Guidance Document for the Design, Siting and Operation of Out Wintering Pads

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1 Introduction

1.1 Introduction

An out wintering pad (OWP) is an alternative method of accommodating livestock (excluding pigs) to conventional sheds. The OWP provides a drained lying area outdoors for the animals on a bed of woodchips. The OWP is operated at a much lower stocking rate than conventional accommodation, however the effluent produced from an OWP can have a high concentration of pollutants. Underneath the drainage system the effluent is contained by a liner and the effluent is collected and stored before being recycled onto a suitable crop. The effluent collected by the underdrainage system is classed as slurry. The woodchip bed retains most of the nutrients produced by the livestock and these woodchips are also recycled onto a suitable crop such as grass. Because an OWP depends entirely on a liner to prevent leaks, such a structure shall only be built after a “Site Assessment Report” has been completed by a Local Authority approved site assessor. OWPs require careful construction by a competent contractor. Some locations will be unsuitable for subsoil-lined out wintering pads, by virtue of the presence of very close underlying rock; the presence of unsuitable subsoils such as sand or gravel; high water tables; or other adverse conditions. Such locations may necessitate lining the OWP with a geomembrane, or alternatively incorporating a concrete base. Similarly some sites may be unsuitable for geomembrane-lined out wintering pads. However, the suitability of a site will ultimately be determined by the on-site tests and investigations.

1.2 What is an out wintering pad?

An out wintering pad (OWP) is an animal accommodation system that is constructed by placing a bed of woodchips over a lined (compacted subsoil, geomembrane or concrete) and artificially drained surface. The woodchips provide a soft interface with the animals, the drainage system collects the leachate from the woodchip bed and the liner prevents any downward movement of effluent into the groundwater.

1.3 Advantages and disadvantages of OWPs

Advantages:

- a sustainable design using local materials (where suitable)
- over-wintering facilities on farms can be greatly increased at low cost
- adaptable to the needs of the farmer
- does not pose a significant threat to the environment when designed and constructed properly
- relatively good landscape fit
- improved animal performance and welfare
- less animal disease pressure relative to more confined housing systems
- more adaptable to a range of animal types than conventional housing

Disadvantages:

- requirement for competent site analysis and characterisation skills
- annual requirement for bedding material (similar to straw bedded or similar housing)
- effluent management requirements (similar to standard housing)
- solid waste (spent woodchips) management requirements
- farmer is exposed to the weather during animal management (similar to some other animal accommodations)

1.4 The need for a guidance document for OWPs

The main purpose of this document is to provide comprehensive guidance for the design and construction of an OWP. While this document provides the design guidance, a separate specification document (S132) is available from the Department of Agriculture and Food for the construction of OWPs. Farmers are reminded that they have a duty under the Safety, Health and Welfare at Work Act, 2005 to provide a safe working environment on the farm, including farm buildings, for all people who may work or enter that farm. There is a further duty to ensure that any contractor, or person hired to do building work, provides and/or works in a safe environment during construction. This document is targeted primarily at Local Authority planners, site assessors, agricultural consultants and farm advisors. The guidance document is available on the website of the Department of Agriculture and Food (www.agriculture.gov.ie).

1.5 Overview of guidance document

Chapter 2: Site characterisation: general overview

Chapter 2 gives a general outline of the methodology which is employed when undertaking a site characterisation, which includes a risk based assessment, general site suitability requirements and some minimum design requirements.

Chapter 3: Undertaking the site assessment

This chapter gives guidance on how to carry out a specific assessment of a site being considered for an OWP by collating and analysing data pertaining to site location, farming practices, soil and subsoil type, groundwater protection requirements and general planning information.

Chapter 4: Regulatory procedure

Chapter 4 summarises relevant national legislation and planning regulations pertinent to OWPs.

Chapter 5: Out wintering pad design

This chapter details the design requirements necessary to ensure that the OWP is constructed to best meet the needs of the farmer with minimal environmental impact.

Chapter 6: Out wintering pad construction

Chapter 6 details the steps required for construction of an OWP. These include site preparation, removal of topsoil, bunding and subsoil liner construction, installation of drainage layer, placing of woodchip bedding, feeding system construction, effluent transfer system and fencing. The chapter also gives design guidance on geomembrane-lined OWPs.

Chapter 7: Operation and maintenance

Guidance on ongoing management and maintenance checks is given.

Chapter 8: Health and safety

This section gives guidance on potential health and safety issues which may arise including information on fencing, gates, animal handling and appropriate signage.

Appendices

Appendix 1 gives a brief introduction to the groundwater protection response matrix for OWPs and describes how it is utilised during site assessment and characterisation. Appendix 2 contains guidance on classifying a subsoil using BS 5930:1999. Appendix 3 tabulates excerpts from various documents which assist the designer in sizing and calculating the effluent volumes produced from the proposed OWP. Appendix 4 contains a full copy of the site characterisation form and Appendix 5 lists the references used in the preparation of this document.

2 Site characterisation: general overview

2.1 Introduction

The decision to install an OWP will be based on an integrated evaluation of technological, environmental, economic, and logistical criteria, and personal preference on the part of the farmer, but the suitability or otherwise of the site will be of key importance in the decision making process. It is therefore important that a systematic and logical approach is followed to allow the suitability of the site to be assessed as early as possible in the decision process, so that time and expense is not wasted unnecessarily. The regulatory authorities will need to be provided with adequate information in a standard, easily understood and logical format to assess the proposed development. Chapters, 2 & 3 provide guidance on how to assess site suitability with the objective of collecting sufficient information to:

- determine if the OWP can be developed on the site
- demonstrate that the construction of an OWP will not create a negative impact on the environment
- to provide adequate data to enable the optimal design to be achieved.

The approach is termed site characterisation. Site characterisation combines various assessments including desk study, visual assessment and site tests to satisfy the objectives.

2.2 Objectives of the site assessment

The site assessment should be targeted, rigorous and comprehensive to ensure all areas are properly assessed and that high risk areas are avoided.

2.3 Risk based approach

When we interact with the environment, which by its nature can be variable and heterogeneous, we cannot rely on 100% protection at all times. This means we need to rely on risk minimisation. The concept of risk is therefore important in the overall concept of site assessment and design. Risk based assessment provides a framework for evaluating and managing pressures and impact on identified receptors. The Hazard-Pathway-Receptor model is the recommended approach. Risk can be defined as the likelihood or expected frequency of a specified adverse consequence. Applied to OWPs it expresses the likelihood of damage or contamination arising from the construction or operation of an OWP (hazard). A hazard presents a risk when it is likely to affect something of value such as groundwater or surface water (receptor). An impact can only occur if a linkage (pathway) is established between the hazard and the receptor. Protection, like risk, is a relative concept in the sense that there is an implied degree of protection (absolute protection is not possible). An increasing level of protection is equivalent to reducing the risk of damage to the receptor. Moreover, choosing the appropriate level of protection necessarily involves placing a relative value on the protected entity.

2.4 Key environmental receptors

In the context of an OWP the key environmental receptors include:

Receptor	*Issues*
Groundwater	Unless the underdrainage and containment system is properly constructed, there may be percolation to the aquifer, which will have a resource value in keeping with national groundwater protection criteria. In addition, nearby drinking water supplies need consideration and protection
Surface water	The risk of overland flow from improperly managed OWPs, resulting in transport of contaminated material into a watercourse water will need to be assessed
Soil/subsoil	The subsoil may be used to form the sealing element of the OWP and will then provide the protection to the underlying aquifer
Flora and fauna	Care will need to be taken to ensure that protected areas are not impacted
Air	Minor odours may be associated with the OWP, but shall not significantly increase the odours over and above those already associated with the farmyard
Cultural heritage	The desk study shall identify any known heritage sites. In general OWPs shall not be built within the curtilage of heritage sites. Care during construction must be exercised to eliminate damage to possible undiscovered sites
Human	The potential impact on the farm enterprise and neighbours needs to be assessed

Table 2-1 Key environmental receptors and issues

2.5 Hazard characterisation

2.5.1 General

The principal contaminants, which constitute the hazard, are effluent from the underdrainage system and spent woodchip bedding. Microbial pathogens, ammonia and nitrate pose the greatest threat to groundwater. In addition, phosphate may impact on surface water.

(i) *Typical characteristics of effluent*

It has been noted that the volumes of effluent generated can be very variable. This may be ascribed to variable weather conditions and livestock slurry generation. Similarly the chemical characteristics can also be variable. The effluent will typically have high levels of microbial pathogens. Typical characteristics of effluent from OWPs are;

- N: 300 ~ 1000$g.m^{-3}$
- P: 20 ~ 35$g.m^{-3}$
- Typical BOD effluent values: 1500 ~10,000$mg.L^{-1}$.

The main determinants of nutrient concentrations are the woodchip depth and woodchip particle size (Crosse 2002) (see Tables 2.2 and 2.3 below).

Woodchip Depth	*P ($mg.L^{-1}$)*	*NH_4-N ($mg.L^{-1}$)*	*BOD ($mg.L^{-1}$)*	*Suspended Solids ($mg.L^{-1}$)*
10cm	23	118	3511	1033
20cm	20	60	2517	860
30cm	14	47	1844	488

Table 2-2 Average effluent nutrient concentrations of three different woodchip types over varying woodchip depths

Woodchip Type	*P (mg.L^{-1})*	*NH_4-N (mg.L^{-1})*	*BOD (mg.L^{-1})*	*Suspended Solids (mg.L^{-1})*
PP (Post peelings)	21	50	2294	581
90mm Chips	21	104	3183	1098
30mm Chips	16	70	2394	702

Table 2-3 Average effluent nutrient concentrations at woodchip depth of 20 cm for varying woodchip types

(ii) *Typical characteristics of spent woodchips*

Typical nutrient concentrations of spent woodchips are;

- N: 100 ~ 150g.kg^{-1}
- P: 25 ~ 40g.kg^{-1}
- K: 150 ~ 200g.kg^{-1}.

The factors influencing nutrient concentration of woodchip are the animal stocking rate and length of time animals are on the OWP (Hourihan et al. 2006).

2.6 Site suitability (general requirements)

There are a number of pre-requisites, which must be satisfied before embarking on an assessment of the suitability of a site for the construction of an OWP.

2.6.1 Site restrictions

There are a number of restrictions, which shall be satisfied before embarking on the construction of an OWP. A proposed OWP shall not be considered for:

- sites within 60m of any well or spring used for potable water
- sites within either:
  - o the inner protection zone of a public water drinking supply source (>10m^3.d^{-1} or PE >50) (groundwater) where the vulnerability rating is classified as extreme, or
  - o within 300m up gradient of the abstraction point where an inner protection zone has not been identified and the vulnerability rating has been classed as extreme,
- sites where the minimum design requirements cannot be achieved
- sites within 10m of an open watercourse where effluent can enter
- sites within 50m of a lake
- sites within 15m of a karst feature
- sites liable to flooding
- sites where construction of the OWP will damage or destroy a site of potential natural or cultural heritage value
- sites that are steeply sloping.

2.6.2 Minimum design requirements

- In general all subsoil-lined OWPs shall be underlain by at least 0.5m of moderate to low permeability unsaturated subsoil enhanced by compaction to ensure a permeability of no more than 1 x 10^{-8}m.s^{-1} is achieved. The clay content of the subsoil being used to form the compacted liner shall be at least 10% as determined in the laboratory using a particle size distribution (PSD) test (BS 1377) and where the particle size distribution is adjusted by excluding materials larger than 20mm. Additionally, the compacted subsoil liner shall be underlain by at least 0.25m of unsaturated subsoil.
- Where a regionally important aquifer is present and the groundwater vulnerability rating is high/extreme or the regionally important aquifer is karstified, or where high permeability sand and gravel is encountered and is in vertical hydraulic continuity with the main water table, the minimum thickness of the compacted unsaturated subsoil liner shall be 0.75m. Suitable subsoil may need to be

imported to form the liner. Additionally, the compacted subsoil liner shall be underlain by at least 0.25m of unsaturated subsoil.

- Where the subsoil is at least 1.0m thick below the proposed underdrainage layer and is characterised as moderate to low permeability, unsaturated, impervious, free of preferential flowpaths and has a clay content of at least 13%, the surface of the excavated portion of the OWP will only require plastering with remoulded subsoil.
- All geomembrane-lined OWPs shall be underlain by at least 0.15m of unsaturated subsoil, the upper 0.05m of which may be a protective fine sand layer depending on the requirements of the lining contractor. The geomembrane shall be overlain by subsoil with a minimum thickness of 0.2m of low to moderate permeability and plastered with remoulded subsoil.

3 Undertaking the site assessment

3.1 Introduction

The purpose of site assessment is to determine the suitability of the site for the construction of an out wintering pad (OWP). This chapter details an approach for completing the site assessment. The site assessment provides the basis for the OWP design and the data collected will be used to optimise the design and construction of the proposed OWP. A site assessment form for the collation of data is given in the technical specification for OWPs. This shall be completed and will act as a check list, and aid in the decision making process. The text below follows the layout of this site assessment form, and the form (Appendix 4) should be referred to in combination with the text below.

3.2 Approach to site assessment

The following key steps must be undertaken:

- collation of background information
- visual assessment
- site tests
- decision process and preparation of recommendations.

3.3 Collation of supporting information

3.3.1 Preliminary consultation (Section 12.1)

The purpose of the preliminary consultation is to:

- gather pertinent existing information on the farming enterprise
- establish in general terms, the proposed size of the OWP
- provide the farmer with some general facts on the OWP.

A good understanding of the issue can be gleaned in a telephone conversation or preliminary meeting with the farmer or his/her adviser. In return, useful information can be provided to the farmer on budget project costs and other logistical items. The decision to consider building an OWP usually originates with the farmer. He/she may involve an adviser in the decision and procurement process. The farmer may have one or more reasons for considering the use of an OWP, and these may include:

- insufficient existing over-wintering facilities
- improved environmental and animal performance
- relative cost/benefit advantages when compared to other alternatives.

