



Ministry for the
Environment
Manatū Mō Te Taiao

**Proposed National Environmental
Standard to Control Greenhouse Gas
Emissions from Landfills**

**Resource Management Act
Section 32**

Analysis of the costs and benefits

Published in May 2004 by the
Ministry for the Environment
Manatū Mō Te Taiao
PO Box 10-362, Wellington, New Zealand

ISBN: 0-478-18936-2
ME number: 515

This document is available on the Ministry for the Environment's website:
www.mfe.govt.nz



Ministry for the
Environment
Manatū Mō Te Taiao

Contents

Executive Summary	v
1 Introduction	1
1.1 Overview	1
1.2 The Section 32 evaluation and report	1
2 Statement of the Issue	3
2.1 Objectives for landfill gas management	3
2.2 Methane is a greenhouse gas	3
2.3 Existing landfill gas management	3
2.4 Government climate change policy	4
2.4.1 National direction	4
2.4.2 Resource Management (Energy and Climate Change) Amendment Act 2004	4
2.4.3 The Kyoto Protocol	5
3 What are the Options?	6
3.1 Introduction	6
3.2 Determining the most appropriate option	6
3.2.1 Option 1: Status quo	6
3.2.2 Option 2: Status quo plus climate change project mechanism	7
3.2.3 Option 3: Economic instruments (charging and trading)	8
3.2.4 Option 4: Preparation of a national environmental standard	9
3.3 Findings of the appropriateness test	10
3.4 The call for national environmental standards	11
3.5 Moving to the next stage in the analysis	11
4 The Proposed Landfill Gas Standard	12
4.1 The proposed standard	12
4.1.1 Applies to operational landfills that accept municipal solid waste	12
4.1.2 Applies to landfills that are designed to accept over 1 million tonnes of refuse throughout their design life	12
4.1.3 Applies to sites that are currently operating	12
4.1.4 Applies to proposed sites immediately.	12
4.1.5 Applies after a transitional period	13
4.1.6 Specifies flaring standards based on international best practice	13
4.1.7 Specifies a methane emission limit	13
4.1.8 Flexibility	13
4.2 Implementation	14

5	Efficiency and Effectiveness of the Proposed Standard	15
5.1	Overview	15
5.2	Summary of methodology	15
5.3	Assessment of benefits	16
	5.3.1 Statement of benefits	16
	5.3.2 Valuation of benefits	18
5.4	Assessment of actual costs to stakeholders	19
	5.4.1 Costs to landfill operators	19
	5.4.2 Costs to regional councils	21
	5.4.3 Costs to the consumer	21
	5.4.4 Costs to central government	21
	5.4.5 Summary of total costs	22
5.5	Options appraisal: measuring efficiency	22
5.6	Sensitivity analysis	23
6	Summary of Findings	25
	References	26
	Appendices	
	Appendix 1: Landfill Base Data	27
	Appendix 2: Emissions, Benefit and Cost Model Spreadsheets	28
	Tables	
Table 1:	Advantages and disadvantages of the status quo option	7
Table 2:	Assessment of status quo against the objectives	7
Table 3:	Advantages and disadvantages of the ‘status quo plus projects’ option	7
Table 4:	Assessment of ‘status quo plus projects’ against the objectives	8
Table 5:	Advantages and disadvantages of the ‘economic instruments’ option	8
Table 6:	Assessment of ‘emissions charge’ against objectives	9
Table 7:	Advantages and disadvantages with the ‘NES’ option	10
Table 8:	Assessment of ‘landfill NES’ against objectives	10
Table 9:	Estimated landfill gas emissions	17
Table 10:	Estimated monetary benefits from reductions in landfill gas emissions	18
Table 11:	Total costs of proposed national environmental standard for landfill gas collection and destruction over 10-year appraisal period	22
Table 12:	Summary of key appraisal data	23
Table 13:	Summary of sensitivity test results	24

Executive Summary

The biological decomposition of rubbish in landfills produces landfill gas. This gas contains approximately equal amounts of methane (45 to 60%) and carbon dioxide (40 to 60%), along with a number of trace gases. The effective management of methane is important, as it is a potent greenhouse gas with a global warming capability over 21 times that of carbon dioxide. Methane can be destroyed through combustion, although at present there is no national requirement for landfill operators to collect and destroy methane.

Landfill gas emissions make up 4% of New Zealand's total methane emissions. Although this proportion is not large, the Government has made a commitment to reduce New Zealand's greenhouse gas emissions and has accounted for a reduction from the waste sector in the climate change policy package. If reductions are not made, New Zealand could restrict its ability to meet its obligations under the Kyoto Protocol.

The recently introduced Resource Management (Energy and Climate Change) Amendment 2004 confirms the Government's policy that emissions of greenhouse gases will be controlled at a national level. The Act aims at national co-ordination by removing the power of local government to consider the effect of greenhouse gas emissions on climate change when making rules in regional plans, or when determining air discharge consents (except where necessary to implement a national environmental standard).

This means we need to consider the best form of national policy. In this analysis we assess the four main policy options against the objectives determined by the Minister for the Environment for landfill gas emissions management in New Zealand. We conclude that the best option is a national environmental standard.

Although the Resource Management Act was passed more than 12 years ago, no national environmental standards have been developed under the Act. Unlike other countries, New Zealand has no national standards for environmental protection. The intention of the proposed standard would be to ensure existing best practice for continues.

Section 32 of the Resource Management Act requires the Minister for the Environment to evaluate the objectives and policies of any proposed national environmental standards. A report must be prepared that evaluates whether the proposal is the most appropriate method for achieving the objectives, having regard to their efficiency and effectiveness. This analysis is included within this report.

National environmental standards have been advocated by industry to give both a 'level playing field' across regions, and to provide certainty in decision-making under the Resource Management Act. The benefits in terms of providing a level playing field and increasing certainty in decision-making are large, but are not calculated in the subsequent analysis.

Instead, the report focuses on the costs and benefits of using national environmental standards to provide an equitable bottom-line of health and environmental protection for all New Zealanders.

1 Introduction

1.1 Overview

This document presents an analysis of New Zealand's proposed national environmental standard for landfill gas collection and destruction as required by section 32 of the Resource Management Act 1991 (RMA).

Unlike other countries, New Zealand has no national standards for environmental protection. The introduction of national environmental standards will provide an equitable bottom-line health protection for all New Zealanders. National environmental standards have been advocated by industry to give both a level playing field across regions and certainty in decision-making under the RMA.

The Ministerial Panel on Business Compliance Costs recommended that the Government investigate the use of national planning instruments, such as national standards, to improve consistency in decision-making.

National environmental standards¹ have the force of regulation and will be implemented by agencies and parties with responsibilities under the RMA. The standards are prepared in accordance with sections 43 and 44 of the RMA.

In August 2003 the Government agreed that "the Ministry for the Environment undertake an extensive public consultation on a range of proposed standards, including air quality standards, ... and landfill gas capture and destruction".

1.2 The Section 32 evaluation and report

The Minister for the Environment has proposed introducing a national environmental standard for landfill gas collection and destruction. Section 32 of the RMA requires the Minister, prior to making a regulation, to evaluate the objectives and policies of the regulation and to prepare a report summarising the evaluation. The requirements are contained within section 32 of the RMA:

- (3) *An evaluation must examine:*
 - (a) *the extent to which each objective is the most appropriate way to achieve the purpose of this Act; and*
 - (b) *whether, having regard to their efficiency and effectiveness, the policies, rules, or other methods are the most appropriate for achieving the objectives.*
- (4) *For the purposes of this examination, an evaluation must take into account:*
 - (a) *the benefits and costs of policies, rules, or other methods; and*
 - (b) *the risk of acting or not acting if there is uncertain or insufficient information about the subject matter of the policies, rules, or other methods.*

¹ A separate section 32 document has been prepared for the proposed air quality standards.

There are two main aspects to the test of *appropriateness*:

- weighing up alternative objectives to determine which one will provide environmental outcomes that will best meet the purpose of the Act
- being satisfied that the objective chosen can best be achieved through the Act, rather than through some other mechanism.

Getting a measure of *effectiveness* involves assessing how well something might work.

