National Landfill Climate Change Exposure Assessment

Prepared for: Ministry for Environment

Prepared by: Tonkin & Taylor Ltd

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National Landfill Climate Change Exposure Assessment

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1.0 Project purpose and objectives

The Ministry for Environment (MfE) is seeking to understand the scale of climate change risks to landfills across New Zealand. This will help inform the development of funding options and other resources to support the investigation and remediation of these sites. MfE is also seeking to enable councils to identify and evaluate the climate change risks to their landfills and rank these to identify priority sites.

The first step to understanding these objectives is to understand potential landfill exposure to specific climate hazards. This report summarises the first phase of this project, which sought to understand exposure of landfills to climate-related hazards at a national level. This assessment seeks to help MfE with action 5.11 in the National Adaptation Plan: "*Encourage and support the evaluation of climate risks to landfills and contaminated sites*". It will also provide councils with a preliminary basis from which to carry out a more detailed risk assessment.

This project follows on from the pilot risk assessment undertaken in 2020.

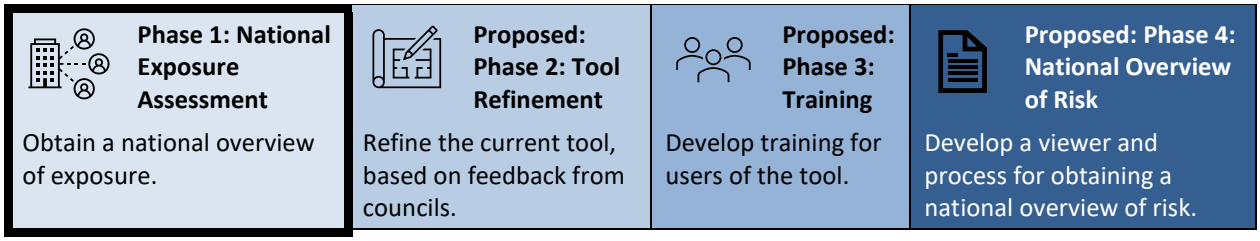


Figure 1.1: Project phases with this report focused on Phase 1.

2.0 Methodology

The methodology is broken down into four sections:

1. Asset data
2. Hazard data
3. Exposure assessment
4. Landfill information questionnaire.

2.1 Asset data

In May 2024, MfE hosted an online meeting with Regional Council and Unitary Authority representatives from the Waste Special Interest Group (SIG) to introduce them to this project, its linkages to previous work, and communicate what information was being requested from them. Councils were requested to share their landfill information to support with the spatial exposure assessment. This included spatial (location and where possible extent) information for their landfills, along with further supporting information as metadata. Focus was given to legacy/ closed landfills. All councils that were engaged with (16) provided information for use within this assessment, through a key contact that was established through the Waste SIG convenor. Tonkin & Taylor Ltd (T+T) also utilised existing connections to source some information (e.g. Auckland and Nelson regions).

Table 2.1 presents the data received and outlines the limitations and assumptions. It is noted that some councils are more established in their landfill asset management and climate risk understanding. This is reflected in the different levels of detail provided as a part of this data collation. Of the 16 councils, all but one provided a spatial dataset that contained a polygon layer (representing either the landfill extent or the property parcel the landfill is located within). For those councils with property parcels as their landfill extents (3), exposure may be over or underestimated in the assessment.

For the one council that provided a CSV format, T+T completed the following process:

- Converted the CSV coordinates into a spatial point location.
- Joined the point location to the Land Information New Zealand (LINZ) property parcel. The joining process allowed the asset to be represented by a polygon extent, which is likely to better represent the waste extent than a single point.

A total of 5,029 features (locations on a map) were received, of which 3,233 were either classified as a G3 HAIL category or as a landfill by council. These 3,233 landfills were incorporated into the exposure assessment. The remaining 1,796 were not classified as a landfill therefore were not included in the assessment. The total number of landfills in this assessment is different to that produced in the 2020 assessment, as it incorporates all councils across New Zealand, not just the three assessed in the pilot study.