In general the client will be able to furnish the site assessor with supporting information pertinent to the existing farm situation such as general animal accommodation requirements and preferred possible OWP site locations. When assessing the requirements of the farmer, a number of logical steps must be followed to ensure that requirements are accurately assessed. Information shall be sought concerning the number of animals requiring accommodation on the farm. Using this information, the amount of effluent likely to be produced from the OWP may be calculated by referring to the most up to date information on effluent production rates (Appendix 3). It is important at this stage that the OWP be sized to take account of any shortfall in over-wintering facilities (this may be discussed with the farmer/advisor). The broad design sizing (see Chapter 5) can be discussed at this stage, giving the farmer a general indication of the approximate size of the OWP and to ascertain if he/she is willing to provide sufficient space to construct the OWP and its associated effluent management facilities. The name, address and contact details of the farmer shall be confirmed and some general items in the form can be filled out at this time.

3.3.2 Collation of relevant environmental data (Section 12.2)

(i) ***General***

The purposes of this section are to:

- obtain information relevant to the site
- identify targets at risk
- establish if there are site restrictions
- allow the ranking of sites if a number of possible sites are being considered.

A desk study involves the assessment of available data pertaining to the site and adjoining area that may determine whether the site has any restrictions to the development of an OWP. The following information will need to be collated and the form completed as necessary.

(ii) ***Topography***

A set of maps suitable for planning applications, termed a planning pack is the most suitable way to buy the maps and these can be used later for the preparation of a planning application. The relevant Discovery series 1:50,000 scale map will establish the regional topographical context, showing relative slopes, surface water features and other relevant topographical features. The grid reference for the site shall be determined, and can be easily computed from the Discovery map. The best available base map information is at scales of 1:2,500 and 1:10,000. These maps provide useful information on the immediate topography and may identify potential sites of natural or cultural heritage.

(iii) ***Surface water***

The location of the nearest surface waters, their distance from the proposed site and where relevant the designation (under national regulations) shall be established.

(iv) ***Geological and hydrogeological (Appendix 1)***

The relevant geological and hydrogeological information for the site shall be compiled. The Geological Survey of Ireland (GSI) is the principal source of this information (www.gsi.ie). In general, this information is available from the website, but the relevant contact details are: The Groundwater Section, Geological Survey of Ireland, Beggars Bush, Dublin 4. General soil and subsoil maps are available from Teagasc. Existing data, available from the GSI includes location of outcropping bedrock and karst features and existing depth to bedrock data from their well databases. Draft aquifer maps, interim vulnerability maps, subsoil maps and source protection area information may be obtained from the GSI. Note that the potential release depth of contaminants for an OWP is between 0.5m and 0.75m. Existing domestic and farm wells within 100m and public water supplies within 300m of the proposed site shall be identified and their distance and location in terms of groundwater flow direction estimated. This information can be used in the desk study.

(v) ***Flora, fauna and cultural heritage***

The relevant Local Authority will have a list of designated NHA's, candidate SAC's and an inventory of protected structures, where this is relevant. If more detail is required government bodies such as the Department of Environment, Heritage and Local Government (DEHLG) and the Office of Public Works (OPW), can be contacted to discuss particular areas. If areas are identified, the extent of the restricted area shall be plotted on a map and a brief description provided in the form.

(vi) ***Drainage***

Field drainage maps for the particular area shall be sought from the farmer or their advisor, and general information on the density of drainage in the area, can be determined from the topographical maps. Reference to topographical maps produced prior to the 1950's will indicate previously wet areas that may have since been drained.

(vii) *Public utilities*

The Local Authority shall be consulted with regard to the location of public water supplies and water mains in the area. Locations of gas lines, electricity cables, and communications networks need to be established in consultation with the relevant utilities. The relevant contact numbers for each utility can be found in the phone book. The status of these shall be assessed at this stage, and the need for further investigation highlighted if necessary.

(viii) *General planning*

The county development plan shall be consulted to establish if there are any restrictions to developments of this sort. This will be available for consultation at the Local Authority offices. The development plan may indicate set back distances that have been decided unilaterally by the Local Authority.

3.3.3 Interpreting the results of the background information

The results of the collation of background information and relevant environmental data shall be interpreted with regard to the risk based assessment methodology and the Hazard-Pathway-Receptor model as outlined in Section 2.3 as follows:

- having reviewed the topographical maps and identified surface water features, wells, possible topographical constraints, and the presence of any mapped areas of heritage you will have discovered and collated any/all information relating to surface water and heritage from the relevant sources
- having collated and examined this information, potential constraints such as significant archaeological, natural heritage and/or historical features within the proposed site may be highlighted. To avoid accidental damage, a trial hole assessment shall not be undertaken in areas which are at or immediately adjacent to significant sites (e.g. SAC's, NHA's)
- the geological information collated will have indicated the possibility of encountering karst or high resource value aquifers. The subsoils information collated from subsoil maps, permeability maps, interim vulnerability maps and other subsoil information sources will have highlighted the possibility of encountering gravel or potentially low permeability material
- once the draft aquifer and interim vulnerability classes for the proposed OWP site are established, reference to the groundwater protection matrix (Appendix 1) will allow determination of the appropriate response and the requirements associated with that response. Areas classed as having a 'low' vulnerability are likely to be underlain by low permeability subsoil. The on-site assessment will later confirm or modify such responses
- you will have established the prevailing climatic data, and established any constraints relating to land drainage, utilities, and planning constraints
- any information on satisfactory or unsatisfactory local experience with OWPs can be incorporated at this time to complete the desk study assessment.

By this stage you may be in a position to eliminate sites that present insurmountable constraints for the installation of an OWP.

3.4 Visual assessment (Section 12.3)

The purpose of the visual assessment is to:

- verify desk study findings
- make an on-site assessment of the hazard

- evaluate the sensitivity of the identified receptors
- finalise the selection of the preferred location.

3.4.1 On-site hazard evaluation

Photographs shall be taken on the site, to record the general layout and structures, and various features of interest. It is important that the farmer is present during this process to discuss the various changes in farm activities that occur through the year.

3.4.2 Visual assessment of receptors

(i) *Topography and landscape fit*

A basic survey which will incorporate relevant site levels, minimum distances etc. shall be undertaken to survey the proposed OWP site. The survey information will be used principally in the design process, to make optimum use of topography.

The landscape position reflects the location of the site in the landscape (e.g. crest of hill, valley, slope of hill). A general overview of landuse, density of dwellings, surface water ponding, waterbodies, drainage, vegetation, and condition of the ground shall be made, and the relative distances of potential receptors from the OWP established.

(ii) *Cultural heritage*

Using the information from the desk study, a visual assessment of the site shall be undertaken and the potential risk assessed. If the desk study had identified any protected sites nearby, then the assessment will need to be more thorough. Photographs shall be taken for reference.

(iii) *Human*

Location of dwellings or other gathering places such as nearby schools, churches, hospitals, etc. shall be established and their distance from the OWP determined. Overhead wires, poles and any other utilities shall be marked on drawings.

(iv) *Flora and fauna*

Using the information from the desk study, a visual assessment of the site shall be undertaken and the potential risk assessed. The vegetation indicators shall be described and photographed. Trees that may potentially be close to the OWP shall be marked on drawings.

(v) *Surface water*

The density of surface water features shall be noted as this will give an indication of the relative permeability of the ground. The characteristics of the nearest watercourse shall be described. Other surface water features such as ponding, lakes, beaches, natural wetlands, streams and drainage ditches shall be identified.

(vi) *Drainage systems*

Shallow land drainage systems need to be identified as they could result in short-circuiting of the system. This shall be evaluated as part of the site assessment.

(vii) *Groundwater*

Existing domestic and farm wells within 100m and public water supplies within 300m of the proposed site shall be identified and their distance and location in terms of groundwater flow direction estimated. Water table levels may possibly be determined as part of the trial hole programme. Baseline groundwater quality data shall be collected at this time if considered appropriate.

(viii) *Climate*

The prevailing wind direction across the proposed OWP shall be identified, and the sensitivity of any receptors downwind identified. Any localised rainfall conditions shall be particularly noted.

(ix) *Soil and subsoils*

Any areas of outcropping rock shall be identified and examined. Road cuttings and any open excavations in the vicinity of the site shall be examined, to provide information on the subsoil profile. Similarly, the shape and nature of banks in watercourses can provide useful insights to the ground conditions.

3.4.3 Interpreting the results of the visual assessment

The minimum set back distances that shall be referenced in the visual assessment are set out in section 2.6.1. If any of the requirements cannot be met then an OWP cannot be developed on the site. The nature of the hazard should be fully understood at this stage. A reasonable understanding of the geological and hydrogeological setting, will have been established, and will be verified as part of the trial hole. Any constraints imposed by the presence of natural or cultural heritage features will be understood, and the potential of encountering drainage systems will have been evaluated. The influence of slopes on surface water run-off shall be considered.

3.5 Trial holes (Section 12.4)

3.5.1 General

The purpose of the trial hole is to determine the following:

- the soil and subsoil characteristics
- the depth of the water table
- the depth to bedrock

If the examination of the trial holes can be arranged to coincide with the visual assessment it may save time and expense.

3.5.2 Conducting and logging the trial hole

The trial holes shall be dug to at least 1 m below the proposed drainage pipe invert level of the OWP. Holes will typically be up to 2.0m deep, so a machine capable of excavating to this depth shall be engaged (excavation shall take account of all health and safety requirements for excavations). A minimum of 3 holes should be dug throughout the proposed OWP area. Further trial holes may be required on sites where the ground conditions are considered to be variable, or where the proposed OWP is particularly large. Suggested minimum number of trial holes is as follows:

- Any OWP — at least 3 trial holes
- Area of OWP $>$ 0.5ha$<$ 1.0ha. — 4 trial holes
- Area of OWP $>$ 1.0ha$<$ 1.5ha. — 5 trial holes
- Area of OWP $>$ 1.5ha$<$ 2.0ha. — 6 trial holes
- Area of OWP $>$ 2.0ha — 7 trial holes

The holes shall be left open for 48 hours to establish the depth to the water table (if present) and shall be securely fenced in line with all health and safety requirements during this period. Groundwater conditions shall be described, and if necessary the holes shall be left open or fitted with a standpipe to enable groundwater levels to be established. The thickness of the topsoil shall be recorded.

For OWPs an accurate description of all subsoils encountered is required to enable design and re-use to be considered. The subsoils shall be recorded in a professional manner with reference to the BS 5930 standard description method. This method is outlined in Appendix 2. The most appropriate horizon for use as liner material shall be identified in each trial hole.

At this stage, the site assessor will know whether the site is either;
(a) unsuitable for an OWP system
(b) suitable for a geomembrane-lined OWP system
(c) likely to be suitable for a subsoil-lined OWP system

The site assessor will have discussed the various options available to the client/advisor at the different stages of the site assessment. Based on the findings of the site assessment to date, the client may wish to proceed with the laboratory testing phase to accurately determine the clay content of the proposed subsoil liner horizons in the trial holes and consequently to facilitate the site assessor in making a decision as to the suitability of the site for a subsoil-lined OWP. In this case, representative samples shall be taken from the horizons identified as most appropriate for use as liner material in each trial hole for laboratory testing. Alternatively, if the site is deemed suitable for a geomembrane-lined OWP and the client decides that he/she wishes to proceed with this system, further laboratory testing is not required. Without laboratory testing, a subsoil-lined OWP cannot be recommended.

Subsoil testing shall be conducted at an approved laboratory and the following test on the samples shall be undertaken to BS 1377; Particle Size Distribution analysis. The results of these tests shall be entered into the site assessment form (Section 12.5).

3.5.3 *Interpreting the findings from the trial hole investigation and laboratory tests (Sections 12.4 and 12.5)*

The results of testing shall meet the following requirements:

Liner type	***Minimum acceptable criteria***	***Subsoil thickness required below OWP underdrainage system***
In situ subsoil liner	13% clay or greater Low/moderate permeability unsaturated subsoil, impervious and free from preferential flowpaths	Minimum 1.0m
Compacted subsoil liner	10% clay or greater	Minimum 0.5m compacted subsoil liner underlain by minimum 0.25m unsaturated subsoil
	10% clay or greater Regionally important aquifer present with groundwater vulnerability rating classified as high or extreme or regionally important karstified aquifer present or High permeability sand and gravel is encountered in vertical continuity with the main water table	Minimum 0.75m compacted subsoil liner underlain by minimum 0.25m unsaturated subsoil
Geomembrane liner	At least 0.2m of low/moderate permeability subsoil between drainage layer and geomembrane liner (may be imported if suitable subsoils not encountered) At least 0.15m subsoil beneath geomembrane	See section 2.6.2

Table 3-1 Minimum acceptable criteria for OWP

When assessing the clay fraction of the subsoil being tested, the methodology used shall be that recommended in BS5930:1999 Code of practice for site investigations. The clay fraction value used in the subsoil assessment shall be the percentage of clay present in the fraction of the subsoil sample whose particle size is < 20mm.

3.6 Decision process and preparation of recommendations

Information collected	***Relevance***	***Implications***
Topography	Slopes	Not allowed if greater than 1:5
Surface water	Receptor sensitivity Receiving water	Set back distance
Hydrogeological setting	Receptor sensitivity Pathway assessment	Design Set back distance Monitoring
Cultural heritage	Receptor sensitivity	Set back distance
Natural heritage	Receptor sensitivity	Set back distance
Climate	Receptor sensitivity (odours)	Set back distance Design (rainfall)
Housing	Receptor sensitivity	Set back distance
Farm animal accommodation requirement survey	Hazard assessment	Design
Depth to rock	Pathway assessment	Design Construction
Subsoil type	Pathway assessment Liner suitability	Site suitability
BS5930 soil/subsoil description	Pathway assessment Liner suitability	Site suitability
Depth to water table (if present)	Pathway assessment	Water table lowering system may be required
Percentage of clay	Pathway assessment Liner suitability	Minimum acceptable criteria

Table 3-2 Desk study information and site assessment phases

Table 3.2 summarises the information collected from the desk study and site assessment phases. The information is used to make recommendations as to what type of OWP can be constructed on the site. In situations where the results of the laboratory tests and the analysis of the trial hole data do not appear to complement each other, then a more conservative design or further investigations may be required.

Recommendations shall be outlined in relation to any site specific requirements necessary for the OWP design. With regard to the installation of a water table lowering system, the assessor will have examined the depth of the water table and the nature of the subsoils. This will enable them to make a judgement on whether such a system is required (e.g. may not be necessary if the soils are naturally impervious as perched water tables can be encountered).

4 Regulatory procedure

4.1 Introduction

The construction of out wintering pads (OWPs) will require obtaining full planning permission. Relevant governing legislation, the planning process and required documentation is described in this chapter.