Determining the relative *efficiency* of various alternatives is a more difficult exercise, and involves an examination of costs and benefits. A measure of efficiency is the extent to which the proposed method achieves the purpose of the Act, compared to the magnitude of what is foregone as a result of using this method. Assessing this involves calculating and comparing the net environmental benefits against the net social and economic benefits. Thus the more the net environmental benefits exceed the net social and economic costs, the more efficient the option is. The smaller the net environmental benefits in relation to the net social and economic costs, the less efficient the option is (Ministry for the Environment, 2000).

In evaluating the efficiency of the proposed national environmental standard, some assumptions have been made about how the policies might be put into practice by local government.

2 Statement of the Issue

2.1 Objectives for landfill gas management

The Minister for the Environment has determined four main objectives for national policy development for landfill gas emissions management in New Zealand:

- to assist in meeting New Zealand's obligations under the Kyoto Protocol
- to establish nationally based landfill gas management for greenhouse gas emissions
- to provide a level-playing field and certainty for the waste management industry
- to provide an incentive to divert organic waste (e.g. food scraps and garden waste) from landfills into composting and other uses.

2.2 Methane is a greenhouse gas

Landfill sites produce landfill gas as a result of the anaerobic decomposition of organic matter. Landfill gas contains approximately equal amounts of methane (45 to 60%) and carbon dioxide (40 to 60%), along with a number of trace gases. The effective management of methane is important, because methane gas has a global warming capability 21 times that of carbon dioxide. Control of methane is also desirable because it reduces the risk of explosions caused by off-site migration of landfill gas, and odour nuisance.

Methane emissions can be relatively easily controlled by collection and combustion. At present there is no national requirement for landfill operators to collect and destroy methane, meaning that landfills can contribute to greenhouse gas emissions.

The waste industry is a relatively minor methane emitter, currently contributing approximately 4% of New Zealand's overall greenhouse gas emissions. However, the government has made a commitment to reducing New Zealand's greenhouse gas emissions and has accounted for a reduction from the waste sector in the climate change policy package. If reductions are not made, this could restrict New Zealand's ability to meet its obligations under the Kyoto Protocol.

2.3 Existing landfill gas management

Over the past 12 years the Government has been encouraging landfill management best practice through promotion of best-practice guidance, such as the Centre for Advanced Engineering's *Landfill Guidelines* (2000). The *Landfill Guidelines* discuss the importance and benefits of landfill gas collection.

The majority of large landfills operating in New Zealand are required to collect and manage landfill gas by way of resource consent conditions set by regional councils. Regional councils have required the management of landfill gas for a variety of reasons, including to reduce odour nuisance, to reduce the risks of explosions or fires due to landfill gas migrating and collecting in confined spaces, and to reduce greenhouse gas emissions.

Information collected during *The 2002 Landfill Review and Audit* (Ministry for the Environment, 2003) shows that that 19 of New Zealand's 116 operating landfills exceed the 1 million tonne threshold, and 75% of these already collect and manage landfill gas or are planning to do so in the near future. Appendix 1 provides a list of landfills over the threshold and gives more detail on each landfill.

The recently introduced Resource Management (Energy and Climate Change) Amendment 2004 alters responsibility for greenhouse gas control from a local to a national level (see section 2.4.2 below).

2.4 Government climate change policy

2.4.1 National direction

Government policy is that emissions of greenhouse gases will be controlled at a national level. This:

- provides greater certainty for meeting New Zealand's commitments under the Kyoto Protocol
- removes the potential for duplication of national and local controls and the potential for elevated costs being borne by industry
- provides greater certainty about the role and responsibility of councils in this regard, thus avoiding litigation costs
- removes the potential for local controls to conflict with national mechanisms.

This policy position (among others) has been provided for within the Resource Management (Energy and Climate Change) Amendment Act 2004.

2.4.2 Resource Management (Energy and Climate Change) Amendment Act 2004

The Resource Management (Energy and Climate Change) Amendment Act 2004 was passed on 26 February 2004, and came into force on 2 March 2004. This Act (among other things) recognises the Government's preference for national co-ordination of controls on greenhouse gas emissions.

One of the motivations for the Amendment Act was to remove the potential for a double-up of greenhouse gas regulation at the local and national levels. The Government considers that greenhouse gas emissions should be addressed and controlled at the national level, given that the climate-change effects of local emissions are observed globally, not locally. National policy will create consistent and even application of climate change policy, and provide a clear indication to industry as to the Government's expectations.

The Amendment Act aims for national co-ordination by removing the power of regional councils to consider the effect of greenhouse gas emissions on climate change when making rules in regional plans or determining air discharge consents, except where necessary to implement a national environmental standard. While regional councils could continue to require controls on landfill gas for health and safety or odour reasons, there is no guarantee that existing best practice will continue without a national landfill gas policy that addresses greenhouse gas emissions. A council must be no more or less restrictive than any national policy when implementing a national environmental standard relating to the discharge of greenhouse gases.

As landfills contribute up to 4% of New Zealand's total methane emissions, there is a need to consider what form of national policy is most relevant.

2.4.3 The Kyoto Protocol

The Kyoto Protocol is an international agreement to address global warming and delay climate change. It aims to reduce the total greenhouse gas emissions of developed countries (and countries with economies in transition) to 5% below the level they were in 1990. The Protocol sets targets for the greenhouse gas emissions of developed countries for the period 2008 to 2012 (the first commitment period). Different countries have different targets. New Zealand ratified the Kyoto Protocol on 10 December 2002 and aims to reduce its greenhouse gas emissions to the level they were in 1990, or take responsibility for excess emissions.

New Zealand's latest greenhouse gas inventory shows that emissions are increasing, with carbon dioxide emissions in 2001 about 28% higher than they were in 1990. Transport sector emissions are continuing to grow rapidly and now make up almost 40% of New Zealand's total carbon dioxide emissions. If nothing is done to reduce greenhouse gas emissions, New Zealand's total emissions could be 14 to 20% over our target by 2012. If New Zealand has excess emissions above its 1990 target, responsibility for these emissions can be handled in a number of ways, including purchasing emission units on the international market or using forest sink credits.

As a result of the Kyoto Protocol and earlier climate change initiatives, the New Zealand Government has a range of programmes to reduce emissions already in place or being developed. The private sector is also engaged in this process.

3 What are the Options?

3.1 Introduction

There are a number of different national policies that could be applied to manage greenhouse gas emissions from landfills. These range from continued guidance, economic instruments, climate projects, national environmental standards, through to the ‘do nothing’ and status quo.

The following sections set out these options and look at their appropriateness for achieving the stated objectives for landfill gas emissions.

3.2 Determining the most appropriate option

In order to find the most appropriate option for controlling landfill gas emissions, the Ministry has considered a list of potential options. These have been analysed, and for the purposes of this report only the following options have been considered in detail:

- Option 1: status quo (the current situation – the baseline in the analysis)
- Option 2: guidance and climate change projects
- Option 3: economic instruments (charging and permit trading)
- Option 4: preparation of national environmental standards.

3.2.1 Option 1: Status quo

Prior to the introduction of the Resource Management (Energy and Climate Change) Amendment Act 2004, the majority of regional councils were requiring large landfills to collect and destroy methane. However, the Amendment Act removes the ability of regional councils to consider the effects on climate change from air discharges, which means there is no certainty that regional councils will continue to place controls on landfill gas emissions.²

For the purpose of this analysis, ‘status quo’ refers to the Government continuing with its promotion of best practice through advocacy of the Centre for Advanced Engineering’s *Landfill Guidelines*, and regional councils not being able to consider the effects of climate change from air discharges.

Tables 1 and 2 set out two types of analysis. Table 1 examines the advantages and disadvantages of the option while Table 2 looks at whether the option achieves the stated objectives.

² Note that regional councils could still require management of landfill gas for health and safety and nuisance impacts.

Table 1: Advantages and disadvantages of the status quo option

Advantages	Disadvantages
There would be no extra monetary costs for all parties.	The amount of methane emitted from landfills could rise.
No new regulation is required.	New Zealand may not be able to meet its climate change commitments under the Kyoto Protocol.
	There would be no formal control of landfill gas except for health and safety and odour issues.