Table 2.1: Asset data received for this assessment and associated commentary

Council	Number of assets	Description	Comments
Auckland	Property Parcel (212) Verified Waste Extents (76)	Closed landfills. Site extents developed by T+T as a part of a separate piece of work. The site extents are based on desktop information, not site investigations. Therefore, the site extents are not 100% accurate.	The verified site extents and property parcels did not join one to one. Therefore, the verified waste extents were prioritised in the assessment (76). Property parcels were excluded from the assessment if they contained a verified waste extent. 150 property parcels were processed in the assessment, alongside the 76 verified waste extents, giving a total of 226 features for the Auckland region. Datasets do not contain privately owned legacy fill sites or operative landfills.
Bay of Plenty	HAIL Sites (103) G3 Landfills (80)	Landfill sites as defined by G3 HAIL category.	All HAIL sites were provided. Only G3 category (80) were taken through to the assessment.
Canterbury	1,892	Landfill sites as defined by G3 HAIL category.	All sites were included within the assessment. Note the large number of landfill sites in the Canterbury region is a result of mapping completed recently to identify sites such as farm dumps. It is unclear whether other councils have completed this type of mapping.
Gisborne	24	'Landfills' layer provided. No information provided on the classification of these sites.	Point and polygon datasets were provided. The polygon dataset was prioritised due to the better representation of waste extents.
Hawkes Bay	HAIL Sites (830) G3 Landfills (48)	Landfill sites as defined by G3 HAIL category.	All HAIL sites were provided. Only G3 category (48) were taken through to the assessment.
Horizons	78	Integrated Regional Information System (IRIS) regulatory activity layer provided with G3 category only.	Point, line and polygon layers were provided. The polygon dataset was prioritised due to the better representation of waste extents. Balgownie landfill was provided as a line feature (and was not captured within the polygon dataset). T+T converted this into a polygon, to aid analysis.
Marlborough	17	Listed land-use register (LLUR) sites layer provided with G3 category only.	All sites were included within the assessment.
Nelson	HAIL Sites (790) G3 Landfills (24)	Landfill sites as defined by G3 HAIL category.	All HAIL sites were provided. Only G3 category (24) were taken through to the assessment. Operative landfills (York Valley Landfill, Eves Valley Landfill) were included in this assessment.

Council	Number of assets	Description	Comments
Northland	70	Selected Land-use (SLU) sites layer provided. Landfill sites as defined by G3 HAIL category.	All sites were included within the assessment.
Otago	184	Landfill sites as defined by G3 HAIL category.	All sites were included within the assessment.
Southland	HAIL Sites (203) G3 Landfills (188)	SLU sites layer provided. Landfill sites as defined by G3 HAIL category.	One feature had a null geometry, so was not included in the analysis (202). Varying HAIL sites were provided. Only G3 category (188) were taken through to the assessment.
Taranaki	18	'Landfills' layer provided. No information provided on the classification of these sites.	All sites were included within the assessment.
Tasman	83	Landfill sites as defined by G3 HAIL category.	CSV data was provided and converted into spatial point locations using X/Y coordinates. T+T spatially joined these points to LINZ property parcels to get a better representation of waste extents. Two points were located on a single land parcel, therefore 83 polygons were taken through the assessment.
Waikato	186	Landfill sites as defined by G3 HAIL category.	All sites were included within the assessment.
Wellington	54	'Landfills' layer provided. No information provided on the classification of these sites.	All sites were included within the assessment.
West Coast	56	Landfill data as provided as part of the Pilot Assessment (2020).	Point and polygon layers were provided as part of the 2020 assessment. West Coast Regional Council requested we use the same data for this assessment, as no updates had been made. The polygon dataset represents property parcels and was prioritised due to the better representation of waste extents.

2.2 Hazard data

Three key climate-related hazards were assessed as part of this exposure assessment:

- Coastal edge proximity (as proxy for coastal erosion)
- Coastal inundation
- River and surface flooding.

Other climate-related hazards such as changes in temperature, rainfall intensity, storms and wind and river scour were not included, due to the lack of high-resolution data at a national scale. MfE requested that analysis be completed to understand landfills in proximity to watercourses, as a high-level indication (proxy) for potential exposure to river scour. This assessment is not representative of river scour, however proximity to a watercourse can allow for a screening of landfills for further assessment. Due to the limitations with this approach, we have not included the results from this analysis within the main body of this report.

To ensure exposure ratings can be more easily applied at a later stage (Phase 4), a range of timeframes and scenarios have been used (where possible), given that timeframes/ scenarios are yet to be confirmed.

2.2.1 Coastal edge proximity

Coastal erosion is the loss of land due to coastal processes such as waves and tidal currents wearing land away over time. Coastal erosion can expose those landfills located within close proximity to the coast, which could result in the dispersal of waste and contaminants into the receiving environment.

There is currently no nationally consistent dataset for coastal erosion. Therefore, this assessment has used an approach that assesses coastal edge proximity as a proxy for susceptibility to coastal erosion. The LINZ coastal boundary layer was used to establish distances from the coast. This boundary represents the mean high water springs boundary (MHWS). The highest visible line of seaweed, driftwood and other marine debris that gathers on a shoreline over a year is generally a good indicator of MHWS. This method allows for a consistent approach nationally.

A subsequent more detailed assessment should be undertaken to understand potential for coastal erosion at screened sites. This is dependent on available information held by Councils.

2.2.2 Coastal inundation

Coastal inundation is the flooding of normally dry, low-lying coastal land due to extreme high water levels. Climate change and warming temperatures are causing sea levels to rise, which can further exacerbate the impacts of coastal inundation. Coastal inundation and storm events can further exacerbate erosion on the coast, which can lead to the exposure of waste and contaminants into the receiving environment. Coastal inundation may also cause structural integrity issues for landfills, if saturated for long enough periods.

