FINAL REPORT

Waste Acceptance Criteria for Class A Landfills

Prepared for

Ministry for the Environment

5 September 2003

49324 021 R004-H

URS

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Date: 5 September 2003
Reference: 49324 021 R001-H
Status: Final Report

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Introduction

The Ministry for the Environment has been developing landfill waste acceptance criteria for landfills based on the Toxicity Characteristic Leaching Procedure (TCLP) approach developed by the USEPA. This report builds on earlier work considering an approach to landfill classification (Basis for a Landfill Classification System, URS New Zealand Limited, 2001). This report:

- recommends a preferred approach for determining thresholds for constituents additional to those on the standard USEPA TCLP list;
- recommends extra waste constituents and leachability limits for addition to the standard USEPA TCLP list,
- recommends an approach to the use of total concentration limits;
- recommends a test method suitable for defining liquid waste in respect of landfill disposal;
- recommends wastes that should be prohibited from landfills;

Approaches to Determining Threshold Concentrations

Based on approaches adopted in New Zealand and internationally for developing leachable and/or total concentration limits it was recommended that threshold concentrations be derived for the additional constituents to be included in the TCLP list for “Class A” landfills using a risk based approach, with a generic landfill (Class A) and constituent specific dilution and attenuation factors. Draft leachability limits are recommended based on modelling using a contaminant fate and transport model incorporating the following assumptions:

- “Class A” siting requirements (conservative);
- “Class A design” requirements (conservative);
- a landfill cell with a plan diameter of 100 metres;
- a compliance point for surface water and groundwater contamination 100 metres downgradient of the landfill edge;
- use of surface water (aquatic criteria) guidelines and New Zealand Standards for Drinking Water (2000), whichever is the most conservative.

Where the leachate to groundwater is not the limiting pathway, alternative exposure pathways were considered including volatile constituent emissions, landfill gas, dust, and dermal exposure to constituents. Modelling indicated that volatilisation in air, landfill gas, dust or dermal exposure pathway were not limiting for the constituents considered.

Draft totals concentration limits are proposed for selected constituents with low solubility using the concentration at which the liquid becomes separate phase in leachate. Acceptance criteria below this concentration should ensure that the constituent remains either bound up in the refuse mass or dissolved in leachate and is not present as a non-aqueous phase liquid (NAPL).

Liquid Waste

The prohibition of bulk liquid wastes requires an appropriate definition and practical test to enable clear, consistent and unequivocal determination of whether or not a waste is suitable for disposal. Based on consideration of a number of approaches to the definition of liquid waste, it is recommended that for waste to be considered non-liquid it must meet the following requirements:

1. a solids content of at least 20 percent and liberate no free liquids when transported;
   or
2. no free liquids when tested in accordance with the USEPA Paint Filter Liquids Test— Method 9095 (US EPA 1986) and liberate no free liquids when transported.

Prohibited Wastes

It is recommended that the following wastes be prohibited from landfill disposal:

- bulk liquids;
- lead acid batteries;
- radioactive wastes;
- used oil;
- explosive substances;
- flammable substances;
- oxidising substances; and
- corrosive substances.

Screening Tools

It is recommended that a total limit, set at 20 time the leachability limit, be used as a screening test to determine the requirement for leachability testing in respect of those constituents for which leachability limits have been proposed. The New Zealand Waste List is also a useful tool for identifying potentially hazardous wastes.

Related Issues

A number of issues related to the development of leachability limits as threshold concentrations for LWAC are also discussed, including:

- leachate treatment;
- handling requirements;
- risk based approach; and
- special waste streams.

1.1 Background

In April 2001 the Ministry for the Environment released an issues and options report entitled “Landfill Acceptance Criteria for Wastes with Hazardous Properties”. The report notes that a nationally consistent approach to waste acceptance criteria is required. The report recommends that this could be achieved through the development of a landfill classification system used in combination with prescriptive lists defining concentration thresholds (leachable concentrations, or total concentrations in combination with leachable concentrations) that are acceptable for disposal of waste constituents in different classes of landfill.

The Ministry considers that the standard USEPA Toxicity Characteristic Leaching Procedure (TCLP 1311) test, whilst having limitations, is the most suitable test method available to determine whether wastes are suitable for landfill disposal. It is widely used and understood and is effective in establishing a level of management control. The time and costs involved in developing an alternative test method are likely to be high and unlikely to outweigh any perceived benefits.

The Ministry also considers that concentration limits are needed for a greater range of constituents than those currently specified in the USEPA TCLP list, that is, compounds that present risks via exposure routes in addition to the human drinking water exposure route.

1.2 Purpose of this Project

The purpose of this project is to:

- recommend extra waste constituents for addition to the standard USEPA TCLP list, taking into account potential emissions to both water and air;
- discuss the advantages and disadvantages of the various approaches that could be undertaken to develop threshold concentrations for additional constituents, particularly taking into account the siting of New Zealand landfills;
- recommend a preferred approach for determining thresholds for constituents additional to those on the standard USEPA TCLP list;
- recommend additional constituents for the development of leachability limits;
- develop leachability limits for the additional constituents recommended;
- discuss the potential role of using total concentration limits in combination with leachable concentrations;
- develop total concentration limits, where appropriate;
- recommend an approach for the consideration of mass loadings.

- recommend a test method suitable for defining liquid waste in respect of landfill disposal;
- recommend wastes that should be prohibited from landfills;
- discuss the suitability of using the New Zealand Waste List for Class B landfills;
- discuss the use of risk based approaches for some types of hazardous wastes;
- develop a list of special waste streams and discuss specific acceptance criteria for these wastes.

1.3 Assumptions

The following assumptions have been made in respect of this project:

- the existing standard USEPA TCLP list and leachability limits will be used unchanged for “Class A” landfills;
- any leachable, or total, concentration limits developed as part of the project refer only to “Class A” municipal solid waste landfills. Landfills that do not comply with “Class A” requirements are likely to require more stringent limits. (“Class A” landfills are described by the Ministry, in its issues and options document “Landfill Acceptance Criteria for Wastes with Hazardous Properties”, as being those landfills that are sited, designed and operated in accordance with the recommendations in the CAE Landfill Guidelines (2000));
- any leachable, or total, concentration limits would be developed for “Class A” landfills as a whole, and not necessarily relate to site specific factors at any particular landfill site;
- any leachable, or total, concentration limits developed need to refer to the most conservative contamination receptor of concern (for example, leachate treatment, human exposure, aquatic environment).

1.4 Scope of this Report

This report summarises, and updates, three earlier project draft reports:

- “Waste Acceptance Criteria For Class A Landfills – Phase 1”, dated 14 June 2002, which:
  - recommended extra constituents for addition to the standard USEPA TCLP list;
  - recommended extra constituents for total concentration limits;
  - discussed various approaches to develop threshold concentrations for the extra constituents; and
  - recommended a preferred approach for determining threshold concentrations;
- “Waste Acceptance Criteria for Class A Landfills - Phase II (Model Set-up)”, dated 22 August 2002, which:

  - described the model landfill set-up and modelling process recommended for determining leachability limits for extra constituents;
  - used the model to derive leachability limits for selected constituents for which a USEPA TCLP limit exist;
  - compared the leachability limits derived, using the model and New Zealand compliance point limits, with the USEPA TCLP limits;
- "Class A Landfill Waste Acceptance Criteria Draft Leachability Limits", dated 21 November 2002, which presented draft leachability limits (developed using the model in the previous report) for consultation with the waste management industry.

This report presents constituents recommended for addition to landfill waste acceptance criteria and proposes leachability limits for those recommended constituents for which the leachate/groundwater/surface water pathway is likely to be the most restrictive pathway in respect of potential adverse effects on the environment..

In addition it addresses the potential for the air pathway to be the most restrictive pathway in respect of potential adverse effects on the environment.

For some constituents, neither the leachate/groundwater/surface water pathway or the air pathway are restrictive, in which cases total limits are proposed, based on the concentration at which the constituent is likely to become separate phase in leachate.

This report also discusses issues associated with:

- mass loadings;
- defining liquid waste;
- recommended prohibited wastes;
- use of total concentrations as a screening tool;
- use of the New Zealand Waste List for Class B landfills;
- leachate treatment;
- handling requirements;
- risk based approaches for some types of hazardous wastes;
- a list of special waste streams.

This report was developed in a number of stages. Later sections of the report were developed to address the results of, and issues arising from, work undertaken in preparing earlier sections.

2.1 Introduction

A number of approaches have been used, or proposed, by selected jurisdictions to develop leachable and/or total concentration limits for landfill waste acceptance criteria (LWAC). Approaches used, or proposed, by the following are discussed:

- United States Environmental Protection Agency (USEPA);
- New South Wales Environmental Protection Agency (NSWEPA);
- Western Australia Environmental Protection Agency (WAEPA);
- South African Department of Water Affairs and Forestry;
- Health and Environmental Guidelines for Selected Timber Treatment Chemicals;
- selected large private landfills in New Zealand;
- selected large municipal landfills in New Zealand;
- risk assessment.

The New Zealand Standard Model Trade Waste Bylaw (NZS9201), the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australia and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000)[1] and the Drinking Water Standards for New Zealand 2000[2], which set guideline limits for their respective receiving environments are described.

Brief descriptions of the relevant components of the Hazardous Substances and New Organisms Act and the New Zealand Waste List are also included.

The different approaches to developing LWAC are then ranked and an approach for determining leachability limits as LWAC for additional constituents in New Zealand is recommended.

2.2 Approaches to Determining Threshold Concentrations

2.2.1 United States Environmental Protection Agency (USEPA)

The USEPA developed a testing procedure, the toxicity characteristic leaching procedure (TCLP), designed to identify wastes likely to leach hazardous concentrations of particular toxic constituents into the groundwater under conditions of improper management. Under this procedure constituents are

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[1] Commonly referred to as the ANZECC Guidelines for Fresh and Marine Water Quality, 2000.

[2] Commonly referred to as the NZ Drinking Water Guidelines, 2000.

extracted from the waste in a manner designed to simulate leaching in landfills (using acetic acid with a pH of 5.0 over 24 hours). The extract is then analysed to determine whether it possesses toxic constituents identified in the National Interim Primary Drinking Water Standards (NIPDWS). A dilution and attenuation factor (DAF) of 100, in respect of the NIPDWS, is used to determine if the waste is hazardous. That is, if the extract contains any of the listed constituents in concentrations 100 times greater than that specified in the NIPDWS, the waste is considered hazardous.

The list of constituents and regulatory levels for the Toxicity Characteristic is given in Table 2-1 below.

Table 2-1 Toxicity Characteristic Constituents and Regulatory Levels

Constituent Examples	Maximum Concentration (mg per litre)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon Tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0*
m -Cresol	200.0*
p-Cresol	200.0*
2,4-Dichlorophenoxyacetic acid	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor	0.008
Hexachlorobenzene	0.13
Hexachloro–1,3-butadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.7
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-Trichlorophenoxypropionic acid	1.0
Vinyl chloride	0.2

The advantages and disadvantages of the USEPA approach are outlined in Table 2-2.

Table 2-2 Advantages and Disadvantages of USEPA TCLP Approach

Advantages	Disadvantages
Well-documented and transparent approach, using drinking water standards multiplied by a dilution and attenuation factor (DAF).	Considers only drinking water supplies as the receiving environment and is restricted to constituents in the US Primary Drinking Water Standard.
Technically defensible with respect to organic constituents, as DAF determined for organic constituents after use of a subsurface contaminant fate and transport model.	Compounds that degrade readily are not considered.
Uses a well-documented standard test to determine leachability.	
Easy and inexpensive to develop limits using existing DAF.	Would likely require additional modelling to justify DAF if new constituents added.
Currently used as the basis for landfill WAC at most major landfill sites in New Zealand.	DAF may be overly conservative for some containment systems and subsurface environments

2.2.2 New South Wales Environmental Protection Agency (NSWEPA)

The NSWEPA uses the USEPA TCLP test, to estimate the potential for the waste to release chemical constituents into a leaching liquid. This property is termed the leachable concentration. NSW set different maximum levels for the leachable concentration of each constituent, in order to classify waste as inert (<TCLP1), solid (<TCLP2) and industrial (<TCLP3). If the level exceeds TCLP 3 the waste is classified as hazardous.

A second test is also used to complete the waste assessment. This is the Specific Contaminant Concentration (SCC) test, which determines the total concentration of each contaminant in the waste sample. NSW sets different maximum levels for the total concentration of each contaminant in order for waste to be classified as inert (<SCC1), solid (<SCC2) and industrial (<SCC3). If the level exceeds SCC3 the waste is classified as hazardous.

NSW use SCC limits as a precaution against a scenario where, in the presence of a high concentration of a contaminant, the TCLP test gives a low result because of interference by certain other non-permanent factors in the waste, such as high alkalinity. There is a potential for these non-permanent factors to change with time, resulting in a much greater release rate for such contaminants.

A contaminant threshold (CT) value, for total constituent concentration, is also used to determine whether, or not, a TCLP test is required for a specific waste. TCLP values are simply multiplied by 20, because for every gram of waste subjected to extraction in the TCLP test, 20 millilitres of leachant solution is used. This means that if 20mg/kg of a contaminant is present in the waste and is completely leached out in the test, the TCLP test result will be 1mg/L.

Under the NSW approach both the TCLP and the SCC criteria must be satisfied before a waste can be classified as inert, solid or industrial, unless the immobilisation of each contaminant exceeding the total concentration limit (SCC1, SCC2, SCC3) is approved by the NSW EPA.

The NSW EPA has adopted the USEPA TCLP Regulatory Levels for leachable concentration for Solid Waste Landfills, Class I and Class II. In addition it has developed leachable and/or total concentration levels for a number constituents not covered in the USEPA list.

The methodology employed by the NSW EPA for the development of leachable and total concentration levels not covered in the USEPA list was not available to URS New Zealand at the time of report preparation.

The advantages and disadvantages of the NSWEPA approach are outlined in Table 2-3.

Table 2-3 Advantages and Disadvantages of NSWEPA Approach

Advantages	Disadvantages
Based on USEPA TCLP limits.	As for the USEPA approach.
Extra constituents have been added that are relevant to the NSW environment and waste stream, which has similarities to the New Zealand situation.	Methodology (used to develop some of the limits) not transparent or necessarily technically robust.
Already established and being implemented by the NSWEPA.	
Uses total concentration limits to account for potential changes in mobilisation of constituents in waste.	Method for determining total limits is not transparent.
Inexpensive. Uses existing information collected by others.	

2.2.3 Western Australia Environmental Protection Agency (WAEPA)

The WAEPA approach is similar to that used by the NSWEPA. Classification systems have been developed for both wastes and landfills.

Two measures are used to indicate the potential toxicity hazard presented by a waste. These measures are:

- the concentration of contaminants in the waste (CT and CL); and
- the leachability of the contaminants (ASLP) in the landfill environment.

The concentrations of contaminant are measured against both contaminant threshold (CT) and concentration limit (CL).

Contaminant threshold criteria are used to assess the acceptability of wastes within a particular landfill class without the need for testing leachability. Four levels of contaminant threshold have been set (CT1-CT4) to correspond with different landfill classes.

If the contaminant threshold is exceeded (the relevant CT level), wastes must then undergo leachability testing and are assessed against the relevant leachability and contaminant limit criteria (ASLP and CL values).

Concentration limits (CL) are total concentration limits, used to ensure that wastes containing high contaminant concentrations may exhibit low leachability as a result of non-permanent interferences like high alkalinity.

As with the contaminant threshold limits, four levels of contaminant limit concentrations have been set corresponding to the landfill classes.

If the CL criteria are exceeded, then fixation, or immobilisation, of the wastes can be used to ensure the waste is suitable for disposal.

The contaminant threshold (CT) value is calculated by multiplying the relevant leaching criteria (ASLP criteria) by a factor of 20. This represents an intrinsic property of the leaching procedure, which means that if all of a contaminant leaches from the analysed sample of waste, the maximum leachate concentration will be one twentieth of the concentration of the contaminant in the waste sample (and the relevant leaching criteria value would not be exceeded).

As with the NSWEPA the WAEPA recommends use of the ASLP – the Australian Standard Leachate test (AS 4439.3-1997, 1999), based on the USEPA TCLP test. Four sets of leaching criteria have been developed to correspond to different landfill classes.

Leachability limits for the equivalent landfill class to Class A are set at 100 times the 1996 Australian Drinking Water Guideline.

Criteria have only been developed for common contaminants. This approach was adopted because of the difficulty in reconciling criteria used in different jurisdictions for organic compounds. The WAEPA advise that criteria for those compounds that are not yet developed should be determined on a case-by-case basis as required after studying literature available on environmental and health effects.

The advantages and disadvantages of the WAEPA approach are outlined in Table 2-4.

Table 2-4 Advantages and Disadvantages of WAEPA Approach

Advantages	Disadvantages
Based on the NSWEPA approach, based on the USEPA TCLP limits.	Same as for the NSWEPA approach.
Already established and being implemented by the WAEPA.	
Uses total concentration limits to account for potential changes in mobilisation of constituents in waste.	
Inexpensive. Uses existing information collected by others.	

2.2.4 South African Department of Water Affairs and Forestry

The South African Department of Water Affairs and Forestry approach combines waste type, size of waste stream, level of risk and hazardousness and potential for significant leachate to manage the disposal of waste.

Waste is classified into two main classes, general and hazardous waste, depending on the risk it presents.

General waste includes domestic, commercial, certain industrial wastes and builders rubble. Hazardous waste is defined as a waste that directly or indirectly represents a threat to human health or the environment by introducing one or more of a number of risks, or multiple effects to the extent that it requires special attention and cannot be released into the environment or be added to sewage or be stored in a situation which is either open to air or from which leachate could be generated and released.

Both general and hazardous wastes are permitted to be disposed of to landfill in South Africa. Hazardous wastes are given a hazard rating to determine which landfills they scan be disposed into. There are specific classes of landfill that accept hazardous wastes and most general waste landfills are not permitted to accept hazardous wastes. For the purposes of this report only the general waste landfills will be discussed further.

Landfills in South Africa are classified according to:

- type of waste;
- size of waste stream; and
- potential for leachate generation.

This leads to ten different classes of landfill. Site-specific factors such as the sensitivity of the receiving environment are addressed during site selection, investigation and environmental impact assessment.

The most important aspect is the potential to generate leachate. A distinction is made between landfills that generate significant leachate and those that simply generate sporadic leachate. Under the South

African approach, those that produce significant leachate require a proper leachate management system. To assess the leachate generation the climatic water balance of the site needs is calculated. Hazardous waste can only be disposed of to a hazardous waste landfill. It is given a hazard rating based on its estimated environmental concentration (EEC). The EEC is also used to determine:

- the amount of the constituent in the waste that can be disposed of in a landfill per hectare, per month;
- the total amount of the constituent that can be disposed of in the landfill before the site must be closed for that constituent;
- assess whether, after treatment or tests, the waste can be reclassified to fall into a lower hazard rating, or even be disposed of as a general waste.

The EEC is expressed in parts per billion and is calculated using the following formula:

EEC (ppb) = dose(g/ha/month) x 0.66 (factor derived from the ratio of the substance in a weight of underground body of water).

The hazard rating is determined according to acute mammalian toxicity (LD_{50}) and acute ecotoxicity (LC_{50}). One tenth of the LC_{50} is termed the Acceptable Risk Level. The EEC is compared to the Acceptable Risk Level to indicate whether the aquatic environment will be at risk or not.

The EEC is used to determine the amount of the constituent in the waste that can be disposed of in a landfill per hectare, per month. The EEC must not exceed the acceptable risk level, therefore:

$$\text{dose (g/ha/month)} = (0.1 \times LC_{50})/0.66.$$

The total load capacity is calculated by multiplying the allowed monthly volume per hectare by 100.

The advantages and disadvantages of the South African approach are outlined in Table 2-5.

Table 2-5 Advantages and Disadvantages of South African Approach

Advantages	Disadvantages
Methodology is transparent and available.	The methodology calculates total limits only and does not derive leachability limits, which is the Ministry's preferred approach.
Based on both mammalian toxicity and ecotoxicity	It is unclear as to why the groundwater dilution factor (0.66) is calculated this way.
Easy and inexpensive to develop acceptance limits	New Zealand landfill operators would be required to learn a new system.
Uses total limits, both monthly quantity per hectare and total quantity for the landfill life.	
Already established and being used by the SA Government.	Only used in South Africa.

2.2.5 Health and Environmental Guidelines for Selected Timber Treatment Chemicals

The 1997 Health and Environmental Guidelines for Selected Timber Treatment Chemicals, published by the Ministry for the Environment and Ministry of Health, contains a landfill classification with three broad classes in respect of disposal of timber treatment wastes (copper, chromium, arsenic, pentachlorophenol (PCP)).

Each class has a set of loosely prescriptive criteria in respect of siting, design and operations. Determination as to whether a specific site meets a number of the criteria requires a subjective assessment.

Each landfill class also has the following factors prescribed, for use in conjunction with environmental, agricultural or drinking water criteria to calculate total and leachable concentration acceptance limits for timber treatment and other chemicals at specific sites:

- Assumed Solid Waste Mix Factor, the ratio of other wastes to timber treatment waste (for total concentration limits);
- Assumed Capping Control Factor, the protection afforded by the landfill's capping (for total concentration limits);
- Leachate Mix Factor, which accounts for leachate mixing and dilution (for leachable concentration limits);
- Receiving Water Dilution Factor, which assumes a level of dilution in the receiving water (for leachable concentration limits).

The factors are multiplied together to derive a single number, which is then multiplied by the appropriate receiving environment standard.

The advantages and disadvantages of the approach used in the Health and Environmental Guidelines for Selected Timber Treatment Sites are outlined in Table 2-6.

Table 2-6 Advantages and Disadvantages of the Health and Environmental Guidelines for Selected Timber Treatment Chemicals Approach

Advantages	Disadvantages
Transparent methodology.	Little technical justification for mixing and dilution factors, which allow higher leachable concentration limits than USEPA and related approaches.
Limits are developed for the most sensitive receiving environment.	The methodology must be applied with caution particularly for constituents other than those used in timber treatment.
Easy and inexpensive to develop acceptance limits.	The approach adopted for the landfill acceptance criteria was relevant at the time of publication, but, is likely in need of review.
Already in use at some landfill sites in New Zealand for some constituents.	Only used in New Zealand.

2.2.6 Selected Large Private Landfills in New Zealand

Two large private landfills have used a variety of methods to establish their constituent lists and corresponding concentration limits. The leachability limits are based predominantly on USEPA TCLP limits with other overseas limits (for example the NSWEPA limits) for some compounds. NZS 9201 Model Trade Waste Bylaw and the Auckland Trade Waste Bylaw acceptance limits for wastewater treatment plants have been used to set limits for compounds where leachate treatment is a potentially limiting factor.

In addition to the above private landfills have developed their own limit values through the use of compound and site specific risk assessments.

Both landfills are likely to comply with the Ministry’s envisaged “Class A” landfill requirements.

One of the private landfills uses HSNO characteristics when assessing a constituent that does not already have a USEPA leachability limit. If the constituent is defined as hazardous under the HSNO criteria then a risk assessment is carried out prior to acceptance into the landfill. This assessment includes the ecotoxicity thresholds derived in the HSNO Regulations 2001. If the waste is not defined as hazardous under the HSNO criteria then it may be accepted without undergoing a risk assessment.

The advantages and disadvantages of the approach used by two large private landfills in New Zealand are outlined in Table 2-7.

Table 2-7 Advantages and Disadvantages of Selected Large Private Landfill Approaches

Advantages	Disadvantages
Uses existing limits from other jurisdictions for landfills with a similar degree of environmental protection.	Risk assessment procedures (used to develop some of the limits) not currently available to URS New Zealand
	Not consistent in determination of receiving environment.
Limits are adopted/developed for the specific characteristics of landfills.	Concentration limits not fully tested by an external party. Accuracy and robustness not tested.
Already in place and accepted by landfill users.	
Inexpensive. Uses existing information collected by others.	

2.2.7 Selected Large Municipal Landfills in New Zealand

Two large municipal landfills have used a variety of methods to establish their constituent lists and corresponding concentration limits. Both have used a combination of the USEPA TCLP limits, other overseas limits, the NZS 9201 and have developed their own leachability limit values.

In contrast to the private landfills discussed these landfills are unlikely to comply with the Ministry's envisaged "Class A" landfill requirements. Neither has an engineered liner system.

The limits for one of the municipal landfills are, in most cases, more stringent than the USEPA TCLP limits.

The advantages and disadvantages of the approach used by two large municipal landfills in New Zealand are outlined in Table 2-8.

Table 2-8 Advantages and Disadvantages of Selected Large Municipal Landfill Approaches

Advantages	Disadvantages
Uses existing limits from other jurisdictions for landfills with a similar degree of environmental protection.	Risk assessment procedures (used to develop some of the limits) not currently available to URS New Zealand.
	Not consistent in determination of receiving environment.
Limits are adopted/developed for the specific characteristics of landfills.	Concentration limits not fully tested by an external party. Accuracy and robustness not tested.
Already in place and accepted by landfill users.	
Inexpensive. Uses existing information collected by others.	

2.2.8 Risk Based Approach

For the purposes of this report a risk based approach to determining WAC for Class A landfills would involve a contaminant fate and transport model to determine appropriate dilution and attenuation factors by which standards/guidelines for the protection of receiving environments can be multiplied to arrive at leachability limits for constituents in waste.

A risk based approach to determining WAC could be developed and implemented in either of three ways:

3. development of a methodology based on a generic landfill to derive a single dilution and attenuation factor for all constituents; or
4. development of a methodology based on a generic landfill to derive a different dilution attenuation factor for each specific constituent; or
5. development of a methodology defining the approach to be used in deriving site-specific dilution and attenuation factors for each specific constituent.

Generic Landfill with Single Dilution and Attenuation Factor

A single dilution and attenuation factor would be developed for each receiving environment (for example, drinking water, aquatic ecosystem), using a standard model landfill, conforming to “Class A” siting and design criteria.

This is essentially the USEPA approach used to increase the number of constituents in the TCLP list in the March 1990 final rule, but taking account of receiving environments other than drinking water.

It would need to be inherently conservative to ensure that the receiving environments are protected from the most mobile and toxic constituents, for a generic site at the lower end of the “Class A” range in respect of natural containment characteristics.

The advantages and disadvantages of this risk-based approach are outlined in Table 2-9.

Table 2-9 Advantages and Disadvantages of Generic Landfill with a Single Dilution and Attenuation Factor Approach

Advantages	Disadvantages
Transparent methodology	
Similar to the USEPA approach, but considers additional receiving environments.	Dilution and attenuation factor may be overly conservative for some containment systems and subsurface environments.
Easy and inexpensive to develop leachability limits once dilution and attenuation factor has been determined.	Expensive and time consuming to develop a standardised landfill model and modelling approach.
	Does not consider the specific characteristics of different constituents.

Generic Landfill with Constituent Specific Dilution and Attenuation Factors

This approach would take account of differing attenuation characteristics (for example, degradation, adsorption, precipitation) of different constituents. However, there would still be a degree of inherent conservatism due to the generic approach in respect of the landfill, underlying characteristics of the site and receiving environment.

Both risk assessment approaches using a generic landfill site could be made less conservative if Monte Carlo simulations were undertaken for selected parameters. Final acceptance limits could then be based on probabilities, at an appropriate level of confidence.

The advantages and disadvantages of this risk-based approach are outlined in Table 2-10.

Table 2-10 Advantages and Disadvantages of
Generic Landfill with Constituent Specific Dilution and Attenuation Factor Approach

Advantages	Disadvantages
Transparent methodology.	Considers only one receiving environment, likely to be the most potentially sensitive.
Considers the specific characteristics of different constituents.	Dilution and attenuation factor may be overly conservative for some containment systems and subsurface environments.
	Expensive and time consuming to develop a standardised modelling approach.
	Requires modelling parameters to be modified and modelling to be repeated to develop leachability limits for each constituent.

Site Specific Dilution and Attenuation Factors for Specific Constituents

This approach would be the most transparent and technically robust, as each landfill site’s specific siting and engineered containment characteristics would be taken into account and leachability limits for each individual constituent of concern determined in respect of the most appropriate environmental receptor(s).

This approach would require the development of a standardised model and procedures for undertaking site-specific fate and transport modelling. All parameters required for input into the model would be prescribed, as would procedures to determine the most appropriate receiving environment(s) for which to determine acceptance limits.

Such a risk assessment approach could be incorporated into a guideline or standard, or be used as the basis for waste acceptance in landfill consent conditions.

The advantages and disadvantages of this risk-based approach are outlined in Table 2-11.

Table 2-11 Advantages and Disadvantages of Site Specific Dilution and Attenuation Factors for Specific Constituents Approach

Advantages	Disadvantages
Most technically robust risk based approach	Expensive and time consuming to develop standardised procedure.
Transparent methodology.	Less certainty and clarity for waste generators.
Considers the specific characteristics of different constituents.	
Considers the specific characteristics of different sites.	

2.2.9 New Zealand Guidelines for Receiving Environments

NZS 9201 Model Trade Waste By Law

This model was developed as a guideline for setting wastewater quality limits to ensure that wastewater treatment systems can operate effectively and discharges of wastewater are acceptable. In addition, trade waste bylaws are intended to protect the fabric of the sewerage treatment system, to ensure the health and safety of workers, and to protect the receiving environment.

It has a set of limits for acceptance of constituents in municipal and industrial wastewater, to protect a treatment plant's biological treatment processes.

Australia and New Zealand Guidelines for Fresh And Marine Water Quality 2000

The primary objective of the Australia and New Zealand Guidelines for Fresh and Marine Water Quality 2000 is to provide a standard for setting water quality objectives required to sustain current, or likely future, environmental values for natural and semi-natural water resources.

For some environmental values the guideline value provided is an adequate guide to quality (for example, the guidelines for recreation or drinking water). For other specific environmental values the guideline is just a starting point to trigger an investigation to develop more appropriate guidelines based on the type of water resource and inherent differences in water quality across regions. Where the issue of concern is the protection of aquatic species, the investigation should aim to develop and adapt the guidelines to suit the local area or region. The ANZECC guidelines, 2000 incorporate protocols and detailed advice to assist users in tailoring water quality guidelines to local conditions.

The ANZECC values, 2000 were developed using the latest scientific national and international information. Recent local and overseas scientific and resource management documents, relevant overseas water quality guideline documents, government submissions and public submissions were all used in the development of the ANZECC guideline values, 2000.

Drinking Water Standards for New Zealand

The Drinking Water Standards for New Zealand (2000) detail how to assess the quality and safety of drinking water. The standards define drinking water – water intended to be used for human consumption, food preparation, utensil washing, oral hygiene or personal hygiene.

The Drinking Water Standards list the maximum concentrations of chemical, radiological and microbiological constituents acceptable for public health and drinking water.

The Ministry of Health developed the Standards with assistance of an expert working group. Extensive use was made of the World Health Organisation Guidelines for Drinking Water Quality and addenda up to 1998. Reference is also made to the Drinking Water Standards for New Zealand 1984 and 1995 and to the Australian Drinking Water Guidelines 1996.

The standards are set to protect public health and apply predominantly to constituents that have the potential to affect human health.

2.2.10 Hazardous Substances and New Organisms Act 1996 (HSNO)

Under the Hazardous Substances and New Organisms Act 1996 (HSNO), the definition of a hazardous substance is as follows:

A substance that has any one or more of the following intrinsic "hazardous properties" exceeding specified thresholds or Minimum Degrees of Hazard regulations made under the Act.

- explosiveness;
- flammability;
- ability to oxidise;
- human toxicity (acute or chronic);
- corrosiveness (to human tissue or metal);
- ecotoxicity (with or without bioaccumulation);
- capacity, on contact with air or water, to develop one or more of the above properties.

