the day by non-combustible soil materials.
Refuelling	Any spills of fuel are to be cleaned up immediately.
Other prevention measures	No hot works on the landfill (unless procedures are developed and implemented on a case-by-case basis to prevent fire).

5.4 Fire detection and reporting

There are a number of fire detection measures that are presently and will be adopted in addition to those detailed in the LDMP (Stantec 2023) and LOP (WM 2018) to reduce the risk of landfill fires occurring or becoming extensive and severe at the site. These are outlined in Table 5.

Table 5 Detection measures

Measure	Implementation
Operational staff training in fire detection	Operational staff will undergo training as described in section 5.6.8 on the detection of both surface and subsurface landfill fires. Indicators for the presence of fires may include: <ul style="list-style-type: none"> – Surface fire: <ul style="list-style-type: none"> • Smoke/smouldering waste; and • Visible flames at the surface. – Subsurface fire: <ul style="list-style-type: none"> • Elevated temperatures/hot spots as detected by thermal imagery; • Exceedance of trigger values for carbon monoxide and/or oxygen from landfill gas monitoring data; • Depressions or cracking at the landfill surface; and • Venting of hot gases.
Thermal imaging cameras	A hand-held thermal imaging camera will be purchased and made available to site staff and they will be trained on its use. This will be able to be utilised to confirm that hot loads are not deposited and any surface fires or exposed smouldering waste is extinguished. <p>A review will be undertaken by Council by 1 Jan 2024 with the aim to set up a fixed mounted thermal imaging camera which is capable of scanning the active landfill area and vegetated surface of the landfill. The camera will include standard visual capability and will trigger an alarm sent to nominated site representatives should a surface fire be detected. This review will consider:</p> <ul style="list-style-type: none"> – the surface coverage that a mobile trailer mounted thermal imaging camera would afford the daily moving active tipping area and areas over and adjoining the landfill which are vegetated; – after hours procedures for the detection of a fire at the site; – the risks in terms of the extent and duration of an after hours fire not being detected in a short duration. <p>If implemented the system will be tested for its effectiveness on a 6 monthly basis.</p>
Surveillance of the active tipping area (surface fires – operational hours)	During filling operations (when the active area is not covered) the active tipping area is to be under observation for signs of fire and smoke. Should fire or smoke be observed the area should be isolated, where safe to do so, the fire will be extinguished as rapidly as possible before it spreads (e.g., by fire extinguisher, smothering using cover material or water sprayed from the water cart), the material exhumed and confirmed the fire was extinguished before applying daily cover. The thermal camera onsite can confirm that the fire has been extinguished. <p>Thermal imagery involves the infrared mapping of surface temperatures. This approach allows for a non-intrusive method. However, it does not allow for the depth of the hot spot to be determined.</p> <p>The first response to surface fires at the site is detailed in section 6.</p>
Surveillance of the site (operational hours)	Visual checking across the site for signs of fires.
Surveillance of the site (after hours)	As described above a thermal imaging system may be established at the site, subject to the review described above.

Measure	Implementation
Landfill gas monitoring – collection and treatment system (sub-surface fires)	<p>The LOP (WM 2018) identifies key landfill gas indicators for the presence of a potential subsurface landfill fire and provides triggers for investigation and actions.</p> <p>The LOP will be updated to include a procedure to isolate and turn off the landfill gas collection system in the area of a surface fire that is not able to be rapidly extinguished or for the portion of the landfill where there is a possible or actual subsurface fire</p>

5.5 Fire notification

5.5.1 Operating and after hours

The fire notification procedures are provided in the Site Emergency Management Plan (Stantec 2023). This plan will be updated to include the procedures that will be adopted if the thermal imaging camera(s) is installed at the site (and as described in section 5.4 above). It will also be updated to detail a procedure for members of the public, FENZ or other authorities reporting to Council the identification of a fire at the site or approaching it.

5.6 Fire risk mitigation and readiness

5.6.1 Overview

Fire risk can be mitigated through implementing risk control measures which serve to reduce the extent and/or intensity of any fire that may ignite, and which may enable response phase measures to be undertaken to control a fire. Mitigation measures are outlined below.

5.6.2 Site access road network

A perimeter track exists around approximately three quarters of the site with the remaining area mostly adjacent to the proposed borrow area. This perimeter track will be reviewed and potentially an additional segment added between the proposed borrow area and extending up towards Taylor Street. The review will be undertaken with FENZ to ensure that it is accessible to FENZ fire appliances and will provide opportunity for fire responders to contain and extinguish any vegetation fire burning in fragmented patches of vegetation cover at the site.

