

# Closed Landfill Guidelines



Environment  
Protection  
Authority Victoria

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Guideline

## Introduction

The environmental risks posed by a landfill site continue for a significant period of time after waste acceptance has ceased. To control these risks clause 16(4) of the Waste Management Policy (*Siting, Design and Management of Landfills*, No. S264, Gazette 14 December 2004) states once a licensed landfill site has closed, the Environment Protection Authority (EPA) will require, through a notice, the occupier of the site to undertake ongoing aftercare until such time as the site does not pose a risk to human health or the environment, as determined by the Authority.

EPA requirements for environmental management of landfills have changed as part of the licence reform program. These changes have required landfill operators to better identify and manage the environmental impacts of their landfill. Post closure pollution abatement notices (PC PANs), which are used to regulate environmental risks from closed landfill sites upon surrender of the landfill licence, have been changed in line with the licence reform program and current best practice guidelines.

There are many closed landfills across Victoria in widely varying states of management and regulation. EPA will assess whether a closed landfill should receive a PC PAN or, in some cases, receive a reformed PC PAN to replace an existing notice. The decision is based on:

- Information gathered using desktop assessments of monitoring data
- Environmental audits
- Inspection records or other data requested from the current or former site occupier
- EPA conducting its own monitoring or requiring an audit of the closed landfill under Section 53V of the *Environment Protection Act 1970* (the 'EP Act').

The reformed PC PANs also introduce requirements to manage leachate levels at un-engineered sites and at sites that are not engineered to current standards, based on a hydrogeological assessment (HA).

This document provides guidance to assist landfill operators with rehabilitation and aftercare management requirements for closed landfills, and assist with seeking EPA approval for construction or augmentation of landfill caps. It identifies the steps to be taken by landfill operators during preparation of an environmental monitoring program – a HA, a rehabilitation plan and an aftercare management plan, as well as ongoing auditing of landfill rehabilitation and aftercare. Where a landfill operator can demonstrate, through robust assessment, that further work to protect the environment is not required, the PC PAN will account for this through site specific requirements or removal of standard requirements.

Guidance is also provided to environmental auditors for conducting environmental audits and the verification of landfill operators' plans and assessments.

Guidance on understanding landfill PC PAN requirements is provided in Appendix 1.2. These guidelines reference the most recent version of, *Best Practice Environmental Management; Siting, Design, Operation and Rehabilitation of Landfills* (EPA Publication 788) (Landfill BPEM), which is the primary waste management policy implementation and guidance document for landfill management in Victoria.

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## Management of closed landfill sites

Ongoing environmental management of closed landfill sites undergoing rehabilitation and aftercare will be regulated by EPA through the use of a PC PAN as an ongoing regulatory tool.

In order for the PC PAN to function as a regulatory tool for regulating ongoing aftercare management (functioning in a similar way to reformed EPA licences), landfill operators will first be required to produce aftercare management and rehabilitation plans, show evidence of an environmental monitoring program and undertake a hydrogeological assessment to enable appropriate leachate levels to be determined and maintained. These plans, programs and assessments will be required by EPA in a pollution abatement notice (PAN), which, for the purposes of management of closed landfill sites, are called supporting PANs. Some of this information, such as the auditor verified environmental monitoring program, may have been produced under the former EPA licence. In these cases the information will not be required again and existing information will be used if it remains relevant. The plans and assessments generated under the supporting PANs then become part of the ongoing aftercare management under the PC PAN. This regulatory procedure means landfill operators will be regulated by plans, programs and assessments they have generated themselves with input from an EPA appointed environmental auditor and environmental consultants as required.

The order of the procedure is:

### Step 1.

A supporting PAN will be issued requiring production of an auditor verified rehabilitation plan, an aftercare management plan and an auditor verified environmental monitoring program.

### Step 2.

Another supporting PAN will be issued requiring the landfill operator to define maximum leachate levels to be maintained at the site based on a hydrogeological assessment (HA) or, in the case of lined cells, the Landfill BPEM.

### Step 3.

A PC PAN will be issued once the supporting PANs under steps 1 and 2 above have been complied with. The PC PAN contains ongoing management requirements including:

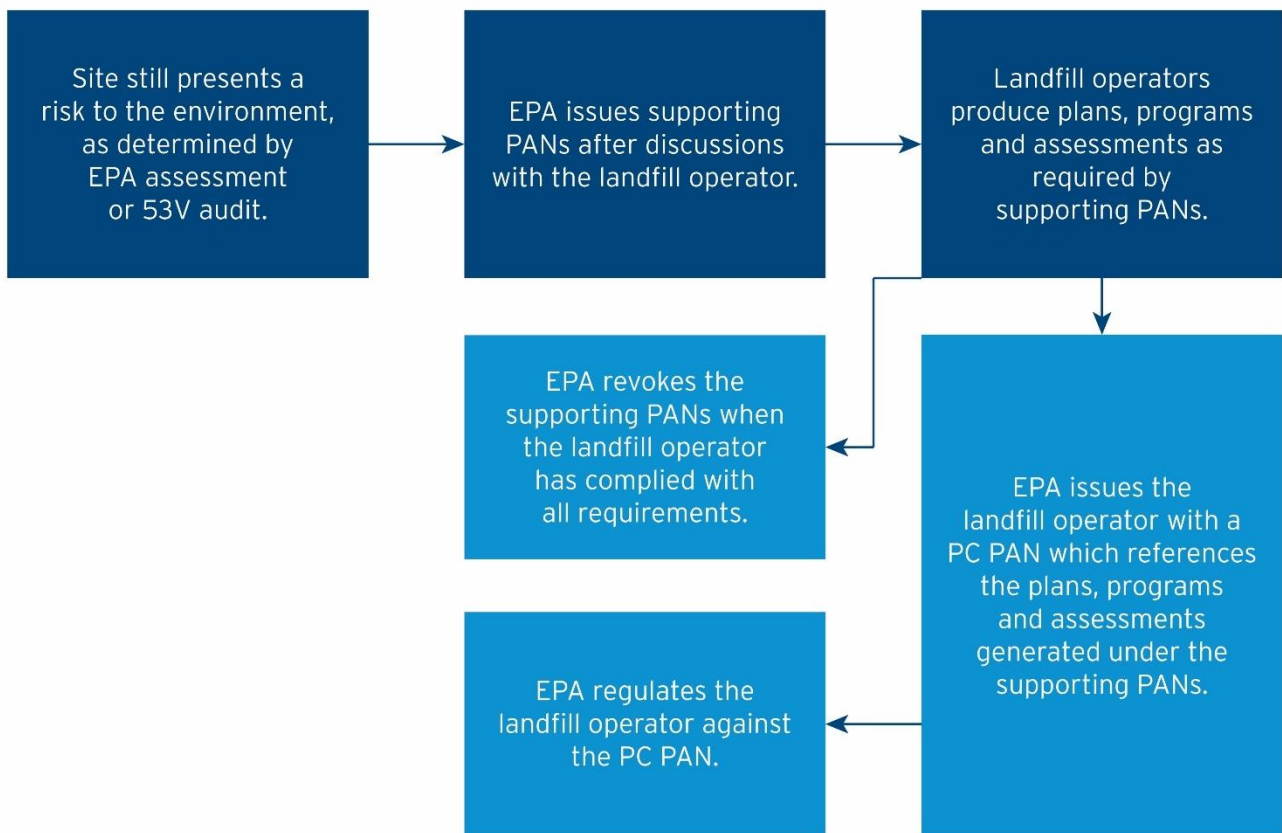
- implementing the environmental monitoring program
- implementing the rehabilitation plan
- managing the landfill in accordance with the aftercare management plan
- achieving and maintaining the leachate levels determined by the HA or in accordance with the landfill BPEM.

Steps 1 and 2 will only be undertaken where those assessments or plans are deemed to be required.

Steps 1, 2 and 3 above are shown in Figure 1 below and described in detail in sections a, b and c of this guideline.

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**Figure 1: Procedure for ongoing environmental management of closed landfill sites undergoing rehabilitation and aftercare.**



This procedure requires the participation of the landfill operator, environmental auditors and EPA. Details of the procedure and the roles of the respective parties are provided in the following sections of these guidelines.

**a. Supporting PAN — Producing a rehabilitation plan, an aftercare management plan and an auditor verified environmental monitoring program**

**Preparation of rehabilitation and aftercare management plans**

A supporting PAN will require the notice holder to produce a rehabilitation plan, an aftercare management plan and an environmental auditor verified environmental monitoring program.

**Rehabilitation plan — Landfill capping**

The rehabilitation plan must include an assessment of the landfill cap performance against environmental outcomes (see Appendix 1, requirement 3.4) for groundwater protection and landfill gas emissions where:

- the whole site or some of the cells have existing final capping but it was not constructed to the standards of the most recent version of the Landfill BPEM

or

- a former version of the landfill BPEM (which was the most up-to-date version at the time)

or

- in accordance with an EPA approval or licence condition.

This approach is taken to prevent notice holders being required to remove any existing final capping and replace it with a cap fully engineered to the standards in most recent version of the Landfill BPEM when the current cap is sufficiently allowing protection of groundwater and control of landfill gas emissions.

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Where the site or some cells on the site do not have any final landfill capping, the rehabilitation plan must include the cap design specification, CQA plan and timeframe for constructing a cap to the standards in the most recent version of the Landfill BPEM. Design of the landfill cap is subject to the approval process that applies to landfill cells for operational sites. The full design and approval process is described in the most recent version of the *Landfill Licensing* guidelines (EPA Publication 1323).

The requirement for design verification and construction certification of the final cap by an environmental auditor may be waived for 'low risk rural landfills' (refer to chapter 6.12 of the Landfill BPEM).

Detailed information on compliance with the rehabilitation plan requirement of this supporting PAN is in Appendix 1, under requirements 3.1 to 3.4.