Under the Act regulations in respect of the following can been developed for hazardous substances:

- thresholds (minimum degrees of hazard), which define a hazardous substance;
- classifications, which specify degree of hazard; and
- performance based controls, including:
  - property controls;

  - acceptable limits on exposure;
  - requirements to prevent hazard occurring;
  - pan life cycle controls.

The classification scheme used by HSNO is a matrix. It contains columns that set out the type of hazard and rows that set out the degree of hazard (or, for explosives, the category of explosive).

The classification scheme is based on the 6 hazardous properties outlined above. It specifies:

- a number of degrees or types of hazard (classes); and
- a number of types (subclasses) and degrees (categories) of hazard.

A combination of the class, subclass and category constitutes a hazard classification (e.g. 3.1A-flammable liquid: very high hazard).

Each hazardous property classification triggers a suite of controls. These controls apply to the particular substance and take into account all hazards; they are applied by ERMA (the Environmental Risk Management Authority). The controls may vary for a particular substance. Controls can include packaging requirements, handling, tracking, labelling, storage and signage requirements, emergency plans and explicit requirements for disposal. In addition, ERMA may set exposure limits for toxic and ecotoxic hazards. These limits are called EEL's (Environmental Exposure Limits) and TEL's (Tolerable Exposure Limits).

EEL's and TEL's aim to provide control on the discharge of a substance. A substance that has EEL's or TEL's attached can only be discharged if the EEL's and TEL's are not exceeded.

To date no HSNO EEL/TEL values have been set. This will only occur when substances requiring them are transferred from regulations under previous legislation to HSNO regulation, or gain a new approval under the HSNO regime.

2.2.11 New Zealand Waste List

The New Zealand Waste List was developed to provide a definition of hazardous waste and a waste list to provide guidance on the types of wastes that are generated by various sectors in the community. It comprises two codes:

- waste categories (W – Code); and
- the New Zealand Waste List (L – Code).

W - Code

Hazardous waste is defined as any substance, material or object that is included in the following Waste Categories (W-Code), as detailed in Table 2-12, and that:

- exceeds the minimum degrees of hazard for hazardous substances specified by Hazardous Substances Minimum Degrees of Hazard Regulations 2000 under the Hazardous Substances and New Organism Act 1996 (HSNO), or
- meets the definition for infectious waste included in the Land Transport Rule: Dangerous Goods 1999 and NZ Standard 5433: 1999 – Transport of Dangerous Goods on Land [1] , or
- meets the definition for radioactive material included in the Radiation Protection Act 1965 and Regulations 1982.[2]

L - Code

The New Zealand Waste List (L-Code) provides guidance on wastes that are generated by various industry sectors and municipal wastes. The L-Code contains a wide range of wastes including those that typically exhibit hazardous characteristics and therefore fall under the definition of hazardous wastes. Hazardous wastes on the L-Code are identifiable by an asterisk (*) after their 6-digit code (for example, 01 03 04* acid-generating tailings from processing of sulphide ore). The L-Code will be a step toward the adoption of a common language for identifying wastes and will be an important element in the development of a nationally consistent waste management system.

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[1] Substances known, or reasonably expected, to contain pathogens, including bacteria, viruses, ricksettia, parasites, fungi or recombinant micro-organisms (hybrid or mutant) that are known, or reasonably expected, to cause infectious disease in humans or animals that are exposed to them.

[2] Radioactive material means any article containing a radioactive substance giving it a specific radioactivity exceeding 100 kilobecquerels per kilogram and a total radioactivity exceeding 3 kilobecquerels.

Table 2-12 Waste Categories (W-Code)

Waste Categories (W-Code)	
1.	Production and consumption residues not otherwise specified below
2.	Off-specification products
3.	Products whose date for appropriate use has expired
4.	Materials spilled, lost or having undergone other mishap, including any materials, equipment, etc., contaminated as a result of the mishap
5.	Materials contaminated or soiled as a result of planned actions (e.g. residues from cleaning operations, packing materials, containers)
6.	Unusable parts (e.g. reject batteries, exhausted catalysts)
7.	Substances that no longer perform satisfactorily (e.g. contaminated acids, contaminated solvents, exhausted tempering salts)
8.	Residues of industrial processes (e.g. slags, still bottoms, spent filters)
9.	Residues from pollution abatement processes (e.g. scrubber sludges, baghouse dusts, spent filters)
10.	Machining/finishing residues (e.g. lathe turnings, mill scales)
11.	Residues from raw materials extraction and processing (e.g. mining residues, oil field slops)
12.	Adulterated materials (e.g. oils contaminated with PCBs)
13.	Any materials, substances or products whose use has been banned by law
14.	Products for which the holder has no further use (e.g. agricultural, household, office, commercial and shop discards)
15.	Contaminated materials, substances or products resulting from remedial action with respect to land

2.3 Ranking of Approaches

The approaches to developing LWAC, as outlined in Section 2, are ranked, in order of technical robustness and defensibility, as below. The first approach listed is ranked highest.

1. Risk Based - Site Specific Dilution and Attenuation Factors for Specific Constituents.

   This approach is considered the most technically robust as it uses both site specific and constituent specific factors to determine threshold concentrations. However it is reliant upon the development of a standard model and procedures for undertaking site-specific fate and transport modelling.

   This approach would be expensive to both develop and use in determining threshold concentrations. It would also require a degree of specialised technical competence in those using the model to calculate threshold concentrations.

2. Risk Based - Generic Landfill with Constituent Specific Dilution and Attenuation Factors.

   This approach uses constituent specific factors to determine threshold concentrations for a model landfill site that conforms to “Class A” siting and design criteria. However, it is also reliant upon the development of a standard model and procedures for undertaking constituent specific fate and transport modelling.

This approach would be expensive to both develop and use in determining threshold concentrations. It would also require a degree of specialised technical competence in those using the model to calculate threshold concentrations. However the cost and technical requirements would be less than for an approach using site specific dilution and attenuation factors for specific constituents.

3. Risk Based - Generic Landfill with a Single Dilution and Attenuation Factor.

   This approach uses a model landfill site that conforms to “Class A” siting and design criteria. Modelling would be undertaken as a one-off project, using a range of constituents to derive a single dilution and attenuation factor for the most likely or sensitive receiving environment.

   Once the dilution and attenuation factor is determined, implementation of this approach is simple and inexpensive to apply to specific constituents and receiving environments.

   However, it is reliant upon the development of a standard model landfill and would be more conservative than the other risk based approaches. It must be noted that if an approach is too conservative and a waste cannot be cost effectively treated to meet criteria then negative environmental outcomes could result (for example illegal dumping).

4. Selected Large Private Landfills in New Zealand

   These landfills have used the USEPA criteria and developed site-specific threshold concentrations for constituents not in the USEPA list. In developing site specific WAC the receiving environment has been considered when selecting the appropriate guidelines/standards on which to base the calculation of a threshold concentration.

   It is noted that the risk assessment procedure used is not transparent in all cases.

5. USEPA, NSWEPA and WAEPA.

   The USEPA used a subsurface contaminant fate and transport model to confirm earlier criteria and develop new criteria, based on drinking water supplies as the receiving environment. The USEPA considers that an order of magnitude is an appropriate level of accuracy. It determined that multiplication of drinking water standards by two orders of magnitude to derive threshold concentrations provides an appropriate level of protection.

   The NSWEPA and WAEPA based their threshold concentrations on the USEPA numbers and used the same order of magnitude to calculate threshold concentrations for additional constituents, using drinking water guidelines.

6. Health and Environmental Guidelines for Selected Timber Treatment Chemicals.

   These guidelines use dilution and mixing factors, developed for a limited range of constituents. While they provide a straightforward methodology to calculate threshold concentrations, there is no robust technical justification for the dilution and mixing factors proposed.

7. Selected Large Municipal Landfills

   These sites have used a range of methodologies to derive threshold concentrations, based on a variety of sources (USEPA criteria, NSWEPA, NZS 9201).

The South African approach has not been ranked as it does not use leachability limits as concentration thresholds.

2.4 Recommended Approach

The following assumptions were made in recommending an approach to determining threshold concentrations for constituents not currently in the USEPA TCLP list of Regulatory Levels:

- the most sensitive receiving environment should be considered as the basis for deriving a threshold concentration;
- guidelines/standards for receiving environments were developed using robust methodologies;
- in using receiving environment guidelines/standards to develop concentration thresholds an order of magnitude is likely to provide an appropriate degree of precaution with respect to dilutions for "Class A" landfills.

It is recommended that threshold concentrations be derived for those constituents recommended for inclusion in the TCLP list for "Class A" landfills using a risk based approach, with a generic landfill (Class A) and constituent specific dilution and attenuation factors.

The use of a generic Class A landfill (in terms of both siting and landfill design) provides a degree of conservatism to ensure that leachability limits are appropriate for all Class A landfills. It also enables leachability limits to be determined in a single exercise, thereby avoiding costs to landfill operators and regulators in developing and verifying site-specific limits for the protection of groundwater and surface water.

The use of constituent specific dilution and attenuation factors enables the setting of leachability limits appropriate to that constituent's behaviour in the landfill liner or underlying geology.

This approach is considered to provide an appropriate balance between:

- the operational requirements of landfill operators and users;
- protection of the downgradient groundwater and surface water environments; and
- costs for landfill operators and regulators.

It is recommended that modelling be undertaken using a contaminant fate and transport model incorporating the following assumptions:

- "Class A" siting requirements (conservative);

- "Class A design" requirements (conservative);
- a landfill cell with a plan diameter of 100 metres;
- a compliance point for surface water and groundwater contamination 100 metres downgradient of the landfill edge;
- use of surface water (aquatic criteria) guidelines and New Zealand Standards for Drinking Water (2000), whichever is the most conservative;
- aquatic criteria values selected according to the following hierarchy;
  - ANZECC (2000);
  - ANZECC (1999) – Draft;
  - ANZECC 1992.

For comparison purposes, the fate and transport model should also be used for a range of constituents in the current USEPA TCLP criteria list.

Threshold concentrations derived using the above methodology should also be checked, on a site-specific basis, in respect of:

- potential effects on landfill workers and the local environment due to discharges into the air; and
- potential effects on the leachate treatment/disposal system.

In some cases site-specific factors may make it necessary to apply lower concentrations.

3.1 Introduction

This section lists the constituents considered in respect of addition to the list of TCLP constituents. Recommendations on constituents to be added are made.

The model used to determine leachability limits is described and the leachability limits developed presented.

3.2 Additional Constituents for Leachability Limits

3.2.1 Background Constituent Tables

Tables were developed to list constituents present (and their corresponding limit values) in a range of environmental guidelines and criteria, waste acceptance criteria from selected jurisdictions and waste acceptance criteria currently in use at selected New Zealand landfills, including:

- USEPA;
- NSWEPA;
- WAEPA;
- private landfill 1;
- private landfill 2
- NZ Standard 9201 Model Trade Waste Bylaw acceptance limits;
- ANZECC Guidelines for fresh water (aquatic ecosystems), 2000;
- Auckland Trade Waste Bylaw;
- NZ Drinking Water Guidelines, 2000;
- municipal landfill 1;
- municipal landfill 2;

These sources were chosen due to their relevance to the New Zealand environment, or compatibility with the USEPA TCLP system.

The first table (Appendix A) lists all the constituents in alphabetical order and also identifies leachable concentration limits.

The second table (Appendix B) lists constituents in alphabetical order and identifies the total concentration limits and screening values that were available.

These tables were used to provide background information on the constituents for which leachability limits have been set and for which environmental criteria exist.

3.2.2 Additional Constituents

Following discussions with MfE and comments from the Hazardous Waste Technical Advisory Group it is recommended that leachability limits be set for as broad a range as possible of constituents that have the potential to adversely affect human health and the aquatic environment (as identified by their presence in recently developed standards, guidelines and criteria for the protection of human health and the environment).

The following criteria were used to identify constituents that have the potential to adversely affect human health and the aquatic environment:

- the presence of a New Zealand Standard for Drinking Water (NZSDW) for that constituent; or
- inclusion in the following criteria:
    - ANZECC (2000);
    - ANZECC (1999) – Draft;
    - Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Criteria for the Protection of Aquatic Life (1999);
    - ANZECC 1992.

Where no other criteria existed the Dutch Intervention Values for Groundwater (1998) were used.

The constituents on the USEPA list of priority pollutants are recognised constituents of environmental concern. Inorganic priority pollutants already have a USEPA TCLP limit. However, a large number of the organic priority pollutants do not have a USEPA TCLP limit.

The majority of organic priority pollutants that are typically present in New Zealand wastes are determined using analytical scans for semi-volatile organic compounds (SVOCs) and volatile organic compounds (VOCs). Therefore the RJ Hill Laboratories list of SVOCs and VOCs (SVOC in Water and Soil and VOC in Water and Soil from the Environmental Division Catalogue CD.PGR.3424 (valid until 30 June 2002) was used to select priority pollutants in New Zealand for consideration for development of leachability limits. This list is attached in Appendix C.

For constituents classed as SVOCs or VOCs, the log K_{oc} value was used to determine suitability for the development leachability limits. Where log K_{oc} is less than three (that is, the constituent has the potential to be leached rather than sorbed onto organic solids) the constituent is recommended for a leachability limit. (The maximum value of log K_{oc} used in deriving leachability limits was 3.34.)

In general, where log K_{oc} is greater than three (that is, the constituent is not readily soluble) the development of a total concentration limit is recommended as more appropriate for that constituent.

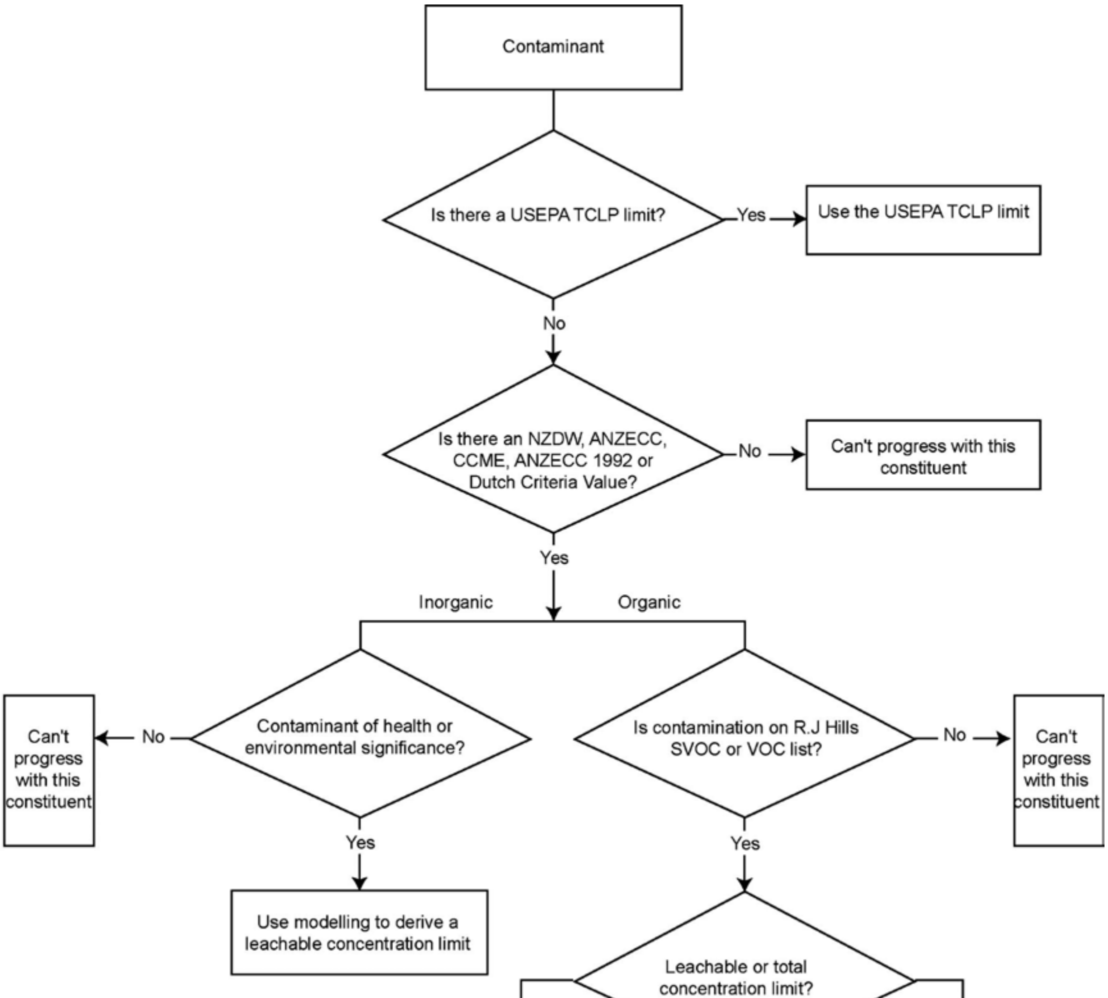
Log K_{oc} values used were taken from Montgomery, J. H., Groundwater Chemicals, Third Edition, 2000.

If more than one log K_{oc} value was found the lowest log K_{oc} value provided for that particular constituent was, as a conservative assumption.

Figure 3-1 is a flow chart which outlines the decision making process for the development of leachability limits.

The Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Criteria for the Protection of Aquatic Life (1999), Dutch Intervention Values for Groundwater (1998) or ANZECC 1992 criteria values were not used for modelling. Where no NZSDW criteria, or ANZECC (2000) criteria existed for a constituent, the ANZECC interim value, not listed in the final criteria table was used. This was considered to provide a consistent approach to criteria derivation and more suitable, compared to using criteria developed overseas using different methodologies.

Figure 3-1 Decision Making Process for Constituent Selection for Leachability Limits



3.2.3 Recommended Additional Constituents

Table 3-1 shows those constituents for which new leachability limits are recommended and those for which total concentration limits are considered more appropriate.

A number of constituents for which leachability limits are not recommended were also considered. The constituents, and reasons for not recommending the development leachability limits are listed below.

Bromine	Not recommended for inclusion because of presence, due to natural factors, which would make it impractical to set a limit.
Cobalt	Not recommended for inclusion as the most potentially harmful aspects relate to radioactivity of Cobalt 60. In addition, there is insufficient data for cobalt.
Dioxins	Testing for dioxins is not undertaken routinely and is expensive. It is more appropriate to consider the management of waste materials, in which dioxin contamination may be suspected, on an event specific basis.
Iron	Not recommended for inclusion as it may be present naturally at concentrations that may exceed limits as a result of it's mobility in reducing environments.
Manganese	Not recommended for inclusion as it may be present naturally at concentrations that may exceed limits as a result of it's mobility in reducing environments.
PAHs (non-carcinogenic)	Napthalene, which has the lowest log K_{oc} (is the most mobile), is considered to be the risk driver for non-carcinogenic PAHs.
Sodium	Not recommended for inclusion because of presence, due to natural factors, in a high number of wastes and high leachate concentrations, which would make it impractical to set a limit.
Thallium	Not recommended for inclusion as it is not used widely enough to warrant inclusion. In addition, there is insufficient data for thallium.
Formaldehyde	Not recommended as it commonly used in processed wood products, and, therefore present in any wastes that contain manufactured wood products. There are issues associated with handling of some manufactured wood wastes (for example dust from sawdust), but these relate more to site management procedures. The groundwater pathway is not the limiting factor in this case.
Uranium	Not recommended for inclusion as it is not used widely enough to warrant inclusion and the most potentially harmful aspects relate to radioactivity.

Table 3-1 Constituent Table (all concentrations in milligrams per litre)

Constituent	USEPA TCLP (Total)	NZ Drinking Water Standard (2000)	ANZECC (2000)	Draft ANZECC (1999)	CCME (1999)	ANZECC (1992)	Dutch Groundwater (1998)	Leachability Limit (TCLP)	Total Concentration Limit
Inorganics									
Aluminium		0.15 [VI]	0.027	0.0012	0.005-0.1	<0.005 (if pH<=6.5) <100 (if pH>6.5)		New Limit [A]	
Antimony		0.003 [II]		0.0076		0.03		New Limit	
Arsenic	5	0.01 [II]	0.024	0.0016	0.005	0.05		USEPA [B]	
Barium	100	0.7 [II]						USEPA	
Beryllium		0.004 [II]				0.004		New Limit	
Boron		1.4 [II]	0.37	0.0048				New Limit	
Cadmium	1	0.003 [II]	0.0002	0.000013	0.000017	0.0002-0.002		USEPA	
Chromium	5	0.05 [II]		0.009	0.0089	0.01		USEPA	
Copper		2 [II], 1 [VI]	0.0014	0.00033	0.002-0.004	0.002-0.005		New Limit	
Fluoride		1.5 [II]						New Limit	
Lead	5	0.01 [II]	0.0034	0.0012	0.001-0.007	0.001-0.005		USEPA	
Lithium		0.9 [II]						New Limit	
Mercury	0.2	0.002 [II]	0.00006	0.000013		0.0001		USEPA	
Molybdenum		0.07 [II]		0.0067	0.073			New Limit	

Constituent	USEPA TCLP (Total)	NZ Drinking Water Standard (2000)	ANZECC (2000)	Draft ANZECC (1999)	CCME (1999)	ANZECC (1992)	Dutch Groundwater (1998)	Leachability Limit (TCLP)	Total Concentration Limit
Nickel		0.02[II]	0.011	0.0007	0.025-0.15	0.015-0.15		New Limit	
Selenium	1	0.01[II]	0.005	0.0014	0.001	0.005		USEPA	
Silver	5	0.02[II]	0.00005	0.000005	0.0001	0.0001		USEPA	
Tin		1[II]				0.000008		New Limit	
Vanadium				0.006				New Limit	
Zinc		3[VI]	0.008	0.0024	0.03	0.005-0.05		New Limit	
Organics									
Aromatic Hydrocarbons									
Styrene (vinyl benzene)		0.03[III], 0.004[VI]			0.072			New Limit	
2,4 Dinitrotoluene	0.13			0.013				USEPA	
Aniline				0.002	0.0022			New Limit	
Nitrobenzene	2			0.06				USEPA	
Total Polychlorinated Biphenyls	(50)				work toward virtual elimination	0.000001		USEPA	
Polynuclear Aromatic Hydrocarbons									
Naphthalene			0.016000	0.0003	0.0011				New Limit
Total PAH's									NA
Benzo(a)pyrene (carcinogenic PAH's)		0.0007[III, VII]		0.0003[VII]	0.000015[VII]	0.0002[VIII]			New Limit
Other Halogenated Aromatic Hydrocarbons									
1,2,3 Trichlorobenzene			0.003	0.0018		0.0009		New Limit	

Constituent	**USEPA TCLP (Total)**	**NZ Drinking Water Standard (2000)**	**ANZECC (2000)**	**Draft ANZECC (1999)**	**CCME (1999)**	**ANZECC (1992)**	**Dutch Groundwater (1998)**	**Leachability Limit (TCLP)**	**Total Concentration Limit**
Chlorobenzene	100							USEPA	
Hexachlorobenzene	0.13	0.001 [IV]		0.0002		0.000007		USEPA	
1,2 Dichlorobenzene		1 [III], 0.001 [VI]	0.16	0.007	0.0007	0.0025		New Limit	
1,2,4 Trichlorobenzene			0.085	0.017	0.024	0.0005		New Limit	
1,3 Dichlorobenzene			0.26	0.0017	0.15	0.0025		New Limit	
1,4 Dichlorobenzene	7.5	0.4 [III], 0.003 [VI]	0.06	0.003	0.026	0.004		USEPA	
BTEX									
Benzene	0.5	0.01 [III]	0.95	0.23	0.37	0.3		USEPA	
Toluene		0.8 [III], 0.024-0.17 [VI]		0.17	0.002	0.3		New Limit	
Ethyl benzene		0.3 [III], 0.002 [VI]		0.086	0.09			New Limit	
Xylene (m,o,p)		0.6 [III], 0.02-1.8 [VI]	0.2	0.032				New Limit	
Aliphatic Hydrocarbons									
Chlorinated Aliphatic Hydrocarbons									
1,2 Dichloroethene		0.06 [III]						New Limit	
1,3 Dichloropropene		0.02 [IV]						New Limit	
Carbon Tetrachloride	0.5	0.002 [III]		0.24	0.0133			USEPA	
Dichloromethane		0.02 [III]		3.1	0.0981			New Limit	
Trichloroethene	0.7	0.08 [III]			0.021			USEPA	
Vinyl Chloride	0.2	0.005 [III]					0.005	USEPA	

Constituent	USEPA TCLP (Total)	NZ Drinking Water Standard (2000)	ANZECC (2000)	Draft ANZECC (1999)	CCME (1999)	ANZECC (1992)	Dutch Groundwater (1998)	Leachability Limit (TCLP)	Total Concentration Limit
Hexachloroethane	3		0.29	0.308				USEPA	
1,1 Dichloroethene	0.7	0.03 [III]	0.61	0.1				USEPA	
1,1,1 Trichloroethane		2 [III]		0.13				New Limit	
1,1,2 Trichloroethane			6.5	0.27				New Limit	
1,1,2,2 Tetrachloroethane				0.2				New Limit	
1,2 Dibromo-3-chloropropane		0.001 [IV]						New Limit	
1,2 Dichloroethane	0.5	0.03 [III]		1.1	0.1			USEPA	
1,2 Dichloropropane		0.05 [III, IV]		0.6				New Limit	
Tetrachloroethene	0.7				0.111			USEPA	
Hexachloro-1,3-butadiene	0.5	0.0007 [III]			0.0013			USEPA	
Other Halogenated Aliphatic Hydrocarbons									
Bromodichloromethane		0.06 [III]						New Limit	
Bromoform		0.1 [III]						New Limit	
Chloroform	6	0.2 [III]		0.17	0.0018			USEPA	
Dibromochloromethane		0.1 [III]						New Limit	
Ketones									
Methyl ethyl ketone	200							USEPA	
Phenols									
2 Chlorophenol		0.0003 [VI]						New Limit	

Constituent	USEPA TCLP (Total)	NZ Drinking Water Standard (2000)	ANZECC (2000)	Draft ANZECC (1999)	CCME (1999)	ANZECC (1992)	Dutch Groundwater (1998)	Leachability Limit (TCLP)	Total Concentration Limit
2,4 Dichlorophenol		0.0003 [VI]	0.12	0.03	0.0002			New Limit	
2,4,5 Trichlorophenol	400							USEPA	
2,4,6-Trichlorophenol	2	0.2 [III], 0.002 [VI]	0.003	0.0018				USEPA	
Phenol			0.32	0.006	0.004	0.05		New Limit	
Total Cresol	200							USEPA	
Pentachlorophenol (PCP)	100	0.01 [IV]	0.0036	0.0005	0.0005			USEPA	
Pesticides									
Acidic Herbicides									
2,4 Dichlorophenoxyacetic acid (2,4 D)	10	0.04 [IV]	0.28	0.014				USEPA	
2,4,5-Trichlorophenoxypropionic acid	1							USEPA	
Organochlorine Pesticides									
Heptachlor	0.008	0.00004 [IV]	0.00001	0.000005	work toward virtual elimination	0.01		USEPA	
Heptachlor Epoxide		0.00004 [IV]			work toward virtual elimination				New Limit
4,4 DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene)						0.014			New Limit
Aldrin				0.000001	work toward virtual elimination	0.01		New Limit	

Constituent	USEPA TCLP (Total)	NZ Drinking Water Standard (2000)	ANZECC (2000)	Draft ANZECC (1999)	CCME (1999)	ANZECC (1992)	Dutch Groundwater (1998)	Leachability Limit (TCLP)	Total Concentration Limit
DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane)		0.002 (+isomers) [IV]	0.000006	0.0000005	work toward virtual elimination	0.001			New Limit
Dieldrin				0.000006	work toward virtual elimination	0.002		New Limit	
Endosulfan			0.00003	0.000001		0.01		New Limit	
Endosulfan I					0.00002				NA
Endosulfan II					0.00002				NA
Endrin	0.02		0.00001	0.000001	work toward virtual elimination	0.003		USEPA	
Chlordane	0.03	0.0002 [IV]	0.00003	0.00001	work toward virtual elimination	0.004		USEPA	
Lindane	0.4	0.002 [IV]	0.0002	0.00002	0.00001	0.003		USEPA	
Methoxychlor	10	0.02 [IV]		0.000005		0.04		USEPA	
Phthalates									
Diethylphthalate			1	0.12				New Limit	
Dimethylphthalate			3	0.35				New Limit	
Di-n-butylphthalate			0.026			0.004		New Limit	
Other Organics									
Carbon disulphide				0.021				New Limit	
Cyanide	50	0.08 [II]	0.007	0.001	0.005	0.005		USEPA	
Pyridine	5							USEPA	

Constituent	**USEPA TCLP (Total)**	**NZ Drinking Water Standard (2000)**	**ANZECC (2000)**	**Draft ANZECC (1999)**	**CCME (1999)**	**ANZECC (1992)**	**Dutch Groundwater (1998)**	**Leachability Limit (TCLP)**	**Total Concentration Limit**
Sulphides	50					0.002		USEPA	
Total halogenated compounds	(1000)							USEPA	
Total synthetic non-halogenated compounds	(10000)							USEPA	
Toxaphene	0.5			0.000004	work toward virtual elimination	0.008		USEPA	
Organometallics									
Tributyltin oxide (TBTO)		0.002 III			0.000008			New Limit	

Notes:

A New limit to be determined
B USEPA limit already in use
C Mass limit to be determined
I Micro-organisms of health significance
II Inorganic determinands of health significance
III Organic determinands of health significance
IV MAV for Pesticides
V MAV for radiological determinands
VI Aesthetic determinands
VII Based on BaP
VIII Based on Chrysene

3.3 Development of Leachability Limits

3.3.1 Model Set-up

Following acceptance, by MfE, of the recommendations in terms of the approach to the development of, and constituents, for leachability limits, the following landfill model was set-up to represent a cell in a Class A landfill. The model landfill cell is shown in Figure 3-2.

Landfill Design Parameters

A one hectare lined cell (100 metres by 100 metres square or a circle of radius 56.4 metres).

Table 3-2 outlines the design parameters for the liner and leachate collection system.

Table 3-2 Model Landfill Design Parameters

Liner	
Liner Construction	Compacted clay
Liner Thickness	900 millimetres
Liner Permeability	1.0 x 10^{-9} metres per second
Leachate Collection System	
Liner Slope	1:50 (2%)
Slope Length	50 metres
Leachate Drainage Layer Thickness	300 millimetres
Leachate Drainage Layer Permeability	3 x 10^{-5} metres per second
Waste	
Waste Type	Municipal solid waste with channelling
Waste Thickness	10 metres
Waste Permeability	1.0 x 10^{-5} metres per second

A liner comprising 900 millimetres of clay compacted to a permeability (K) of less than or equal to 1 x 10^{-9} metres per second has been chosen as it is considered to represent the minimum likely requirement for a Class A landfill in respect of hydraulic containment.