5.6.3 Water sources

Water sources on site include:

- Site water
- Potable water and two hydrants
- Fire extinguishers
- Water truck and application hose/cannon
- 60 kL tank(s) in close proximity to the active landfill area
- Sediment Ponds

5.6.4 Landfill cover procedures

Refer to Section 5.3.

5.6.5 Perimeter fuel break

The long-term Landscape Management Plan for the site will be focused on low flammability species (typically soft leaved plant types with low leaf oil content). This will be based on the Flammability Guide for Some Common New Zealand Native Tree and Shrub Species (Fogarty, 2001).

5.6.6 Onsite evacuation assembly areas

Require information on onsite command point. The Evacuation Plan details the site assembly areas (LMDP Stantec 2023).

5.6.7 Onsite equipment

Onsite equipment is described in the LMDP (Stantec 2023) and additional equipment identified in this report.

Site personnel involved in a fire response will wear appropriate personal protective equipment (PPE). Equipment required includes:

- A mask fitted with a vapour filter;
- Half face respirator (for personnel who are required to be on the ground and not operating machinery);
- Fire protective gloves;
- Steel capped boots;
- Long sleeves and long pants; and
- Eye protection.

5.6.8 Staff training

Staff training is detailed in the LMDP (Stantec 2023) and LOP (2018). In addition, all operational site staff will be trained in the content of this report and will require formal first response and fire rescue training recognised by FENZ, that is relevant to their role onsite in the event of an emergency. Formal first response and fire rescue training courses are provided by private companies such as Fire Rescue and First Response, Fire Security Services and Vertical Horizonz. Refresher training will be undertaken on an annual basis.

Site specific fire response training exercises will be undertaken on a biannual basis, encompassing all levels of the FMP including prevention, detection and reporting, mitigation, fire response and incident reporting and investigating.

Fire drills will be run for all types of fires, including surface, sub-surface and 'after hours' fires, and be located at different areas of the site to present new challenges. A full-scale site evacuation drill is to be undertaken on a yearly basis. All site personnel should be familiar with the FMP and emergency plans prior to implementation of fire drills. The drill will test compliance against the FMP procedures.

Simulated fire drills will:

- Be consistent with the identified risks and response procedures outlined in the report;
- Identify simple objectives and outcomes of the fire drill (such as ensuring the weighbridge has all site personnel accounted for, site personnel trained for fire response are at the locations specified by Site Manager);
- Have an observer appointed to watch and record the details of the drills;
- Notify all site personnel that it is a drill only;
- Target procedures relating to response to subsurface fire including how to isolate the landfill gas collection system;
- Include participation from Dunedin FENZ;
- Have a post-drill report detailing any deficiencies or issues identified, time for evacuation and any other concerns raised by the Site Manager, site personnel or the observer. This report will provide the basis for improvements to the fire response protocol outlined in the report.

6. Fire response

6.1 Operating procedure – Fire response

6.1.1 Landfill surface fire response (operational hours)

The general process for managing surface fires at the site is as follows:

1. Landfill Ops personnel (operating plant) are trained in recognising the early signs of fire in landfill, and the typical sources of ignition which can come in through waste streams – they maintain vigilance as they operate to detect any early signs of fire/hotspots such as flames, smoke, steam, smouldering material, embers etc.
2. Upon visual detection of fire or hotspots, waste unloading at the active area is ceased, and landfill operations personnel undertake immediate initial fire suppression response using on site equipment to smother and quench any incipient fire sources to prevent spread beyond the source location. This is done by using machinery to initially smother the ignition source/hotspot with non-combustible cover material, and then mobilise an onsite water cart to the ignition/hotspot location to quench the hotspot. Machinery will be used to pull material apart at the ignition location to allow direct quenching, and once fully quenched the ignition location is again covered with non-combustible cover after the area is scanned with a handheld infrared camera to confirm that the fire has been extinguished.
3. At the earliest sign that initial on-site response may not be able to extinguish the fire, FENZ assistance is called. Once FENZ arrive at the site, control is transferred to FENZ, and Landfill Ops personnel assist FENZ as requested and directed by FENZ
4. For any response requiring FENZ assistance, the Operations Supervisor issues direction for all personnel and visitors not required for fire operations support to assemble at the relevant assembly points.
5. All incoming traffic to the landfill area is halted, other than appliances and support units required for the fire response
6. During the fire response, FENZ remain in control of the fire response operations, until such time as they have deemed it safe to depart the site and transfer control of site monitoring back to the landfill operator.
7. In consultation with FENZ, the Operations Supervisor determines site fire monitoring protocol to be implemented until a full assessment has been made that the fire is extinguished
8. If the fire is a chemical fire, is too big, is moving quickly or if there is a change in wind direction, withdraw immediately, sound the evacuation alarm and wait for FENZ to arrive at the relevant assembly point.

