# Landfills exempt from licensing

EPA VICTORIA | Environment Protection Authority Victoria

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**Guideline**

## Contents



## Introduction

### Scope and purpose

This guideline fulfils the Environment Protection Authority's (EPA) commitments under Clause 17 (1)(b) of the Victorian Waste Management Policy (Siting, Design and Management of Landfills) 2004 (the WMP). Clause 17 (1)(b) of the WMP states that the EPA, in conjunction with local government and regional waste management groups, will develop guidelines on the design and management of landfill sites exempt from licensing. This guideline can be used by operators of a landfill site exempt from licensing in order to demonstrate compliance with the WMP. It also provides guidance for works approval applicants for landfill sites exempt from licensing.

The guideline is consistent with the Statewide Waste and Resource Recovery Infrastructure Plan (SWRRIP). Its purpose is to help ensure Victoria's current and future facilities and waste services are well sited, well built and operated at the highest standards, consequently enabling EPA to deliver the environmental and public health benefits that Victorians expect.

Landfills provide an important service to business and the community but, if not managed properly, they can cause problems for those living in the surrounding areas and the environment. This guideline provides direction regarding the siting, design, operation, rehabilitation and aftercare of small municipal landfills that are exempt from holding an EPA licence.

Adopting a risk-based approach, the Environment Protection (Scheduled Premises) Regulations 2017 exempt landfills from requiring licenses when serving a population of less than 5,000 people. While these sites are exempt from licensing, they still pose a risk to the environment and are required to be managed in a way that is consistent with the WMP.

This guideline provides a framework of cost-effective waste disposal standards applicable to landfills exempt from licensing. A risk-based approach is used which recognises that some sites have favourable natural conditions rendering them more suitable as a landfill. Therefore, landfill design standards vary based on the natural site characteristics. This guideline is intended to provide public assurance with regards to the protection of groundwater and surface water, and the appropriate management of nuisances associated with small landfill development.

### Application of this guideline

As stated in Clause 17 (2) of the WMP, the recommendations in this guideline should be implemented by landfill operators to ensure that they are compliant with the WMP and relevant State Environment Protection Policies (SEPPs). This is clearly stated in the *Environment Protection Act 1970* (EP Act) (section 44 (a)) which requires that anybody who deposits waste onto land shall at all times comply with the relevant SEPPs or WMPs that specify acceptable standards and conditions.

Using statutory instruments such as Pollution Abatement Notices (PANs), EPA may also use this guideline for any regulatory requirements (to address non-conformance of works approval conditions or potential impacts on the environment) that are determined by EPA. EPA will use this guideline as the basis for assessing works approval applications for new landfill sites exempt from licensing and for the expansion of existing landfills exempt from licensing.

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EPA recommends that operators undertake an assessment of all their operating landfills exempt from licensing against this guideline. Operators should then prioritise site upgrades based on risk and develop a plan to implement any improvements required. Applying the recommendations in this guideline will assist sites to comply with the WMP and EP Act. Implementation recommendations for the guideline are as follows.

| Section of guideline | Implementation recommendations |
|---|---|
| Establishment and siting | Regional Waste Management Groups to implement through their regional waste management plans (or equivalent) |
| Landfill design | All new landfills exempt from licensing and new cells to implement during design phase |
| Landfill management (Operations) | All landfills exempt from licensing to implement by 30 December 2014 |
| Rehabilitation and aftercare | All landfills exempt from licensing to implement. If rehabilitation of the filled cell/area starts prior to 1 January 2015, then publication 674 – Rehabilitation of Landfills Exempt from Licensing (1999) applies. If rehabilitation of the filled cell/area starts after 1 January 2015, then this guideline applies. Please note that from 1 January 2015, the aftercare management requirements of this new guideline applies to all filled cells/areas. |

Appendix A provides risk assessment guidance and a checklist that councils may use to assist in implementing this guideline.

## Legal status of this guideline

This guideline is advisory in nature. Technical details in this guideline are suggested measures for meeting the requirements in the EP Act.

If landfills exempt from licensing are found to be impacting upon the environment, EPA will take into account whether the advice in this guideline has been followed when assessing enforcement response.

## Landfill economics

To avoid future liabilities due to past landfill practices, landfills need to be appropriately designed, managed and rehabilitated. The decision to open a new landfill, or to continue operation of an existing landfill, should be made only after gaining an appreciation of the costs incurred for the whole life of the landfill and then comparing those costs to that of other waste management options. Other factors such as social outcomes may aid in decision making when the costs of various waste management options are similar.

The main costs to consider when estimating the true cost of waste disposal at existing or proposed municipal landfills exempt from licensing are:

- purchase or lease costs for the site
- obtaining any necessary approvals (planning and/or EPA works approval)
- construction of infrastructure, for example roads, fencing, site buildings etc.
- construction of the landfill
- landfill operational costs i.e. periodic cover, site maintenance, plant costs and maintenance
- environmental monitoring costs
- landfill rehabilitation
- site maintenance and monitoring during aftercare
- potential future value of the land.

The recommended measures in this guideline should be used as a basis for calculating what level of engineering or other factors may affect the costs of operating a landfill exempt from licensing. The resulting assessment may lead to waste being diverted to larger sites which offer both the benefits of economies of scale and reduction of the potential number of contaminated sites that would require ongoing management.

The cost of a landfill exempt from licensing needs to be benchmarked against the alternative costs of:

- providing an alternative waste collection or drop-off point
- the transportation costs in taking waste to the alternative facility
- the cost associated with waste disposal at the alternative facility.

This costing should be completed in consultation with, or by, the relevant Regional Waste and Resource Recovery Group (RWRRG) as it is responsible for the planning of waste management facilities and their inclusion in their Waste and Resource Recovery Implementation Plan (WRRIP).

# Landfills exempt from licensing

## Establishment and siting

### Key establishment and siting recommendations

- EPA will only issue a works approval for a new landfill where the landfill site has been identified in the relevant RWMP.
- New landfills exempt from licensing are not to fill a natural gully or erosion channel.
- Consider the most appropriate landfilling type to suit the constraints imposed by local conditions.
- Provide separation distances in accordance with Table 1 and Table 2. Where it is impractical to provide these, demonstrate that the risks are mitigated to the same standard as having the full separation distances in place.
- Landfill design should utilise natural features to channel stormwater flows and should not be located in land designated as subject to inundation.
- The slope of the site should not be greater than 5 per cent (1 vertical to 20 horizontal), particularly where the trenching landfill method of disposal is used.
- A site with already degraded or low conservation value should be considered ahead of a high conservation area with a greater diversity of flora and fauna.

#### Overview

The EP Act requires that EPA only issues a works approval for a new landfill where the landfill site has been identified in the relevant RWMP and the timing of the development is consistent with the RWMP landfill schedule. Section 9 of the Landfill WMP includes two important policy objectives that inform EPA's implementation of this guideline and states that:

> (3) the development and use of landfills for the management of waste in Victoria be minimised, consistent with the policy principles.
>
> (5) the number of landfill sites exempt from licensing be progressively reduced and replaced with a system of resource recovery and waste transfer facilities to service local communities.

Consistent with the WMP, EPA may not approve a RWMP that includes a new landfill exempt from licensing which is in close proximity (approximately 50 km) to a landfill that has sufficient capacity to receive wastes. In addition, EPA will not approve works approval applications for expansions of existing sites (listed in the RWMP) where there is sufficient landfill capacity in the surrounding area.

EPA will be seeking to ensure that the number of landfills exempt from licensing is kept to a minimum and will only approve new landfills or works approvals for expansion to existing landfills where a need for additional landfill capacity in the surrounding area can be demonstrated.

#### Landfill types

The three basic methods of landfilling potentially suitable for municipal landfills are:

- the area method where an existing hole such as a quarry void is filled
- the trench and fill method where a hole is dug and backfilled with waste using excavated material as cover
- the mound method where most or all of the landfill is located above the natural ground.

Each method of landfilling has its advantages and disadvantages. The filling of a quarry void provides the potential benefit of rehabilitating the site but may place waste closer to the water table and require a higher standard of engineered liner in order to protect groundwater.