## **Aftercare management plan**

The aftercare management plan is the primary document to manage the environmental risks from a landfill site during the aftercare phase. The aftercare management plan must as a minimum contain the following:

- a) inspection and maintenance of the landfill cap to prevent, control and remediate erosion, restore depressions, seal cracks and maintain vegetation
- b) inspection, maintenance and operation of the leachate collection and treatment system
- c) inspection, maintenance and operation of the landfill gas management system
- d) inspection and maintenance of surface water control and collection infrastructure
- e) an environmental monitoring program for the landfill, verified by an environmental auditor appointed pursuant to the EP Act.

Detailed information on compliance with the aftercare plan requirement of this supporting PAN is in Appendix 1, under requirement 3.5.

## **Auditor verified environmental monitoring program**

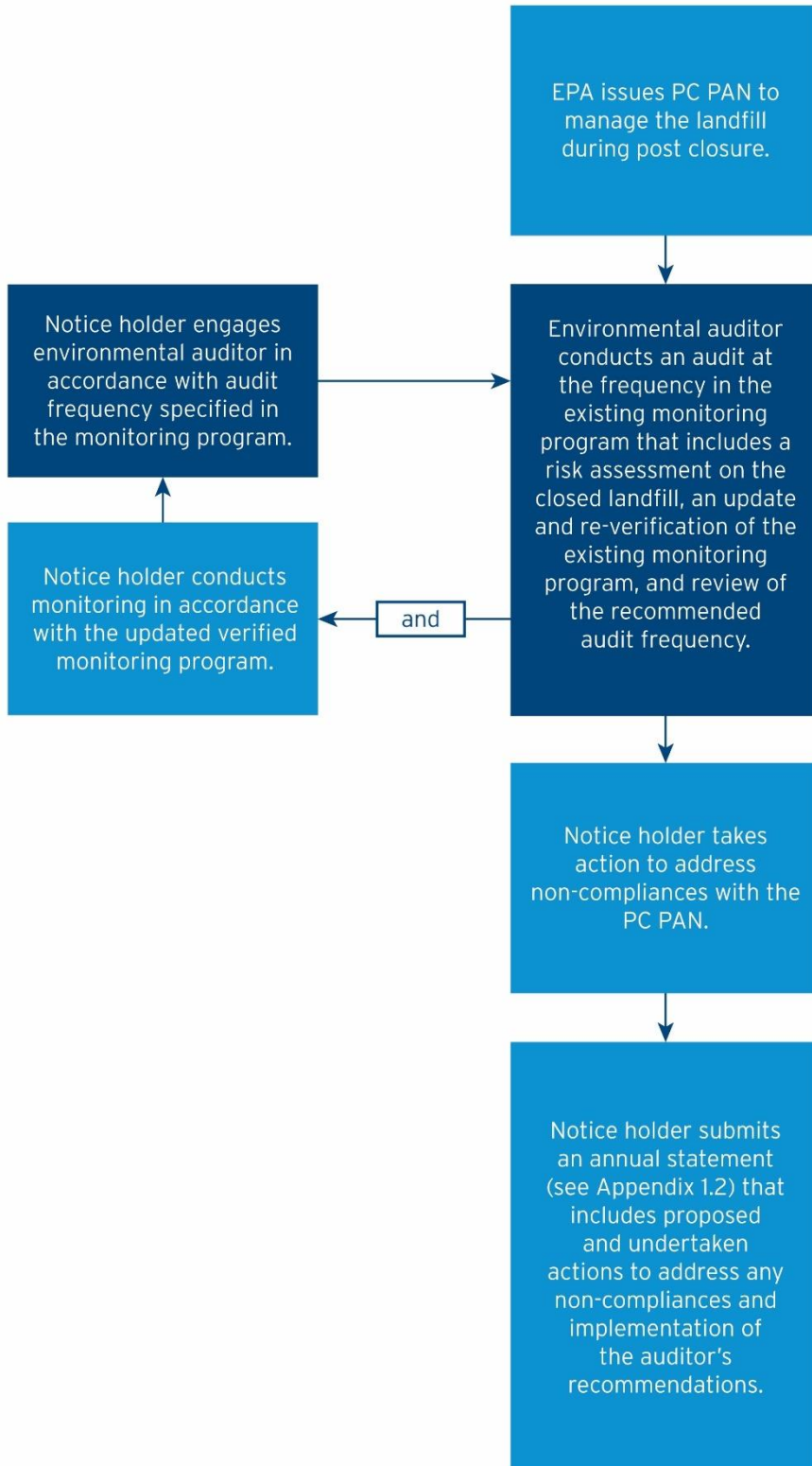
Notice holders are required to develop an environmental monitoring and auditing program based on a landfill risk assessment. The supporting PAN requires that the monitoring program and auditing frequency be verified by an EPA appointed environmental auditor (see Figure 3).

The supporting PAN will not require a new monitoring program where a landfill has an existing environmental auditor verified environmental monitoring and auditing program developed during the operational phase of the landfill (requirement 3.5e will not be used). The existing monitoring should continue to be followed for the closed phase of landfill management based upon an updated risk assessment (see Figure 2).

Detailed information on compliance with the environmental monitoring/auditing requirement of this supporting PAN is in Appendix 1, under requirement 3.5.

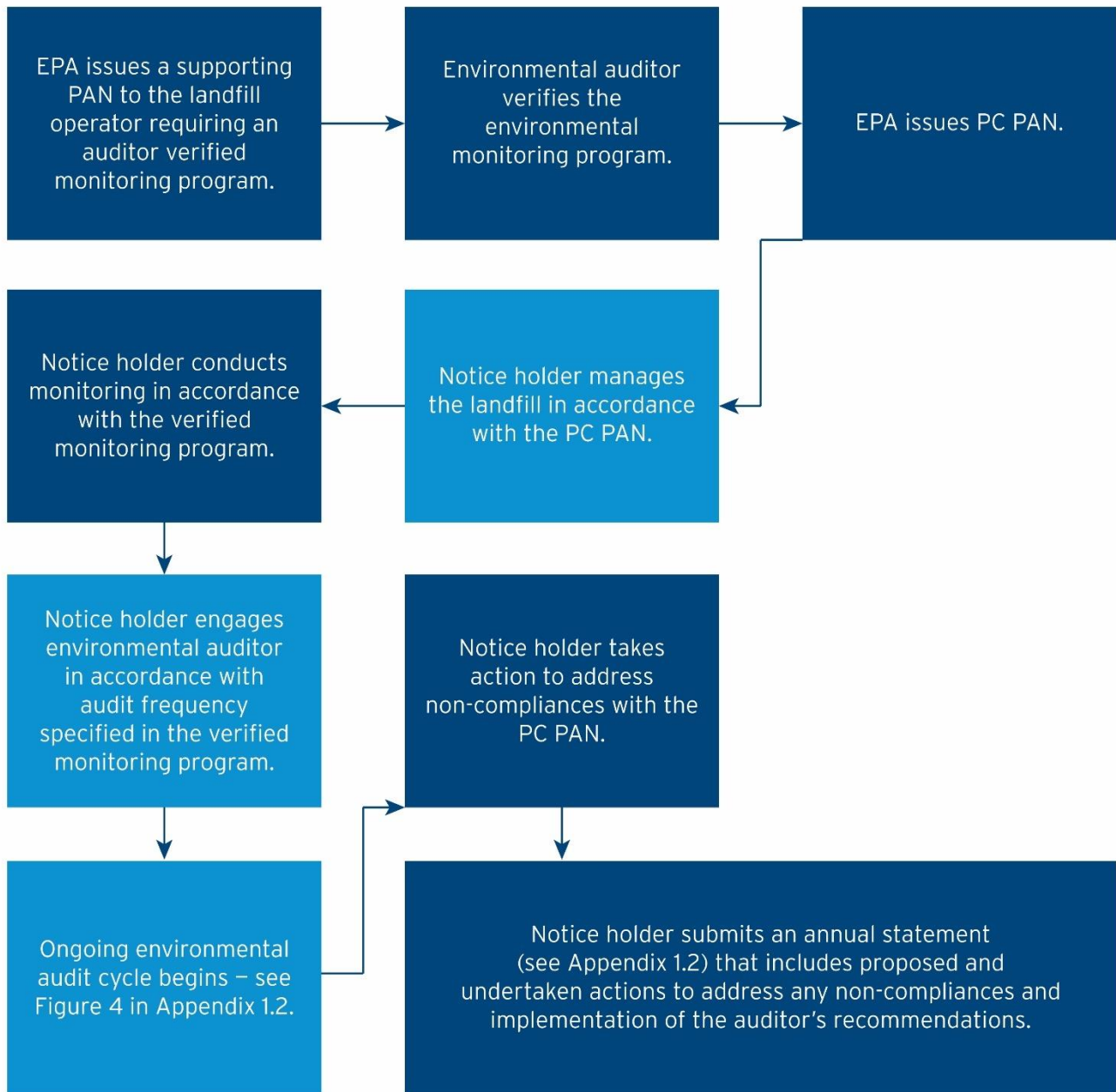
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**Figure 2: Risk assessment, auditing and monitoring program for a closed landfill where an existing environmental auditor verified monitoring program was implemented under the former landfill licence.**



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**Figure 3: Risk assessment, auditing and monitoring program establishment where a site does not have an existing environmental auditor verified monitoring program.**



Documentation must be retained by the notice holder confirming that the risk assessment has been undertaken, that the environmental monitoring program has been prepared and that it has been verified by an environmental auditor.

Re-verification of the environmental monitoring program must be conducted as part of each environmental audit undertaken.

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## **b. Supporting PAN – Determining leachate levels to be maintained**

The notice holder will be required to undertake a HA to determine leachate levels to be achieved and maintained at the site which minimise risks to groundwater and allow effective management of landfill gas.

