Landfilling of waste

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Disclaimer

This English version of the handbook is not an official translation. The Swedish EPA has provided the translation as a service but takes no legal responsibility for the translation or for any consequences arising from its use.

The translation was done in 2011-2012, within the cooperation project “Capacity building for implementation of the EU-landfill directive” (IP 1012) between the Swedish Environmental Protection Agency and the Ministry of Environment and Physical Planning in Macedonia.

To make the English version more useful to the reader, we have chosen to add some references to regulations, guidelines, etc. that was issued after the Swedish version was published.

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SWEDISH ENVIRONMENTAL PROTECTION AGENCY
Preface

This handbook with general guidelines is aimed at providing guidance to authorities responsible for licensing and inspection, as well as the operators, on the application of the Swedish Landfill Ordinance. The handbook has been circulated for comments from the representatives of inspection authorities and the landfill operators.


Each section of this handbook begins with excerpts from relevant legislation, marked with a §. The text that consists of guidelines can be found under the headings listed as General Guidelines. The remaining text in the handbook should be considered as guidance. The handbook includes mathematical equations that describe the nature's behaviour. However, the reality is often more complex than the formulas can express.

The Director of the Environmental Protection Agency's Implementation and Enforcement Department has decided to publish this handbook. The General Guidelines has been adopted by the Environmental Protection Agency's Director-General.

Stockholm, May 2004

Kerstin Cederlöf
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3 § of the Ordinance (2001:512) on the Landfill of Waste

3 §
This Ordinance uses terms with the following meaning.

... Liquid Waste: All liquid waste, including waste water but excluding sludge.

... General guidelines
Liquid waste should comprise the kinds of waste that emit liquid. If waste is to be considered non-liquid, the fluid in the material should be bound into the material itself.

Sludge should be referred to as a mixture of solid material and water resulting from the separation of different types of solutions in a process.

There is no given definition for liquid waste. The dry matter content (DM) is not suitable to use as a general parameter as different wastes are not liquid at the same dry matter content.

There are many different opinions on how to determine what a liquid waste is. An example of a method is the model that the U.S. Environmental Protection Agency advocates. According to the U.S. EPA, liquid waste is a waste containing “free liquids” as defined in Method 9095A – Paint Filter Liquid Test. This method is used to determine the presence of free liquids in a representative sample of waste. In this method a certain amount of waste is placed in a paint filter that is placed in a funnel in an experimental plant. If any part of the waste passes and drops through the filter during a five-minute period, it is considered that the waste contains free liquids. The test shall be performed at temperatures between 0-25°C. The filter must have a mesh number 60 +/- 5%.

The term sludge is not defined in the Swedish Landfill Ordinance, but there is a definition in a European standard (European Standard EN 12832:1999 Characterisation of Sludge, Utilisation and disposal of sludge - Vocabulary). Here, sludge is defined as a “Mixture of water and solids separated from various types of water, as a result of natural or artificial processes”.

8 § of the Ordinance (2001:512) on the Landfill of Waste

8 §
The following waste may not be disposed of:

1. Liquid waste;
2. ..... 
3. ..... 
4. ..... 
5. Whole used tires that are not bicycle tires and that have a diameter less than 1400 millimetres.

---

1 The test is published in a US EPA publication, Test methods for evaluating solid wastes, Physical/ Chemical methods EPA Pub. No SW-846
**Liquid waste**

There are several reasons why liquid wastes must not be disposed of in a landfill. Liquid waste fills the landfill’s void spaces, and can eventually clog the drainage layers and drainage canals in the landfills. Also, liquid waste has a low retention strength, which may cause stability problems in the landfill. Sludge is excluded from the definition of liquid waste, which means that the sludge is not prohibited by 8 § - 1 p. For sludges containing organic matter, however, the prohibition in the 10 § of the Landfill Ordinance is valid, which states that organic waste must not be landfilled as of 2005, unless otherwise stated in the Swedish EPA’s regulations on the handling of combustible and organic waste. This means that as of 2005, the exemption applies only for inorganic sludge.

**Disposal of tires**

According to the paragraph, it is allowed to deposit the used tires that have a diameter of more than 1 400 millimetres and bike tires. Tires, however, constitute combustible waste and according to the 9 § it is prohibited to deposit combustible waste from January 1st, 2002. In addition, the Ordinance (1994:1236) on producer’s responsibility for tires is in effect as well.

**9 § of the Ordinance (2001:512) on the Landfill of Waste**

9 §

Sorted combustible waste may not be landfilled.

The Swedish EPA has regulated the handling of combustible waste in the regulations and general guidelines on management of combustible waste and organic waste (NFS 2004:4).

**10 § of the Ordinance (2001:512) on the Landfill of Waste**

10 §

Organic waste may not be landfilled.

The Swedish EPA has the authoritsation, according to the 13 §, to issue exceptions and exemptions from the ban. The Swedish EPA issued these regulations and guidelines in spring 2004 (the Environmental Protection Agency’s regulations and general guidelines on management of combustible waste and organic waste (NFS 2004:4).
14 § of the Ordinance (2001:512) on the Landfill of Waste

14 §

Only waste that has been treated may be landfilled. By treatment is meant the use of physical, thermal, chemical or biological methods, including sorting, which changes the properties of the waste so that its volume or the hazardousness is reduced, its handling is facilitated or the recycling process is enhanced.

The requirement for treatment does not apply to inert waste where the treatment is not technically feasible or to other waste where the treatment does not lead to decreased negative effects on human health or the environment.

General guidelines

The treatment method selected should contribute to fulfilling the objectives of the Landfill Ordinance. Waste separation at the source or at a recycling facility should in some cases be considered as adequate treatment.

Treatment

The purpose of allowing only treated waste to be disposed is to give the landfill the safest design possible, given the risks of the waste that is landfilled. When the waste is destined to go to a landfill, it is assumed that all the alternative waste treatment options have been considered, and none was judged as appropriate/possible to use.

In addition to the requirement on treatment, of the 14 § in the Ordinance, there are also requirements to separate combustible waste at the source, in the Environmental Protection Agency’s regulations and general guidelines on management of combustible waste and organic waste (NFS 2004:4). Some waste types may need to be treated in a special way to be suitable for landfilling. Ashes, for example, may require treatment to reduce dust emissions or to prevent leaching of pollutants from the ashes. Also, it may be necessary to separate the liquid from sludge.

The term treatment in the 14 § includes all treatment methods; from biological treatment to sorting. Therefore the question arises what treatment(s) should be considered adequate to allow landfilling, and how far the requirement for treatment should be applied. There is no obvious answer to that question. It is clear, however, that neither the Landfill Ordinance nor the Landfill Directive supports requirements that waste always must be treated as far as possible. Furthermore, it is reasonable to assume that it is adequate to demand such treatment that will contribute to meeting the objectives of the Ordinance.

Requirements on treatment can also be made with support of the General Rules of Consideration, in Chapter 2 of the Swedish Environmental Code. When applying the General Rules of Consideration, both the extent to which an action may prevent or limit damage or inconvenience and the costs that such a measure incurs must be considered (see Govt/prop. 1997/98: 45, Part 2, p. 24).
15 § of the Ordinance (2001:512) on the Landfill of Waste

15 §
The Environmental Protection Agency issues regulations on the conditions that waste must fulfill in order to be deposited in the different classes of landfills pursuant to Article 6 and Annex II of the Landfill Directive.

If the Environmental Protection Agency has not prescribed otherwise, only inert waste may be disposed of at landfills for inert waste and only household waste, non-hazardous waste and inert waste may be disposed of at landfills for non-hazardous waste.

Waste must not be diluted or mixed solely with the aim to meet the conditions for landfilling.

General guidelines
Mixing or dilution that takes place to ensure a safe landfilling should not be covered by the ban.

In 2004 the Swedish EPA issued regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10).

It is prohibited to dilute waste solely in order to obtain dilution of pollutants. Such a dilution could, for example, be done in order to enable the waste to be put on a lower class landfill than would otherwise be the case. However, for some types of wastes, mixing is an appropriate treatment, e.g. wastes with alkaline properties that are mixed with an acid for neutralization. Similarly, stabilizing by wetting of ash or mixing with cement or other stabilizers can lead to a safer landfilling.

16 § of the Ordinance (2001:512) on the Landfill of Waste

16 §
Before the waste is landfilled, the operator shall have acquired as much knowledge as possible about the waste composition, leachability, and its other properties and effects, in general and in the long term.

The operator shall verify that the waste may be disposed of at the landfill.

The purpose of this provision is that the operator shall be required to acquire knowledge about the environmental impact that the waste can cause. It is important to know the properties and characteristics of the waste in order to manage it in the best possible way.

In the Environmental Protection Agency’s regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10) there are detailed rules on what the operator must control and verify. Rules on this subject are also available in the Council Decision of the 19 December 2002 on criteria and procedures for the acceptance of waste at landfills (2003/33/EC) which was implemented in Sweden through the regulation mentioned (NFS 2004:10) in 2004.

Regulations on the operator's Self-monitoring can be found in the Environmental Code, Chapter 26, 19 § and in the Ordinance (1998:901) on operator self-monitoring and in the Environmental Protection Agency’s General Guidelines (NFS 2001:2) on self monitoring.
17 § of the Ordinance (2001:512) on the Landfill of Waste

17 §
The Environmental Protection Agency issues regulations on the actions that the operator must undertake when waste is accepted for landfilling in accordance with Article 11 of the Landfill Directive.

The Swedish EPA has issued regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10).

18 § of the Ordinance (2001:512) on the Landfill of Waste

18 §
A landfill must be located so that it does not pose a serious risk to the environment with regard to:

1. the distance from the landfill to urban areas, residential areas, recreational areas, agricultural areas, water bodies and waterways,
2. the presence of surface water, groundwater, coastal waters and protected nature areas,
3. the geological and hydrogeological conditions at and around the site,
4. the risk of flooding, settlements, landslides or avalanches on the site,
   And
5. The protection of nature and cultural heritage in and around the site.

General guidelines
The landfill should be placed in such a way that there is enough space for protection measures after landfill closure, such as protection of the downstream side of the landfill in accordance with the 21 §. The landfill should be localised in such a way that such protection can function passively in the long term. Accessibility and reparation should be considered when designing in the event that repairs or additional security measures must be undertaken in the future. Control measures in the landfill area should be considered in regard to the environmental impacts as well as the opportunities to undertake and control measures if the reference, background values or if the conditions of the permit are exceeded.

It is difficult to find locations for landfills: both general requirements on the location of environmentally hazardous activities in the Environmental Code, and the requirements of the Landfill Ordinance must be taken into account. Furthermore, attention must also be paid to local/municipal plans. By reserving land in the municipal plans, the siting of future landfills can be facilitated, and thus a long-term planning for a future need of landfills is achieved.

