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Transport Infrastructure Ireland

TII Publications

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Design of Soakaways

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Standards

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For all documents that existed within the NRA DMRB or the NRA MCDRW prior to the launch of TII Publications, the NRA document reference used previously is listed above under 'historical reference'. The TII Publication Number also shown above now supersedes this historical reference. All historical references within this document are deemed to be replaced by the TII Publication Number. For the equivalent TII Publication Number for all other historical references contained within this document, please refer to the TII Publications website.

An tÚdarás um Bóithre Náisiúnta
National Roads Authority

Design of Soakaways

March 2015

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Summary:

This Standard gives design guidance on how soakaways shall be incorporated into systems used to treat and store road runoff prior to discharging to ground. It describes the steps needed to protect receiving groundwater and the constraints these may place on soakaway design and construction.

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VOLUME 4 GEOTECHNICS AND DRAINAGE

SECTION 2 DRAINAGE

PART 8

NRA HD 118/15

DESIGN OF SOAKAWAYS

Contents

1. INTRODUCTION

General

1.1 This Standard gives guidance on how soakaways shall be incorporated into systems used to treat and store road runoff prior to discharging to ground. This Standard has been compiled to summarise and review the current available design guidance in use within Ireland on the selection and construction of soakaways. The design guidance provided in this document focuses on 'point' discharges to the ground from 'single' soakaways (or combinations of these). These are defined as drainage structures (pits, chambers and trenches) that allow infiltration to the ground through their base and sides and that incorporate below ground storage.

1.2 The Standard originates from a review of available information on the fate and transport of road contaminants and the design of existing road soakaway systems. The review focused primarily on an understanding of the processes operating in the unsaturated zone (i.e. above the water table) and how these may influence soakaway design and prevent groundwater pollution.

Background

1.3 The 2015 revision of the NRA's drainage standards was precipitated by post-doctoral research carried out under the NRA's Research Fellowship Programme and mentored by the NRA's Environment Unit. This research looked at the impacts of national road drainage systems on both surface and groundwater. The research concluded that the NRA's drainage standards needed to be expanded to promote the use of sustainable drainage systems and to maximise environmental benefits. A report entitled *Drainage Design for National Road Schemes – Sustainable Drainage Options* (NRA, 2014) documents this research and provides useful background reading to the NRA's drainage standards. This document is available at: nrastandards.nra.ie/latest/other-nra-documents.

1.4 There is growing awareness that road runoff may, under certain circumstances, have an adverse effect on receiving waters, including groundwater. This has arisen both because of improving knowledge of the polluting content of road runoff and because of improved treatment of other sources of pollution. For further guidance on pollution protection and water quality refer to NRA HD 45 Road Drainage and the Water Environment.

1.5 The disposal of road runoff through soakaway systems is reasonably well established within Ireland. However, the attenuation mechanisms operating on road runoff to reduce pollutant loadings at the discharge point below the soakaway, and within the unsaturated zone above the water table, have in the past been poorly understood. Recent UK research has identified significant pollution attenuation mechanisms operating within soakaway drainage systems and these should be taken into account during soakaway design.

1.6 Design of other drainage structures such as linear drains is discussed in NRA HD 33 Drainage Systems for National Roads. The design of infiltration basins and other vegetated systems to treat road runoff is discussed in NRA HD 103 Vegetated Drainage Systems for Road Runoff. NRA HD 45 provides guidance on assessing the risks to groundwater from road runoff. This may preclude the use of a soakaway to discharge to ground.

Design Concepts

1.7 There are three major objectives in the drainage of roads:

a) the speedy removal of surface water to provide safety and minimum nuisance for the road user;

b) provision of effective sub-surface drainage to maximise longevity of the pavement and its associated earthworks;

c) minimisation of the impact of road runoff on the receiving environment.

1.8 These design objectives require that to operate successfully, soakaways shall be sited in porous and permeable ground of sufficient depth and lateral extent to be able to accommodate potential maximum discharges under storm conditions. Furthermore, what is good for the physical disposal of road drainage (i.e. rapid dispersal of flow) is the exact opposite of what is required with respect to the in-ground attenuation of pollutants. Where slow infiltration rates are utilised to optimise these in-ground processes, the use of detention ponds or other flow attenuation mechanisms may be required to accept the quantity of runoff generated under peak flow conditions by the road drainage.