Table 2: Assessment of status quo against the objectives

Objective	Does this option meet this objective?
To help New Zealand meet its obligations under the Kyoto Protocol	No
To establish nationally based landfill gas management for greenhouse gas emissions	No
To provide certainty for the waste management industry	No
To encourage the diversion of organic waste from landfills into composting and other uses	No

This option clearly does not achieve the stated objectives. However, the use of this option as a baseline in the analysis is crucial in comparing the benefits and costs of other options.

3.2.2 Option 2: Status quo plus climate change project mechanism

This is similar to the status quo, but with the inclusion of the climate change project mechanism. The climate change project system means applicants can apply for a grant of carbon credits if they have a project that will decrease the amount of greenhouse gas that would have otherwise been emitted into the atmosphere when compared to business as usual. In turn, these project operators can sell these credits to other nations who produce more carbon than their quota, thus generating income. A number of landfill operators have recently received credits, and this option assumes that a similar process continues into the future.

Tables 3 and 4 set out two types of analysis for this option. Table 3 examines the advantages and disadvantages of this option, while Table 4 looks at whether the option achieves the stated objectives.

Table 3: Advantages and disadvantages of the 'status quo plus projects' option

Advantages	Disadvantages
There would be relatively low costs (dependent on the extent of funding of projects).	This option may create an incentive for landfill operators to exaggerate their estimated emissions to receive more carbon credits.
No new regulation is required.	It does not fully address the issue of emissions growth.
	Landfills that currently capture and flare landfill gas are unlikely to qualify for carbon credits. There is no certainty that the Government will continue to offer carbon credits through the Climate Change Projects Mechanism.

Table 4: Assessment of ‘status quo plus projects’ against the objectives

Objective	Does this option meet this objective?
To help New Zealand meet its obligations under the Kyoto Protocol	Partially
To establish nationally based landfill gas management for greenhouse gas emissions	No
To provide certainty for the waste management industry	No
To encourage the diversion of organic waste from landfills into composting and other uses	Partially

This option is not appropriate because it does not meet the crucial objective of establishing nationally based landfill gas management greenhouse gas emissions.

3.2.3 Option 3: Economic instruments (charging and trading)

This option would involve placing a tax or charge on landfill gas emissions, whereby a polluter is forced to pay a certain amount of money for every unit of pollutant emitted. The aim of such an option is to provide an economic incentive for landfill operators to minimise emissions and in this case divert organic waste or collect and flare their gas. This option may also form the basis of a tradable permit scheme.

The RMA supports investigating imposing financial charges, but the Act, on its own, would not facilitate the use of charges. Changes to existing legislation would likely to be needed. A question also remains over the ability to trade discharge permits.

Tables 5 and 6 set out two types of analysis for this option. Table 5 examines the advantages and disadvantages of this option, while Table 6 looks at whether the option achieves the stated objectives.

Table 5: Advantages and disadvantages of the ‘economic instruments’ option

Advantages	Disadvantages
The charge could raise revenue that is then recycled to encourage the further reduction of greenhouse gas emissions.	Methane quantities from individual landfills are difficult to measure because they require a high level of accuracy. This would inevitably result in the use of estimates, which can create large differences when emission charges are high.
A tradable permits regime offers a method to encourage efficiency and cost savings.	The charge would be costly to implement due to the high measurement and verification costs. The charge would need to be very high (higher than the cost of infrastructure) to actually encourage methane capture. This option may require alternative legislation or an amendment to the RMA – a costly and time-consuming process.

Table 6: Assessment of ‘emissions charge’ against objectives

Objective	Does this option meet this objective?
To help New Zealand meet its obligations under the Kyoto Protocol	Yes
To establish nationally based landfill gas management for greenhouse gas emissions	No
To provide certainty for the waste management industry	No
To encourage the diversion of organic waste from landfills into composting and other uses	Yes

This option is not appropriate for a number of reasons. There are questions over its feasibility (particularly under the RMA in its existing form), and it does not meet the objectives of establishing nationally based landfill gas management greenhouse gas emissions to provide certainty for the waste management industry. If a tradable permit approach were found to be feasible, there would still need to be some sort of emissions cap (to establish a ‘cap and trade’ programme, for example). To sum up, as a stand-alone option the use of charging or a trading regime will not achieve the stated objectives.

3.2.4 Option 4: Preparation of a national environmental standard

The Resource Management (Energy and Climate Change) Amendment Act 2004 specifies the use of national instruments to control greenhouse gas emissions. The Act makes explicit mention of national environmental standards in this regard:

New section 70A removes the power of regional councils, in making rules on the discharge of greenhouse gases into air, to have regard to the effects of a discharge on climate changes ... new section 70B permits regional councils to make rules as necessary to implement a relevant national environmental standard made by regulation under section 43.

New section 104F provides, as a further exception to the prohibition in new section 104E, that regional councils may determine the specified applications that are necessary to implement a relevant national environmental standard made by regulation under section 43, but must be no more or less restrictive than the national environmental standard being implemented.

Due to the specific reference to national environmental standards within the Amendment Act, consideration of national instruments is restricted to the consideration of a national environmental standard, and not other alternatives such as national policy statements.

National environmental standards are regulations that set a national technical standard that all operators in the country are required to meet. The proposed standard sets a consistent national approach by specifying the requirement to collect and destroy landfill gas emissions for landfills over a million tonnes in capacity, unless the landfill contains less than 5% organic matter.

Tables 7 and 8 set out two types of analysis for this option. Table 7 examines the advantages and disadvantages of this option, while Table 8 looks at whether the option achieves the stated objectives.

Table 7: Advantages and disadvantages with the ‘NES’ option

Advantages	Disadvantages
Ensures that greenhouse gas emissions from landfill sites are controlled.	Regulations can be costly and time consuming to implement – less so in this case.
Sets a national approach to the management of greenhouse gas emissions from landfill sites.	Additional resourcing requirements would be placed on regional councils and landfill consent holders to implement and enforce the NES.
Gives regional councils the ability to control greenhouse gas emissions from landfill sites (removed by the RMA amendment).	
All landfill sites in New Zealand will be treated the same, setting a level playing field.	
Allows regional councils flexibility to introduce additional instruments to ensure the standard is achieved (eg, tradable permits, emission charges, education, etc.)	

Table 8: Assessment of ‘landfill NES’ against objectives

Objective	Does this option meet this objective?
To help New Zealand meet its obligations under the Kyoto Protocol	Yes
To establish nationally based landfill gas management for greenhouse gas emissions	Yes
To provide certainty for the waste management industry	Yes
To encourage the diversion of organic waste from landfills into composting and other uses	Yes

From the above it can be seen that this option meets the stated objectives and has a number of advantages. This option will, therefore, be taken forward the next step for further analysis.

3.3 Findings of the appropriateness test

The appropriateness test has assessed a range of options, setting out their relative advantages and disadvantages and whether each option can meet the stated objectives.

We found that only one option has the ability to meet the stated objectives: the national environmental standard option. This option is considered to be the most appropriate from the range of option assessed. Further analysis of this option will determine its effectiveness and efficiency.

3.4 The call for national environmental standards

As further support for the national environmental standard option, a number of events have led to calls from stakeholders for the Ministry to consider the introduction of standards.

- At a series of public meetings held in mid-2002, business, councils and community groups called on the Ministry to get on with developing a national policy approach for key resource management issues.
- A consultative process was held with regional councils to scope the policy programme needed to support a national approach.
- In May 2003 the Ministry for the Environment presented the concept of national environmental standards to regional council representatives, and feedback was positive.
- The Ministry for the Environment hosted a national roadshow to obtain further input from the community and key interest groups in November 2003. Feedback at the roadshow meetings was largely supportive of the proposed national standards.

3.5 Moving to the next stage in the analysis

Given the above tests and taking into account calls from stakeholders, the national environmental standards option has been taken forward for more detailed analysis. This is not to suggest that this is the only viable option, but it is the only option that meets the current stated objectives.

In order to test the effectiveness and efficiency of the national environmental standard option, the proposed standard is set out in summary in section 4. Section 5 then examines the costs and benefits associated with this option in order to determine its efficiency. The benefits will measure the effectiveness of this option to reduce greenhouse gas emissions from landfill sites.

4 The Proposed Landfill Gas Standard

4.1 The proposed standard

The objective of the proposed standard is to develop a national policy that ensures that landfill greenhouse gas emissions are being effectively managed. It aims to lock in existing best practice of capturing and flaring landfill gas at all large landfills, but also aims to provide flexibility to encourage organic waste diversion.