Site-specific conditions often influence what constitutes an appropriate location of a landfill. Examples of such conditions can be private and public wells for drinking water. The distance to built environment is an important aspect, e.g. to limit the effects of odour arising when handling waste. According to the general guidelines 1995:5 from the Swedish National Board of Housing, Building and Planning (Better place for work), the distances between the built environment and the waste facility should be 500 meters, but adaptation to local conditions is of great importance. Other important aspects to consider in order to reduce the risk of inconvenience are: predominant wind direction, type of housing in the area, and the nature of the intermediate zone (open, forested, planted or hilly area). The design of the landfill process, the size of the landfill, and what management practices are chosen also significantly
affect the formation and spreading of odours and other emissions. These aspects can vary widely depending on the conditions; a general safety distance can therefore not be set.

19 § of the Ordinance (2001:512) on the Landfill of Waste

19 §

A landfill shall be located so that all the leachate after the operational phase and not collected leachate during the operational phase passes through a geological barrier which meets the following requirements: the transport time for the leachate through the barrier must not be less than 200 years for landfills for hazardous waste, 50 years for landfills for non-hazardous waste and 1 year for landfills for inert waste.

If the natural conditions at the site do not result in that the requirements of the first paragraph are met with respect to a particular part of the leachate, supplement actions are needed to protect land and water by a geological barrier which meets the requirements of the 20 §, second subsection.

General guidelines

A geological barrier should function without active measures over a long period of time and should not require maintenance.

The transport time should be calculated from the point where the leachate leaves the downstream side of the landfill site to the point where the leachate reaches the groundwater or surface water which, in this context, are recipient waters. With regard to soil and groundwater, however, not all the land and all groundwater should be considered as recipient in these contexts. The recipient, in this context, means a groundwater, surface water or land area that must not be contaminated because of the need to protect human health, the environment in terms of living resources or ecosystems, or any other existing or foreseeable justified interest.

The extent of the barrier downstream the landfill edge should not normally exceed 300 metres. Depending on local conditions, however, this extent could be reduced or increased.

It should be ensured that the leachate will pass through the barrier with retention and degradation of pollutants and that the leachate is prevented from flowing on the surface and rapidly to the recipient. This should apply after that the active measures for emission reduction and control are no longer undertaken. Earthworks which may impair the geological barrier function should not be permitted as it may cause a break or short circuit of the flow through the barrier.

The time of the flow from the landfill to the recipient should be calculated by adding the flow times for the vertical flow in the unsaturated zone and the horizontal flow of the water saturated zone. The barrier layer composition (stratigraphy) should thus be identified with an indication of the hydraulic conductivity (“permeability”) in each aquifer.

The extent of the aquifer as well as the continuity should be reported. The transportation time should be calculated for the layers of the highest hydraulic conductivity or for the layers that combined gives the shortest flow time to the protected recipient.

In determining the hydraulic gradient (or gradients) in the calculations, this (these) should be based on documented water table measurements.
Principle design of the bottom structure

Calculation of flow time through the geological barrier
Flow time T through the barrier can be calculated as the sum of the vertical $t_v$ and the horizontal flow time $t_h$.

$T = t_v + t_h$

where, $t_v = 10 \cdot D_v \cdot n_e / k_v \cdot i_v$
and $t_h = D_h \cdot n_e / k_h \cdot i_h$

$t = \text{the total flow time (seconds)}$
$t_v = \text{the flow time of the vertical barrier under non water saturated conditions (s)}$
$t_h = \text{the flow time of the horizontal barrier under water saturated conditions (s)}$
$D_v, D_h = \text{the flow distance vertically and horizontally on the respective barrier part (meters)}$
$n_{ev}, n_{eh} = \text{the effective porosity of the respective barrier part (dimensionless)}$
$k_v, k_h = \text{the hydraulic conductivity in the respective barrier part (meters per second)}$
$i_v, i_h = \text{the hydraulic gradient over the respective barrier part (dimensionless)}$

The function of the geological barrier
The geological barrier is a long-term protection against the spreading of contaminants from a landfill. The leachate from the landfill site shall be filtered through the underlying soil layer so that the contaminants are retained and/or degraded in these layers. In the longer perspective the geological barrier, together with the final cover, is the primary protection against the spreading of contaminants to the surroundings.
The Swedish geological conditions are different from those in central Europe and in Sweden aquifers are not connected in large areas, as often found in other parts of Europe. Sweden has smaller catchment areas, often smaller and more well-defined aquifers and relatively short distances to the surface water recipients. The Landfill Directive sets out specific requirements on the thickness and hydraulic conductivity. In the Swedish Landfill Ordinance, those requirements are expressed in the 19 § as a requirement on the transport time for the contaminants through the barrier. The transport time is seen as an indicator for retention and degradation of the pollutants. Factor 10 at vertical flow is used as a standard value, to take into account that the flow in the unsaturated zone above the water table is usually much slower than in an aquifer. If the transport time for the contaminants through the barrier is sufficiently long, the retention and degradation of contaminants in the barrier is considered to be sufficient.

![Diagram of geological barrier](image)

*Figure 2 The function and extent of the geological barrier*

**The extent of the geological barrier**

The Landfill Ordinance does not stipulate any exact limits for the size of the natural geological barrier. In order to maintain the intended function, ground works, constructions, etc. that may affect the flow and the flow time of the water, are not allowed within the area of the barrier. How much of the area that may be considered as part of the barrier, therefore depends on how much of the area that can be safeguarded from impacts from activities in the surroundings. One way of ensuring the function of the barrier even after the landfill is closed is to reserve land as a geological barrier through municipal spatial planning.

The size of the barrier as specified in the reference case (300 metres) is a generalization of what can often be described as a area, around the landfill, large enough to have the potential to meet the performance requirements and at the same time provide long term protection (for example, by reserving space for the geological barrier in the operational area of the landfill). There is no guarantee that 300 metres is adequate to meet the flow requirements in the regulation, but in each case, the question arises whether the geological and hydrogeological conditions below and in the vicinity of the landfill are such that the requirement for a natural geological barrier is fulfilled.
20 § of the Ordinance (2001:512) on the Landfill of Waste

20 §
If a landfill is not located so that the requirements of the 19 § are fulfilled, the landfill should be constructed on or provided with a geological barrier which fulfills the requirements in this paragraph.

Below the landfill and on the sides of the landfill where the leachate can contaminate the land or the water, the barrier shall be at least 0.5 meters thick and, in terms of permeability and thickness, provide protection that is at least equivalent to the effect of the following requirements:

<table>
<thead>
<tr>
<th>Landfill for</th>
<th>Permeability</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>hazardous waste</td>
<td>$&lt; 1.0 \times 10^{-9}$ m/s</td>
<td>$&gt; 5$ m</td>
</tr>
<tr>
<td>non-hazardous waste</td>
<td>$&lt; 1.0 \times 10^{-9}$ m/s</td>
<td>$&gt; 1$ m</td>
</tr>
<tr>
<td>inert waste</td>
<td>$&lt; 1.0 \times 10^{-7}$ m/s</td>
<td>$&gt; 1$ m</td>
</tr>
</tbody>
</table>

General guidelines
An artificial geological barrier should consist of one or multiple coherent layers. The barrier should be persistant in the long term, which means that even the materials in the layers should be persistent and have characteristics similar to those of a natural soil. The material should be tested to ensure that it has these characteristics and to ensure that the material is clean. The results of the samples should be possible to validate. When choosing the material, its persistency over time concerning thermal, chemical, biological and physical properties should be taken into account. When constructing an artificial geological barrier, the calculations should be done keeping in mind that a lateral water barrier will be needed.

The design of the bottom structure should be carefully planned and appropriate tests should be carried out in order to ensure that the performance corresponds to the requirements in the Ordinance.

Principle design of the bottom structure

*Figure 3 Principle design of the bottom structure*
Calculation of flow time

If the barrier consists of one layer of material, the vertical flow time in the barrier is calculated according to the following formula:

\[ t = 10 \frac{D \cdot n_e}{k \cdot i} \]

- \( D \) = the thickness of the barrier (meters)
- \( n_e \) = the effective porosity of the barrier (dimensionless)
- \( k \) = the hydraulic conductivity of the barrier material (meters per second)
- \( i \) = the hydraulic gradient over the the construction (dimensionless)

If the barrier consists of several layers of material, an equivalent hydraulic conductivity can be calculated with the formula:

\[
\frac{D}{k} = \frac{D_1}{k_1} + \frac{D_2}{k_2} + \ldots + \frac{D_n}{k_n}, \text{ where}
\]

- \( D \) = the thickness of the barrier (meters)
- \( k \) = the equivalent hydraulic conductivity for the whole barrier (meters per second)
- \( D_1-D_n \) = the thickness of the respective sub-layers (meters)
- \( k_1-k_n \) = the hydraulic conductivity of the respective sub-layers (meters per second)

In order to take into account the corresponding variation in porosity, an equivalent effective porosity can be calculated with the formula:

\[
\frac{n_e}{(D_1 + D_2 + \ldots + D_n)} = \frac{n_1 \cdot D_1 + n_2 \cdot D_2 + \ldots + n_n \cdot D_n}{(D_1 + D_2 + \ldots + D_n)}
\]

Natural or artificial geological barrier?

When locating a landfill questions can arise on whether a site that meets the requirements for a natural geological barrier (19 §) is preferable to a location that better fulfills other characteristics to be considered when making the choice on location. It is not possible to give a general recommendation on what is to be preferred. An overall assessment of the individual case must always be performed. What is the best option in an environment aspect - location based on the requirements in the 19 §, or construction of an artificial barrier according to the 20 § - will vary from case to case. Considering geological and hydrogeological aspects, a location that fulfills the requirements for a natural geological barrier may be preferable as it will give better conditions to avoid lateral water flows on the surface. A benefit of constructing an artificial geological barrier is that there will be better conditions to demonstrate that the functional requirement is fulfilled.
The design of the geological barrier

The geological barrier shall be persistent for a long period of time. This means that the materials chosen for an artificial geological barrier must fulfill this requirement and, in general, must have the characteristics as a geological barrier shall have according to the definition in the 3 § (soil or rock layers with properties that prevent, break down, retain or delay the transportation of substances and contaminants from a landfill to a recipient). For landfills for non-hazardous waste, a long period of time can imply several hundred years. Landfills for hazardous waste can pose a risk over a thousand years. As indicated in the 19 §, the purpose of the barrier is to filter the leachate and thus degrade, retain and delay contaminants. If a material with excessive permeability is chosen for the geological barrier, there is a risk that leachate will run off as a lateral water flow on the surface, instead of being filtered down through the barrier. Also, due to the requirements on the bottom barrier, according to the 22 §, the bottom structure will be tighter than the final cover of the landfill during a long time. It is therefore better to assume that a lateral barrier, constructed in accordance with the 21 §, probably will be required, when the landfill has a barrier according to the 20 §.

An example of material suitable to use in an artificial barrier is especially processed clay (bentonite), in combination with other geological materials such as sand or stone dust. It is important to ensure that the construction of the barrier will function as intended, and that the requirements of the Ordinance are fulfilled.