The trench and fill method has the advantage of being tailored to suit the anticipated waste volumes and of providing plenty of soil that may be used for cover or rehabilitating the landfill. In areas of high watertable, it may place waste closer to the groundwater and require a higher standard of engineered liner to protect the groundwater.

The mound method may be used in cases where there is a high watertable, but issues such as litter control and visual amenity impacts would require additional management.

In the past, some landfills have been located in natural gullies or erosion channels (known as valley or gully fill landfills). These are high-risk sites due to the constant risk of water inundation and seepage from the site-affecting waterways. This method of landfilling for small municipal landfills will not be approved by EPA.

#### Site buffer distances

In EPA Victoria's Best Practice Environmental Management publication *Siting, design, operation and rehabilitation of landfills* (Landfill BPEM) separation distances are specified which also apply to landfills exempt from licensing. Sites not meeting these buffer distances are likely to incur additional costs at all stages of the life of the landfill in order to protect sensitive land uses (receptors) against any impacts resulting from a failure of landfill design, management or abnormal weather conditions. These failures might include discharge from the site of landfill gas, offensive odours, noise, litter and dust.

Relevant separation distances recommended for landfills exempt from licensing are shown in Table 1.

Table 1: Recommended separation distances to the natural and built environment

| Natural or built environment | Separation distance (metres) |
|---|---|
| Residential or other sensitive (see table note 1) development | 500(see table note 2) |
| Surface waters | 100 |
| Aerodrome for jet aircraft | 3,000 |
| Aerodrome for piston-engine propeller-driven aircraft | 1,500 |
| Unstable areas. These could include fault zones, seismic zones and dolomitic or karst areas where sinkholes and subsidence are likely | Not within designated land (see table note 3) |
| Land within a 1 per cent annual exceedance probability (1% AEP) floodplain | Not within designated land |

Table notes:

1. Sensitive land use is any land use zoning which requires a particular focus on protecting the beneficial uses of the environment relating to human health and wellbeing, local amenity and aesthetic enjoyment. For example: residential premises; childcare centres, pre-schools; primary schools; and education centres.
2. Any application to EPA for decreased buffer distances would require site-specific studies into noise, dust and odour in accordance with geographical surrounds.
3. Karst landscapes are formed from the dissolution of soluble rocks including limestone, dolomite and gypsum. They are characterised by sinkholes, caves, and underground drainage systems. Nearly all surface karst features are formed by internal drainage, subsidence, and collapse triggered by the development of underlying caves resulting from the subsurface solution of rock. If considering a landfill in a karst area, a detailed study examining the geology and hydrogeology needs to be undertaken to ensure the site is stable over the long term. Landfills should be avoided in karst areas wherever possible.

Prevailing wind direction should be away from the closest sensitive receptors, particularly during warmer months, as this helps the existing separation distance to reduce any amenity-reducing impacts.

Subject to an environmental evaluation and risk assessment, lesser buffer distances may be applied. As part of the risk management approach, additional design and operational measures may be required by EPA.

## Works approvals

Works approvals are public documents issued by EPA under the EP Act and are required for industrial and waste management activities that have the potential for significant environmental impact. A works approval permits the construction of a plant, the installation of equipment or the modification of processes. Under the Environment Protection (Scheduled Premises) Regulations 2017, municipal landfill facilities occupied by a municipal council, in use before 25 June 2017, and serving less than 500 people are exempt from a works approval under section 19A of the EP Act.

If a works approval is required for proposed works, an environmental assessment must be completed and a completed application form lodged (available on EPA's works approval webpage). This assessment must be accompanied by all necessary supporting information to EPA and the application fee. Refer to EPA Publication 1658 – *Works Approval Guidelines* for information on how to complete the form. Once EPA confirms that the application is complete, the formal environmental assessment of the project begins.

A 21-day public comment period will be advertised in the newspaper and on EPA's website. The application will be referred to local council for any environmental planning comments, the Department of Health and Human Services for any public health comments and any other relevant agencies.

If comments are received from any third parties, an opportunity to address concerns will be provided. EPA may convene a conference of the parties to assist in resolving those concerns.

EPA will complete its assessment, taking into account any comments received and any applicant responses. EPA will then decide whether to issue a works approval and whether to attach any conditions to the approval. Proposed conditions will be discussed with applicants. EPA allows comment on works approvals but not the negotiation of their conditions.

The EP Act requires that EPA makes a decision on the works approval application within four months of receiving a complete application. EPA's reformed approvals process sets benchmarks of six weeks for determining decisions on fast track works approval applications and 12 weeks for standard works approval applications decisions. In rare cases, EPA may request further information during the process or require an extension.

## Groundwater separation

The Landfill WMP sets out minimum separation distances to groundwater (Table 2). A preferred site for a landfill is one that minimises the risk to groundwater by providing a natural, unsaturated attenuation layer beneath the landfill comprising low permeability clays. An engineered liner may also be required depending on the quality and surrounding uses of the local groundwater. Planning for landfills exempt from licensing should include appropriate data gathering in advance to determine long-term undisturbed groundwater levels.

If the most appropriate site for a landfill exempt from licensing is in an area where regional groundwater is close to the surface, or near the base of a quarry proposed to be landfilled, then the base of the landfill is to be raised to ensure a 2-metre separation

between the natural long-term undisturbed groundwater level[1] and the waste. A lesser separation between the natural long-term undisturbed groundwater level and the waste would only be considered acceptable if:

- sufficient additional design and management practices are to be implemented
- EPA determines that regional circumstances exist that warrant the development of the landfill.

Table 2: Recommended separation distances relating to groundwater

| Groundwater siting issue | Separation distance (metres) |
|---|---|
| Minimum separation of wastes from groundwater | 2 |
| Land with Segment A[2] water table | Not within such designated land (see table note 1) |

Table notes:

1. The WMP requires that new landfill sites must not be established or extended into any area where an aquifer contains Segment A groundwater, unless:

   a) the landfill operator satisfies the EPA that sufficient additional design and management practices will be implemented; and

   b) EPA determines that regional circumstances exist that warrant the development of a landfill in the area.

### Surface waters

The design of a landfill should utilise natural features to channel stormwater flows away from areas where waste has or is being deposited. This may be accomplished by constructing bund walls or by excavating culverts. These should release water into down-gradient stormwater drains or natural flow lines at a rate that does not cause erosion. Depending on the anticipated velocity and quantity of water that may be released, stormwater retarding basins may be necessary.

To reduce the risk of contaminated stormwater or sediment-loaded runoff impacting any surface-water body, the waste disposal area and leachate storage pond should be no closer than 100m to any waterways.

Landfills should not be located on land that is covered by the Land Subject to Inundation Overlay (LSIO) in the planning scheme. LSIO identifies land that is within a 1per cent Annual Exceedance Probability ((AEP) flood plain).

The potential pollution of surface waters by leachate at existing municipal landfills exempt from licensing is highest for those sites located in a natural gully or erosion channel. Operators of existing sites in these locations are encouraged to implement measures to protect surface and groundwater.

### Topography

Local terrain will influence what type of landfill may be best suited for the area as well as the layout of the landfill and any supporting waste management infrastructure such as recycling areas.

Steep slopes are: more likely to experience erosion; may be more visible; have a greater potential to spread litter; and can be harder to rehabilitate. At a flat site, stormwater management becomes difficult as stormwater run-off in the area may be harder to divert from the waste areas. Ideally the slope of the site should not be greater than 5 per cent (1 vertical to 20 horizontal), particularly where the trenching landfill method of disposal is used. Modest slopes enable easier stormwater control, leachate control and site stability measures, as well as facilitating operation of the site. Where possible, the completed landfill should be sympathetic to the existing natural surrounding landform.

Natural site features such as vegetation can reduce the visual impact of the site, hence reducing the need to plant vegetation to screen the site.

### Flora and fauna

At all landfill sites an assessment should be made about any potential impacts on native flora and fauna. In particular, a new landfill should examine the direct removal of native vegetation and potential disturbance to habitat of threatened flora and fauna species. It should also consider the potential increase in weed infestation, vermin populations and disease vectors (flies and other insect pests).

A site already degraded or classified as having a low conservation value should be considered ahead of a high conservation value site with a greater diversity of flora and fauna.