The standard would require landfill gas collection and destruction, with the flaring of gas likely to be the most common option. Beneficial uses of methane such as electricity generation would be permissible provided the landfill owner can demonstrate equivalent or better mitigation of methane gas emissions. The following summarises features of the draft standard. Note that aspects of the standard may be subject to change.

4.1.1 Applies to operational landfills that accept municipal solid waste

The standard would not apply to sites that accept only cleanfill (soil and rubble) or construction and demolition landfill sites, which produce only minor amounts of methane.

4.1.2 Applies to landfills that are designed to accept over 1 million tonnes of refuse throughout their design life

Installing gas collection systems at landfills smaller than this threshold is not likely to be economically viable.

4.1.3 Applies to sites that are currently operating

It would not apply to existing closed landfills. It is expected that existing gas management control systems at closed landfills will continue to operate as per existing consent conditions.

4.1.4 Applies to proposed sites immediately.

Note, however, that in practice gas collection systems are generally not installed until adequate methane generation is occurring. This is dependent on the period of time the refuse has been in place and the total quantity of refuse. This varies, but is usually between 80 and 260 days after refuse placement begins for approximately 200,000 tonnes of refuse.

4.1.5 Applies after a transitional period

The standard will apply to existing operational sites after a transitional period of three years if a site does not currently have a landfill gas collection system. This provides time for the landfill owner to fund, design and install a landfill gas collection system.

4.1.6 Specifies flaring standards based on international best practice

This would include a minimum flare temperature of 750 degrees centigrade for a retention time of 0.5 seconds. Conditions would also address flame arrestors and back-flow protection devices to prevent flash-back and landfill fires, plus a flame detector with an automatic slam-shut valve and blower isolation to prevent unburnt discharges of landfill gas.

4.1.7 Specifies a methane emission limit

Gas collection efficiencies are variable and so measurements are relatively inaccurate and unreliable. It is therefore not possible for the standard to specify a percentage efficiency for a gas collection system. Measuring methane emissions at the landfill surface and at monitoring points around the landfill is currently common practice in resource consent conditions at major landfills, including many recently closed sites. The limit is commonly 1% methane (by volume in air), corresponding to approximately 25% of the lower explosive limit. We recommend that this be adopted as the draft methane emission limit during consultation, but will be guided by submissions.

After consideration of submissions, the Minister for the Environment will inform Cabinet that the surface methane emission limit will be 0.5% methane (5000 ppm).

4.1.8 Flexibility

There may be situations where a landfill exceeds the refuse quantity threshold of 1 million tonnes but through the effective diversion of organic matter, or shallow landfill cells, methane emissions are below the surface methane emission limit.

In this case effective operation of a methane collection and destruction system may not be warranted or feasible. This could occur at sites with waste quantities close to the proposed threshold, sites with a shallow depth of refuse, dry sites, or those where organic waste diversion has resulted in a reduction in methane generation.

After consideration of submissions, the Minister for the Environment will inform Cabinet that landfill sites may apply for an exemption to installing a landfill gas collection system if the site contains less than 5% biodegradable and putrescible matter.

4.2 Implementation

Within three years after the introduction of the standard, regional councils will be required to place consent conditions requiring the installation of a landfill gas collection and destruction system on any resource consent granted for landfills with a projected total capacity of over 1 million tonnes, unless the applicant can demonstrate that they will be able to limit surface methane emissions below the performance limit specified by this standard.

Regional councils will be required to review landfill gas monitoring data to ensure that landfills are complying with the surface methane emission limits.

5 Efficiency and Effectiveness of the Proposed Standard

5.1 Overview

Effectiveness considers whether the policy option will actually be effective in achieving its aims and objectives. In this case, the setting of national environmental standards provides firm regulation for the achievement of the stated aims and objectives. It is, therefore, the most direct and effective option,³ assuming full implementation by local government.

Efficiency needs to consider the benefits and costs of any policy intervention. If the benefits outweigh the costs over time, then the policy is deemed to be 'efficient'. This, however, usually assumes that benefits and costs can be quantified in monetary terms. In this case there are a number of 'intangible' benefits such as certainty and consistency. With this in mind the benefits identified in this section should be viewed as the baseline level of benefits, as the more intangible benefits will be additional to those identified.

5.2 Summary of methodology

As the proposed national standard only affects a small number of landfills,⁴ the methodological approach for deriving the costs and benefits of the proposed standard is relatively straightforward.

Cost information was gathered through:

- direct contact with affected landfill operators to determine the costs to them
- discussion with operators to determine whether there would be any costs passed on to users of the landfill sites
- discussions with local government to determine any additional costs of monitoring, reporting, and processing consents
- discussions within central government to determine any costs in terms of administration, auditing or validation.

³ This will be considered further via the use of cost-effectiveness analysis in the overall appraisal.

⁴ The benefits modelling focuses on the landfills over 1 million tonnes affected by the proposals. Appendix 1 lists the landfill sites that will be affected.

The method for estimating benefits has focused on the reduction in greenhouse gas emissions. This has involved:

- determining current greenhouse gas emissions from landfill sites in New Zealand (this forms the baseline for the analysis)
- determining greenhouse gas emissions from landfill sites under the national environmental standard option.

The derivation of emissions used methods recommended by the International Panel on Climate Change for generating greenhouse gas inventories. The difference between the two levels of emissions provides the benefits of the national environmental standards option. The greenhouse gas emissions are then converted into a monetary measure using the expected market value of carbon dioxide equivalents.

In both cases, the timeframe is assumed to be a transition period of three years, with the appraisal timeframe set at 10 years after this. Costs and benefits are discounted at 10%.⁵

The final stage is to compare the monetised costs with the monetised benefits. A further measure of cost-effectiveness has also been derived – cost per tonne of carbon dioxide equivalent. The following sections set out the costs and benefits in more detail.

5.3 Assessment of benefits

5.3.1 Statement of benefits

One of the drivers for the Resource Management (Energy and Climate Change) Amendment Act 2004 was to remove the potential for a double-up of greenhouse gas regulation at the local and national levels. The Government has stated that greenhouse gas emissions should be addressed and controlled at the national level because the climate change effects of local emissions are not observed locally. A national environmental standard for landfill gas collection and destruction fits well within this framework and will create consistent and even application of climate change policy across landfills and provide a clear indication to industry as to Government expectations.

The proposed standard will also compensate for the provisions of the Amendment Act 2004, which removed local government's ability to address landfill gas for climate change reasons. A standard will provide assurance that the current best practice of capturing and flaring gas is used in all present and future landfills over a certain threshold, and will thereby achieve a level playing field for all operators.

⁵ The process of discounting refers to the fact that society has a preference for 'a bird in the hand'; i.e., money today rather than at some point in the future. This is referred to as time preference, and values in the future are given less weight via the process of discounting. In this case, a discount rate of 10% has been used.

Initially the Government decided not to impose an emissions charge on landfill greenhouse gases for feasibility reasons and because the New Zealand Waste Strategy appeared to offer emission reductions over time through the application of a general waste levy. A waste levy is unlikely to be applied in the near future. The New Zealand Climate Change Office wishes to develop policy instruments to encourage methane reductions from the waste sector in light of current policy changes, and a national environmental standard will help achieve this.

In terms of the quantification of reductions in greenhouse gas emissions, the analysis has used a methodology recommended by the International Panel on Climate Change⁶ in order to determine emissions under both the 'status quo' and 'national environmental standard' options. Waste data from *The 2002 Landfill Review and Audit* (Ministry for the Environment, 2003⁷) has been used to generate emissions estimates for the base data year, which is 2001. An annual increase of 1.5% of waste to landfill⁸ has then been used to extrapolate the waste contained in landfills to 2016 (the end of the analysis period – 10 years after the transition period). This then allows the derivation of greenhouse gas emissions per annum for the landfill sites of interest. Emissions have first been derived in terms of methane and then converted to their carbon dioxide equivalent (to reflect the fact that methane has a greater global warming potential than carbon dioxide).

The predicted emissions are shown in the spreadsheet tables in Appendix 2, and are summarised in Table 9.