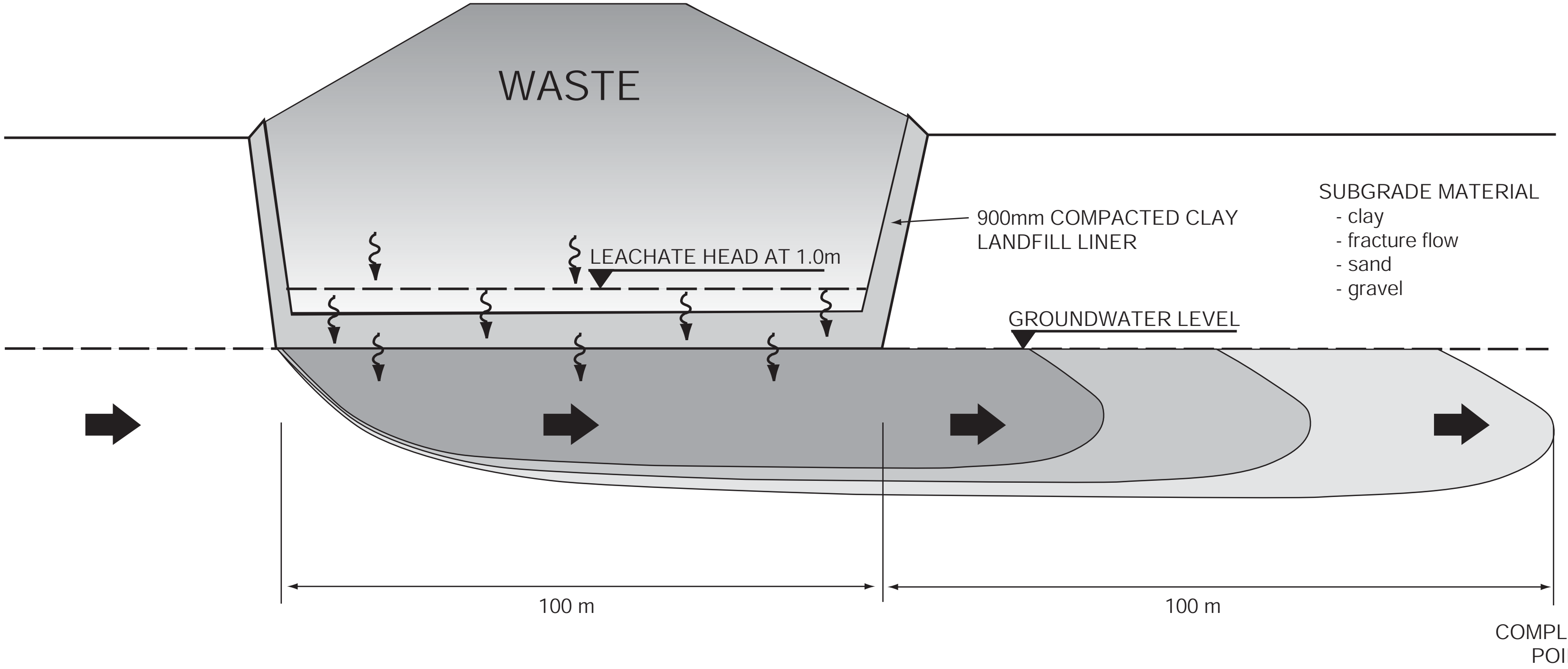


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FIGURE 3-2

Leachate Leakage Through Liner

The leachate leakage rate from the model landfill liner was estimated using the USEPA “Hydrological Evaluation of Landfill Performance” (HELP) model.

This computer model is used to evaluate alternative landfill designs and gives an indication of likely landfill leachate production and leakage through the base of the liner system.

The HELP Model requires rainfall; solar radiation; wind; humidity and mean daily temperatures as climatic inputs. Published data from South Auckland was used to generate twenty years of climatic data for input into the model. The mean annual rainfall used for the data set was 1349 millimetres, which is considered to represent typical New Zealand temperate climatic zone.

The leachate drainage layer permeability was adjusted to achieve a hydraulic head of one metre of leachate above the liner. The resulting permeability (3.05×10^{-5} metres per second) assumes clogging of the leachate drainage layer over time. The leachate head of one metre, while greater than the usual design maximum head of 300 millimetres, allows for a reduction in the efficiency of the leachate drainage system over time.

The annual rate of leachate leakage (that is, the flow of fluid) through the one-hectare surface area of the compacted clay liner was estimated to be 653 cubic metres per year, or 1789 litres per day.

Underlying Geology

Four types of underlying geology were used for the model:

- clay/silt;
- fracture flow;
- sand; and
- gravel.

The hydrogeological properties are listed in Table 3-3. In general the most conservative parameters were selected. However, the hydraulic conductivity for fracture flow selected (1×10^{-5} metres per second) was in the middle of the expected range. This was taken to be indicative of fractures infilled with silty material.

It is assumed that the groundwater table is at the base of the liner, and that all contaminant transport occurs in saturated conditions. This is a conservative assumption, as an unsaturated zone will further limit contaminant migration, but is consistent with the generally shallow groundwater table in most areas of New Zealand. A limitation is landfills that are below the water table. In this instance there will be an inward groundwater gradient, provided the landfill has a leachate collection system.

Table 3-3 Hydrogeological Properties of Underlying Geology

	Gravel	**Sand**	**Fracture**	**Clay/silt**
Hydraulic Conductivity (m/d):	864	86.4	0.864	0.864
	$1x10^{-2}$	$1x10^{-3}$	$1x10^{-5}$	$1x10^{-5}$
Range (m/s)	$1x10^{-2}$ - $1x10^{-3}$	$1x10^{-3}$ - $1x10^{-6}$	$1x10^{-2}$ - $1x10^{-8}$	$1x10^{-5}$ - $1x10^{-9}$
Gradient (m/m):	0.001	0.01	0.01	0.1
Range	$1x10^{-3}$ - $1x10^{-5}$	$1x10^{-2}$ - $1x10^{-4}$	$2x10^{-1}$ - $1x10^{-3}$	$2x10^{-1}$ - $1x10^{-3}$
Porosity (n):	0.35	0.35	0.05	0.4
Range	0.1 - 0.35	0.1 - 0.35	0.01 - 0.2	0.01 - 0.4
Bulk Density (ρ) (tonnes/m^3)	1.3	1.7	1.3	1.4
Range (t/m^3)	1.3 - 2.3	1.3 - 1.9	1.3 - 2.3	1.3 - 1.9

Compliance Point

For the purposes of developing a generic landfill model, a compliance point 100 metres downgradient of the landfill edge has been set. This assumes that there is likely to be some buffer distance between the edge of a Class A landfill and the potential groundwater and surface water receptors.

3.3.2 Determination of Leachability Limits

Leachability limits were derived by back calculation from the appropriate environmental criteria at the compliance point.

Contaminant transport in groundwater from the base of the landfill to the compliance point was modelled using WinTran. WinTran is a simple combined steady-state groundwater flow model and contaminant transport model. It considers groundwater flow and contaminant transport in three dimensions. It assumes that groundwater flow is horizontal and that contaminant source concentrations are the same throughout the entire aquifer thickness. For the purposes of this exercise vertical dispersion has been limited to three metres. The model also assumes that hydraulic conductivity is isotropic and homogeneous.

Groundwater flow in the aquifer beneath, and downstream of the landfill, is determined by WinTran, based on model input parameters.

The governing mechanisms for contaminant release rates, accounted for in the modelling exercise for organic and inorganic constituents, are described below.

Organic Compounds

Attenuation mechanisms considered for organic compounds during the modelling process were dilution, lateral dispersion, retardation and first order decay.

For organic constituents adsorption is the main factor governing the rate of release (otherwise known as the retardation factor, or R_f) from the landfill. Adsorption for organic chemicals is then a function of organic carbon content in the soils.

$R_f = [1+K_d.(\rho/\eta)]$ and $K_d = f_{oc}.K_{oc}$

where

K_d = Distribution coefficient for the constituent
f_{oc} = Fraction of organic carbon
K_{oc} = Organic carbon partitioning coefficient
ρ = Bulk density of the aquifer material
η = Effective porosity of the aquifer material

For organic constituents R_f was a direct input into the model, thereby automatically correcting for retardation occurring in the aquifer. No allowance is made for retardation of organic constituents by the liner, as these processes are less predictable within the liner than for inorganic constituents due to the potential for volatile or separate phase constituents.

Inorganic Compounds

Attenuation mechanisms considered for inorganic compounds were dilution, dispersion and retardation through the liner.

For inorganic constituents the flux rate through the liner is the principal mechanism controlling the rate of release (retardation factor or R_f) from the contaminant source. Attenuation of inorganic constituents is then a function of the liner properties.

$R_f = [1+K_d.(\rho/\eta)]$

where

K_d = Distribution coefficient for the constituent
ρ = Bulk density of the liner
η = Effective porosity of the liner

The mass of contaminant flux through the liner was estimated based on advective flow rather than diffusion.

The reduction in contaminant mass flux that will occur across the landfill liner was considered for inorganic constituents. This conceptual approach differs from that used for organic constituents. The approach is considered more defensible in the case of inorganic constituents for the following reasons:

- the distribution coefficients for inorganic constituents are very much site specific and susceptible to a large number of variables compared to organic constituents, given the range of processes that may influence physico-chemical and chemical attenuation mechanisms (precipitation, hydrolysis, complexation, oxidation/reduction, adsorption, fixation). Applying generic distribution coefficients would therefore require a wide range of values to be defensible. Comprehensive and robust data is not available for the different geological environments considered.

- the geochemical environment within the landfill liner is less variable, with conditions that are known to be reducing, and a compacted soil material that will fall within the clay/silt class. More extensive geochemical or distribution coefficients are available for these materials;
- because inorganic constituents do not degrade over time, retardation only delays the time it takes for the equilibrium maximum concentration to reach the receptor point. However, on a mass flux basis this will reduce the effective concentration. Attenuation of inorganic constituents is, therefore, applied to the liner in this manner.

For the inorganic constituents a retardation correction factor (C_f, the liner R_f)was applied to the model predicted TCLP results to allow for simulation of the release rate from the liner.

The retardation factors for inorganic constituents are applied to the mass of leachate discharge from the base of the landfill liner. For example, the distribution coefficients (K_d) for arsenic and cadmium are 1.0 and 1.3 respectively. For a bulk density of 1.4 and a porosity of 0.4 this equates to the retardation factors of 7.0 and 8.8 respectively, which are applied directly as factors to the leachate discharge.

Inputs used in transport modelling are given in Table 3-4.

Table 3-4 Transport Model Inputs

	Gravel	**Sand**	**Fracture**	**Clay/silt**
Longitudinal Dispersivity (m):	20	20	20	20
Range	10 - 20	10 - 20	10 - 20	10 - 20
Transverse Dispersivity (m):	1	1	1	1
Range	1-2	1-2	1-2	1-2
Diffusion Coefficient (m^2/d) [1]	2.0×10^{-12}	2.0×10^{-12}	1.0×10^{-12}	2.5×10^{-12}
Organic Carbon Content (f_{oc}) [1]	0.001	0.001	0.0001	0.01

[1] Domenico and Schwartz, Physical and Chemical Hydrogeology, 1990

3.3.3 Constituent Modelling Comparison

Constituents Modelled

Five constituents (two inorganic and three organic) were used to compare the results of the model with respect to the USEPA TCLP limits:

- vinyl chloride;
- benzene;
- 2 4 6 trichlorophenol;
- arsenic; and

- cadmium.

In addition naphthalene, a polyaromatic hydrocarbon (PAH) was modelled as it has a log K_{oc} at the upper end of the range for constituents selected for leachability limits (that is, retardation in the underlying geology is at the upper end of the range).

Constituent Compliance Limits and Modelling Parameters

The compliance limits and USEPA TCLP limits for the selected constituents are given in Table 3-5.

Table 3-5 Constituent Compliance Limits

Constituent	NZ Drinking Water Standard (g/m^3)	ANZECC 2000 (95%) (g/m^3)	Compliance Limit for USEPA TCLP limit (g/m^3)
Vinyl Chloride	0.005		0.002
Benzene	0.01	0.95	0.005
2 4 6 Trichlorophenol	0.002	0.003	0.02
Arsenic	0.01	0.024	0.05
Cadmium	0.003	0.0002	0.01
Naphthalene		0.016	

The parameters used for constituents modelling are outlined in Table 3-6.

Modelling Results

The results of comparison modelling are given in Table 3-7. The dilution and attenuation factor (DAF), derived by dividing the leachability limit by the compliance limit, is given in italics.

In all cases the use of fracture flow as the underlying geology gave the lowest leachability limit, with a DAF of between 30 and 244.

Table 3-6 Parameters Used for Constituent Modelling

	Gravel	Sand	Fracture	Clay/silt
Vinyl Chloride				
Constituent Half-life (days) (organic)[1]	2897	2897	2897	2897
Range	56-2897	56-2897	56-2897	56-2897
log K_{oc} [2]	0.39	0.39	0.39	0.39
$K_d = f_{oc} . K_{oc}$	0.0024	0.0024	0.00024	0.024
Retardation Coefficient: $R = [1+K_d. (\rho/\eta)]$	1.009	1.01	1.006	1.08
Benzene				
Constituent Half-life (days) (organic) [1]	732	732	732	732
Range	10 - 732	10 - 732	10 - 732	10 - 732
log K_{oc} [2]	1.7	1.7	1.7	1.7
$K_d = f_{oc} . K_{oc}$	0.05	0.05	0.005	0.5
Retardation Coefficient: $R = [1+K_d. (\rho/\eta)]$	1.19	1.24	1.13	2.75
2,4,6 Trichlorophenol				
Constituent Half-life (days) (organic) [1]	1825	1825	1825	1825
Range	14 - 1825	14 - 1825	14 - 1825	14 - 1825
log K_{oc} [2]	2.64	2.64	2.64	2.64
$K_d = f_{oc} . K_{oc}$	0.44	0.44	0.044	4.4
Retardation Coefficient: $R = [1+K_d. (\rho/\eta)]$	2.62	3.13	2.13	16.3
Naphthalene				
Constituent Half-life (days) (organic) [1]	258	258	258	258
Range	1 - 258	1 - 258	1 - 258	1 - 258
log K_{oc} [2]	2.67	2.67	2.67	2.67
$K_d = f_{oc} . K_{oc}$	0.468	0.468	0.0468	0.0468
Retardation Coefficient: $R = [1+K_d. (\rho/\eta)]$	2.74	3.27	2.22	17.37
Arsenic				
K_d [2]	1	1	1	1
(ρ/η)	6	6	6	6
Retardation Coefficient: $R = [1+K_d.(\rho/\eta)]$	7.00	7.00	7.00	7.00
Cadmium				
K_d [2]	1.3	1.3	1.3	1.3
(ρ/η)	6	6	6	6
Retardation Coefficient: $R = [1+K_d.(\rho/\eta)]$	8.80	8.80	8.80	8.80

[1] Howard et al., Environmental Degradation Rates, 1991

[2] Montgomery J., Groundwater Chemicals Desk Reference, 2000.

Table 3-7 Modelling Results

Constituent	**Compliance Limit (CL) (g/m^3)**	**Leachability Limit (LL) (g/m^3)**			
		Gravel	Sand	Fracture Flow	Clay/Silt
Vinyl Chloride	0.005	**12**	**12**	**0.16**	**1.3**
DAF (LL/CL)		*2400*	*2400*	*32*	*260*
Benzene	0.01	**25**	**25**	**0.62**	**4.2**
DAF (LL/CL)		*2500*	*2500*	*62*	*420*
2,4,6 Trichlorophenol	0.002	**4.8**	**4.8**	**0.12**	**0.60**
DAF (LL/CL)		*2400*	*2400*	*35*	*300*
Arsenic	0.01	**161**	**161**	**3.1**	**15.4**
DAF (LL/CL)		*16100*	*16100*	*310*	*1540*
Cadmium	0.003 [1]	**57.2**	**57.2**	**0.6**	**6.16**
DAF (LL/CL)		*19066*	*19066*	*200*	*2053*
Cadmium	0.0002 [2]	**1.9**	**1.9**	**0.04**	**0.4**
DAF (LL/CL)		*9500*	*9500*	*200*	*2000*
Naphthalene	0.016	**52**	**50.5**	**17.5**	**53**
DAF (LL/CL)		*3250*	*3156*	*244*	*3313*

[1] NZ Drinking Water Standard

[2] ANZECC (2000)

3.3.4 Comparison with USEPA Model

Model Similarities and Differences

The USEPA sub-surface fate and transport model, known as EPACML (unsaturated model) and formerly referred to as EPASMOD (saturated model) is simply an advection dispersion model with chemical specific attenuation. The model used in this project is also an advection dispersion model with chemical specific attenuation.

Both models assume that the TCLP test produces a leachate that will be of the same strength as is present in a leachate from a landfill containing the waste of concern. This is a reasonable assumption based on the total waste within a landfill comprising a small percentage of the waste producing the specific contaminant(s) of concern.

The following are factors common to the flow component of both models:

- Darcian flow in saturated environment;
- the aquifer is homogenous and of uniform thickness;
- groundwater flow is uniform and continuous in direction and velocity;
- hydraulic conductivity does not vary with temperature.

The following are factors that are different for the flow component of each model:

- the USEPA model has a zone of unsaturated flow beneath the landfill, whereas saturated flow has been assumed for the model used for this project;
- the USEPA model has rainfall recharge providing water to the aquifer, whereas no recharge has been assumed for the model used for this project.

The following are factors common to the transport component of both models:

- both are advection and dispersion models.
- chemical retardation and time dependant degradation are taken into account;
- constituents follow a linear equilibrium adsorption isotherm;
- an infinite source supplies a constant mass flux of constituent;
- degradation by-products are assumed to be non hazardous;
- groundwater upstream of the site is free of constituents;
- there is no vapour phase and water is the only flowing material.

The following are factors that are different for the transport component of each model:

- the USEPA model assumes oxidation in the unsaturated zone, whereas there is no unsaturated zone in the model used for this project;
- initially EPASMOD used a fixed compliance point 150 metres downgradient of the landfill. The more recent EPACML model used a Monte Carlo analysis of random well locations anywhere within the plume. A compliance point 100 metres downstream of the landfill is assumed in the model used for this project;
- the USEPA model assumes variable dispersivity based on the compliance point location, whereas fixed dispersivity at the fixed compliance point is assumed in the model used for this project.

A significant difference in the approach adopted by the USEPA and that used in this project is that the USEPA model was used to confirm the appropriateness of a DAF of 100 in respect of drinking water standard for all constituents. The modelling undertaken for this project establishes constituent specific DAFs.

Discussion of Results

The results obtained using the model are compared with USEPA model in Table 3-8. This shows:

- modelling results from Table 3-7;
- results obtained from the model using the US Drinking Water Standard (at the time the USEPA TCLP limit was developed) as the compliance limit and the USEPA model compliance point 150 metres downgradient from the landfill; and
- the USEPA TCLP limit (100 times the US primary Drinking Water Standard at the time limits were set).

The Canadian Council of Ministers of the Environment (CCME) TCLP limits (100 times the Canadian Drinking Water Guideline) are also provided for comparison.

The results for vinyl chloride, benzene are similar to the USEPA TCLP limits for those constituents. The result for arsenic is within the same order of magnitude as the USEPA TCLP limit (3.1 grams per cubic metre compared to the USEPA TCLP limit of 5.0 grams per cubic metre).

When the New Zealand Drinking Water Standard is used as the compliance limit for cadmium the result is similar to the USEPA TCLP limit. However, the ANZECC (2000) criteria for cadmium is an order of magnitude lower than the New Zealand Drinking Water Standard. When this is used as the compliance limit the result is an order of magnitude lower.

The result for 2,4,6 trichlorophenol is two orders of magnitude less than the USEPA TCLP limit (0.07 grams per cubic metre compared to the USEPA TCLP limit of 2.0 grams per cubic metre). However, the USEPA compliance limit is an order of magnitude greater than the New Zealand Drinking Water Standard used as the model compliance limit (0.02 grams per cubic metre compared to 0.002 grams per cubic metre).

Table 3-8 Comparison of Modelling Results

	Compliance Limit (g/m^3)	Compliance Point (m)	Leachability Limit (g/m^3)
Vinyl Chloride			
MfE [A]	0.005	100	**0.16**
MfE/USEPA [B]	0.002	150	0.08
USEPA TCLP [C]	0.002		0.2
CCME TCLP [D]	0.002		0.2
Benzene			
MfE	0.01	100	**0.62**
MfE/USEPA	0.005	150	0.16
USEPA TCLP	0.005		0.5
CCME TCLP	0.005		0.5
2,4,6 Trichlorophenol			
MfE	0.002	100	**0.12**
MfE/USEPA	0.02	150	0.8
USEPA TCLP	0.02		2
CCME TCLP	0.005		0.5
Arsenic			
MfE	0.01	100	**3.1**
MfE/USEPA	0.05	150	9.10
USEPA TCLP	0.05		5
CCME TCLP	0.025		2.5
Cadmium			
MfE	0.003 [1]	100	**0.6**
MfE	0.0002 [2]	100	0.04
MfE/USEPA	0.01	150	2.38
USEPA TCLP	0.01		1
CCME TCLP	0.005		0.5

[A] Leachabilty limit determined using the method described in this section

[B] Leachabilty limit determined using the method described in this section with the USEPA compliance limit

[C] USEPA TCLP Limit

[D] Leachabilty limit determined using the method described in this section with the CCME compliance limit

[1] NZ Drinking Water Standard

[2] ANZECC (2000)

When the USEPA TCLP limit original compliance point, of 150 metres downgradient, and compliance limit are used in the model developed the results are more conservative than the USEPA TCLP limits for organics and less conservative for inorganics.

3.3.5 Alternative Compliance Points and Limits

Modelling was also undertaken using the following alternative compliance points:

- 200 metres downgradient of the landfill edge, where the New Zealand Drinking Water Standard is used as the compliance limit;
- 100 metres downstream of the landfill edge, where the ANZECC (2000) Guidelines for the protection of Aquatic Environments are used as the compliance limit, with the compliance limit multiplied by 10 to account for dilution in a surface water body.

The results of this modelling are shown in Tables 3-9 and 3-10.

Table 3-9 NZDWS as Compliance Limit

Constituent	Compliance Limit (NZDWS) (g/m^3)	Compliance Point (m downgradient)	Leachability Limit (g/m^3)
Vinyl Chloride	0.005	200	0.2
Benzene	0.01	200	1
246 Trichlorophenol	0.002	200	0.16
Arsenic	0.01	200	3.5
Cadmium	0.003 [1]	200	0.704

Table 3-10 ANZECC (2000) x 10 as Compliance Limit

Constituent	Compliance Limit (ANZECC x 10) (g/m^3)	Compliance Point (m downgradient)	Leachability Limit (g/m^3)
Vinyl Chloride			
Benzene	9.5	100	530
246 Trichlorophenol	0.03	100	1
Arsenic	2.4	100	385
Cadmium	0.0002	100	0.44
Naphthalene	0.16	100	34

Movement of the compliance point to 200 metres downgradient results in a small increase in the leachability limit. This increase is no more than if the limit derived using a compliance point at 100 metres were to be rounded up.

Multiplying the ANZECC criteria by an order of magnitude results in a significant increase in the leachability limit. However, this approach is not considered justified as the groundwater discharge will affect the surface water receptors at the discharge point and the degree of dilution is highly variable depending on the type of water body and water flow at the discharge point.

3.4 Recommended Draft Leachability Limits

Leachability limits, developed using the methodologies described in Section 3.3, recommended as draft limits for further consideration and consultation, are presented in Table 3-11.

Draft limits have been reported following rounding down to one significant figure, from the result obtained by modelling.

Table 3-11 also lists the dilution and attenuation factor (DAF), the degree to which constituents concentrations are reduced in reaching the compliance point, following rounding.

The NZDWS and ANZECC compliance guidelines multiplied by 100 and 1000 respectively (DAFs commonly specified, in resource consents, for calculating acceptance criteria for constituents for which no USEPA TCLP limits exist) are also listed for comparison.

The New Zealand Standard Model Trade Waste Bylaw (NZS 9201: Part 23:1999) limits for acceptance of trade wastes are also commonly specified, in resource consents, for calculating acceptance criteria for constituents for which no USEPA TCLP limits exist. These provide a guide as to the potential for leachate treatability to be a constraint on waste acceptance.

Leachability limits for a number of organic and inorganic constituents for which USEPA TCLP limits exist have also been determined, for comparison.

A number of organic constituents have short half-lives and low K_{oc}s which, when modelled, result in limits that are extremely high, or virtually unlimited, in respect of the groundwater pathway. With some exceptions, those constituents with half-lives of less than 365 days were remodelled using a half-life of 365 days.

Table 3-11 Draft Leachability Limits (all concentrations g/m^3)

ORGANIC CONTAMINANTS	R	Half Life (days)	USEPA TCLP	NZDWS	ANZECC 2000	ANZECC 1999	Guideline/ Standard	Compliance Value	MfE TCLP		**Proposed Limit**	DAF (proposed limit)	NZDWS x 100	ANZECC x 1000	NZS 9201
									No Decay	Decay					
Aromatic Hydrocarbons															
Aniline	1.12	365*	-	-	-	0.002	ANZEEC 99	0.002	0.045	0.25	**0.2**	100		2	5**
Styrene	27.00	365*		0.004			NZDWS	0.004	0.1	6	**6**	1500	0.4		5**
Polynuclear Aromatic Hydrocarbons															
Naphthalene	2.22	258	-	-	0.016	0.0003	ANZEEC 00	0.016	0.38	17.5	**10**	625		16	0.05**
Other Halogenated Aromatic Hydrocarbons															
1,2,3 Trichlorobenzene	6.69	365*			0.003	0.018	ANZEEC 00	0.003	0.07	50	**50**	16667		3	0.002**
1,2,4 Trichlorobenzene	2.40	365*			0.085	0.017	ANZEEC 00	0.085	2.2	45	**40**	471		85	0.002**
1,2 Dichlorobenzene	1.70	365	-	0.001	0.16	0.007	NZDWS	0.001	0.025	0.28	**0.2**	200	0.1	160	0.002**
1,3 Dichlorobenzene	1.44	365*			0.26	0.0017	ANZEEC 00	0.26	6.3	52	**50**	192		260	0.002**
BTEX															
Benzene	1.13	732	0.5	0.01	0.95	0.23	NZDWS	0.01	0.24	0.62		62	1	950	5**
Toluene	1.14	365*	-	0.80	0.80	0.17	NZDWS	0.80	16.5	100	**100**	125	80	800	5**
Ethyl benzene	1.41	365	-	0.30	-	0.086	NZDWS	0.30	14	59	**50**	167	30		5**
Xylene (m,o,p)	1.80	365*	-	0.60	0.2	0.032	NZDWS	0.60	19	175	**100**	167	60	200	5**
Chlorinated Aliphatic Hydrocarbons															
Vinyl Chloride	1.01	2897	0.2	0.005			NZDWS	0.005	0.125	0.16		32	0.5		1**
1,2 Dichloroethene	1.26	336	-	0.06	-	-	NZDWS	0.06	1.4	11	**10**	167	6		1**
1,3 Dichloropropene	1.08	365*	-	0.02	-	-	NZDWS	0.02	0.5	2.5	**2**	100	2		1**
Dichloromethane	1.03	365*	-	0.02	-	3.1	NZDWS	0.02	0.47	2.5	**2**	100	2		1**
1,1,1, Trichloroethane	1.23	546	-	2	-	0.13	NZDWS	2	46	250	**200**	100	200		1**
1,1,2 Trichloroethane	1.16	732	-	-	6.5	0.27	ANZECC 00	6.5	150	520	**500**	77		6500	1**
1,1,2,2 Tetrachloroethane	1.21	365*	-	-	-	0.2	ANZECC 99	0.2	4.7	49	**40**	200		200	1**
1,2 Dibromo-3-chloropropane	1.08	365	-	0.001	-	0.001	NZDWS	0.001	0.025	0.2	**0.2**	200	0.1		1**
1,2 Dichloropropane	1.12	2590	-	0.05	-	0.6	NZDWS	0.05	1.2	1.7	**1**	20	5		1**
Other Halogenated Aliphatic Hydrocarbons															
Bromodichloromethane	1.15	6570	-	0.06	-	-	NZDWS	0.06	1.4	1.6	**1**	17	6		1**
Bromoform	1.33	365	-	0.1	-	-	NZDWS	0.1	2.35	18	**10**	100	10		1**
Dibromochloromethane	1.22	365*	-	0.1	-	-	NZDWS	0.1	2.35	16	**10**	100	10		1**
Phenols															
2,4,6 Trichlorophenol	2.13	1825	2	0.002			NZDWS	0.002	0.05	0.12			0.2		0.02**
2 Chlorophenol	1.13	365*	-	0.0003	-	-	NZDWS	0.0003	0.007	0.05	**0.05**	167	0.03		0.02**
2,4 Dichlorophenol	1.38	365*	-	0.0003	0.12	0.03	NZDWS	0.0003	0.007	0.05	**0.05**	167	0.03	120	0.02**
Phenol	1.04	365*	-	-	0.32	0.006	ANZECC 00	0.32	7	40	**40**	125		320	50**
Organochlorine Pesticides															
Aldrin	2.06	1095			0.000001		ANZECC 99	0.000001	0.000024	0.00008	**0.00008**	80		0.001	0.2**
Dieldrin	34.49	2190				0.000006	ANZECC 99	0.000006	0.00014	0.45	**0.4**	66667		0.006	0.2**
Endosulfan	6.31	365*			0.00003		ANZECC 00	0.00003	0.0007	0.35	**0.3**	10000		0.03	0.2**

* Half-life set at 365 days, rather than literature value.

** Total for all compounds in group

Table 3-11 Draft Leachability Limits (continued) (all concentrations g/m^3)

ORGANIC CONTAMINANTS	R	Half Life (days)	USEPA TCLP	NZDWS	ANZECC 2000	ANZECC 1999	Guideline/ Standard	Compliance Value	MfE TCLP No Decay	MfE TCLP Decay	**Proposed Limit**	DAF (proposed limit)	NZDWS x 100	ANZECC x 1000	NZS 9201
Acidic Herbicides															
2,4 Dichlorophenoxyacetic acid (2,4 D)	1.05	182	10	0.04	0.28	0.014	NZDWS	0.04	0.9	17		425	4	280	0.2**
Phthalates															
Diethylphthalate	1.18	365*	-	-	1	0.12	ANZECC 00	1	23	150	**100**	100		100	
Dimethylphthalate	1.02	365*	-	-	3.7	0.35	ANZECC 00	3.7	90	450	**400**	108		370	
Di-n-butylphthlate	4.59	365*			0.026		ANZECC 00	0.026	0.6	350	**300**	11538		2.6	
Other Organics															
Carbon disulphide	1.18	365*	-	-	-	0.021	ANZECC 99	0.021	0.5	3.5	**3**	143		2.1	
Organometallics															
Tributyltin oxide (TBTO)	237.08	335	-	0.002	-	-	NZDWS	0.002	0.048	3.2	**3**	1500	0.2		

* Half-life set at 365 days, rather than literature value.

** Total for all compounds in group

INORGANIC CONTAMINANTS		Cf	USEPA TCLP	NZDWS	ANZECC 2000	ANZECC 1999	Guideline/ Standard	Compliance Value	MfE TCLP Uncorrected	MfE TCLP Corrected	**Proposed Limit**	DAF (proposed limit)	NZDWS x 100	ANZECC x 1000	NZS 9201
Aluminium		75		0.15	0.027	0.0012	ANZECC 00	0.027	0.65	48.8	**40**	1481	15	27	300
Antimony		9		0.003		0.0076	NZDWS	0.003	0.07	0.6	**0.6**	200	0.3		10
Arsenic		13	5	0.01	0.024	0.0016	NZDWS	0.01	0.24	3.1			1	24	5
Barium		31	100	0.7	0.70		ANZECC 00	0.7	16.5	513			70	700	10
Beryllium		151		0.004			NZDWS	0.004	0.09	14	**10**	2500	0.4		0.005
Boron		2		1.4	0.37	0.0048	ANZECC 00	0.37	9	20	**20**	54	140	370	25
Cadmium		9	1	0.003	0.0002	0.000013	ANZECC 00	0.0002	0.005	0.04			0.3	0.2	0.5
Chromium		61	5	0.05		0.009	NZDWS	0.05	1.3	79.3			5		5
Copper		151		2	0.0014	0.00033	ANZECC 00	0.0014	0.035	5.3	**5.0**	3571	200	1.4	5
Fluoride		7		1.5			NZDWS	1.5	38	266	**200**	133	150		30
Lead		31	5	0.01	0.0034	0.0012	ANZECC 00	0.0034	0.09	2.8			1	3.4	10
Lithium		-		0.9			NZDWS	0.9	21	-	**20**		90		
Mercury		952	0.2	0.002	0.00006	0.000013	ANZECC 00	0.00006	0.00135	1.3			0.2	0.06	0.005
Molybdenum		11		0.07		0.0067	NZDWS	0.07	1.15	12	**10**	143	7		10
Nickel		61		0.02	0.011	0.0007	ANZECC 00	0.011	0.25	15	**10**	909	2	11	5
Selenium		13	1	0.01	0.005	0.0014	ANZECC 00	0.005	0.11	1.4			1	5	10
Silver		61	5	0.02	0.00005	0.000005	ANZECC 00	0.00005	0.0017	0.104			2	0.05	
Tin		61		1			NZDWS	1	22.5	1373	**1000**	1000	100		20
Vanadium		20				0.006	ANZECC 99	0.006	0.135	2.7	**2.0**	333		6	
Zinc		61		3	0.008	0.0024	ANZECC 00	0.008	0.18	11.0	**10**	1250	300	8	10

4.1 Introduction

This section discusses issues related to the use of total as threshold concentrations for LWAC and mass loading of constituents.