1 The Landfill WMP defines the long-term undisturbed groundwater level as the ‘naturally occurring depth to groundwater that has not been disturbed by human activities or seasonal or climatic variations.’

2 The Victorian State Environment Protection Policy (Groundwaters of Victoria) 1997 defines Segment A groundwater as having a total dissolved salts range of between 0 and 1000 mg/L.

# Landfill design

## Key landfill design recommendations

- A landfill needs to be designed to ensure the surrounding environment is not impacted.
- Site layout needs to consider safety and efficient waste management practices.
- Landfill cells should be sized to provide enough airspace for waste disposal for a period not exceeding two years.
- Landfill liners should be constructed in accordance with landfill designs in Table 3.
- Properties of clay used to construct a low-permeability clay liner should have:
    - no rock or soil clumps greater than 50 mm in any dimension
    - 70 per cent passing through a 19 mm sieve
    - 30 per cent passing through a 0.075 mm sieve
    - soil plasticity index > 10
    - Cation Exchange Capacity (CEC) > 10 mEq/100 g.
- Clay liners should be constructed under a Construction Quality Assurance plan which specifies field testing for liner density and moisture content at a frequency the greater of:
    - one test per 500 $m^3$ of soil;
    - one test per 2,500 $m^2$ area per clay lift; or
    - three tests per site visit.
- A leachate drainage layer at least 300 mm thick should be constructed across the base of the landfill from materials with these recommended properties:
    - drainage layer aggregate size to be less than 50 mm and greater than 20 mm
    - fines content to be less than one per cent
    - aggregate material should not contain limestone or other calcareous material that would be subject to chemical attack.
- Offsite discharge of leachate or discharge of stormwater contaminated by leachate should be prevented.
- Adequate storage and management facilities for leachate should be provided.
- Leachate levels should be checked at least monthly. If the level exceeds 300 mm over the lowest point of the liner surrounding the sump, leachate is to be extracted so that the remaining level is less than 300 mm.
- A free board of at least 500 mm should be maintained in any onsite leachate storage ponds.
- A stormwater diversion system should be constructed and maintained around the landfill able to cope with at least a one-in-20-years storm event.
- Stormwater control systems should be constructed and maintained to prevent contaminated stormwater from leaving the site.
- Waste drop-off areas should be clearly marked and the site should be screened by using existing features or planting appropriate vegetation.

### Overview

Once a landfill has been sited, it needs to be designed to ensure that the surrounding environment is not impacted. The design of the landfill will be influenced by the existing natural environment, adjacent land uses, available infrastructure, received waste and the need to provide integrated waste management facilities that supply both disposal and recycling options.

### Site layout

The site layout needs to consider safety, for both on-site workers and the public. It also needs to provide for efficient waste management practices. The site layout should:

- provide separate drop-off points for recycling materials before vehicles reach the general waste disposal area
- clearly indicate where waste will be deposited, and the associated traffic flow directions
- site general waste disposal areas initially at the furthest point at which landfilling will occur and then progressively move them closer, allowing for the public to dispose of waste but not interfere with landfill rehabilitation
- provide all weather trafficable internal roads.

If trenches are used to dispose of waste, expert advice should be sought about what safety devices need to be incorporated into the design and how these will need to be maintained and repositioned during the life of the facility.

For further information on site layout refer to Guide to Best Practice at Resource Recovery Centres (Sustainability Victoria 2009).

### Dimensions of landfill cells

Landfill cells should be sized to provide enough airspace for waste disposal for a period not exceeding two years. In many cases, a

smaller cell size may be advantageous to minimise the period where the landfill liner is exposed to the elements or where there is only a thin layer of waste over the base of the cell. This will avoid significant leachate production due to the limited capacity of the waste to absorb rainwater before releasing leachate. Rehabilitation should occur as soon as possible after the cell is full.

To minimise litter, waste placement should be aligned perpendicular to the prevailing wind. If compaction equipment is used, any trenches should be at least twice as wide as the compaction equipment used.

Ideally, cells should operate for as short a period as practical while recognising that local climate conditions may make it difficult to construct landfills during the wetter period of the year.

### Landfill liners

The two key elements of landfill design comprise the containment system (i.e. the liner) and the leachate management system. Even when using premium landfill liners, if leachate is not removed from a landfill it will eventually seep out and contaminate groundwater and even surface waters.

This guideline does not advocate a universal design for all municipal landfills exempt from licensing but, rather, provides some indicative designs based on local conditions, thereby simplifying design and construction requirements for those landfills in less sensitive locations. Table 3 outlines landfill design alternatives based on local conditions.

The profile of soils and subsoils used to determine soil types in Table 3 should contain no less than 60 per cent of the identified soil's subgrade in order to be considered as that soil type. Where this percentage is not achieved, the soil structure classification will be based on the soil type of the highest fraction of the next least permeable soil as determined by a suitably experienced professional.

Where the substrata predominately consists of fractured or fissured rock-type formations such as fractured basalt, Table 3 provides information about what type of landfill design may be applicable.

Where non-uniform matrix-dominated strata or complex stratification is present, and it is considered that the permeability of these strata lies somewhere between the subsoil textures in Table 3, the type of landfill design should be based on the most permeable strata.

Where the design classification is unclear, landfill operators should seek clarification from EPA.

Table 3: Required landfill design based on local conditions

**(a)**

| | Segment A groundwater | | | | Segment B groundwater | | | | Segment C groundwater | | | | Segment D groundwater | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Waste separation from groundwater (metres)** | Subsoil texture(AS/NZS 1547:2,000) (metres) | | | | Subsoil texture(AS/NZS 1547:2,000) (metres) | | | | Subsoil texture(AS/NZS 1547:2,000) (metres) | | | | Subsoil texture(AS/NZS 1547:2,000) (metres) | | | |
| | heavy clays to light clays | clay loams to loams | sandy loams to sands | fractured or fissured rock | heavy clays to light clays | clay loams to loams | sandy loams to sands | fractured or fissured rock | heavy clays to light clays | clay loams to loams | sandy loams to sands | fractured or fissured rock | heavy clays to light clays | clay loams to loams | sandy loams to sands | fractured or fissured rock |
| **More than 10 m** | A | B | C | D | A | B | C | D | A | A | C | D | A | A | C | C |
| **More than 5 m but less than 10 m** | B | C | C | D | B | B | C | D | A | B | C | D | A | B | C | D |
| **More than 2 m but less than 5 m** | C | C | D | D | B | C | D | D | B | C | C | D | A | B | C | D |

**(b)**

| Landfill design | Description |
|---|---|
| A | In-situ soils shaped to form the landfill |
| B | Top 300 mm of in-situ soils compacted in layers and shaped to form the landfill |
| C | Landfill lined with 600 mm of compacted low permeability clay |
| D | Landfill lined with 1,000 mm of compacted low permeability clay |

### In-situ liner (design A and B)

Existing soils can provide an adequate containment system for the landfilling of wastes. In some cases, such as landfill design B, loosening the upper 300 mm of the soil and then compacting the soil by suitable machinery may provide an adequate containment system. In this case, the 300-mm-thick soil liner would be constructed in layers with no individual layer exceeding 150 mm in thickness after compaction.

Fractured or fissured rock cannot be worked into a component of the landfill containment system and should not be used. Non-uniform matrix-dominated strata will provide lateral and vertical permeability that are too variable and should not be used.

### Engineered low-permeability clay liner (design C and D)

Some landfills may need to be constructed with a low-permeability clay liner. The hydraulic conductivity of the compacted clay should be less than $1 \times 10^{-9}$ m/s. The particle size fraction and other properties of the clay will need to be assessed to determine that they are suitable for use, and that with appropriate moisture and compaction they will achieve a hydraulic conductivity of less than $1 \times 10^{-9}$ m/s using 50,000 ppm NaCl solution according to Australian Standard AS 1289.6.7.1 – 1999: Soil strength and consolidation tests – Determination of permeability of a soil – Constant head method for a remoulded specimen. Properties of clay used to construct a low-permeability clay liner have:

- no rock or soil clumps greater than 50 mm in any dimension
- 70 per cent passing through a 19 mm sieve
- 30 per cent passing through a 0.075 mm sieve
- soil plasticity index > 10
- Cation Exchange Capacity (CEC) > 10 mEq/100 g.