There is a nationally consistent dataset that represents the 1% Annual Exceedance Probability (AEP) extreme sea level flooding under current sea conditions, along with increments of relative sea level rise up to 2 m. This dataset has been used in this analysis. The following sea level rise increments were assessed to allow for a range of climate change scenarios and timeframes to be chosen when completing the future risk assessment:

- 0 m sea level rise
- 0.4 m sea level rise
- 0.6 m sea level rise
- 0.8 m sea level rise
- 1.0 m sea level rise
- 1.2 m sea level rise

- 1.6 m sea level rise.

2.2.3 River and surface flooding

River flooding occurs when heavy rainfall increases the water levels in streams, rivers and lakes which can cause water to overflow into surrounding land. Surface flooding occurs due to rainfall on saturated/ impermeable land, and is common in urban areas when rainfall exceeds capacities of drainage systems. River flooding can exacerbate erosion that occurs along river banks, which can lead to the dispersal of waste and contaminants into the receiving environment. Surface flooding can also cause integrity issues for landfills, and can further entrain material that may have been dispersed.

There is currently no nationally consistent dataset for river and surface flooding at an appropriate resolution for identifying assets in river and surface floodplains. Data is held individually by Councils, and this is of varying quality and consistency. Councils have different approaches with regard to:

- The AEP of rainfall scenarios which have been modelled;
- The climate change scenario and timeframes which are used to inform future rainfall intensities; and
- A range of other assumptions specific to the flood modelling approach undertaken.

The National Institute for Water and Atmospheric Research (NIWA) created a national flood hazard dataset in 2019 that consolidated council datasets alongside flood prone soil maps. Both this dataset and those held by individual councils (that are publicly available) have been used in this assessment, to identify landfills exposed to flood-prone areas.

While there are inconsistencies across these datasets regarding whether specific locations are identified as exposed, both these datasets provide valuable information relating to potential exposure. Further interrogation of these datasets will be considered in later phases when considering probability of occurrence and risk.

2.3 Exposure assessment

An assessment was completed that overlaid the hazard and asset information to understand whether an asset was ‘exposed’ to the relevant hazard. An asset was considered exposed if any portion of the asset (feature) layer intersected the hazard layer. Where an asset does not intersect a hazard layer, the distance to the nearest hazard layer was measured. This provides opportunity for considering proximity to hazard layers, given the uncertainty with climate projections within hazard layers.

The exposure numbers generated in this assessment provide a “first cut” understanding of the potential scale of landfills that could be at risk. Refinement is required through a full risk assessment, which would take into account both landfill vulnerability and consequence. These later stages are reliant on the availability and certainty of landfill attributes.

2.4 Landfill information questionnaire

As a part of this initial exposure assessment, MfE wishes to understand how councils are currently managing their landfills and spatial and non-spatial data, in relation to climate change. A questionnaire was developed and sent out to all 16 regional councils/ unitary authorities to help gain an understanding of this, and some of the blockers to completing this work. Of the 16 councils engaged with, 12 responded to this questionnaire.

3.0 Results

Of the landfills assessed nationally, 1,797 (56%) are potentially exposed to one or more hazards, while 176 (5%) are potentially exposed to all three hazards assessed. Canterbury represents 51% national exposure, with 922 landfills identified as potentially exposed to one or more hazards. Of those landfills exposed to all three hazards, 40% are located in the Auckland region, followed by 13% in Tasman and 10% in Canterbury.

River and surface flooding had the highest exposure nationally, with 1,683 (52%) landfills identified as exposed, and was the hazard with the highest exposure across the regions (Table 3.1). Out of the 1,683 landfills assessed as exposed to river and surface flooding, 892 (53%) are located within the Canterbury region, followed by 186 (11%) in Auckland and 99 (6%) in the Southland region. It is likely that the large proportion of landfills exposed in Canterbury are related to smaller farm dumps, and waste sites captured post the Canterbury Earthquakes.

There are 288 (9%) landfills potentially exposed to the 1% AEP coastal inundation storm event under climate current conditions nationally, with 52% of those landfills being located in the Auckland (87) and Canterbury (63) regions. The total number of landfills potentially exposed increases to 379 (12%) with 0.4 m sea level rise, where the regions with the most landfills exposed are Auckland (93), Canterbury (79) and Bay of Plenty (48).

The assessment identified that there are 111 (3%) landfills that intersect the mean high water springs boundary (average high tide mark) of which 50% are located in the Auckland region. A range of distances from the coastal boundary were also analysed to capture the proportion of landfills located within 100 m of the coast. When considering the upper limit of 100 m, no more than 274 (8%) of landfills are exposed nationally.

It was identified that the Auckland region contributes the highest number of landfills to the national total for coastal hazards. Additionally, Canterbury contributes the highest number of landfills to the nation total for river and surface flooding (Table 3.1).