4.2 Relevant legislation for OWPs

The primary piece of legislation governing the requirement and process of planning permission is the Local Government (Planning and Development) Act of 2000 and any subsequent regulations (Planning and Development Regulations, SI No. 600, 2001 and Nitrates Regulations, SI No. 378, 2006).

4.3 Planning pre-consultation

Like any proposed development requiring planning permission, it is always wise to have prior consultation with the local Planning Authority, in order to ascertain their likely requirements, including any fees or charges, possible response, and to ensure as smooth a path through the planning process as possible. Once the applicant has some idea of the approximate details of the OWP planning proposal, with approximate sizing, location and site information, they should enter into discussion with the local planning officer to ensure the proposal will meet with all the local planning authority's requirements. If an OWP is less than $200m^2$ and the overall area of class 8 structures is less than $300m^2$, then planning permission may not be needed. The requirements of S132 must be adhered to in all circumstances. It will be necessary at this stage to confirm the full extent of the planning category and the fee and the required ancillary documentation to accompany the basic planning application. All planning authorities now have websites, on which most planning material can be easily accessed.

4.4 Planning permission/documentation

Local Authority planning application forms and guidance documents are normally available directly from the planning office of each local authority, or can be downloaded from the local authority website. In addition, at least two weeks before submission of the planning application, a notice must be placed in an approved newspaper, and a site notice erected in accordance with Local Authority requirements. In general, the basic documentation required with any farm planning application includes the following:

- completed planning application form, including farm operation details
- copy of advertisement from local/national papers detailing planning application
- copy of necessary site notice, required to be displayed prominently at site during application period
- payment of planning application fee
- map showing location(s) of site notice
- proposed construction layout, cross section, and design
- site characterisation report detailing trial hole and subsoil analysis results.

Ensure that all documents are fully completed as errors/omissions could result in a delay to your planning application being processed.

5 Out wintering pad design

5.1 Introduction

This chapter gives guidance on the design aspects of an out wintering pad (OWP). The design approach recognises that each site will have its own special characteristics and requirements and each design will therefore be tailored to meet the needs of the farmer based on the his/her over-wintering requirements utilising the information and recommendations of the site assessment. The design process is concerned with ensuring that the structure is constructed in an environmentally safe manner.

5.2 Preparation for the design

In approaching the design for an OWP, familiarity with the available background information, in particular the requirements of the farm, the site assessment results and the site layout is essential. The designer shall be fully familiar with the proposed site, through actually visiting the site and also speaking with the farmer/client. This ensures that the client's requirements will be fully understood and that the designer can consider the incorporation of particular existing landscape features into the proposed design. The designer must be able to visualise the finished product, and its impact on the surrounding environment. An understanding of current animal management procedures is of particular importance as this will allow the designer to incorporate the OWP into the existing farm system in the most appropriate way. The requirements of the site shall be fully incorporated into the design. If necessary, this may require the installation of a water table lowering system or the location and rerouting of land drains which may have been encountered during the trial hole investigations. Any such requirements will comprise part of the site assessor's recommendations.

5.3 Area and effluent volume calculations

5.3.1 Sizing an OWP

The size of an OWP will be determined by the number of animals requiring accommodation, the type/age of the stock and the feeding system planned. Guidance on minimum area requirements is given in Table 11.1 (Appendix 3). Guidance on construction of off-pad feeding facilities is contained in Department of Agriculture and Food Specification S. 123. On-pad feeding requires a larger woodchip area than for off-pad feeding. Off-pad feeding generally comprises a smaller woodchip pad and a concrete feeding passage located alongside the pad, separated by a raised concrete kerb or timber boards. In situations where OWPs are attached to existing animal accommodation, the existing feeding facilities may be utilised.

5.3.2 Calculation of effluent volumes

Where it is planned to feed the animals on the OWP the volume of effluent produced from the OWP shall be calculated using the following equation:

$$E = (P \times R) + (N \times V) - (P \times 0.013)$$ **Effluent from on-pad feeding OWP**

where:

- E = effluent produced ($m^3.wk^{-1}$)
- P = pad area (m^2)
- R = net rainfall on the pad ($m.wk^{-1}$) (see Table 11.5, Appendix 3)
- N = no. of animals on the pad
- V = neat excreta produced per animal per week ($m^3.wk^{-1}$) (see Table 11.2, Appendix 3)

Where it is planned to feed the livestock off the OWP, the volume of effluent produced shall be calculated using the following equation:

$$E = (P \times R) + (N \times V \times 0.66) - (P \times 0.013)$$ **Effluent from off-pad feeding OWP**

Provision must also be made for collection and storage of effluent deposited on off-pad feeding facilities, where incorporated into the OWP system. Volumes shall be calculated as follows:

$$E = (A \times R) + (N \times V \times 0.33)$$ **Effluent from OWP off-pad feeding area**

where:

E = effluent produced ($m^3.wk^{-1}$)
A = area of off-pad feeding facilities (m^2)
R = net rainfall on the off-pad feeding facilities ($m.wk^{-1}$) (see Table 11.5, Appendix 3)
N = no. of animals using the facilities
V = neat excreta produced per animal per week ($m^3.wk^{-1}$) (see Table 11.2, Appendix 3)

5.3.3 Management of effluent

All the effluent produced on the OWP shall be contained and stored in an appropriate storage facility. The construction of the effluent storage tank shall be in accordance with the requirements of the Department of Agriculture and Food Specifications and any other regulations or conditions (SI No 378, 2006). Appendix 3 gives more guidance on how to calculate effluent volumes.

5.4 Woodchips

5.4.1 Woodchip specifications

The woodchip used shall be less than 50mm in diameter and may be produced from sawmill by-product, chipped logs or recycled timber. The woodchips produced for woodchip corrals (50-90mm diameter wood cones) are not suitable for out wintering pads. It is not desirable to use products containing too much (>20%) fine material (<5mm) as this may impede the drainage system. In all situations the woodchip bedding shall not contain any material that is not derived from wood.

5.4.2 Calculation of woodchip volumes required and spent woodchip volumes produced

Woodchip is normally purchased per m^3 uncompacted or per tonne. To factor in woodchip compaction it is necessary to allow for a 30% volume reduction i.e. if a $1000m^2$ pad is to be covered with 200mm depth of woodchip then the compacted volume is $200m^3$ and the uncompacted volume purchased will be $285m^3$. Where woodchip is purchased per tonne, the approximate bulk density is $400kg.m^{-3}$ for sawmill by-product and freshly chipped log and $250kg.m^{-3}$ for recycled timber. The volume of spent woodchip removed from an out wintering pad is approximately 120% of the volume of woodchip applied; however the bulk density is approximately $850kg.m^{-3}$.

5.4.3 Management of woodchip

Spent woodchip shall be collected and stored in accordance with the requirements of the Department of Agriculture and Food Specifications and any other regulations or conditions for farmyard manure (FYM). Alternatively the woodchip may be stored on a suitably sized OWP until such time as it is landspread in accordance with best management practices (Chapter 7) and the requirements of the Nitrates Regulations (SI No. 378, 2006).

5.5 Design of feeding facilities

5.5.1 On-pad feeding facilities

Where the animals are fed on the OWP this may be done by allowing the animals to self-feed silage on top of the OWP surface at the highest point on the OWP. This can be done by placing the silage pit on the edge of the OWP on top of the woodchip layer. In this situation the minimum depth of woodchip underneath the silage pit shall be 300mm. Care shall be taken in placing the silage on the OWP not to damage the drainage layer. OWP surface area shall be increased to account for the silage pit area on the pad where necessary.

5.5.2 Off-pad feeding facilities

Where the animals are fed off the pad the feed facilities shall be constructed in accordance with the requirements of Department of Agriculture specifications S101 or S123. Animals may be fed on existing structures provided they are of sound structure and comply with directives on cross compliance and Nitrates.

These facilities may include a roofed or unroofed concrete apron or slatted tank. Where the animals are fed off the pad a minimum of 0.3m of head feed space/adult animal is required and 0.6m where restricted allowances of concentrates are offered. Where new concrete head feed aprons are being constructed the liner shall extend a minimum of 1m under the feed apron. Where existing structures are in place the liner shall make full contact with the existing facility and shall have a minimum of 0.5m vertical height of the line in contact with the existing facilities.

5.6 Watering facilities

All animals shall have access to water at all times. A minimum of one water trough per 50 livestock units shall be installed. As there is a risk of freezing of the water supply on the OWP it would be prudent to use large water troughs supplying a minimum of 80 litres of water per head particularly where high dry matter feeds such as concentrates are fed as a large proportion of the diet. Because of the low stocking rate on OWPs relative to indoor facilities the risk of defecation into the water trough is reduced.

5.7 Configuration of a subsoil-lined OWP

Table 5.1 below tabulates the basic essential requirements of an OWP configuration.

Minimum compacted liner thickness	mm	500
Minimum underlying unsaturated subsoil thickness	mm	250
Minimum ridge height	mm	150
Minimum drainage pipe diameter	mm	80
Minimum drainage spacing	mm	3000
Drainage stone size range	mm	(see section 6.2.5)
Minimum drainage stone depth	mm	300
Minimum woodchip depth	mm	200

Table 5-1 Minimum configuration requirements for a subsoil-lined OWP

5.8 Subsoil liner design

The subsoil liner component of an OWP is designed by utilising the information in the site assessment form to select the most appropriate of a number of possible design scenarios. The requirements and design layout of each of four possible scenarios is detailed below.

Note: In all scenarios, the value of the clay percentage used is that percentage of clay obtained when the particle size distribution is adjusted by excluding materials larger than 20mm. Also, the minimum subsoil liner thickness is taken from the invert of the drainage pipework.

5.8.1 Scenario A

Scenario A			
			Properties
Minimum requirements	At least 1.0m *in situ* unsaturated subsoil		Low to moderate permeability
			Impervious
			At least 13% clay

If the minimum design requirements listed above are met, the subsoil liner need not have a compacted element. It is sufficient that the minimum thickness be 1.0m and the final surface of the liner is plastered with remoulded subsoil.

5.8.2 Scenario B

Scenario B		
		Properties
Minimum requirements	0.5m unsaturated subsoil depth beneath OWP drainage layer compacted to ensure a permeability of 1×10^{-8}m.s^{-1} is achieved	Low to moderate permeability
		At least 10% clay
	0.25m unsaturated subsoil underlying compacted subsoil liner component	

If the minimum requirements listed above are met, then the compacted subsoil liner shall be designed as follows:

- the upper layers of the subsoil underlying the OWP shall be reworked to form the compacted subsoil liner component of the OWP. The liner shall be constructed by building up the minimum thickness of 0.5m in layers. Each layer shall be constructed by placing 150mm of subsoil in position and making four passes (two each in cross directions) with a hydraulic excavator (capable of exerting a ground pressure of 40kPa) or equivalent compaction plant over the entire layer.
- a minimum thickness of 0.25m unsaturated subsoil shall be provided beneath the compacted subsoil liner component

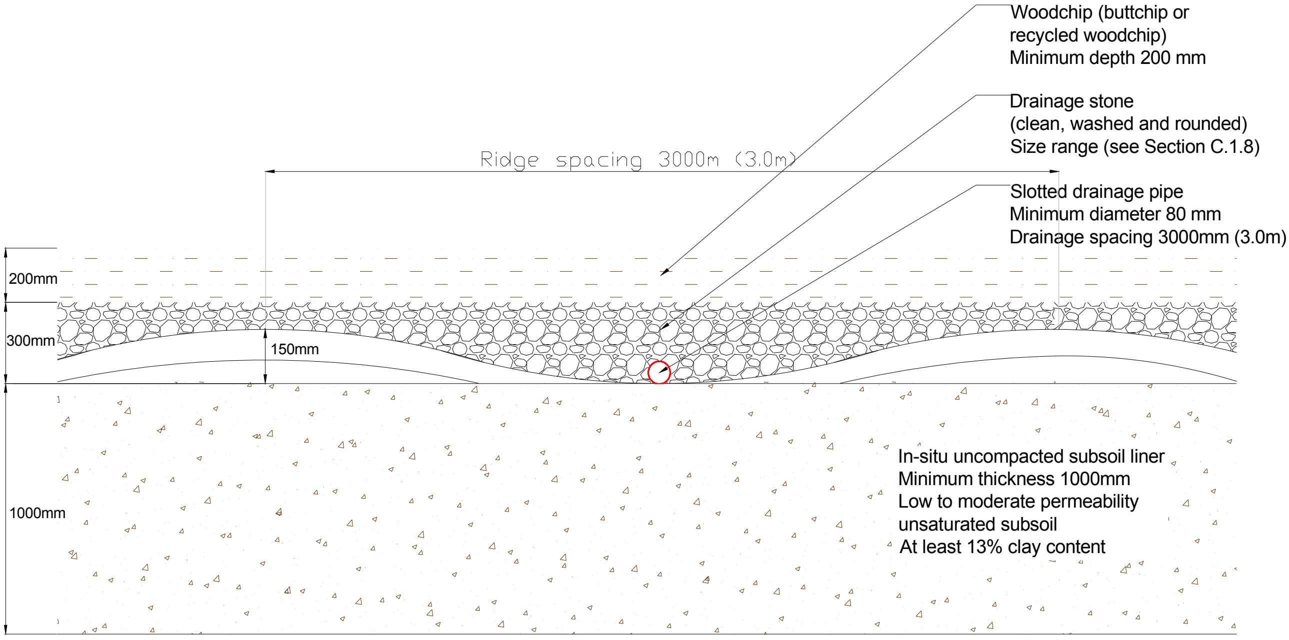
5.8.3 Scenario C

Scenario C		
		Properties
Minimum requirements	0.75m unsaturated subsoil depth beneath OWP drainage layer compacted to ensure a permeability of 1×10^{-8}m.s^{-1} is achieved	Low to moderate permeability
		At least 10% clay
	0.25m unsaturated subsoil underlying compacted subsoil liner component	
	Underlying conditions	Underlain by a regionally important aquifer with groundwater vulnerability rating classified as high or extreme or regionally important karstified aquifer or High permeability sand and gravel is encountered in vertical continuity with the main water table