Table 9: Estimated landfill gas emissions

Date year	Analysis year	Emissions (tonnes of carbon dioxide equivalent)*		
		CO ₂ e (status quo)*	CO ₂ e (NES)	Benefits of NES
2004	0	1,680,000	1,600,000	Transition period
2005	1	1,710,000	1,610,000	
2006	2	1,740,000	1,610,000	
2007	3	1,770,000	1,610,000	
2008	4	1,800,000	1,610,000	158,000
2009	5	1,830,000	1,620,000	184,000
2010	6	1,860,000	1,620,000	211,000
2011	7	1,880,000	1,620,000	237,000
2012	8	1,910,000	1,620,000	263,000
2013	9	1,940,000	1,630,000	290,000
2014	10	1,970,000	1,630,000	316,000
2015	11	2,000,000	1,630,000	342,000
2016	12	2,030,000	1,630,000	369,000
			Total	2,765,000

* Rounded to three significant figures.

⁶ The 'Tier 1' methodology has been used in this case. See IPCC (2001).

⁷ Available from <http://www.mfe.govt.nz/publications/waste>.

⁸ Personal comment, Chris Purchas, Ministry for the Environment, 2004.

This means that over the period of analysis, greenhouse gas emissions from large landfills are reduced by 2.77 million tonnes of carbon dioxide equivalent (CO₂e) by the introduction of a national environmental standard. This clearly signals the use of a national environmental standard as an extremely effective option in controlling greenhouse emissions from large landfill sites.

In addition to the reduction in greenhouse gas emissions, the installation of a gas collection system helps to address the problems of odour and explosive potential related to methane management at landfills. This is generally regulated well through the current consenting process, so additional benefits are not considered here.

5.3.2 Valuation of benefits

The reduction in greenhouse gas emissions has been measured in terms of the market value of CO₂, as used for permit trading internationally. This represents the cost saving generated by a reduction in emissions (i.e., there will be no need to purchase credits to cover additional emissions). The value of CO₂ will also go some way to reflecting the external costs of greenhouse gas emissions, and hence the value demonstrates the benefit to society of the reduction in harmful emissions.

It is currently predicted that the market price of CO₂ will be around US\$5 to US\$25 (NZ\$7.08 to NZ\$35.38)⁹ per tonne. Using these values as a basis for benefits (with a lower and upper estimate) results in the benefit values summarised in Table 10. The full benefits spreadsheet can be found in Appendix 2. It is also worth noting that the maximum level of the proposed carbon charge in New Zealand will be NZ\$25 per tonne of CO₂.

Table 10: Estimated monetary benefits from reductions in landfill gas emissions

Date year	Analysis year	PV benefits (upper)*	PV benefits (lower)*
2004	0	Transition period	
2005	1		
2006	2		
2007	3	\$4,200,000	\$840,000
2008	4	\$4,450,000	\$891,000
2009	5	\$4,630,000	\$925,000
2010	6	\$4,730,000	\$946,000
2011	7	\$4,780,000	\$956,000
2012	8	\$4,780,000	\$956,000
2013	9	\$4,740,000	\$948,000
2014	10	\$4,670,000	\$934,000
2015	11	\$4,570,000	\$914,000
2016	12	\$4,450,000	\$890,000
Total		\$46,000,000	\$9,200,000

* Rounded to three significant figures.

⁹ Source: www.CO2e.com, an internet-based emissions trading market. Using exchange rate as at 17/2/04. No adjustment for purchasing power parity has been made due to current purchasing power parity similarity between the US and New Zealand (*The Economist*, 15 January 2004).

Table 10 indicates that over the 10 years of the appraisal period, benefits range from around \$9.2 million to around \$46 million (in present values). Clearly this is a wide range of benefits, but it does indicate the magnitude of the benefits and allows a degree of comparison with the costs of the proposals.

Wider benefits of standards such as certainty and providing a level playing field remain intangible, and as such no attempt to quantify these has been made.

5.4 Assessment of actual costs to stakeholders

In broad terms the affected sectors are:

- local government
- central government
- landfill consent holders, both private and local government.

The proposed landfill gas standard reflects current best practice in New Zealand and other developed countries. This can be confirmed for New Zealand through the findings of the Ministry for the Environment's *2002 Landfill Review and Audit* (2003), which indicates that only four landfills would have to alter existing practices.

5.4.1 Costs to landfill operators

On the basis of this report we estimate that 19 of New Zealand's 116 currently operating landfills exceed the 1 million tonne threshold. Appendix 1 shows a list of landfills over the threshold and gives more detail on each landfill. Of these:

- three will be closed within the next three years, and therefore under the proposed transitional period would not be required to install a gas collection system
- seven currently collect and destroy landfill gas
- two are planning to install systems but have not yet placed enough waste to generate adequate gas volumes
- three sites are designing systems
- two sites have systems installed that are currently not operating
- one landfill site may be required to design and construct a landfill gas and destruction system, or apply for dispensation through demonstrating that the site contains less than 5% biodegradable and putrescible matter,¹⁰ as a result of the standard.

To sum up, 75% of current landfills in New Zealand with a capacity of over 1 million tonnes (and which are not going to close in the next three years) already collect and flare landfill gas, or are planning to do so in the near future.

¹⁰ This means that landfills which significantly divert organic matter from the site (down to less than x% organic matter) will not be required to collect and flare their gas as the amount produced would not be large enough to collect.

There will also be costs associated with the monitoring, reporting and enforcement of the standard. The costs of monitoring surface methane emissions will fall on operators, who then have to report back to their regional council. The cost of purchasing a surface methane monitor is \$10,000 per landfill site and it is assumed that this will be purchased for all sites. This is a conservative estimate as sites may already own the equipment, or contracting in periodic monitoring may be a less expensive option.

The costs of the standard will be kept relatively low due to only four landfills having to change their practices because of the standard. The costs associated with these four landfills are now detailed.

Landfill 1

This landfill is planning to avoid collecting and flaring its gas by diverting its organic waste and applying for dispensation through containing less than 5% organic matter. It is planning on banning organic waste from landfills and setting up a fortnightly organic waste collection so that all of the district's organic waste can be converted to compost.

There will be two different kinds of costs associated with establishing this kind of system: set-up costs and per annum operational costs. The set-up costs are the costs of installing the equipment to be used to convert organic waste into compost, and setting up a workable system. These costs are believed to be between \$1,000,000 and \$3,000,000. It is also estimated that there will be a per annum operational cost of around \$700,000. However, following discussion with the operators of this landfill, the decision to undertake this has already been made and the proposed standard was not a key driver. This is, therefore, a sunk cost and will not be considered further in the analysis.

Landfill 2

One of the landfills that would have incurred cost under the standard has recently received carbon credits under the recent Climate Change Office projects round. Any compliance costs the landfill faces will be off-set by the revenue raised from the sale of carbon credits, and so these costs are not considered further in this analysis.

Two other landfills are affected by the standard. These landfills will need to restart their gas collection systems, which are currently not in operation.

Landfill 3

Landfill 3 has an out-of-date, inefficient system that needs to be removed and a new (more efficient) system installed. This particular landfill is considering two options:

- design and install a new gas collection and destruction system at a cost of \$1,000,000, or
- design and install a system to collect landfill gas and generate electricity, estimated at \$2,000,000.

In the case of the proposed standard, there is no specific requirement to generate electricity, so the lower figure will be used in the analysis. The operational costs to the landfill for collection and destruction would be around \$50,000 per annum.

Landfill 4

Landfill 4 previously had a collection system that harnessed gas to generate electricity. However, this use has since been deemed economically unviable at the site. The landfill will, therefore, need to install a flare as the previous system did not destroy gas. The cost of this will be around \$10,000.

This landfill will also have high operational costs as the current filling practices are not conducive to efficient gas collection. There will, therefore, be an additional per annum operational cost of around \$50,000.

New landfills

It is considered best practice for large landfills to have gas collection systems. This means that it is unlikely that there will be additional costs for new landfills, as gas collection is more than likely to already be proposed.

5.4.2 Costs to regional councils

Regional councils will incur initial costs assessing which landfills in their region are required to comply with the proposed standard. Regional councils will incur further costs reviewing surface methane emission monitoring data. It has been estimated that this will result in costs of approximately \$525 per landfill.¹¹ Regional councils may have policies that will result in these costs being charged back to the landfill consent holder.