An air pathway model was used to investigate whether or not total limits are necessary for selected volatile organic constituents in respect of the air pathway. That is, whether or not the dispersion of constituents via vapour, landfill gas, or dust, in the air to the most sensitive receptor via the air pathway results in the most conservative acceptance criteria.

Total concentration limits for some constituents are developed based on separate phase concentrations.

4.2 Total Concentration Limits

Total concentration limits can be used in landfill waste acceptance criteria in three ways.

- in conjunction with leachable concentrations to determine acceptance;
- as a screening test to determine if leachability testing is required;
- as an acceptance limit, for wastes which may not be appropriate for leachability limits.

4.2.1 Total Concentrations In Conjunction with Leachable Limits

Where LWAC are reliant predominantly on the use of leachability limits, and no mass loading limits are used, there is a potential for concentrations of constituents of concern in leachate to increase if the leachability of constituents increases over time.

Both the New South Wales EPA and Western Australia EPA use total concentration and leachable concentrations together when determining waste acceptance.

For initial acceptance the constituent(s) in question must have both leachable and total concentrations within the limits.

If the leachable concentration is within the leachable limit but the total concentration exceeds the total limit then the constituent with the waste must be immobilised in an approved manner. This is to ensure that constituent immobilisation is sustained over time and that the chemical matrix of the waste does not change under landfill conditions, resulting in an increase in the rate of constituent release over time.

The primary advantage in the use of total concentration limits relates to the following types of constituents:

- persistent chemicals;
- chemicals that do not degrade readily;

- chemicals that do not readily undergo precipitation or complexation reactions within the landfill or subsurface environment; and
- chemicals that are not readily adsorbed by other landfilled materials or subsurface materials.

The use of total concentration limits in conjunction with leachable concentrations is not recommended for all constituents. It is considered that landfill sites that conform with Class A criteria, will provide a high level of protection in respect of groundwater and surface water receptors. Therefore, the use of leachability limits to control constituent concentrations in leachate is considered an appropriate mechanism to limit groundwater and surface water contamination.

The potential for discharges to the air to be a limiting factor in waste acceptance is addressed in Section 4.4.1.

4.2.2 Total Concentrations as a Screening Test

Total concentrations can be used to determine whether or not a TCLP test is required. This issue is discussed in more detail in Section 7.2.

4.2.3 Total Concentrations as Acceptance Limits

The use of total concentration limits is likely to be more appropriate for constituents that are not highly soluble. In this report constituents with a K_{oc} of greater than three are considered to be relatively immobile in respect of leachate discharges via groundwater. For these constituents a total concentration limit is recommended in preference to a leachability limit, as detailed in Table 3-1.

The development of total concentration limits for non-volatile constituents is addressed in Section 4.4.2.

4.3 Mass Loadings

Mass loading limits are a means of ensuring that the mass of constituent release can never exceed prescribed limits.

Mass loading limits can be used to ensure that constituents of concern are dispersed throughout a landfill by applying limits in the following ways:

- per truckload entering the landfill site;
- over a specified time period (for example per week or per month)

Mass loading limits can also be set in relation to the total landfill capacity. However, if a total capacity limit is used alone (with no truckload or time period limits or leachability limits) problems could potentially result.

If the total allowable mass loading is accepted within a short amount of time early in a landfill's life this could result in high concentration of the constituent concerned in leachate, and affect leachate treatment/disposal systems and, potentially, the containment system.

Similarly if the total allowable mass is concentrated within a small area of the landfill, leachate from that area could also have high concentrations of the constituent concerned.

The South African approach uses mass loading limits on both a per month basis and also a total loading limit for the whole landfill site. This provides a means of ensuring that constituents are dispersed throughout a landfill, while at the same time minimising the potential for constituent leachate concentration to exceed acceptable levels.

There is currently no reliable, well defined, method for linking mass loading limits, leachable concentrations and siting and design requirements to determine the rate of constituent release into the environment. It is suggested that a risk-based methodology could be developed to determine appropriate mass loading limits.

The use of TCLP limits is intended to control constituent concentrations in leachate. The setting of a mass-loading limit for those constituents for which TCLP limits exist, or will be determined, would provide an additional level of conservatism, in respect of waste acceptance.

The TCLP test uses a solid to liquid ratio of 1:20. The solid to liquid ratio of leachate within a landfill is 2:1, based on refuse at a density of 1 tonne per cubic metre with a porosity of 0.5. For the solid to liquid ratio used in TCLP tests to be representative of the leachate it can, therefore, be assumed that the mass load of contaminated waste within the landfill cannot exceed 2.5 percent.

Some constituents are not suitable for TCLP limits (for example, non mobile organics). In these cases it may be appropriate to develop mass loadings, both on an annual basis, and for the design capacity of the landfill, are an appropriate means to control the potential for adverse effects on the environment.

The development of mass loading limits would require a risk based approach taking into account:

- the most sensitive pathway for the constituents of concern;
- constituent characteristics (for example volatility, persistence);
- local site characteristics; and
- potential long term uses of the site.

4.4 Air Discharges

4.4.1 Discussion

Discharge of contaminants into the air is another route by which people and the environment can be affected by wastes being landfilled. Discharges can include emissions from volatile organic compounds, landfill gas and dust.

This section describes an air pathway model used to investigate the whether or not total limits are necessary for selected volatile organic constituents for the air pathway. That is, whether or not the dispersion of constituents via vapour, or dust, in the air to the most sensitive receptor via the air pathway results in the most conservative acceptance criteria.

The proposed leachability limits in Table 3-11, are intended to protect groundwater, and surface water via groundwater discharge, from constituents in leachate. However, there may be some constituents for which the proposed leachability limits do not provide appropriate protection in respect of the air discharge pathway.

Acceptance criteria for some volatile organic compounds may be limited by the potential health or odour effects due to air discharges. Potential effects need to be considered on a constituent specific basis taking into account the following:

- constituent volatility;
- constituent toxicity;
- quantity of waste requiring disposal;
- frequency of disposal;
- site location;
- site weather conditions;
- proximity of site neighbours.

At a site level emissions from volatile organic compounds can generally be controlled through operating procedures and a landfill gas collection and treatment/disposal system. However, additional measures may need to be put in place to protect drivers transporting wastes and landfill site workers and machinery operators in respect of some constituents. In addition, normal site operating practices may not be sufficient to avoid odour nuisance, for some volatile constituents with characteristic odours.

The use of total concentration limits for broad classes of compounds (for example non-halogenated hydrocarbons, halogenated hydrocarbons, BTEX) can be used to limit potential air effects. Where the health and safety of workers is a concern total limits can be developed based on workplace exposure standards for the relevant constituent(s).

The USEPA has total limits for the following classes of compounds:

• total halogenated compounds	1000 mg/kg;
• total synthetic non-halogenated compounds	10,000 mg/kg;
• polychlorinated biphenyls	50 mg/kg.

Some landfills in New Zealand have set total limits for the above classes of compounds at a more restrictive level.

Constituents for which total limits are more appropriate may need additional checking to ensure that no separate phase product is present in the waste or leachate.

4.4.2 Model Set-up

A model landfill and two scenarios (operating and closed landfill) were used to develop air exposure/pathway assumptions.

The following landfill design and operating parameters were assumed.

- a one hectare lined cell (100 metres by 100 metres square or a circle of radius 56.4 metres);
- contaminated waste containing each constituent of concern could cover the whole of the working face during the working day;
- contaminated waste containing each constituent of concern could cover the whole of the cell area beneath the cover, once installed.

Table 4-1 outlines the model design and operating parameters for the operating landfill working face and cover and closed landfill cover.

Model Scenarios

The operating landfill scenario is summarised diagrammatically in Figures 4-1 and 4-2. The operating landfill scenario is further divided into effects on site workers and downwind residents.

The closed landfill scenario is summarised diagrammatically in Figures 4-3 and 4-4. The closed landfill scenario is further divided into effects on site users and downwind residents.

Table 4-1 Model Landfill Design Parameters

Landfill Cell Dimensions	
Landfill Area	1 hectare (100 metres by 100 metres square or a circle of radius 56.4 metres)
Waste Depth	10 metres
Waste Volume	100,000 cubic metres
Total Waste Tonnage	75,000 tonnes
Working Face Dimensions	
Working Face Area	900 square metres (30 metres by 30 metres or a circle of radius 16.9 metres.)
Landfill Cover System	
Cover Depth	600 millimetres
Cover Permeability	1×10^{-7} metres per second
Contaminated Waste	
Total Volume per Constituent	2,500 cubic metres
Total Tonnage per Constituent	1,875 tonnes
Maximum Area of Contaminated Waste on Working Face	900 square metres
Maximum Area of Contaminated Waste Beneath Cover	10,000 square metres

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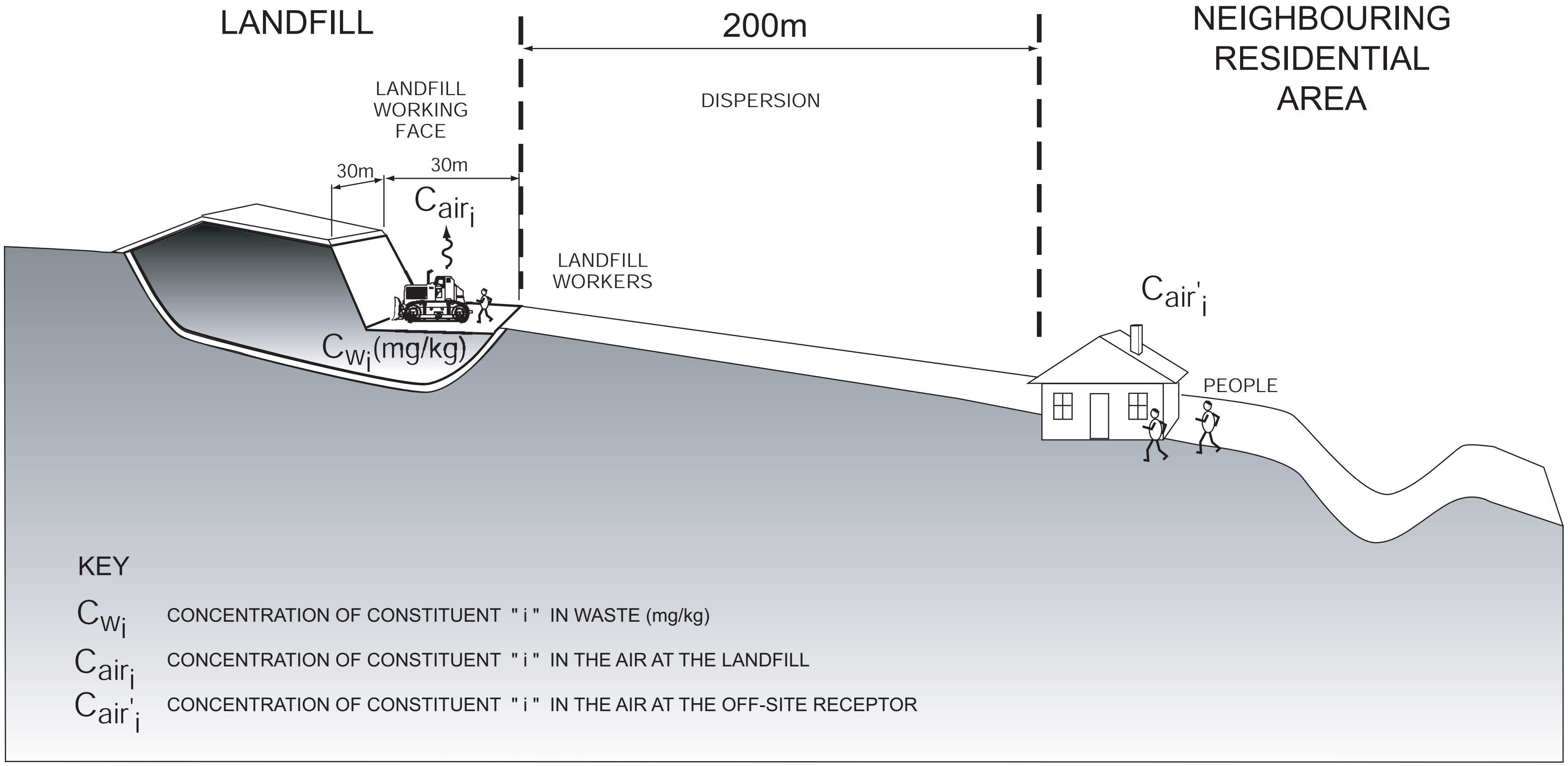

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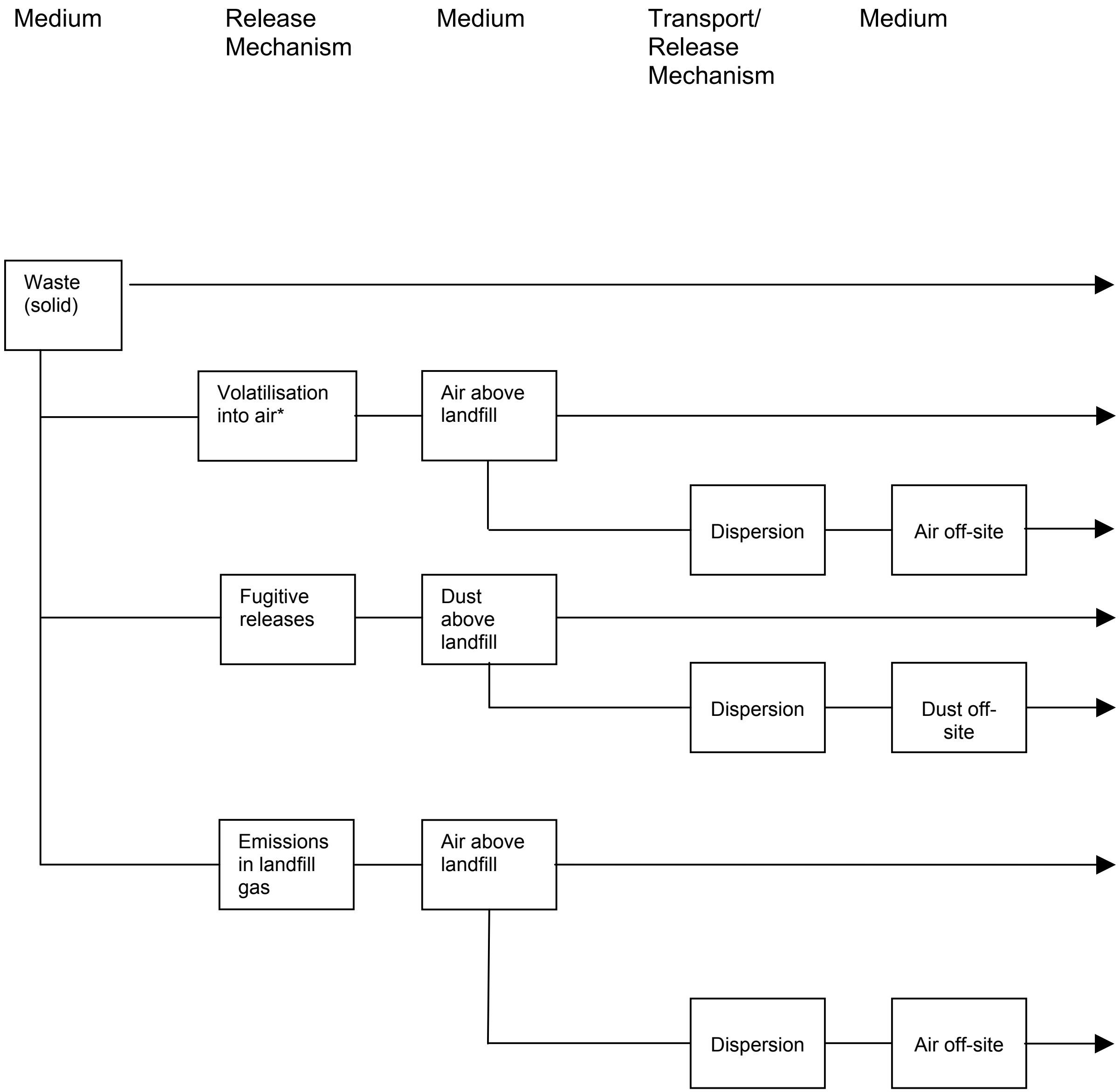
SCENARIO 1 - OPERATING LANDFILL
FIGURE 4-1

Figure 4-2 Scenario I – Operating Landfill



	LANDFILL WORKER				NEIGHBOUR			
	Inhalation of vapour	Inhalation of dust	Ingestion	Dermal contact	Inhalation of vapour	Inhalation of dust	Ingestion	Dermal contact
Waste (solid)	N/A	N/A	X	X	N/A	N/A	X	X
Air above landfill	✓	N/A	N/A	N/A	-	-	-	-
Air off-site	-	-	-	-	✓	N/A	N/A	N/A
Dust above landfill	N/A	✓	✓	N/A	-	-	-	-
Dust off-site	-	-	-	-	-	-	-	-
Air above landfill	✓	N/A	N/A	N/A	-	-	-	-
Air off-site	-	-	-	-	✓	N/A	N/A	N/A

← Resident is most sensitive

Notes/Assumption

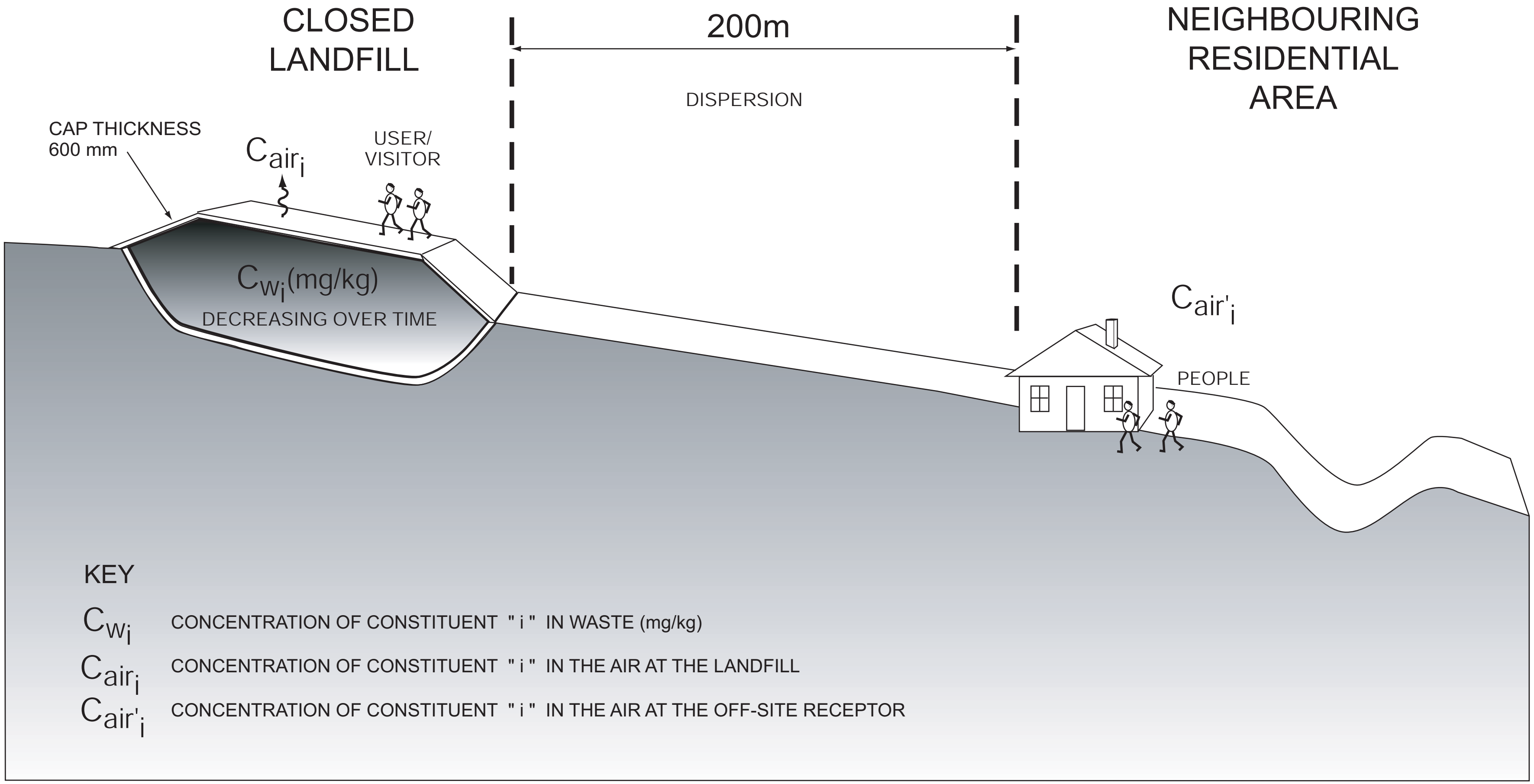
- No public access on landfill
- Workers eliminate direct contact with waste by PPE

- No cover/cap attenuation
- Applies only to volatile constituents

Vap >? pressure

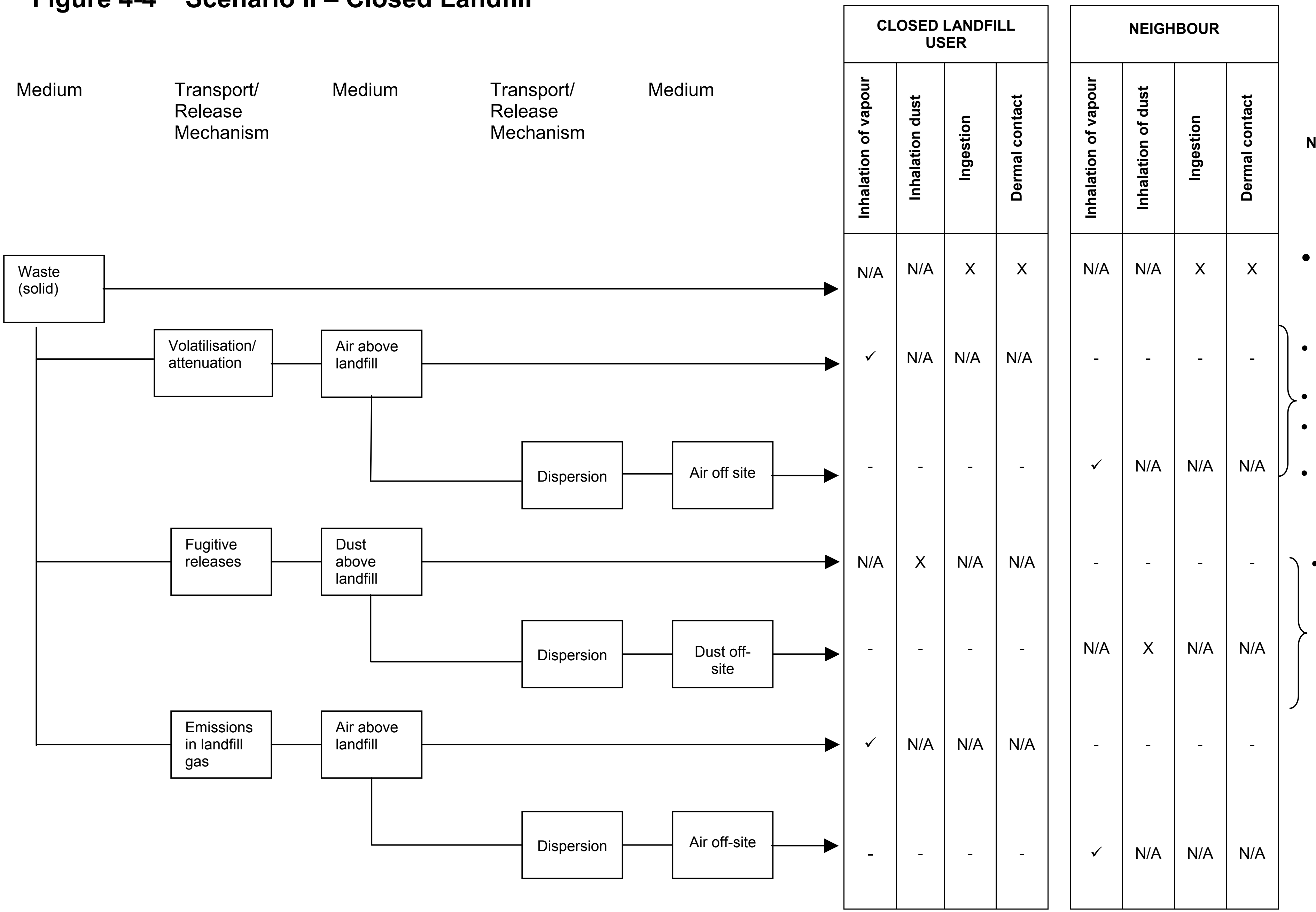
- applies primarily to non-volatile constituents that occur in dusts
- use of control mechanisms in landfill will significantly reduce this pathway → could be eliminated from calcs

X	Exposure route possible but not complete
N/A	Exposure route not applicable to medium
✓	Exposure route complete



SCENARIO 2 - CLOSED LANDFILL
FIGURE 4-3

Figure 4-4 Scenario II – Closed Landfill



Medium	Transport/ Release Mechanism	Medium	Transport/ Release Mechanism	Medium	CLOSED LANDFILL USER: Inhalation of vapour	CLOSED LANDFILL USER: Inhalation dust	CLOSED LANDFILL USER: Ingestion	CLOSED LANDFILL USER: Dermal contact	NEIGHBOUR: Inhalation of vapour	NEIGHBOUR: Inhalation of dust	NEIGHBOUR: Ingestion	NEIGHBOUR: Dermal contact	Notes/Assumption
Waste (solid)					N/A	N/A	X	X	N/A	N/A	X	X	Cap eliminates contact with waste
	Volatilisation/ attenuation	Air above landfill			✓	N/A	N/A	N/A	-	-	-	-	Applies to volatile construction only [Vap >? press] Attenuation through cap
			Dispersion	Air off site	-	-	-	-	✓	N/A	N/A	N/A	Concentration diminishes over time
	Fugitive releases	Dust above landfill			N/A	X	N/A	N/A	-	-	-	-	No dust created/eliminated by cap
			Dispersion	Dust off-site	-	-	-	-	N/A	X	N/A	N/A	
	Emissions in landfill gas	Air above landfill			✓	N/A	N/A	N/A	-	-	-	-	
			Dispersion	Air off-site	-	-	-	-	✓	N/A	N/A	N/A	

Notes/Assumption

- Cap eliminates contact with waste
- Applies to volatile construction only
- [Vap >? press]
- Attenuation through cap
- Concentration diminishes over time
- No dust created/eliminated by cap

X	Exposure route possible but not complete
N/A	Exposure route not applicable to medium
✓	Exposure route complete

Air Quality Criteria for Pathways

Table 4-2 details the criteria that can be used to calculate limits for each exposure pathway.

Table 4-2 Pathway Air Quality Criteria

Receptor / Pathway	Operating Landfill Worker	Operating Landfill Neighbour	Closed Landfill Site User	Closed Landfill Neighbour
Air above Landfill	WES-TWA [1]	-	Human Health	-
Air dispersion off-site	-	Human Health	-	Human Health
Dust above landfill	WES-TWA	-	Human Health	-
Dust dispersion off-site	-	Human Health	-	Human Health
Landfill gas	WES-TWA [1]	-	Human Health	-
Landfill gas dispersion off-site	-	Human Health		Human Health

[1] WES-TWA = Workplace Exposure Standard – Time Weighted Average

Determination of Total Limits Based on Air Volatilisation Pathway

Three models can be used to back calculate, from air quality criteria, total limits for constituents in contaminated material arriving at, or contained in, a the model landfill

- a soil volatilisation model, which is used to determine concentrations in contaminated material;
- a box model, which estimates the concentration of a constituent in the breathing zone overlying a contaminated area; and
- an air dispersion model, which is used to estimate ground level concentrations of constituents emitted from a source.

Soil Volatilisation and Box Models Set-up

A combined soil volatilisation and box model was initially set up for the vapour in air pathway for a site worker at the downwind end of the operating landfill working face. The soil volatilisation model was based on the Johnson and Ettinger (1991) model, as per the MfE Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (1999).

Table 4-3 details the input parameters for the soil volatilisation model. Porosity, moisture content, bulk density and organic carbon fraction are based on the constituents being present in a sandy silt.

Table 4-3 Soil Volatilisation Model Input Parameters

Parameter	Value
Area of Emission	900 square metres
Soil Temperature	20 degrees C
Total Porosity	0.38 percent
Moisture Content	0.12 percent
Volumetric Water Content	0.12 percent
Soil Bulk Density	1.9 grams per cubic centimetre
Organic Carbon Fraction	0.025 percent

The box model takes the volatile emission rate from the contaminated area (in this case the landfill working face) and calculates a concentration at two metres above ground level, conservatively assuming that the receptor is located at the edge of the box and downwind of the source.

The input parameters used in the box model are detailed in Table 4-4.

Table 4-5 details the vapour pressures of selected constituents.

Table 4-4 Box Model Input Parameters

Parameter	Value
Area of landfill cell	10,000 square metres
Area of working face	900 square metres
Length of box – L	33.8 metres (assumes working face circular)
Height of box - H	2 metres
Wind speed - *u*	0.5 metres per second

Table 4-5 Constituent Vapour Pressures

Constituent	Vapour Pressure at Specified Temperature (mmHg)			
	15°C	20°C	25°C	30°C
Styrene (vinyl benzene)	4.3	5	6.45	9.5
Benzo(a)pyrene (carcinogenic PAH's)		5.09E-08		1.90E-07
1,2,3 Trichlorobenzene			1.1	
1,2,4 Trichlorobenzene		1	0.35	
1,3 Dichlorobenzene			2.1	
4,4 DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene)			14.4E-06	9.7 E-06
Aldrin		4.9E-05	19.1 E-05	
DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane)		1.7E-07	17.0 E-07	6.0 E-07
Dieldrin		29.5e10-7	362 E-07	100 E-07
Endosulfan			1.0 E-05	

Those constituents with a vapour pressure of less than one millimetre of mercury are not sufficiently volatile to provide vapour concentrations that are a potential issue. Therefore, the vapour in air pathway is not the sensitive pathway.

Modelling Results

The model results for constituents with a vapour pressure greater than one (styrene and 1,3 dichlorobenzene) are detailed in Table 4-6. 1,2,3 trichlorobenzene was not modelled as no published workplace exposure standards or air quality criteria could be sourced for this constituent.