Quality assurance of the bottom structure during the construction phase can for example be accomplished by measuring the density of the material in the field after compaction. When density is measured, calibration is usually performed through permeability tests performed in a laboratory, where the permeability is determined as a function of the density. This can then be compared with the performed tests on permeability of the optimum degree of compaction and density of the material in the laboratory.

21 § of the Ordinance (2001:512) on the Landfill of Waste

21 §

If there is a risk that the leachate overflows or leaks by the side of the geological barrier that is required, according to the 19 and 20 §§, protection measures against contamination of soil and water shall be constructed in the direction of the leachate flow. The protection measures must result in that the leachate is collected and treated or does not contaminate soil or water to a greater extent than what follows from the requirements in the 19 and 20 §§.

General guidelines

The protection measures shall be dimensioned based on the characteristics of the leachate and the sensitivity of the surroundings. The protection measures shall consist of, for example, filters and/or reactive barriers which detain, delay or degrade the contaminants. The protection shall provide a long-term treatment and be in accordance with the requirements in the 19-20 §§ regarding the retention, delayment and degradation of contaminants. A material with porous and adsorptive properties shall be selected.

A site-specific environmental impact analysis covering environmentally harmful substances in the leachate shall be conducted in order to determine the criteria that the protection measures shall fulfill.

In order to establish the design of the protection measures, studies shall be performed during the operational phase. The protection measures shall be examined and their effect possible to demonstrate. The tests shall be made to such an extent that it is ensured that the discharge of contaminants from the leachate are prevented by the protection measures. The protection measures shall be functioning after the completion of the active protection measures.
During the construction phase of the landfill, an assessment shall always be performed on whether a protection measure in accordance with the 21 § will be needed in the future. Protection measures shall always be constructed in two cases. One case is when a natural geological barrier exists, but the flow section in the barrier is too small, i.e. the incoming water through the final cover of the landfill (the leakage per m² multiplied with the landfill surface) is larger than the flow capacity of the barrier. The second case is when there is a risk that the geological barrier, either alone or in combination with the bottom liner, is less permeable than the final cover of the landfill.

**Protection against contamination due to leakage on the surface**

After the operational phase/when the landfill is closed, there must be a passive protection against contamination due to leakage on the surface. The protection shall reduce the transport of contaminants that may occur through the surface leachate. It must function for a long time after active protection measures are no longer undertaken. The function of the geological barrier is to retain, delay and degrade contaminants. In order to achieve this, a certain flow time is required (the time requirement) and that the amount of leachate that is produced and not diverted in another way (the flow requirement), can be transported through the barrier. If the barrier does not have the flow capacity, the leachate will overflow and leak out from the side of the landfill. If the leachate cannot flow out from the landfill, the water pressure in the landfill can increase and thus create instability in the bottom-slope of the landfill. The bottom barrier, in combination with the geological barrier, will in many cases be less permeable than the final cover, which also leads to overflow. The requirements in the 21 § are intended to ensure that the leachate that overflows and streems out of the landfill can be managed of in an environmentally safe manner. Thus, the landfill site should be technically designed in such a way that the leachate can stream out of the landfill during an overflow. Measures to ensure this should be taken as early as in the planning process. It is often good to steer the overflow towards a certain point, or a certain section, on the downstream side of the landfill from where the leachate thereafter can be led to protection outside the landfill.

It is important that the protection has properties that retain, delay and degrade the contaminants in the overflow. As the protection shall constitute a filter, the permeability cannot be considered crucial. Which material the reactive barrier can consist of is determined by which contaminants that are present in the leachate. The filter material determines whether the contaminants will be adsorbed by the filter, if there is a precipitateation in the filter or if the contaminants are degraded or converted by the filter material.

The characteristics of the contaminants in the leachate determines the design of the protection. An analysis should be done to determine the properties and concentrations of contaminants present in the leachate and how they are transported to the recipient. If there is a particle bound pollutant in the leachate, it is appropriate to have a material in the protection which has a filtering effect. Other properties that should be analysed are whether the contaminants in the leachate occur in oxidizing or reducing environments. There may, for example, be a need to adjust the pH of the leachate in the protection. This could be done by e.g. adding crushed limestone, gypsum, or seashells. Currently, only a few protection measures of this kind have been constructed in Sweden. Most protections consist of peat or a mixture of peat material, sea shells and a mineral material such as sand. One way to develop, test and evaluate the protection is to (during use) divert a part of the leachate to an experimental filter, where the efficiency and capacity of the protection can be analysed.
22 § of the Ordinance (2001:512) on the Landfill of Waste

22 §
Landfills for hazardous waste and landfills for non-hazardous waste shall, during the operational phase, be equipped with a bottom sealing, a drainage layer that is at least 0.5 meters thick and a collection system for leachate. The sealing, the drainage layer and the collection system must be designed so that leachate does not leak by more than 5 litres per square meter and year from a hazardous waste landfill, and 50 litres per square meter and year from a landfill for non-hazardous waste.

Collected leachate shall be treated so that it can be discharged without being in conflict with current regulations on protection of human health and the environment or with the applicable conditions for the activity.

General guidelines

The bottom sealing

The bottom sealing must only be operational/functioning during the years when there is no final cover on the landfill, i.e. when leachate is generated through the provision of waste and rainfall.

It should be specified which layer or part of layer that compose the bottom sealing. Materials for the bottom sealing may for example consist of geomembranes of various kinds, natural clay or residues. If the barrier and the sealing layer consist of the same material (for example in case of thick clay layers), the proportion of the clay layer that constitutes the sealing layer should be specified.

When evaluating the hydraulic conductivity of the bottom sealing, one should take into account the errors that may arise during installation and that increase the conductivity, as well as changes over time caused by for example chemical/biological processes, ageing and ion exchange. The characteristics of the material or materials that are proposed as sealing layer should be tested and documented.

When calculating the flow rate of leakage through the bottom sealing, the hydraulic gradient should be motivated in each case and in light of the current circumstances, such as anticipated settlements in the landfill or in the soil under the landfill.

The installation of the bottom structure should be carefully planned and appropriate tests should be carried out to ensure that the performance corresponds to the requirements of the Ordinance.

The drainage layer

The drainage material of the bottom sealing should be durable over a long period of time and it should have a hydraulic conductivity of at least $1 \times 10^{-4}$ m / s at the overload that the landfill will be exerting.

Leachate treatment

The choice of treatment should be based on the particular leachate composition, its nature and volumes, etc. An analysis should thereafter be made through an assessment of the receiving water and the impact that the leachate can have on it. For treatment more should be required than a mere diversion of leachate for infiltration into the soil or into a wetland without a clear outlet.

The function of the bottom sealing

The function of the bottom sealing is to be dense enough to collect leachate during the operational phase, until the final cover of the landfill. Hence, the requirements on durability of the bottom sealing are not as high as for the geological barrier. Suitable materials are for example clays of various kinds and geomembranes, as well as some types of waste.

The leakage depends on the hydraulic conductivity (permeability) of the sealing material and the hydraulic gradient (“driving force”) that will prevail across the sealing layer.
Principle design of the bottom structure

![Diagram of bottom structure]

**Figure 4 Principle design of the bottom structure**

**Calculation of leakage**

The leakage through the bottom sealing can be calculated using the following formulas:

*The bottom sealing of a layer (geomembrane)*

The leakage can be calculated by using Darcy's law as:

\[ q = k \cdot i \]

where

- \( q \) = leakage rate (cubic meters of water per square meter of sealing layer surface and second)
- \( k \) = hydraulic conductivity (m/s)
- \( i \) = hydraulic gradient over the layer (dimensionless)

*Bottom sealing of multiple layers (geomembranes)*

If multiple membranes are used together and geomembranes of polymer materials does not occur, an equivalent hydraulic conductivity of the structure is calculated by using the formula:

\[ D/k = \frac{D_1}{k_1} + \frac{D_2}{k_2} + \ldots + \frac{D_n}{k_n}, \text{ where} \]

\( D = \) the thickness of the whole bottom sealing (meters)
\( k = \) the equivalent hydraulic conductivity of the whole bottom sealing (meters per second)
\( D_1 - D_n = \) the thickness of the respective sub-layers (meters)
\( k_1 - k_n = \) the hydraulic conductivity in the respective sub-layers (meters per second)

and the leakage is calculated by using the formula:

\[ q = k \cdot i, \text{ where} i = \text{the hydraulic gradient across the whole bottom sealing (dimensionless).} \]
**Bottom sealing with polymeric materials**

For the flow through the geomembrane of, for example polymeric materials, the formulas above do not apply as these membranes do not have the same hydraulically properties as porous materials. The calculation of the leakage may instead be based on the damages to the membrane. Unless otherwise is proven to be more correct, it can be assumed that there are four damages (holes) per hectare on the membrane, each with an area of \(1 \cdot 10^{-4} \text{ m}^2\).

The leakage rate through one hole of the geomembrane can be calculated according to the formula:

\[
q = 0.6 \cdot a \cdot (2 \cdot g \cdot h)^{0.5} \quad \text{(for drainage materials under the membrane)}
\]

\[
q = 1.15 \cdot i_{\text{avg}} \cdot a^{0.1} \cdot h^{0.9} \cdot K^{0.74} \quad \text{(when lack of contact with the adjacent “impermeable” layers)}
\]

\[
q = 0.21 \cdot i_{\text{avg}} \cdot a^{0.1} \cdot h^{0.9} \cdot K^{0.74} \quad \text{(when good contact with the adjacent “impermeable” layers)}
\]

\[q = \text{the flow rate through the hole (m}^3/\text{s)}\]
\[g = \text{the gravitational constant 9.81 (m/s}^2)\]
\[a = \text{the surface of the hole (m}^2)\]
\[h = \text{the water pressure over the hole (m)}\]
\[D = \text{the thickness of the adjacent layer (m)}\]
\[i_{\text{avg}} = \text{a dimensionless constant according to the nomogram below. If } h \text{ is less than } D \text{ then } i_{\text{avg}} = 1.\]

With “impermeable” layer in the formulas above is meant soil or other equivalent material that has a hydraulic conductivity that is less than \(1 \cdot 10^{-6} \text{ m/s}\).

When determining the constant \(i_{\text{avg}}\), the following nomogram can be used:

*Figure 5 Nomogram for determining the constant \(i_{\text{avg}}\) (Giroud et al 1994)*

In the General Guidelines, it is stated that the material in the bottom should be tested and the results documented. Such testing may, for example, include hydraulic conductivity, durability, content of contaminants and compaction properties of the material. The testing can have been carried out e.g. in laboratories or in the field. Quality assurance of the bottom sealing during the construction phase can for example be accomplished by measuring the density of the material in the field after compacting. When density is measured, it is usually calibrated to permeability tests performed on the materials in laboratory, where the permeability is determined as a function of the density. This can thereafter be compared to tests of permeability at optimum degree of compaction and density of the material in the laboratory.
23 § of the Ordinance (2001:512) on the Landfill of Waste

23 §
Landfills for hazardous waste and landfills for non-hazardous waste shall, through diversion and drainage, be protected from surface water and groundwater entering into the landfill.