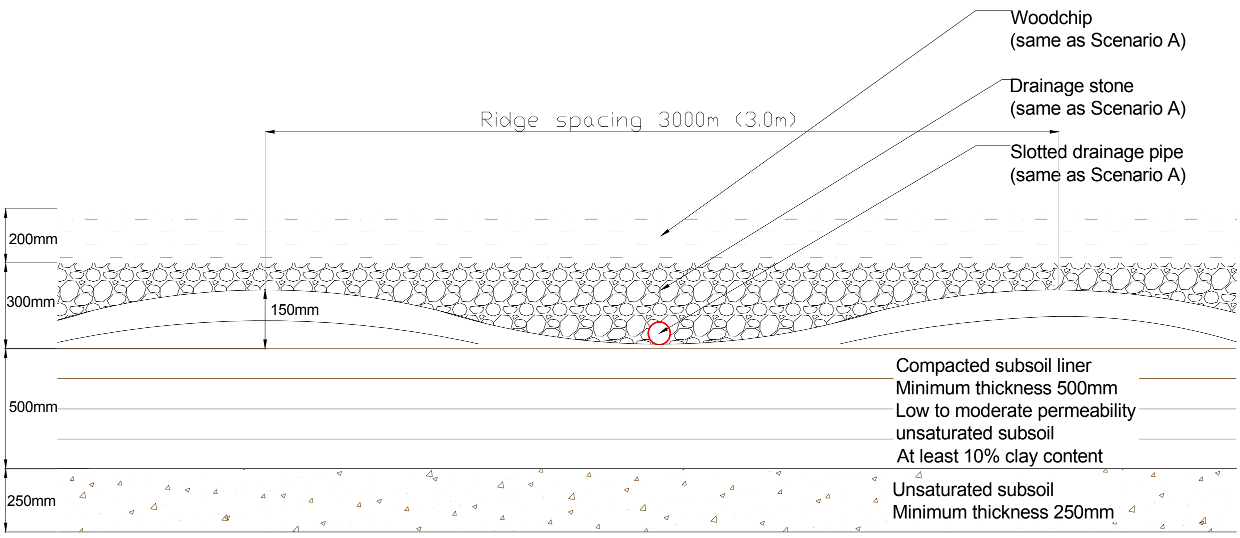
The recommended design methodology is similar to that of scenario B with the following exceptions:

- the compacted subsoil liner component shall be at least 0.75m thick

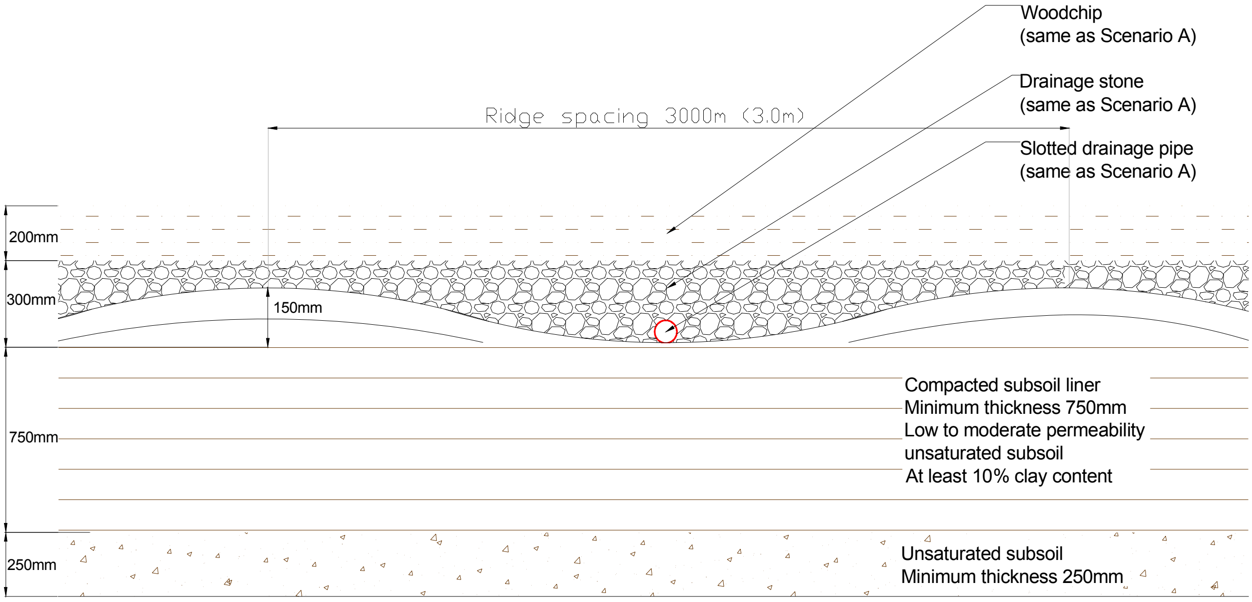
The basic requirements of each of the three design scenarios is summarised in Figure 5.1 below.



Subsoil Liner Scenario A



Subsoil Liner Scenario B



Subsoil Liner Scenario C

Figure 5-1 Scenario A, B and C options for design of compacted subsoil liner in an OWP

Examination of the site assessment information will enable the designer to select the most appropriate design. It must be borne in mind at all times that the basic design requirement is that all OWPs shall be underlain by at least 0.5m of moderate or low permeability subsoil, compacted to ensure that a maximum permeability of $1 \times 10^{-8} m.s^{-1}$ is achieved with a further 0.25m of unsaturated subsoil underlying the compacted liner component. If this requirement cannot be achieved then a subsoil-lined OWP may not be installed and an alternative containment system may need to be considered.

5.9 Geomembrane liner design

5.9.1 Introduction

Geomembrane-lined OWP area determination, effluent generation volume determination, woodchip specification, watering facility specification and design of feeding facilities are all identical to the requirements of a subsoil-lined OWP. The main difference between both systems is that a geomembrane is installed to provide protection to the underlying environment rather than using compacted subsoils to fulfil this function. This system is necessary if unsuitable subsoil conditions are identified during the site assessment or where it is impractical to import suitable subsoils. Geomembranes are vulnerable to the underlying and overlying environment. They can be punctured by sharp protuberances such as jagged rock, debris, roots etc. In addition, they may be damaged by excessive loading. Many geomembranes are vulnerable to continual UV ray exposure.

5.9.2 Geomembrane liner protection

Once the site footprint has been excavated, the subsoil surface needs to be smooth and free of anything which could compromise the geomembrane. Where subsoil surface conditions are unsuitable, a fine sand layer (50mm minimum thickness) shall be installed to provide underlying protection to the geomembrane. The total minimum subsoil depth beneath the geomembrane (*in situ* + sand layer (if required)) shall be 150mm. A protection geotextile may be placed over the geomembrane depending on the lining contractors requirements. Suitable subsoil, (stone free) shall be placed on top of the protection geotextile and compacted using suitable compaction plant. When driving onto the pad, care must be taken to ensure that there is always 200mm of subsoil beneath the machine tracks. The ridges in the subsoil on top of the completed 200mm liner and the drainage layer shall be constructed in accordance with the requirements of section 6.2.5.

5.9.3 Geomembrane liner

The geomembrane liner used shall be approved by the Department of Agriculture and Food and installed by an accepted lining contractor. A list of accepted lining contractors for OWP geomembrane liners is available on the website of the Department of Agriculture and Food (www.agriculture.gov.ie) under specification S132A. In all cases the geomembrane shall at least meet all of the requirements of this specification.

5.10Underdrainage system

5.10.1 Introduction

The OWP underdrainage system is an important component of the overall OWP system as it provides a means of capturing and transferring effluent which passes through the woodchip bedding area. It needs to be sufficiently robust to withstand animal treading on the woodchip and occasional heavy trafficking by machinery when the pad is being cleaned off, replenished with fresh woodchip or when animals are being fed. General drainage layer design comprises slotted land drainage pipes and a gravel layer. Recent developments in geosynthetic technology has resulted in the introduction of new drainage systems which may be used once designed and installed in accordance with manufacturer's instructions. These may include geocomposite drainage layers, geonets etc.

5.10.2 Gravel drainage layer and drainage pipework

This particular drainage system requires that a ridged subsoil layer as illustrated in Figure 5.1 be installed. The purpose of this layer is to provide trenches for the land drainage pipes thereby facilitating transfer of effluent through the gravel layer to the drainage network. Consequently, when specifying the subsoil type for use in the ridge formation it need only be free of sharp protuberances, contain no topsoil and be of moderate permeability. However, using moderate or low permeability subsoils in the ridge formation will provide an additional level of protection to the underlying environment. The height of ridges shall be at least 150mm. The ridges should be plastered and their surfaces smoothed off and plastered with remoulded subsoil.

The drainage pipes shall be a minimum of 80mm internal diameter and installed in the trenches formed by the subsoil ridges. They shall be installed at minimum 3.0m spacing. The drainage pipes shall be connected to solid walled pipe for effluent transfer to a storage facility. The drainage pipes shall have a slight fall towards the effluent collection pipe and this pipe shall, in turn fall towards the effluent storage facility. Most perforated solid-walled or flexible-walled land drainage pipes should be suitable for use. It may be preferable in areas of regular trafficking or occasional trafficking by very heavy vehicles to use solid-walled perforated underdrainage pipes and to increase the minimum depth of drainage stone.

In general, the drainage stone shall be similar to that used as filter drain material in road works and shall be at least 300mm deep. This material is classified in the Specification for Road Works as follows:

Material	***Percentage by Mass Passing Sieve BS Sieve Sizes (mm)***					
	63	**37.5**	**20**	**14**	**10**	**5**
Type B	100	85 ~ 100	0 ~ 20	-	0 ~ 5	-

Table 5-2 Range of grading of filter drain material (adapted from Specification for Road Works Volume 1 Series 500)

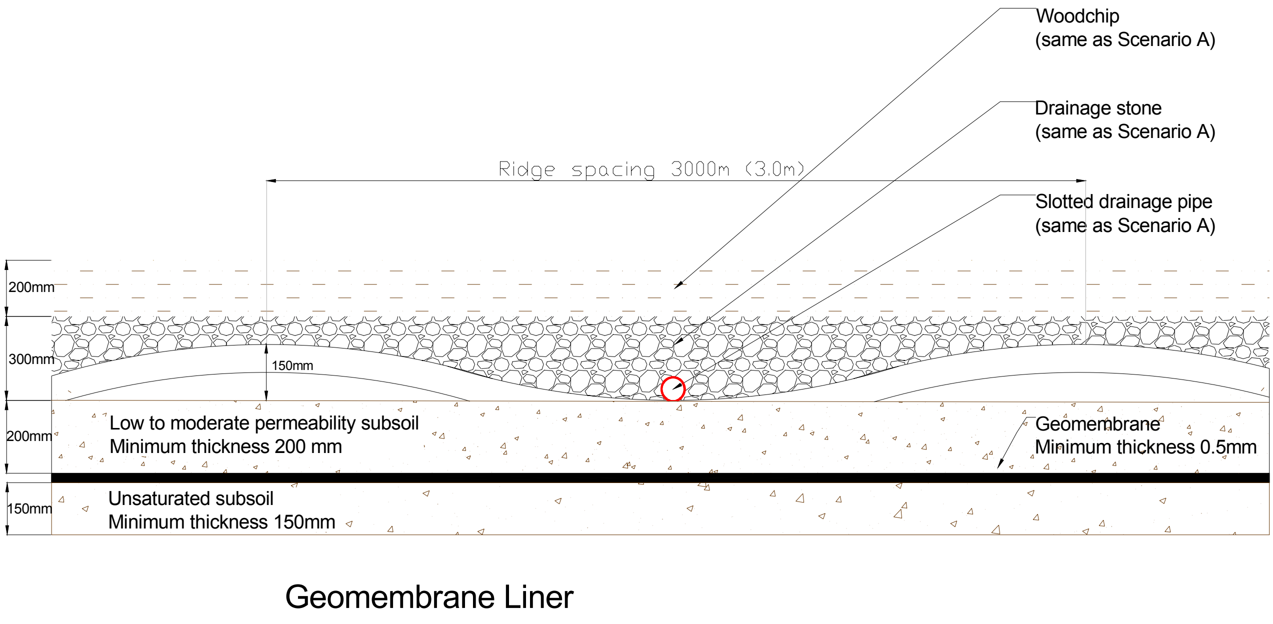


Figure 5-2 Typical schematic of geomembrane-lined out wintering pad

6 Out wintering pad construction

6.1 Introduction

The method of construction of an out wintering pad (OWP) is site-specific and shall always be in accordance with Department of Agriculture and Food Specification S132: minimum specification for out wintering pads and ancillary works together with any/all necessary health and safety requirements. Where ideal site criteria are not encountered works must be undertaken to ensure that all requirements are met.

6.2 Subsoil-lined OWP construction

6.2.1 Working conditions

Where possible, the works must be planned so that they shall be carried out in dry weather conditions (Clause C.1.1. of S132). During construction, care must be taken to ensure that excavated subsoil being used in the construction of the subsoil liner is not allowed to dry out excessively as this could reduce the subsoils compactibility. In Ireland, with the main types of compaction plant the optimum moisture contents of many subsoils are fairly close to their natural moisture contents and in such cases compaction can be carried out successfully. Irish subsoils are generally within ± five percent of optimum moisture content and therefore are suitable for compaction without normally requiring moisture content amendment. However, if subsoils being utilised in the compacted subsoil liner become excessively wet or dry, construction of the compacted subsoil liner shall not take place until the subsoil has returned to at or near its *in situ* moisture content.

6.2.2 Site preparation

(i) *Clearing the site*

The construction site must be cleared of trees (a tree felling licence may be required), scrub, roots and all other vegetation. A Limited Felling Licence application form (Forestry Act, 1946. Section 37(1)) may be obtained from any local Garda Station and must be completed and submitted to the Garda Station located nearest the felling site. Trees located near a proposed site can pose particular problems since their root systems can affect ground moisture levels for a distance of approximately 1.5 times the tree height. On all sites, the topsoil within the OWP footprint shall be stripped. Any other unsuitable subsoil layers as indicated by the designer based on the site assessment shall also be removed.

(ii) *Installation of water table lowering system*

The water table at its estimated highest point, or at its cut-off point where groundwater table drainage is to be provided, shall be below the bottom level of all construction works. Where deemed necessary by the site assessor, a groundwater control drainage system shall be installed (Clause C.1.4 of S132). This shall consist of deep cut-off drains 7.0m outside the site footprint and extending 600mm ~ 750mm below the base of the OWP.