A HA will be required in the following circumstances:

- where the site has un-engineered cells (i.e. no basal or sidewall engineered containment) and the former licence or PC PAN did not require maintenance of leachate at, or below, a maximum compliance level
- where the site has un-engineered cells and the former licence or PC PAN required a leachate compliance level which could not be achieved (for example if an un-engineered cell was required to achieve a leachate level from the lowest point of the drainage layer)
- where a landfill site has some form of basal and/or sidewall engineered containment but this containment does not meet the engineering standards specified in the most recent version of the Landfill BPEM.

Cells that are fully engineered to BPEM standards are not to be included in the HA as a maximum leachate level of 300mm from the lowest point of the drainage layer must be maintained in these cells, in line with the Landfill BPEM. The 300mm leachate level for these cells must be included in Schedule 1 of the HA expressed as mAHD.

Where all cells on site are engineered to the standards of the most recent version of the Landfill BPEM, a HA is not required and this supporting PAN will not be issued. See Requirement LC9.2 in Appendix 1.2.

The HA is required to be verified by an EPA appointed environmental auditor.

Guidance on understanding the requirements of the supporting PAN to determine leachate levels is provided in Appendix 1.1.

## **c. The PC PAN**

The PC PAN contains the requirements for ongoing management of the landfill that must be met during the rehabilitation and aftercare phase. It includes requirements to comply with the specified leachate levels, rehabilitation plan and aftercare management plan produced under the supporting PANs.

EPA appointed environmental auditors are used in a similar manner to the reformed licensing system. The recommendations made by auditors will be reviewed by EPA regarding any decisions about PC PAN compliance and enforcement. Notice holders will be required to implement the reviewed recommendations.

The PC PAN will remain in force until such time as EPA, via the ongoing environmental monitoring and audit program, concludes that the landfill has stabilised to the point where the waste is no longer causing or no longer has the potential to cause pollution or an environmental hazard. This is based on the Waste Management Policy (*Siting, Design and Management of Landfills*) and section 31A of the *Environment Protection Act 1970*. An important consideration in determining stabilisation of the landfill concerns what environmental benefits, impact reduction or risk reduction that further management and monitoring would bring about.

The requirements of the PC PAN and how to comply with them are described in Appendix 1.2.

## **d. Auditor verification**

The following documents require verification by an EPA appointed environmental auditor:

- The hydrogeological assessment.
- The rehabilitation plan.
- The environmental monitoring program, which forms part of the aftercare management plan.



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## Appendix 1. Understanding supporting PAN requirements for rehabilitation, aftercare and developing an environmental auditor verified monitoring program.

**Requirement 3.1. By <insert date> you must supply to the Authority a Landfill Rehabilitation Plan for the premises. The Landfill Rehabilitation Plan must contain time bound milestones for implementation.**

Notice holders are required to provide a plan which details the rehabilitation and intended future use of the landfill site during the aftercare phase. This plan must consider the potential afteruses of the site, taking into consideration current and likely future land use in the area surrounding the site. The most critical parts of the rehabilitation plan are the considerations relating to the landfill cap (see guidance notes on requirements 3.3 and 3.4 below). The intended future use of the landfill must be appropriate to minimise risks to the environment and human health, and not prevent effective aftercare management of the site.

The notice holder must agree a date with EPA by which the rehabilitation plan will be submitted, allowing suitable time for verification by an environmental auditor (see requirement 3.3 below).

**Requirement 3.2. The landfill rehabilitation plan referred to in Requirement 3.1 must be verified by an environmental auditor appointed pursuant to the Act to ensure that it is in accordance with the most recent version of the Best Practice Environmental Management Guidelines, Siting, Design, Operation and Rehabilitation of Landfills (EPA Publication 788) (the Landfill BPEM).**

The rehabilitation plan must be verified by an environmental auditor. Particular attention must be paid to the decisions made around the assessment of existing capping and that the future land use does not prevent effective aftercare management of the site.

**Requirement 3.3. The landfill rehabilitation plan referred to in Requirement 3.1 must include:**

**a) cap design and a Construction Quality Assurance (CQA) plan for construction of the cap for cells xxxx in accordance with the Landfill BPEM.**

This requirement will only be used in the supporting PAN where the site, or some cells at the site do not have a final cap of any type or standard, and the landfill licence requires capping to the standard in the Landfill BPEM.

Requirement 3.3 requires that all capping at the landfill is constructed in accordance with the most recent version of the Landfill BPEM. As the process is identical to cap construction for a recently closed cell on an operating landfill site, operators are required to follow sections of the most recent version of EPA publication 1323 relating to the cap design, approval, construction, CQA and auditor involvement. At sites where a final cap has been placed but assessment of the standard of capping is required, requirement 3.4 (below) will be used instead of requirement 3.3. The compliance advice for requirement 3.4 describes the situations which require a cap to be assessed.

**b) a pre-settlement and post-settlement contour plan of the premises**

The landfill rehabilitation plan should contain the pre-settlement contours, which represent the maximum elevation of the rehabilitated landform, and the post-settlement contours, which form the final landform of the site after settlement. Both the pre-settlement and the post-settlement contours are for the top of the rehabilitated landform, not the top of the waste.

The pre-settlement contour accounts for the effects of mass loss in the waste due to the extraction and fugitive emissions of landfill gas. Therefore, if settlement is expected, the pre-settlement contour represents an elevation higher than what the final landform (the post-settlement contour) will be.

The amount of settlement is dependent on several variables, the most significant being:

- waste type
- moisture content
- extent of gas extraction undertaken
- leachate management measures
- compaction rates achieved
- extent and type of landfill capping
- fugitive emissions of landfill gas.

Equations based on these variables can be used to calculate the settlement amount. This allows calculation of a pre-settlement level for the waste to be tipped to, allowing enough vertical space for the cap construction on top of the waste to achieve the desired post-settlement contours. Over time as the waste settles due to gas extraction/emission, if the calculations were robust, the post-settlement contour is achieved. The post-settlement contour plan should be in accordance with final landform profile approved by your local council and should be included within the rehabilitation plan and any CQA plans for cap construction.

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## **Requirement 3.4. The landfill rehabilitation plan must include:**

- a) **an assessment of landfill cap performance on cells <insert cell identification> to determine if current capping at the premises:**
  - i. **reduces infiltration of surface water to minimise the risks of impacts on groundwater, or where impacts on groundwater have occurred, that these impacts are not worsened**  
**and**
  - ii. **is sufficient to allow landfill gas management measures to achieve compliance with the landfill gas action levels in Table 6.4 of the Landfill BPEM.**

### **OR**

- a) **an assessment of the cap construction against the standards required in the former landfill licence.**
- b) **where required, a landfill cap design specification and Construction Quality Assurance (CQA) plan in accordance with Section 18 of the most recent version of Landfill Licensing guidelines (EPA Publication 1323), detailing any additional capping work needed to meet this requirement.**

An assessment of the cap performance is required for the whole site or individual cells, where it cannot be demonstrated that:

- the cap has been constructed to standards set in the former or most recent version of the Landfill BPEM
- the cap has been constructed in accordance with EPA approval or with a former licence condition.

Requirement 3.4 recognises that landfill caps constructed prior to the issue of the first version of the Landfill BPEM are unlikely to meet the seepage standard for landfill liners in the most recent version of the Landfill BPEM. These caps need to be assessed against the environmental outcomes specified in i. and ii. of requirement 3.4 or the standards of capping required by the former licence.

If the cap assessment determines that further construction works are required for the cap to meet these environmental outcomes or the standards required by the former licence, details of the specification to be achieved, the CQA for these works and the completion date must be included in the rehabilitation plan.

Except where capping standards in a former licence must be met, if it can be shown on the basis of cost benefit that additional works to the cap will not reduce or minimise risks to the environment, landfill management measures to reduce or minimise these risks should be specified as an alternative. For example, where a landfill is located below the groundwater table and groundwater ingress is the major source of leachate generation, reducing infiltration through the cap may not have a major impact on leachate generation. In this situation, improved leachate management and ex-situ groundwater management measures, as an alternative to improving capping, could be specified in the rehabilitation plan and aftercare management plan. Such alternative measures include, but are not limited to:

- increasing leachate extraction infrastructure to remove greater volumes of leachate. Groundwater would be drawn into the waste, generating greater volumes of leachate for extraction. This process over time reduces the leachate contaminant 'source term' reducing groundwater impacts
- groundwater level reduction to reduce the leachate volumes generated. This management measure requires that leachate be maintained below the pumped groundwater level, otherwise groundwater pollution is likely to increase
- groundwater interception and diversion.

All management measures must consider impacts on the local hydrogeological conditions and beneficial uses of the affected groundwater.

Such management measures must consider the need to maintain effective landfill gas extraction to meet gas action levels in Table 6.4 of the Landfill BPEM. Improvements to the cap may still be required for maintenance of effective vacuum on an active landfill gas extraction system, or emissions abatement on a passive oxidation or passive flaring system.

## **Requirement 3.5. By <insert date> you must supply to the Authority an aftercare management plan for the premises that is consistent with Aftercare management in Section 8.2 of the Landfill BPEM. The aftercare management plan must, as a minimum, contain management of the following:**

The aftercare management plan is the primary document to manage the environmental risks from a landfill site during the aftercare phase. This requirement includes the main areas for inclusion (described in more detail below) in an aftercare management plan not covered by other requirements in the notice. These areas should form specific sections of the aftercare management plan. In addition, operators must also ensure that the plan is consistent with the aftercare management section of the Landfill BPEM. Where an operating landfill site is closing and moving into the post closure phase, it is expected that management plans for cap inspection and maintenance, and operation of gas, leachate and surface water collection and treatment systems are already in use. These plans form part of the aftercare management plan.

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## **a) inspection and maintenance of the landfill cap to prevent, control and remediate erosion, restore depressions, seal cracks and maintain vegetation**

Regular cap inspections are essential to identify areas of erosion and cracking. This could lead to increased infiltration of surface water, increased surface emissions of landfill gas and/or the gas extraction system drawing air into the waste mass, adversely affecting the gas balance in nearby wells and potentially causing fires. Global positioning system (GPS) coordinates of locations needing attention should be recorded. Alternatively, the locations could be marked on the cap using spray paint or a marker post. The aftercare management plan should detail how any areas of erosion or cracking are to be repaired. The cap inspection procedure should link to the assessment of surface emissions of landfill gas in the environmental monitoring plan. Surface emissions assessments which identify areas of the cap which exceed the landfill gas action levels in the Landfill BPEM will need to be re-assessed after the cap has been remediated.