The liner should undergo construction by uniform moisture conditioning and compaction using a sheepsfoot roller in layers with a maximum compacted thickness of 200 mm. The layers should be compacted to 95 per cent of standard Proctor dry density at a water content between optimum and optimum plus 3 per cent. There should be effective bonding between successive layers that includes kneading between layers, scarification and moisture conditioning. Clay liners have a smooth final surface that are graded to promote the movement of leachate through the leachate collection layer to the point where it can be extracted.

A Construction Quality Assurance (CQA) plan should be developed and implemented as a means of managing quality during construction and reporting, so that the materials used, construction methods and complete works comply with the landfill design. In-situ testing of each layer of the clay liner should be conducted at specified frequencies to confirm that the moisture content and density of the clay meet the physical properties required for the clay to comply with the hydraulic conductivity requirement. Field testing needs to be conducted at a frequency the greater of:

- one test per 500 $m^3$ of soil;
- one test per 2,500 $m^2$ area per clay lift; or
- three tests per site visit.

Where the landfill liner is constructed on or near a vertical face, it should be constructed as a series of vertical lifts which are progressively constructed as waste fills the site. In order for the clay to be compacted, it should be constructed in widths of approximately 4 m to allow for compaction machinery to safely traverse the length and width of the side wall liner. The surplus clay may then be cut back, leaving a safe margin of clay in excess of the minimum specified thickness. Alternatively, if the grade of the side wall is no steeper than approximately 1 vertical metre to 3 horizontal metres (1:3), then it is possible to drive compaction machinery up the side wall eliminating the need to use an extra-wide layer of clay.

If clay is exposed it will experience wet and dry cycles depending on the weather. This will lead to the permeability of clay increasing so that it no longer complies with the specified limit for hydraulic conductivity. The side walls of a clay liner should be covered with a protective level of soil, or an additional sacrificial layer of clay of about 100 mm thickness, to prevent desiccation of the underlying low-permeability clay liner.

### Equivalent performance

Subject to achieving the same level of performance as the landfill design categories outlined in Table 3, other material such as bentonite may be added to existing soils to improve their performance. Alternatively a synthetic liner such as a geosynthetic clay liner may be used to replace natural soil liners.

## Leachate collection and management system

All landfills need to be constructed with a leachate extraction system to ensure leachate does not accumulate to a level where seepage from the landfill impacts on groundwater quality. New or expanding landfills require a leachate collection system designed to ensure that leachate accumulation at the lowest point of the base of the landfill – excluding any specially constructed sumps in the landfill – does not exceed a depth of 300 mm. The leachate head in the sump may exceed 300 mm as the sump is generally recessed below the level of the liner and some liquid is necessary for the pump to function.

Leachate collection systems typically comprise a high-permeability drainage layer, perforated collection pipes, a sump where collected leachate is extracted from the landfill and geotextiles, to protect any geomembrane and prevent clogging of the drainage layer. The liner is sloped into the leachate collection pipes, which in turn are sloped to the leachate collection sump. Slope gradient should be a minimum of 3 per cent to the pipes and 1 per cent to the sump. It may be adequate to slope the base of the landfill at a minimum of 3 per cent to a drain and then for that drain to grade at a minimum of 1 per cent to the low point in the cell where a

pump can be installed to remove accumulated leachate.

A series of large-diameter concrete stand pipes placed end to end and positioned on a concrete plate or other load-bearing structure at the lowest point of the cell can be used to create a leachate standing pipe. The leachate pump can then be lowered down to the base of the leachate sump. The standing pipe will require holes to allow leachate to freely flow into it. To prevent the pipe from penetrating the liner and to improve its stability, it should sit on a base plate which spreads the load over a greater area of the liner.

The drainage layer is a high-porosity medium and provides a preferential flow-path to the leachate collection pipes and/or sump. To avoid clogging and capillary action from holding water in the drainage layer, coarse material should be used so that there is space within the drainage layer for leachate to drain freely. Using coarse material also ensures leachate flow in the event of some clogging within the leachate collection pipes. The hydraulic conductivity of the drainage layer should be greater than 1x10–3 m/s. The drainage layer should reach across the entire landfill base and comprise at least 300 mm of coarse aggregate or a geosynthetic drainage material with:

- drainage layer aggregate size to be less than 50 mm and greater than 20 mm
- fines content to be less than 1 per cent
- aggregate material that doesn't contain limestone or other calcareous material that would be subject to chemical attack.

As leachate contains high levels of nutrients, salt and potentially other contaminants, it should be managed to prevent pollution of groundwater and surface waters. Leachate extracted from a landfill is commonly stored in a leachate storage pond. The design of the leachate pond should be the same as that of the landfill it serves. The depth of leachate in an earthen pond should not exceed 1 m and the slope of the pond should not be steeper than 1 vertical metre to 3 horizontal metres (1:3). Fencing of the pond should also be considered to prevent public access.

Sizing of the leachate pond is reliant on a water balance calculation which should account for:

- all sources of water entering into the waste mass such as groundwater flows and infiltration by precipitation or overland drainage flows
- leachate storage in the waste mass. This depends on: the containment system or liner – or both; waste types; compaction; perched leachate; and the removal of leachate to maintain the required leachate depths
- discharges of leachate from the waste mass such as leachate removed to maintain required leachate depths and known leachate leakage rates through the containment system or liner – or both
- calculated site-specific evaporative losses from the pond area.

Alternatively, the sizing of the pond may be based on previous measured flows of leachate produced at the site.

If evaporation of leachate is the proposed method of disposal, then the pond size should be based on the formula contained in Appendix B5 of the Landfill BPEM.

Any ponds containing leachate should have a freeboard of at least 500 mm to guard against wave action causing leachate to overtop the banks, and should also provide capacity for any unforeseen events.

On at least a monthly basis, the leachate level in the landfill should be checked and if necessary be removed from the landfill to ensure that the level of leachate does not exceed a height of 300 mm above the top of the base of the landfill. The leachate level in the storage pond should not encroach within 500 mm of the top of the pond. The integrity of the leachate storage pond should be visually checked for any leaks or erosion.

### Stormwater management

Landfills exempt from licensing are generally situated in areas where there is minimal stormwater management infrastructure. Stormwater drainage therefore relies upon the natural topography of the land to direct stormwater offsite. Stormwater management on the landfill site should reduce the stormwater that flows or collects in waste disposal areas, and release the diverted stormwater that does not add sediment or other contaminants to the existing watercourses or contribute to local erosion problems. Stormwater control systems should be constructed and maintained to prevent contaminated stormwater from leaving the site, and be able to cope with at least a one-in-20-years storm event.

Depending on the capacity of drainage lines, or the amount of sediment collected by the stormwater on-site, it may be necessary to construct a stormwater retarding basin. The slow release of water from the retarding basin outlet reduces sediment loads and the potential for downstream erosion or flooding.

The stormwater diversion system needs to be maintained to ensure its continued efficient operation. Periodic removal of vegetation or any other blockages should be carried out.

### Landscaping

Waste drop-off areas should be clearly marked and the site should be screened by using existing features or by planting appropriate vegetation.

# Landfill management

## Key landfill management recommendations

- Landfill management should regularly check the composition of materials being deposited.
- Prohibited materials and recyclable materials should be removed from the wastes being landfilled and either separated for recycling onsite (e.g. concrete) or for processing offsite.
- Signage near the landfill entrance should provide hours of operation, waste types accepted and contact details.
- Fencing should be maintained to prevent unauthorised access to the site.
- Frequency of cover of waste in the landfill should be no less than the minimum frequency specified in Table 4.
- No litter should leave the site
- A passive landfill gas system or potentially the use of a passive biofilter can provide a cost-effective method of landfill gas control.
- The offsite discharge of nuisance dust should be prevented from arising from the site.
- The level of environmental monitoring required to protect sensitive receptors should be assessed by a suitably experienced professional.
- Country Fire Authority and Department of Environment and Primary Industries should be consulted for advice on fire control measures.

### Overview

It is important that Victoria's current and future waste facilities and infrastructure be well sited, well built and operated at the highest standards so that we can deliver environmental and public health benefits that Victorians expect. Even with the best-designed and constructed landfill, good management is required to maintain the site, evaluate its performance, provide for progressive rehabilitation and plan and build for future waste management needs.