6.1.2 Landfill surface fire response (after hours)

The risk of a fire occurring at the landfill is significantly lower after hours as the waste is covered by non-combustible material. See Table 5 for details for a review to assess whether to implement a thermal camera detection and reporting system.

Further details on responding to an after hours fire will be provided in the LMDP and LOP when they are updated following the determination of the project.

6.1.3 Landfill sub-surface fire response

1. The landfill sub-surface fire response plan is outlined below. These fires are typically slow moving and difficult to extinguish. If there is a suspected sub-surface fire due to observations of smoke, gas composition during monitoring, odour or ground depressions, contact the Operations Manager.
2. The Operations Manager will seek specialist input and advice from FENZ as well as technical input from operational staff with relevant experience elsewhere in NZ and overseas to manage and extinguish a subsurface fire, the following responses will be taken into account in developing the plan:

3. Sub-surface fires can cause land depressions. Staff managing sub-surface fires are to be trained in the risks of sub-surface fires and isolate the area of potential surface collapse. All site personnel to move slowly around the landfill and try to stay upwind of any indicators of fire including smoke, odour or ground depressions.
4. Landfill Environmental Technician will monitor surrounding wells to assess the extent of the fire (assess gas temperature, ppm carbon monoxide, presence of residue, smoke and odour) and stop extracting gas from the wells-on-site.
5. Landfill Environmental Technician to advise Operations Supervisor of the status of sub-surface fire and estimated extent of fire.
6. Operations Supervisor and Landfill Supervisor will identify landfill vents (locations of smoke) and smother with stockpiled non-combustible cover soil to limit oxygen availability to the fire.
7. Operations Supervisor to contact FENZ for assistance. Following the arrival of FENZ, hand over responsibility and offer assistance. Fire may only be dug out using site plant and extinguished once FENZ has control of the fire.

6.1.4 Operating procedure – Site safety

In the event of a fire, the Operations Supervisor will direct the trained site personnel in the fire response. The remaining site personnel not required in the fire response are to withdraw to the assembly point. General fire safety considerations include:

- All personnel besides firefighters on site are to keep between the fire and their escape route.
- All personnel responding to the fire should stay up-wind from smoke and monitor wind speed and direction for any significant changes. Responding vehicles and plant will have the cabin air-conditioning set to recirculate, fire suppression systems and have the appropriate PPE, as outlined in Section 5.6.7. Accessible breathing apparatus must be available for staff involved in fire response activities.
- Site personnel trained in fire response are to relocate vehicles and plant away from the fire at the direction of the Operations Manager to prevent any equipment damage.
- Abandon any plant or equipment if it catches fire.
- Site personnel involved in fire response will be wearing PPE as outlined in Section **Error! Reference source not found.**
- If irritating or noxious fumes are associated with the fire, or if anyone is presenting symptoms of toxic fume inhalation, or if a fire is escalating beyond control, all personnel will be withdrawn immediately and sound the evacuation alarm located at the weighbridge.
- Only trained personnel will attempt to extinguish any fire, and only if it is safe to do so.
- All new personnel to site will be trained in the site's emergency response procedures during an induction, outlining the location of the emergency muster point and emergency contact lists.
- The gas extraction system should be shut down in the event of an uncontrolled fire, where safe to do so.

6.1.5 Personnel evacuation

All site personnel not responding to a fire incident are to withdraw to their relevant assembly point.

If a fire occurs that is considered dangerous or out of control, the Operations Supervisor will sound the evacuation alarm and all site personnel are to evacuate to their relevant assembly point. If at any point the assembly point is deemed potentially unsafe, all personnel are to demobilise from the site in an orderly manner via the main entrance.