(iii) *Drainage system*

All old drainage or percolation systems encountered shall be completely removed from and rerouted around the OWP footprint to a distance of at least 7.0m and the exposed vacant channels thoroughly filled and compacted with cohesive subsoil. Farms, even in naturally dry soils can have generations of land-drain pipelines beneath the surface.

6.2.3 Compacted subsoil liner construction

It is imperative that the compacted subsoil liner component in the base of the OWP is well compacted. If the subsoil liner is stony or has a relatively high gravel content, the proportion of these materials present shall be such that they are embedded in the dense matrix of the subsoil liner itself and do not create any air-filled porosity by bridging or result in the liner subsoil losing any of its overall plasticity. A 20+ tonne (at minimum) tracked excavator shall be used to construct the compacted subsoil liner component and effect optimum compaction. The liner shall be built in layers/lifts of 150mm and compacted until the desired density and sealing has been achieved (Clause C.1.6 of S132). A minimum of four runs (two each in cross directions) per lift should give adequate compaction in normal conditions. On sites susceptible to groundwater pollution a minimum of six runs or its equivalent with compacting machinery shall be used. Alternative compaction plant may be used if it can be clearly demonstrated that at least equivalent compaction will be achieved. In situations where the *in situ* unsaturated subsoil has a clay content of at least 13%, is of low to moderate permeability, impervious and free of preferential flowpaths, then the subsoil liner does not require compaction. However, the final surface of the liner shall be plastered with remoulded subsoil.

(i) *Compaction of subsoils*

The design and construction of compacted subsoil liners is governed by the strength and degree of compaction required to ensure low permeability. The geotechnical component of a subsoil liner is determined by the nature of the subsoil being utilised. The base of the OWP shall consist of a mineral layer which satisfies permeability and thickness requirements with a combined effect in terms of protection of soil, groundwater and surface water at least equivalent to a permeability of 1×10^{-8}m.s^{-1} with a minimum thickness of between 0.5m and 0.75m depending on the underlying aquifer classification and subsoil/bedrock conditions (see section 5.8 for various design scenarios). Additionally, the compacted subsoil liner component shall be underlain by 0.25m unsaturated subsoil. The site assessment will have determined the presence of the required thickness of subsoil and the designer will have utilised this in his/her design.

(ii) *Compactive energy*

Compactive energy is a function of the weight of the machine used to effect compaction, the thickness of the lift and the number of passes of the machine over each lift. Additional passes cannot be used to compensate for machines which are too light for the liner construction. Machine size is usually specified in terms of contact pressure exerted by the machine. For a hydraulic excavator, the contact pressure is determined based on the operating weight of the machine and the contact area of the machine on the ground. (e.g. hydraulic excavator 20000kg operating weight, track width 600mm, tumbler length 2.5m. Therefore the contact pressure = (20000/(2.5 x 2 x 0.6)) = 65.4kPa). Weight is important to ensure that penetration of the specified loose lift is attained. A lift thickness of 150mm is suitable for most compaction procedures and coupled with a 20000kg hydraulic excavator capable of exerting a ground pressure greater than 40kPa and a minimum of four passes per lift, effective compaction should be achieved. Compactive effort may be through vibration, kneading, impact or pressure. These four different types of effort may be found in two principle types of compaction force; static or vibratory. The difference between the two is summarised below:

- Static force: This is simply the deadweight of the machine, applying downward force on the soil surface, compressing the soil particles. The only way to change the effective compaction force is to add to or subtract from the weight of the machine. Static compaction is effective over relatively shallow depths (<300mm approximately). Kneading and pressure are two examples of static compaction.
- Vibratory force: This uses a mechanism, usually engine-driven, to create a downward force in addition to the machine's static weight. The vibrating mechanism is usually a rotating eccentric weight or piston/spring combination (in rammers). The compactors deliver a rapid sequence of blows (impacts) to the surface, thereby affecting the shallow layers as well as the deeper layers. Vibration moves through

the material, setting particles in motion and moving them closer together to achieve the highest density possible.

Some compaction specification guidance

Track length on ground	***Track width***	***Machine weight***	***Ground pressure***		
(m)	(m)	(kg)	($kg.m^{-2}$)	(kPa)	(psi)
3.00	0.6	13950	3875.0	38.0	5.5
3.27	0.6	19700	5028.1	49.3	7.2
3.28	0.6	20575	5235.4	51.3	7.4
3.37	0.6	18070	4468.3	43.8	6.4
3.37	0.6	19300	4772.5	46.8	6.8
3.37	0.6	20095	4969.1	48.7	7.1
3.37	0.6	19021	4703.5	46.1	6.7
3.45	0.6	19650	4746.4	46.5	6.8
3.66	0.6	23069	5252.5	51.5	7.5
3.66	0.6	21340	4858.8	47.6	6.9
3.83	0.6	24200	5265.4	51.6	7.5

Table 6-1 Ground pressure values for a sample of hydraulic excavators

Table 6.1 gives calculated ground pressure values for common hydraulic excavators used in Ireland. Ground pressure is calculated as follows:

$$GP = \frac{\text{operating weight of machine}}{\text{track area in contact with ground}} = \frac{\text{operating weight (kg)}}{\text{track length on ground (m) x track width (m)}}$$

where:

GP = ground pressure ($kg.m^{-2}$)

When specifying compaction using compaction plant such as static or vibratory rollers, reference is usually made to the Table 6/4 of the Earthworks Specification for Road Works (NRA 2005). The table below is adapted from this specification and gives guidance on the required construction requirements for different types of compaction plant to ensure an impermeable compacted subsoil liner.

Type of compaction plant	***Category***	***Max. depth of compacted layer***	***Minimum number of passes***
		(mm)	(No.)
Smooth wheeled roller (mass per metre width of roll):	over 2100kg to 2700kg over 2700kg to 5400kg over 5400kg	125 125 150	8 6 4
Grid roller (mass per metre width of roll):	over 2700kg to 5400kg over 5400kg to 8000kg over 8000kg	150 150 150	10 8 4
Tamping roller (mass per metre width of roll):	over 4000kg	225	4
Vibratory roller (mass per metre width of a vibratory roll):	less than 700kg over 700kg to 1300kg over 1300kg to 1800kg over 1800kg to 2300kg over 2300kg to 2900kg over 2900kg to 3600kg over 3600kg to 4300kg over 4300kg to 5000kg over 5000kg	100 125 150 175 200 225 250 275	Unsuitable 12 8 4 4 4 4 4 4

Table 6-2 Compaction guidance using different compaction plant (NRA 2005)

(iii) *Construction of subsoil ridges*

Subsoil ridges shall be at a minimum spacing of 3.0m and at least 0.15m high. The ridges shall be constructed by placing and compacting moderate/low permeability subsoil in ridges perpendicular to the OWP system effluent collection pipe at the rear of the pad. The ridges shall run the whole length of the pad. A completed ridged system is illustrated in Figure 6.1 below. Alternatively, the compacted subsoil liner can be installed to the minimum design height and a further 0.15m of moderately compacted subsoil placed on the liner before subsoil ridges are then formed using suitable plant.

Figure 6-1 Compacted subsoil ridges in a subsoil-lined OWP effluent collection system

The inside floor shall be smoothed off and plastered with remoulded subsoil. Plastering with remoulded subsoil seals any minor cracks or pores.

6.2.4 Perimeter embankment construction

The embankments shall be at least than 300mm above ground level and be well-compacted. The embankments shall be constructed of suitable excavated material identified during the site assessment. Uncontrolled ingress of surface water or runoff from the OWPs shall not be possible. Soil embankments generally experience 5% settlement.

6.2.5 Installation of underdrainage system

The drainage system shall be as shown in Figure 6.2. The drainage system should ideally collect all of the effluent to a single point, the lowest point of the OWP. The drainage pipes shall run parallel with the slope on the OWP and shall be tee-joined to a single drainage pipe running perpendicular to all other pipes. There shall be a maximum space of 3.5m between drainage pipes. Drainage pipes shall be a minimum of 80mm and a maximum diameter of 120mm. There shall be a minimum of 220mm of drainage stone above the drainage pipe. Alternative systems such as those referred to in Section 5.10 may be used if correctly designed and installed according to manufacturer's recommendations.

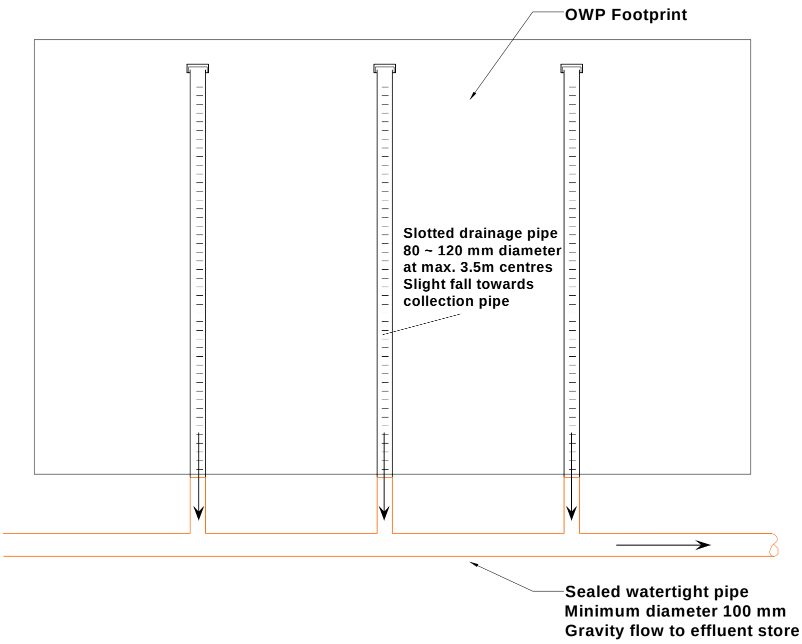


Figure 6-2 Typical OWP underdrainage system configuration

6.3 Construction of geomembrane-lined OWP

6.3.1 Site preparation

(i) *Site clearance*

See section 6.2.2 (i).

(ii) *Installation of water table lowering system*

See section 6.2.2 (ii).

(iii) *Drainage system*

See section 6.2.2 (iii).

(iv) *Subsoil surface preparation*

The excavated and/or made-up ground must be finished uniform and smooth and free of any sharp protuberances. In particular, the surfaces being lined must be free of water, jagged rock, debris, roots or any matter that could damage the lining material (see section 5.9.2). There shall be a minimum unsaturated subsoil thickness beneath the geomembrane lining system of 150mm.

6.3.2 Lining and drainage installation

(i) *Installation of the geomembrane liner*

The liner shall be installed by the Lining Contractor strictly in accordance with the manufacturer's instructions and any requirements of the specification. When laid, the liner shall be free of creasing. Liner installation should not take place in temperatures below 5˚C or above 30˚C. The liner should be securely anchored above the top level of woodchips to ensure that only infiltration through the pad is collected by the underdrainage system. Anchoring systems shall be installed as per the Liner Contractor's instructions. Any additional protection for the liner surface as recommended by the lining contractor shall be installed.

(ii) *Installation of subsoil layer*

The subsoil layer overlying the geomembrane shall be installed using appropriate machinery to effect good compaction whilst protecting the underlying geomembrane system. Low to moderate permeability subsoil free of sharp protuberances shall be used as identified during the site assessment to form the unridged portion of the system. If there is insufficient suitable subsoil available on the site, additional suitable subsoil may be used. The subsoil liner shall be at least 0.2 m thick after installation.

(iii) *Perimeter embankment construction*

See section 6.2.4.

(iv) *Installation of underdrainage system*

See section 6.2.5.

6.4 Installation of woodchip bedding

The woodchip shall be placed on the drainage layer taking every reasonable precaution not to disturb the drainage layer underneath. This may be achieved using a tractor loader or an industrial loader and is effected by placing the woodchips on the nearest point initially and gradually covering the pad by driving on the lain woodchip.

6.5 Final surfaces

Excess topsoil can be placed against the outer toe of the perimeter embankments. The banks shall be sown as detailed in Clause C.1.5 of S132. The banks shall be maintained with a short grass mat thus minimising soil erosion potential and maximising bank stability. Non pasture species such as bushes or scrub shall not be allowed to develop on the banks nor shall trees be planted within 5.0m of the toe of the banks.

6.6 Effluent transfer

Effluent shall be transferred from the OWP to the storage or holding structure via a sealed watertight pipe with a minimum diameter of 100mm for pads less than 2000m^2 and 125mm for larger pads. This pipe shall be protected to minimise risk of damage by machinery or livestock.

6.7 Access to OWP

6.7.1 Tractor access

Tractor access shall be through a gated opening in the surrounding fence, normally 3.6m wide.

6.8 Fencing

The requirements of the fencing and gating component of the OWP are detailed in S132. Any fencing and access points (gates) shall be constructed in accordance with the requirements of Clause A.2.3 of S132.

Where necessary to sub-divide the OWP for livestock management purposes, the internal fences shall be attached to posts which are embedded in 0.1m^3 of concrete on top of the drainage stone.

7 Operation and maintenance of the out wintering pad

7.1 General operational requirements

The operational requirements of an OWP are dependant on the farming system being utilised by the farmer. Basic precautions shall be taken to ensure the safety of personnel (see Chapter 8). The OWP surfaces shall be inspected daily to assess surface cleanliness. The four photographs in the quadrat below show the progressive dirtying (a, b, c and d) of the surface over time in a clockwise direction. The top left is clean woodchip and the bottom left is woodchip that has been completely covered in a faecal layer. The pad surface on the bottom left is considered unacceptable as a lying area for animals; the other three categories are acceptable. When the entire pad surface does not allow a minimum area for all the animals to lie simultaneously on an acceptable surface, then the OWP shall be cleaned. The minimum lying area for a bovine animal is $2.2m^2$ for an adult and $1.5m^2$ for a yearling.

(a)

(d)

Figure 7-1 Different OWP woodchip surface conditions

During cleaning, the top 10cm approximately of woodchips are removed with a fork loader or similar and the OWP surface is replenished with a similar depth of clean chips. Care shall be taken to ensure that at no time the integrity of the liner is compromised during OWP operation.

Under normal circumstances the OWP is cleaned at the end of the winter and the woodchips are removed from the pad and landspread directly onto grassland in accordance with guidelines of the Nitrates Regulations and Code of Good Farming Practice.