Operators of landfills exempt from licensing are encouraged to develop a management plan that outlines the environmental performance outcomes required for the landfill exempt from licensing, the roles and responsibilities of the staff involved, and a performance auditing and review program. Management measures outlined in this guideline are suggested measures for meeting the requirements in the EP Act, bringing landfills exempt from licensing in line with best-practice landfills.

### Waste acceptance

Section 19 (6) of the WMP prohibits landfilling of several waste types including:

- liquid wastes
- automotive batteries
- small batteries, except where they are dispersed in small quantities on disposal, such as those from domestic origins.

### Separation of waste

Many waste materials/products (including those above) can be recovered including:

- paper and cardboard
- plastic and glass bottles
- concrete and/or bricks
- steel (including white goods)
- timber
- green waste
- oil (stored in a bonded area).

These materials should be removed from waste being landfilled and either separated for recycling onsite or for processing offsite. Where recycling is proposed to occur onsite, adequate space needs to be set aside for the raw material stockpile, the recycling operation (such as a concrete crusher) and for the material awaiting sale or use onsite.

Mulch should be kept apart from any areas that contains combustible material and from the landfill. The minimum distance between any tyre stockpiles and any other flammable or combustible material including grass or weeds should not be less than 20 m.

### Signage and access

Signs in the vicinity of the landfill should clearly exhibit the landfill's location. A noticeboard at the site's entrance should provide contact details for appropriate staff in the case of emergency, the hours of operation and the types of waste accepted. Within the landfill, recycling drop-off points should be clearly identified.

Road access to and within the site should be maintained at all times. All roads, particularly onsite roads, should be surfaced and maintained for all weather access.

For more detail on signage recommendations see Sustainability Victoria 2009, *Guide to Best Practice at Resource Recovery Centres.*

## Site security and fencing

The site should be securely fenced to prevent the unauthorised entry of people or livestock. When unattended, gates should be securely locked. Fencing should be regularly inspected and repaired if required.

Minimum recommended fencing requirements:

- for extractive industry sites (area method) – a wire mesh fence at least 2 m high constructed around the landfill site perimeter
- for trench and fill sites – a stock-proof fence constructed around the perimeter of the landfill site, and relocatable litter screens erected near the tipping area
- where there is a topography change (above ground level) – a wire mesh fence at least 2 m high constructed around the tipping area only, and a stock-proof fence around the perimeter of the site.

In areas where there may be a higher risk of unauthorised people entering the site, such as where the landfill is next to a recreational area, these minimum fencing requirements may need to be increased.

## Cover

Cover material helps suppress odours from the decomposition of the waste, controls litter, helps prevents infestation by insects or vermin and reduces the quantity of leachate that may otherwise be produced following rain.

Landfills exempt from licensing should follow the covering frequency specified in Table 4 as a minimum.

Table 4: Frequency of covering waste

| Tonnes of waste received per year/population served | Frequency of applying cover(table notes 1, 3) |
|---|---|
| Less than 2,000 | Weekly |
| Between 2,000 to 5,000 | Not less than once in every four days of opening |
| Greater than 5,000(table note 2) | Daily |

Table notes:

1. These are the maximum lengths of time in ideal siting and operating conditions before cover material is applied over exposed putrescible wastes. Where the separation distance from sensitive receptors specified in Table 1 is not met, or if pests and insects have infested the landfill, then cover requirements may need to be increased, even to a daily frequency, and a pest control program implemented.
2. Where a site is receiving more than 5,000 tonnes of waste per year it would suggest that the site may be serving populations of more than 5,000 people, if so, the site will require an EPA licence to operate.
3. For landfills that are open less than weekly, cover the landfill at the frequency of opening (i.e. if only open every fortnight, cover at the end of each day of operation).

Suitable cover comprises 300 mm layer of earthen material applied over all surfaces of exposed wastes within the landfill. The landfill operator should ensure that there is enough cover material (at any time) stored and readily available onsite for at least one week of operation.

Solid inert waste, such as building rubble, requires a minimum 150 mm of cover. If putrescible material, food, cardboard or fabric is mixed with the solid inert wastes, then it should be treated as putrescible waste and covered accordingly.

Alternative cover materials such as tarpaulins, proprietary product sprays or hard covers may be used to provide daily cover but officers of the local municipal council's health department should be consulted to review the performance of these alternative covers and confirm that they function satisfactorily.

## Litter

Uncontrolled litter can cause a nuisance offsite and may pose a threat to livestock. The primary management strategy for litter control is to regularly cover the waste material.

Other ways to minimise the quantity of litter that may be carried offsite include:

- constructing an earthen bund wall immediately upwind of the waste disposal area
- using relocatable/transportable litter screens
- constructing a higher perimeter fence.

Transportable litter screens with horizontal barriers (to stop litter creeping up and over the barrier) should be placed immediately adjacent to the active working face as required to facilitate the control of windblown litter. Changes in the orientation of the disposal area or the direction of prevailing winds may require the repositioning of these screens. The need to use litter screens or other litter control approaches will depend on the frequency of cover is applied over the waste, the degree of exposure to the wind at the site and the quantity of waste deposited at the landfill. Nets and fences should be inspected and cleared regularly and as required depending on wind conditions.

## Landfill gas management

Due to their small size, landfills exempt from licensing are unlikely to require an extensive or active landfill gas control system. A

passive landfill gas system or potentially the use of passive biofilter or biocovers can provide a cost-effective method of landfill gas control.

Where the separation distances from the natural and built environment to the landfill site is less than the distances outlined in Table 1 and Table 5, the level of landfill gas control required to protect these developments will need to be assessed by a suitably experienced professional. The selected system would also be based on landfill type i.e. area, trench and fill, or mound.

### Dust management

Dust management may be necessary due to exposed stockpiled soils and vehicle movement on unsealed roads. Restricting vehicle speeds and using crushed concrete and bricks that are compacted into a hard road surface can reduce dust emissions. Where there is a risk of offsite dust impact, such as on dry days with strong winds, measures need to be in place to mitigate dust leaving the site. This could include water sprays to suppress dust.

Areas of bare soil should be revegetated as soon as possible or may be covered in mulch. Stockpiles of soil could be covered by a tarpaulin or mulch. Some mulch mixed in with soil and used as daily cover will generally provide acceptable cover material performance.

Where leachate is to be used for dust suppression it may only be applied to areas that are within the active landfill cell to ensure leachate does not contaminate stormwater run-off. The site should be periodically inspected on high wind days to ascertain the effectiveness of dust control measures and for where any additional controls may be required.

### Environmental monitoring

Groundwater and surface water monitoring should be undertaken where they are at risk from site operations, even if separation distances are intact. If potential pathways to the aquifer or water body can be shown to be broken, or a considerable retarding layer is present in the pathway, then monitoring may not be required.

Due to relatively low waste volumes received and the often remote nature of landfills exempt from licensing, landfill gas monitoring may not be required. However, this should be based on risk to sensitive receptors. For example, if a site is located remotely, where human receptors are considered but gas-sensitive flora are present, then it should be managed according to the sensitive receptor. A suitably experienced professional would be able to advise on the extent of any monitoring program required. When sensitive land uses (such as residential use) are within the separation distances outlined in Table 5, an environmental monitoring program should be developed by a suitably experienced professional and be based on the size of the landfill exempt from licensing, the population size it serves and the quantity and composition of wastes received each year.

Table 5: Environmental monitoring triggers

| Environmental use | Separation distance (metres) | Environment to be monitored |
|---|---|---|
| Domestic water use groundwater extraction bore | 500 | Groundwater |
| Offsite enclosed structure or house | 500 (for sand or gravel terrain)<br>200 (all other soil types) | Subsurface landfill gas |
| Surface water intake for domestic use | 500 | Surface water |

**Appendix A provides a summary of the main risks posed by landfills exempt from licensing to the environment and human health and includes a description of the risk source, pathways, receptors and risk mitigation recommendations.**

### Firebreaks

The local Country Fire Authority (CFA) and the Department of Environment and Primary Industries (DEPI) can advise on the most current fire control techniques and about fire equipment that should be maintained at the site as well as the firebreaks requirements and water access to the site.