## **b) inspection, maintenance and operation of the leachate collection and treatment system**

Leachate control in the aftercare phase is as intensive and important as during the active phase of the landfill to protect groundwater and allow effective extraction of landfill gas. The system should be maintained in full working order to achieve the maximum leachate levels (see Appendix 1.1, understanding PAN requirements for determining leachate levels and Appendix 1.2, requirement LC9 and LC9.1).

## **c) inspection, maintenance and operation of the landfill gas management system**

Landfill gas control in the aftercare phase is as intensive and important as during the active phase of the landfill in order to maintain compliance with the gas action levels specified in the Landfill BPEM. Extraction will be easier to manage once the landfill has been capped, if given the appropriate amount of attention. However, certain additional complexities are introduced in closed sites, such as maintaining appropriate falls on buried pipework, managing gas balance during times of declining landfill gas concentrations in older cells, and managing gas balance where phytocaps form part of the rehabilitated landfill. After capping the gas management system will need expanding into recently capped cells. Triggers for this will need to be included within the aftercare management plan for the inspection, maintenance and operation of the gas management system. The list is not exhaustive and advice should be sought from an independent contractor engaged to extract landfill gas from the site to fully produce the gas management section of the aftercare management plan.

Considerations include:

- gas well balance and flow parameters to be maintained (CH<sub>4</sub> v/v min, CO<sub>2</sub> v/v max (including CH<sub>4</sub>:CO<sub>2</sub> ratios), O<sub>2</sub> v/v max, N<sub>2</sub> v/v max (including free nitrogen assessment when compared to O<sub>2</sub>% v/v), flow rate (Nm<sup>3</sup>/hr) and method of measurement (i.e. orifice plate, pitot tube etc.)
- gas well balance and flow assessment frequency
- identification of monitoring results which may indicate issues for gas management (for example, elevated H<sub>2</sub>S, CO, N<sub>2</sub>, excessive vacuum but low flow)
- well condition inspections
- pipework inspections, maintenance of drainage falls and checking butt/electro fusion joints for expansion/contraction damage etc.
- identification of dull spots in the field vacuum - results of surface emissions and sub-surface geology monitoring are key to this. Vacuum tests at knock-out pots/J-traps and cross suction tests on gas wells can assist in this.
- gas treatment plant capacity considerations - do the gas engines/flares have sufficient combustion capacity to deal with projected gas production volumes and the required extraction rates to maintain compliance with BPEM gas action levels?
- electrical interconnection - does the export limit of the electrical interconnection allow enough additional gas engines to be used to combust the projected gas production volumes? If not, the management plan should detail how the interconnection will be expanded or if it cannot be expanded, at what point landfill gas flares (which do not export electrical energy and so are not limited by interconnection size) will be used to expand gas combustion capacity to meet projected landfill gas production volumes.
- provision of spare parts for the gas management system and response times for repairs or system alarms such as engine shutdowns or flare flame-outs
- gas treatment plant maintenance and inspection (for example maintenance schedule, oil change frequency, oil analysis, siloxane build up checks, acid gas formation etc.)
- procedures for engaging gas well drilling contractors
- gas well and perimeter monitoring bore designs to be used
- well field, pipework and perimeter monitoring bore location diagram – updated regularly
- condensate management
- in-waste fire procedures, fire identification (monitoring and visual signs), gas system management during fires,

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extinguishing fires, monitoring to confirm the fire is extinguished and phased re-introduction of vacuum to the area

- links to the gas monitoring section of the environmental monitoring program.

#### **d) inspection and maintenance of surface water control and collection infrastructure**

The landfill site should be rehabilitated to ensure that the final landform sufficiently sheds water to prevent excessive infiltration of water into the waste mass. This creates surface water run-off that needs to be managed to prevent pollution of land, surface water and groundwater. The primary pollutant of concern in the aftercare phase is suspended solids, however, there remains a risk of contamination of surface water run-off with leachate from outbreaks at batters, the waste surface or from pipework leaks. The aftercare management plan must consider how surface water is managed based upon the risk of contamination. The aftercare management plan must detail the re-use, evaporation or disposal methods intended for surface water, as well as methods of draining the surface of the rehabilitated landfill. Section 6.5.1 of the Landfill BPEM contains best practice information for stormwater management.

#### **e) an environmental monitoring program for the landfill, verified by an environmental auditor appointed pursuant to the EP Act.**

An environmental monitoring program must be included in the aftercare management plan which allows assessment of the impacts of the landfill on all the segments of the environment deemed to be at risk of pollution. The environmental monitoring program should be determined after a landfill risk assessment has been completed. The environmental monitoring program must be sufficient to allow operators to demonstrate compliance, non-compliance or progress towards compliance with the requirements of the PC PAN.

Guidance on landfill risk assessment is provided below. Guidance on the parameters to be included in the monitoring program is provided below and in Appendix 3. Guidance on the scope of auditor verification of the environmental monitoring program is provided in Appendix 4.

### Risk assessment

An environmental risk assessment of the landfill in the rehabilitation and aftercare phase is required to identify and evaluate the potential risks to the environment. A conceptual site model should be developed to aid evaluation of the risks. Conceptual site models aid this process by allowing better interpretation of the source-pathway-receptor links. To produce a robust conceptual site model two detailed assessments must be included:

- the landfill gas risk assessment, described in detail in Appendix 2
- the hydrogeological assessment, conducted in accordance with EPA Publication 668.

The scope of the risk assessment must be clearly defined prior to conducting the assessment and be tailored to enable use of the results for the preparation of the environmental monitoring program. The process must be sufficiently well documented to support the conclusions reached and to enable an independent person to understand and verify the process used. The risk assessment must be re-verified by the auditor as part of each environmental audit and this must include consideration of whether the HA requires review. After each audit, the risk assessment and, if necessary, the HA, must be updated to incorporate the environmental audit findings or recommendations made by the auditor. The scope of a review and re-verification of the HA is only expected to be concerned with changes to leachate drawdown timeframes in light of unforeseen circumstances. A review of the maximum leachate levels determined in the HA should only be undertaken where new information comes to light which changes the hydrogeological setting, leachate composition, site engineering standards or other critical aspect of the conceptual site model. Reviews of the environmental risk assessment must be conducted by a suitably experienced person in between auditor verifications if changes to site conditions are likely to increase the risk posed to the environment. A review of the risk assessment undertaken between audits must not exclude any recommendations previously made by an environmental auditor. Each review must include consideration of the monitoring results obtained, complaints received, changes to landfill activities, cell capping and progressive rehabilitation works, changes to surrounding land uses or sensitive receptors that have occurred since the preceding review.

### The environmental monitoring program

The notice holder must prepare and implement an environmental monitoring program for the landfill based on the results of the risk assessment. The monitoring program must be verified by an environmental auditor. The monitoring program must, as a minimum:

- list the environmental elements to be included in the program. These must include groundwater, landfill gas, air and the land. The need for monitoring of landfill gas would be determined using the landfill gas risk assessment process described in Appendix 2
- list the parameters to be monitored — based on the risk assessment, waste received, nature of the site activities, sensitivity of the site location (hydrology/hydrogeology/geology), location of sensitive receptors (human and environmental) and be consistent with the listed environmental elements
- identify sampling point locations, associated sampling infrastructure and equipment, and provide comment on the suitability of those locations. If the sampling infrastructure or locations are insufficient, the risk assessment should identify this and the auditor should make recommendations to bring the sampling infrastructure and locations up to a standard

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which enables the collection of representative monitoring data

- specify sampling methods to be applied, with reference to standards or procedures
- include a requirement for regularly measuring the leachate level in each cell in metres Australian height datum (mAHD). The maximum leachate level is to be specified in the HA (where relevant) or as 300mm above the lowest point of the drainage layer where the cell is engineered to the standards in the most recent version of the Landfill BPEM
- include a schedule of monitoring frequencies for the sampling or testing of each parameter, with justification provided for the frequency adopted. This would include consideration of the age of the landfill, past monitoring results, data gaps and identified impacts on adjacent land or receptors. EPA expects the default monitoring frequency to be quarterly, with the minimum frequency being half-yearly. Selection of a half-yearly monitoring frequency must be justified by reference to past monitoring results
- specify required analysis method detection limits
- specify quality assurance requirements
- specify trigger levels and concentrations for action for each of the parameters being monitored (actions for trigger level/concentration exceedances should be within the aftercare management plan)
- include a requirement for an environmental audit program and specify the frequency of the audits, which meets or exceeds the frequency recommended by the environmental auditor
- the audit frequency should reflect the risk to the environment presented by activities at the landfill.

Parameters that need to be considered for inclusion in an environmental monitoring program are identified in Appendix 3.

The notice holder must monitor landfill rehabilitation and aftercare in accordance with the monitoring program. Prior to the ensuing audit of the landfill, the notice holder must review and update the environmental monitoring program with regard to audit recommendations, past monitoring results, any direction by EPA and any changes to operations, the environment or receptors.

The environmental monitoring program must be verified by an environmental auditor and re-verified as part of each subsequent environmental audit.

The steps to be taken by an environmental auditor during verification of a monitoring program are listed in Appendix 4.

## Appendix 1.1. Understanding supporting PAN requirements for determining leachate levels by a Hydrogeological Assessment.

The following information about the requirements of the supporting PANs issued prior to the PC PAN is designed to assist you, the notice holder, in understanding how to comply with these PANs.