6.1.6 Residual fire risk monitoring

The landfill will be closely monitored following a fire incident to ensure there is no residual fire risk. Confirmation the fire is completely extinguished will be based on site observations such as smoke, odour and temperature. A thermal imaging camera will be used to assist fire monitoring.

Gas concentrations in surrounding wells will be monitored over the following week and compared to background well gas concentrations to determine whether there is still a potential fire risk.

7. Incident reporting and cause investigation protocol

7.1 Overview

Following the determination of the project the LOP will be reviewed and the following incident reporting and cause investigation protocol will be addressed, where needed.

7.2 Incident reporting

Incident reporting at the time of a landfill fire is the responsibility of the Operations Supervisor. The Operations Supervisor must record all details of the fire incident in a pre-prepared fire response form, provided in Attachment 1. The details required in the form include:

- Date;
- Time (incident reported and incident concluded including the duration of the fire from detection to when it was extinguished and timing for first response actions);
- Time FENZ was contacted (if applicable);
- Time FENZ arrived (if applicable);
- Location of incident (infrastructure, landfill area, surface, subsurface etc.);
- Overview of incident (size, ignition sources, fuel sources, nearby hazards);
- Is there safe access to and from the main gate?;
- Are there any injuries reported? Provide details;
- Is site-wide evacuation required? If yes, record time of evacuation;
- Describe the fire smoke and fumes (colour, plume, smell);
- Did the Operations Manager confirm it is safe to undertake fire response procedures?;
- Suspected cause of the fire;
- Did the fire spread and how?;
- Fire response procedures undertaken, how was the fire extinguished and evidence this happened before further waste placement over the impacted area?;
- Site personnel involved in fire response;
- Vehicles or plant involved in fire response;
- Weather conditions (temperature, wind speed and direction, humidity, recent rain history);
- The evacuation of site personnel not required for fire response; and
- Outcomes of fire response (extinguished, mitigating spread and intensity, fire response abandoned, waiting for FENZ).

The outcomes of the fire response form will be added into an incident register, to be reviewed during the FMP and Site Emergency Management Plan annual review. A photographic log may assist the fire response form.

7.3 Cause investigation protocol

Following every fire incident, a cause investigation will be undertaken by the Operations Supervisor and FENZ Officer (if applicable) to establish the probable cause of the fire. The investigation will involve:

- Discussions with site personnel who were directly involved with the fire response; and

- Review of the fire response form completed at the time of the event.

Outcomes of the cause investigation will be documented, collated with the relevant fire response form and added to the incident register. The investigation will provide a basis for reviewing and improving the fire prevention, detection and mitigation measures.

8. Review and evacuation protocol

The FMP will be reviewed following each significant fire incident at the site (any fire incident requiring FENZ assistance), to analyse the effectiveness of the fire prevention, detection, mitigation and response protocol and incident reporting. Regardless of the occurrence of fire incidents, the FMP will also be reviewed on an annual basis. The review should reflect on all previous fire incidents and modify the FMP accordingly.

Changes to the FMP will be reflected in the site's LDMP and LOP.

8.1 Checklist and Action Plan

A fire prevention, detection and mitigation checklist (Attachment 2) has been prepared for the site and should be undertaken every two weeks, or daily when the fire rating for the area is very high or extreme. The checklist is to be reviewed and amended, where relevant, at least every six months and prior to each fire season to ensure the continual improvement of prevention measures.

A Fire Management Action Plan (Attachment 4 **Error! Reference source not found.**) has been developed to summarise key actions outlined in the FMP. The plan should be updated if any procedures are amended.

8.2 Fire cause review

Fire causes are investigated following each fire incident as outlined in the cause investigation protocol (Section 7). By determining the cause of a fire, the prevention measures undertaken can be suitably adapted and improved to assess if it is practical to reduce the incidence of landfill fires from occurring and their extent and duration. An internal review of fire causes and potential fire prevention, detection and mitigation improvements should be conducted annually.

8.3 Process for continuous improvement

The FMP will be reviewed on an annual basis to maintain its currency and pursue improvement, to ensure suitability of the FMP to site specific hazards and provide general updates to firefighting technologies and procedures. The FMP will also be reviewed if a significant fire incident occurs after hours or takes more than 4 hours to extinguish. Reviews will take into consideration the incident register collating the fire response forms and cause investigations. The incident register will clearly categorise the type of fire, cause of fire, mitigation measures undertaken, severity of fire, time of fire and more, providing a clear indication of the FMP areas with the biggest potential for improvement.