# Rehabilitation and aftercare

## Key rehabilitation and aftercare recommendations

- Install an intermediate cover on waste if an area of landfill is not yet ready to have the final cap installed, or if waste will not be placed in that area for six months or more.
- A landfill is considered successfully rehabilitated when it is returned to a state where it is fit for its intended after-use.
- Rehabilitate the landfill in accordance with the cap specifications in Table 6 or Table 7.
- The recommended design of the final landform should:
    - be compatible with the future land use of the site
    - adequately shed water
    - minimise erosion potential.
- Provide aftercare for a minimum of 10 years post closure.
- Landfill capping needs to be maintained in good condition with inspection records and any follow-up actions retained.
- Prepare and implement an aftercare management plan that checks and documents the performance of the landfill through periodic inspections.
- Prepare and implement a monitoring program where the landfill is located in close proximity to sensitive receptors and/or environments (refer to Table 5).

### Overview

The long-term level of environmental protection provided by landfill design is heavily influenced by the final cap or cover that is placed over the waste. An appropriate landfill cap is one which makes the best use of local resources, prevents excessive water movement through the cap and into the waste and provides a landform that is suitable for the intended after-use of the site. Capping of landfills exempt from licensing should occur as soon as the area has been filled with waste, or as soon as possible after closure, to minimise leachate generation.

### Intermediate cover

Installation of an intermediate cover is recommended to prevent leachate generation if the landfill is not ready to have the final cap installed, or if waste will not be placed in that area for six months or more. Intermediate cover is a layer of compacted clay soil not less than 300 mm thick over the waste with a sloped surface area. Once the intermediate cover is in place, rainfall running off the area should be directed to a sediment basin. The contents of the sediment basin should be evaporated off, used for dust suppression purposes on the landfill site, or be slowly released into stormwater drainage lines after the sediment has settled. As soon as possible after an area has been filled with waste, it should be rehabilitated with the final landfill cap.

### After-use considerations

A landfill is not considered rehabilitated unless it is returned to a state where it is fit for its intended after-use. Where flatter grades are used, the thickness of the cap may need to be increased to provide the same level of water infiltration control as a sloped surface.

The site may be restored to allow farming activities such as grazing to occur. The final topsoil layer in this case should be of adequate thickness and quality to support pasture growth. Crops for human consumption should not be planted on the landfill surface.

If the site is to be returned to its original natural condition, then the topsoil and subsoil should be comparable to the immediate surrounding area in order to support indigenous flora.

The shape and structure of the final landfill cap should be determined before the landfill is filled to ensure the cap does not unduly restrict the future use of the site.

### Landfill capping

#### Barrier capping

A suitable low permeability cap at a landfill exempt from licensing comprises the specifications and construction techniques in Table 6.

Table 6: Minimum recommended barrier capping specifications

| Capping component | Minimum specifications |
|---|---|
| Subgrade | • 300 mm soil subgrade over the wastes |
| Clay | • Compacted total thickness of 600 mm of material<br>• Hydraulic conductivity of clay not more than 1 x 10-9 m/s; or<br>• In areas where average annual rainfall is less than 600 mm, the hydraulic conductivity of clay not more than 1 x 10-8 m/s |

| | |
|---|---|
| Subsoil layer | • 200 mm subsoil or an appropriate depth to allow for plant growth |
| Topsoil | • 100 mm of top soil or soil/mulch mix to help establish plant growth |
| Construction specifications | |
| Subgrade | • Subgrade should be proof-rolled to assess whether there are mechanically unstable areas that show significant deformation and which may require subgrade improvement |
| Clay | • To be a minimum of three layers; each no thicker than 200 mm compacted thickness.<br>• Clay to be compacted with machinery such as a sheepsfoot roller.<br>• Each lift of the clay to be scarified and moisture-conditioned before the next lift is placed.<br>• The clay used to construct the cap will have:<br>  ○ no rock or soil clumps greater than 50 mm in any dimension<br>  ○ 70 per cent passing through a 19 mm sieve<br>  ○ 30 per cent passing through a 0.075 mm sieve<br>  ○ soil plasticity index > 10<br>  ○ CEC > 10 mEq/100g.<br>• Construct the clay cap under a Construction Quality Assurance Plan which specifies field testing for liner density and moisture content at a frequency the greater of:<br>  ○ one test per 500 m3 of soil;<br>  ○ one test per 2,500 m2 area per clay lift; or<br>  ○ three tests per site visit. |
| Subsoil | Loosely placed and not compacted |
| Topsoil | Loosely placed and not compacted |

Depending on the final use of the site and what structures may be placed on it, there may not be a need to apply the subsoil and top soil layers to all of the affected parts of the site.

Landfill capping does not need to be completely impervious. A supply of moisture into the waste will help it to decompose and ultimately stabilise so that the landfill does not pose an ongoing risk to the environment. In low rainfall areas, the clay cap can be slightly more permeable than would otherwise be recommended because even with the greater percentage of rainfall that will infiltrate the cap, the overall level of moisture within the landfill should not reach a level where it would become a risk to the surrounding environment.

**Evapotranspiration capping**

An alternative landfill cap approach is to utilise the natural moisture-holding capacity of soil combined with the ability of plants to draw water from the soil. These caps rely upon natural processes such as evapotranspiration (ET) to remove the stored moisture from the soil before it can migrate into the waste mass itself. This is often referred to as phytocapping or ET capping.

ET capping is particularly suitable in areas where evaporation exceeds monthly precipitation (dry sunny climates) for most of the year and where there is a moderate amount of clay in the soil (15 to 35 per cent) (Table 7). A landfill exempt from licensing would generally not be required to conduct a field test to demonstrate the suitability of ET capping.

Table 7: Minimum specifications for ET capping

| Property | Specification |
|---|---|
| Soil thickness | 1,300 mm in areas where annual rainfall less than 600 mm<br>1,500 mm in all other areas |
| Clay content | 15 to 35 per cent |

The addition of compost into the soil mix can also help improve the structure of the soil. The selection of vegetation used in ET capping should be based on what is local to the area and which of those plants have the highest transpiration rate. Further guidance on the use of ET capping can be found in the Guidelines for the Assessment, Design, Construction and Maintenance of Phytocaps as Final Covers (Waste Management Association of Australia, October 2011).

## Final landform shape

The recommended design of the final landform should:

- be compatible with the future land use of the site. Where no future land use has been proposed, then the final surface should blend in with the topography of the surrounding area

- adequately shed water, which requires a gradient in excess of 5 per cent. With shallower gradients there is an increased risk of rain infiltration through the cap. To compensate for shallow grades, the thickness of the cap may need to increase
- minimise erosion potential, which increases when the gradient exceeds 10 per cent. Avoid gradients in excess of 20 per cent.

### Landfill aftercare

For landfills exempt from licensing, the risks to the environment and the surrounding community are significantly lower. A minimum aftercare period of 10 years is recommended.

### Capping aftercare

As landfill capping provides one of the primary protection measures for the environment, it is essential that it is maintained in a good condition. Other infrastructure such as leachate ponds may still need to be maintained, particularly if leachate is still continuing to be produced at a rate of more than 300-mm-deep over the liner.

The cap should be inspected on a quarterly basis within the first 12 months, and then reduced to half yearly after 12 months and annually after five years. The following actions may be required:

- filling of depressions resulting from differential settlement (with clean fill)
- prevention of cap erosion and subsequent exposure of the clay barrier
- planting and/or watering to revegetate the site
- controlling any leachate springs that may break out through the cap.

A record should be retained of these inspections and any follow-up actions.

### Aftercare management

All operators should prepare and implement an aftercare management plan that checks and documents the performance of the landfill through periodic inspections of:

- the presence of landfill gas odours
- the integrity of the cap and any vegetation growing on the cap
- the condition of stormwater drains
- the level of leachate within the landfill
- the condition and capacity of the leachate pond
- the fences
- other site infrastructure such as biofilters for landfill gas control
- environmental monitoring (if required)
- the illegal dumping of rubbish at the site outside the landfill cell.

A monitoring program may be required where the landfill is located in a sensitive environment such that a groundwater resource is potentially at risk (refer to Table 5).