**Requirement 3.1. By <insert date> you must supply to the Authority a hydrogeological assessment (HA) report for the premises in accordance with Hydrogeological assessment (groundwater quality) guidelines (EPA Publication 668)), which includes but is not limited to:**

- a) **measurements of the level of leachate within each cell of the landfill and the groundwater elevations in the surrounding strata;**
- b) **In Schedule 1 of the HA report, the maximum levels of leachate to be maintained within each cell of the landfill which minimises the impacts on groundwater and allows effective management of landfill gas;**
- c) **In Schedule 1 of the HA report, if required, the timeframe within which the maximum leachate level(s) will be achieved in each cell with annual drawdown targets.**
- d) **all leachate levels must be reported in metres Australian Height Datum;**
- e) **commitment to manage leachate levels at 300mm above the lowest point of the drainage layer in cells which are engineered to the standards set in the most recent version of the Best Practice Environment Management, Siting, Design, Operation and Rehabilitation of Landfills (EPA Publication 788).**
- f) **Schedule 1 of the HA report must be in the format shown in the most recent version of the Closed Landfill Guidelines (EPA Publication 1490).**

Leachate levels to be maintained in cells that are not engineered or are engineered to standards that do not meet the most recent version of the Landfill BPEM are required to be assessed against the risk posed to groundwater and the effective management of landfill gas.

The leachate levels to be maintained in each cell are to be determined by undertaking a HA. The HA is undertaken by first producing a robust conceptual model of the site which includes, but is not limited to, wastes deposited, leachate composition, leachate depth, site engineering, hydrogeological setting, groundwater quality, groundwater beneficial uses and the potential for their realisation. The conceptual model is used to undertake a groundwater risk assessment on the landfill, known as a HA. The risk assessment can be undertaken with numerical models and the aid of computer based models. Guidelines on completing a HA can be found in *Hydrogeological Assessment (Groundwater Quality) guidelines* (EPA Publication 668). The UK Environment Agency guidance document LFTGN 01 *Hydrogeological Risk Assessments for Landfills* is also likely to be useful.

The current and future gas extraction needs of the site must be considered. This means that leachate levels should be managed to prevent or minimise pollution of groundwater and allow effective management of landfill gas. When leachate levels are too high the slotted sections of landfill gas wells become flooded, preventing effective extraction. This flooding often means that the gas extraction system is run at excessively high vacuum which draws the leachate into the gas extraction pipework, reducing its capacity. This typically results in landfill gas migration via the sub-surface geology or landfill surface.

Under requirement 3.1, notice holders must find out what the current leachate levels are in each cell of the landfill site. If the infrastructure to do this is not present, it will need to be installed. Notice holders then need to gather the relevant site information to undertake the HA (see above) and identify the appropriate leachate level to be maintained in each cell that meets requirement 3.1b. If leachate levels in any cell exceed those to be maintained as identified under the HA, a timeframe by which the leachate levels will be drawn down must be nominated. Landfill cells that have been engineered to the specifications in the most recent version of the Landfill BPEM do not require a HA. Leachate levels in these cells are to be maintained at 300mm above the lowest point of the drainage layer (see requirement 3.1e) but the 300mm leachate level for these cells must be put into Schedule 1 of the HA expressed as mAHD. Requirement 3.1e will be removed from the supporting PAN when it is not required, that is, where no cells engineered to standards in the most recent version of the Landfill BPEM have been constructed at the site.

Under requirement 3.1f, all leachate levels determined under the HA are to be stated in Schedule 1 of the HA report. If drawdown of leachate is required, the drawdown timeframes must also be stated in Schedule 1. Schedule 1 of the HA report must be in the format shown in Appendix 6 of these guidelines. The PC PAN will require compliance with Schedule 1 of the HA report. Once leachate drawdown is achieved, the HA should be updated and the HA report amended to remove the drawdown timeframes. The requirement to maintain the specified leachate levels is to remain in the HA report and all future iterations of the report. A review and re-verification of the HA is to be undertaken at each environmental audit. This review may yield changes to the leachate drawdown timeframes in Schedule 1 if situations occur which are not reasonably foreseeable. As the HA and each subsequent review is verified by an environmental auditor, any changes to the drawdown timeframes are covered by this verification.

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For some sites it may not be practicable to install leachate wells and manage leachate to a level that minimises impacts on groundwater. An example of such a site would be a shallow (<5m waste depth) un-engineered landfill. In such cases the HA should recommend that other leachate management strategies are used, such as:

- improvements to the landfill cap to reduce surface water infiltration and leachate generation
- groundwater diversion where groundwater is the major contributor to leachate generation
- consideration of leachate contaminant biodegradation and attenuation properties of the vadose zone (if present) and aquifer
- ex-situ management techniques such as groundwater interception and extraction.

Any recommended leachate management strategies which do not involve extraction of leachate from the waste mass must be validated by the HA conclusions.

Notice holders must agree a date with EPA by which the HA will be completed, verified by an environmental auditor and submitted to EPA. This should be agreed prior to formal issuing of the supporting PAN. However, should agreement not be reached EPA will determine a reasonable timeframe for completion and verification of the HA.

***Requirement 3.2. The HA report referred to in requirement 3.1 must be verified by an environmental auditor appointed pursuant to the EP Act to confirm:***

- a) that the maximum leachate levels determined under the HA do not pose an unacceptable risk to the groundwater environment and allow for effective management of landfill gas; and***
- b) that where leachate level(s) in any cell exceed the maximum level determined under the HA, that the timeframe for achieving the maximum leachate level(s) in these cells appropriately takes into account the significance of the risks to the environment***

Once the HA report has been completed, incorporating leachate levels to be maintained and drawdown timeframes (if required), it must be verified by an environmental auditor in accordance with this requirement. Where an environmental auditor disagrees with any of the leachate levels determined under the HA or the drawdown timeframes, the auditor should make recommendations on what level(s) and timeframe(s) they consider appropriate and why. The auditor's verification or recommendations are to be submitted to EPA with the HA report.

## Appendix 1.2. Understanding Landfill PC PAN requirements

The following information about the standard PC PAN requirements for landfills is designed to assist you (the notice holder) in understanding and managing your landfill in the rehabilitation and aftercare phases.

**LC1. You must not accept any wastes at the premises.**

Notice holders must not accept any wastes for disposal or storage at the premises. Clean fill may be accepted for the purposes of remediating or rehabilitating the capping or landform. Any clean fill used for this purpose must have been sampled in accordance with *Soil Sampling* (EPA Publication IWRG702), tested in accordance with *Sampling and Analysis of Waters, Wastewaters, Soils and Wastes* (EPA Publication IWRG701) and compared to soil hazard categorisation thresholds in *Soil Hazard Categorisation and Management* (EPA Publication IWRG621).

Or

**LC1. You must not accept any wastes for landfilling at the premises.**

This requirement will be used where notice holders run an appropriately approved waste management facility at or on the closed landfill. An example of such a facility is a transfer station or recycling process.

**LC2. You must control all sources of offensive odours at the premises such that they are not discharged beyond the boundaries of the premises.**

Notice holders must prevent odours offensive to the senses of humans from being discharged beyond the boundaries of the premises. The boundaries of the premises are shown within your notice. This is a required outcome of the Landfill BPEM. Further guidance on preventing and managing odours can be found in the most recent version of *Licence Management guidelines* (EPA Publication 1322).

**LC3. You must install and maintain controls such that contaminated water or leachate is not discharged beyond the boundaries of the premises.**

Any water contaminated by anything originating within the premises boundary must not be allowed to be discharged beyond the boundaries of the premises. The boundaries of the premises are shown within your notice.

Leachate levels must be maintained in accordance with the leachate management requirement(s) of the notice.

Any contamination of surface waters from surface storage or treatment of leachate will be regarded as a non-compliance with this requirement. Any surface breakouts of leachate that discharge beyond the boundaries of the premises will also be regarded as a non-compliance with this requirement. Surface breakouts of leachate typically occur due to perched leachate levels within the waste mass or excessive leachate depths. Breakouts can be controlled by managing removal of daily or intermediate cover material during waste placement and controlling leachate levels in the site through extraction. Discharges of leachate to sewer under a trade waste agreement by direct discharge or tanker are not considered non-compliances with this requirement.

**LC4. You must control all sources of dust such that it is not discharged beyond the boundaries of the premises.**

Notice holders must prevent nuisance dust from being discharged beyond the boundaries of the premises. The boundaries of the premises are shown within your notice. This is a required outcome of the Landfill BPEM. Further guidance on preventing and managing nuisance dust can be found in *Licence Management guidelines* (EPA Publication 1322). Activities on site that are likely to generate dust must be anticipated and mitigating measures must be taken to ensure that nuisance dust does not discharge beyond the boundaries of the premises. Leachate is not to be used as a dust suppressant, only un-contaminated surface/stormwater may be used.

**LC5. You must not burn waste at the premises.**

No burning of waste can take place at the premises. This includes waste burned anywhere within the premises boundary and sub-surface fires in the waste mass. This requirement does not apply to combustion of landfill gas in a flare or engine for the purposes of complying with requirement LC8 (see below).

**LC6. You must control all sources of litter that it is not deposited beyond the boundaries of the premises.**

Notice holders must prevent litter from being discharged beyond the boundaries of the premises. The boundaries of the premises are shown within your notice. This is a required outcome of the Landfill BPEM. Further guidance on preventing and managing litter can be found in the most recent version of *Licence Management guidelines* (EPA Publication 1322), under waste containment.

All cells should be sufficiently capped to prevent litter being discharged beyond the boundaries of the premises. Where cells are awaiting construction of a final cap, an intermediate cover layer consisting of no less than 500mm of compacted clay should be put in place. The aftercare management plan should require regular cap inspection to identify areas needing attention to effectively contain waste.