Site specific fire response training exercises will be undertaken on a biannual basis, developed in collaboration with the DCC Landfill Engineer, WM, and FENZ to clearly outline the responsibilities of each party in fire response. Fire drills will be based on both the potential future incidents and previous incidents at the site, to provide site specific examples on how the responding site staff can improve their fire response measures as individuals and as a team.

8.4 Recovery

Recovery efforts for fire incidents will include:

- Good incident management practices that minimise the short-term and long-term impacts and consequences of the fire incident;
- Ensuring those immediately affected by the incident get the support they need, including staff suffering any trauma receive the appropriate support from relevant agencies;
- Inspection of landfill gas and leachate infrastructure for any damage such as damage to pipes and electrical systems;
- Coordinated clean up efforts following fire events to restore operations in a timely manner; and

- Reduce future exposure to hazards and associated risks following the protocol outlined in section **Error! Reference source not found.**

9. External notification protocols

The external notification protocols should be developed by FENZ, local police and Council in the event that:

- a fire may migrate off the landfill; or
- smoke generated by a landfill fire may impact nearby neighbours.

10. Response and notifications contact details directory

Emergency contact details are outlined in the LOP and will be displayed on the main access gates.

11. Recommendations

11.1 Changes to LDMP and LOP

The LDMP and LOP will be reviewed and updated following the determination of the project and the commitments in this FMP will be reflected in them as are relevant. Proposed amendments to the LDMP associated with fire risk issues are documented in a list of proposed updates to the LDMP appended to the AEE.

12. References

- Anderson Lloyd . (2022). *Statement of evidence of Anthony Dixon*.
- Beca Steven. (1992). *Environmental Impact Statement of the Extended Green Island Sanitary Landfill*.
- Boffa Miskell. (2022). Images of landfill plantings.
- C&P Environmental Ltd, Biffa, Infinis Limited, Sita UK, Viridor Waste Management, Waste Recycling Group. (2008). *Industry Code of Practice Management and Prevention of Sub-surface fire*. United Kingdom.
- Chamberlain, R. (2016, April 19). Toxic smoke fears in landfill fire (+ video). *Otago Daily Times*.
- DCC. (2021). *Green Island Landfill - Update of Landfill Development Management Plan (LDMP) for 2022 Capping Works*.
- Department of Conservation. (2000). *Succession in the Kaimaumu gumland, Northland, New Zealand following fire*.
- Dunedin City Council (DCC). (2021). *Green Island Resource Recovery and Processing Precinct Park Masterplan Report*.
- Dunedin City Council (DCC). (2022). *Acceptable waste at Green Island landfill*. Retrieved from <https://www.dunedin.govt.nz/services/rubbish-and-recycling/landfills>
- Environment Agency. (2007). *Review and Investigation of deep-seated fires within landfill*. Bristol.
- Environment Protection Authority (EPA). (2019). *Solid waste disposal*.
- FENZ. (2019). *Risk Reduction Strategy 2019 - 2029*.
- FENZ. (2023). *Fire indices map*. <https://fireweather.niwa.co.nz/region/Otago>.
- Institute for Sustainable Futures (ISF). (2016). *Waste Fires in Australia: Cause for Concern?* Department of the Environment Australian Government.
- International Solid Waste Association (ISWA). (2010). *Landfill Operational Guidelines, 2nd Ed*.
- MfE. (2015). *Waste Assessments and Waste Management and Minimisation Planning - A guide for territorial authorities*.
- Ministry for the Environment (MfE). (2004). *Hazardous Waste Guidelines: Landfill Waste Acceptance Criteria and Landfill Classification*.
- MWH New Zealand Limited. (2007). *Green Island Landfill Development and Management Plan*.
- National Institute of Water and Atmospheric Research (NIWA). (2022). *Overview of New Zealand's climate Southern New Zealand*.
- Queensland Government . (2020). *Environmental Services and Regulation*.
- Scion. (2012). *Forests and climate change*. TriData Corporation. (2002). *Landfill Fires: Their magnitude, characteristics and mitigation, prepared for Federal Emergency Management Agency United States Fire Administration National Fire Data Center*. Virginia.
- Waste Management Institute New Zealand (WasteMINZ). (2018). *Technical Guidelines for Disposal to Land*.
- Waste Management NZ Ltd (WM). (2018). *Green Island Landfill Landfill Management Plan*.
- WasteMINZ. (2022). , *Record of fires at Green Island facility between August 2017 and January 2022*.