In addition benzene, naphthalene, 1,2 dichlorobenzene and dichloromethane (volatile constituents, with a vapour pressure greater than one millimetre of mercury, for which leachability limits have been proposed) were modelled for comparison.

The concentration in waste, shown in Table 4-6, for styrene and 1,3 dichlorobenzene is the concentration at which the maximum concentration in air, due to volatilisation, is reached. The resulting concentration at the downwind end of the working face is well within the WES – TWA, indicating that the vapour in air pathway is not the limiting pathway for these constituents. This is also the case for naphthalene and 1,2 dichlorobenzene.

Modelling was repeated using estimated emission rates of landfill gas through refuse on the working face, which gave less conservative results.

Table 4-6 Modelling Results for Selected Constituents

Constituent	**Air Diffusion Coefficient (cm^2/sec)**	**Concentration in Waste (mg/kg)**	**Concentration in Air (mg/m^3)**	**WES – TWA (mg/m^3)**
Styrene	0.071	6000 [1]	145	213
1,3 Dichlorobenzene	0.064	503 [1]	6	18
Naphthalene	0.059	8 [1]	2.0	52
Benzene	0.088	20	16	16
1,2 Dichlorobenzene	0.069	2090 [1]	32	301
Dichloromethane	0.101	120	174	174

[1] Waste concentration at which maximum emission rate reached.

Use of the soil volatilisation and box model in modelling of vapour discharges from the model landfill working face indicates that volatilisation of the constituents considered is unlikely to be a restrictive pathway in terms of harmful effects on landfill site workers.

The volatilisation scenario whereby the receptor is a site worker at the downwind edge of the landfill working face will provide the highest constituent concentrations in air at the receptor. The scenarios involving off-site receptors downwind of the operating landfill and site users and downwind receptors for a closed landfill will result in lower constituent concentrations due to the effects of dispersion and soil cover. Therefore, these scenarios were not modelled.

However, the results indicate that the vapour in air pathway may be limiting for benzene and dichloromethane. This issue is addressed in Section 4.5.

Other Potential Pathways

While it is assumed that the volatilisation of volatile constituents will be the most likely pathway for effects on people, other potential pathways are:

- landfill gas, for operating site workers and site neighbours and closed site users;
- dust ingestion, by operating site workers and site neighbours;
- dermal exposure, for operating site workers and closed site users.

Dust

The amount, and potential effects, of dust produced at the working face of an operating landfill is affected by a number of factors, including:

- moisture content of the material being landfilled;
- type of machinery used at the working face;
- weather conditions (temperature, wind and rain).

The potential for adverse effects on site workers, by way of dust ingestion, can be controlled through good operational practices, such as wetting of dusty material, immediate burial and use of personal protective equipment. However, there are some wastes (for example, sawdust from MDF manufacture, that is difficult to wet due to glue constituents which can also cause eye irritation) for which more specific management procedures may be required.

The potential for adverse effects on site neighbours, by way of dust ingestion, can be reduced through the use of operating practices such as wetting of dusty material and immediate burial.

The number of variables involved make it difficult to predict dust quantities, constituent concentrations in dust and exposure of potential on-site and off-site receptors. Therefore, no attempt has been made to model potential dust effects.

Landfill Gas

Landfill gas is a mixture of methane, carbon dioxide and a number of trace organic constituents emanating from landfill wastes and the breakdown products of landfilled waste. These trace constituents can be carcinogenic and also tend to be odorous.

It is likely that any constituents of concern will be dilute in landfill gas and that landfill gas will require controls based on it's inherent properties (flammability, toxicity of components such as carbon dioxide and sulphur dioxide, and odour), rather than any specific constituent accepted at a landfill.

Dermal Exposure

The potential for adverse effects on site workers, by way of dermal exposure, can be reduced through the use of personal protective equipment.

The potential for adverse effects on closed site users, by way of dermal exposure, can be reduced through the installation and maintenance of an appropriate depth of site capping.

A minimum depth of 600 millimetres of compacted clay and 150 millimetres of topsoil, as recommended in the CAE Landfill Guidelines (2000), is considered to reduce the potential for dermal exposure to an acceptable level.

4.4.3 Recommendation

It is recommended that no total limits be established for individual constituents, based on the landfill gas, dust and dermal exposure pathways.

4.5 Separate Phase Constituents in Leachate

A number of constituents, for which the development of landfill waste acceptance criteria is recommended, are not restricted by the leachate/groundwater/surface water pathway, or the volatilisation in air pathway.

An alternative approach to developing an appropriate acceptance criteria is to determine the concentration at which the constituent becomes separate phase in leachate. Acceptance criteria below, this concentration should ensure that the constituent remains either bound up in the refuse mass or dissolved in leachate and is not present as a non-aqueous phase liquid (NAPL).

4.5.1 Determination of Separate Phase Concentration

The concentration at which constituents become separate phase in leachate (S_c) was calculated using the following equation, where S_c equals the solubility limit for the constituent.

Equation 1

$$\text{leachate concentration } (S_c \text{ in gm}^{-3}) = \frac{\text{concentration of constituent in waste (mg/kg)}}{\text{distribution coefficient } (K_d \text{ in ml/g})}$$

The results for selected constituents are detailed in Table 4-7. The results for benzene and dichloromethane indicate that the proposed leachability limits will ensure a total concentration that does not result in the air pathway being the limiting pathway.

In addition total concentrations were calculated for carcinogenic PAHs. The results are detailed in Table 4-8.

This approach is inherently conservative for PAHs, as typical concentrations of greater than 10,000 mg/kg for total petroleum hydrocarbons are required in soil to result in mobile separate phase constituents. The indeno(1,2,3-cd)pyrene, chrysene and benzo(k)fluoranthene concentrations are unrealistically low as total limits, due to their low solubility, and the benzo(a)pyrene number is recommended for adoption.

Table 4-7 Separate Phase Concentration Calculations

Constituent	logK_{oc}	K_{oc}	f_{oc}	K_d	Solubility (g/m^3)	Total Conc. in Waste [1] (mg/kg)	Proposed Leachability Limit [2] (g/m^3)	Total Conc. from Leachability Limit [1] (mg/kg)	Total Conc. from Air Model [3] (mg/kg)	Leachate Conc. from Air Model [1] (g/m^3)
Styrene	2.96	912	0.254	232	310	71,812	6	1,390		
Benzo(a)pyrene	5.94	870,964	0.254	221,225	0.00162	358				
1,2,3 Trichlorobenzene	3.34	2,188	0.254	556	18	10,002	50	27,785		
1,2,4 Trichlorobenzene	2.73	537	0.254	136	300	40,922	40	5,456		
1,3 Dichlorobenzene	2.23	170	0.254	43	70	3,019	50	2,157		
Heptachlor	4.38	23,988	0.254	6,093	0.18	1,097				
Heptachlor Epoxide	4.32	20,893	0.254	5,307	0.35	1,857				
DDE	4.42	26,303	0.254	6,681	0.12	802				
Aldrin	2.61	407	0.254	103	0.18	19	0.0008	0.083		
DDT	4.98	95,499	0.254	24,257	0.025	606				
Dieldrin	4.11	12,882	0.254	3,272	0.195	638	0.4	1,309		
Endosulfan	3.31	2,042	0.254	519	0.51	264	0.3	156		
Benzene	1.7	58.9	0.254	15	1750	26,181	0.5	7.4803	20	1
Dichloromethane		10	0.254	3	13000	33,020	2	5.08	120	47
Napthalene	2.67	468	0.254	119	31	3,683	10	1,188		
1,2 Dichlorobenzene	2.43	269	0.254	68	156	10,659	0.2	14		

[1] Calculated using equation 1

[2] From Table 3-11

[3] From Table 4-6

Table 4-8 Total Concentration Calculations – Carcinogenic PAHs

Constituent	$\log K_{oc}$	K_{oc}	f_{oc}	K_d	Solubility (g/m^3)	Total Conc. in Waste [1] (mg/kg)
CARCINOGENIC PAHs						
Benzo(a)pyrene	5.94	870,964	0.254	221,225	0.00162	358
Benzo(a)anthracene	5.81	645,654	0.254	163,996	0.016	2,624
Benzo(b)fluoranthene	6.7	5,011,872	0.254	1,273,016	1.50E-03	1,910
Benzo(k)fluoranthene	5.99	977,237	0.254	248,218	8.00E-04	199
Chyrsene	5.27	186,209	0.254	47,297	1.60E-03	76
Dibenzo(a,h)anthracene	6.22	1,659,587	0.254	421,535	2.49E-01	104,962
Indeno(1,2,3-cd)pyrene	6.3	1,995,262	0.254	506,797	2.20E-05	11

4.6 Recommended Draft Total Limits

Based on the results of air discharge modelling, it is recommended that no total limits be established for waste acceptance for individual constituents at Class A landfills, based on the volatilisation in air pathway. The use of leachability limits, recommended in Section 3.4, is likely to provide adequate environmental protection. However, as discussed in Section 4.4.1, site specific conditions and operating practices may make it advisable to set site specific total limits for some classes of constituents.

Total limits, developed using the methodology described in Section 4.5, recommended as draft limits for further consideration and consultation, are presented in Table 4-9.

The proposed draft total limits for carcinogenic PAHs is based on benzo(a)pyrene.

Table 4-9 Draft Total Limits

Constituent	Total Concentration in Waste (mg/kg)	Proposed Total Concentration Limit (mg/kg)
Benzo(a)pyrene	358	300
Carcinogenic PAHs		300
Heptachlor Epoxide	1,857	1,500
DDE	802	500
DDT	606	500

5.1 Introduction

Bulk liquid waste is generally prohibited from disposal at landfills for the following reasons:

- it increases the volume of leachate generated and requiring treatment and/or disposal;
- it can result in increased odour nuisance; and
- it can reduce the stability of the refuse mass, under certain conditions.

The prohibition of bulk liquid wastes requires an appropriate definition and practical test to enable clear, consistent and unequivocal determination of whether or not a waste is suitable for disposal.

This section discusses a number of definitions of liquid waste and some of the most frequently used methods to determine what constitutes a liquid waste. These include:

- the USEPA paint filter liquids test;
- the USEPA liquid release test;
- the USEPA liquid release test, pre-test;
- the UK liquid waste definition;
- classification of waste as a liquid – South Australia EPA;
- New South Wales EPA liquid waste definition;
- IB 49 slump test (Cement and Concrete Association of New Zealand);
- 2540 G. total, fixed, and volatile solids in solid and semi-solid samples (APHA).

The advantages and disadvantages of the different definitions and test methods are outlined and a recommendation in respect of a liquid waste tests for New Zealand is made.

5.2 Liquid Waste Tests

5.2.1 The USEPA Paint Filter Liquids Test

This method was designed by the EPA to determine the presence of free liquids in a representative sample of waste (US EPA, 1996, Method 9095A, Paint Filter Liquids Test).

A representative sample of waste is placed in a paint filter (Mesh number: 60 +/- 5%). If any portion of the material passes through and drops from the filter (within a 5 minute test period) the material is deemed to contain free liquids.

The test must not be conducted below the freezing point of any liquid in the sample. The test can, but is not required to, exceed room temperature (25 degrees Celsius).

Table 5-1 Advantages and Disadvantages of the USEPA Paint Filter Liquids Test

Advantages	Disadvantages
Commonly used in the USA (and Australia).	Test could be easily tampered with.
The test is easy to conduct.	An element of trust required to perform the test correctly.
Quick test results.	Does not appear to address issues relating to the response of waste to heat.
Inexpensive test methodology.	
Incorporates issues associated with ‘freezing’.	
Test apparatus easily obtainable from paint shops.	

5.2.2 The USEPA Liquid Release Test

The Liquid Release Test (LRT) is a test that was designed to determine whether or not liquids will be released from sorbents when they are subjected to overburden pressures in a landfill (US EPA, 1994, Method 9096).

It is assumed that any waste that fails the Paint Filter Free Liquids Test (Method 9095A – outlined above) will also fail this test (LRT). It is therefore important to undertake the Paint Filter Free Liquids Test first because this will save time and money (the LRT is not necessary if the waste fails the Paint Filter Free Liquids Test).

A representative sample of liquid loaded sorbent is placed into a testing device (between twin stainless steel screens and two stainless steel grids). The testing device must be able to simulate the pressures within a landfill. Filter paper is placed on either side of each stainless steel grid, opposite the sample. A compressive force of 50 psi is applied to the top of the sample. Release of liquid is obvious when a wet spot appears on the filter paper.

Observations need to be done immediately after the test to ensure that any volatile liquids are seen before they evaporate.

Table 5-2 Advantages and Disadvantages of the USEPA Liquid Release Test

Advantages	Disadvantages
Commonly used in the USA.	Test could be easily tampered with.
The test is easy to conduct.	An element of trust required to perform the test correctly.
Quick test results.	Requires special testing apparatus.

5.2.3 The USEPA Liquid Release Test Pre-test

This is an optional test developed by the USEPA to try and reduce costs, time, and to help prevent unnecessary cleanup and possible damage to the LRT testing device.

A representative sample is loaded onto a glass grid that is placed on a glass plate (stained with 2 dyes (a water soluble dye and an oil soluble dye)). A second glass plate is placed on top of the dyes and a 2 lb. weight placed on the top (for 5 minutes). At the end of the 5-minute period the glass grid is observed to see if any dye has run along the edges.

If dye can be seen along the edges of the glass grid, this indicates liquid release.

Table 5-3 Advantages and Disadvantages of the USEPA Liquid Release Test Pre-test

Advantages	**Disadvantages**
Commonly used in the USA.	Test could be easily tampered with.
The test is easy to conduct.	An element of trust required - to perform the test correctly
Quick test results.	Requires special testing apparatus.
The test can save time and money for the waste holder.	May end up being an additional test for the waste holder.
	Does not appear to address issues relating to the response of waste to heat or ‘freezing’.

5.2.4 The UK Liquid Waste Definition

The UK Government has banned the disposal of liquid waste in landfills. The Government consulted on a definition of liquid waste as it was not defined elsewhere in UK legislation.

The following definition was drawn up by consultants working on behalf of the Department of Environment, Transport and the Regions (DETR).

Liquid waste:

- any waste that near instantaneously flows into an indentation void made in the surface of the waste;
- any waste (load) containing free draining liquid substance in excess of 250 litres or 10%, whichever represents the lesser amount.

The UK Government also gave consideration to the issue of liquid, which is used as an aid to the transportation/deposition of waste and then removed. The Government decided that in some cases the liquid itself might not be waste, but rather the medium of transport. However, it decided that each case like this needs to be considered on its merits and judged independently.

Table 5-4 Advantages and Disadvantages of the UK Liquid Waste Definition

Advantages	Disadvantages
Definition used in the UK.	Requires judgement or measurement of free draining liquid quantity.
Relatively simple, straightforward definition.	
Inexpensive methodology.	

5.2.5 Classification of Waste as a Liquid – South Australia EPA

This method is very similar to the US EPA Paint Filter Test.

A 100 millilitre or 100 milligram representative sample of waste is placed into a paint filter (mesh number: 60 +/- 5%) and observed for 5 minutes. If any of the waste passes through and drops from the filter during the 5 minutes, the waste is classed as liquid.

The test must be performed at no less than 20 degrees Celsius.

Liquid waste includes:

- any liquid waste irrespective of whether or not it is packaged or otherwise contained and irrespective of whether or not the packaging or container is to be disposed of together with the liquid that it contains;
- any waste that is liquid (as determined by the test outlined above) at 20 degrees Celsius.

Table 5-5 Advantages and Disadvantages of the South Australia EPA Classification of Waste as a Liquid

Advantages	Disadvantages
Commonly used in Australia .	Test could be easily tampered with.
Quick test results.	An element of trust required to perform the test correctly.
Inexpensive test methodology.	Does not seem to address issues relating to the response of waste to heat.
Test apparatus easily obtainable from paint shops.	
The test is easy to conduct.	
The test incorporates issues associated with ‘freezing’ and packaging.	

5.2.6 New South Wales EPA Liquid Waste Definition

Under the NSW EPA waste definition all waste is classified into one of three categories: non-liquid, liquid or gaseous. A summary is outlined below.

For waste to be considered non-liquid it must meet all of the following requirements:

- it has an angle of repose of greater than five degrees (5°);
- it has no free liquids when tested in accordance with the USEPA Paint Filter Liquids Test— Method 9095 (US EPA 1986);
- it liberates no free liquids when transported;
- it does not become free flowing at or below 60°C or when transported;
- it is spadeable.

All other waste that is not gaseous is considered to be liquid waste.

Table 5-6 Advantages and Disadvantages of the New South Wales EPA Liquid Waste Definition

Advantages	Disadvantages
The USEPA test is well known and commonly used.	Test could be easily tampered with.
The US EPA test provides quick results, is cheap and easy to conduct.	An element of trust required to perform the test correctly.
Includes the influence of high temperatures and low temperatures (incorporated in Paint Filter test).	Room for error in interpretation.
Includes the influence of transport.	Some expertise required to perform tests.
Includes handling issues (spadeable).	

5.2.7 IB 49 Slump Test (Cement and Concrete Association of New Zealand)

The slump test was developed, by the Cement and Concrete Association of New Zealand, to check the properties of successive batches of concrete on site. However, some councils (for example, Hutt City Council) have used it as part of their liquid waste testing regime.

The slump test involves the use of a cone, representative sample of waste, compaction and then removal of the cone to see how far the sample slumps downward. A measurement is taken from the top of the cone to where the material has slumped.

The slump test provides an effective means of assessing the physical behaviour of various sludge wastes.

Table 5-7 Advantages and Disadvantages of the IB 49 Slump Test

Advantages	Disadvantages
Assesses physical behaviour of sludges.	Methodology requires some expertise.
Quick test results.	An element of trust required to perform the test correctly. Certified lab likely to be required.
Inexpensive test methodology.	Test based on concrete – may not suit some waste types.
	Does not appear to address issues relating to the response of waste to heat or ‘freezing’.

5.2.8 2540 G. Total, Fixed, and Volatile Solids in Solid and Semi-solid Samples (APHA)

This test is used to determine the total solids content and its fixed and volatile fractions in both solid and semi-solid samples.

This method involves evaporation and desiccation of representative samples of material (25-50g of material). Heating, cooling, desiccating and weighing of the material must be repeated until the weight change of the material is less than 4% or 50 milligrams.

The methodology and calculations vary depending on whether the sample is being measured for total, fixed or volatile solids.

Table 5-8 Advantages and Disadvantages of 2540 G Total, Fixed, and Volatile Solids in Solid and Semi-solid Samples (APHA)

Advantages	Disadvantages
Defining solids content enables a specific limit to be set (for example, no less than 20% solids).	Difficult methodology, expertise required.
Little room for error in interpretation. Calculations provide numbers, rather than subjective comments.	Testing is a lengthy process, and may be expensive. Certified laboratory likely to be required.

The percentage solids content is currently a common method used to determine acceptance of sludges, particularly biosolids at landfills in new Zealand. A solids content of at least 20 percent is likely to ensure that no free liquid is present in a waste. Some wastes may also liberate no free liquids with solids contents less than 20 percent.

5.3 Recommendation

The following definition of liquid waste is recommended, as providing a consistent means of determining whether or not a waste is liquid, and therefore acceptable for landfill disposal.

For waste to be considered non-liquid it must meet the following requirements:

8. a solids content of at least 20 percent and liberate no free liquids when transported;

   or

9. no free liquids when tested in accordance with the USEPA Paint Filter Liquids Test— Method 9095 (US EPA 1986) and liberate no free liquids when transported.

Consultation with waste managers, operators and local councils to discuss current methods and definitions should be undertaken. In addition, it is recommended that no new definition be instituted until it has been trailed.

6.1 Introduction

There are a number of substances that, due to their inherent nature or characteristics, can adversely affect the operation of a landfill site and, therefore, should be prohibited from landfill disposal.

This section describes a number of waste types that are not considered suitable for landfill disposal.

6.2 Recommended Prohibited Wastes

It is recommended that the following wastes generally be prohibited from Class A landfills.

6.2.1 Bulk Liquids

As outlined in Section 5.1, the disposal of bulk liquid waste in landfills:

- increases the volume of leachate generated and requiring treatment and/or disposal;
- can result in increased odour nuisance; and
- can reduce the stability of the refuse mass, under certain conditions.

In addition, pits, or trenches, for the discharge of bulk liquids can create odour nuisance and increase the risk of injury to site workers.

Bulk liquids does not include the recirculation of leachate or addition of water in a controlled manner at landfill sites where these practices are an integral part of the landfill's design and operation to increase the rate of refuse stabilisation. Liquid wastes are unlikely to be suitable for the liquid distribution systems in such landfills.

6.2.2 Lead Acid Batteries

Wet cell (lead-acid batteries) can be recycled in New Zealand. There is no need for wet cell batteries to be landfilled and their prohibition reduces the potential for the acid to react with other landfilled materials.

6.2.3 Radioactive Wastes

The disposal of radioactive wastes is controlled by the National Radiation Laboratory. Guidance on identifying radioactive wastes can be found in documents published by the National Radiation Laboratory, specifically "Radioactive Waste Disposal - Policies and Practices in New Zealand (1996)".

A common source of small quantities of radioactive waste is household smoke detectors, the presence of which in domestic wastes is very difficult to monitor.

6.2.4 Used Oil

The Ministry for the Environment, in conjunction with the Chief Inspector, Explosives and Dangerous Goods, developed Guidelines for the Management and Handling of Used Oil (2000). The Guidelines clarify the status of used oil under the Dangerous Goods Act 1974, and provide guidance on handling used oil for do-it-yourselfers, managers of public collection sites and commercial workshops, transporters and processors.

6.2.5 Explosive Substances

The term explosive is defined in the HSNO Act 1996 as meaning capable of sudden expansion owing to a release of internal energy and includes the capability to generate:

- deflagration;
- pyrotechnic effects.

Thresholds for the determination of the property of explosiveness are outlined in the "User Guide to HSNO Thresholds and Classifications ER-UG-03-1 08/01 (2001).

HSNO regulations prohibit the disposal of explosive substances to landfill (User Guide to the HSNO Control Regulations ER-UG-05-1 11/01 (2001)).

6.2.6 Flammable Substances

The HSNO Act 1996 contains separate thresholds and classifications for gaseous, liquid and solid flammable substances, with a total of nine subclasses.

Thresholds for the determination of the property of flammability are outlined in the "User Guide to HSNO Thresholds and Classifications ER-UG-03-1 08/01 (2001).

HSNO regulations prohibit the disposal of some flammable substances to landfill (User Guide to the HSNO Control Regulations ER-UG-05-1 11/01 (2001)). However, flammable gasses, aerosols, or liquids (classes 2.1.1, 2.1.2, 3.1) or readily combustible solids of class 4.1.1, may be deposited in a landfill, provided it is managed so that:

- the substance does not, or will not, come into contact with any substances with explosive or oxidising properties; and
- no ignition source is present; and
- in the event of accidental fire, harm to people or the environment does not occur.

In practice it would be difficult to manage the disposal of flammable substances at a landfill site to ensure compliance with the above provisions. In order to ensure the safety of site workers and minimise the potential for adverse effects on the environment it is recommended that flammable substances be prohibited from landfills.

6.2.7 Oxidising Substances

HSNO thresholds for oxidising substances distinguish between substances that are organic peroxides and those that are not.

Thresholds for the determination of oxidising substances are outlined in the "User Guide to HSNO Thresholds and Classifications ER-UG-03-1 08/01 (2001).

HSNO regulations allow the disposal of oxidising substances to landfill (User Guide to the HSNO Control Regulations ER-UG-05-1 11/01 (2001)), provided it is managed so that:

- the substance does not, or will not, come into contact with any substances with explosive or flammable properties; and
- no ignition source is present; and
- in the event of accidental fire, the performance requirements for controlled detonation or burning can be met.

In practice it would be difficult to manage the disposal of oxidising substances at a landfill site to ensure compliance with the above provisions. In order to ensure the safety of site workers and minimise the potential for adverse effects on the environment it is recommended that oxidising substances be prohibited from landfills.

6.2.8 Corrosive Substances

The HSNO Act 1996 recognises three classes of corrosive substances:

- substances corrosive to metals;
- substances corrosive to skin; and
- substances corrosive to eyes.

Thresholds for the determination of corrosive substances are outlined in the "User Guide to HSNO Thresholds and Classifications ER-UG-03-1 08/01 (2001).

HSNO regulations allow the disposal of corrosive substances to landfill (User Guide to the HSNO Control Regulations ER-UG-05-1 11/01 (2001)), provided the landfill will render the substance non-hazardous.

In practice it would be difficult to ensure that landfill disposal will render a corrosive substance non-hazardous. In order to ensure the safety of site workers and minimise the potential for adverse effects on the environment it is recommended that corrosive substances be prohibited from landfills.

7.1 Introduction

In order to reduce the complexity of testing required, screening tools, such as a total concentration limits can be used in conjunction with leachability limits to screen the requirement for TCLP testing.

In addition, the use of the New Zealand waste list as a prescriptive list of types of hazardous, or potentially hazardous, wastes to exclude from Class B landfill sites is discussed.

7.2 Total Concentrations as a Screening Test

7.2.1 TCLP Leachability Limit x 20

The USEPA TCLP test involves using 20 millilitres of eluent for every gram of the material being analysed. Therefore the maximum leachable concentration will be one twentieth of the total concentration, assuming all of the constituent in question leaches out.

Such a total concentration limit is generally referred to as a contaminant threshold or screening limit. This limit is set at 20 times the leachable concentration limit, to determine the requirement for TCLP testing, in the following criteria reviewed:

- NSWEPA (contaminant threshold);
- WAEPA contaminant threshold;
- municipal landfill 2 (screening limit).

The use of total concentration limits in this way reduces the need for more time consuming and costly leachability testing.

7.2.2 Recommendation

It is recommended that a total limit, set at 20 time the leachability limit, be used as a screening test to determine the requirement for leachability testing in respect of those constituents for which leachability limits have been proposed.

7.3 New Zealand Waste List

7.3.1 New Zealand Waste List as a Screening Tool

This report proposes a methodology and leachability limits for the acceptance of waste with potentially hazardous properties at Class A landfills.

As outlined in Section 2.2.11, the New Zealand Waste List was developed to provide a definition of hazardous waste and a waste list to provide guidance on the types of wastes that are generated by various sectors in the community. It can provide a useful indication of the types of wastes, and/or industries producing wastes, that may contain hazardous constituents. It can therefore, be used a screening tool to indicate the requirement for testing in respect of total and/or leachability limits.

7.3.2 New Zealand Waste List as Acceptance Criteria for Class B Landfills

MfE is seeking methods by which waste acceptance criteria can be developed for Class B landfills, that is, landfills which do not meet the siting and/or design requirements of Class A landfills. Class B landfills could potentially range from unlined sites, located in high permeability geologies, or close to sensitive environmental receptors, to landfills which may provide a reasonable level of containment by complying with some, but not all, of the siting or design requirements for Class A landfills.

One option to control the acceptance of waste at Class B landfills is to use prescriptive lists of types of hazardous, or potentially hazardous, wastes to exclude specific waste types from Class B sites.

The New Zealand Waste List, as outlined in Section 2.12, was developed to provide a definition of hazardous waste and a waste list to provide guidance on the types of wastes that are generated by various sectors in the community.

Its two codes, the W – Code and the L – Code could provide the basis for lists of wastes and waste types to be specifically prohibited from Class B landfills, irrespective of any treatment they may have received, or leachability of constituents of concern.

The New Zealand Waste List identifies wastes considered to be hazardous. These wastes, and their W and L codes, are listed in Appendix D.

Such an approach has been used by regulatory authorities for some landfill sites. In these cases waste lists in the CAE document, Our Waste: Our Responsibility, Hazardous Waste, have been used, or adapted as lists specifying waste prohibited for disposal.

Potential advantages of this approach include:

- It is a conservative approach that excludes potentially hazardous wastes from sites that do not have the highest level of containment;
- it would provide a level playing field in respect of waste acceptance at landfills not meeting Class A requirements;
- ease of interpretation;
- no testing required;
- easy for operators and landfill users to understand and implement;

- clear cut enforcement issues;
- waste minimisation initiatives could be encouraged;
- public support for environmental responsibility and improvement of existing landfills.

Potential disadvantages include:

- it is not a purely effects based system and may be seen as contradictory to the RMA;
- it is not based on the level of hazard inherent on the specific waste load(s) being disposed;
- actual environmental effects, on a site by site basis are not considered;
- illegal dumping could increase;
- Class A landfills, that could accept wastes prohibited from Class B sites, would need to be available within a reasonable transport distance.

Implementation of such acceptance criteria could result in the following responses from industry and regulatory authorities:

- opposition from Class B landfill owners/operators, particularly local authorities in remote areas with industry specific disposal requirements;
- opposition from local councils and regional councils that do not have Class A landfills within their boundaries;
- opposition from landfill owners/operators that have landfills that could be considered B+ (better than most Class B's but not Class A);
- support from Class A landfill owners/operators;
- support from regulatory authorities that have Class A landfills in their region.

Such a system would likely require a transition period. This could enable:

- cleaner production and waste minimisation activities in respect of constituents of concern;
- arrangements to be made for disposal at alternative sites;
- upgrading, if possible, Class B sites to Class A containment standards;
- siting and development of new landfills;
- development of regional or sub-regional solutions.

7.3.3 Recommendation

It is recommended that the New Zealand Waste List be used as a screening tool to indicate the types of wastes, or processes producing wastes, that will require testing in respect of total or leachability limit acceptance criteria.

It is not recommended that the New Zealand waste List be the principal acceptance criteria for Class B landfills.

8.1 Introduction

This section discusses the following issues related to the development of leachability limits as threshold concentrations for LWAC:

- leachate treatment;
- handling requirements;
- risk based approach;
- special waste streams.

8.2 Leachate Treatment

The method(s) of leachate treatment and/or disposal to be used by a landfill should also be considered in respect of waste acceptance criteria. High concentrations of some constituents can block or damage sewer lines, impair leachate treatment processes and affect the receiving environment. The degree to which leachate treatment affects the setting of waste acceptance criteria will depend on a range of factors, including the following:

- the type of leachate treatment/disposal system used (for example, off-site wastewater treatment plant, on-site leachate evaporation, on-site irrigation);
- potential effects on biological treatment systems;
- the degree of pre-treatment undertaken on-site;
- waste acceptance criteria (for example, trade waste limits) at off-site treatment facilities.

The New Zealand Standard Model Trade Waste Bylaw (NZS 9201: Part 23:1999) provides guidance on maximum concentration limits for selected inorganic and organic constituents, in respect of acceptance of trade wastes, for the protection of sewerage systems, wastewater treatment processes and treatment facility personnel.

The following are examples of the types of effects of selected constituents, as outlined in the Model Trade Waste Bylaw:

- aluminium compounds have the potential to precipitate as a scale, which may cause sewer blockage;
- boron is not removed by conventional treatment and high concentrations in effluent may restrict irrigation applications;
- fluoride is not removed by conventional wastewater treatment;
- heavy metals have the potential to:

  - impair the treatment process;
  - impact on the receiving environment;
  - limit the re-use of sludge and effluent;
- phenols may adversely affect biological treatment processes;
- chlorinated phenols can adversely affect biological treatment processes;
- petroleum hydrocarbons may adversely affect the safety of operations and maintenance personnel;
- halogenated aliphatic compounds may:
  - adversely affect the treatment process;
  - impair the quality of the receiving environment;
  - adversely affect the safety of operations and maintenance personnel;
- monocyclic aromatic hydrocarbons may be carcinogenic and may adversely affect the safety of operations and maintenance personnel;
- polycyclic aromatic hydrocarbons may not be degraded by conventional treatment processes;
- pesticides may:
  - adversely affect the treatment process;
  - impair the quality of the receiving environment;
  - adversely affect the safety of operations and maintenance personnel.