### References

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# Appendix A – Risk assessment guidance and implementation checklist

### Risk assessment guidance

EPA defines risk as a combination of two elements: consequence (the risk or harm to health and environment) and likelihood (the chance that non-compliance will occur). In environmental risk assessment the concept of source – pathway – receptor is often used[3].

Using this concept the pathway between a hazard source (for example, waste in a landfill) and a receptor (for example, a groundwater bore for domestic use) is assessed. The pathway is the 'linkage' by which the receptor could come into contact with the source and a number of pathways often need to be considered. If no pathway exists between the source and the receptor, then no risk to the receptor exists. It also follows that where a source – pathway – receptor can be shown to be linked, or are likely to be linked, then the risk to receptors may be high and needs to be further investigated.

For landfills exempt from licensing risk assessment, the source of risk is the waste deposited into the landfill. Risk will vary from site to site. The main variables in determining the level of risk posed by the waste deposited are:

- Tonnage/volume: the tonnage of waste deposited directly affects the risk posed by the source. The higher the tonnage, the higher the risk.
- Mobility: leachate head is the major driver for leachate mobility and gas generation in landfills. Landfill leachate and landfill gas generated by the waste deposited in landfills is highly mobile unless contained.
- Toxicity: will depend on the waste types deposited. For example green waste may not have high concentrations of metals in the leachate but may generate significant volumes of landfill gas. Toxicity of leachate from solid inert landfills is likely to be low, while industrial waste (unlikely to be found in a landfill exempt from licensing) may have highly toxic components. The age of the waste deposited also affects the toxicity for some waste types (for example, green waste landfill gas generation).
- Lining/containment: it is expected that landfills exempt from licensing will have little to no engineered lining. This will result in poor source containment unless the soils underlying the site are fine-grained clay soils of significant thicknesses (metres).

Table A1 provides a summary of the main risks posed by landfills exempt from licensing to the environment and human health, and includes a description of the risk, pathways, receptors, and risk mitigation recommendations.

This list is not exhaustive.

[3] The following definitions apply to this section:

- Source – a substance which is located in, on or under the land and has the potential to cause harm to human health, water resources or the wider environment.
- Pathway – the means or route which a source of contamination can migrate through or an identified receptor can be exposed.
- Receptor – something which could come to harm as a result of exposure to the source, including human health, water resources, surface water courses or the wider environment.

Table A1 Summary of risk, pathways, receptors, and mitigation

| Risk | Description of risk and pathways | Receptors | Risk mitigation recommendations |
|---|---|---|---|
| 1. Groundwater contamination | If leachate enters groundwater it can significantly impact on the quality of surrounding groundwater and potentially surface water (where groundwater discharges to local surface water). The likelihood of this occurring is influenced by:<br>• Permeability and thickness of the landfill lining or the materials underlying the landfill. Groundwater is generally protected against contamination from leachate if the materials underlying the site are fine grained (impermeable), and deposited as a thick (metres) sequence. The degree of protection is generally less (or may be negligible) if materials are coarse grained (free draining), or where low permeability materials have been deposited in thin layers or have been disturbed through geological processes such as faulting.<br>• Groundwater level at the site. Consideration of likely groundwater levels is also important. Some landfills are built with the base of the cells beneath surrounding groundwater levels, either permanently or intermittently when the groundwater rises after heavy rain or during the winter months. Other landfills may be located in clean gravel of high permeability with interbeds of clay and silt, but with groundwater at some depth below. In this case the likelihood of contaminants entering the groundwater system is lessened.<br>• Effectiveness of the landfill cap. The volume of leachate produced from a landfill is primarily a function of the rainfall that enters the landfill. This means that the nature and condition of the capping is important, as this generally controls the hydraulic gradient through the landfill. Landfill capping effectiveness is affected by:<br>○ the nature of materials used (clay provides good protection; gravels and sand allow high infiltration)<br>○ amount and type of vegetation on the surface (large tree roots can penetrate a cap and provide a pathway for rain)<br>○ thickness of the cap and the extent of capping (some closed landfills have not been capped, are incompletely capped or the cap has eroded)<br>○ shaping of the cap to promote runoff<br>○ condition of the cap, as cracks and slumps or material which is easily eroded (e.g. sand) would increase the amount of rainfall likely to penetrate the cap<br>○ existence and operational effectiveness of stormwater cut-off drains to direct overland flow away from the landfill.<br>• The volume of leachate in the landfill cells. Higher leachate volume results in increased mobility and leachate head, which leads to increased leachate migration to groundwater. This hydraulic head will push the leachate through the landfill and into the receiving environment where containment is poor.<br>• Distance to aquifer and user. The depth and the distance to an aquifer affect the likelihood of contamination and impact on the receptor. The depth of the aquifer and its distance from the user are considered key determining factors because physical and biological processes such | 1. Beneficial use of groundwater<br>Groundwater is a potential source for drinking water, irrigation and stock drinking water.<br>The consequence of contamination by leachate is that the beneficial use of groundwater may be adversely affected. As the leachate plume migrates from the landfill, it will be diluted and dispersed.<br>The closer the abstraction is to the landfill site, the greater the risk that the groundwater is contaminated.<br>The beneficial use value is determined by the actual quality of the groundwater as measured by its salinity.<br>In addition, some groundwater is poor in quality naturally, due to land uses such as intensive farming or the geochemistry of the area. In addition, there may be insufficient quantities for use. | 1. For new cells/areas: install liner to recommended specification.<br>2. Retrospective installation of remedial leachate extraction and management systems in high-risk situations.<br>3. For new cells/areas: ensure separation from groundwater and locate the landfill as far as practical from potential users of groundwater.<br>4. Install landfill capping to the recommended specification.<br>5. Ensure stormwater is diverted away from the landfill cells.<br>6. Monitor groundwater quality where there is potentially a linkage between the landfill and receptors. |

| Risk | Description of risk and pathways | Receptors | Risk mitigation recommendations |
|---|---|---|---|
| | as adsorption, diffusion, dispersion and degradation will occur during leachate transport through the aquifer. | | |
| 2. Surface water contamination | The contamination of surface water by landfill leachate is a particularly high risk for operating landfills and/or landfills that have not been rehabilitated.<br>As for groundwater, the effectiveness of the landfill capping and stormwater control at the site is key to the assessment of the volume of leachate produced from the landfill, and hence the risk of contamination to surface waters.<br>Rainfall is a key factor because the greater the rainfall, the greater the volume of leachate produced, and the more likely it is to migrate offsite. Leachate dams at or near capacity may overflow during rainfall events resulting in the contamination of runoff entering nearby surface waters.<br>Distance to aquifer and user is also a key factor. The closer a landfill is to a water body, the more likely it is that leachate will enter it through seepage. Conversely, the further away a landfill is from a surface-water body, the more adsorption, diffusion and infiltration will occur as the leachate migrates. Existing landfills exempt from licensing may also be located permanently in water bodies such as a spring or a wetland, or leachate may discharge directly into a surface-water body adjacent to the landfill or via drainage ditches. Existing landfills exempt from licensing may be located within flood plains or abandoned river channels, so there is potential for a flood to cause erosion of the landfill's sides or cap. Inundation increases the volume of leachate during the flood. | 1. Sensitivity of receiving water<br>Most surface waters provide a habitat for aquatic organisms.<br>The sensitivity of the surface-water body to contamination by leachate will depend on the size of the water body. A large river is less sensitive to a discharge compared to a small stream, or spring.<br>Surface water can be used as a potable water source. This would be highly sensitive to contamination. Other common uses such as stock watering and irrigation are less sensitive to contamination. | 1. Retrospective installation of remedial leachate extraction and management systems in high-risk situations.<br>2. For new cells/areas: locate the landfill as far as practical from surface-water bodies.<br>3. Ensure stormwater is diverted away from the landfill cells.<br>4. Install landfill capping to the recommended specification.<br>5. Monitor surface-water body quality where there is potentially a linkage between the landfill and receptors. |
| 3. Landfill gas | Landfill gas is produced from the degradation of the organic material in the landfill. Initially, the level of oxygen reduces and levels of carbon dioxide and hydrogen increase as conditions in the landfill become anaerobic. As degradation progresses, methane generation dominates.<br>The hazards associated with gas are:<br>• physical hazard of explosion (from methane mixing with air and ignited by a spark), or from asphyxiation (by methane build up within enclosed spaces).<br>• toxic hazard from gases generated in the landfill. For a landfill that has received hazardous wastes, there may be potentially harmful significant concentrations of gases other than the traditional landfill gases.<br>The length of time gas generation occurs, and the volume of gas produced is dependent on a number of factors such as the organic content of the waste, moisture content, temperature and the presence of inhibitory compounds in the landfill.<br>The nature of the gas will depend on the type of waste received and the landfill age. Landfills that have taken hazardous waste or industrial waste have a higher risk with respect to the potential for generation of toxic gas. Landfills dominated by highly putrescible waste such as that from domestic sources or green waste, have a higher risk for the potential for physical hazard. | 1. Contact with gas<br>Land use will determine the likelihood for direct contact via surface exposure. For example, there is higher potential for contact on an industrial site that has been developed near to a landfill, especially for maintenance staff who may enter service trenches.<br>Conversely there is low likelihood of contact with gas in an agricultural setting, as the land is less likely to be disturbed and has few or no confined | 1. Ensure separation distances to sensitive land uses are maintained.<br>2. For new cells/areas: install liner to recommended specification.<br>3. Retrospective installation of remedial leachate extraction and management systems in high-risk situations. Install landfill capping to the recommended specification.<br>4. Ensure stormwater is diverted away from the landfill cells.<br>5. Monitor subsurface landfill gas where there is potentially a linkage between the landfill and receptors. |