The requirement for cleaning during the winter period is dependant on the stocking rate and the length of the accommodation period. Where the winter is longer than normal due to the system of production then it will be necessary to put in place facilities to accommodate the spent woodchip and these shall be built in accordance with DAF specifications S108. Alternatively, the spent woodchip may be stored within the OWP system, once the system is adequately sized.

7.2 General maintenance requirements

- OWP surface should be inspected daily for dirtiness and dryness (surface condition of pad);
- OWP outlet pipe should be inspected twice weekly to ensure that there are no leaks from the pad;
- If excessive volumes of effluent are observed flowing from the underdrainage system, inspect all water troughs for leaks and surrounding embankments for breaches;
- Very low outlet volumes could indicate leakage from the underdrainage system or a blockage;
- OWP drainage and lower woodchip layer should be inspected bi-annually to determine extent of lower woodchip layer breakdown.

8 Health and safety

8.1 Introduction

The overriding document covering all health and safety issues in Ireland is the Safety, Health and Welfare at Work Act 2005 which must be adhered to before, during and post construction of an out wintering pad (Clause A.2.1 of S132). Simple precautions can greatly reduce the risk of injury. A list of health and safety references which may be referred to is given at the end of this chapter. Farmers are required by law to identify the hazards and assess the risks on their farm and to draw up a written safety statement setting out the arrangements and resources provided to safeguard the safety and health of persons on the farm. Therefore, this task can be made much easier for the farmer if the correct health and safety precautions are taken at an early stage in the pad construction and operation. Section 8.4 of this chapter gives some general guidance on the possible health and safety issues for children and young persons with OWPs.

8.2 Health and safety issues for OWPs

The main safety concern with OWPs is the risk of animals injuring humans. To minimise this risk, cows with calves at foot and adult bulls should be managed with caution. Where bulls are present on an OWP, a sign at all access points to the OWPs shall alert all persons of the risk posed by bulls.

8.3 Children and young persons

Every year children are killed during agricultural work activities. Some simple precautions and supervision can drastically reduce the risk of injury to children. Children are naturally curious and will invariably gain entry to seemingly inaccessible places. OWPs must be fenced and gated in a fashion to deter children from entering. Children who have access to farm areas shall be properly supervised and instructed in proper safety measures. Any dedicated children's play area set aside for recreation shall be at a safe distance from the OWP.

8.4 General health and safety references for agriculture

- Health & Safety Authority: Guidelines on the preparation of a safety statement for a farm (www.hsa.ie)
- Health & Safety Authority: Play safe, stay safe on the farm (www.hsa.ie)
- Health & Safety Authority: Farm safety plan 2003 ~ 2007 (www.hsa.ie)
- National Authority for Occupational Safety and Health: Code of practice on preventing accidents to children and young persons in agriculture (www.hsa.ie)
- Department of Agriculture, Food and Rural Development: Good farming practice, 2001 (www.agriculture.gov.ie)
- Teagasc: Farm safety statement (www.teagasc.ie)
- Teagasc, Health and Safety Authority: Farm safety handbook (www.hsa.ie)

9 Appendix 1 Groundwater response matrix for OWPs

9.1 Introduction

The role of the groundwater response matrix is to provide an initial evaluation of the general suitability of a site for an out wintering pad (OWP), from a hydrogeological perspective, as part of the desk study. It can also be used to indicate the measures that may be required to meet the required specification. An explanation of the role of groundwater protection responses in a groundwater protection scheme is given in Groundwater Protection Schemes (DoELG/EPA/GSI, 1999). The geological and hydrogeological data that place a site within a response category is general to an area, and not specific to a site. It is therefore incumbent on the developer to demonstrate that the site conditions of a specific site are determined, before a decision is taken on the suitability or otherwise of a site. Examples of uncertainty on available data can include depth to rock values (and hence vulnerability ratings) and the presence of sand/gravel. A risk assessment approach is taken in the development of this response matrix.

9.2 Vulnerability rating and aquifer classification

Table 9.1 summarises how a vulnerability rating is assigned to a site. Once the rating has been assigned the classification of the aquifer underlying the site being investigated is assessed. The aquifer is classed as regionally important, locally important or poor. These classes are then subdivided as shown in Table 9.2.

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0m	0 - 3.0m	0 - 3.0m	0 - 3.0m	-
High (H)	>3.0m	3.0 - 10.0m	3.0 - 5.0m	>3.0m	N/A
Moderate (M)	N/A	>10.0m	5.0 - 10.0m	N/A	N/A
Low (L)	N/A	N/A	>10.0m	N/A	N/A

Notes: (1) N/A = not applicable.
(2) Precise permeability values cannot be given at present.
(3) Release point of contaminants is assumed to be 1-2 m below ground surface.

Table 9-1 Vulnerability rating (DELG/EPA/GSI, 1999)

Note: For an OWP, the release point of contaminants is assumed to be 0.5m to 0.75m below ground surface.

Aquifer classification					
Regionally important aquifers (R)		***Locally important aquifers (L)***		***Poor aquifers (P)***	
Karstified aquifers	Rk	Karstified aquifers	Lk	Bedrock which is generally unproductive except for local zones	Pl
Fissured bedrock aquifers	Rf	Sand/gravel	Lg	Bedrock which is generally unproductive	Pu
Extensive sand/gravel aquifers	Rg	Bedrock which is generally moderately productive	Lm		
		Bedrock which is moderately productive only in local zones	Ll		

Table 9-2 Aquifer classification (adapted from DELG/EPA/GSI,1999)

The source protection areas are delineated for public, group and industrial supplies. These areas provide additional protection by placing tighter controls on activities within the vicinity of the source. The matrix in Table 9.3 below gives the result of integrating the two regional elements of land surface zoning (vulnerability categories and resource protection areas). In practice this is achieved by superimposing the interim vulnerability map on the draft aquifer map. Each zone is represented by a code e.g. Rf/M, which represents areas of regionally important fissured aquifers where the groundwater is moderately vulnerable to contamination. All of the hydrogeological settings represented by the zones may not be present in each local authority area.

Vulnerability Rating	Source Protection Area		RESOURCE PROTECTION AREA Aquifer Category							
	Inner (SI)	Outer (SO)	Regionally Important Aquifer			Locally Important Aquifer		Poor Aquifer		
			Rk	Rf	Rg	Lg	Ll/Lm	Pl	Pu	
Extreme	SI/E	SO/E	Rk/E	Rf/E	Rg/E	Lg/E	Ll/E	Pl/E	Pu/E	
High	SI/H	SO/H	Rk/H	Rf/H	Rg/H	Lg/H	Ll/H	Pl/H	Pu/H	↓
Moderate	SI/M	SO/M	Rk/M	Rf/M	Rg/M	Lg/M	Ll/M	Pl/M	Pu/M	↓
Low	SI/L	SO/L	Rk/L	Rf/L	Rg/L	Lg/L	Ll/L	Pl/L	Pu/L	
	→	→		→	→		→	→	→	

↓→ directions of decreasing risk to groundwater

Table 9-3 Matrix of groundwater protection zones (DELG/EPA/GSI, 2005)

The appropriate response to the risk of groundwater contamination from an OWP in the different hydrogeological settings in Ireland (Table 9.3) is given by the assigned response category (R) appropriate to each protection zone (see Table 9.4).

9.3 Groundwater response matrix for OWPs

Note: In all responses listed below, a geomembrane-lined out wintering pad may be used in place of a subsoil-lined out wintering pad except for response R4.

Vulnerability Rating	Source Protection Area		RESOURCE PROTECTION AREA Aquifer Category						
	Inner (SI)	Outer (SO)	Regionally Important Aquifer			Locally Important Aquifer		Poor Aquifer	
			Rk*	Rf	Rg	Lg	Ll/Lm	Pl	Pu
Extreme	R4	R3[4]	R3[3]	R3[2]	R3[2]	R3[2]	R3[1]	R3[1]	R3[1]
High	R3[4]	R2[3]	R2[2]	R2[1]	R2[1]	R2[1]	R1	R1	R1
Moderate	R2[4]	R2[3]	R2[2]	R1	R1	R1	R1	R1	R1
Low	R2[3]	R2[3]	R2[2]	R1	R1	R1	R1	R1	R1

**A small proportion of the country (~0.6%) is underlain by locally important karstic aquifers (Lk); in these areas, the groundwater protection responses for the Rk groundwater protection zone shall apply.*

Table 9-4 Response matrix for out wintering pads (OWPs)

The responses are given below:

R1 Acceptable, subject to normal good practice (i.e. investigation, construction, operation and maintenance in accordance with DAFF Minimum Specification S132) and to meeting the following requirements:

(1) The OWP shall be underlain by either a subsoil liner or a geomembrane liner.
(2) In general all subsoil-lined OWPs shall be underlain by at least 0.5m of moderate to low permeability unsaturated subsoil enhanced by compaction to ensure a maximum permeability of $1 \times 10^{-8} m.s^{-1}$ is achieved. The clay content of the subsoil being used as a compacted liner shall be at least 10% as determined in the laboratory using a particle size distribution (PSD) test (BS 1377) and where the particle size distribution is adjusted by excluding materials larger than 20mm. Additionally, the compacted subsoil liner shall be underlain by at least 0.25m of unsaturated subsoil (see Note 1 below).
(3) Where the subsoil is at least 1.0m thick and is characterised as moderate to low permeability, unsaturated, impervious, free of preferential flowpaths and has a clay content of at least 13%, the surface of the excavated portion of the OWP will only require plastering with remoulded subsoil.
(4) The OWP shall not be underlain directly by sand/gravel in vertical hydraulic conductivity with the main watertable. Therefore, if the underlying subsoil is classed as sand or gravel (or where the clay content is <10%), suitable subsoil will need to be imported to form the subsoil liner (see Note 1 below).
(5) All geomembrane-lined OWPs shall be underlain by at least 150mm of unsaturated subsoil, the upper 50mm of which may be a protective fine sand layer depending on the requirements of the lining contractor. The geomembrane shall be overlain by low to moderate permeability subsoil with a minimum thickness of 200mm (see note 1).
(6) The OWP shall be at least 60m away from any well or spring used for potable water.

$R2^1$ As R1 with the following additional requirement:

(7) Where the permeability of the subsoil is considered to be greater than $1 \times 10^{-8} m.s^{-1}$, the minimum thickness of the compacted unsaturated subsoil liner component shall be 0.75m. Additionally, the compacted subsoil liner shall be underlain by at least 0.25m of unsaturated subsoil (see Note 1 below).

$R2^2$ As R1, also meeting requirements (7) and with the following additional requirements:

(8) The OWP shall be at least 15m away from karst features that indicate enhanced zones of high bedrock permeability (e.g. swallow holes and dolines (collapse features).
(9) The site assessment shall pay particular attention to the possibility of instability in these karst areas.

$R2^3$ As R1, also meeting requirements (7), (8) (in karst areas) and (9) (in karst areas).

$R2^4$ As R1, also meeting requirements (7), (8) (in karst areas) and (9) (in karst areas) and with the following additional requirements:

(10) Where microbial pathogens and/or high nitrate concentrations are known to be present in the water supply source, more detailed site investigation and/or restrictive design requirements may be necessary.

$R3^1$ Not generally acceptable, unless requirements (1), (2), (3), (4), (5), and (6) can be met (see Notes below).

$R3^2$ Not generally acceptable, unless requirements (1), (2), (3), (4), (5), (6) and (7) can be met (see Notes below).

$R3^3$ Not generally acceptable, unless requirements (1), (2), (3), (4), (5), (6), (7), (8) and (9) can be met (see Notes below).

R3[4] Not generally acceptable, unless requirements (1), (2), (3), (4), (5), (6), (7), (8) (in karst areas), (9) (in karst areas) and (10) can be met (see Notes below).

R4 Not acceptable.

Note 1: In cases where sufficient suitable subsoil is not available, suitable subsoil may be imported for use.

Note 2: Achieving the required minimum subsoil thickness beneath the OWP underdrainage system may be difficult to achieve in these situations.

	Requirements	R1	R2[1]	R2[2]	R2[3]	R2[4]	R3[1]	R3[2]	R3[3]	R3[4]	R4
1	The OWP shall be underlain by either a subsoil liner or a geomembrane liner.										NOT ACCEPTABLE
2	In general all subsoil-lined OWPs shall be underlain by at least 0.5m of moderate to low permeability unsaturated subsoil enhanced by compaction to ensure a maximum permeability of 1 x 10^{-8}m.s^{-1} is achieved. The clay content of the subsoil being used as a compacted liner shall be at least 10% as determined in the laboratory using a particle size distribution (PSD) test (BS 1377) and where the particle size distribution is adjusted by excluding materials larger than 20mm. Additionally, the compacted subsoil liner shall be underlain by at least 0.25m of unsaturated subsoil (see Note 1 below).										
3	Where the subsoil is at least 1.0m thick and is characterised as moderate to low permeability, unsaturated, impervious, free of preferential flowpaths and has a clay content of at least 13%, the surface of the excavated portion of the OWP will only require plastering with remoulded subsoil.										
4	The OWP shall not be underlain directly by sand/gravel in vertical hydraulic conductivity with the main watertable. Therefore, if the underlying subsoil is classed as sand or gravel (or where the clay content is <10%), suitable subsoil will need to be imported to form the subsoil liner (see Note 1 below).										
5	All geomembrane-lined OWPs shall be underlain by at least 150mm of unsaturated subsoil, the upper 50mm of which may be a protective fine sand layer depending on the requirements of the lining contractor. The geomembrane shall be overlain by low to moderate permeability subsoil with a minimum thickness of 200mm (see note 1).										
6	The OWP shall be at least 60m away from any well or spring used for potable water.										
7	Where the permeability of the subsoil is considered to be greater than 1x10^{-8}m.s^{-1}, the minimum thickness of the compacted unsaturated subsoil liner component shall be 0.75m. Additionally, the compacted subsoil liner shall be underlain by at least 0.25m of unsaturated subsoil (see Note 1 below).										
8	The OWP shall be at least 15m away from karst features that indicate enhanced zones of high bedrock permeability (e.g. swallow holes and dolines (collapse features)).										
9	The site assessment shall pay particular attention to the possibility of instability in these karst areas.										
10	Where microbial pathogens and/or high nitrate concentrations are known to be present in the water supply source, more detailed site investigation and/or restrictive design requirements may be necessary.										