8.3 Handling Requirements

Any wastes requiring testing and/or treatment to determine their acceptance in respect of toxicity characteristics should be subject to a special waste disposal agreement and may have special handling requirements. These are to ensure that the waste is handled to avoid adverse effects on site workers and site neighbours.

Handling requirements will generally be specific to the particular waste, or waste type, and should be specified on the disposal acceptance agreement (or waste manifest form).

Handling requirements could include the following:

- cover during transport;
- bagging prior to disposal (for example asbestos);
- minimum solids content (for example, for biosolids and other sludges);

- damping down of dusty material;
- immediate burial at the working face, or hole excavated for the purpose;
- burial in specific locations within the landfill;
- personal protective equipment for site workers;
- mixture with other wastes at the working face (for example hexavalent chromium);
- a minimum depth of refuse underlying the waste.

The location of all wastes subject to a special disposal agreement should be recorded in three dimensions, both to avoid those areas of the site being used for future excavations and in case excavation of the waste is required at a later date.

8.4 Risk Based Approach

Adoption of leachability limits for an increased number of constituents is likely to reduce the incidence of disposal requests for constituents for which waste acceptance criteria do not exist. However, there will be constituents for which waste acceptance criteria do not exist, but for which disposal requests may be made due to:

- lack of leachability limit for the specific constituent;
- request to dispose of a specific constituent in a Class B landfill, where there is no Class A landfill within a reasonable travel distance;
- specific request for a one-off disposal for a waste that does not comply with leachability limits, and for which additional treatment is impractical, or not possible.

Disposal applications may be a one-off events or relate to an ongoing disposal requirement.

Ideally, landfill waste acceptance criteria (as specified in landfill resource consents) will also specify the means of determining acceptance limits for constituents that do not have existing TCLP limits.

If the means for determining acceptance limits is not specified in a resource consent, then proposed new acceptance limits would require some form of approval. This could be by the regional council, if provision for such approval is made in the resource consent. However, this approach is not recommended as it does not provide certainty of outcome for interested and affected parties at the time consents are granted. Alternatively, if no provision is made for in a resource consent for developing new acceptance limits, an application for change in consent conditions may need to be made.

An alternative to rejecting such waste disposal applications is the use of a risk-based approach to determine an appropriate waste acceptance criteria, which could be a TCLP limit, a total limit or a mass loading limit, or a combination of limits.

Such a risk assessment approach could be based on the following:

- a site specific risk assessment for the constituent, using site specific and constituent specific factors in constituent fate and transport modelling and environmental receptors;
- a generic landfill risk assessment using a generic landfill that conforms with conservative Class A siting and design factors and compliance point, with constituent specific factors for fate and transport modelling;
- use of a conservative dilution and attenuation factor applied to the most conservative guideline relating to environmental receptors.

Site Specific Risk Assessment

This is the most technically robust approach, which would determine acceptance limits in accordance with site characteristics and local environmental receptors. It would involve site investigation, or use of information obtained during previous investigations (for example supporting information for resource consent applications).

Additional factors that would require consideration include:

- whether the request is for a one-off disposal or regular disposal;
- potential interactions or synergistic effects on receptors from other constituents not included in the risk assessment.

If landfill waste acceptance criteria are to include a site specific risk assessment for constituents that do not have existing TCLP limits the following should be specified:

- the type of model(s) that can be used for constituent fate and transport modelling;
- the environmental receptor(s) to consider and compliance limits.

Generic Landfill Risk Assessment

A generic risk assessment would use a similar approach to that used in this report to determine leachability limits. A generic risk assessment is likely to be more conservative than a site-specific risk assessment, as conservative assumptions would be made in respect of landfill design and siting characteristics.

If landfill waste acceptance criteria are to include a generic risk assessment for constituents that do not have existing TCLP limits the following should be specified:

- siting and design characteristics;
- the type of model(s) that can be used for constituent fate and transport modelling;

- the environmental receptor(s) to consider along with compliance point and environmental compliance limits.

A generic approach would have the advantage of providing acceptance limits that could then be appropriate for use at other Class A landfill sites.

Conservative Dilution and Attenuation Factor

This approach is more conservative than the site-specific and generic. Landfill waste acceptance criteria would specify dilution and attenuation factors (DAF) to be applied to environmental compliance limits.

Currently DAFs of 100 and 1000 are commonly applied to New Zealand Drinking Water Standards and ANZECC Criteria for Aquatic Ecosystems in landfill resource consents.

8.5 Special Waste Streams

Special wastes are wastes that, due to their source, inherent physical characteristics, properties, or composition, have specific treatment, handling or disposal requirements. Special wastes may be hazardous, but in most cases require special treatment due to their source, or physical characteristics.

The special wastes that most commonly require some sort of management at New Zealand landfills are:

- medical and veterinary wastes;
- asbestos;
- odorous wastes;
- biosolids;
- tyres;
- household hazardous wastes and agricultural and horticultural chemicals;
- bulky items;

8.5.1 Medical and Veterinary Wastes

Medical and veterinary wastes should be managed in accordance with NZS 4304:2002 “Healthcare Waste Management”. This standard covers management of wastes generated in the provision of healthcare services.

The standard sets out requirements for the following:

- classification of healthcare wastes;

- waste generator responsibilities;
- waste segregation and packaging (for example sharps containers for sharps, with different colours based on whether the sharps are cytotoxic (purple), radioactive (red or yellow), or infectious (yellow);
- packaging and labelling for transport;
- storage;
- transportation and tracking;
- waste treatment and disposal.

Acceptable methods of waste treatment and disposal are specified for different waste classifications. These include:

- compaction followed by landfilling for non-hazardous wastes;
- incineration, or sterilisation and grinding followed by landfilling for hazardous sharps;
- sterilisation and grinding followed by landfilling for infectious body parts;
- sterilisation followed by landfilling for infectious solids;

Sterilisation would generally involve autoclaving, or chemical sterilisation.

When wastes are landfilled they should be either placed at the base of the working face and covered immediately with refuse or, if this is not possible, refuse excavated and then replaced on top of the deposited material.

It is recommended that veterinary wastes and dead animals be managed in the same way as healthcare wastes.

8.5.2 Asbestos Wastes

Asbestos is a long fibroid mineral that has very good insulating and chemical resisting properties. It has been widely used in brake linings, and for heat and sound insulation in buildings. The risk from asbestos is associated with breathing the microscopic fibres when they become airbourne. The fibres lodge in the lungs and after prolonged exposure can cause the fatal disease asbestosis.

Disposal practices for asbestos are designed to prevent asbestos particles becoming airbourne.

The disposal of asbestos wastes is controlled by the Health and Safety in Employment (Asbestos) Regulations 1998.

These regulations require that asbestos wast awaiting disposal be kept in containers that are

a) Closed; and

b) Impermeable to asbestos dust; and

c) Conspicuously marked in letters at least 25 millimetres high, with the words "ASBESTOS HAZARD – WEAR RESPIRATOR AND PROTECTIVE CLOTHING WHILE HANDLING CONTENTS".

They state that every employer must take all practical steps to ensure that all asbestos waste is, as soon as possible after it is produced, disposed of safely and regularly by-

(a) Depositing it in a place approved for the purpose by a territorial authority under the Resource Management Act 1991; and

(b) Immediately covering it with mot less than 1 metre of earth.

In addition every employer must take all practical steps to ensure that-

(a) Every container that has been emptied of asbestos-

  (i) Is rendered unusable, in a manner that does not create asbestos dust; and

  (ii) Is disposed of in the same manner as if it were asbestos waste; and

(b) No previously used product that contains asbestos is re-used or offered for sale.

The location of asbestos wastes should be recorded in three dimensions, to avoid the possibility that they are dug up should it be necessary to excavate into the landfill at a future time.

8.5.3 Odorous Wastes

The acceptance of odorous special loads at the landfill can result in significant odour emissions from the landfill face and, in some cases, from vehicles transporting the waste along site access routes. Odorous wastes typically include aged fish and animal wastes (for example, offal and paunch grass), industrial organic wastes, undigested biosolids from wastewater treatment plants, and possibly refuse from distant transfer stations, that has been held for several days.

Wastes that are known to be odorous should be treated to reduce odour prior to acceptance for disposal. This reduces the potential for odour nuisance both during transport and at the landfill. The potential for adverse effects due to odorous loads that may arrive at a landfill can be reduced by use of the following management procedures:

- rejection of odorous loads that have not been treated with odour suppressing chemicals;
- planning the delivery of potentially odorous loads to occur during the typically windier period in the middle of the day (not early morning), providing the wind direction is not towards sensitive receptors;

- allowing sufficient time for thorough covering prior to landfill closure;
- requiring the delivery of potentially odorous loads to be booked, to ensure odour masking agents and a suitable area for deposition and burial is available.
- depositing odorous wastes at the base of the working face and covering immediately with refuse or at least 150millimetres of soil;
- odour suppressing chemicals and lime should be applied, as required.

8.5.4 Biosolids

Biosolids is the term used to describe the solid organic matter produced during the treatment of municipal wastewater. Biosolids contain pathogens, and, depending on sources of wastewater entering the treatment plant, may contain heavy metals and organic chemicals (for example pesticides). Biosolids can range from untreated sludges with a low solids content (as low as 2 percent) and high organic content, which means that the material is highly odorous, to stabilised digested material, where readily degradable organics have predominantly been converted to gas, with little odour, that has been dewatered to give a solids content of between 20 and 25 percent.

Biosolids should only be accepted by prior arrangement to ensure that they will comply with a landfill’s waste acceptance criteria and that appropriate management procedures are in place at the landfill.

In general biosolids from municipal wastewater treatment plants do not have heavy metals concentrations in excess of USEPA TCLP limits. However, this should be checked prior to acceptance of biosolids from a specific treatment plant. Where a treatment plant accepts a high proportion of wastewater from industrial sources, TCLP tests should be repeated on a regular basis.

In order to reduce the potential for odour nuisance undigested biosolids should not be accepted.

Biosolids should not be accepted if they can be classed as a liquid waste, using the standard test methods employed by the landfill. As a general rule of thumb biosolids that have been dewatered to achieve a solids content in excess of 20 percent are unlikely to contain free liquid and fail a liquid waste test.

Biosolids can be disposed of in landfills either with mixed municipal refuse, or mixed with soil for use as daily cover.

If biosolids are to be disposed of with mixed municipal waste the following management procedures are recommended:

- rejection of odorous loads;
- biosolids should be spread in a thin layer at the base of the working face and covered immediately with refuse to sufficient depth to prevent biosolids forcing their way up to the surface during compaction;

- odour suppressing chemicals and lime should be applied, as required.

A biosolids/soil mixture in a 1:1 ratio can be used as daily cover, provided the biosolids are not odorous. An area will need to be set-aside at the landfill site for storage and mixing of biosolids with soil.

The New Zealand Waste Strategy has the following target in respect of biosolids:

> "By December 2007, more than 95 percent of sewage sludge currently disposed of to landfill will be composted, beneficially used or appropriately treated to minimise the production of methane and leachate."

8.5.5 Tyres

The disposal of whole car and truck tyres can cause a number of problems at landfills. Their shape and composition mean that, when landfilled with municipal refuse they are hard to compact. As the landfill settles and consolidates, tyres "float" to the landfill surface and can affect the integrity of the landfill cap. This is thought to be due to a combination of gas collecting within the tyre, and the tyre shape and flexibility, allowing refuse to settle down at a faster rate.

Stockpiles of tyres also present a fire risk. If tyre stockpiles catch fire the chemicals released as products of combustion (both as smoke and in leachate, when doused with water) are a potential hazard to human health and the environment. Tyre fires are also very difficult, and expensive, to extinguish.

Tyres should not be excluded from landfills if no other practical disposal alternatives exist. If tyres are to be accepted at a landfill, for disposal with general refuse, they should be shredded, or at least cut in half.

Shredded tyres may also be used as part of a leachate drainage system (provided they will not damage the liner and subject to specific design) or a bedding material for pipes for leachate recirculation (where they assist in liquid distribution).

The use of shredded tyres as a media for landfill gas biofilters is not recommended as reaction between components of landfill gas and the tyres can result in the production of mercaptans and consequent odour nuisance.

Due to fire risk, large quantities of whole, or shredded tyres should not be stockpiled at landfill sites.

8.5.6 Household Hazardous Wastes and Agricultural and Horticultural Chemicals

Leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients are considered to be "household hazardous waste" or "HHW." Products, such as paints, cleaners, oils, batteries, herbicides and pesticides, that contain potentially hazardous ingredients the acceptance of which at landfills should be avoided wherever possible.

It is recognised that the municipal solid waste stream contains a small proportion of hazardous waste from households and small commercial premises that standard waste screening procedures will not exclude from landfills.

There are many common hazardous households and farm materials for which alternative disposal options exist. Increasingly collection services and facilities are being provided for these materials, either by way of specific collection programmes (for example the Auckland Regional Council's "HazMobile") or separate collection and temporary storage facilities at transfer stations and landfills.

The following outlines some of the common materials that should be excluded from landfill disposal, and for which alternative treatment or disposal options are likely to be accessible in New Zealand.

Waste Paint

Most waste paint can be recycled for use by councils and community groups for community projects or anti-graffiti work. The remaining toxic, or otherwise unusable paint can be treated prior to landfill disposal.

Used Oil

Used oil recovery programmes have been in place for some years. The major oil companies operate nationwide collection networks and supply used oil to Milburn, New Zealand's Westport cement kiln.

The Ministry for the Environment has prepared "Guidelines for the Management and Handling of Used Oil". These provide guidance on handling used oil for "do-it-yourselfers", managers of public collection sites and commercial workshops, transporters and processors.

Batteries

Wet cell (lead-acid batteries) can be recycled in New Zealand. Rechargeable nickel-cadmium and mercury containing batteries can be recycled overseas. Other dry cell batteries, without heavy metals can be treated and landfilled.

Chemicals

Materials safety data sheets and container labels should be checked in respect of disposal instructions or restrictions.

Agricultural, horticultural and garden chemicals that are still currently in use can be used for the purpose for which they are intended. Chemical no longer suitable for use cannot generally be treated in New Zealand and must be sent overseas for destruction.

Chemical containers should be triple rinsed prior to landfill disposal, or, if appropriate, recycling.

Information on chemicals collection services and facilities is generally available via the local district or regional council.

1080

The use of 1080 (sodium monofluoroacetate) as a poison (for rabbits and possums)in New Zealand is strictly regulated. Because it is controlled it is unlikely that small quantities from domestic sources will require disposal. More likely is a request for disposal of old 1080 bait material (pellets or paste) or “off-spec” product.

A study of the effects of disposal of approximately 12,000 kilograms of 1080 cereal pellets and pastes in a Winton Landfill was published in 1999 (Bowman 1999). Following deterioration during storage, the material was buried in a purpose dug pit within the landfill. Water samples were taken from boreholes five and 13 metres from the disposal pit over 13 months. 1080 concentrations in samples from the bores were either below or close to the Ministry of Health acceptable values standards for drinking water. No 1080 was detected in samples taken after 10 months.

Sampling of the waste material found that the 1080 concentration had reduced to 10% of their original concentration within 12 months.

The report concluded that the waste materials buried in a purpose built pit did not appear to pose any significant risk to public safety or the environment, providing the site is not disturbed and natural breakdown processes are able to continue. The active anaerobic bacterial processes appeared to provide an ideal environment for the rapid natural breakdown of 1080.

It is recommended that disposal requests for materials containing 1080 should be considered on a case specific basis, and material deposited in cells dug into mature refuse.

Fluorescent Lights

Fluorescent light tubes contain mercury and cadmium. The contents of the tubes should be removed by an approved operator, prior to disposal.

8.5.7 Bulky Items

Bulky items includes such items as large appliances, furniture and tree stumps. These wastes are difficult to handle or compact with normal landfill equipment and disposal in the landfill can result in voids and differential settlement.

Potential methods for handling these wastes include:

- salvaging and/or recycling;
- use of a separate area of the landfill;
- compacting on solid ground.

ANZECC, 1992. *Australian Water Quality Guidelines for Fresh and Marine Waters.* Australia and New Zealand Environment and Conservation Council.

Auckland Regional Council, 2002. *The HazMobile Report 2001/2002.* New Zealand.

Australia and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Environment Australia.

Bowman, R.G., 1999. *Fate of Sodium Monofluoroacetate (1080) Following Disposal of Pest Bait to a Landfill.* New Zealand Journal of Ecology (1999) 23(2): 193-197.

British Crop Protection Council, The Royal Society of Chemistry, 1994. *The Pesticide Manual, Tenth Edition.* Editor Clive Tomlin.

CCME, 1999. *Canadian Environmental Quality Guidelines.* Canadian Council of Ministers of the Environment.

Centre for Advanced Engineering, 2000. *Landfill Guidelines, toward sustainable waste management in New Zealand.* University of Canterbury, New Zealand.

Davies R. D., 2002. *Draft Guide to Landfill of Sludge and Sludge Treatment Residues*, WRC Report No. CO 5029/1, February 2002.

Department of Environmental Protection, 2001. *Guidelines for Acceptance of Solid Waste to Landfill.* Western Australia.

Department of Water Affairs and Forestry, second edition 1998. *Minimum Requirements for Waste Disposal by Landfill.* Republic of South Africa.

Department of Water Affairs and Forestry, second edition 1998. *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste.* Republic of South Africa.

Domenico and Schwartz, 1990. *Physical and Chemical Hydrogeology.* John Wiley & Sons.

Health and Safety in Employment (Asbestos) Regulations 1998.

Howard P H et al. 1991. *Handbook of Environmental Degradation Rates.* Lewis Publishers.

Irving Sax, N, Lewis RJ Sr., 1987. *Hawley's Condensed Chemical Dictionary, Eleventh Edition.* Van Nostrand Reinhold Company Inc.

Ministry for the Environment, 2002. *The New Zealand Waste Strategy.*

Ministry for the Environment, 2000. *Guidelines for the Management and Handling of Used Oil.*

Ministry for the Environment, 1999. *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand.*

Ministry for the Environment, 1998. *Ambient Concentrations of Selected Organochlorines in Soils.* Organochlorines Programme, Ministry for the Environment.

Ministry of Health, 1995. *Drinking Water Standards for New Zealand.*

Montgomery J., 2000. *Groundwater Chemicals Desk Reference, Third Edition*. Lewis Publishers.

New South Wales Environmental Protection Authority ,1999. *Environmental Guidelines: Assessment and Management of Liquid and Non-Liquid Wastes*, Australia.

New South Wales Environmental Protection Authority, 1996. *Environmental Guidelines: Solid Waste Landfills*, Australia.

Solid Waste Association of North America ,1993. *Training Sanitary Landfill Operating Personnel, Student Manual.* USA

Standards New Zealand, 1999. Model General Bylaws. *Part 23 – Trade Waste*. NZS 9201: Part 23: 1999.

Standards New Zealand, 2002. *Healthcare Waste Management*. NZS 4304:2002.

United States Environmental Protection Agency,1997. *Solid Waste Disposal Facility Criteria*. Title 40, Part 258 of the Code of Federal Regulations.

United States Environmental Protection Agency,1997. *Land Disposal Restrictions*. Title 40, Part 258 of the Code of Federal Regulations.

United States Environmental Protection Agency ,1991. *Water Quality Criteria*.

United States Environmental Protection Agency,1990. Part V Environmental Protection Agency. 40 CFR Parts 261, 264, 265, 268, 271 and 302. *Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule*. Federal Register.

United States Environmental Protection Agency,1990. Part II Environmental Protection Agency. 40 CFR Part 261 et al. *Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule*. Federal Register.

United States Environmental Protection Agency,1980. Part III Environmental Protection Agency. *Hazardous Waste Management System; Identification and Listing of Hazardous Waste.* Federal Register.

URS New Zealand Limited, 2001. *Basis for Landfill Classification System*. Report prepared for the Ministry for the Environment.

VROM, 1998. Dutch Target and Intervention Values for Soil and Groundwater. Ministry of Housing, Spatial Planning and Environment (VROM).

WHO, 1993. Guidelines for Drinking-Water Quality. World Health Organisation Geneva.

Appendix A
Constituent Leachability Limits

Appendix A Constituent Leachability Limits

Constituent	US EPA (mg/L)	NSW EPA (mg/L)	WA - ASLP 3 (mg/L)	Private Landfill 1 (mg/L) *Class A*	Private Landfill 2 (g/m^3) *Class A* ^{25}	NZS 9201 (g/m^3) ^{15}	ANZECC - 95% & 99% as appropriate (mg/L)	ANZECC - 95% & 99% as appropriate (ug/L)	Auckland Trade Waste By Law (mg/L) ^{27}	Drinking Water Std (mg/L) ^{11}	Municipal Landfill 1 (mg/L) *Note: not Class A*	Municipal Landfill 2 (mg/L) *Note: not Class A* ^{14}
1080										0.0035 ^{IV}		
1,1 Dichloroethane				0.7000							0.5000	
1,1 Dichloroethene										0.03 ^{III}		
1,1 Dichloroethylene	0.7000	0.7000										0.7000
1,1,1, Trichloroethane		30.0000								2 ^{III}		
1,1,1,2 Tetrachloroethane		10.0000										
1,1,2 Trichloroethane		1.2000					6.500000	6500.0000				
1,1,2 Trichlorotriflouroethane (Freon 112)												
1,1,2,2 Tetrachloroethane		1.3000										
1,2 Dibromo-3-chloropropane										0.001 ^{IV}		
1,2 Dichlorobenzene		4.3000					0.160000	160.0000		1 ^{III,} 0.001 ^{VI}		
1,2 Dichloroethane	0.5000	0.5000		0.5000						0.03 ^{III}	0.5000	7.5000
1,2 Dichloroethene										0.06 ^{III}		
1,2 Dichloropropane										0.05 $^{III, IV}$		
1,2 Diphenylhydrazine					0.10000							
1,2,3 Trichlorobenzene							0.003000	3.0000				
1,2,4 Trichlorobenzene							0.085000	85.0000				
1,2,4,5 Tetrachlorobenzene												
1,3 Dichlorobenzene							0.260000	260.0000				
1,3 Dichloropropene										0.02 ^{IV}		
1,4 Dichlorobenzene	7.5000	7.5000		7.5000			0.060000	60.0000		0.4 ^{III,} 0.003 ^{VI}	7.5000	0.5000
2 Chlorophenol										0.0003 ^{VI}		
2 Nitrophenol					10.00000							
2,3,4,6 tetrachlorophenol							0.010000	10.0000				
2,3,4,6 Trichlorobenzene												
2,4 Dichlorophenol					5.00000		0.120000	120.0000		0.0003 ^{VI}		
2,4 Dichlorophenoxyacetic acid (2,4 D)	10.0000			10 ^{10}			0.280000	280.0000		0.04 ^{IV}		10.0000
2,4 Dichlorophenoxybutyric acid (2,4 DB)										0.1 ^{IV}		
2,4 Dimethylphenol					10.00000							
2,4 Dinitrotoluene	0.1300	0.1300		0.1300							0.1300	0.1300
2,4,5 Trichlorophenol					2.00000						400.0000	
2,4,5 Trichlorophenoxyacetic acid				1.0000			0.036000	36.0000		0.01 ^{IV}		
2,4,5-Trichlorophenol	400.0000	400.0000		400.0000	2.00000							400.0000
2,4,5-Trichlorophenoxypropionic acid	1.0000											1.0000
2,4,6 Trichlorophenol					2.00000		0.003000	3.0000		0.2 ^{III,} 0.002 ^{VI}	2.0000	
2,4,6-Trichlorophenol	2.0000	2.0000		2.0000	2.00000							2.0000
2-chlorophenol							0.340000	340.0000				
3,3 Dichlorobenzidine					0.05000							
4,4 DDD (1,1 dichloro-2,2-bis(p-chlorophenyl)ethane)												
4,4 DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene)												
4-Chloro 3-methylphenol					5.00000							
4-chlorophenol							0.220000	220.0000				
Acenaphthlene					0.10000							
Acenaphthylene					0.10000							
Acephate												
Acetone									10000.0000			
Acetonitrile									2000.0000			
Acrylamide										0.0005 ^{III}		
Alachlor										0.02 ^{IV}		
Aldicarb										.01 ^{IV}		
Aldrin												
Aldrin + dieldrin										0.00003 ^{IV}		
Algae										Less than 1 toxic alga present in 10mL of sample ^{I}		
Alpha BHC												
Aluminium							0.027000	27.0000		0.15 ^{VI}		
Ammonia						50.0000	0.900000	900.0000		1.5 ^{VI}		
Ammonium salts						200.0000						
Anatoxin (as STX-eq)										0.003 ^{III}		
Anatoxin-a (S)										0.001 ^{III}		
Anthracene					0.01000							

Appendix A Constituent Leachability Limits

Constituent	US EPA (mg/L)	NSW EPA (mg/L)	WA - ASLP 3 (mg/L)	Private Landfill 1 (mg/L) *Class A*	Private Landfill 2 (g/m^3) *Class A* [25]	NZS 9201 (g/m^3) [15]	ANZECC - 95% & 99% as appropriate (mg/L)	ANZECC - 95% & 99% as appropriate (ug/L)	Auckland Trade Waste By Law (mg/L) [27]	Drinking Water Std (mg/L) [11]	Municipal Landfill 1 (mg/L) *Note: not Class A*	Municipal Landfill 2 (mg/L) *Note: not Class A* [14]
Antimony				10 [9]	10.00000	10.0000			10.0000	0.003 [II]		0.3 [a]
Aroclor 1242							0.000300	0.3000				
Aroclor 1254							0.000010	0.0100				
Arsenic	5.0000	5.0000	0.7 [18]	5.0000	5.00000	5.0000			5.0000	0.01 [II]	2.0000	5.0000
Arsenic IV							0.013000	13.0000				
Arsenic III							0.024000	24.0000				
Asbestos	Any amount if unbound in matrix											
Atrazine										0.002 [IV]		
Azinphos methyl							0.000020	0.0200		0.004 [IV]		
Barium	100.0000			100.0000		10.0000				0.7 [II]		100.0000
Bendiocarb												
Bentazone										0.4 [IV]		
Benzene	0.5000	0.5000	0.1000	0.5000			0.950000	950.0000		0.01 [III]	0.5000	0.5000
Benzene Pentachloronitro												
Benzene, hexachloro												
Benzidene					0.01000							
Benzo(a)anthracene					0.05000							
Benzo(a)pyrene		0.04 [1]			0.05000					0.0007 [III]		
Benzo(b)flouranthene					0.05000							
Benzo(g,h,I)perylene					0.10000							
Benzo(k)flouranthene					0.05000							
Beryllium		1 [2]	1 [18,19]		0.10000	0.0050				0.004 [II]		0.4 [a]
Beta BHC												
Bis(2-ethylhexyl)phthalate					1.00000							
Bis(chloromethyl)ether					0.10000							
Boron				25 [9]	25.00000	25.0000	0.370000	370.0000	25.0000	1.4 [II]	20.0000	140 [a]
Bromacil										0.4 [IV]		
Bromate										0.025 [II]		
Bromine						5.0000						50 [b]
Bromodichloromethane										0.06 [III]		
Bromoform										0.1 [III]		
Bupirimate												
Buprofezin												
Butylbenzylphthalate					2.00000							
C10 - C36 Petroleum hydrocarbon												
C16-C35 Petroleum hydrocarbons (aliphatics)						1.0000						
C16-C35 Petroleum hydrocarbons (aromatics)												
C6-C15 Petroleum hydrocarbon												
C6-C9 Petroleum hydrocarbon												
Ca + Mg (total hardness)										200 [VI]		
Cadmium	1.0000	1.0000	0.2 [18]	1.0000	1.00000	0.5000	0.000200	0.2000	1.0000	0.003 [II]	0.1000	1.0000
Captan												
Carbaryl												
Carbofuran										0.008 [IV]		
Carbon Tetrachloride	0.5000	0.5000		0.5000						0.002 [III]	0.5000	0.5000
Chlorate										0.3 [II]		
Chlordane	0.0300			0.03 [10]			0.000030	0.0300		0.0002 [IV]		0.0300
Chloride										250 [VI]		
Chlorinated Phenols						0.0200						0.2 [b]
Chlorine							0.003000	3.0000		0.6 [VI]		
Chlorine (free)						3.0000				5 [II]		
Chlorine (hypochlorite)						30.0000						
Chlorite										0.3 [II]		
Chlorobenzene	100.0000	100.0000		100.0000							100.0000	100.0000
Chloroform	6.0000	6.0000		6.0000						0.2 [III]	6.0000	6.0000
Chlorophenol					5.00000							
Chlorpyriphos		0.2000					0.000010	0.0100		0.07 [IV]		
Chlorpyriphos methyl												
Chlortoluron										0.04 [IV]		
Chromium	5.0000		5.0000	5.0000		5.0000				0.05 [II]	2.0000	5.0000
Chromium 3					30.00000				30.0000			
Chromium 6		5.0000		5 [9]	5.00000		0.001000	1.0000	5.0000			
Chrysene					0.10000							
Cobalt				20 [9]	20.00000	10.0000			20.0000			100 [b]
Colour										10 [VI]		
Copper				25 [10]	10.00000	10.0000	0.001400	1.4000	10.0000	2 [II], 1 [VI]	2.0000	200 [a]
Cresol (total)		200.0000	200 [19]	200.0000							200.0000	200.0000
Cyanazine										0.0007 [IV]		
Cyanide (amenable) [5]		3.5 [5]	3.5 [19]									
Cyanide (total) [5]		16 [5]	8.0000							0.08 [II]		
Cyanide containing compounds					2.50000				10.0000			
Cyanides	50ppm			10 [9]		5.00 (weak acid dissociable)	0.007000	7.0000			10.0000	50ppm (weak acid dissociable)