General guidelines
Selection of measures for the diversion and drainage of groundwater or surface water should be based on hydrological and hydrogeological data and on water balance calculations. The measures used should have a reducing effect, which means that groundwater or surface water coming into contact with the waste and creating leachate should be avoided as much as possible. The measures should also prevent leachate from being mixed with surface water or groundwater before treatment unless there are special reasons for this. The design of the ditches and drainage solutions should be sustainable and therefor materials that remain stable over time should be selected. Furthermore, the protection should be of a passive nature and should not require maintenance.

How large the quantities of leachate generated at a landfill site are, is mainly dependent upon the efficiency of the final cover and the size of the possible leakage of surface water and groundwater into the landfill. The inflow of surface water and groundwater can affect the amount of leachate when the leaking water comes in contact with the waste and thus generates leachate. If there is not a sufficient barrier, the water from precipitation and the surrounding land will dilute the leachate and thereby increase the amount of leachate. Such dilution means a greater hydraulic load on the water treatment plant or the protection constructed for cleaning the leachate according to the 21 §. The hydraulic load is often a critical factor in the local treatment of the leachate, which is why the water balance calculations are of crucial importance.

A water balance calculation can be performed using the following formula:

\[ P + I_S + I_G + W = E + R + L_C + L_L + M \]

where

- \( P \) = Precipitation
- \( I_S \) = Surface water inflow
- \( I_G \) = Groundwater inflow
- \( W \) = Water that is supplied with the waste
- \( E \) = Evaporation
- \( R \) = Runoff
- \( L_C \) = Collected leachate
- \( L_L \) = Leakage of leachate
- \( M \) = Magazine change
The equation expresses the fact that all the water that goes into the landfill in various ways is either stored, evaporated or diverted, as surface runoff, collected leachate or a diffuse leakage of leachate.

Measures to divert ground and surface water cannot guarantee an absolute protection, hence some leakage must to be accepted. However, it is desirable to aim for protection that is as good as possible in order to not risk damage to the other protection measures in the landfill due to the leakage.

24 § of the Ordinance (2001:512) on the Landfill of Waste

24 §
A licensing authority may, in the individual case, grant exceptions or exemptions from the requirements in the 19-22 §§, if it can be done without risk of damage or inconvenience to human health or the environment.

General guidelines
The applicant should demonstrate through a properly substantiated basis that the exception or exemption will not result in any risk of damage or inconvenience. The application for exemption should consist of a detailed analysis of the environmental impact from an approved exemption, where a comparison should be made with the presence of the current protective measure.

The licensing authority should make a careful assessment in the light of the purpose of the Landfill Ordinance. The fact that the protective measures in 19-22 §§ are practically unreasonable to implement should not alone be the reason for the exemption or exception. In that case, the landfill should instead be closed. The mere risk of damage or inconvenience to human health or the environment should be sufficient for not allowing exemptions or exceptions. An exemption should be approved if other equivalent protection measures are applied that provides the same degree of protection as the protective measures regulated in the Ordinance.

The purpose of the Landfill Ordinance is, according to the 1 §, to prevent and reduce the negative effects that landfilling of waste can cause to human health and the environment. The requirements of the Landfill Ordinance implies a substantial rise in standard for landfills and will probably result in that many existing landfills will be closed and that new landfills might need to be constructed. One of the intermediate targets (target 6) of the National environmental quality objective “A Good Built Environment” that has been adopted by the Swedish Parliament, states that all landfills by 2008 shall have a uniform standard and fulfill the high environmental requirements according to the EU directive on landfilling of waste. Hence, all landfills in operation after 2008 must fulfill the requirements in the Landfill Ordinance. Landfills that cannot meet these more stringent requirements must be closed. Hence, the assessment of whether exceptions or exemptions should be granted should be made in light of the objectives of Ordinance and the National environmental quality objective “A Good Built Environment”. It should therefore be difficult to grant exceptions or exemptions merely based on practical or financial difficulties in fulfilling the protective measures stipulated in the Ordinance. The outcome of the assessment may result in the conclusion that an existing landfill site is unsuitable for further disposal of waste.

The Ordinance stipulates requirements that provide a certain level of protection. It is important to achieve that level of protection. An exception or exemption must not result in a lower level of protection and thereby cause increased risk of damage or inconvenience to human health or the environment. However, if alternative protection measure can be applied
that provides equivalent protection as what is stated in the Ordinance, such an exemption can be granted.

In a ruling from the Environmental Court of Appeal (Case No. M 4182 notified on the 18th of December 2003) where Telge Recycling AB applied for a permission for landfilling, the question on exemption from the requirement for bottom sealing according to the 22 § was, inter alia, assessed. The Environmental Court of Appeal made a thorough assessment of the conditions on whether to grant the exemption applied for, including the goal and the purpose of the Landfill Directive, and concluded that the possibility for exemption available under the 24 § of the Ordinance should obviously be seen as an exception and that it lies in its very nature that it must be applied restrictively so that the goals and the purpose of the Landfill Directive are achieved and its effectiveness are maintained. When the assessment of the case showed that the company had a system that corresponds to the requirements of the Ordinance, the Environmental Court of Appeal concluded that the exemption from the requirement on a bottom sealing may be made without risk of damage or inconvenience to human health or the environment, and without the landfill posing any potential risk to soil, groundwater or surface water.

25 § of the Ordinance (2001:512) on the Landfill of Waste

25 §

The operator shall ensure that landfill gas is collected from landfills that accepts biodegradable waste for disposal. The Environmental Protection Agency issues further regulations on the collection and management of landfill gas.

General guidelines

An assessment of whether measures for the management of landfill gas production is needed or not and the measures necessary for landfills containing organic waste should be based on a calculation of the estimated potential amount of methane gas produced in the landfill in question. The calculation shall be based on all biodegradable waste, incoming as well as already disposed of, and the quantity, type, age, gas potential and degradation rate of the waste should be considered. In order to verify the results, the theoretical evaluations should be supplemented by field investigations, e.g. pumping tests. An individual assessment based on the current conditions should always be made in order to determine whether gas collection shall be performed. As soon as the amount of waste and the gas production admits it, a landfill gas plant should be constructed. The landfill gas plant should be developed to take care of the produced gas in all parts of the landfill. The gas plant should be expanded in phases as the deposited waste volumes are increasing and it should be designed to have a high collection rate of produced methane. An assessment should be done regularly in order to see if there is a need for further expansion or improvement of the plant efficiency. The landfill gas plant should also be designed to have a high accessibility and the gas system should be designed so that the collected methane does not leak into the air. During the closure of a landfill, an assessment should be made if there is a need for landfill gas collection in the same way as for a continuous operation. It should always be considered if the gas drainage layer or the gas drainage pipes should be installed immediately during the final coverage. Landfills or landfill cells that have stopped accepting waste and have not been provided with the final cover should be provided with a methane oxidizing layer to take care of the gas and prevent the emission of methane, if the landfill has not been finally covered within five years. This should apply to all landfills, regardless of whether they have a gas collection system or not. The potential for methane oxidation in the material selected should be possible to show either through previously conducted tests or through own experiments. Landfills receiving organic waste have to collect landfill gas. If there is no gas, however, there should be no need to install a gas collection system. The methane oxidizing layer that is placed on the landfill while pending the final cover should not be regarded as landfilling if the thickness of the layer is below 0.5 m.
Whether it is necessary to collect gas is determined by calculations of the gas potential based on the quantity and content of the disposed waste. It is also important to consider during how long time that the waste has been added to landfill. Wastes that are likely to generate significant quantities of gas is waste, from households and industry, that contain large amounts of paper. Landfills that contain larger quantities of other biodegradable waste, such as fibre sludge, can also generate substantial quantities of gas.

Below are examples of how the need for gas collection can be assessed. The table is based on a normal landfill, where household waste is the dominant biodegradable waste with an addition of paper from industrial waste in an average amount. The table is based on the ideal cases where the same amount of waste is landfilled each year.

<table>
<thead>
<tr>
<th>Waste Years</th>
<th>1000 tonnes/year</th>
<th>3000 tonnes/year</th>
<th>5000 tonnes/year</th>
<th>10000 tonnes/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years</td>
<td>No need for gas collection</td>
<td>No need for gas collection</td>
<td>No need for gas collection</td>
<td>Research is needed</td>
</tr>
<tr>
<td>10 years</td>
<td>No need for gas collection</td>
<td>No need for gas collection</td>
<td>Research is needed</td>
<td>Gas collection</td>
</tr>
<tr>
<td>20 years</td>
<td>No need for gas collection</td>
<td>Research is needed</td>
<td>Research is needed</td>
<td>Gas collection</td>
</tr>
<tr>
<td>40 years</td>
<td>No need for gas collection</td>
<td>Research is needed</td>
<td>Gas collection</td>
<td>Gas collection</td>
</tr>
</tbody>
</table>

A general answer to when gas collection must be performed is impossible to give. The decision must be based on an individual, site-specific assessment. A major factor of uncertainty is the difficulty to estimate how much organic waste that has been disposed of at a landfill as the documentation of what has been landfilled is often inadequate.

The systems for gas collection were expanded during the 80’s and 90’s, and hence, many existing landfills have systems for gas collection already. However, it is important that the effectiveness of these systems is assessed. In many cases the system has been expanded for the sole purpose of using the gas, and consequently the system covers only a certain part of the landfill where the presence of gas is the highest. Also, it is not always the case that the expansion was done in pace with the amount of waste landfilled. It might therefore be necessary to revise and, if necessary, complement the existing system. During the expansion of a landfill, it is also important that the system for gas collection is expanded and that the system is adjusted to the new landfill design. A continuous expansion is desirable in order to avoid that any part of the landfill is without gas collection.

The existing landfill sites that will be closed (in accordance with the 38 §) are not subject to the requirement for the collection of landfill gas. In many cases, however, there may be a need for gas collection also for these landfills in order to reduce the greenhouse effect that the
methane gas causes, and in order to reduce the risk of damage to the final cover. The requirements for the collection of landfill gas from landfills that will be closed can then be made with support from the General Rules of Consideration in Chapter 2 of the Environmental Code. This can for example be relevant if the landfill has been accepting large amounts of organic waste.

If the gas production potential is large, a so-called methane-oxidizing cover layer can be used as a treatment technology for the reduction of greenhouse gases. A methane-oxidizing layer can consist of a common soil layer with good conditions for bacteria, which implies neutral pH, a certain humidity and the availability of nutrients. The need for a methane-oxidizing cover layer exists at all landfills where there is a potential for methane production. In order to achieve the intended effect, the layer must be of a certain thickness and quality but the thickness may not be larger than that oxygen can gain access to the layer.