5.4.3 Costs to the consumer

Some costs may be passed on to the consumer if operators' costs are high. These costs are likely to be in the form of increased gate charges and/or an increase in rates. However, given that these costs are first incurred by the landfill operator and then passed on to the consumer, they are considered transfer payments and so are excluded from the analysis in order to avoid double counting.

5.4.4 Costs to central government

There will be costs to central government in terms of the administration of the standards, plus any auditing and verification actions that may need to be undertaken. It is not expected that this cost will exceed 0.25 full time equivalent – an estimate of \$35,000 per annum has been used in the analysis.

¹¹ This figure is calculated by estimating that it would take two hours to make an initial assessment, and five hours to assess yearly landfill gas monitoring data, at a cost of \$75 per hour. Personal comment, Glenn Wigley, Ministry for the Environment, 2004.

5.4.5 Summary of total costs

Table 11 provides a summary of total costs.

Table 11: Total costs of proposed national environmental standard for landfill gas collection and destruction over 10-year appraisal period

Area of cost	Total cost (undiscounted)*
Landfill operators	\$2,300,000
Regional councils	\$110,000
Central government	\$350,000
Total costs (in present values)*	\$1,900,000

* Numbers do not sum as the total figure is presented after being discounted.

As can be seen from the table, present value costs (which have been discounted at 10%) are \$1.9 million over the period of the appraisal.

5.5 Options appraisal: measuring efficiency

In order to measure the efficiency of the proposed national environmental standard for landfill gas collection and destruction, the costs are compared with the benefits to provide an overall measure. In addition, it is also possible to use a cost-effectiveness measure in terms of cost per tonne of carbon dioxide equivalent reduced (CO₂e). Both measures have been assessed in order to provide a fuller picture of the impact of the proposed standard.

Bringing together the benefits and costs as set out in the preceding two sections provides the basis to apply the key decision-making criteria:

- net present value (NPV): the benefits minus costs over time (a positive result is deemed to be 'justified')
- benefit-cost ratio (B/C): benefits divided by costs over time (a result greater than one is deemed to be 'justified')
- cost-effectiveness ratio: the cost of achieving per unit reduction (in this case per tonne of carbon dioxide equivalent reduced).

An option is deemed to be efficient in pure cost-benefit terms when its benefits exceed the costs over time (i.e., a positive NPV or a benefit-cost ratio greater than one). Table 12 sets out the key appraisal data to determine whether the proposed national environmental standard is efficient (the full spreadsheets can be found in Appendix 2).

Table 12: Summary of key appraisal data

Benefits (total emissions reduced)	2,765,000 tonnes CO ₂ e
Benefits (in present values)	\$9.2 m to \$46 m
Cost (in present values)	\$1.9 m
Net present value	\$7.3 m to \$44.1 m
Benefit-cost ratio	4.80 to 23.98
Cost-effectiveness (\$ per tonne CO ₂ e reduced)	\$0.69

From the above data it can be concluded that:

- greenhouse gas emissions will be substantially reduced
- quantified benefits in monetary terms are substantial
- the net present value is always above zero, hence ensuring the option is efficient
- the benefit-cost ratio is always above one, thereby ensuring the option is efficient
- the cost-effectiveness ratio shows that the cost for reducing one tonne of CO₂e is very low when compared to the expected market price of CO₂e or the proposed carbon charge (with a maximum charge of \$25 per tonne of CO₂e).

From these results, overall it can be concluded that the proposed national environmental standard for landfill gas collection and destruction is efficient and effective.

5.6 Sensitivity analysis

Although the findings of the efficiency test have shown that the air quality standard is both efficient and cost-effective, we need to test how sensitive the analysis is to the variation of key parameters. This testing process shows how uncertain and reliable the conclusions of the analysis are.

Sensitivity analysis is a process for testing the robustness of an appraisal by varying key parameters within the analysis. This process determines whether the results of the analysis are dependent on any particular variable. A number of sensitivity tests have been run:

- discount rate decreased to 5%
- predicted emissions increased by 25%
- predicted emissions reduced by 25%
- costs increased by 25%
- costs reduced by 25%.

The results from these tests are shown in Table 13.

Table 13: Summary of sensitivity test results

Sensitivity test	Result	Change in decision-making parameters
Discount rate reduced to 5%	Benefits: \$13.2 m to \$66.9 m Costs: \$2.3 m	NPV: \$10.9 m to \$65.9 m B/C: 5.83 to 29.17 C/E: \$0.82
Increase predicted emissions by 25%	Emissions reduced: 3.5 m tonnes Benefits: \$11.5 m to \$57.5 m	NPV: \$9.6 m to \$55.6 m B/C: 6.00 to 29.98 C/E: \$0.56
Reduce predicted emissions by 25%	Emissions reduced: 2.1 m tonnes Benefits: \$6.9 m to \$34.5 m	NPV: \$5.0 m to \$34.5 m B/C: 3.60 to 17.99 C/E: \$0.93
Costs increased by 25%	Costs: \$2.4 m	NPV: 6.8 m to \$43.6 m B/C: 3.84 to 19.18 C/E: \$0.87
Costs reduced by 25%	Costs: \$1.4 m	NPV: \$7.8 m to \$44.6 m B/C: 6.39 to 31.97 C/E: \$0.52

The results presented in the table indicate that the analysis is slightly sensitive to two key parameters: the level of predicted emissions and costs. However, even in these cases the key decision-making parameters are very positive. In terms of the estimate of emissions, the International Panel on Climate Change guidelines have been followed, along with advice from the New Zealand Climate Change Office. These estimates, therefore, are believed to be robust and defensible.

The key consistent measure throughout the sensitivity testing is the cost-effectiveness measure showing the cost per tonne of CO₂e reduced. For all tests this is below \$1. This value is very low when compared to the expected market price of carbon dioxide equivalent. In this respect, in the main analysis and with the sensitivity testing the proposed national environmental standard is extremely cost-effective.

It can be concluded, therefore, that the sensitivity tests show that the analysis is robust and defensible. The proposed national environmental standard is efficient and extremely cost-effective.

6 Summary of Findings

Section 32 of the Resource Management Act requires that before a regulation is made, an evaluation is to be undertaken of the proposals' appropriateness, effectiveness and efficiency. This report has undertaken this process for the proposed national environmental standard for landfill gas collection and destruction. The report shows that, from a list of potential options, the national environmental standard is the most appropriate option.

The proposed national environmental standard option has been shown to be efficient, with a net present value between \$9.2 million to \$46 million and a benefit-cost ratio of between 4.80 and 23.98.

The proposed national environmental standard has also been shown to be extremely effective, reducing greenhouse gas emissions by 2.77 million tonnes CO₂e over the appraisal period. This equates to \$0.69 per tonne of CO₂e reduced.

Sensitivity analysis has been undertaken and confirmed that the analysis is robust and defensible. The methods recommended by the International Panel on Climate Change have been used to estimate greenhouse gas emissions, so uncertainty has been minimised in this respect.

It is the finding, therefore, of this section 32 report that the proposals for a national environmental standard for landfill gas collection and destruction are appropriate, effective and efficient.

References

Centre for Advanced Engineering. 2000. *Landfill Guidelines*. Centre for Advanced Engineering, Christchurch, New Zealand.

IPCC. 2001. *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. IPCC, Geneva, Switzerland.

Ministry for the Environment. 2000. *What Are the Options? A guide to using Section 32 of the Resource Management Act*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment. 2003. *The 2002 Landfill Review and Audit*. Ministry for the Environment, Wellington, New Zealand.