Attachments

Attachment 1

Fire response form

FIRE RESPONSE FORM

In the event of a fire emergency, the weighbridge operator is to stop all vehicles from entering the landfill and advise customers of the temporary landfill closure.

Fire response details			
Date:			
Time incident reported:		Time incident concluded (including when fire was extinguished):	
Time fire detected:		Time for first response actions:	
Time FENZ was contacted:		Time FENZ arrived:	
Location of incident (infrastructure, landfill area, surface, sub-surface etc.):			
Overview of incident (size, ignition sources, fuel sources, nearby hazards):			
Are all personnel accounted for?			
Is there safe access through the main gate?			
Are there any injuries reported? Provide details.			
Is site-wide evacuation required? If yes, record time of evacuation.			
Describe the fire smoke and fumes (colour, plume, smell):			
Suspected cause of the fire:			
Fire response procedures undertaken:			
Site personnel involved in fire response:			
Vehicles or plant involved in fire response:			
Weather conditions (temperature, wind speed and direction, humidity, recent rain history):			
Outcomes of fire response (extinguish, mitigating spread and intensity, fire response abandoned, waiting for FENZ):			

Fire response details

Other comments:

Attachment 2

Checklist

FIRE PREVENTION, DETECTION AND MITIGATION CHECKLIST

The below checklist should be undertaken every two weeks or daily when the fire rating for the area is very high or extreme.

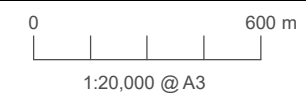
The checklist is to be reviewed and amended, where relevant, every six months and prior to each fire season to ensure the continual improvement of prevention, detection and mitigation measures.

Landfill operations area	Yes	No
A stockpile of at least 2 weeks of non-combustible cover material is located close to the tip face.		
Plant and equipment are located nearby the tip face and available to move earth during operational hours.		
Active tipping area (exposed waste) is limited to generally 500 m ² and no greater than 1,200 m ² on infrequent occasions or 300 m ² if the fire danger rating is very high to extreme.		
All incoming waste loads are visually inspected during placement in accordance with the procedures to be developed in the LOP.		
All plant on site have accessible fire extinguishers.		
All fire extinguishers on plant are certified and within expiry dates.		
Landfill operations area is tidy and orderly.		
Supporting infrastructure		
Access roads are clear and unobstructed.		
Front access gates are unobstructed and maintained to ensure 24-hour emergency access.		
Emergency exits signs are clearly identifiable 24-hours a day. Emergency assembly points have clear signage and directions.		
A total of 60 kL of water is stored in tank(s) near the active tipping area. A map of the site will be developed to identify the location of water access including ponds and streams on site.		
The site water cart is located nearby the tip face (on high or extreme fire day).		
Fire extinguishers are located in the site office and weighbridge. Fire extinguishers are certified and within expiry dates.		
Fire alarm in weighbridge is accessible and working.		
All fuel on site is stored in accordance with relevant standards.		
Site personnel		
Emergency contact details and site maps are clearly displayed on the main access gates.		
All site staff have undergone site induction training.		
All personnel onsite are aware of the muster point and evacuation protocols.		
Plant operators are educated and trained in fire prevention and response.		
All personnel onsite are in appropriate PPE including steel capped boots, long sleeves, long pants and eye protection. Staff trained in fire response have a readily available mask fitted with a vapour filter/breathing apparatus and fire protective gloves.		
Any fire hazards identified are reported to the Operations Manager.		
Vegetation and surrounding environment		
The 10 m fuel break around the active landfill area is free of any vegetation.		

Landfill operations area	Yes	No
Windblown litter from the landfill tip face is assessed and where excessive removed from surrounding vegetation and perimeter fences.		


Attachment 3

Site map



Data Sources:
LINZ Data Service, and Eagle Technologies.