The Swedish EPA has regulated the collection and disposal of landfill gas. See the 41 § in the Swedish EPA’s regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10).

It may also be important to note that there are regulations on the handling of flammable and explosive goods in the Law (1988:868) on the handling of flammable and explosive substances as well as The Explosive Inspectorate’s regulations and General Guidelines (SÄIFS 1996:8) on natural gas.

27 § of the Ordinance (2001:512) on the Landfill of Waste

27 §

Waste shall be landfilled in such a way that uneven settlements or landslide is avoided that can damage the cover layer or other protective measures.

General guidelines

In the assessment of the stability, the stability of the ground should also be taken into account in addition to the landfill stability. For this procedure, the factors that reduce the durability should be considered, e.g. a lower durability due to impact from the leachate. The landfill stability should be regarded to comprise the waste, but also certain protective measures, such as the stability of the final cover.

The relationship between the resisting and driving momentums/forces (the geotechnical safety factor) should be at least 1.5, calculated with a total stress analysis, or at least 1.35 calculated with a combined analysis in a detailed investigation.

The landfilling should take place in such a way that the differential settlement (millimetres per meter) are as small as possible, especially after that the protective measures (e.g. final cover) have been undertaken. Examples on actions to minimize the differences in settling is to homogenize the waste and to compact (pack) the waste.

The landfilling should take place in such a way that the need for a levelling and smoothing layer is reduced.

In the total stress analysis (or undrained analysis), only the undrained shear strength in the soil, the cover layer and the landfilled wastes are considered. However, during the combined analysis the pore water pressure in the soil and in the deposited masses shall also be taken into account. The undrained shear strength is the resistance to force that gives shear during water-saturated conditions or so-called prevented water departure².

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² Technical Terminology No. 59, Geotechnical Glossary 1975
For the construction of structures where there is a risk of a landslide, safety factors are often used as a measure of the stability of the construction. The safety factors listed above originate from the work of the Landslide Commission. The selection of the safety factors depends on the impact a landslide makes and also on how closely the ground has been examined i.e. whether a perspicuous, detailed or thorough investigation has been made. More information on landslide and instructions regarding landslide can be found in the Landslide Commission’s publications No 3: 95, 4:95, 5:95.3

How much the waste should be compacted depends on the characteristics of the waste and how the final cover will be designed. Some materials should be compacted more, i.e. it takes more time and more work to achieve a desired degree of compaction and stability, while other wastes are easy to compact and requires less work. The important thing is that the landfill achieves such a stability that the cover will be durable over time.

To landfill in such a way that the need for a levelling and smoothing layer is reduced, requires that the operator as early as in the operational phase, i.e. when the deposit of waste is in progress, keeps the final closure of the landfill in mind. If the operator deposit the waste so that a landfill with a dome-shaped appearance is obtained, i.e. a landfill which does not have too steep slopes and does not have a too flat top surface, the need for additional measures for the final landfill cover is reduced.

28 § of the Ordinance (2001:512) on the Landfill of Waste

28 §
The operator shall, during the operational phase ensure that:
1. uncontrolled access to the landfill is prevented;
2. gates are locked when the landfill is unattended,
   and
3. there is a system for control and access which is intended to detect and prevent illegal landfilling.

General guidelines
All roads that allow access to the site by vehicles should be closed by locked gates or a gate barrier. The barriers should be placed as far from the landfill as possible.

There is no general requirement on that landfills must be fenced, but it may be necessary in cases where there is a risk of illegal disposal. In order to reduce the risk of illegal disposal further, as well as to minimise the view in to the facility, it may be appropriate to put the fence and the enclosure at an ample distance from the landfill.

29 § of the Ordinance (2001:512) on the Landfill of Waste

29 §

The operator shall keep a register of the deposited quantity of waste, the waste characteristics, origin and delivery date, the waste producer's identity or, in the case of household waste being transported by the municipality, the identity of the transporter of the waste. The Register shall also specify in which part of the landfill the waste in question is placed. In the case of hazardous waste, the exact location of the waste in the landfill must be recorded. At the request of the Swedish Environmental Protection Agency, the operator shall make the information referred to in the first section available for the authority.

General guidelines

Compulsory registration of waste should be applied to all classes of landfills. For the hazardous waste, the waste location in the landfill should be specified by coordinates \((x, y, z)\) and for the non-hazardous waste it should be specified which cell the waste has been deposited in. Landfills for inert waste should not have to keep records of information on where in the landfill the waste is placed or on the waste properties. For landfills for inert waste it should be considered sufficient that the waste deliverer can document that the waste is inert and that there is an acceptance control on the site that confirms this.

The waste producer's identity should refer to the company generating the waste.

In order to adjust the treatment and disposal of the waste in the best manner and have as little environmental impact as possible, it is important to know what the waste contains. Which kind of waste that may be landfilled at which type of a landfill is determined by the Swedish EPA's regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10). It is the landfill owner's responsibility to ensure that such wastes is received that is encompassed within the permit and the applicable law. In order for the landfill owner to be able to determine whether the waste may be accepted or not, good knowledge is needed about the content and the source of the waste.

30 § of the Ordinance (2001:512) on the Landfill of Waste

30 §

During the active phase of the landfill, the operator shall measure the landfill structure, composition and settling behaviour as well as take samples and make measurements of the leachate, the groundwater, the surface water and the landfill gas.

The Swedish Environmental Protection Agency issues more detailed regulations on sampling and measurements as well as on such guideline values or limit values that are set out in section 4c in Appendix 3 to the Landfill Directive.

The Swedish EPA has issued regulations on sampling and measurements, see the regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10).
31 § of the Ordinance (2001:512) on the Landfill of Waste

31 §

The operator shall ensure that a landfill that is under closure is provided with final cover. The final cover shall be constructed so that the amount of leachate that passes through the cover does not exceed or is likely to exceed 5 litres per square meter and year for landfills for hazardous waste and 50 litres per square meter and year for landfills for non-hazardous waste.

A licensing authority may in the individual case, grant exceptions or exemptions from the requirements on permeability that are stated in the first section, if it can be done without risk for damage or inconvenience to human health or the environment.

General guidelines

The final cover of the landfill should be performed as soon as possible after the completed landfilling in order to reduce the formation of leachate. An individual assessment should always be done in order to determine the most appropriate time for the final cover. A plan for when and how the final cover will be done shall be made well in advance.

If the final cover is not performed until after a certain period, a temporary cover should be constructed up to that time in order to reduce the leakage of rainfall into the landfill.

The development of settlements in the landfill should be analyzed and evaluated before the work with the final cover starts. The calculation of the leakage through the sealing layer should be performed in accordance with the same principle as is stated in the 22 § regarding the bottom sealing.

Before the final cover is made considerations should be made on if and what measures shall be undertaken in order to reduce the effect of the differential settlements on the final cover. Calculations of stability (landslide) and projected deformation (settlements) in the final cover should be reported in the dimensioning of the final cover. Unless otherwise is shown to be more correct, the minimal slope of the sealing layer in the final cover should be 1:20 (V:H) and the maximum gradient of the final cover should be 1:3 (V:H).

During the dimensioning, all of the layers in the final cover should be reported along with their properties and what these properties mean in order for the final cover to meet the set criteria on permeability. Proposals should be reported on the control parameters that should be included in the performance and monitoring in order to ensure adequate properties of the materials.

During the selection of materials for the sealing layer, the long-term function should be considered. Factors that can change the properties of the materials over time should be considered separately. Examples on such factors are:

- differential settlement
- penetration of roots
- erosion (internal and external)
- ground frost
- physical impact of overload
- biological and chemical aging
- ion exchange
- dry cracks
- gas condensation.

When using wastes, for example from industrial processes, the waste should, through tests and documented results from full-scale experiments, show properties that meet and maintain established requirements on the permeability of the final cover and durability over time. The waste should also be properly examined in respect to pollution content and leachability. When used within the sealing layers in the landfill, the waste should fulfill the general criterias for the waste that may be accepted at the current landfill. When used for the protection and
drainage layers, biodegradable wastes should be stabilised in order to reduce the risks of settlements and leaching of nutrients.

The same requirements on characteristics should also apply for the use of virgin materials in the final cover. Materials in the final cover should not have a negative impact on the function of the cover and it should not cause such an effect on the water draining to or through the protective cover that it poses a risk of significant damage to human health or the environment. Biodegradable waste should not be used in the sealing layer. With stabilisation of biodegradable material should be meant composting for at least six months. For digested sludge, composting for at least three months should be considered sufficient as stabilisation. The compost should thereafter in all cases be stored for at least six months prior to any use. Other methods in which the corresponding stability is achieved are considered feasible as well. The proportion of wastes containing significant amounts of nutrients, metals or organic compounds should not exceed a total of 40 weight percent of the content of the protective layer. The thickness of the final cover should be determined by reference to the stress that the cover is considered to be exposed to (e.g. ground frost). The sealing layer should not be closer to the ground surface than 1.5 meters due to the risk of penetration of roots. An estimate should show that the drainage layer has the capacity to transport the water that reaches the surface. The plantation of plants should take place as soon as possible after the completion of the final cover. A landfill for inert waste should be provided with a layer of soil in which plantation of plants can be done. Exemptions should be granted if the operator, through a site-specific analysis of the environmental impact, can prove that the exemption does not risk to cause damage or inconvenience to human health or the environment. The construction of the final cover should be carefully planned and appropriate tests should be carried out in order to ensure that the performance is in compliance with the requirements in the Ordinance.

**Timing for the final cover**

It cannot be said in general what is the most appropriate time for the final cover but an individual assessment of the landfill must be made which takes into account the types of waste landfilled, how well the waste has been compacted and what is the best from an environmental point of view. The settlements in a landfill can be formed over a relatively long time. If the final cover is performed too early, there is a risk that the differential settlements of the waste can cause damage to the sealing layer.

If the final cover is not performed until after a long time, the settlements in the landfill will have decreased which probably means that the final cover will be more durable. Meanwhile, the more time that passes before the final cover takes place, the greater the leakage of gas and other pollutants from the landfill through the leachate will occur than would be the case if the final cover had been made directly. In order to determine when and how the final cover will be made, a plan may be helpful. As a basis for the plan, the characteristics of the landfill can be examined in terms of appearance, development of settlements and pollution leakage. The plan can also serve as a basis for getting knowledge on how much and what materials will be needed for the final cover and it can serve as a help to plan for the future material needs.

**Calculation of leakage through the final cover**

According to what is stated in the General Guidelines, the calculation of leakage through the final cover should be carried out according to the same principle as mentioned in the handbook text to the 22 §. For the final cover, there are also some cases where a reduction of the leakage through the final cover is made, as there is not a constant water pressure against the sealing layer, for example during the summer period. In order to ensure that such conditions prevail, such a reduction is verified, for example by measuring the water pressure.
Function and design of the final cover

If the bottom sealing is more dense than the top sealing and the landfill is sealed completely, there is a great risk that the level of the leachate in the landfill will rise and the stability of the landfill or of the landfill final cover will be compromised. This can be solved by building different constructions that creates a possibility for overflow at the foot of the slope.