Appendix 1: Landfill Base Data

Landfill	Region	2001	2016	Gas collection?	Situation
		<i>2002 Landfill Review and Audit</i>	<i>1.5% annual growth</i>		
Redvale	ARC	400,000	490,000	Yes	Electrical
Burwood	ECan	238,000	291,550	No	Designing
Greenmont	ARC	210,000	257,250	Yes	Electrical
Whitford	ARC	200,000	245,000	Yes	Electrical
Silverstream	GW	119,043	145,828	Yes	Electrical
Horotiu	EW	100,000	122,500	Yes	Electrical
Spicers	GW	91,000	111,475	No	Switched off
Carey's Gully	GW	90,000	110,250	Yes	Flare
Omarunui	HBRC	90,000	110,250	No	Designing
Rotorua	EBoP	90,000	110,250	No	
Northern	GW	75,000	91,875	No	Closing
Bonny Glen	Horizons	70,000	85,750	No	Planned
Tirohia	EW	70,000	85,750	No	Planned
Awapuni	Horizons	56,000	68,600	No	Designing
York Valley	NCC	52,794	64,673	Yes	Flare
Green Island	ORC	48,000	58,800	No	Switched off
Pohe Island	NRC	45,000	55,125	No	Closing
Redruth	ECan	41,981	51,427	No	Closing
Invercargill	ES	40,000	49,000	No	Closing

Key:

ARC	Auckland Regional Council
ECan	Environment Canterbury
GW	Greater Wellington
EW	Environment Waikato
HBRC	Hawke's Bay Regional Council
EBoP	Environment Bay of Plenty
Horizons	Manawatu-Wanganui Regional Council
NCC	Nelson City Council
ORC	Otago Regional Council
NRC	Northland Regional Council
ES	Environment Southland

Appendix 2: Emissions, Benefit and Cost Model Spreadsheets

Option: Status Quo Year 2001

Landfill	Region	MSW per annum (Gg)	MCF	Lo	Methane before collection (Gg)	Methane after collection (Gg)	Gas collection?	Net annual methane (Gg)
Redvale	ARC	400	0.964	0.049193	19.68	12.79	Yes	11.51
Burwood	ECan	238	0.964	0.049193	11.71	11.71	No	10.54
Greenmont	ARC	210	0.964	0.049193	10.33	6.71	Yes	6.04
Whitford	ARC	200	0.964	0.049193	9.84	6.40	Yes	5.76
Silverstream	GW	119	0.964	0.049193	5.86	3.81	Yes	3.43
Horotiu	EW	100	0.964	0.049193	4.92	3.20	Yes	2.88
Spicers	GW	91	0.964	0.049193	4.48	4.48	No	4.03
Carey's Gully	GW	90	0.964	0.049193	4.43	2.88	Yes	2.59
Omarunui	HBRC	90	0.964	0.049193	4.43	4.43	No	3.98
Rotorua	EBoP	90	0.964	0.049193	4.43	4.43	No	3.98
Northern	GW	75	0.964	0.049193	3.69	3.69	No	3.32
Bonny Glen	Horizons	70	0.964	0.049193	3.44	3.44	No	3.10
Tirohia	EW	70	0.964	0.049193	3.44	3.44	No	3.10
Awapuni	Horizons	56	0.964	0.049193	2.75	2.75	No	2.48
York Valley	NCC	53	0.964	0.049193	2.60	1.69	Yes	1.52
Green Island	ORC	48	0.964	0.049193	2.36	2.36	No	2.13
Pohe Island	NRC	45	0.964	0.049193	2.21	2.21	No	1.99
Redruth	ECan	42	0.964	0.049193	2.07	2.07	No	1.86
Invercargill	ES	40	0.964	0.049193	1.97	1.97	No	1.77
Total methane year 2001 (tonnes)		76,003						

Key (as prescribed by IPCC Good Practice Guidelines):

MSW Municipal Solid Waste

Gg Gigagram

MCF Methane Correction Factor

Lo Methane Generation Potential

Option: Status Quo Year 2016

Landfill	Region	MSW per annum (Gg)	MCF	Lo	Methane before collection (Gg)	Methane after collection (Gg)	Gas collection?	Net annual methane (Gg)
Redvale	ARC	490	1	0.0510	25.00	16.25	Yes	14.63
Burwood	ECan	292	1	0.0510	14.88	14.88	No	13.39
Greenmont	ARC	257	1	0.0510	13.13	8.53	Yes	7.68
Whitford	ARC	245	1	0.0510	12.50	8.13	Yes	7.31
Silverstream	GW	146	1	0.0510	7.44	4.84	Yes	4.35
Horotiu	EW	123	1	0.0510	6.25	4.06	Yes	3.66
Spicers	GW	111	1	0.0510	5.69	5.69	No	5.12
Carey's Gully	GW	110	1	0.0510	5.63	3.66	Yes	3.29
Omarunui	HBRC	110	1	0.0510	5.63	5.63	No	5.06
Rotorua	EBoP	110	1	0.0510	5.63	5.63	No	5.06
Northern	GW	92	1	0.0510	4.69	4.69	No	4.22
Bonny Glen	Horizons	86	1	0.0510	4.38	4.38	No	3.94
Tirohia	EW	86	1	0.0510	4.38	4.38	No	3.94
Awapuni	Horizons	69	1	0.0510	3.50	3.50	No	3.15
York Valley	NCC	65	1	0.0510	3.30	2.15	Yes	1.93
Green Island	ORC	59	1	0.0510	3.00	3.00	No	2.70
Pohe Island	NRC	55	1	0.0510	2.81	2.81	No	2.53
Redruth	ECan	51	1	0.0510	2.62	2.62	No	2.36
Invercargill	ES	49	1	0.0510	2.50	2.50	No	2.25
Total methane year 2016 (tonnes)		96,581						

Option: NES Year 2001

Landfill	Region	MSW per annum (Gg)	MCF	Lo	Methane before collection (Gg)	Methane after collection (Gg)	Gas collection?	Net annual methane (Gg)
Redvale	ARC	400	0.964	0.049	19.68	12.79	Yes	11.51
Burwood	ECan	238	0.964	0.049	11.71	11.71	No	10.54
Greenmont	ARC	210	0.964	0.049	10.33	6.71	Yes	6.04
Whitford	ARC	200	0.964	0.049	9.84	6.40	Yes	5.76
Silverstream	GW	119	0.964	0.049	5.86	3.81	Yes	3.43
Horotiu	EW	100	0.964	0.049	4.92	3.20	Yes	2.88
Spicers	GW	91	0.964	0.049	4.48	4.48	No	4.03
Carey's Gully	GW	90	0.964	0.049	4.43	2.88	Yes	2.59
Omarunui	HBRC	90	0.964	0.049	4.43	4.43	No	3.98
Rotorua	EBoP	90	0.964	0.049	4.43	4.43	No	3.98
Northern	GW	75	0.964	0.049	3.69	3.69	No	3.32
Bonny Glen	Horizons	70	0.964	0.049	3.44	3.44	No	3.10
Tirohia	EW	70	0.964	0.049	3.44	3.44	No	3.10
Awapuni	Horizons	56	0.964	0.049	2.75	2.75	No	2.48
York Valley	NCC	53	0.964	0.049	2.60	1.69	Yes	1.52
Green Island	ORC	48	0.964	0.049	2.36	2.36	No	2.13
Pohe Island	NRC	45	0.964	0.049	2.21	2.21	No	1.99
Redruth	ECan	42	0.964	0.049	2.07	2.07	No	1.86
Invercargill	ES	40	0.964	0.049	1.97	1.97	No	1.77
Total methane year 2001 (tonnes)		76,003						

Option: Status Quo Year 2016

Landfill	Region	MSW per annum (Gg)	MCF	Lo	Methane before collection (Gg)	Methane after collection (Gg)	Gas collection?	Net annual methane (Gg)
Redvale	ARC	490	1	0.0510	25.00	16.25	Yes	14.63
Burwood	ECan	292	1	0.0510	14.88	9.67	No	8.70
Greenmont	ARC	257	1	0.0510	13.13	8.53	Yes	7.68
Whitford	ARC	245	1	0.0510	12.50	8.13	Yes	7.31
Silverstream	GW	146	1	0.0510	7.44	4.84	Yes	4.35
Horotiu	EW	123	1	0.0510	6.25	4.06	Yes	3.66
Spicers	GW	111	1	0.0510	5.69	3.70	No	3.33
Carey's Gully	GW	110	1	0.0510	5.63	3.66	Yes	3.29
Omarunui	HBRC	110	1	0.0510	5.63	3.66	No	3.29
Rotorua	EBoP	110	1	0.0510	5.63	3.66	No	3.29
Northern	GW	92	1	0.0510	4.69	3.05	No	2.74
Bonny Glen	Horizons	86	1	0.0510	4.38	2.84	No	2.56
Tirohia	EW	86	1	0.0510	4.38	2.84	No	2.56
Awapuni	Horizons	69	1	0.0510	3.50	2.28	No	2.05
York Valley	NCC	65	1	0.0510	3.30	2.15	Yes	1.93
Green Island	ORC	59	1	0.0510	3.00	1.95	No	1.76
Pohe Island	NRC	55	1	0.0510	2.81	1.83	No	1.65
Redruth	ECan	51	1	0.0510	2.62	1.71	No	1.54
Invercargill	ES	49	1	0.0510	2.50	1.63	No	1.46
Total methane year 2016 (tonnes)		77,776						