Table 3.1: Region contributing the highest exposure per hazard

Hazard	Region
Coastal edge proximity (Present day)	Auckland (50%)
Coastal inundation (Present day)	Auckland (30%)
River and surface flooding	Canterbury (53%)

Table 3.2: Regional breakdown of exposure to each of the hazards and scenarios assessed

Region	Total number of landfills	One or more hazards	Coastal edge proximity				Coastal inundation							River and surface flooding
			0 m	20 m inland	50 m inland	100 m inland	0 m	0.4 m	0.6 m	0.8 m	1 m	1.2 m	1.6 m	
National	**3,233**	**1,797**	**111**	**183**	**233**	**274**	**288**	**379**	**418**	**442**	**460**	**472**	**509**	**1,683**
Auckland	226	200	56	78	84	89	87	93	94	97	97	99	103	186
Bay of Plenty	80	63	2	3	3	13	10	48	51	52	52	53	54	61
Canterbury	1,892	922	7	17	31	43	63	79	84	92	98	104	119	892
Gisborne	24	16	0	1	2	2	6	6	8	9	9	9	10	11
Hawkes Bay	48	36	1	2	6	7	4	8	8	8	8	8	10	34
Horizons	79	35	0	0	0	0	3	6	6	6	6	6	7	34
Marlborough	17	14	0	1	1	1	0	0	0	0	2	2	2	13
Nelson	28	23	0	4	6	7	7	12	12	16	17	17	19	18
Northland	70	38	8	10	14	15	17	19	20	21	22	22	24	35
Otago	184	95	7	13	19	23	20	25	29	35	38	38	40	81
Southland	188	114	6	12	15	18	9	11	28	28	30	31	34	99
Taranaki	18	1	0	0	0	0	0	0	0	0	0	0	0	1
Tasman	83	67	14	23	28	29	23	28	32	32	33	34	35	60
Waikato	186	102	6	11	13	13	24	28	29	29	30	31	32	92
Wellington	54	37	2	3	4	4	3	3	3	3	3	3	4	35
West Coast	56	34	2	5	7	10	12	13	14	14	15	15	16	31

Note: River and surface flooding results include both the NIWA and openly sourced datasets.

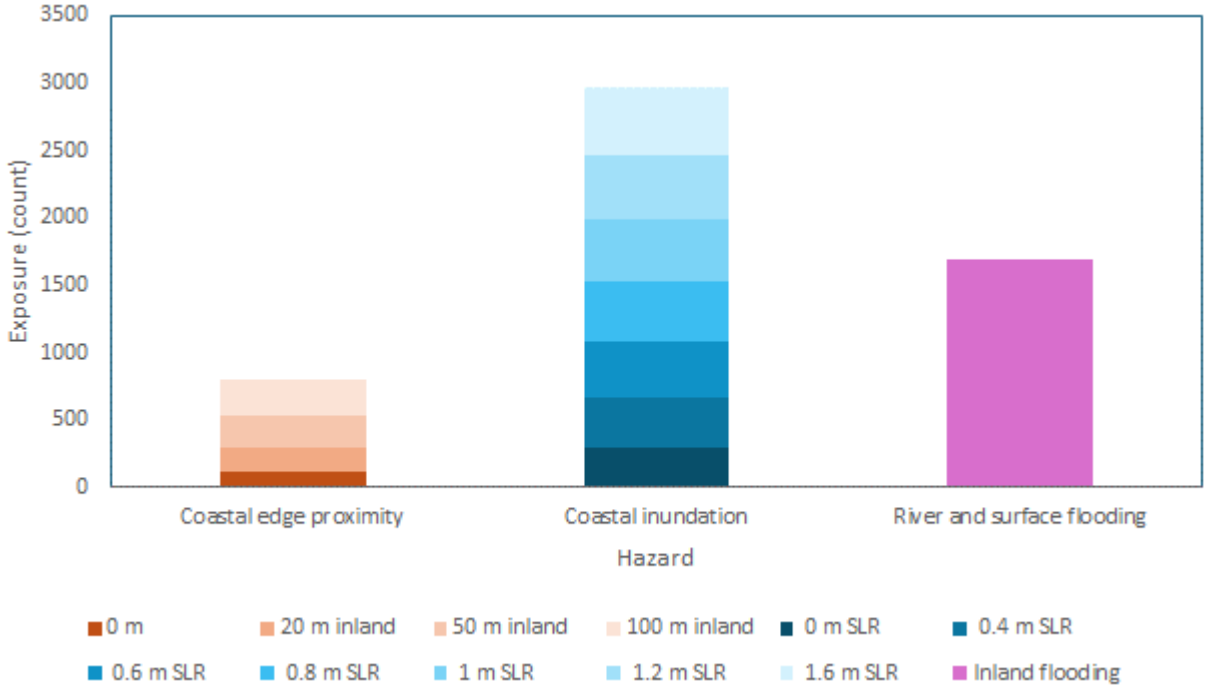


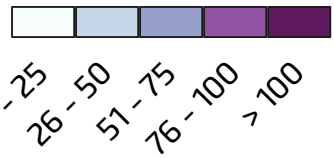
Figure 3.1: Count of landfills nationally, exposed to the relevant climate-related hazards. Coastal inundation and coastal edge proximity counts are inclusive of previous levels/ distances respectively.