Normally, the final cover consists of a sealing layer at the bottom, and on top of this a drainage layer and a protective layer are placed. The protective layer includes a vegetation layer.

The function of the drainage layer is to channel the water that penetrates through the protective layer and to reduce the water pressure on the sealing layer. It can also act as a digging protection if it reaches a certain thickness, that is if excavation on the landfill is done over time, by mistake or because of ignorance of the existence of the landfill, the drainage layer can act as a signal that something is constructed here and thus can prevent the sealing layer from damage. Usually, a levelling layer is also placed below as well as, where necessary, a layer for gas drainage. There is probably also a need for a durable layer for material separation between the layers mentioned in order for the structure to function in the long term.

The final cover of landfills often requires large amounts of materials for the construction of a levelling layer, terracing of slopes, sealing layer, drainage layer and protective layers. Hence, the lack of suitable materials can be a limiting factor as to when and for how long the final cover can be performed. A plan for the final cover can be helpful in order to secure a future material balance.

Choice of materials

In the long term, natural materials are usually more advantageous to use than various types of artificial materials. It should be clear from the investigations made prior to the final cover how durable the materials in the protection and drainage layers are and if there is a need for maintenance, replacement or repair of any layer in the future. Waste can be included in the final cover if it fulfills the requirements on durability, etc.
Unacceptable emissions to surface water that is diverted above the sealing layer can be avoided by taking into consideration the amount of pollutants present in the waste to be used in the protection and drainage layers.

One way to reduce the risk of leachate formation and leakage of pollutants is to stabilise the biodegradable waste that is planned be included in the protective layer. Examples of biodegradable waste are: forestry waste, food waste, garden waste and various types of sludge from wastewater treatment. During stabilisation, a large part of the organic material is degraded, at the same time as the water content decreases and the water-holding capacity increases. The humus formation also results in that nutrients and metals are bound more firmly to organic matter and particles, which reduces the leaching of potential contaminants. This means that the risk of significant gas and leachate emissions as well as the settlements of the stabilised waste is reduced in the subsequent use.

The proportion of different types of waste that is suitable to use in the protection and vegetation layers is partly depending on the possible environmental impacts as well as the benefits that can be achieved. So far there is only limited experience of what proportions that can be justified in different cases. Positive effects like reduced leachate formation and increased methane oxidation can be achieved through mixing in for example composted waste. There are also potential negative effects such as leakage of unwanted substances in the longer term with the blending of certain types of waste. Given that these effects have not yet been evaluated on a larger scale, there is at the moment a reason, based on the Precautionary Principle of the Environmental Code, not to mix more than 40 weight percent of wastes containing significant amounts of nutrients, metals or organic pollutants. Examples of such wastes are sludge from municipal sewage treatment, bio- and chemical sludge from the forest industries, green liquor sludge, food waste, garden waste, ashes from waste incineration and certain types of ash from combustion of bio fuel and certain types of foundry sand. As the experience and knowledge increase, there is a reason to reconsider this upper level.

The function of the drainage layer is to divert water from rainfall and to reduce the water pressure against the sealing layer. It can consist of sand, gravel or crushed rock.

Waste can be advantageously used for the leveling layer, provided that it has properties that favors the levelling, for example, masses of coarse grain such as sand or larger grain fraction and provided that the waste does not affect the underlying waste or overlying sealing layer in a negative way. It is an advantage if the levelling layer is evenly distributed. The appropriate thickness needs to be determined on a case by case basis. One factor to consider is, however, if the layer is thicker than necessary. Then, there is a risk that the layer should not be considered as a part of the final cover, but as landfilling of waste.

The function of the sealing layer is to prevent rainfall from entering into the waste. The sealing layer can be composed of mineral materials such as clays and bentonite mixed stone dust. Also, geomembranes in combination with mineral materials can be used in so-called composite layers as well as suitable wastes with dense and durable properties. The sealing layer has a great environmental importance as it prevents leakage of contaminants in the long term. Today it is not supported by evidence that it is possible to ensure the durability of the sealing layer if it contains biodegradable materials. Research is being conducted on the suitability of using ash and sludge as a sealing layer. While awaiting better evidence from the research, there is therefore a reason to avoid such materials in the sealing layer and thus avoid adverse environmental impact through the use of the materials. Aerobic conditions in the surface of the sealing layer can arise as an effect of an effective drainage layer. Such
conditions may partly result in some degradation of biodegradable materials in the sealing layer.

The task of the protective layer is to protect the sealing layer from ground frost, dehydration, penetration of roots, erosion and other impacts. Moraine, suitable and clean excavated soil and treated contaminated soil are examples of waste and materials that may be included in the protective layer. In the upper part of the protection layer, the vegetation layer, certain organic materials such as for example topsoil and sludge can be mixed in to provide good conditions for vegetation.

The completion of the final cover

According to the 32 § of the Landfill Ordinance, a landfill is finally closed first after that the final cover has been inspected by the inspection authority and the authority has approved it. In order to facilitate the approval, it is an advantage to document the completion of the final cover.

One way to ensure that the final cover meets the requirements of the Ordinance is to carefully assure the quality of the design, materials and to document the performed work.

33 § of the Ordinance (2001:512) on the Landfill of Waste

33 §

During the after care phase of the landfill, the operator shall ensure that for at least 30 years, or longer as the inspection authority determines, the measures will be undertaken for the maintenance, monitoring and control that are necessary for the protection of human health and the environment.

Regulations on financial security are found in Chapter 16, 3 § of the Environmental Code.

The basis for the authority's decision can, for example, be based on an analysis of the environmental impact, containing an overall assessment of the consequences of stopping the ongoing activities.

Regulations on financial security for landfills can also be found in Chapter 15, 34 § of the Environmental Code.

38 § of the Ordinance (2001:512) on the Landfill of Waste

38 §

An operator shall submit a plan for conditioning or closure of the landfill to the inspection authority no later than July 1st 2002, if the landfill has a valid permit on July 16th 2001 or has not been closed before July 16th 2001. The conditioning plan shall specify the actions needed to, as soon as possible and no later than the end of 2008, fulfil the regulations in 7, 8, 11, 14-17 and 19-37 §§ as well as the regulations issued with support of the Ordinance.

The plan for closure shall specify the actions needed to close the landfill as soon as possible in accordance with the provisions of this Ordinance as well as a timetable for the closure.
General guidelines

A landfill should be considered to be closed before July 16th 2001 if the operator before that time has undertaken all measures for closure (e.g. compaction, final cover, etc.) that were required according to the permit or another decision issued before that date. If such measures were not required and no disposal occurred after July 15th 2001, the landfill should be considered as closed. If the inspection authority make the assessment that there is a need for additional measures for a closed landfill, such measures may be claimed with the support of Chapter 26 of the Environmental Code, but not by the Ordinance (2001:512) on the Landfill of Waste.

For landfills that will continue to accept waste after January 1st 2009, a conditioning plan should be submitted. For landfills that will be closed after July 16th 2001, and for those that will not accept waste after January 1st 2009, a closure plan should be submitted.

General information about the content of the plan

Conditioning and closure plans should start with a description of the current activities. This description should be the starting point for the assessment of what additional actions are needed at the landfill due to the requirements of the Ordinance and of the Environmental Protection Agency’s regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10). The current activities should be described in this way, regardless of the future that the landfill is planned to have. The description of the current activity should be adjusted according to the documents relating to the operation that have previously been submitted to the inspection authority or which are already available there, such as annual environmental reports and documents relating to permit and reporting matters. If the operator refers to such documents, this should be clearly stated in the plan, either through references to the documents that are available within the the authority or by adding the documents to the plan.

Conditioning and closure plans should include the following information about the current activities:

- administrative data, such as the name of the landfill, address, contact person, etc.
- valid permits, injunctions and other decisions for the operation,
- information on the types of waste that has been accepted and that are accepted as well as an indication of the total quantities of each type of waste that has been accepted at the plant (also see what is indicated below on the classification of landfills),
- information on the acceptance control,
- information on performed coverage, leachate management and gas collection,
- information on how the self-monitoring activities are performed, including control programmes, if any, that has been submitted to the inspection authority,
- description of the design and function of any existing bottom sealing and artificial geological barrier,
- description of the disturbance from activities that affect the environment e.g. noise and odour,
- information on how waste has been deposited at the landfill, for example how settlements are avoided,
- information on the security controls for prevention of unauthorised access to the landfill.

Conditioning and closure plans should include a description of the physical conditions within and around the landfill, which should at least include the following:

- information on the geological and hydrogeological conditions in the area, for example the existence of a natural geological barrier and the transport times for leachate through the barrier,
- information on the natural and cultural values within and around the facility;
- the distance from the landfill to the nearest residential and recreational areas, the surrounding recipient conditions.
Special notes on the content of the conditioning plans

The operator should specify the types of waste that has been accepted at the landfill and assess the types of waste that will be accepted at the landfill in the future, as well as indicate which landfill class that the landfill shall be assigned to according to the 7 § of the Ordinance. The inspection authority should give the operator the opportunity to supplement the plan with a revised assessment of the types of waste that will be accepted at the landfill, or what landfill class the landfill shall be assigned to, when there are criteria for what wastes may be deposited in the different classes of landfills.

The starting point for the assessments of what class a landfill should be assigned to depends primarily on the type of waste that has been disposed of at the landfill since the Ordinance entered into force on July 16th 2001. This means, for example, that a landfill which at some point after July 16th 2001 accepted waste, which according to the valid regulations was classified as hazardous waste, should be considered as a hazardous waste landfill. Furthermore, the types of waste that is planned to be accepted in the future should also be referred to as the basis for classification. If the operator, for example, intends to accept hazardous waste in the future, this should be stated in the plan. The assessment of which landfill class that a landfill should be assigned to should, however, also be possible to base on other circumstances in the individual case, depending on what is known about the waste that was previously deposited. For example, if it is known that before July 16th 2001 larger quantities of hazardous waste was deposited at a landfill, which after this date has accepted only non-hazardous or inert waste, the landfill should be classified as a hazardous waste landfill.

The operator's information on the measures needed in order to ensure that the landfill meets the requirements of the Landfill Ordinance and the Environmental Protection Agency’s regulations (NFS 2004:10) on landfilling of waste, should at least include the following:

- a description of the work to be undertaken,
- a description of the measures’ direct and indirect effects on the environment and human health,
- suggestions for the sampling, monitoring and other controls deemed necessary,
- information on the activity’s compatibility with the municipal waste management plan according to Chapter 15, 11 § of the Environmental Code.