Summary of benefits

	Year																Total
	-3 2001	-2 2002	-1 2003	0 2004	1 2005	2 2006	3 2007	4 2008	5 2009	6 2010	7 2011	8 2012	9 2013	10 2014	11 2015	12 2016	
Methane emissions (status quo)	76,003	77,375	78,747	80,119	81,491	82,863	84,235	85,606	86,978	88,350	89,722	91,094	92,466	93,837	95,209	96,581	1,380,676
Methane emissions (NES)	76,003	76,122	76,240	76,358	76,476	76,594	76,713	76,831	76,949	77,067	77,185	77,304	77,422	77,540	77,658	77,776	1,230,239
CO2e (status quo)	1,596,072	1,624,881	1,653,690	1,682,498	1,711,307	1,740,116	1,768,925	1,797,733	1,826,542	1,855,351	1,884,160	1,912,969	1,941,777	1,970,586	1,999,395	2,028,204	28,994,206
CO2e (NES)	1,596,072	1,598,554	1,601,036	1,603,519	1,606,001	1,608,483	1,610,965	1,613,447	1,615,929	1,618,412	1,620,894	1,623,376	1,625,858	1,628,340	1,630,822	1,633,304	25,835,012
Benefit of NES (tonnes CO2e)	0	0	0	0	0	0	157,960	184,286	210,613	236,940	263,266	289,593	315,919	342,246	368,573	394,899	2,764,294
Benefit per tonne CO2e (upper)	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38	\$35.38
Benefit per tonne CO2e (lower)	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08	\$7.08
Discount factor	1.3310	1.2100	1.1000	1.0000	0.9091	0.8264	0.7513	0.6830	0.6209	0.5645	0.5132	0.4665	0.4241	0.3855	0.3505	0.3186	
PV benefits (upper)	0	0	0	0	0	0	\$4,198,214	\$4,452,652	\$4,626,132	\$4,731,271	\$4,779,062	\$4,779,062	\$4,739,565	\$4,667,754	\$4,569,829	\$4,451,132	\$45,994,672
PV benefits (lower)	0	0	0	0	0	0	\$839,643	\$890,530	\$925,226	\$946,254	\$955,812	\$955,812	\$947,913	\$933,551	\$913,966	\$890,226	\$9,198,934
	Extrapolation period			Transition period			Appraisal period										

Discount rate
10%

"Value" of emissions	International markets for CO2
Upper value \$35.38 per tonne CO2e	\$25 US Exchange rate 1.415 as at 17 February 2004
Lower value \$7.08 per tonne CO2e	\$5 US rate US to NZ Source: www.xe.com

Source: www.co2e.com

Total PV benefits (upper)	\$45,994,672
Total PV benefit (lower)	\$9,198,934

Summary of costs

Area of cost	Year												Total	
	0 2004	1 2005	2 2006	3 2007	4 2008	5 2009	6 2010	7 2011	8 2012	9 2013	10 2014	11 2015		12 2016
Landfill operators														
Design and installation of collection system		\$1,010,000												\$1,010,000
Operation of collection system			\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$1,100,000
Installation of alternative system														\$0
Operation of alternative system														\$0
Monitoring methane emissions														\$190,000
													Total	\$2,300,000
Regional councils														
Assessing, collating and recording monitoring data			\$9,975	\$9,975	\$9,975	\$9,975	\$9,975	\$9,975	\$9,975	\$9,975	\$9,975	\$9,975	\$9,975	\$109,725
Central government														
Administration				\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$100,000
Auditing and verification				\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$250,000
Total	\$0	\$1,200,000	\$109,975	\$144,975	\$144,975	\$144,975	\$144,975	\$144,975	\$144,975	\$144,975	\$144,975	\$144,975	\$144,975	\$2,759,725
Discount factor	1.0000	0.9091	0.8264	0.7513	0.6830	0.6209	0.5645	0.5132	0.4665	0.4241	0.3855	0.3505	0.3186	
Total (present values)	\$0	\$1,090,909	\$90,888	\$108,922	\$99,020	\$90,018	\$81,835	\$74,395	\$67,632	\$61,484	\$55,894	\$50,813	\$46,194	\$1,918,003

Discount rate	10%
---------------	-----

Total PV costs **\$1,918,003**

Summary of analysis

Date year	Analysis year	Emissions (tonnes of CO2e)		
		CO2e (status quo)	CO2e (NES)	Benefits of NES
2004	0	1,682,498	1,603,519	Transition period
2005	1	1,711,307	1,606,001	
2006	2	1,740,116	1,608,483	
2007	3	1,768,925	1,610,965	157,960
2008	4	1,797,733	1,613,447	184,286
2009	5	1,826,542	1,615,929	210,613
2010	6	1,855,351	1,618,412	236,940
2011	7	1,884,160	1,620,894	263,266
2012	8	1,912,969	1,623,376	289,593
2013	9	1,941,777	1,625,858	315,919
2014	10	1,970,586	1,628,340	342,246
2015	11	1,999,395	1,630,822	368,573
2016	12	2,028,204	1,633,304	394,899
			Total	2,764,294

Date year	Analysis year	PV benefits (upper)	PV benefits (lower)
2004	0	Transition period	Transition period
2005	1		
2006	2		
2007	3	\$4,198,214	\$839,643
2008	4	\$4,452,652	\$890,530
2009	5	\$4,626,132	\$925,226
2010	6	\$4,731,271	\$946,254
2011	7	\$4,779,062	\$955,812
2012	8	\$4,779,062	\$955,812
2013	9	\$4,739,565	\$947,913
2014	10	\$4,667,754	\$933,551
2015	11	\$4,569,829	\$913,966
2016	12	\$4,451,132	\$890,226
Totals		\$45,994,672	\$9,198,934

Rounded to three significant figures

Date year	Analysis year	Emissions (tonnes of CO2e)		
		CO2e (status quo)	CO2e (NES)	Benefits of NES
2004	0	1,680,000	1,600,000	Transition period
2005	1	1,710,000	1,610,000	
2006	2	1,740,000	1,610,000	
2007	3	1,770,000	1,610,000	158,000
2008	4	1,800,000	1,610,000	184,000
2009	5	1,830,000	1,620,000	211,000
2010	6	1,860,000	1,620,000	237,000
2011	7	1,880,000	1,620,000	263,000
2012	8	1,910,000	1,620,000	290,000
2013	9	1,940,000	1,630,000	316,000
2014	10	1,970,000	1,630,000	342,000
2015	11	2,000,000	1,630,000	369,000
2016	12	2,030,000	1,630,000	395,000
			Total	2,765,000

Date year	Analysis year	PV benefits (upper)	PV benefits (lower)
2004	0	Transition period	Transition period
2005	1		
2006	2		
2007	3	\$4,200,000	\$840,000
2008	4	\$4,450,000	\$891,000
2009	5	\$4,630,000	\$925,000
2010	6	\$4,730,000	\$946,000
2011	7	\$4,780,000	\$956,000
2012	8	\$4,780,000	\$956,000
2013	9	\$4,740,000	\$948,000
2014	10	\$4,670,000	\$934,000
2015	11	\$4,570,000	\$914,000
2016	12	\$4,450,000	\$890,000
Totals		\$46,000,000	\$9,200,000

CBA/CEA calculations

Benefits (total emissions reduced – tonnes CO2e)	2,764,294	
Benefits (in present values)	\$9,198,934	\$45,994,672
Cost (in present values)	\$1,918,003	
Net present value	\$7,280,931	\$44,076,669
Benefit–cost ratio	4.80	23.98
Cost-effectiveness (cost per tonne CO2e reduced)	\$0.69	