LEGEND





 Green Island Landfill
Designation (2GP)



Attachment 4

Action plan

Fire management action plan

Fire danger class	Fire Intensity (kW/m)
L - low	>10
M - moderate	10-500
H - high	500-2,000
VH – very high	2,000-4,000
E - extreme	4,000-10,000
VE – very extreme	>10,000

Forest fire danger class	Scenario	Actions
 <p>Low – Moderate - High</p>	General operations	No additional prevention measures required other than those identified in this FMP
 <p>Very high – Extreme/Very extreme</p>	General operations	<ol style="list-style-type: none"> 1. Notify site personnel of fire danger risk at the start of the day 2. Limit tipping face to no greater than 300 m² 3. Site water cart to be positioned at the immediate vicinity of the active tipping area to provide immediate response if required 4. Fire water tanks should be checked to confirm they are full 5. Landfill cover procedures outlined in section 5.3 should be implemented
	CO greater than 100 ppm and/or oxygen > 5% detected at the flare or gas extraction system	<ol style="list-style-type: none"> 1. Review gas composition monitoring to confirm if the exceedance is an outlier or shows a trend of increasing CO. 2. Collect laboratory sample to confirm CO concentration 3. Investigate active area for hot spots using thermal imaging camera 4. Further gas composition sampling and sampling at vertical gas wells in the vicinity of the hot spot. Sampling and testing for the following gases and trigger gas concentrations based on the UK Environment Agency guidance on the review and investigation of deep-seated fires within landfill sites (2007): <ol style="list-style-type: none"> a. Methane (drop of 10% against background concentrations) b. Carbon dioxide (drop of 10% against background concentrations) c. Hydrogen sulphide (>10ppm, then scrubbers required)) d. Oxygen (>5%) e. Carbon monoxide (>100ppm) 5. Procedure for management of subsurface fire to be followed if further investigation indicates the presence of a subsurface fire
	Surface fire detected during operational hours	<ol style="list-style-type: none"> 1. Site personnel at the scene of the incident to contact Operations Supervisor and Landfill Supervisor immediately and notify of incident. 2. If safe to do so, plant operators on scene to immediately place cover material over the incident area and smother the fire, using machinery available at the point of detection. 3. Landfill Supervisor to mobilise water cart. 4. On arrival of the water cart at the smothered fire scene, drench any hot spots using the water cart, using machinery to re-expose and break up any smouldering hotspots for drenching to ensure complete extinguishment, then re-cover with non-combustible cover. The area is scanned with a handheld infrared camera to confirm that the fire has

Forest fire danger class	Scenario	Actions
		<p>been extinguished by measuring temperatures less than 40 degrees Celsius.</p> <ol style="list-style-type: none"> 5. All personnel not trained in fire response will withdraw to their relevant assembly point, where they will be accounted for by the weighbridge operator. The weighbridge operator will also stop all traffic entering the landfill portion of the site and advise all customers that the landfill is temporarily closed. 6. If the fire cannot be rapidly extinguished the gas extraction lead, to stop extracting gas from the wells on-site, to prevent the ingress of air and potential propagation of the fire into the waste. 7. Operations Manager is to monitor the first response measures undertaken and assess the likelihood of extinguishing the fire without external assistance. If any doubt as to whether external assistance is required, Site Manager to contact and mobilise FENZ. 8. Once FENZ arrives, hand over responsibility and offer assistance.
	Surface fire detected after hours	<ol style="list-style-type: none"> 1. Operations Manager and Landfill Team Leader to be onsite as soon as possible of fire notification (to be confirmed). 2. FENZ arrives and takes command of the site.
	Subsurface fire detected	<ol style="list-style-type: none"> 3. If there is a suspected sub-surface fire due to observations of smoke, gas and/or temperature composition during monitoring, odour or ground depressions, contact the Operations Supervisor . 4. DCC will seek specialist input and advice from FENZ or other expertise to manage and extinguish a subsurface fire, the following responses will be taken into account in developing the plan: <ol style="list-style-type: none"> a. Sub-surface fires can cause land depressions . Staff managing sub-surface fires are to be trained in the risks of sub-surface fires and isolate the area of potential surface collapse. All site personnel to move slowly around the landfill and try to stay upwind of any indicators of fire including smoke, odour or ground depressions. b. Landfill Supervisor will monitor surrounding wells to assess the extent of the fire (assess gas temperature, ppm carbon monoxide, presence of residue, smoke and odour). c. Gas extraction lead, , to stop extracting gas from the wells on-site d. Landfill Supervisor to advise Operations Supervisor of the status of sub-surface fire and estimated extent of fire. e. Operations Supervisor and Landfill Supervisor will identify landfill vents (locations of smoke) and smother with stockpiled non-combustible cover soil to limit oxygen availability to the fire. f. Operations Supervisor to contact FENZ for assistance. Following the arrival of FENZ, hand over responsibility and offer assistance. Fire may only be dug out using site plant and extinguished once FENZ has control of the fire.