Appendix A Constituent Leachability Limits

Constituent	**US EPA (mg/L)**	**NSW EPA (mg/L)**	**WA - ASLP 3 (mg/L)**	**Private Landfill 1 (mg/L) *Class A***	**Private Landfill 2 (g/m^3) *Class A*** [25]	**NZS 9201 (g/m^3)** [15]	**ANZECC - 95% & 99% as appropriate (mg/L)**	**ANZECC - 95% & 99% as appropriate (ug/L)**	**Auckland Trade Waste By Law (mg/L)** [27]	**Drinking Water Std (mg/L)** [11]	**Municipal Landfill 1 (mg/L) *Note: not Class A***	**Municipal Landfill 2 (mg/L) *Note: not Class A*** [14]
Cyanogen chloride (as CN)										0.08 [II]		
Cylindrospermopsin										0.003 [III]		
Cynobacteria										Less than 1 potentially toxic cyno present in 10mL of sample [I]		
DDD (1,1-dichloro-2,2-bis(p-chlorophenyl)ethane)												
DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene)												
DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane)				0.02 [10]			0.000006	0.0060		0.002 (+isomers) [IV]		
Delta BHC												
Demeton-S-methyl												
Di (2-ethylhexyl)adipate										0.1 [III]		
Di (2-ethylhexyl)phthalate										0.009 [III]		
Diazinon							0.000010	0.0100		0.01 [IV]		
Dibenzo(a,h)anthracene					0.05000							
Dibromoacetonitrile										0.2 [III]		
Dibromochloromethane										0.1 [III]		
Dibromomethane												
Dibutylpthalate							0.009900	9.9000				
Dichlofluanid												
Dichloroacetic acid										0.05 [III]		
Dichloroacetonitrile										0.1 [III]		
Dichlorobenzidine					0.05000							
Dichlorodiflouromethane												
Dichloromethane		8.6000								0.02 [III]		
Dichlorprop										0.1 [IV]		
Dichlorvos												
Dieldrin												
Diethylether									0.0000			
Diethylphthalate					10.00000		1.000000	1000.0000				
Dimethoate							0.000150	0.1500				
Dimethylphthalate					10.00000		3.700000	3700.0000				
Di-n-butylphthalate					2.00000							
Di-n-octylphthalate					2.00000							
Dioxane									2000.0000			
Diquat										0.01 [IV]		
Dissolved Aluminium						300.0000						
Diuron										0.02 [IV]		
Edrin Aldehyde												
EDTA										0.7 [III]		
Endosulfan							0.000030	0.0300				
Endosulfan I												
Endosulfan II												
Endosulfan sulphate												
Endrin	0.0200			0.02 [10]			0.000010	0.0100				0.0200
Endrin Aldehyde												
Epichlorohydrin										0.0005 [III]		
Escherischia coli (E.coli)										Less than 1 in 100mL of sample [I]		
Ethanol									50000.0000			
Ethyl benzene		30 [3]	30.0000	5.0000						0.3 [III], 0.002 [VI]		
Ethylene Benzene											0.7000	
Fenamiphos												
Fenarimol												
Fenitrothion							0.000200	0.2000				
Fenoprop										0.01 [IV]		
Flouranthene					0.10000					0.004 [III]		
Flourene					0.10000							
Flouride		150 [3]	150.0000			30.0000				1.5 [II]		50 [b]
Fluroxypyr		2.0000										
Flusilazole												
Formaldehyde						50.0000			5000.0000	1 [III]		100 [a]
Halogenated aliphatic hydrocarbons												10 [b]
Halogenated aromatic hydrocarbons						0.0020						0.02 [b]
Helminths (pathogenic)										Less than 1 in 100L sample [I]		
Heptachlor	0.0080						0.000010	0.0100		0.00004 [IV]		0.0080
Heptachlor Epoxide				0.008 [10]						0.00004 [IV]		
Hexachloro -1,3 -butadiene	0.5000			0.5000						0.0007 [III]		0.5000
Hexachlorobenzene	0.1300			0.1300	0.02000					0.001 [IV]		0.1300
Hexachloroethane	3.0000			3.0000			0.290000	290.0000				3.0000
Hexachlorophene												
Hexazinone										0.4 [IV]		

Appendix A Constituent Leachability Limits

Constituent	US EPA (mg/L)	NSW EPA (mg/L)	WA - ASLP 3 (mg/L)	Private Landfill 1 (mg/L) *Class A*	Private Landfill 2 (g/m^3) *Class A* [25]	NZS 9201 (g/m^3) [15]	ANZECC - 95% & 99% as appropriate (mg/L)	ANZECC - 95% & 99% as appropriate (ug/L)	Auckland Trade Waste By Law (mg/L) [27]	Drinking Water Std (mg/L) [11]	Municipal Landfill 1 (mg/L) *Note: not Class A*	Municipal Landfill 2 (mg/L) *Note: not Class A* [14]
Homoanatoxin -a												
Hydrogen Sulphide							0.001000	1.0000		0.05 [VI]		
Indeno(1,2,3-c,d)pyrene					0.10000							
Iron				tba		300.00 (dissolved)				0.2 [VI]		
Isodrin												
Isoproturon										0.01 [IV]		
Kjeldahl nitrogen						500.0000						
Lead	5.0000	5.0000	1.0000	5.0000	10.00000	10.0000	0.003400	3.4000	10.0000	0.01 [II]	2.0000	5.0000
Lindane	0.4000			0.4 [10]			0.000200	0.2000		0.002 [IV]		0.4000
Linuron												
Lithium										0.9 [II]		
LPS endoxins										0.003 [III]		
Malathion							0.000050	0.0500				
Manganese				20 [9]	20.00000	20.0000	1.900000	1900.0000	20.0000	0.5 [II], 0.05 [VI]	2.0000	
MCPA										0.002 [IV]		
m-Cresol	200.0000	200.0000		200.0000							200.0000	
Mecoprop										0.01 [IV]		
Mercury	0.2000	0.2000	0.1000	0.2000	0.20000	0.0050	0.000060	0.0600		0.002 [II]	0.0200	0.2000
Metalaxyl										0.1 [IV]		
Methanol									10000.0000			
Methiocarb												
Methoxychlor	10.0000			10 [10]						0.02 [IV]		10.0000
Methyl acetate									2000.0000			
Methyl ethyl ketone	200.0000	200.0000		200.0000					2000.0000		5.0000	200.0000
Methylene Blue Active Substances						500.0000						
Metolachlor										0.01 [IV]		
Metribuzin										0.07 [IV]		
Mevinphos												
Microcystins										0.001 [III]		
Molinate										0.007 [IV]		
Molybdenum		5 [3]	5 [19]	15 [9]	15.00000	10.0000			15.0000	0.07 [II]		0.2917
Monochloramine										3 [II]		
Monochlorobenzene										0.3 [III], 0.01 [VI]		
Monocyclic aromatic hydrocarbons						5.0000						50 [b]
m-t p-cresol (3-+4 methyl phenol)					10.00000							
myclobutanil												
Napthalene					10.00000		0.016000	16.0000	50.0000			
Nickel		2 [3]	2.0000	10 [9]	10.00000	10.0000	0.011000	11.0000	10.0000	0.02 [II]	1.0000	0.0833
Nitrate							0.700000	700.0000		50 [II]		
Nitrilotriacetic acid										0.2 [III]		
Nitrite										3 [II]		
Nitrobenzene	2.0000	2.0000		2.0000							2.0000	2.0000
Nodularin										0.001 [III]		
OCP Scheduled wastes												
o-Cresol	200.0000	200.0000		200.0000	10.00000						200.0000	
Odour				300 OU/m2/s [12,13]						Threshold Odour No. 4 [VI]		
Organophosphate Pesticides						0.1000						1 [b]
Oryzalin										0.4 [IV]		
Other solvents												
Oxadiazon										0.2 [IV]		
Oxidised sulphur compounds					1200.00000				1200.0000			
o-Xylene							0.350000	350.0000				
Parathion							0.000004	0.0040				
Pathogenic Bacteria										Less than 1 in 100mL of sample [I]		
p-Cresol	200.0000	200.0000		200.0000							200.0000	
Pendimethalin										0.02 [IV]		
Pentachlorobenzene												
Pentachlorophenol	100.0000			100 [10]	2.00000		0.003600	3.6000		0.01 [IV]		100.0000
Permethrin										0.02 [IV]		
Pesticides (general)						0.2000						10 [b]
Petroleum Hydrocarbons						30.0000						300 [b]
pH				2.0 - 12.5						7.0 - 8.5 [VI]		
Phenathrene					0.10000							
Phenol							0.320000	320.0000	100.0000			
Phenol (non halogenated)		14.4 [4]			100.00000							
Phenols (total non-chlorinated)			14.4000			50.0000						50 [b]
Phorate												
Picloram		3.0000								0.2 [IV]		
Pirimiphos methyl										0.1 [IV]		
Pirimisulfuron methyl										0.9 [IV]		
Plasticiser Compounds		1.0000										
Polybrominated biphenyls						0.0020						
Polychlorinated Biphenals	50ppm			0.0001 [10]		0.0020						0 [b]
Polycyclic aromatic hydrocarbons (total)						0.0500						0.5 (excl. napthalene) [b]

Appendix A Constituent Leachability Limits

Constituent	US EPA (mg/L)	NSW EPA (mg/L)	WA - ASLP 3 (mg/L)	Private Landfill 1 (mg/L) *Class A*	Private Landfill 2 (g/m^3) *Class A* [25]	NZS 9201 (g/m^3) [15]	ANZECC - 95% & 99% as appropriate (mg/L)	ANZECC - 95% & 99% as appropriate (ug/L)	Auckland Trade Waste By Law (mg/L) [27]	Drinking Water Std (mg/L) [11]	Municipal Landfill 1 (mg/L) *Note: not Class A*	Municipal Landfill 2 (mg/L) *Note: not Class A* [14]
Procymidone										0.7 [IV]		
Propanil										0.02 [IV]		
Propazine										0.07 [IV]		
Protozoa (pathogenic)										Less than 1 (oo) cyst in 100L sample [I]		
p-Xylene							0.200000	200.0000				
Pyrene					0.10000							
Pyridate										0.1 [IV]		
Pyridine	5.0000			5.0000					300.0000			5.0000
Radon										100 [V]		
Reactive Cyanide												
Reactive Sulphide (17)												
Saxitoxins										0.001 [III]		
Selenium	1.0000	1.0000	1 [18]	1.0000	5.00000	10.0000	0.005000	5.0000	5.0000	0.01 [II]	0.4000	1.0000
Silver	5.0000	5.0000	10.0000	5.0000	1.00000	2.0000	0.000050	0.0500	1.0000	0.02 [II]	0.4000	5.0000
Silvex (2,4,5 TP)				1 [10]								
Simazine										0.002 [IV]		
Sodium										200 [VI]		
Styrene (vinyl benzene)		3 [3]	3 [18]							0.03 [III], 0.004 [VI]		
Sulphate						500.0000				250 [VI]		
Sulphate with good mixing						1500.0000						
Sulphide containing compounds					2.00000				5.0000			
Sulphides	50ppm			5 [9]		5.0000					5.0000	50.0000
Sulphite						15.0000						
Tebuconazole		6.4000										
Terbuthylazine										0.008 [IV]		
Tetrachloroethene				0.7000						0.05 [III]	0.7000	
Tetrachloroethylene	0.7000	0.7000										0.7000
Thallium				5 [9]	5.00000	10.0000			5.0000			100 [b]
Thiabendazole										0.40000		
Tin					.0002 (as organotin)	20.0000				1 [II]	20.0000	100 [a]
Toluene		14.4 [4]	80.0000	5.0000						0.8 [III], 0.024-0.17 [VI]	5.0000	
Total acidic herbicides					1.00000							
Total Alpha Activity										0.10 [V]		
Total Beta Activity										0.50 [V]		
Total BTEX				10.0000							10.0000	
Total Dissolved Solids										1000 [VI]		
Total Halogenated compounds	1000ppm											
Total Halogenated VOC					1.00000							
Total non-halogenated VOC					10.00000							
Total of all chloronapthalenes					1.70000							
Total of all Dioxins					0.00000							
Total of all PCB compounds					0.00004							
Total of all polychlorinated dibenzofufans					0.00000							
Total Organochlorine Pesticides					0.00010							
Total Organonitrogens and organophospates					1.00000							
Total Phosphorus						150.0000						
Total SVOC					10.00000							
Total synthetic non-halogenated compounds	10000ppm											
Toxaphene	0.5000			0.5 [10]								0.5000
Toxaphor							0.000200	0.2000				
Tributyltin oxide (TBTO)				0.02 [10]						0.002 [III]		
Trichloroacetaldehyde/chloral hydrate										0.01 [III]		
Trichloroacetic acid										0.1 [III]		
Trichloroacetonitrile										0.001 [III]		
Trichlorobenzenes (total)										0.03 [III], 0.005 [VI]		
Trichloroethene				0.5000						0.08 [III]	0.5000	
Trichloroethylene	0.7000	0.5000									0.5000	0.7000
Trichloroflouromethane												
Triclopyr		2.0000								0.1 [IV]		
Trifluralin										0.03 [IV]		
Turbidity										2.5 [VI]		
Uranium										0.002 [II]		
Vanadium				tba							tba	
Vinyl Chloride	0.2000	0.2000		0.2000						0.005 [III]	0.2000	0.2000
Viruses										Less than 1 enteric virus in 100L of sample [I]		

Appendix A Constituent Leachability Limits

Constituent	US EPA (mg/L)	NSW EPA (mg/L)	WA - ASLP 3 (mg/L)	Private Landfill 1 (mg/L) *Class A*	Private Landfill 2 (g/m^3) *Class A* [25]	NZS 9201 (g/m^3) [15]	ANZECC - 95% & 99% as appropriate (mg/L)	ANZECC - 95% & 99% as appropriate (ug/L)	Auckland Trade Waste By Law (mg/L) [27]	Drinking Water Std (mg/L) [11]	Municipal Landfill 1 (mg/L) *Note: not Class A*	Municipal Landfill 2 (mg/L) *Note: not Class A* [14]
Xylenes		50 [7]	60.0000	5.0000						0.6 [III,] 0.02-1.8 [VI]	0.5000	
Zinc				25 [9]	25.00000	10.0000	0.008000	8.0000	25.0000	3 [VI]	60.0000	300 [a]

Appendix B
Total Concentration Limits and Screening Values

Appendix B Total Concentration Limits and Screening Values

	US EPA (mg/L)	**NSW EPA (mg/kg)**	**WA - CL 3 (mg/kg)**	**Private Landfill 1 (mg/L)** *Class A*	**Private Landfill 2 (g/m^3)** ***Class A*** [26]	**NZS 9201 (g/m^3)**	**ANZECC - 95% & 99% as appropriate (ug/L)**	**Auckland Trade Waste By Law (mg/L)**	**Drinking Water Std (mg/L)**	**Municipal Landfill 1 (mg/L)** ***Note: not Class A***	**Municipal Landfill 2 (mg/kg) Screening Limit Only** *Note: not Class A*
1080											
1,1 Dichloroethane											
1,1 Dichloroethene											
1,1 Dichloroethylene		25.0000									14.0000
1,1,1, Trichloroethane		1080.0000									
1,1,1,2 Tetrachloroethane		360.0000									
1,1,2 Trichloroethane		43.2000									
1,1,2 Trichlorotriflouroethane (Freon 112)											
1,1,2,2 Tetrachloroethane		46.8000									
1,2 Dibromo-3-chloropropane											
1,2 Dichlorobenzene		155.0000									
1,2 Dichloroethane		18.0000									150.0000
1,2 Dichloroethene											
1,2 Dichloropropane											
1,2 Diphenylhydrazine											
1,2,3 Trichlorobenzene											
1,2,4 Trichlorobenzene											
1,2,4,5 Tetrachlorobenzene		50.0000									
1,3 Dichlorobenzene											
1,3 Dichloropropene											
1,4 Dichlorobenzene		270.0000									10.0000
2 Chlorophenol											
2 Nitrophenol					200.00000						
2,3,4,6 tetrachlorophenol											
2,3,4,6 Trichlorobenzene		50.0000									
2,4 Dichlorophenol					100.00000						
2,4 Dichlorophenoxyacetic acid (2,4 D)		360.0000	1440 [20]								200.0000
2,4 Dichlorophenoxybutyric acid											
2,4 Dimethylphenol					200.00000						
2,4 Dinitrotoluene		4.6800									2.6000
2,4,5 Trichlorophenol		14400.0000			40.00000						
2,4,5 Trichlorophenoxyacetic acid A59		50.0000									
2,4,5-Trichlorophenol											8000.0000
2,4,5-Trichlorophenoxypropionic acid											20.0000
2,4,6 Trichlorophenol					40.00000						40.0000
2,4,6-Trichlorophenol		72.0000									
2-chlorophenol											
3,3 Dichlorobenzidine											
4,4 DDD (1,1 dichloro-2,2-bis(p-chlorophenyl)ethane)											
4,4 DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene)											
4-Chloro 3-methylphenol					100.00000						
4-chlorophenol											
Acenaphthlene					2.00000						
Acenaphthylene					2.00000						
Acephate											
Acetone											
Acetonitrile											
Acrylamide											
Alachlor											
Aldicarb											
Aldrin		50.0000									
Aldrin + dieldrin			500 [22]								
Algae											
Alpha BHC		50.0000									
Aluminium pH>6.5											

Appendix B Total Concentration Limits and Screening Values

	US EPA (mg/L)	NSW EPA (mg/kg)	WA - CL 3 (mg/kg)	Private Landfill 1 (mg/L) *Class A*	Private Landfill 2 (g/m^3) *Class A* [26]	NZS 9201 (g/m^3)	ANZECC - 95% & 99% as appropriate (ug/L)	Auckland Trade Waste By Law (mg/L)	Drinking Water Std (mg/L)	Municipal Landfill 1 (mg/L) ***Note: not Class A***	Municipal Landfill 2 (mg/kg) Screening Limit Only *Note:* ***not Class A***
Ammonia - free											
Ammonium salts											
Anatoxin (as STX-eq)											
Anatoxin-a (S)											
Anthracene					0.20000						
Antimony											6.0000
Aroclor 1242											
Aroclor 1254											
Arsenic		500.0000	5000.0000								100.0000
Arsenic IV											
Arsenic III											
Asbestos											
Atrazine											
Azinphos methyl											
Barium											2000.0000
Bendiocarb											
Bentazone											
Benzene		18.0000	180.0000	500.0000							10.0000
Benzene Pentachloronitro		50.0000									
Benzene, hexachloro		50.0000									
Benzidene											
Benzo(a)anthracene											
Benzo(a)pyrene		10.0000	50.0000								
Benzo(b)flouranthene											
Benzo(g,h,I)perylene											
Benzo(k)flouranthene											
Beryllium		100.0000	1000.0000								8.0000
Beta BHC		50.0000									
Bis(2-ethylhexyl)phthalate											
Bis(chloromethyl)ether											
Boron											2800.0000
Bromacil											
Bromate											
Bromine											1000.0000
Bromodichloromethane											
Bromoform											
Bupirimate											
Buprofezin											
Butylbenzylphthalate											
C10 - C36 Petroleum hydrocarbon		10000.0000									
C16-C35 Petroleum hydrocarbons (aliphatics)			280000.0000								
C16-C35 Petroleum hydrocarbons (aromatics)			4500.0000								
C6-C15 Petroleum hydrocarbon			28000 [21]								
C6-C9 Petroleum hydrocarbon		650.0000									
Ca + Mg (total hardness)											
Cadmium		100.0000	1000.0000								20.0000
Captan											
Carbaryl											
Carbofuran											
Carbon Tetrachloride		18.0000									10.0000
Chlorate											
Chlordane		50.0000	2500 [22]								0.6000
Chloride											
Chlorinated Phenols											4.0000
Chlorine											
Chlorine (free)											
Chlorine (hypochlorite)											
Chlorite											
Chlorobenzene		3600.0000									2000.0000
Chloroform		216.0000									120.0000
Chloroform											
Chlorophenol					100.00000						
Chlorpyriphos		7.5000									
Chlorpyriphos methyl											
Chlortoluron											
Chromium			500.0000								100.0000
Chromium 3											
Chromium 6		1900.0000									
Chrysene											

Appendix B Total Concentration Limits and Screening Values

	US EPA (mg/L)	**NSW EPA (mg/kg)**	**WA - CL 3 (mg/kg)**	**Private Landfill 1 (mg/L)** *Class A*	**Private Landfill 2 (g/m^3)** ***Class A*** [26]	**NZS 9201 (g/m^3)**	**ANZECC - 95% & 99% as appropriate (ug/L)**	**Auckland Trade Waste By Law (mg/L)**	**Drinking Water Std (mg/L)**	**Municipal Landfill 1 (mg/L)** ***Note: not Class A***	**Municipal Landfill 2 (mg/kg) Screening Limit Only** *Note:* ***not Class A***
Cobalt											2000.0000
Colour											
Copper											4000.0000
Cresol (total)		7200.0000	72000[20]								4000.0000
Cyanazine											
Cyanide (amenable)		300.0000	12500.0000								
Cyanide (total)		5900.0000	25000.0000								
Cyanide containing compounds											
Cyanides											1000 (weak dissociable as CN)
Cyanogen chloride (as CN)											
Cylindrospermopsin											
Cynobacteria											
DDD (1,1-dichloro-2,2-bis(p-chlorophenyl)ethane)		50.0000	10000.0000								
DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene)		50.0000									
DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane)		50.0000									
DDT +DDD + DDE			10000[22]								
Delta BHC		50.0000									
Demeton-S-methyl											
Di (2-ethylhexyl)adipate											
Di (2-ethylhexyl)phthalate											
Diazinon											
Dibenzo(a,h)anthracene											
Dibromoacetonitrile											
Dibromochloromethane											
Dibromomethane											
Dibutylpthalate											
Dichlofluanid											
Dichloroacetic acid											
Dichloroacetonitrile											
Dichlorobenzidine					1.00000						
Dichlorodiflouromethane											
Dichloromethane		310.0000									
Dichlorprop											
Dichlorvos											
Dieldrin		50.0000									
Diethylether											
Diethylphthalate											
Dimethoate											
Dimethylphthalate											
Di-n-butylphthalate											
Di-n-octylphthalate											
Dioxane											
Diquat											
Dissolved Aluminium											
Diuron											
Edrin Aldehyde		50.0000									
EDTA											
Endosulfan											
Endosulfan I											
Endosulfan II											
Endosulfan sulphate											
Endrin		50.0000									0.4000
Endrin Aldehyde											
Epichlorohydrin											
Escherischia coli (E.coli)											
Ethanol											
Ethyl benzene		1080.0000	4320[20]	500.0000							
Ethylene Benzene											
Fenamiphos											
Fenarimol											
Fenitrothion											
Fenoprop											
Flouranthene					2.00000						
Flourene					2.00000						
Flouride			100000[20]								
Flouride		10000.0000	100000.0000								1000.0000
Fluroxypyr		75.0000									

Appendix B Total Concentration Limits and Screening Values

	US EPA (mg/L)	NSW EPA (mg/kg)	WA - CL 3 (mg/kg)	Private Landfill 1 (mg/L) *Class A*	Private Landfill 2 (g/m^3) *Class A* [26]	NZS 9201 (g/m^3)	ANZECC - 95% & 99% as appropriate (ug/L)	Auckland Trade Waste By Law (mg/L)	Drinking Water Std (mg/L)	Municipal Landfill 1 (mg/L) *Note: not Class A*	Municipal Landfill 2 (mg/kg) Screening Limit Only *Note: not Class A*
Flusilazole											
Formaldehyde											2000.0000
Gamma - BHC - Lindane		50.0000									
Halogenated aliphatic hydrocarbons											200 (compounds)
Halogenated aromatic hydrocarbons											0.4000
Helminths (pathogenic)											
Heptachlor		50.0000	500 [22]								0.1600
Heptachlor Epoxide		50.0000									
Hexachloro -1,3 - butadiene											10.0000
Hexachlorobenzene					0.40000						2.6000
Hexachloroethane											60.0000
Hexachlorophene		50.0000									
Hexazinone											
Homoanatoxin -a											
Hydrogen Sulphide											
Indeno(1,2,3-c,d)pyrene											
Iron											
Isodrin		50.0000									
Isoproturon											
Kjeldahl nitrogen											
Lead		1500.0000	15000.0000								100.0000
Lindane											8.0000
Linuron											
Lithium											
LPS endoxins											
Malathion											
Manganese											
MCPA											
m-Cresol		7200.0000									
Mecoprop											
Mercury		50.0000	750.0000								4.0000
Metalaxyl											
Methanol											
Methiocarb											
Methoxychlor											200.0000
Methyl acetate											
Methyl ethyl ketone		7200.0000		1000.0000							4000.0000
Methylene Blue Active Substances											
Metolachlor											
Metribuzin											
Mevinphos											
Microcystins											
Molinate											
Molybdenum		1000.0000	10000 [20]								140.0000
Monochloramine											
Monochlorobenzene											
Monocyclic aromatic hydrocarbons											1000.0000
m-t p-cresol (3-+4 methyl phenol)					200.00000						
myclobutanil											
Napthalene					200.00000						
Nickel		1050.0000	30000.0000								40.0000
Nitrate											
Nitrilotriacetic acid											
Nitrite											
Nitrobenzene		72.0000									40.0000
Nodularin											
OCP Scheduled wastes			50 [23]								
o-Cresol		7200.0000			200.00000						
Odour				300 OU/m2/s [12,13]							
Odour [18]				300 OU/m2/s [19]							
Organophosphate Pesticides											20.0000
Oryzalin											
Other solvents			500.0000								
Oxadiazon											
Oxidised sulphur compounds											
o-Xylene											
Parathion											
Pathogenic Bacteria											
p-Cresol		7200.0000									
Pendimethalin											

Appendix B Total Concentration Limits and Screening Values

	US EPA (mg/L)	**NSW EPA (mg/kg)**	**WA - CL 3 (mg/kg)**	**Private Landfill 1 (mg/L)** *Class A*	**Private Landfill 2 (g/m^3)** ***Class A*** [26]	**NZS 9201 (g/m^3)**	**ANZECC - 95% & 99% as appropriate (ug/L)**	**Auckland Trade Waste By Law (mg/L)**	**Drinking Water Std (mg/L)**	**Municipal Landfill 1 (mg/L)** ***Note: not Class A***	**Municipal Landfill 2 (mg/kg) Screening Limit Only** *Note:* ***not Class A***
Pentachlorobenzene		50.0000									
Pentachlorophenol		50.0000									2000.0000
Permethrin											
Pesticides (general)											200.0000
Petroleum Hydrocarbons											6000.0000
pH				2.0 - 12.5							
Phenathrene					2.00000						
Phenol		518.0000			2000.00000						
Phenol (non halogenated)		518.0000									
Phenols (total non-chlorinated)			425000.0000								1000.0000
Phorate											
Picloram		110.0000									
Pirimiphos methyl											
Pirimisulfuron methyl											
Plasticiser Compounds		600.0000									
Polybrominated biphenyls											
Polychlorinated Biphenals		50.0000		50.0000							0.0000
Polycyclic aromatic hydrocarbons (total)		200.0000	1000.0000								10.0000
Procymidone											
Propanil											
Propazine											
Protozoa (pathogenic)											
p-Xylene											
Pyrene											
Pyridate											
Pyridine											100.0000
Radon											
Reactive Cyanide				50.0000							
Reactive Sulphide (17)				50.0000							
Saxitoxins											
Selenium		50.0000	500.0000								20.0000
Silver		180.0000	1800 [20]								100.0000
Silvex											
Simazine											
Sodium											
Styrene (vinyl benzene)		108.0000	1080 [20]								
Sulphate											
Sulphate with good mixing											
Sulphide containing compounds											
Sulphides											1000.0000
Sulphite											
TBTO											
Tebuconazole		230.0000									
Terbuthylazine											
Tetrachloroethene											
Tetrachloroethylene		25.2000									14.0000
Thallium											2000.0000
Thiabendazole											
Tin											2000.0000
Toluene		518.0000	1580 [20]	500.0000							
Total acidic herbicides											
Total Alpha Activity											
Total Beta Activity											
Total BTEX				1000.0000							
Total Dissolved Solids											
Total Halogenated compounds											
Total Halogenated VOC					20.00000						
Total non-halogenated VOC					200.00000						
Total of all chloronapthalenes											
Total of all Dioxins											
Total of all PCB compounds											
Total of all polychlorinated dibenzofufans											
Total Organochlorine Pesticides											

Appendix B Total Concentration Limits and Screening Values

	US EPA (mg/L)	**NSW EPA (mg/kg)**	**WA - CL 3 (mg/kg)**	**Private Landfill 1 (mg/L)** *Class A*	**Private Landfill 2 (g/m^3)** ***Class A*** [26]	**NZS 9201 (g/m^3)**	**ANZECC - 95% & 99% as appropriate (ug/L)**	**Auckland Trade Waste By Law (mg/L)**	**Drinking Water Std (mg/L)**	**Municipal Landfill 1 (mg/L)** ***Note: not Class A***	**Municipal Landfill 2 (mg/kg) Screening Limit Only** *Note:* ***not Class A***
Total Organonitrogens and organophospates											
Total Phosphorus											
Total SVOC					200.00000						
Total synthetic non-halogenated compounds											
Toxaphene											10.0000
Toxaphor											
Trichloroacetaldehyde/chl oral hydrate											
Trichloroacetic acid											
Trichloroacetonitrile											
Trichlorobenzenes (total)											
Trichloroethene											
Trichloroethylene		18.0000									14.0000
Trichloroflouromethane											
Triclopyr		75.0000									
Trifluralin											
Turbidity											
Uranium											
Vanadium											
Vinyl Chloride		7.2000									4.0000
Viruses											
Xylenes		1800.0000	1000 [20]	500.0000							
Zinc											6000.0000

Appendix C
R J Hills Laboratories
List of SVOCs and VOCs

Appendix C
R J Hills Laboratories
List of SVOCs and VOCs

Semi-Volatile Organic Compounds

Phenols

2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
2-Chlorophenol
2-Methylphenol (o-cresol)
2-Nitrophenol
4-Chloro-3-methylphenol
3 & 4-Methylphenol (m- + p-cresol)
Phenol

PAHs

2-Chloronaphthalene
2-Methylnaphthalene
Acenaphthene
Acenaphthylene
Anthracene
Benzo[a]anthracene
Benzo[a]pyrene
Benzo[b]fluoranthene
Benzo[g,h,i]perylene
Benzo[k]fluoranthene
Chrysene
Dibenzo[a,h]anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-c,d)pyrene
Naphthalene
Phenanthrene
Pyrene

OCPs

4,4'-DDD
4,4'-DDE
4,4'-DDT
Aldrin
Alpha BHC
Beta BHC
Delta BHC
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan sulphate
Endrin

Endrin Aldehyde
Gamma BHC (Lindane)
Heptachlor epoxide
Heptachlor
Hexachlorobenzene

Plasticisers

Di-(2-ethylhexyl)adipate
Bis(2-ethylhexyl)phthalate
Butylbenzylphthalate
Diethylphthalate
Dimethylphthalate
Di-n-butylphthalate
Di-n-octylphthalate

Haloethers

4-Chlorophenyl phenyl ether
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether

Other halogenated compounds

1,2,4-Trichlorobenzene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Hexachlorobutadiene
Hexachloroethane

Nitrogen containing compounds

2,4-Dinitrotoluene
2,6-Dinitrotoluene
Nitrobenzene
N-nitrosodi-n-propyl amine
N-Nitrosodiphenylamine

Other SVOCs

Carbazole
Dibenzofuran
Isophorone

Appendix C
R J Hills Laboratories
List of SVOCs and VOCs

Volatile Organic Compounds

BTEX

Benzene
Toluene
Toluene-d8 (% Recovery)
Ethylbenzene
m & p-Xylene
o-Xylene

Other Monocyclic aromatic hydrocarbons

1,2,4-Trimethylbenzene
1,3,5-Trimethylbenzene
4-Isopropyltoluene
Isopropylbenzene
n-Butylbenzene
n-Propylbenzene
sec-Butylbenzene
Styrene
Tert-Butylbenzene

Trihalomethanes

Bromodichloromethane
Bromoform (tribromomethane)
Chloroform (Trichloromethane)
Dibromochloromethane

Oxygenated compounds

2-Butanone (MEK)
MTBE (methyl-tert-butylether)
4-Methylpentan-2-one (MIBK)

Halogenated Aliphatics

1,1,1,2-Tetrachloroethane
1,1,1-Trichloroethane
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1,2-Trichlorotrifluoroethane (Freon 113)
1,1-Dichloroethane
1,1-Dichloroethene
1,1-Dichloropropene
1,2,3-Trichloropropane
1,2-Dibromo-3-chloropropane
1,2-Dibromoethane
1,2-Dichloroethane

1,2-Dichloropropane
1,3-Dichloropropane
2,2-Dichloropropane
Bromomethane
Carbon tetrachloride
Chloroethane
Chloromethane
cis-1,2-Dichloroethene
cis-1,3-Dichloropropene
Dibromomethane
Dichlorodifluoromethane
Hexachlorobutadiene
Dichloromethane (Methylene chloride)
Tetrachloroethene
trans-1,2-Dichloroethene
trans-1,3-Dichloropropene
Trichloroethene
Trichlorofluoromethane
Vinyl chloride

Halogenated Aromatics

1,2,3-Trichlorobenzene
1,2,4-Trichlorobenzene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
2-Chlorotoluene
4-Bromofluorobenzene (% Recovery)
4-Chlorotoluene
Bromobenzene
Chlorobenzene

Other VOCs

Carbon disulphide
Naphthalene

Appendix D
New Zealand Waste List
Hazardous Wastes

Appendix D
New Zealand Waste List
Hazardous Wastes

New Zealand Waste List

Note: Wastes marked with an asterisk (*) are potentially hazardous. For further information contact Jonathan Coakley (jonathan.coakley@mfe.govt.nz).