**LC7. You must provide EPA with a financial assurance satisfactory to the EPA, and maintain such assurance (including any part of such assurance) so that it can be claimed on, utilised or realised as and when required.**

Note: PC PANs issued prior to July 2017 contain the following requirement: LC7. *You must maintain a financial assurance calculated in accordance with the EPA Method.*



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Financial assurance is a financial mechanism that assists in reducing the risk that the State will incur cleanup costs in the event that the notice holder defaults on its obligations. The amount a notice holder is required to provide in a financial assurance is based on the activities occurring at the premises and the quantity and type of wastes disposed of in the landfill.

Financial assurance is calculated in accordance with *Calculation of financial assurance for landfills, Prescribed Industrial Waste management (PIW) and container washing* (EPA Publication 1596). *Types of Financial Assurance* (EPA Publication 1595) describes the types of financial assurance that may be accepted by EPA. Financial assurances must be kept up to date and maintained in line with the EPA guidelines, particularly following any changes to the activities at a site.

To show compliance with this requirement, as a minimum:

- You must have a current financial assurance in place that matches the amount and type of financial assurance approved by the Authority in writing.

or

- If you do not yet have a financial assurance in place AND EPA has requested you to submit a financial assurance proposal to determine the amount and type of financial assurance, you must have submitted the financial assurance proposal by the date specified in correspondence from EPA.

Additional things to consider:

- If your financial assurance is a Guarantee by Deed Poll, you must also maintain an ongoing surveillance arrangement by a credit ratings agency.
- If your financial assurance is a security over land, you must arrange a valuation of the secured land by the Valuer-General in consultation with EPA every two years.
- If your financial assurance includes an insurance policy you must maintain a certificate of currency for the insurance policy.
- If you are a public entity operating a landfill and are using financial provisioning as financial assurance, your financial statements must comply with the relevant accounting and financial reporting standards relating to accounting for landfill liabilities. If EPA has requested a calculation of landfill closure, rehabilitation and aftercare costs, you must submit the requested calculation. The Local Government Victoria guideline "Accounting for Landfills" sets out principles-based guidance to assist councils to comply with the accounting standard and financial reporting requirements applicable to the costs of landfilling.
- If your financial assurance is an accumulating fund you must make the required deposits as set out in the corresponding fund governance document.
- Notice holders that do not have a financial assurance in place and who have not received a request by EPA to submit a financial assurance proposal to determine the amount and type of financial assurance must declare that they are not compliant with this requirement in their annual statement – requirement LC13.

**LC8. You must take all practicable measures to prevent emissions of landfill gas from exceeding the action levels specified in Table 6.4 of the most recent version of the Best Practice Environmental Management Guidelines, Siting, Design, Operation and Rehabilitation of Landfills (EPA Publication 788).**

Notice holders must prevent emissions of landfill gas from exceeding the action levels specified in Table 6.4 of the Landfill BPEM. All practicable measures are required to be taken to meet these action levels. Where a landfill has an existing gas extraction system, its function should be maintained during the rehabilitation and aftercare phase to meet the Landfill BPEM action levels. Typically, the gas extraction system is progressively decommissioned as gas yields decrease over time. Progressive decommissioning should be supported by gas forecasting validated by gas quality and flow data from the site. Critically, any decommissioning of the gas extraction system must not cause emissions of landfill gas to exceed the gas action levels in the Landfill BPEM.

Where a landfill gas extraction system is not installed, a landfill gas risk assessment and, if needed, a pumping trial should be undertaken to determine the need for such a system and used to inform its design, if it is required. The final system may be active or passive and may constitute combustion of landfill gas in an engine to produce electricity, combustion of landfill gas in a flare or oxidation of methane to CO<sub>2</sub>, H<sub>2</sub>O and heat by microbes in the capping layer. Guidance on which is appropriate can only be determined by an appropriately detailed on-site investigation. Guidance on which management technology is appropriate for a range of gas yields is contained within the Landfill BPEM. In all cases the notice holder must demonstrate that the chosen management technique is sufficient to maintain compliance with this notice requirement.

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**LC9.** NOTE: There are three potential requirements for regulating leachate levels, LC9 LC9.1, LC9.2. Which are used depends on the outcome of the HA AND the design of the cells at the landfill.

**LC9.** You must extract leachate from the landfill such that it does not exceed the level specified for each cell in Schedule 1 of the Hydrogeological Assessment Report <ref: xxxx>

and/or

**LC9.1.** By the dates specified in Schedule 1 of the Hydrogeological Assessment Report <ref: xxxx>, you must extract leachate from the cells such that it does not exceed the levels specified for each cell.

Under a supporting PAN issued prior to the PC PAN, notice holders will have been required to undertake a HA to determine the maximum leachate level to be maintained in each cell of the landfill. These leachate levels are shown in Schedule 1 of the HA report and must be managed at or below the maximum level to prevent or minimise pollution of groundwater and allow effective management of landfill gas (see Appendix 1.1). LC9 is used to ensure that the maximum leachate levels determined under the HA are not exceeded.

If the leachate levels across all or some of the cells at the site are non-compliant with the maximum leachate levels determined under the HA, requirement LC9.1 requires that the leachate drawdown timeframe in Schedule 1 of the HA is met.

If the site has a combination of cells which are compliant with the leachate levels determined under the HA and cells which are non-compliant, both LC9 and LC9.1 will be used in the PC PAN.

In cells engineered to the standards in the most recent version of the Landfill BPEM, a leachate depth of 300mm from the lowest point of the drainage layer is required to be maintained but will be expressed as metres Australian height datum (mAHD) in the Schedule 1 of the HA. For example, if the base of the drainage layer in a cell is 10.5m AHD, the leachate compliance level of 300mm depth would be expressed as 10.8m AHD.

In cells which are not engineered to the standards in the most recent version of the Landfill BPEM, the leachate level to be maintained is determined under the HA against the objectives of protecting groundwater and allowing extraction of landfill gas. The leachate levels to be maintained are expressed as metres Australian height datum (mAHD) in the tables. mAHD is used to measure leachate to allow the level to be determined relative to the lowest point of the liner (known from construction surveys) or groundwater elevations, as long as the top of the leachate sump is regularly surveyed in mAHD.

**LC9.2.** You must extract leachate from cells <insert cell identification> such that it does not exceed 300mm above the lowest point of the drainage layer.

This requirement will only be used for landfill sites where all cells have been engineered to the standards in the most recent version of the Landfill BPEM and therefore no hydrogeological assessment is to be undertaken for leachate management.

**LC10** You must comply with the Landfill Rehabilitation Plan <ref: XXXX>

Under a supporting PAN issued prior to the PC PAN, notice holders will have been required to produce a landfill rehabilitation plan with time bound milestones for rehabilitation of the landfill, including landfill cap construction or remediation of existing capping or both (see Appendix 1). You must implement the rehabilitation plan by meeting each of the time bound milestones.

**LC11.** You must comply with the Aftercare Management Plan <ref: XXXX>

Requirement LC11 requires notice holders to manage their landfill in accordance with their aftercare management plan. The initial production of the aftercare management plan is required by a supporting PAN.

**LC12.** You must engage an environmental auditor to conduct environmental audits in accordance with section 53V of the Environment Protection Act 1970 at the frequency specified in the verified monitoring program.

Notice holders must engage an environmental auditor appointed pursuant to the Act to conduct the environmental audits at the frequency specified in the verified monitoring program, based on the risk assessment undertaken on the site.

An integral part of the environmental monitoring of landfill rehabilitation and aftercare is the engagement of an environmental auditor to independently assess compliance with the notice requirements and verify the completeness of the risk assessment and monitoring program on an ongoing basis. The notice holder is responsible for engaging the auditor to conduct the audits.

The required frequency of the audits will have been initially specified in the monitoring program prepared by the notice holder and verified by an environmental auditor. As part of the audit process, the auditor will review the monitoring program and recommend a frequency for subsequent audits. This frequency must reflect the environmental risks presented by the landfill as determined by assessment of the results of the monitoring program. The ongoing audit cycle is shown in Figure 4.

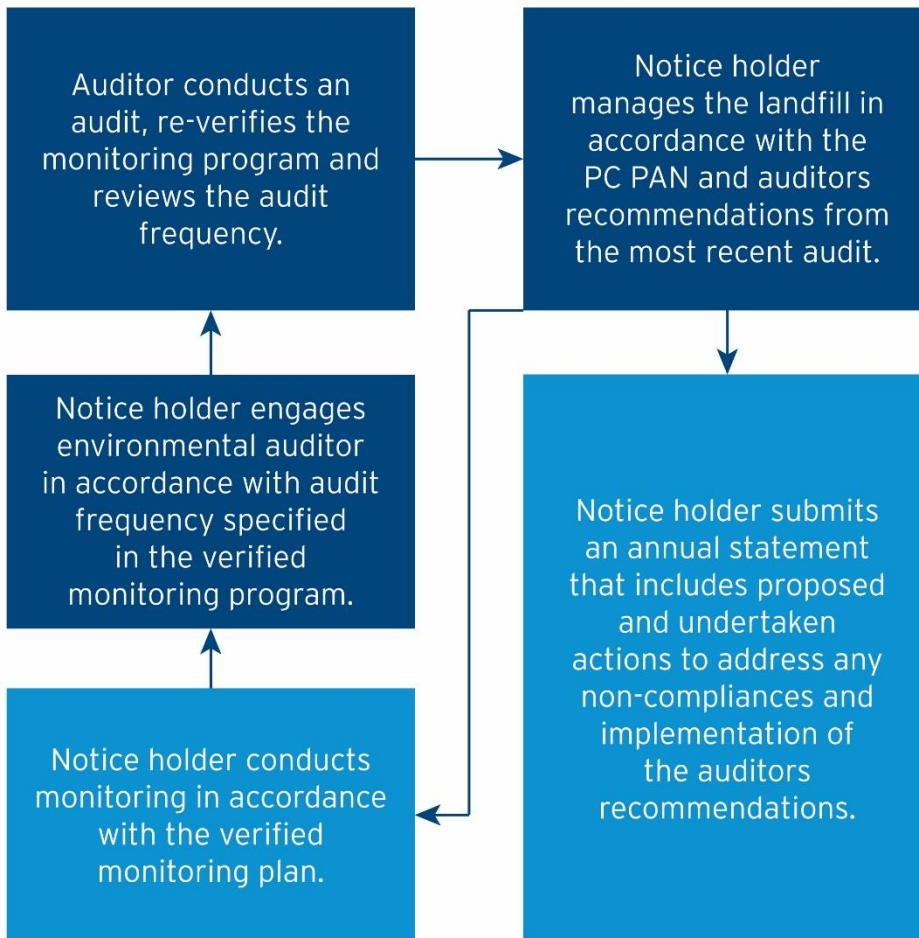
Where a landfill has an existing environmental auditor verified environmental monitoring and auditing program developed during the operational phase of the landfill, this should continue to be followed. The next audit should update the risk assessment and monitoring/audit program for the closed phase of landfill management (see Figure 2).