| Risk | Description of risk and pathways | Receptors | Risk mitigation recommendations |
|---|---|---|---|
| | It is expected that landfills exempt from licensing will have little to no engineered lining resulting in poor landfill gas containment, unless the soils underlying the site are fine-grained (impermeable) clay soils.<br>The nature of the capping material (if present) will determine the likelihood for lateral migration of landfill gas. Use of a highly impervious capping material, such as clay, will increase the potential for gas to migrate laterally.<br>Rainfall will affect the rate of degradation of organic matter in the landfill and hence the volume of gas produced. | spaces where landfill gas could accumulate. | |
| 4. Exposure to waste (ingestion or physical harm from sharps) | Hazards due to physical contact with a landfill comprise:<br>• physical hazard from objects such as sharps<br>• hazard from ingesting contaminated material.<br>Uncontrolled access to the landfill will increase this risk. Appropriate fencing to ensure public access and livestock access are controlled will reduce the risk. The application of cover material will also reduce the risk of litter leaving the site and being ingested by livestock and will also reduce exposure to waste until the landfill is capped.<br>The absence of an engineered cap will increase the risk of surface exposure. If a site is well capped and well maintained then the potential for surface exposure is low. If a cap is too thin, or there is significant slumping and cracking which is not rectified, then there is the potential for waste to work its way to the surface.<br>Rainfall is a key factor because capping materials subject to high rainfall have a greater potential for surface erosion and hence the risk of surface exposure is high.<br>Distance to population and other receptors such as livestock is another factor that can enable contact with the waste. | Surrounding land users and users of the landfill facility can come into direct contact with waste. | 1. Install fencing to the recommended specification.<br>2. Apply cover material at the recommended rates.<br>3. Ensure litter does not leave the site.<br>4. Install landfill capping to the recommended specification. |
| 5. Loss of amenity | All landfills create a potential loss of amenity typically through litter, dust, odours, and vermin.<br>The management of the landfill, including application of cover material and use of litter controls are the main measures to reduce this risk. The application of cover will reduce odour generation, vermin infestation, and prevent litter and nuisance dust leaving the premises. | Surrounding land holders can be affected by loss of amenity. | 1. Apply cover material at the recommended rates.<br>2. Ensure litter does not leave the premises.<br>3. Install landfill capping to the recommended specification. |

Sources: Golder Associates (2002), NSW DECC (2008), NSW DECC (2008)(b).

### Implementation checklist

The following checklist provides a template that landfill operators may use to assist in implementing this guideline. Each recommendation is linked to the main risk categories identified and discussed in Table A1 to help landfill operators to prioritise site risks. The level of risk for each category increases as the number of recommendations not implemented increases. It follows that for sites that have implemented all of the recommendations, the risk to the environment and human health would be low.

Table A2 Checklist of recommendations for implementation of the guideline

| Recommendation from guideline | Completed/implemented | | | Associated risk category (from Table A1) |
|---|---|---|---|---|
| | Yes | No | Unknown | |
| **Establishment and siting** | | | | |
| 1. Assess the need and economic viability for a new landfill exempt from licensing and if needed, ensure it is included in the relevant Regional Waste Management Plan | | | | |
| 2. Ensure new landfills exempt from licensing are not located in a natural gully or erosion channel, have a site slope of less than 1 in 5, and preference a site of low conservation value. | | | | 1,2 |
| 3. Provide separation distances in accordance with Table 1 and Table 2. Where these are not practical to provide, demonstrate that the risks are mitigated to the same standard as having the full separation distances in place. | | | | All |
| **Landfill design** | | | | |
| 4. Ensure new landfill cells are sized to provide enough airspace for waste disposal for a period not exceeding two years. | | | | 1,2 |
| 5. Ensure new landfill cell liners are constructed in accordance with landfill designs, clay specifications and CQA outlined in Table 3. | | | | 1,2,3 |
| 6. Ensure new landfill cells include a leachate drainage layer constructed across the base of the landfill at least 300-mm-thick from materials with the recommended properties. | | | | 1,2,3 |
| 7. Prevent offsite discharges of leachate or stormwater contaminated by leachate. | | | | 2 |
| 8. Construct and maintain a stormwater diversion system around the landfill able to cope with at least a one-in-20-year storm event. | | | | 1,2 |
| 9. Provide adequate storage and management facilities for leachate that allow a free board of 500 mm to be maintained. | | | | 1,2 |
| 10. Check leachate levels at least monthly and if the level exceeds 300 mm over the lowest point of the liner surrounding the sump, leachate is to be extracted so that the remaining level is less than 300 mm. | | | | 1,2 |
| 11. Ensure waste drop-off areas are clearly marked and that the site is screened using existing features or planting. | | | | 1,2,4 |
| **Landfill management** | | | | |

| Recommendation from guideline | Completed/implemented | | | Associated risk category (from Table A1) |
|---|---|---|---|---|
| | Yes | No | Unknown | |
| 12. Landfills should be regularly checked for:<br>i. composition of materials being deposited<br>ii. disposal of prohibited waste<br>iii. disposal outside of tipping area. | | | | 1,2,3,5 |
| 13. Provide signage near the landfill entry that provides contact details, the hours of operation, and the types of waste accepted. | | | | 1,2,5 |
| 14. Maintain fencing to prevent unauthorised access to the site. | | | | 4 |
| 15. Cover wastes in the landfill at no less than the minimum frequency specified. | | | | 4,5 |
| 16. Ensure no litter leaves the site. | | | | 4,5 |
| 17. Prevent the offsite discharge of nuisance dust arising from the site. | | | | 5 |
| 18. A suitable experienced professional to assess the need for environmental monitoring to protect sensitive receptors. | | | | 1,2,3,5 |
| 19. Consult with the CFA and DEPI for advice on fire control measures. | | | | |
| **Landfill rehabilitation** | | | | |
| 20. Install an intermediate cover on waste if an area of landfill is not yet ready to have the final cap installed or if waste will not be placed in that area for six months or more. | | | | 1,2,4,5 |
| 21. Rehabilitate the landfill in accordance with the cap specifications in Table 6 or Table 7. | | | | 1,2,4,5 |
| 22. Ensure the final landform:<br>i. is compatible with the future land use of the site<br>ii. adequately sheds water<br>iii. minimises erosion potential. | | | | 1,2,4,5 |
| 23. Provide aftercare for a minimum of 10 years post closure. | | | | All |
| 24. Prepare and implement an aftercare management plan that checks and documents the performance of the landfill through periodic inspections. | | | | All |
| 25. Prepare and implement a monitoring program where the landfill is located in close proximity to sensitive receptors and/or environments (refer to Table 5). | | | | 1,2,3 |