National Landfill Exposure

To one or more hazards

(Coastal Inundation, Coastal Edge Proximity, River and Surface Flooding)

Count of landfills exposed



Number of landfills exposed

Ministry for the Environment
Manatū Mō Te Taiao

Tonkin+Taylor

This map was created for the Ministry for Environment to undertake a national landfill exposure assessment to climate-related hazards.

3.1 Coastal edge proximity

The assessment identified that the Auckland region has the largest number of landfills within 100 m of the coast (89), followed by Canterbury (43) and Tasman (29). Of the 89 landfills within the Auckland region, 56 are currently intersecting with the MHWS line. For Canterbury there are currently 7 landfills intersecting the coastal boundary which increases to 31 when considering 50 m inland. For Tasman, 14 of their 60 (17%) landfills are currently intersecting the coastal boundary, which increases to 28 when considering 50 m inland. The Horizons and Taranaki regions are the only two regions nationally who do not have landfills (that were assessed) located within 100 m of the coast (Figure 3.2).

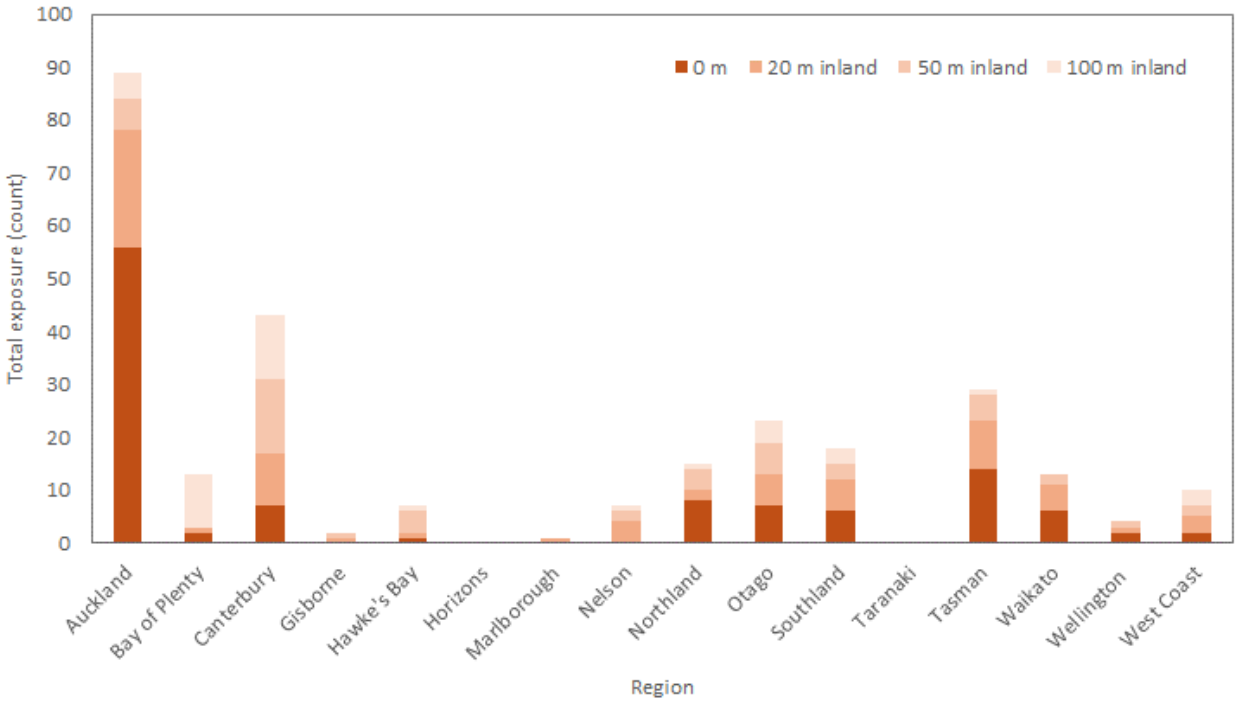


Figure 3.2: Count of landfills exposed to coastal edge proximity by region. Counts are inclusive of previous coastal edge distances.

3.2 Coastal inundation

The assessment identified that the Auckland region has the highest exposure of landfills nationally (87) when assessing against the 1% AEP present day coastal inundation event. Auckland is followed by Canterbury (63), and Waikato (24). Exposure of landfills in the Bay of Plenty region increases three-fold with 0.4 m sea level rise, while exposure in the Southland region increases by 150% between 0.4 m and 0.6 m of sea level rise. When considering the highest level of sea rise assessed (1.6 m), the Canterbury region has the highest number of landfills exposed (119), followed by Auckland (103) and Bay of Plenty (54) (Figure 3.3).