Attachment 5

Images of vegetation onsite

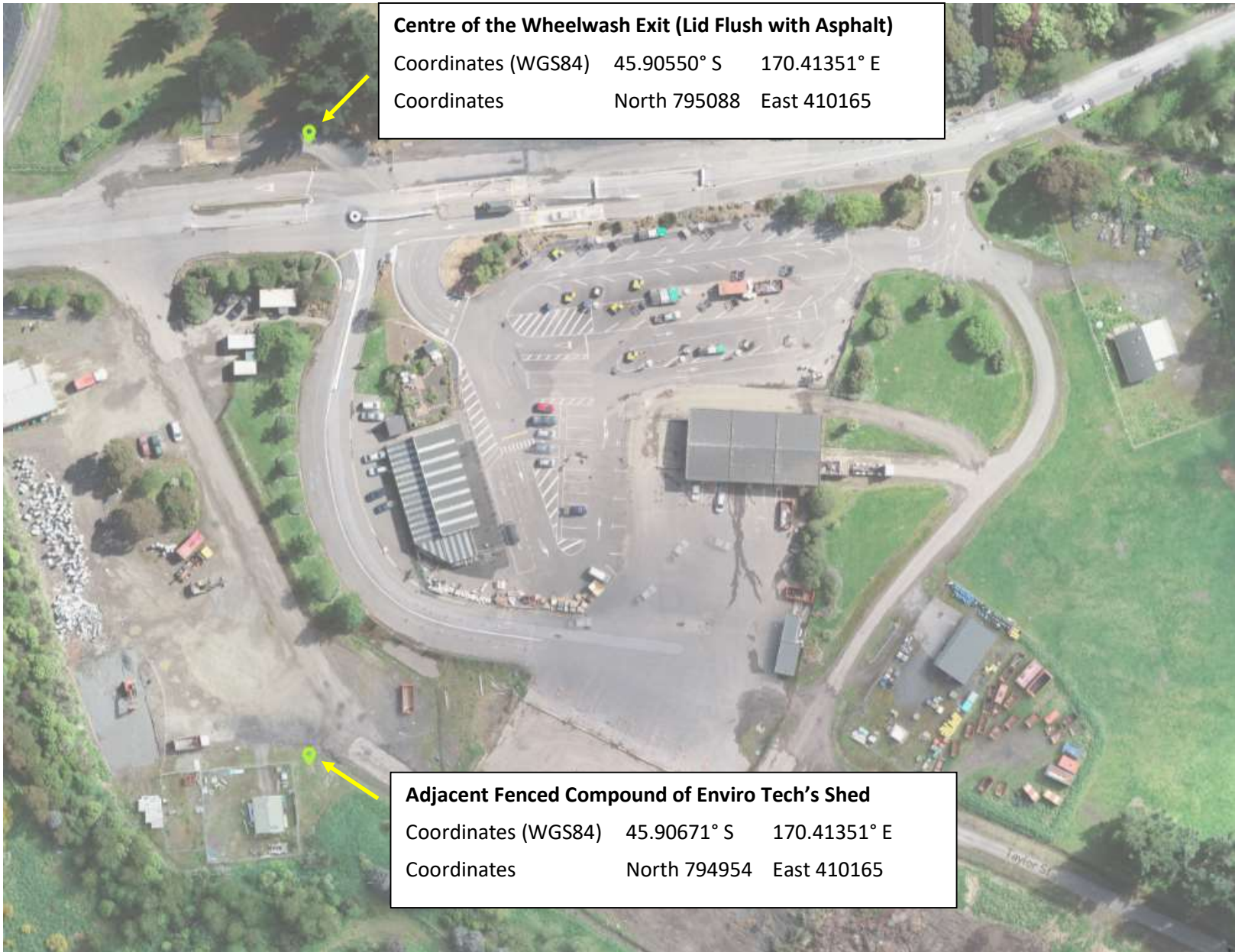






Attachment 6

Locations of fire hydrants



Centre of the Wheelwash Exit (Lid Flush with Asphalt)
Coordinates (WGS84) 45.90550° S 170.41351° E
Coordinates North 795088 East 410165

Adjacent Fenced Compound of Enviro Tech's Shed
Coordinates (WGS84) 45.90671° S 170.41351° E
Coordinates North 794954 East 410165