Table 9-5 General groundwater response requirements for OWPs

10 Appendix 2 Classifying a subsoil

10.1Introduction

Subsoils may be classified by the site assessor using the methodology outlined in BS5930:1999 Code of practice for site investigations. This methodology coupled with the laboratory test results for particle size distribution (PSD) will enable the subsoil to be accurately characterised and its appropriateness for use in the construction of an out wintering pad assessed. A brief description of the laboratory test methodology is given below. The standard followed is BS1377-Part 2:1990 Methods of test for Soils for civil engineering purposes: Classification tests.

10.2Particle size distribution (PSD) test

Particle size distribution tests are conducted to quantify the fraction of gravel, sand, silt and clay present in a subsoil sample. A combination of wet and dry sieving is used to determine the grading of the subsoil down to the fines (silt and clay) fraction. The relative percentages of silt and clay present is determined by sedimentation using either the hydrometer or pipette method as outlined in BS 1377-Part 2:1990. Once the test on the subsoil has been completed, the percentages of each fraction present in the sample will be known. A particle size distribution (PSD) curve may then be drawn which allows the designer to quickly assess the grading and uniformity of the subsoil. When assessing subsoil for use in the construction of an OWP, the subsoil must have a minimum clay content of 10%. The clay content is based on the percentage of clay present in the fraction of the whole subsoil sample passing the 20mm sieve.

10.2.1 Utilising the PSD curve

The purpose of the test method outlined in section 10.2 is to enable the designer to classify the subsoil using BS 5930:1999 and consequently to make a judgement on the suitability of the subsoil for use in the construction of an OWP. Firstly, the soil is classified as either Coarse or Fine.

- COARSE SOILS: <35% of the material is finer than 0.063mm (passes 63µm sieve).
- FINE SOILS: >35% of the material is finer than 0.063mm
- A coarse soil may be further subdivided by sieving into Gravels or Sands.
- GRAVEL: > 50% of the coarse fraction is > 2mm in size.
- SAND: > 50% of the coarse fraction is < 2mm in size.

Further classification is possible by examining the percentage of fines in the subsoil and looking at the grading curve of the sample. A fine soil may be sub-classified by examining the percentage of fines in the sample.

10.3Subsoil field assessment tests

In the field, experience and sound judgement may be used to classify subsoil. The tests described below shall be used in conjunction with Table 10.2 and Figure 10.2 below for the naming of subsoils. This section is adapted from BS 5930:1999.

10.3.1 Field assessment of grading

Coarse and fine soils may be distinguished from each other simply as coarse soils do not stick together when wet whereas fine soils do. It may be necessary to adjust the water content of the sample to correctly assess this. Gravels and sands are simple to classify as sand particles are less than 2mm in size and gravel greater than 2mm.

The boundary between fine sand and coarse silt can be assessed by eye, as coarse silt particles cannot be seen with the naked eye.

10.3.2 Field assessment of plasticity

(i) *Cohesion and plasticity of fine fraction of coarse soils*

The sample shall first be loosened and then moulded and a handful pressed in the hands. It may be necessary to add water and remove the larger gravel pieces. A soil shows cohesion when, at a certain moisture content, its particles stick together to give a relatively firm mass. If the soil can be deformed without rupture, i.e. without losing cohesion, then it exhibits plasticity. Cohesive, plastic soils include clays, silts and some peats. Sands are neither cohesive nor plastic although they do sometimes cohere when wet.

(ii) *Toughness of fine soils*

Toughness refers to the character of a thread of moist soil rolled on the palm of the hand, moulded together, and rolled again until it has dried sufficiently to break at a diameter of approximately 3mm. In this condition:

Subsoil type	*Toughness characteristics*
Inorganic clays of high plasticity	Fairly stiff and tough
Inorganic clays of low plasticity	Softer and more crumbly
Inorganic silts	Weak and often soft thread that breaks up, crumbles readily, and may be difficult to form
Organic soils and peat	Very weak, spongy or fibrous thread, which may be difficult to form at all, and whose lumps crumble readily

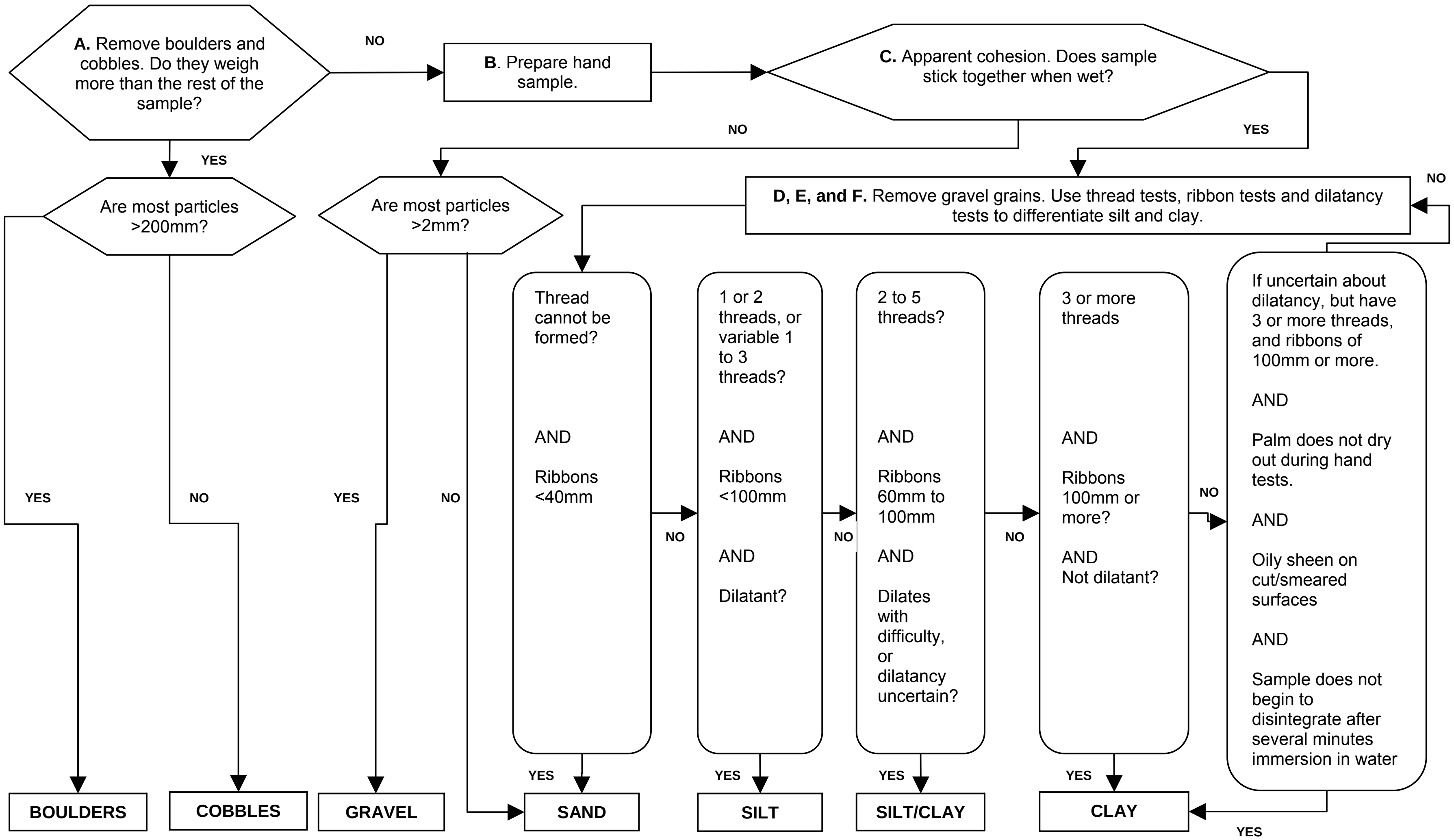
Table 10-1 Toughness characteristics for characterising the toughness of fine soils (BS5930:1999)

(iii) *Dilatancy test*

A pat of subsoil sample moistened to be soft, but not sticky, is held on the open horizontal palm of the hand. The side of the hand is then jarred against the other hand several times. Dilatancy is indicated by the appearance of a shiny film of water on the surface of the pat. When the pat is squeezed or pressed with the fingers, the surface dulls as the pat stiffens and finally crumbles. These reactions are marked only for predominantly silt-size material and fine sand, and normally indicate the presence of these materials.

10.3.3 Using results to classify subsoil

The table and flow chart below assist the assessor is classifying the subsoil being characterised. The results of the field classification tests shall be used in conjunction with the laboratory analysis to ensure that the subsoil has been correctly classified.


A. Remove boulders and cobbles. Do they weigh more than the rest of the sample?
NO
B. Prepare hand sample.
C. Apparent cohesion. Does sample stick together when wet?
NO
YES
YES
Are most particles >200mm?
Are most particles >2mm?
D, E, and F. Remove gravel grains. Use thread tests, ribbon tests and dilatancy tests to differentiate silt and clay.
NO
Thread cannot be formed? AND Ribbons <40mm
1 or 2 threads, or variable 1 to 3 threads? AND Ribbons <100mm AND Dilatant?
2 to 5 threads? AND Ribbons 60mm to 100mm AND Dilates with difficulty, or dilatancy uncertain?
3 or more threads AND Ribbons 100mm or more? AND Not dilatant?
If uncertain about dilatancy, but have 3 or more threads, and ribbons of 100mm or more. AND Palm does not dry out during hand tests. AND Oily sheen on cut/smeared surfaces AND Sample does not begin to disintegrate after several minutes immersion in water
YES
NO
YES
NO
NO
NO
NO
NO
YES
YES
YES
YES
YES
BOULDERS
COBBLES
GRAVEL
SAND
SILT
SILT/CLAY
CLAY

Particle sizes as defined in BS5930:1999		
Boulder	>200mm	Larger than a soccer ball
Cobble	60 ~ 200mm	Smaller than a soccer ball, but larger than a tennis ball
Gravel	2 ~ 60mm	Smaller than a tennis ball, but larger than match heads
Sand	0.06 ~ 2mm	Smaller than match head, but larger than flour
Silt	0.002 ~ 0.06mm	Smaller than flour (not visible to the naked eye)
Clay	< 0.002mm (2μm)	Not visible to the naked eye

A: Examine Boulders and Cobbles (test adapted from BS5930:1999)

- using a hammer, trowel or pick, clean off a portion of trial pit wall.
- examine whether the quantity of boulders/cobbles is dominant over finer material. This will usually be easily done by eye. If unsure, separate boulders/cobbles from finer material in two sample bags and compare weights by hand.

B and C: Preparation of Sample and Apparent Cohesion Test (tests taken from BS5930:1999)

- collect a hand-sized representative sample from the cleaned-off portion of the trial pit wall.
- remove particles larger than 2mm, as far as possible.
- crush clumps of subsoil and break down the structure of the sample.
- slowly add water (preferably as a fine spray), mixing and moulding the sample until it is the consistency of putty; it shall be pliable but not sticky and shouldn't leave a film of material on your hands. Can the sample be made pliable at the appropriate moisture content?
- if it can, squeeze the sample in your fist ~ does it stick together?

D: Thread Test (test adapted from combination of BS5930:1999 and ASTM(1984))

- ensure the sample has the consistency of putty. This is very important! Add extra water or sample to moisten or dry the sample.
- check that no particles greater than 1mm or 2mm occur in the prepared sample.
- gently roll a thread 3mm in diameter across the width of the palm of your hand. Remove excess material.
- if a thread can be rolled, break it and try to re-roll without adding additional water.
- repeat until the thread can no longer be rolled without breaking.
- record the total number of threads that were rolled and re-rolled.
- repeat the test at least twice per sample. Water can be added between each test repetition, to return the sample to the consistency of putty.

E: Ribbon Test (test adapted from the USDA (NRCS/SCS Soil Survey Handbook)

- ensure the sample has the consistency of putty. This is very important! Add extra water or sample to moisten or dry the sample.
- check that no particles greater than 1mm or 2mm occur.
- form your moist sample into a large roll in your hand, approximately the width of your thumb.
- hold your hand and arm parallel with the ground. Using your thumb, press the sample over your index finger to form a uniform ribbon about thumb-width and 0.5cm thick. Let this ribbon hang over your index finger and continue to extrude the ribbon between thumb and index finger until it breaks. Be careful not to press your thumb through the ribbon.
- measure the total length of the formed ribbon when it breaks (i.e. from tip of thumb to end of ribbon).
- repeat this test at least three times per sample to obtain an average ribbon value. Water can be added between each repetition, to return the sample to the consistency of putty.

F: Dilatancy Test (test taken from BS5930:1999)

- wet the sample such that it is slightly wetter (and softer) than for a thread test, but not so wet that free water is visible at the surface.
- spread the sample in the palm of one hand, such that no free water is visible at the surface.
- using the other hand, jar the sample 5 times by slapping the heel of your hand or the ball of your thumb. Take note of whether water rises to the surface or not, and how quickly it

does so.

- squeeze the sample, again noting if the water disappears or not, and how quickly.
- dilatant samples will show clear and rapid emergence of a sheen of water at the surface during shaking, and clear and rapid disappearance from the surface during squeezing. Non dilatant samples will show no discernible sheen.
- decide whether your sample has Dilatancy. Beginners often find it quite difficult to determine the presence of a sheen, unless it is very obvious. It will become easier once samples with clear Dilatancy are observed.

Criteria for describing density /compactness (fine subsoils) (BS5930:1999)		***Criteria for describing discontinuities (BS5930:1999)***	
Term	Field Test	Term	Mean spacing (mm)
Uncompact	Easily moulded or crushed in fingers	Very widely	>2000
Compact	Can be moulded or crushed by strong finger pressure	Widely	2000 ~ 600
Very soft	Finger easily pushed up to 25mm	Medium	600 ~ 200
Soft	Finger pushed up to 10mm	Closely	200 ~ 60
Firm	Thumb makes impression easily	Very closely	60 ~ 20
Stiff	Can be indented slightly by thumb	Extremely closely	<20
Very stiff	Can be indented by thumbnail	Fissured	Breaks into blocks along unpolished discontinuities
Hard	Can be scratched by thumbnail	Sheared	Breaks into blocks along polished discontinuities

Figure 10-1 Flow chart to aid in classification of subsoils in Ireland (adapted from GSI, 2001)

Table 10-2 Field tests for classification of subsoils (GSI, 2001)

11 Appendix 3 OWP sizing and effluent production calculations

11.1 Introduction

The area of the OWP is determined by

- calculating the amount of animals requiring accommodation
- deciding whether the animals shall be fed on or off the OWP
- assigning the corresponding animal spacing allowances

The required effluent storage for an out wintering pad may be calculated using the following information:

- the area of the OWP
- the annual net rainfall on the pad
- the number of animals producing slurry on the pad
- the area of the feeding facilities (where appropriate)
- the regulatory effluent storage capacity requirements for the area

11.2 Sizing an OWP

The area of an OWP is determined based on the number of animals requiring accommodation and the method of feeding selected. If an on-pad feeding regime is selected for beef cattle then each animal being accommodated will require 16m^2 of pad area. Spacing allowances for different animal types for both on and off pad feeding are given in Table 11.1 below.