Where a landfill does not have an environmental auditor verified environmental monitoring program, a risk assessment of the closed landfill will need to be undertaken and used to prepare the environmental monitoring program. This program must subsequently be verified by an environmental auditor (see Figure 3).

A list of environmental auditors is available on EPA's website.

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Figure 4: Ongoing environmental audit cycle.



The audit program must be conducted by an EPA appointed environmental auditor in accordance with section 53V of the *Environment Protection Act 1970*.

## Scope

Appendix 5 specifies the required scope of each audit.

The audits must examine all elements of the environment that may be subject to significant impacts from former landfill operations and the current rehabilitation and aftercare management. It must include assessment of landfill gas and groundwater. The significant impacts should include those identified by the completed risk assessment for the rehabilitation and aftercare management phase of the landfill. They may be supplemented by impacts identified by a risk assessment conducted by the environmental auditor.

Each audit must include a review of the completeness of the site risk assessment (landfill rehabilitation and aftercare) and verification of the environmental monitoring program.

EPA approval of the audit scope is not required, provided the audit scope is consistent with that specified in Appendix 5 and the environmental auditor has a documented, detailed audit plan. EPA does not require submission of a courtesy copy of the audit scope.

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## Audit report

All findings of the audit must be detailed in an environmental audit report prepared by the environmental auditor, in accordance with *Preparation of environmental audit reports on risk to the environment* (EPA Publication 952).

The audit report must include a section that provides comment on the completeness and conclusions of the risk assessment, and verification of the adequacy of the monitoring program. Where necessary, the audit report should include recommendations for modification of the monitoring program.

The audit report must also include a recommendation and provide justification for the frequency of subsequent environmental audits. This provides a feedback loop between the environmental monitoring and environmental audit programs.

Audit recommendations, notice holder response and progress made will be reported as part of the annual statement under requirement LC13.

**LC13. By 31st March each year you must supply to the Authority an annual statement for the previous calendar year on your compliance with, or progress toward compliance with, each requirement of this notice.**

The annual statement under this requirement must include a statement of compliance with each notice requirement; and a summary of the results of environmental monitoring carried out in accordance with your Auditor verified Environmental Monitoring program. The annual statement should provide sufficient detail to justify to EPA compliance with each notice requirement. Where notice holders are non-compliant, it must be explained why, what action is being taken to become compliant and how long this will take. The statement should provide evidence of compliance or progress towards compliance where necessary. For example, if you state you are compliant with leachate levels required under LC9, you should provide all of the leachate level monitoring data for the year demonstrating this. The statement must be signed by a senior officer in the notice holder's organisation, ideally the CEO, and must be submitted to EPA via email to [contact@epa.vic.gov.au](mailto:contact@epa.vic.gov.au).

**LC13.1. You must retain all documents and monitoring records used for the preparation of the annual statement for a period of at least 7 years.**

EPA may require information from these documents for verifying the annual statement. Notice holders are required to retain them for a period of seven years to allow for this. The documents are not required to be held on site but must be readily accessible to an EPA authorised officer upon request.

**LC14. You must immediately notify EPA of non-compliance with any requirement of this notice.**

Where a non-compliance with this notice has caused or has the potential to cause pollution or an environmental hazard, the notice holder must immediately notify EPA on becoming aware of the non-compliance. Immediately means as soon as is practicable. Where a non-compliance with this notice has not caused or does not have the potential to cause pollution or an environmental hazard, the notice holder must notify EPA within 24 hours of becoming aware of the non-compliance.

To notify EPA you must call the 24-hour Pollution Hotline, 1300 EPA VIC (1300 372 842) with:

- your notice number
- site details
- notice requirement breached
- details of the incident and scale of issue
- name and number of a contact person onsite.

You will be required by EPA to complete an incident report describing the root cause and corrective measures taken.

## Appendix 2: Landfill gas risk assessment

### Introduction

The landfill gas risk assessment process described below is adapted from the risk assessment and gas generation and composition assessment procedure described in the UK Environment Agency publication LFTGN 03. A risk assessment based only on air dispersion modelling is not appropriate for a landfill gas risk assessment, as this does not consider sub-surface migration pathways.

The risk assessment approach, summarised below, involves:

- development of a conceptual model of the landfill and its surroundings
- hazard identification and risk screening
- quantitative risk assessment.

### Conceptual model

A conceptual model for the landfill and surrounding environment should be prepared with regard to landfill gas generation and management. The model should include information on:

- the environmental setting of the landfill, including all receptors
- the pathways to receptors, including emission points for landfill gases and combustion products
- the nature of the waste
- landfill gas production forecasting and validation with on-site data. Where necessary (for example in the absence of robust data to inform a forecasting model) a landfill gas pumping trial should be undertaken. Advice on how to conduct a pumping trial should be sought from EPA or a specialist contractor.
- action levels to be met (BPEM Table 6.4)
- landfill gas perimeter bore monitoring
- landfill gas surface emissions monitoring
- the design of the landfill gas management system
- operational management and control measures to be implemented
- a hydrogeological cross-section.

The form and content of the conceptual model should be selected to reflect the scale and complexity of the site and be suitable for use in the risk assessment. Consideration should also be given to the potential requirements of the environmental auditor, who will be examining the landfill gas risk assessment as part of the environmental audit program.

### Hazard identification and risk screening

The objective of the hazard identification and risk screening stage is to consider the information contained in the conceptual model to determine:

- the scale of risk — based on the landfill gas forecasting or pumping trial, the landfill gas monitoring results, the site design and the landfill gas management system
- the sensitivity of the receptors — their number, type and location
- the pathways to the receptors — for example, direct release to the atmosphere, sub-surface migration, indirect release to the atmosphere or direct release of combustion products
- prioritisation of receptors and impact assessment.

### Quantitative risk assessment

The risk assessment should use the output from the hazard identification and screening to evaluate the risk to each receptor. The objective of the risk assessment is to determine if the landfill gas management and monitoring at the landfill site is sufficient to:

- enable completion of a representative quantitative landfill gas risk assessment
- mitigate any risks identified to receptors
- where the management and monitoring of landfill gas is not sufficient to enable the completion of a representative landfill gas risk assessment, the environmental audit which follows the risk assessment or risk assessment review should make recommendations to enable a representative landfill gas risk assessment to be undertaken.
- where the management and monitoring of landfill gas is not sufficient to mitigate risks identified to receptors, to recommend what action needs to be taken. These recommendations should be included in the environmental audit which follows the risk assessment or risk assessment review.

## Appendix 3: Parameters that should be included in an environmental monitoring program

An environmental monitoring program for a landfill must be appropriate to the nature and extent of its potential environmental impacts. The monitoring program must be sufficient for the PC PAN holder to be able to demonstrate compliance with all notice requirements and applicable legislation.

Consideration should be given to the types of waste that are deposited in the landfill, its chemical characteristics and the geological and hydrogeological context of the landfill. Development of a conceptual model is essential in this process.

Landfills can have impacts on various segments of the environment. These impacts might include:

- groundwater contamination
- surface water contamination
- landfill gas migration (vertical and lateral in the sub-surface geology)
- odour emissions
- dust emissions
- litter and waste emissions
- noise emissions.

The monitoring program should produce data on groundwater quality (up-hydraulic gradient and down-hydraulic gradient in all aquifers at risk from the landfill), surface water quality, leachate levels, leachate composition (for HA), landfill gas concentrations in the sub-surface geology at the site perimeter, surface emissions of landfill gas, landfill gas presence in buildings on site, landfill gas presence in sub-surface services at risk, volatile organic compound (VOC), destruction efficiency of landfill gas flares (measured by flare temperature and retention time), air quality (dust and odour) and noise levels.

The monitoring program should assess both the emissions from the landfill site and the impact on the receiving environment.

Parameters that need to be considered when developing a monitoring program should include:

- analytes (organic and inorganic indicators)
- physico-chemical indicators (pH, temperature, dissolved oxygen, electrical conductivity, visible dust, litter, odour etc)
- method detection limits for the analytes
- groundwater and leachate standing water levels
- acceptance limits and action trigger levels for each parameter
- landfill gas action levels in Table 6.4 of the Landfill BPEM
- results of the landfill gas risk assessment (see Appendix 2)
- infrastructure required for monitoring
- location of monitoring or sampling points
- design of the monitoring points
- equipment required for monitoring
- training of personnel undertaking the monitoring
- frequency of monitoring
- monitoring procedures to be followed, including sample storage and transport requirements
- other triggers for monitoring (for example, appropriate meteorological conditions for surface emissions monitoring)
- analysis of monitoring results
- trending of monitoring results as data is built up
- relevant EPA guidelines.

## Appendix 4: Scope of Environmental Auditor verification of an Environmental Monitoring Program

The purpose of this appendix is to provide additional support to an environmental auditor undertaking an assessment of a landfill environmental monitoring program for the purpose of verification in accordance with PC PAN requirement LC12 and supporting PAN requirement 3.7.