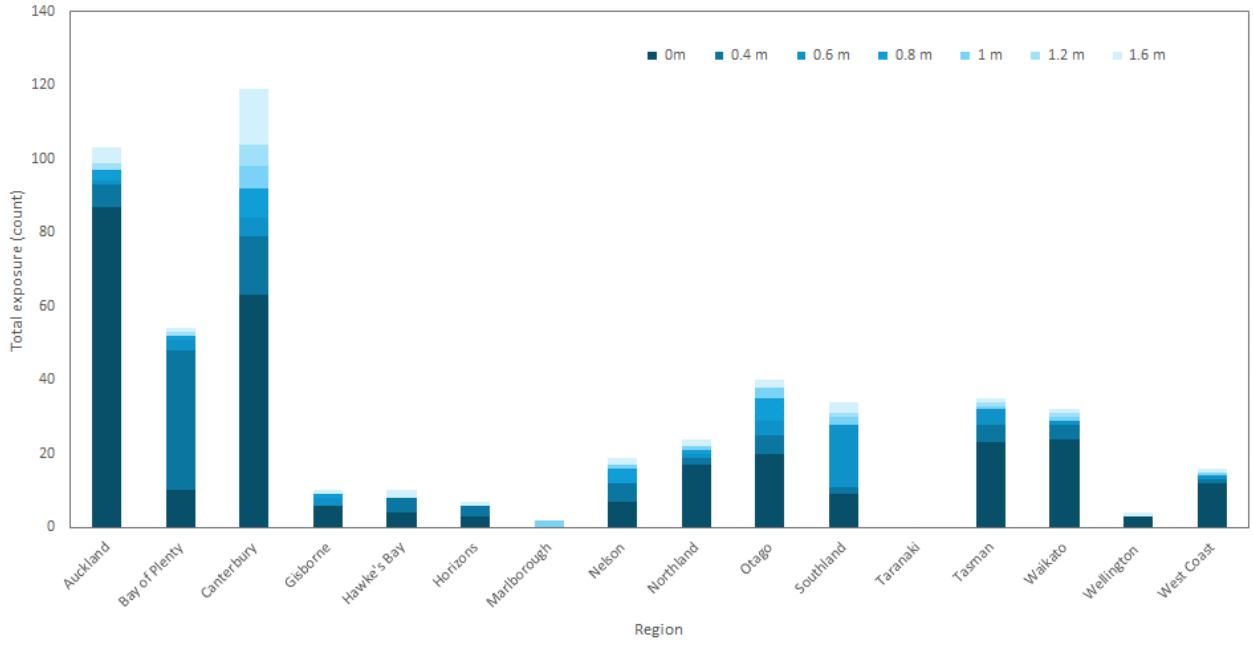


Figure 3.3: Count of landfills exposed to coastal inundation by region. Counts are inclusive of previous sea level rise increments.

3.3 River and surface flooding

Of the 3,233 landfills assessed, 1,683 (52%) are potentially exposed to river and surface flooding nationally. Of those landfills that are currently identified as not exposed, 135 (9%) are located within 150 m of a known flood hazard extent.

As noted, Canterbury has the highest exposure to river and surface flooding nationally (when considering the total number of landfills), followed by Auckland (186), Southland (99), and Waikato (84) (Figure 3.4). At a regional level, Auckland, Bay of Plenty and Hawke's Bay have the highest exposure with 80%, 70% and 65%, of their landfills exposed, respectively.

The Taranaki region has one out of the 17 landfills assessed potentially exposed to river and surface flooding, with two landfills identified within 150 m of a known flood hazard extent. There is a lack of detailed modelling within this region which could explain the lower number of landfills exposed.