Animal type	***Minimum space requirements per animal (m^2)***	
	On pad feeding	Off pad feeding
Dairy cows	18	12
Suckler cow	16	10
Beef cattle (> 2 years)	16	10
Cattle (1 to 2 years)	12	8
Cattle (< 1 year)	10	6

Table 11-1 Minimum space allowances for animals accommodated on an OWP system

11.3 Slurry production

The European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006, has produced data which enables the estimation of neat excreta quantities produced by different classes of livestock. Table 11.2 below is adapted from this data and is used to assist in the calculation of slurry production.

Livestock category	***Sub-category***	***Neat excreta (N.E.) (urine & faeces) (m^3.wk^{-1})***
Cattle	Dairy cows	0.33
	Suckler cow	0.29
	Cattle (> 2years)	0.26
	Cattle (18 to 24months)	0.26
	Cattle (12 to 18months)	0.15
	Cattle (6 to 12months)	0.15
	Cattle (0 to 6months)	0.08
Sheep	Lowland ewe	0.03
	Mountain ewe	0.02
	Lamb-finishing	0.01

Table 11-2 Estimated quantities of neat excreta produced by different classes of livestock (av. weight animals) (adapted from Table 2, Schedule 2, GAPPW, 2006)

11.4Regulatory effluent capacity requirement

Once the weekly effluent production from the farm has been established, the next stage is to ascertain the required storage period (usually in weeks). This period is determined by referring to the most current regulatory guidelines including Local Authority Agricultural Bye-Laws and the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006. The most current guidance is given below (Table 11.3) but it must be noted that this guidance may change and that at all times the designer must apply the most up-to date guidance available.

Zonal configuration	
Zone A	16 weeks slurry storage capacity
Zone B	18 weeks slurry storage capacity
Zone C	C1: 22 weeks slurry storage capacity
	C2: 20 weeks slurry storage capacity

Table 11-3 Proposed zonal configuration under European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006 (adapted from GAPPW, 2006)

Zonal Configuration			
Counties in Zone A	Counties in Zone B	Counties in Zone C	
		C1	C2
Carlow	Clare	Cavan	Donegal
Cork	Galway	Monaghan	Leitrim
Dublin	Kerry		
Kildare	Limerick		
Kilkenny	Longford		
Laois	Louth		
Offaly	Mayo		
Tipperary	Meath		
Waterford	Roscommon		
Wexford	Sligo		
Wicklow	Westmeath		

C2 Recognising the high water quality in counties Leitrim and Donegal and the lesser agricultural pressures in comparison with counties Cavan and Monaghan, two weeks lesser storage is required in Counties Donegal and Leitrim.

Table 11-4 Proposed zonal configuration under European Communities (Good Agricultural Practice for Protection of Waters), 2006 (adapted from GAPPW, 2006)

Figure 11.1 illustrates the proposed zonal configuration.

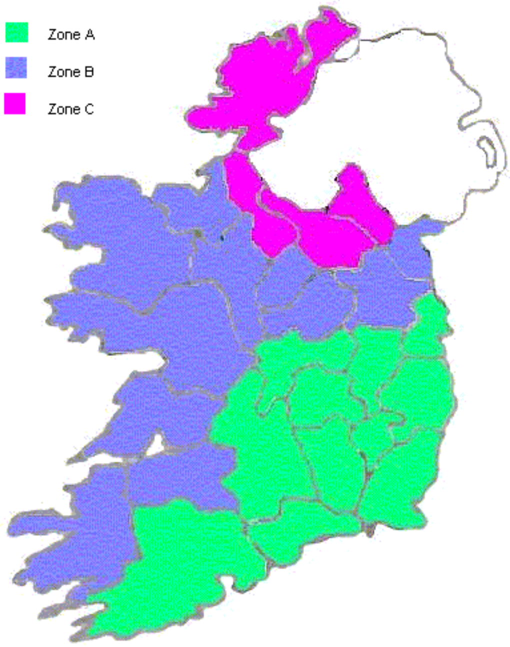


Figure 11-1 Proposed zonal configuration under European Communities (Good Agricultural Practice for Protection of Waters), 2006

11.5Net rainfall capacity calculation

Current guidance on net rainfall calculations are as follows:

- a net rainfall (mm.wk^{-1}) is given for each county

County	***mm.wk^{-1}***
Carlow	24
Cavan	27
Clare	32
Cork	37
Donegal	38
Dublin	17
Galway	34
Kerry	45
Kildare	18
Kilkenny	23
Laois	22
Leitrim	33
Limerick	26
Longford	23
Louth	20
Mayo	40
Meath	19
Monaghan	23
Offaly	20
Roscommon	26
Sligo	32
Tipperary	27
Waterford	31
Westmeath	21
Wexford	25
Wicklow	33

Table 11-5 Average net rainfall during the specified storage period (GAPPW, 2006), (www.environ.ie)

11.6OWP storage capacity

By following the steps in this appendix, you will have calculated the minimum size of the proposed OWP and its associated effluent storage requirement.

11.7 OWP liquid volume calculation (worked example)

Minimum size of OWP				
A	Animal type		(Table 11.2)	Beef cattle (>2 years)
B	No. of animals	no.		150
C	Feeding method			On-pad
D	Minimum space allowance per animal	m^2	(Table 11.1)	16
E	Minimum pad area	m^2	B x D	2400
Effluent storage requirements				
F	Location of farm		County	Meath
G	Zoning designation of farm		Table 11.4	B
H	Minimum slurry storage requirements	wk	Table 11.3	18
J	Net rainfall on pad	$m.wk^{-1}$	Table 11.5	0.019
K	Net excreta (N.E.) per animal	$m^3.wk^{-1}$	Table 11.2	0.26
L	Effluent production (see below)	$m^3.wk^{-1}$	Section 5.5*	53.4
M	Minimum effluent capacity required	m^3	H x L	961.2

Table 11-6 Worked example of an OWP design

*The effluent production calculation is outlined below:

Appropriate effluent production equation:

$$E = (P \times R) + (N \times V) - (P \times 0.013)$$ **Effluent from on-pad feeding OWP**

where:

E = effluent produced ($m^3.wk^{-1}$)
P = pad area (m^2)
R = net rainfall on the pad ($m.wk^{-1}$) (see Table 11.5, Appendix 3)
N = no. of animals on the pad
V = neat excreta produced per animal per week ($m^3.wk^{-1}$) (see Table 11.2, Appendix 3)

Pad area (P): $2400m^2$
Net rainfall on pad (R): $0.019m.wk^{-1}$
Number of animals on pad (N): 150
Neat excreta produced per animal per week (V): $0.26m^3.wk^{-1}$

Therefore effluent produced (E) is calculated as follows:

$E(m^3.wk^{-1})$ = (2400 x 0.019) + (150 x 0.26) – (2400 x 0.013) = 45.6 + 39 – 31.2 = 53.4

The minimum effluent storage period is 18 weeks; therefore the minimum effluent capacity required is 53.4 x 18 = $961.2m^3$.

12 Appendix 4 Site assessment form

12.1General details

Name and address of applicant:	
Telephone number:	
Fax number:	
Email address:	
PPS number:	
Herd number:	
Name and address of consultant:	
Telephone number:	
Fax number:	
Email address:	
Site location and townland:	
Grid reference:	

12.2Background information

Topographical maps as per planning pack to accompany this application:					YES/NO
Local experience of OWPs (if available):					
Surface water~ Description of surface water features in proximity of the site including designation:					
Geology and Hydrogeology					
Soil (name and type):					
Subsoil:					
Bedrock geology:					
Aquifer category (tick as appropriate):		Regionally important	Locally important		Poor
Groundwater vulnerability (tick as appropriate where available):		Extreme	High	Moderate	Low
Is there a groundwater protection scheme (Yes/No):			***Groundwater protection response for OWP:***		
Presence of significant sites (including reference):	Archaeological:				
	Natural:				
Utilities (locations):		***Safe***		***Needs further investigation***	
Power lines:	Above ground:				
	Below ground:				
Gas mains:					
Sewerage:					
Water mains:					
County development plan:					
No. and type of animals requiring accommodation:					
Comments: (integrate the information above in order to comment on the potential suitability of the site, potential targets at risk and/or any potential site restrictions)					

12.3Visual assessment

Slope:	
Density of dwellings, places of gathering within 500m of site (give distance to nearest feature):	
Property boundaries (distance to nearest):	
Roads (distance to):	
Existing land use:	
Outcrops (rock and/or subsoil): Note if any and describe	
Surface water ponding:	
Beaches/shellfish areas/wetlands:	
Karst features:	
Lakes/watercourses/streams*:	
Drainage Systems*:	Open – Piped -
Wells*:	
Springs*:	
Type of vegetation (note any areas of wetland vegetation):	
Cultural heritage assessment (comment on potential risk):	
Natural heritage assessment (comment on potential risk):	
Comments: (integrate the information above in order to comment on the potential suitability of the site, potential targets at risk, the suitability of the site to construct an OWP and the location of the proposed system within the site).	

**Note Water Level*

12.4Trial hole

The minimum depth of each trial hole shall be 1.5m.

Trial hole number:		***Date and time of excavation:***	
Depth of trial hole (m):		***Date and time of examination:***	
Depth from ground surface to bedrock (m) if present:			
Depth from ground surface to water table (m) if present:			

Depth below ground surface (m)	***Soil/subsoil texture and classification (note plasticity and dilatancy results)***	***Density/ compactness***	***Colour***	***Preferential flowpaths***
0.2				
0.4				
0.6				
0.6				
1.0				
1.2				
1.4				
1.6				
1.8				
2.0				
2.2				
2.4				
2.6				
2.8				
3.0				

Other information (where relevant)			
Depth of water ingress (m):		***Rock type (if present):***	
Sample depth (m):			
Compaction test result (visual description):			

Evaluation: Use the following questions to crystallise the evaluation of the trial hole assessment and make recommendations on the next stage of the assessment (see section 3.6.2 of the Guidance Document):

At this stage of the site assessment the following questions can be answered:

(a) Is the site unsuitable for an OWP system?
(b) Is the site suitable for a geomembrane-lined OWP system?
(c) Is the site likely to be suitable for a subsoil-lined OWP system?

If the site is suitable only for a geomembrane-lined OWP system, then laboratory testing of the sampled subsoils need not be undertaken and the report can be completed.
However, if the assessment thus far has indicated that the site is likely to be suitable for a subsoil-lined OWP and the client/advisor is content to install such a system if site conditions are favourable then laboratory analyses should be undertaken and the results entered in section 12.5.

12.5 Laboratory soil test results

Trial Hole	*% Clay*

12.6 Sketch of site

Sketch of site showing measurement to trial hole locations, wells and direction of groundwater flow (if known), proposed OWP (including distances from boundaries), adjacent structures, watercourses, significant sites and other relevant features. North point shall always be included. (A copy of the site layout drawing shall be used if available)

(Certificate to be typed on Site Assessor's headed paper)

Certificate of completion of site assessment for out wintering pad

Name of Owner: ____

Address of Owner: ____

____

Address of site: ____

____

Depth to bedrock (if encountered): ___________ m

Depth to water table (if encountered): ___________ m

Is the site suitable to construct a subsoil-lined OWP:		YES NO
Thickness of subsoil liner required:	___________	m
Depth to suitable layer for subsoil liner:	___________	m
Thickness of suitable layer for subsoil liner:	___________	m

Is the site suitable to construct a geomembrane-lined OWP system:		YES NO
Depth to suitable layer for subsoil overlying geomembrane:	___________	m
Thickness of suitable layer:	___________	m

Special Conditions (if any)____

____

____

____

Name of Site Assessor: ____

Address of Site Assessor: ____

____

Site Assessor's signature: ________________________________

Date: ____________________

Phone:____________________

Fax: ____________________

Company Stamp:

(Certificate to be typed on contractor's headed paper)

Contractors certificate of installation of subsoil liner for subsoil-lined out wintering pads

Name of Owner: ____

Address of Owner: ____
____
____
____

I hereby certify that the subsoil liner component of the subsoil-lined out wintering pad was installed in full accordance with the requirements of the 'Site Assessment Report' for the site and at least meeting the requirements of the Department of Agriculture and Food specification S132, 'Minimum specification for out wintering pads.'

Name of contractor installing subsoil liner:________________________________

Address of contractor installing subsoil liner:________________________________
____
____
____

Date site certified: ________________________________

Name and position of person certifying installation:__________________________
____

Signature of person certifying installation: ________________________________

Date: __________

Phone:__________

Fax: __________

Company Stamp of Subsoil-Liner Contractor:

(Certificate to be typed on lining contractor's headed paper)

Contractors certificate of ground preparation and leak tightness for geomembrane-lined out wintering pads

Name of Owner: ____

Address of Owner: ____
____
____
____

I hereby certify that the excavation and preparation work performed is of the required standard to at least meet the requirements of the Department of Agriculture and Food specification S132, 'Minimum specification for out wintering pads.'

Name of contractor preparing site: ________________________________

Address of contractor preparing site: ________________________________
____
____
____

Date site certified ready for lining: ________________________________

Name and position of person certifying preparation work: ________________
____

Signature of person certifying preparation work: ______________________

It is further certified that the geomembrane-lining has been installed to, at least, the standard of specification S132 and is hereby certified as leak tight. It is also certified that all safety features have been installed and that the lining shall remain watertight for a minimum of 30 years.

Date of certification: ________________________________

Name and position of person certifying lining: ______________________
____

Signature of person certifying lining: ________________________________

Company Stamp of Lining contractor:

Date: __________

Phone: __________

Fax: __________

13 Appendix 6 References

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