### Assessment objective

The objective of the monitoring program assessment is to verify that the monitoring program is sufficient for the notice holder to:

- determine compliance with the notice requirements
- monitor and evaluate the management of risks to the environment from the aftercare management of the site
- specify an environmental audit frequency that reflects the overall environmental risk presented by the landfill
- enable the environmental audit cycle to determine when the site no longer poses a risk of pollution of the environment or an environmental hazard.

### Assessment scope

The assessment will consider and make comment on all aspects of the site risk assessment and environmental monitoring program as it relates to the site and its impact on the environment.

This may include assessment of sampling infrastructure, sampling methods and protocols, laboratory analysis QA/QC program or any other matter deemed appropriate by the environmental auditor to meet the objective of verifying the notice holder's monitoring program.

### Conducting the assessment

The assessment should be conducted in a manner deemed appropriate by the environmental auditor and may include assessment of:

- monitoring programs, objectives, scope (temporal and spatial), roles and responsibilities, and delivery mechanisms
- the site risk assessment and identified potential impacts
- wastes accepted and likely contaminants
- sampling and testing methods, protocols, parameters and frequencies
- incorporation of applicable state environment protection policy (SEPP) parameters, EPA guidelines etc.
- appropriateness of the analytical parameters to determine the presence and magnitude of the monitored environmental impacts
- sampling infrastructure and sampling locations
- appropriateness of the QA/QC program
- suitability of the monitoring program to clearly specify required monitoring and the delivery of the required monitoring
- adequacy of the document control system as a secure and accessible repository of monitoring information.

### Verification of the monitoring program

An environmental auditor will assess a notice holder's risk assessment and monitoring program to verify that the program is sufficient to enable the notice holder and EPA to determine compliance with the PC PAN. This verification process is based on the auditor's opinion and having regard to the notice requirements and other relevant policies or documents published by EPA (or guidelines, codes of practice etc. of other relevant bodies).

Where an auditor is unable to verify the monitoring program, the auditor must notify the notice holder in writing, providing the reasons and forward a copy to EPA. The notice holder must advise EPA immediately of the action that will be taken to implement any recommendations made by the auditor.

Written verification of a monitoring program is to be included in the environmental audit report and each subsequent audit report.

## Appendix 5: Scope for audits of aftercare management

Aftercare management audits must follow the method specified in *Preparation of environmental audit reports on risk to the environment* (EPA Publication 952).

In order to streamline the landfill auditing process, audits of aftercare management, using the scope specified below, may be conducted without prior approval by EPA. In addition, EPA does not require submission of a courtesy copy of the audit scope.

### Audit objective

The objective of the audit is to identify and, where possible, quantify the risk of any possible harm or detriment to a segment of the environment caused by the aftercare management of the landfill. The audit must include a review of the completeness of the site risk assessment and re-verification of the monitoring program.

### Audit scope

#### Activity to be audited

The activity to be audited is aftercare management of a closed landfill.

#### Component of the activity to be considered

The audit will assess all aspects of landfill aftercare. This includes operation of the landfill gas management system, the leachate collection and treatment system, surface water control and collection, and cap inspection and repair. The audit may also consider the content of the aftercare management plan.

In addition, the audit will consider and make comment on the risk assessment, environmental monitoring program and rehabilitation of landfill cells.

The auditor must provide comment on the ability of the monitoring program to generate sufficient information to enable compliance with the PC PAN requirements to be determined.

#### Segment of the environment to be considered

The segment of the environment to be considered during the audit will be the area of land on which the landfill is located.

It includes the emissions to the air at the site, sub-surface geology, groundwater beneath the site, any surface water on or near the site or linked hydrogeologically to the site, and the environment surrounding the landfill to which the activity may pose a risk.

#### Elements of the environment to be considered

The environmental auditor will consider groundwater, surface water, land, emissions of landfill gas to the air, landfill gas presence in the sub-surface geology, sub-surface services and buildings on the site. Other elements may be included in the audit at the discretion of the environmental auditor.

#### Beneficial uses to be considered

Beneficial uses to be considered during the audit will be those specified in the state environment protection policies to be identified by the environmental auditor.

#### Risk assessment to be conducted

The environmental auditor will conduct a quantitative or semi-quantitative assessment of the risks associated with the landfill as an integral part of the section 53V environmental audit. The method of risk assessment would be determined by the environmental auditor.

#### Period of time over which the audit is to be conducted

The audit would consider rehabilitation and aftercare management at the landfill for the period of time since the last audit, in addition to relevant past operations.

#### Exclusions from the scope of the audit

The environmental auditor will identify any exclusions from the environmental audit.

### Audit criteria

Audit criteria may be drawn from the following policies, documents and guidelines:

- *Environment Protection Act 1970*
- relevant state environment protection policies
- the PC PAN issued for the premises
- EPA-approved technical specifications and CQA plans
- landfill environmental monitoring program



# Closed Landfill Guidelines

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- Best Practice Environmental Management; *Siting, Design, Operation and Rehabilitation of Landfills* (EPA Publication 788)
- Landfill Gas (Fugitive Emissions) Monitoring Guidelines
- Waste Management Policy (Siting, Design and Management of Landfills)
- any other publications deemed relevant by the environmental auditor.

## Conducting the audit

The audit would be conducted in a manner deemed appropriate by the environmental auditor and would typically include the steps of:

- familiarisation with the landfill rehabilitation and aftercare management
- inspection of the landfill area
- detailed assessment of the aftercare management
- assessment of the risk to beneficial uses of the segments concerned
- review of the risk assessment
- examination and verification of the environmental monitoring program
- review of the most recent monitoring data and comparison to previously collected monitoring data over a statistically significant timescale
- preparation of an environmental audit report.

## Environmental audit report

The environmental audit report for this audit would generally be consistent with section 15 of *Preparation of environmental audit reports on risk to the environment* (EPA Publication 952) and therefore section 53V of the *Environment Protection Act 1970*.

The location within the report of the various audit findings, including those listed below, must be identified in a table provided in the report.

The items listed below for inclusion in the table are a minimum requirement. The environmental auditor may elect to include additional items in the table.

The report must clearly state the environmental auditor's opinion on the risks posed by the aftercare management of the landfill to the beneficial uses of the nominated segments of the environment.

In addition, the report must include comment on whether the risks to the environment associated with aftercare management are being adequately identified, managed and monitored.

The audit report must have an EPA CARMS reference number clearly displayed on the report cover. A copy of each audit report must be lodged with EPA.

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**Table 1: Location of audit findings within the aftercare management audit report**

Audit findings	Location in audit report (chapter or section)
Risk of landfill aftercare management to the beneficial uses identified by the environmental auditor	
Comment on the risk assessments (aftercare management and landfill gas) prepared by the landfill operator	
Comment on the completeness of the environmental monitoring program, including comment on the audit frequency	
Assessment of the adequacy of the monitoring program to determine compliance with the PC PAN requirements	
Assessment of the implementation of the monitoring program	
Interpretation of the monitoring results	
Verification of the environmental monitoring program	
Recommendations	
Implementation of the recommendations made in previous audit reports	

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## Appendix 6: Format for Schedule 1 of the Hydrogeological Assessment Report

### Schedule 1

Based on the hydrogeological assessment, leachate levels must be maintained at or below the maximum level shown for each cell in Table 2.

**Table 2: Maximum leachate level**

Cell number/identification	Maximum Leachate level (mAHD)
Cell xx	xx
Cell xx	xx
Cell xx	xx

Where the leachate level for any cell is above the maximum leachate levels determined in the HA, the leachate level must be drawn down to the interim target level shown for each cell in Table 3. Leachate level drawdown must be completed by the dates shown for each cell in Table 3.

**Table 3: Leachate drawdown targets**

Cell number/identification	Interim target leachate level (mAOD)	Drawdown completed by
Cell xx	xx	DD-MM-YYYY
	xx	DD-MM-YYYY
	xx	DD-MM-YYYY
Cell xx	xx	DD-MM-YYYY
	xx	DD-MM-YYYY
	xx	DD-MM-YYYY
Cell xx	xx	DD-MM-YYYY
	xx	DD-MM-YYYY
	xx	DD-MM-YYYY

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## Appendix 7: Format for Environmental Auditor declaration of verification of a Hydrogeological Assessment.

I, \_\_\_\_\_ of \_\_\_\_\_ ,  
an environmental auditor (appointed pursuant to the *Environment Protection Act 1970*), having:

1. been requested by \_\_\_\_\_ (the notice holder)  
to verify the hydrogeological assessment report \_\_\_\_\_ (reference of the report)

to ensure that the maximum leachate levels shown in Schedule 1 of the report do not pose an unacceptable risk to groundwater and allow for effective management of landfill gas; and

ensure that where the leachate level in any cell exceeds the maximum level determined under the hydrogeological assessment, that the timeframe for achieving the maximum leachate level(s) in these cells appropriately takes into account the significance of the risks to the environment.

2. having had regard to, amongst other things (list relevant policies):

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and the following relevant documents (these may be documents published by the Authority or other relevant bodies such as guidelines, codes of practice etc.):

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3. considered the following documents:

(i) the hydrogeological assessment; (ii) the most recent version of the *Best Practice Environmental Management; Siting, Design, Operation and Rehabilitation of Landfills* (EPA Publication 788); (iii) the most recent version of the *Closed Landfill Guidelines* (EPA Publication 1490); *Hydrogeological Assessment (Groundwater Quality) Guidelines* (EPA Publication 668).

HEREBY DECLARE that I am of the opinion that:

i) Schedule 1 of the hydrogeological assessment report \_\_\_\_\_ (reference of the report)

contains adequate information of suitable quality to meet the Authority's requirements (that is, that the maximum leachate levels shown in Schedule 1 of the report do not pose an unacceptable risk to groundwater and allow for effective management of landfill gas; and that where the leachate level in any cell exceeds the maximum level determined under the hydrogeological assessment, that the timeframe for achieving the maximum leachate level(s) in these cells appropriately takes into account the significance of the risks to the environment).

Dated:

Signed:

Environmental Auditor (Appointed pursuant to the *Environment Protection Act 1970*)