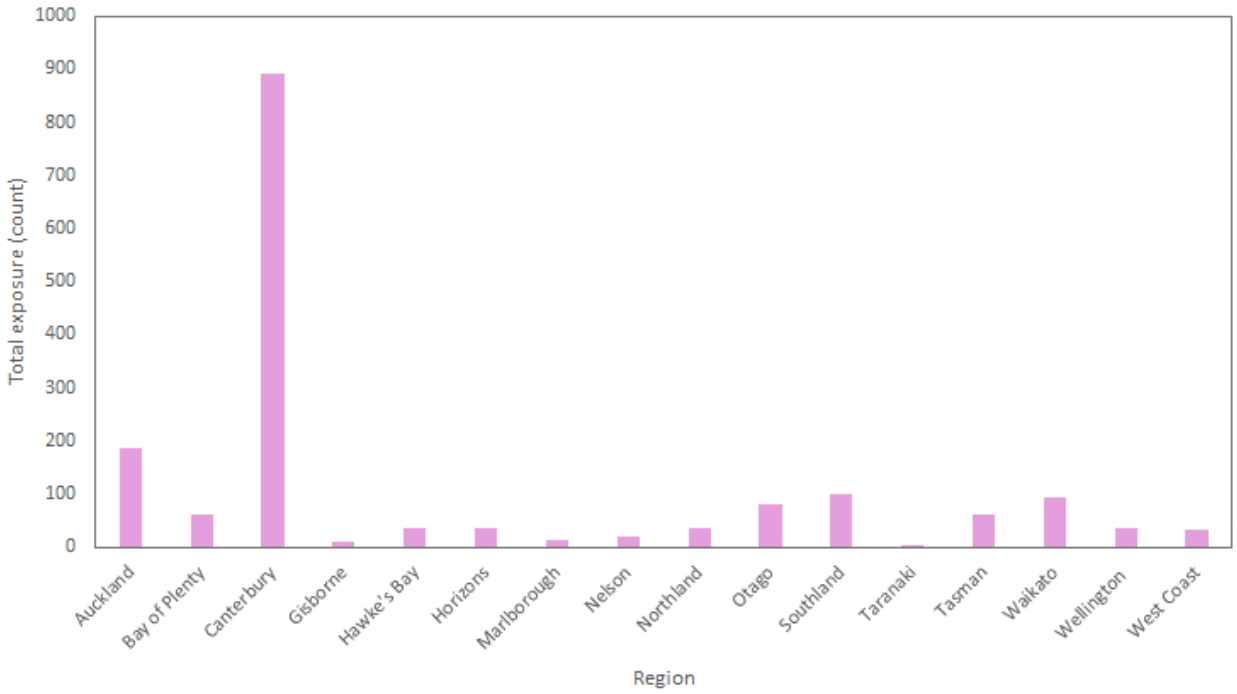


Figure 3.4: Count of landfills exposed to river and surface flooding.

4.0 Questionnaire results

Councils were asked about current work being undertaken to assess the impacts of natural hazards and climate change, whether they had any future work packages planned, and if there were any known issues with current closed and open landfills (Figure 4.1). Of the 12 councils that responded, 10 (83%) currently have concerns with some of their closed/ legacy landfills, while 3 councils identified they have current concerns with open landfills. It was noted by participants that these concerns are often related to landfills that are located in close proximity to rivers and the coastal edge.

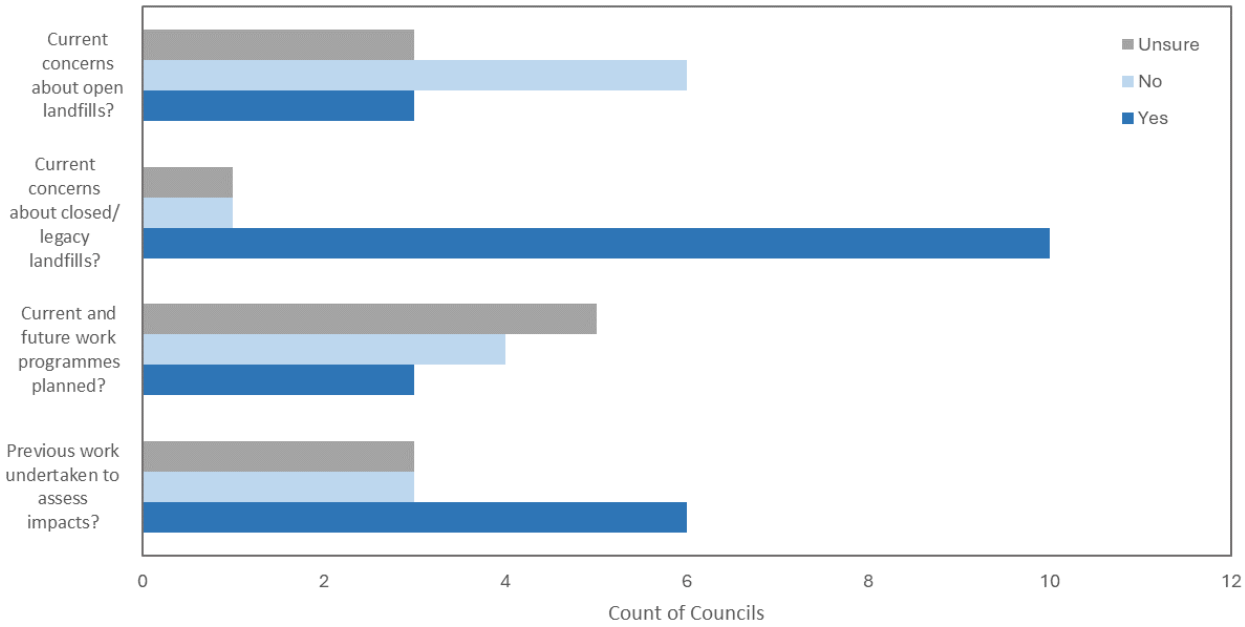


Figure 4.1: Questionnaire results for yes/no questions.

The questionnaire also asked what the current gaps and constraints were for completing this work (Table 4.1).