01 Wastes resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals

01 03 Wastes from physical and chemical processing of metalliferous minerals
- 01 03 04* acid-generating tailings from processing of sulphide ore
- 01 03 05* other tailings containing hazardous substances
- 01 03 07* other wastes containing hazardous substances from physical and chemical processing of metalliferous minerals

01 04 Wastes from physical and chemical processing of non-metalliferous minerals
- 01 04 07* wastes containing hazardous substances from physical and chemical processing of non-metalliferous minerals

01 05 Drilling muds and other drilling wastes
- 01 05 05* oil-containing drilling muds and wastes
- 01 05 06* drilling muds and other drilling wastes containing hazardous substances

02 Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and

02 01 Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing
- 02 01 08* agrichemical waste containing hazardous substances

03 Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard

03 01 Wastes from wood processing and the production of panels and furniture
- 03 01 04* sawdust, shavings, cuttings, wood, particle board and veneer containing hazardous substances

03 02 Wastes from wood preservation
- 03 02 01* non-halogenated organic wood preservatives
- 03 02 02* organochlorinated wood preservatives
- 03 02 03* organometallic wood preservatives
- 03 02 04* inorganic wood preservatives
- 03 02 05* other wood preservatives containing hazardous substances

04 Wastes from the leather, fur and textile industries

04 01 Wastes from the leather and fur industry
- 04 01 03* degreasing wastes containing solvents without a liquid phase

04 02 Wastes from the textile industry
- 04 02 14* wastes from finishing containing organic solvents
- 04 02 16* dyestuffs and pigments containing hazardous substances
- 04 02 19* sludges from on-site effluent treatment containing hazardous substances

Appendix D
New Zealand Waste List
Hazardous Wastes

05	Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal	
05 01	Wastes from petroleum refining	
	05 01 02*	desalter sludges
	05 01 03*	tank bottom sludges
	05 01 04*	acid alkyl sludges
	05 01 05*	oil spills
	05 01 06*	oily sludges from maintenance operations of the plant or equipment
	05 01 07*	acid tars
	05 01 08*	other tars
	05 01 09*	sludges from on-site effluent treatment containing hazardous substances
	05 01 11*	wastes from cleaning of fuels with bases
	05 01 12*	oil containing acids
	05 01 15*	spent filter clays
05 06	Wastes from the pyrolytic treatment of coal	
	05 06 01*	acid tars
	05 06 03*	other tars
05 07	Wastes from natural gas purification and transportation	
	05 07 01*	wastes containing mercury
06	Wastes from inorganic chemical processes	
06 01	Wastes from the manufacture, formulation, supply and use (MFSU) of acids	
	06 01 01*	sulphuric acid and sulphurous acid
	06 01 02*	hydrochloric acid
	06 01 03*	hydrofluoric acid
	06 01 04*	phosphoric and phosphorous acid
	06 01 05*	nitric acid and nitrous acid
	06 01 06*	other acids
06 02	Wastes from the MFSU of bases	
	06 02 01*	calcium hydroxide
	06 02 03*	ammonium hydroxide
	06 02 04*	sodium and potassium hydroxide
	06 02 05*	other bases
06 03	Wastes from the MFSU of salts and their solutions and metallic oxides	
	06 03 11*	solid salts and solutions containing cyanides
	06 03 13*	solid salts and solutions containing heavy metals
	06 03 15*	metallic oxides containing heavy metals
06 04	Metal-containing wastes other than those mentioned in 06 03	
	06 04 03*	wastes containing arsenic
	06 04 04*	wastes containing mercury
	06 04 05*	wastes containing other heavy metals
06 05	Sludges from on-site effluent treatment	
	06 05 02*	sludges from on-site effluent treatment containing hazardous substances
06 06	Wastes from the MFSU of sulphur chemicals, sulphur chemical processes and desulphurisation processes	

06 06 02*	wastes containing hazardous sulphides
06 07 01*	wastes containing asbestos from electrolysis
06 07 02*	activated carbon from chlorine production
06 07 03*	barium sulphate sludge containing mercury
06 07 04*	solutions and acids, e.g. contact acid
06 08	Wastes from the MFSU of silicon and silicon derivatives
06 08 02*	wastes containing hazardous silicones
06 09	Wastes from the MSFU of phosphorous chemicals and phosphorous chemical processes
06 09 03*	calcium-based reaction wastes containing or contaminated with hazardous substances
06 10	Wastes from the MFSU of nitrogen chemicals, nitrogen chemical processes and fertiliser manufacture
06 10 02*	wastes containing hazardous substances
06 10 99	wastes not otherwise specified
06 13	Wastes from inorganic chemical processes not otherwise specified
06 13 01*	inorganic plant protection products, wood-preserving agents and other biocides.
06 13 02*	spent activated carbon (except 06 07 02)
06 13 04*	wastes from asbestos processing
06 13 05*	soot
07	Wastes from organic chemical processes
07 01	Wastes from the manufacture, formulation, supply and use (MFSU) of basic organic chemicals
07 01 01*	aqueous washing liquids and mother liquors
07 01 03*	organic halogenated solvents, washing liquids and mother liquors
07 01 04*	other organic solvents, washing liquids and mother liquors
07 01 07*	halogenated still bottoms and reaction residues
07 01 08*	other still bottoms and reaction residues
07 01 09*	halogenated filter cakes and spent absorbents
07 01 10*	other filter cakes and spent absorbents
07 01 11*	sludges from on-site effluent treatment containing hazardous substances
07 02	Wastes from the MFSU of plastics, synthetic rubber and man-made fibres
07 02 01*	aqueous washing liquids and mother liquors
07 02 03*	organic halogenated solvents, washing liquids and mother liquors
07 02 04*	other organic solvents, washing liquids and mother liquors
07 02 07*	halogenated still bottoms and reaction residues
07 02 08*	other still bottoms and reaction residues
07 02 09*	halogenated filter cakes and spent absorbents
07 02 10*	other filter cakes and spent absorbents
07 02 11*	sludges from on-site effluent treatment containing hazardous substances
07 02 14*	wastes from additives containing hazardous substances
07 02 16*	wastes containing hazardous silicones
07 03	Wastes from the MFSU of organic dyes and pigments (except 06 11)
07 03 01*	aqueous washing liquids and mother liquors

	07 03 03*	organic halogenated solvents, washing liquids and mother liquors
	07 03 04*	other organic solvents, washing liquids and mother liquors
	07 03 07*	halogenated still bottoms and reaction residues
	07 03 08*	other still bottoms and reaction residues
	07 03 09*	halogenated filter cakes and spent absorbents
	07 03 10*	other filter cakes and spent absorbents
	07 03 11*	sludges from on-site effluent treatment containing hazardous substances
07 04	Wastes from the MFSU of organic plant protection products (except 02 01 05), wood preserving agents (except 03 02) and other biocides	
	07 04 01*	aqueous washing liquids and mother liquors
	07 04 03*	organic halogenated solvents, washing liquids and mother liquors
	07 04 04*	other organic solvents, washing liquids and mother liquors
	07 04 07*	halogenated still bottoms and reaction residues
	07 04 08*	other still bottoms and reaction residues
	07 04 09*	halogenated filter cakes and spent absorbents
	07 04 10*	other filter cakes and spent absorbents
	07 04 11*	sludges from on-site effluent treatment containing hazardous substances
	07 04 13*	solid wastes containing hazardous substances
07 05	Wastes from the MFSU of pharmaceuticals	
	07 05 01*	aqueous washing liquids and mother liquors
	07 05 03*	organic halogenated solvents, washing liquids and mother liquors
	07 05 04*	other organic solvents, washing liquids and mother liquors
	07 05 07*	halogenated still bottoms and reaction residues
	07 05 08*	other still bottoms and reaction residues
	07 05 09*	halogenated filter cakes and spent absorbents
	07 05 10*	other filter cakes and spent absorbents
	07 05 11*	sludges from on-site effluent treatment containing hazardous substances
	07 05 13*	solid wastes containing hazardous substances
07 06	Wastes from the MFSU of fats, grease, soaps, detergents, disinfectants and cosmetics	
	07 06 01*	aqueous washing liquids and mother liquors
	07 06 03*	organic halogenated solvents, washing liquids and mother liquors
	07 06 04*	other organic solvents, washing liquids and mother liquors
	07 06 07*	halogenated still bottoms and reaction residues
	07 06 08*	other still bottoms and reaction residues
	07 06 09*	halogenated filter cakes and spent absorbents
	07 06 10*	other filter cakes and spent absorbents
	07 06 11*	sludges from on-site effluent treatment containing hazardous substances
07 07	Wastes from the MFSU of fine chemicals and chemical products not otherwise specified	
	07 07 01*	aqueous washing liquids and mother liquors
	07 07 03*	organic halogenated solvents, washing liquids and mother liquors
	07 07 04*	other organic solvents, washing liquids and mother liquors
	07 07 07*	halogenated still bottoms and reaction residues
	07 07 08*	other still bottoms and reaction residues
	07 07 09*	halogenated filter cakes and spent absorbents

Appendix D
New Zealand Waste List
Hazardous Wastes

	07 07 10*	other filter cakes and spent absorbents
	07 07 11*	sludges from on-site effluent treatment containing hazardous substances
08		Wastes from the manufacture, formulation, supply and use (mfsu) of coatings (paints, varnishes and vitreous enamels), adhesives, sealants and printing inks
08 01		Wastes from MFSU and removal of paint and varnish
	08 01 11*	waste paint and varnish containing organic solvents or other hazardous substances
	08 01 13*	sludges from paint or varnish containing organic solvents or other hazardous substances
	08 01 15*	aqueous sludges containing paint or varnish containing organic solvents or other hazardous substances
	08 01 17*	wastes from paint or varnish removal containing organic solvents or other hazardous substances
	08 01 19*	aqueous suspensions containing paint or varnish containing organic solvents or other hazardous substances
	08 01 21*	waste paint or varnish remover
08 03		Wastes from MFSU of printing inks
	08 03 12*	waste printing ink containing hazardous substances
	08 03 14*	ink sludges containing hazardous substances
	08 03 16*	waste etching solutions
	08 03 17*	waste printing toner containing hazardous substances
	08 03 19*	disperse oil
08 04		Wastes from MFSU of adhesives and sealants (including waterproofing products)
	08 04 09*	waste adhesives and sealants containing organic solvents or other hazardous substances
	08 04 11*	adhesive and sealant sludges containing organic solvents or other hazardous substances
	08 04 13*	aqueous sludges containing adhesives or sealants containing organic solvents or other hazardous substances
	08 04 15*	aqueous liquid waste containing adhesives or sealants containing organic solvents or other hazardous substances
	08 04 17*	rosin oil
08 05		Wastes not otherwise specified in 08
	08 05 01*	waste isocyanates
09		Wastes from the photographic industry
09 01		Wastes from the photographic industry
	09 01 01*	water-based developer and activator solutions
	09 01 02*	water-based offset plate developer solutions
	09 01 03*	solvent-based developer solutions
	09 01 04*	fixer solutions
	09 01 05*	bleach solutions and bleach fixer solutions
	09 01 06*	wastes containing silver from on-site treatment of photographic wastes
	09 01 10	single-use cameras without batteries
	09 01 11*	single-use cameras containing batteries included in 16 06 01, 16 06

		02 or 16 06 03
	09 01 15*	aqueous liquid waste from on-site reclamation of silver other than those mentioned in 09 01 06
10		Wastes from thermal processes
10 01		Wastes from power stations and other combustion plants (except 19)
	10 01 04*	oil fly ash and -boiler dust
	10 01 09*	sulphuric acid
	10 01 13*	fly ash from emulsified hydrocarbons used as fuel
	10 01 14*	bottom ash, slag and boiler dust from co-incineration containing hazardous substances
	10 01 16*	fly ash from co-incineration containing hazardous substances
	10 01 18*	wastes from gas cleaning containing hazardous substances
	10 01 20*	sludges from on-site effluent treatment containing hazardous substances
	10 01 22*	aqueous sludges from boiler cleansing containing hazardous substances
10 02		Wastes from the iron and steel industry
	10 02 07*	solid wastes from gas treatment containing hazardous substances
	10 02 11*	wastes from cooling-water treatment containing oil
	10 02 13*	sludges and filter cakes from gas treatment containing hazardous substances
10 03		Wastes from aluminium thermal metallurgy
	10 03 04*	primary production slags
	10 03 08*	salt slags from secondary production
	10 03 09*	black drosses from secondary production
	10 03 15*	skimmings that are flammable or emit, upon contact with water, flammable gases in hazardous quantities
	10 03 17*	tar-containing wastes from anode manufacture
	10 03 19*	flue-gas dust containing hazardous substances
	10 03 21*	other particulates and dust (including ball-mill dust) containing hazardous substances
	10 03 23*	solid wastes from gas treatment containing hazardous substances
	10 03 25*	sludges and filter cakes from gas treatment containing hazardous substances
	10 03 27*	wastes from cooling-water treatment containing oil
	10 03 29*	wastes from treatment of salt slags and black drosses containing hazardous substances
10 04		Wastes from lead thermal metallurgy
	10 04 01*	slags from primary and secondary production
	10 04 02*	dross and skimmings from primary and secondary production
	10 04 03*	calcium arsenate
	10 04 04*	flue-gas dust
	10 04 05*	other particulates and dust
	10 04 06*	solid wastes from gas treatment
	10 04 07*	sludges and filter cakes from gas treatment
	10 04 09*	wastes from cooling-water treatment containing oil
10 05		Wastes from zinc thermal metallurgy
	10 05 03*	flue-gas dust
	10 05 05*	solid waste from gas treatment
	10 05 06*	sludges and filter cakes from gas treatment
	10 05 08*	wastes from cooling-water treatment containing oil
	10 05 10*	dross and skimmings that are flammable or emit, upon contact with

		water, flammable gases in hazardous quantities
10 06	Wastes from copper thermal metallurgy	
	10 06 03*	flue-gas dust
	10 06 06*	solid wastes from gas treatment
	10 06 07*	sludges and filter cakes from gas treatment
	10 06 09*	wastes from cooling-water treatment containing oil
10 07	Wastes from silver, gold and platinum thermal metallurgy	
	10 07 07*	wastes from cooling-water treatment containing oil
10 08	Wastes from other non-ferrous thermal metallurgy	
	10 08 08*	salt slag from primary and secondary production
	10 08 10*	dross and skimmings that are flammable or emit, upon contact with water, flammable gases in hazardous quantities
	10 08 12*	tar-containing wastes from anode manufacture
	10 08 15*	flue-gas dust containing hazardous substances
	10 08 17*	sludges and filter cakes from flue-gas treatment containing hazardous substances
	10 08 19*	wastes from cooling-water treatment containing oil
10 09	Wastes from casting of ferrous pieces	
	10 09 05*	casting cores and moulds which have not undergone pouring containing hazardous substances
	10 09 07*	casting cores and moulds which have undergone pouring containing hazardous substances
	10 09 09*	flue-gas dust containing hazardous substances
	10 09 11*	other particulates containing hazardous substances
	10 09 13*	waste binders containing hazardous substances
	10 09 15*	waste crack-indicating agent containing hazardous substances
10 10	Wastes from casting of non-ferrous pieces	
	10 10 05*	casting cores and moulds which have not undergone pouring containing hazardous substances
	10 10 07*	casting cores and moulds which have undergone pouring containing hazardous substances
	10 10 09*	flue-gas dust containing hazardous substances
	10 10 11*	other particulates containing hazardous substances
	10 10 13*	waste binders containing hazardous substances
	10 10 15*	waste crack-indicating agent containing hazardous substances
10 11	Wastes from manufacture of glass and glass products	
	10 11 09*	waste preparation mixture before thermal processing containing hazardous substances
	10 11 11*	waste glass in small particles and glass powder containing heavy metals (e.g. from cathode ray tubes)
	10 11 13*	glass-polishing and -grinding sludge containing hazardous substances
	10 11 15*	solid wastes from flue-gas treatment containing hazardous substances
	10 11 17*	sludges and filter cakes from flue-gas treatment containing hazardous substances
	10 11 19*	solid wastes from on-site effluent treatment containing hazardous substances
10 12	Wastes from manufacture of ceramic goods, bricks, tiles and construction products	
	10 12 09*	solid wastes from gas treatment containing hazardous substances
	10 12 11*	wastes from glazing containing heavy metals

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10 13		Wastes from manufacture of cement, lime and plaster and articles and products made from them
	10 13 09*	wastes from asbestos-cement manufacture containing asbestos
	10 13 12*	solid wastes from gas treatment containing hazardous substances
10 14		Waste from crematoria
	10 14 01*	waste from gas cleaning containing mercury
11		Wastes from chemical surface treatment and coating of metals and other materials; non-ferrous
11 01		Wastes from chemical surface treatment and coating of metals and other materials (eg. Galvanic processes, zinc coating processes, pickling processes, etching, phosphatiing, alkaline degreasing, anodising)
	11 01 05*	pickling acids
	11 01 06*	acids not otherwise specified
	11 01 07*	pickling bases
	11 01 08*	phosphatising sludges
	11 01 09*	sludges and filter cakes containing hazardous substances
	11 01 11*	aqueous rinsing liquids containing hazardous substances
	11 01 13*	degreasing wastes containing hazardous substances
	11 01 15*	eluate and sludges from membrane systems or ion exchange systems containing hazardous substances
	11 01 16*	saturated or spent ion exchange resins
	11 01 98*	other wastes containing hazardous substances
11 02		Wastes from non-ferrous hydrometallurgical processes
	11 02 02*	sludges from zinc hydrometallurgy (incl. jarosite, goethite)
	11 02 05*	wastes from copper hydrometallurgical processes containing hazardous substances
	11 02 07*	other wastes containing hazardous substances
11 03		Sludges and solids from tempering processes
	11 03 01*	wastes containing cyanide
	11 03 02*	other wastes
11 05		Wastes from hot galvanising processes
	11 05 03*	solid wastes from gas treatment
	11 05 04*	spent flux
12		Wastes from shaping and physical and mechanical surface treatment of metals and plastics
12 01		Wastes from shaping and physical and mechanical surface treatment of metals and plastics
	12 01 06*	mineral-based machining oils containing halogens (except emulsions and solutions)
	12 01 07*	mineral-based machining oils free of halogens (except emulsions and solutions)
	12 01 08*	machining emulsions and solutions containing halogens
	12 01 09*	machining emulsions and solutions free of halogens
	12 01 10*	synthetic machining oils
	12 01 12*	spent waxes and fats
	12 01 14*	machining sludges containing hazardous substances
	12 01 16*	waste blasting material containing hazardous substances
	12 01 18*	metal sludge (grinding, honing and lapping sludge) containing oil
	12 01 19*	readily biodegradable machining oil

	12 01 20*	spent grinding bodies and grinding materials containing hazardous substances
12 03	Wastes from water and steam degreasing processes (except 11)	
	12 03 01*	aqueous washing liquids
	12 03 02*	steam degreasing wastes
13	Oil wastes and wastes of liquid fuels (except edible oils, 05 and 12)	
13 01	Waste hydraulic oils	
	13 01 01*	hydraulic oils, containing PCBs or PCTs
	13 01 04*	chlorinated emulsions
	13 01 05*	non-chlorinated emulsions
	13 01 09*	mineral-based chlorinated hydraulic oils
	13 01 10*	mineral based non-chlorinated hydraulic oils
	13 01 11*	synthetic hydraulic oils
	13 01 12*	readily biodegradable hydraulic oils
	13 01 13*	other hydraulic oils
13 02	Waste engine, gear and lubricating oils	
	13 02 04*	mineral-based chlorinated engine, gear and lubricating oils
	13 02 05*	mineral-based non-chlorinated engine, gear and lubricating oils
	13 02 06*	synthetic engine, gear and lubricating oils
	13 02 07*	readily biodegradable engine, gear and lubricating oils
	13 02 08*	other engine, gear and lubricating oils
13 03	Waste insulating and heat transmission oils	
	13 03 01*	insulating or heat transmission oils containing PCBs or PCTs
	13 03 06*	mineral-based chlorinated insulating and heat transmission oils other than those mentioned in 13 03 01
	13 03 07*	mineral-based non-chlorinated insulating and heat transmission oils
	13 03 08*	synthetic insulating and heat transmission oils
	13 03 09*	readily biodegradable insulating and heat transmission oils
	13 03 10*	other insulating and heat transmission oils
13 04	Bilge oils	
	13 04 01*	bilge oils from inland navigation
	13 04 02*	bilge oils from jetty sewers
	13 04 03*	bilge oils from other navigation
13 05	Oil/water separator contents	
	13 05 01*	solids from grit chambers and oil/water separators
	13 05 02*	sludges from oil/water separators
	13 05 03*	interceptor sludges
	13 05 06*	oil from oil/water separators
	13 05 07*	oily water from oil/water separators
	13 05 08*	mixtures of wastes from grit chambers and oil/water separators
13 07	Wastes of liquid fuels	
	13 07 01*	fuel oil
	13 07 02*	petrol and diesel
	13 07 03*	other fuels (including mixtures)
13 08	Oil wastes not otherwise specified	
	13 08 01*	desalter sludges or emulsions
	13 08 02*	other emulsions
	13 08 99*	wastes not otherwise specified
14	Waste organic solvents, refrigerants and propellants (except 07 and 08)	
14 06	Waste organic solvents, refrigerants and propellants	

	14 06 01*	chlorofluorocarbons, HCFC, HFC
	14 06 02*	other halogenated solvents and solvent mixtures
	14 06 03*	other solvents and solvent mixtures
	14 06 04*	sludges or solid wastes containing halogenated solvents
	14 06 05*	sludges or solid wastes containing other solvents
15	Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise	
15 01	Packaging (including separately collected municipal packaging waste)	
	15 01 09*	packaging containing residues of or contaminated by hazardous substances
	15 01 10*	metallic packaging containing a hazardous solid porous matrix, including empty pressure containers
15 02	Absorbents, filter materials, wiping cloths and protective clothing	
	15 02 02*	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by hazardous substances
16	Wastes not otherwise specified in the list	
16 01	End-of-life vehicles and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08)	
	16 01 04*	end-of-life vehicles
	16 01 07*	oil filters
	16 01 08*	components containing mercury
	16 01 09*	components containing PCBs or PCTs
	16 01 10*	explosive components (e.g. air bags)
	16 01 11*	brake pads containing asbestos
	16 01 13*	brake fluids
	16 01 14*	antifreeze fluids containing hazardous substances
	16 01 21*	hazardous components other than those mentioned in 16 01 07 to 16 01 11 and 16 01 13 and 16 01 14
16 02	Wastes from electrical and electronic equipment	
	16 02 09*	transformers and capacitors containing PCBs or PCTs
	16 02 10*	discarded equipment containing or contaminated by PCBs or PCTs other than those mentioned in 16 02 09
	16 02 11*	discarded equipment containing chlorofluorocarbons
	16 02 12*	discarded equipment containing free asbestos
	16 02 13*	discarded equipment containing hazardous components other than those mentioned in 16 02 09 to 16 02 12
	16 02 15*	hazardous components removed from discarded equipment
16 03	Off-specification batches and unused products	
	16 03 03*	inorganic wastes containing hazardous substances
	16 03 05*	organic wastes containing hazardous substances
16 04	Waste explosives	
	16 04 01*	waste ammunition
	16 04 02*	fireworks wastes
	16 04 03*	other waste explosives
16 05	Gases in pressure containers and discarded chemicals	
	16 05 04*	gases in pressure containers (including halons) containing hazardous substances
	16 05 06*	laboratory chemicals consisting of or containing hazardous

		substances including mixtures of laboratory chemicals
	16 05 07*	discarded inorganic chemicals consisting of or containing hazardous substances
	16 05 08*	discarded organic chemicals consisting of or containing hazardous substances
16 06	Batteries and accumulators	
	16 06 01*	lead batteries
	16 06 02*	Ni-Cd batteries
	16 06 03*	mercury- containing batteries
	16 06 06*	separately collected electrolyte from batteries and accumulators
16 07	Wastes from transport tank, storage tank and barrel cleaning (except 05 and 13)	
	16 07 08*	wastes containing oil
	16 07 09*	wastes containing other hazardous substances
16 08	Spent catalysts	
	16 08 02*	spent catalysts containing hazardous transition metals or transition metal compounds
	16 08 05*	spent catalysts containing phosphoric acid
	16 08 06*	spent liquids used as catalysts
	16 08 07*	spent catalysts contaminated with hazardous substances
16 09	Oxidising substances	
	16 09 01*	permanganates, e.g. potassium permanganate
	16 09 02*	chromates, e.g. potassium chromate, potassium or sodium dichromate
	16 09 03*	peroxides, e.g. hydrogen peroxide
	16 09 04*	oxidising substances, not otherwise specified
16 10	Aqueous liquid wastes destined for off-site treatment	
	16 10 01*	aqueous liquid wastes containing hazardous substances
	16 10 03*	aqueous concentrates containing hazardous substances
16 11	Waste linings and refractories	
	16 11 01*	carbon-based linings and refractories from metallurgical processes containing hazardous substances
	16 11 03*	other linings and refractories from metallurgical processes containing hazardous substances
	16 11 05*	linings and refractories from non-metallurgical processes containing hazardous substances
17	Construction and demolition wastes (including excavated soil from contaminated sites)	
17 01	Concrete, bricks, tiles and ceramics	
	17 01 06*	mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing hazardous substances
17 02	Wood, glass and plastic	
	17 02 04*	glass, plastic and wood containing or contaminated with hazardous substances
17 03	Bituminous mixtures, coal tar and tarred products	
	17 03 01*	bituminous mixtures containing coal tar
	17 03 03*	coal tar and tarred products
17 04	Metals (including their alloys)	
	17 04 09*	metal waste contaminated with hazardous substances
	17 04 10*	cables containing oil or coal tar
17 05	Soil (including excavated soil from contaminated sites), stones and dredging	

	spoil	
	17 05 03*	soil and stones containing hazardous substances
	17 05 05*	dredging spoil containing hazardous substances
	17 05 07*	track ballast containing hazardous substances
17 06	Insulation materials and asbestos-containing construction materials	
	17 06 01*	insulation materials containing asbestos
	17 06 03*	other insulation materials consisting of or containing hazardous substances
	17 06 05*	construction materials containing asbestos
17 08	Gypsum-based construction material	
	17 08 01*	gypsum-based construction materials contaminated with hazardous substances
17 09	Other construction and demolition wastes	
	17 09 01*	construction and demolition wastes containing mercury
	17 09 02*	construction and demolition wastes containing PCB (e.g. PCB-containing sealants, PCB-containing resin-based floorings, PCB-containing sealed glazing units, PCB-containing capacitors, PCB-containing cables)
	17 09 03*	other construction and demolition wastes (including mixed wastes) containing hazardous substances
18	Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)	
18 01	Wastes from natal care, diagnosis, treatment or prevention of disease in humans	
	18 01 03*	wastes whose collection and disposal is subject to special requirements in order to prevent infection
	18 01 06*	chemicals consisting of or containing hazardous substances
	18 01 08*	cytotoxic and cytostatic medicines
	18 01 10*	amalgam waste from dental care
18 02	Wastes from research, diagnosis, treatment or prevention of disease involving animals	
	18 02 02*	wastes whose collection and disposal is subject to special requirements in order to prevent infection
	18 02 05*	chemicals consisting of or containing hazardous substances
	18 02 07*	cytotoxic and cytostatic medicines
19	Wastes from waste management facilities, off-site waste water treatment plants and the preparation of drinking water and water for industrial use	
19 01	Wastes from incineration or pyrolysis of waste	
	19 01 05*	filter cake from gas treatment
	19 01 06*	aqueous liquid wastes from gas treatment and other aqueous liquid wastes
	19 01 07*	solid wastes from gas treatment
	19 01 10*	spent activated carbon from flue-gas treatment
	19 01 11*	bottom ash and slag containing hazardous substances
	19 01 13*	fly ash containing hazardous substances
	19 01 15*	boiler dust containing hazardous substances
	19 01 17*	pyrolysis wastes containing hazardous substances

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- 19 02 Wastes from physico/chemical treatments of waste (e.g. Dechromatation, decyanidation, neutralisation)
  - 19 02 04* premixed wastes composed of at least one waste marked as hazardous
  - 19 02 05* sludges from physico/chemical treatment containing hazardous substances
  - 19 02 07* oil concentrates from separation
  - 19 02 08* liquid combustible wastes containing hazardous substances
  - 19 02 09* solid combustible wastes containing hazardous substances
  - 19 02 11* other wastes containing hazardous substances
- 19 03 Stabilised/solidified wastes
  - 19 03 04* wastes marked as hazardous, partly stabilised
  - 19 03 06* wastes marked as hazardous, solidified
- 19 04 Vitrified waste and wastes from vitrification
  - 19 04 02* fly ash and other flue-gas treatment wastes
  - 19 04 03* non-vitrified solid phase
- 19 07 Landfill leachate
  - 19 07 02* landfill leachate containing hazardous substances
- 19 08 Wastes from waste water treatment plants not otherwise specified
  - 19 08 06* saturated or spent ion exchange resins
  - 19 08 07* solutions and sludges from regeneration of ion exchangers
  - 19 08 08* membrane system eluate containing heavy metals
  - 19 08 10* grease and oil mixture from oil/water separation other than those mentioned in 19 08 09
  - 19 08 11* sludges containing hazardous substances from biological treatment of industrial waste water
  - 19 08 13* sludges containing hazardous substances from other treatment of industrial waste water
- 19 10 Wastes from shredding of metal-containing wastes
  - 19 10 03* fluff - light fraction containing hazardous substances
  - 19 10 05* dust and other fractions containing hazardous substances
- 19 11 Wastes from oil regeneration
  - 19 11 01* spent filter clays
  - 19 11 02* acid tars
  - 19 11 03* aqueous liquid wastes
  - 19 11 04* wastes from cleaning of fuel with bases
  - 19 11 05* sludges from on-site effluent treatment containing hazardous substances
  - 19 11 07* wastes from flue-gas cleaning
- 19 12 Wastes from the mechanical treatment of waste (e.g. Sorting, crushing, compacting, pelletising) not otherwise specified
  - 19 12 06* wood containing hazardous substances
  - 19 12 11* other wastes (including mixtures of materials) from mechanical treatment of waste containing hazardous substances
- 19 13 Wastes from soil and groundwater remediation
  - 19 13 01* solid wastes from soil remediation containing hazardous substances
  - 19 13 03* sludges from soil remediation containing hazardous substances
  - 19 13 05* sludges from groundwater remediation containing hazardous substances
  - 19 13 07* aqueous liquid wastes and aqueous concentrates from groundwater remediation containing hazardous substances

- 20 Municipal wastes (household waste and similar

	commercial, industrial and institutional wastes) including separately collected fractions	
20 01	Separately collected fractions (except 15 01)	
	20 01 13*	solvents
	20 01 14*	acids
	20 01 15*	alkalines
	20 01 17*	photochemicals
	20 01 19*	pesticides
	20 01 21*	fluorescent tubes and other mercury-containing waste
	20 01 23*	discarded equipment containing chlorofluorocarbons
	20 01 26*	oil and fat other than those mentioned in 20 01 25
	20 01 27*	paint, inks, adhesives and resins containing hazardous substances
	20 01 29*	detergents containing hazardous substances
	20 01 31*	cytotoxic and cytostatic medicines
	20 01 33*	unsorted batteries and accumulators containing batteries or accumulators included in 16 06 01, 16 06 02 or 16 06 03
	20 01 35*	discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components
	20 01 37*	wood containing hazardous substances