The operator should state to what extent and on what basis the planned measures are subject to licensing or to a notification according to the 5 or 21 §§ of the Ordinance (1998:899) of Environmentally Hazardous Activities and Health Protection. If a proposed action is considered to require a permit or notification it should be sufficient that the plan’s description of the measure/action is relatively generalised. Instead, a more detailed report should be prepared on the measure and its impact on the environment in the application process for a permit or in the notification. The measures that are not subject to licensing or notifications should however be described in more detail in the plan.

An conditioning plan should not be regarded as a notification according to the 21 § of the Ordinance (1998:899) of Environmentally Hazardous Activities and Health Protection if it is not explicitly stated in the plan and if it in other respects fulfills the requirements of the 25 § in the same Ordinance.

A conditioning plan should also include a timetable indicating when the necessary measures can be performed.

Special notes on the content of the closure plans

In addition to what was mentioned above about the general content of the plans, a closure plan should include information about the types of waste that has been accepted at the landfill and an assessment of what landfill class that the landfill shall be assigned to according to the 7 § of the Ordinance. Furthermore, a closure plan should include an description of the measures needed to fulfill the requirements in the 26, 30, 31 and 33 §§ of the Ordinance, as well as the 42 and 43 §§ of the Environmental Protection Agency’s regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfiling of waste (NFS 2004:10). What was stated about the requirements on permit and notification regarding the conditioning plans should also apply to the closure plans.

Landfills that will be closed according to the 38 § of the Ordinance should be assigned a landfill class on the basis of how the types of waste accepted at the landfill were classified when they were accepted.
The time schedule should show the time required to undertake the various closure activities, how soon the landfill can be closed and the length of time that sampling, measurements, maintenance, monitoring and control of the landfill is considered to be necessary.

The transitional provisions of the Ordinance indicate which landfills are not covered by the requirements in the Ordinance. It is stated there that the Ordinance does not apply to landfills where the operator stopped adding waste to the landfill before July 16th 2001 and had undertaken the actions necessary for the closure.

It should be noted that the Ordinance does not contain any restrictions on the types of existing landfills (i.e. the landfills covered by valid permits on July 16th 2001 or those that had not been closed before that date) covered by the obligation to submit a conditioning plan or a closure plan. Hence, the requirement to submit a plan covers both the landfills that requires a permit, landfills that had the obligation for making a notification, and landfills that neither need or needed a permit or a notification, for example, because they were not large enough or they had exemptions under the previous regulations.

In the 5 § of the Waste Ordinance (2001:1063) it is stated what is meant by a landfill. In the transitional provision of the Ordinance (2001:513) amending the Ordinance of environmentally hazardous activities and health protection states that from January 1, 2009 permits are required for all landfills subject to the 38 § of the Landfill Ordinance. This means that operators of facilities that previously had an obligation to make a notification and therefore have no permits, must apply for and obtain permits by this date, if they want to continue receiving waste at the landfill after the end of 2008.

**Special notes on the content of the conditioning plans**

The Council of the European Union has, in the Council Decision (2003/33/EC) of the 19th December 2002, established criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC. The Swedish EPA has thereafter issued regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10), according to the 15 §, first section of the Ordinance.

**Special notes on the content of the closure plans**

Article 14 of the Landfill Directive states that existing landfills that will not continue to accept waste after the end of 2008 are not required to meet the conditions in the Directive on how landfills should be designed. Instead, the inspection authorities should make sure that those landfills will be closed as soon as possible, in accordance with what is stated in Articles 7 (g) and 13 of the Directive. These regulations essentially mean that the operator shall propose a plan for closure and after care and that control, sampling, monitoring and maintenance of the landfill shall be performed during the after care phase. In addition to this, the Directive does not have any requirements on the landfills that are to be closed.

In the Ordinance, it has been prescribed that a closure plan shall include a description of the measures needed in order to close the landfill in accordance with the regulations in the Ordinance. This should be interpreted in such a way that the landfills to be closed under the regulations in the 38-42 §§ of the Ordinance only need to fulfil the requirements of the Ordinance that are of importance for the closure and after care of landfills. Thus, the
regulations that are still in force are those dealing with the classification of the landfill (7 §), the general precautions required (26 §), the final cover and the control, sampling and monitoring during the after care phase (30-33 §§). In addition, the Swedish EPA’s regulations on landfilling of waste shall be fulfilled accordingly in applicable parts (9 and 10 §§). Hence, landfills that will be closed should not be forced to fulfill the other provisions in the Ordinance or the regulations. The Landfill Directive imposes an obligation for closure of those landfills that cannot meet the stringent requirements for disposal made in the Directive. Against this background, it can not be intended that landfills that are to be closed in accordance with the provisions of the 38-42 §§ of the Ordinance must fulfill the same requirements that landfills that will continue to accept waste after the end of 2008.

For the evaluation of which class of landfill a landfill should be assigned to, it should be justified to draw a distinction between the landfills that will continue to accept waste after the end of 2008 and those that will be closed in accordance with the provisions of the 38-42 §§ of the Ordinance.

For landfills that will continue to accept waste after the end of 2008, fairly extensive protective measures will be required, for example in the form of a geological barrier and bottom sealing and eventually also the final cover. Thus, it will be possible to achieve an adequate level of protection of human health and the environment by taking into consideration the waste deposited at the landfill after July 16th 2001 and the waste that will be deposited at the landfill in the future. As stated in the General guidelines above, there may, however, in a particular case, be a reason to consider what type of waste has been deposited at the landfills, even before this point of time.

For landfills that will be closed in accordance with the regulations in the 38-42 §§ of the Ordinance, only limited protection measures will be required, primarily in the form of the final cover. The environmental protection for such landfills will thus be less extensive. In addition, this may also apply to landfills which have not accepted any waste after July 16th 2001, as well as to those which will continue to accept waste for one or two more years. For the former category, it will not be possible to base the assessment on which type of waste that has been accepted after July 16th 2001. The inspection authority must therefore be able to base their assessment on what types of waste that were accepted before that date. Furthermore, there are no reasons to have different criteria for landfills subject to the requirement of submitting closure plans, depending on when they stopped or will stop receiving waste. In view of this, it should be possible to require that all landfills that will be closed in accordance with the provisions of the 38-42 §§ of the Ordinance, report what type of waste that was deposited in them during the whole time that they have been accepting waste, in order to assess what class of landfill they should be assigned to and thus what final design the cover should have.

39 § of the Ordinance (2001:512) on the Landfill of Waste

39 §

In case of landfills for hazardous waste, the provisions of the 7, 8, 16 and 17 §§ shall be fulfilled as of July 1st 2002 and the provisions of the 14 § shall be fulfilled as of July 1st 2004. The development of the conditioning plans and closure plans shall take this into consideration.

Landfills for hazardous wastes that have not yet been closed, but that are expected to be closed before the end of 2008, shall fulfill the requirements in the regulations at the specified times. Hence, there is no room for exemptions from these requirements for landfills that will
be closed, if they are not closed before the specified times. From the 11 § of the Swedish EPA’s regulations on landfilling of waste it is also clear that the requirements in the 4-7 §§ of the regulation shall be fulfilled as of July 1st 2002 in the case of landfills for hazardous waste. This shall be taken into consideration as well when designing conditioning and closure plans.

40 § of the Ordinance (2001:512) on the Landfill of Waste

40 §
If the inspection authority assess that the measures listed in the conditioning plan or the closure plan are sufficient in order to comply with the provisions of this Ordinance and regulations issued with support of the Ordinance, the authority shall approve the plan. What is stated in the 31 §, second section, about the licensing authority shall here instead refer to the inspection authority.

If the inspection authority assess that a measure in accordance with the plan, is subject to licensing under Chapter 9 of the Environmental Code and the Ordinance (1998:899) of Environmentally Hazardous Activities and Health Protection, the authority shall state this fact in its decision. If the measures are not subject to licensing, the inspection authority shall indicate in its decision when the measures shall be implemented.

General guidelines
If the inspection authority assess that the reported data or the proposed measures can not be considered sufficient in any respect, the inspection authority should give the operator the opportunity to complete the plan. Only in cases where the operator declares unwilling to undertake the necessary measures or does not hand in any completion, the inspection authority should consider disapproving the plan. The inspection authority should not impose any special conditions or require special precautions, if it considers that the measures proposed in the plan do not correspond to what is required. If the operator is not willing to propose the measures necessary to comply with the provisions of the Ordinance and the Swedish Environmental Protection Agency’s regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10), the plan should instead be disapproved. In the decision on the approval the inspection authority should only decide whether the measures set out in the plan fulfill the requirements of the Ordinance and the Environmental Protection Agency regulations for landfilling of waste.

The measures specified in a closure plan should be deemed sufficient if they fulfill the requirements of the Ordinance and the Environmental Protection Agency’s regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10) that are important for the closure and after care activities. Thus, this refers to the provisions of the Ordinance that deal with the classification of landfills (7 §), the general required precautions (26 §), the final cover, control, sampling and monitoring during the after care phase (30-33 §§), as well as the 9 and 10 §§ of the regulations.

Exemptions / Exceptions
When the inspection authority assess a conditioning plan, it should not anticipate the review from the licensing authority by assessing whether the exemption or exception according to the 24 § of the Ordinance, should be granted or is expected to be granted. If the operator indicates in the plan an intention to apply for such exemption or exception, the inspection authority should wait with the decision on the case while pending on the resolution to the issue of exceptions or exemptions. If the exemption or exception is not granted, the operator should be required to complete the plan with a description of the measures that need to be undertaken in order to fulfill the requirements of the 19-22 §§ of the Ordinance.

Licensing and notification measures
If an inspection authority determines that, according to the plan, a measure is subject to a notification according to the 21 § of the Ordinance (1998:899) of Environmentally Hazardous Activities and Health Protection or according to any other regulation, this should be stated in the decision.
Financial security

The inspection authority should not require the operator to provide financial security for the costs of after care and restoration in cases where it deems that the actions listed in a conditioning plan are subject to licensing. The question on security should instead be assessed by the licensing authority. If the inspection authority determines that the security required in conjunction with the licensing process is not sufficient, it may require additional financial security with the support of Chapter 16, 3 §, second section of the Environmental Code.

If the inspection authority combines its approval of a conditioning plan with requirements on financial security, the operator should not have to provide the security before the time that the inspection authority declares that the requirements according to the Ordinance shall be fulfilled.

Approval of the plan

The inspection authority may approve a plan which in practice means that a permit can no longer be used, as a whole or in part.

Timetable for conducting measures and closure

In evaluating whether the measures set out in a conditioning plan should be implemented earlier than the end of 2008, the inspection or licensing authority should base its position on what can be considered to be environmentally justified. An earlier date for the implementation of the measures should be set, if it can be assumed to have a negative impact from an environmental perspective to not take action until 2008. In other cases as well, when it is favourable from an environmental perspective, the inspection or licensing authorities shall decide that the measures set out in a conditioning plan should be implemented before the end of 2008.

The inspection authority can set a date for closure that is further ahead in time than 2008, provided that waste is not deposited at the site after the end of 2008 and that it is not considered possible to close the landfill earlier in an environmentally safe manner.