Table 4.1: Gaps and constraints as identified through landfill information questionnaire

Gaps	• The completeness and reliability of landfill specific data e.g., area, volume, dates of operation, cap details etc. • Lack of comprehensive risk assessments, particularly for landfills located within close proximity to rivers and the coast. • Monitoring and maintenance are insufficient. • Lack of funding and resources makes understanding identified landfill risks and implementing actions more difficult. • Lack of information on what practical actions to make for landfill sites at risk, i.e., remediation, protection, removal, or others. • Lack of proactive measures and central government funding to support a considered response. • Waste Minimisation Fund or Contaminated Sites Remediation Fund (CSRF) criteria does not allow for the remediation of legacy sites, or to complete data collation on landfills (DSI/PSI's).
Constraints	• Time, resources and funding. • Insufficient staff with appropriate knowledge and skills to undertake tasks that need completing. • Quality of landfill information. • Land ownership challenges and sites in remote locations. • Councils' own ability to fund improvements.

5.0 Summary and next steps

MfE is seeking to understand the scale of climate change risks to landfills across New Zealand. This exposure assessment has stepped MfE in the right direction into achieving this objective. This assessment identified that 1,797 (56%) of the landfills assessed are potentially exposed to one or more of the climate-related hazards assessed. When considering exposure to all three hazards, there are 176 landfills nationally. River and surface flooding was assessed as having the highest exposure, with more than 50% of landfills exposed nationally. This was followed by coastal inundation with 9% exposed currently, then costal edge proximity with 3% exposed currently. When considering the largest increment of sea level rise, more than 500 landfills are exposed nationally. While, when considering those landfills located within 100 m from the coast no more than 274 are exposed.

When comparing exposure across the regions, the Auckland region has the highest number of landfills exposed to all climate-related hazards assessed (31%), while Taranaki had the lowest. Additionally, Auckland contributes the highest number of landfills to the national total for coastal hazards, while Canterbury contributes the highest number of landfills for river and surface flooding.

This summary of exposure provides MfE with a high level overview of the scale of the problem nationally. It also provides MfE and councils a preliminary basis from which to carry out a more detailed risk assessment (if they have not completed one already). The proposed next phases of this work are:

1. Engagement with council to validate the exposure assessment, assumptions and outputs.
2. Future work into how river scour could be assessed with a higher level of certainty.
3. Engagement with councils to further refine and improve the current risk assessment tool
4. Developing training and guidance for councils on how to use the tool.

It is intended that this will enable councils to complete a detailed climate change risk assessment, which will in turn help MfE gain an understanding of the scale of climate change risks to landfills in New Zealand.

The intention is that the national risk assessment will help inform the development of funding options and other resources to support the investigation and remediation of these sites.

Document control and review

Document control and review

Date	Version	Description	Prepared by:	Authorised by:
05/08/2024	0.1	DRAFT for client comment	M. Lindsay	P. Walker
23/08/2024	1.0	Final issue	M. Lindsay	P. Walker

Quality management

To ensure alignment with our Quality Management System, technical review of differing elements within this report is documented below.

Quality management

Element:	Prepared by:	Reviewed by:
Geospatial exposure assessment	Rachael Nilsson	Josie Robison Morgan Lindsay
Climate change exposure assessment report	Morgan Lindsay	Alex Cartwright

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Appendix A. River Proximity Method & Analysis

The inclusion of a proxy analysis for river scour was requested by MfE, due to it being the mechanism in which the Fox River landfill was exposed in 2019. River scour occurs when sediment or engineered materials are removed from the bed and banks of a river due to the force of a flow. There is currently no nationally consistent dataset for river scour, and limited information at the regional level. A detailed river scour dataset could take into consideration aspects such as geomorphology of the river, bank widths, sediment loads, water velocities etc. Development of this fell outside of the scope of this assessment. Therefore proximity to watercourse was used to identify landfill distance from known watercourses. While not a representation of river scour, this provides a high-level screening for landfill proximity to watercourses.

The MfE river centreline dataset was used for this assessment, including information on river order. River order gives an indication of the relative size of the stream/ river, and ranges from one to eight. A proximity to watercourse analysis was completed to understand the distance each landfill was from different river orders.

Table 6.1 presents the results of this proximity analysis. Two sets of analyses were completed:

1. Landfill intersection with watercourse for river orders 4 and 5 and > 6.
2. Distance to watercourse for river orders 4 and 5 and > 6.

The distances presented in Table A.1 for each river order category were determined by the buffer distances established in the pilot risk assessment (2020).

Table A.1: Proximity to watercourse analysis

Region	Intersects river order 4 or 5	Intersects river order > 6	Within 100 m of river order 4 or 5	Within 400 m of river order > 6
National	**102**	**24**	**317**	**179**
Auckland	4	0	10	0
Bay of Plenty	2	1	5	6
Canterbury	47	0	190	42
Gisborne	0	0	3	7
Hawkes Bay	2	0	5	9
Horizons	2	0	7	1
Marlborough	2	0	3	0
Nelson	2	0	8	2
Northland	2	3	16	26
Otago	7	7	11	38
Southland	3	0	1	0
Taranaki	2	6	4	1
Tasman	9	5	14	14
Waikato	16	0	36	33
Wellington	2	2	4	0
West Coast	8	25	13	5