It should however not be accepted that landfilling continues longer than what is necessary in order to start a final cover of the landfill. If it turns out later that it is unreasonable to require that a landfill is closed at the date originally set by the inspection authority, the authority should be able to change its decision at the request of the operator.

In a comparison with the 41 § of the Ordinance, it appears that an inspection authority will only approve a conditioning plan if it is clear that the requirements of the Ordinance and of the Swedish EPA’s regulations for disposal of waste will be fulfilled by the end of 2008 at the latest. The inspection authority may also decide that the measures specified in the plan shall be implemented at an earlier time than 2008.

As regards the requirements that should be made on measures according to closure plans, it is referred to the above mentioned, in the guidance to the 38 §.

Exceptions / Exemptions

The inspection authority may not grant exceptions or exemptions from other provisions of the Ordinance than the 31 § (relating to final cover). Exemptions according to the 24 § of the Ordinance cannot be granted by the inspection authority, neither for activities that are subject to licensing or a notification. If an operator applies for exceptions or exemptions according to the 24 § of the Ordinance, he or she is directed to submit an application to the licensing authority.
Financial security

From Article 8 in reference to Article 14 of the Landfill Directive it is clear that for existing landfills that will continue to accept waste after the end of 2008, a financial security or its equivalent is required, in order to ensure that the operator fulfills its obligations according to the Directive, including after care and restoration. In the 33 § of the Ordinance there is a reference to the regulations on security in Chapter 16, 3 § of the Environmental Code. According to these regulations, the inspection authority may approve a conditioning plan depending on whether the operator provides financial security for the costs for after care and other restoration measures. From an EC legal principle it follows that a national authority is required to apply a provision of an EU directive which has not been directly implemented into national law, if there is room for interpretation in the national legal system to allow such an application (see Chapter 1, 6 § of the Environmental Code). This means that the inspection authorities are obliged to require that an operator who intends to continue receiving waste at a landfill after the end of 2008, provides a security for costs for after care and other restoration measures.

In cases where the inspection authority assesses that the operator must apply for a permit for the proposed measures however, it is appropriate that the inspection authority refrain from requiring security. As a result of the provision in Chapter 15, 34 § of the Environmental Code, which comes into force on July 1st 2002, the prerequisite for the permit for an activity that involves landfiling of waste is that the operator provides a financial security or takes other appropriate actions in order to ensure the fulfilment of the obligations concerning the landfill. A licensing process in respect of the measures resulting from a conditioning plan can cause that the entire installation is reviewed. Thus, requirements on financial security for the entire installation will be possible to make in the licensing process, and therefore there is no need for the inspection authority to require a security in the matter concerning the conditioning plan.

Regarding the closure plans, the directive makes no requirements on security for landfills that will be closed. Thus, the inspection authorities are not obliged to require security for landfills that will be closed in accordance with the provisions of the 38-42 §§ of the Ordinance. The inspection authority may however make the approval of a closure plan depending on that the operator provides security, with the support of Chapter 16, 3 § of the Environmental Code. This may be relevant, for example, if the inspection authority determines that there is a risk that the operator will not be able to undertake the measures for closure and after care that are required according to the Ordinance.

Approval of the plan

Since the Landfill Ordinance is adopted pursuant to Chapter 9, 5 § of the Environmental Code, the approval of a conditioning or a closure plan could mean that a permit for the activity under the Environmental Code or older regulations, is limited, modified or disregarded, as a result of the provision in Chapter 24, 1 §, fourth sentence of the Environmental Code. It should however be pointed out that the inspection authority’s approval of a plan must not lead to a restriction of a permit for the activity on any other basis than that it follows directly from the requirements of the Ordinance.

According to the Swedish EPA’s view, matters relating to conditioning and closure plans are inspection matters. Hence, an approval of a plan has a legal effect in the way that the operator is required to undertake the measures specified in the approved plan. The approval, however,
Timing of the measures and closure

In the 41 § of the Ordinance it is stated that an inspection or licensing authority may decide that measures that are specified in a conditioning plan should be completed by an earlier date than the end of 2008. Such a decision should be based on what is considered to be environmentally justified in each individual case. If, for example, there is a risk of leakage of pollutants with leachate which can cause damage to the environment, there may be a reason for the inspection or licensing authority to require that the construction of an artificial geological barrier and bottom sealing shall be performed earlier than by the end of 2008. Another example of when it may be beneficial from an environmental perspective to stipulate that measures should be implemented before the end of 2008, is to define that the operator shall establish a system for acceptance control. It should be advantageous from an environmental point of view that the operator has an early control over the properties of the waste that is landfilled and will be landfilled at the facility.

The fact that a landfill can be closed at a point that is further ahead in time than the end of 2008 results from the fact that the latest date for when landfills that will not continue to accept waste after the end of 2008 should be closed, is not specified in the Landfill Directive or in the Ordinance. It is only stated that they should be closed “as soon as possible”. For example, in some cases it might be necessary to continue to build up the landfill by adding waste for a certain period of time in order to achieve the desired stability and to create the conditions for a proper closure of the landfill in general. Furthermore, the measures for the final cover might need to be implemented over a longer period of time, to offset settlements and to provide an environmentally optimal closure. According to the Swedish EPA’s assessment, such a procedure complies with the requirements of the Ordinance, provided that there is no landfilling of waste after the end of 2008.

41 § of the Ordinance (2001:512) on the Landfill of Waste

41 §

If the inspection authority approves the conditioning plan according to the 40 §, the installation shall fulfill the requirements of the 7, 8, 11, 14 -17 and 19-37 §§ by the end of 2008 or by an earlier date decided by the inspection authority or licensing authority.

Landfills for hazardous waste shall comply with the requirements of the 39 § of the Ordinance and of the 4-7 §§ of the Swedish EPA’s regulations for landfilling of waste, at the earlier date that is stated in these regulations. As stated above for the 39 §, this may also apply for landfills for hazardous wastes that have not stopped receiving waste but that will not continue to accept waste after the end of 2008.
42 § of the Ordinance (2001:512) on the Landfill of Waste

42 §
If a conditioning plan or a closure plan is not handed in, or cannot be approved, the landfill should be closed as soon as possible.

General guidelines
The inspection authority should decide on the date for when the landfill shall be closed at the latest. The inspection authority should, at the time also consider what has been said above about the time for closure, in reference to the 40 §.
If the inspection authority does not receive a plan or any other basis for the assessment of how soon a landfill should be closed, the inspection authority should make an injunction of the operator to ensure that the landfill is closed at a specific date. In determining this date, the authority should use the documentation that is available or that can be obtained by other means.
If a landfill shall be closed as a result of that a plan has not been submitted or approved, the landfill shall be closed in accordance with the requirements for closure and after care in the Ordinance and in the Swedish EPA’s regulations for landfilling of waste, as well as in accordance with any conditions in the permit.
If the inspection authority does not consider the available information to be a sufficient basis for assessing when a landfill should be closed, e.g. because the operator has not submitted any plan, the authority may make an injunction of the operator to submit the required documents and also require investigation of the landfill, with support of Chapter 26, 21 and 22 §§ of the Environmental Code.
An injunction that a landfill shall be closed no later than at a particular date can be combined with a fine, according to Chapter 26, 14 § of the Environmental Code. If such an injunction is not fulfilled, the inspection authority can also use the regulations on enforcement and legal remedies in Chapter 26, 17 and 18 §§ of the Environmental Code. Furthermore, criminal liability according to Chapter 29, 8 § and 13 p of the Environment Code can be eligible if an operator fails to take the precautions imposed by the Ordinance or the Swedish EPA’s regulations on landfilling of waste.

Chapter 15, 34 § of the Environmental Code (1998:808)

34 §
A permit for an activity involving landfilling of waste may be granted only if the operator provides a financial security for that the obligations of the landfill will be fulfilled, or takes other appropriate measures for such security.
According to the preparatory work (prop. 2001/02:65 p.66 f) this provision was introduced when the regulations of Chapter 16, 3 § of the Environmental Code were not considered sufficient to fulfill the requirements in the Landfill Directive. In order for the provision of security to function as a mandatory requirement for the permit, the provisions needed to be completed.
There are many questions about the financial security including the forms in which the security can be provided and how the security shall be calculated. There is no clear practice regarding these questions. There are numerous decisions from various environmental courts, but unfortunately, these assessments differ. So far, there is hardly any ruling from the Environmental Court of Appeal. One of the few court decisions, available from the...
Environmental Court of Appeal, is that of December 22nd 2003 (Case M 10565-02) regarding Zinkgruvan Mining AB. Here, the Environmental Court of Appeal brought up a number of issues concerning the provision of security. As regards the size of the security, the Environmental Court of Appeal concluded that neither Chapter 15, 34 § or Chapter 16, 3 § of the Environmental Code include a requirement that the security should be provided as a lump sum payment. Provided that it is possible to examine the pace of the need for after care, there is, according to the Environmental Court of Appeal, no obstacle to that the security is provided gradually. The security shall, according to a temporary condition, exist and be approved by the Environment Court before the permit may be utilized. In addition, the Environmental Court of Appeal raised the issue on the constitution of the security and decided that, in order for a security in this case to serve its purpose, the funds must be made available for the after care measures, which would not otherwise be performed. Therefore, according to the opinion of the Environmental Court of Appeal, it can not be deemed as sufficient that a company makes continuous provisions in the financial statements.

**Dates of entry into force**

On July 16th, 2001. The Landfill Ordinance came into force. It applies directly to the new landfills. The existing landfill sites (which are or were covered by valid permits on July 16th 2001) that will be closed by the end of 2008 only need to fulfill the requirements of the Ordinance on closure (see the 38 §). The landfills that will be operational after the end of 2008 must fulfill the requirements of the 7, 8, 11, 14-17, 19-37 §§ by December 31st 2008 or at an earlier date, decided by the inspection authority.


July 1st 2004. Landfills for hazardous waste shall fulfill with the provisions of the 14 §.

On January 1st 2005. Parts of the Swedish EPA’s regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10) came into force.

On July 16th 2005. The remaining parts of the Swedish EPA’s regulations concerning the disposal of waste with the criteria and procedures for acceptance of waste at facilities for landfilling of waste (NFS 2004:10) came into force.


December 31st 2005. Permits are required for all of the landfills that became subject to licensing when the Environmental Code came into force on January 1st 1999.

January 1st 2009. The landfills which were subject to licensing due to the change of the Ordinance for Environmentally Hazardous Activities and Health Protection at the entry of the Landfill Ordinance into force must have a permit. During the entry into force of the Landfill Ordinance, also a requirement for a permit for the landfill sites where less than 50 tonnes is disposed off per year was introduced (transitional provision 2001:513). These landfills must have a permit on January 1st 2009. Up until and including the changes of the Ordinance for Environmentally Hazardous Activities and Health Protection on July 16th 2001, landfills for the disposal of less than 50 tons per year were subject to the requirement on a notification.