1.9 This Standard allows the designer to consider those processes that may occur in the passage of road runoff through the soakaway system and through the unsaturated zone, prior to its ultimate discharge into groundwater. NRA HD 45 provides guidance on assessing the risks to groundwater from road runoff. The ground water protection response (GPR) shall be carried out for all direct discharges to ground. It is good practice to include a range of pollutant mitigation measures upstream of soakaway discharge. Refer to chapter 3 of this standard for further guidance. Such measures could include structures for the control and containment of accidental spillages, or introduce methods for the treatment of pollution derived from routine road runoff. Guidance for these measures may be found in NRA HD 33 and NRA HD 103.

1.10 Recently much attention has been paid to the design of drainage systems with more emphasis on controlled transmittal of runoff to discharge points (notably to surface waters). Such systems place a greater reliance on retaining water in storage ponds and allowing slow recharge to groundwater and have in particular been applied to the reduction of the flashy nature of runoff from urban drainage. Guidance on the use of these systems for roads is provided in NRA HD 103.

1.11 The design of soakaways, of any description, shall also take into account constraints arising from the possible impact on landscape and ecology. Discharges to groundwater may potentially affect biodiversity (e.g. through impacts on wetland habitats) and any such effects shall be considered both in the location and the function of the soakaways. Guidance on groundwater protection from discharges to ground is provided in NRA HD 45.

1.12 In spite of the promotion and introduction of measures that allow for the slow infiltration of road drainage into the ground, there is little data available that provides a sufficient basis to be able to quantify these effects, either in the short or longer term. As discussed above, further research, particularly on the fate of contaminants on the unsaturated zone, is needed to determine what these effects may be.

Purpose

1.13 The purpose of this Standard is to provide advice on the design and construction of soakaways comprising an excavated pit or trench rather than systems such as attenuation ponds for which there is design advice available elsewhere (NRA HD 103). This Standard also discusses the measures that can be made to complement the pollutant attenuation capacity of the soakaway system, including taking into account the underlying unsaturated zone, in order to prevent the risk of groundwater pollution. The Standard should therefore be read in conjunction with NRA HD 45 which provides an overview of the current knowledge of road runoff in Ireland, the ground conditions that are believed to affect its nature and a guide to assessing the risk of pollution arising from routine road runoff and accidental spillages.

1.14 The design of soakaways cannot be prescribed. Each situation should be considered individually as there are many factors that shall be taken into consideration, for example, depth of unsaturated zone, geology.

Scope

1.15 The principles outlined in this Standard apply to all National Road Projects.

Implementation

1.16 This Standard shall be used forthwith for all schemes for the construction and/or improvements of national roads. The standard shall be applied to the design of schemes already being prepared unless, in the opinion of the National Roads Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations shall confirm the application of this Standard to particular schemes with the National Roads Authority.

2. DESCRIPTION OF SOAKAWAY SYTEMS

General

2.1 There are a range of drainage systems which may act as soakaways, where the primary discharge from the system is to groundwater. Fundamentally, these aim to encourage efficient hydraulic contact between the drainage system and the underlying ground in order to provide effective drainage. Such options include for example:

a) combined surface water and sub-surface drains;

b) fin drains;

c) filter drains;

d) informal drains or ‘over the edge drainage.’

In addition there may be systems wherein discharge to groundwater occurs but is incidental to the function of the drainage (e.g. unlined ditches).

Further details of both these types of system are provided in NRA HD 33.

2.2 Additionally a number of surface water drainage features also incorporate discharges to the unsaturated zone for example:

a) detention ponds;

b) retention ponds;

c) sedimentation ponds;

d) infiltration basins;

e) wetlands;

f) swales/grassed channels.

Further details of these are provided in NRA HD 103.

2.3 These options all provide varying degrees of protection to groundwater resources. Guidance on the design of these types of drainage is provided in the NRA HD 33 and the NRA HD 103. Guidance on groundwater protection from discharges to ground is provided in the NRA HD 45. In order to produce a suitable design and to minimise the impact of road drainage on groundwater quality, whilst accounting for the attenuation properties of the unsaturated zone, soakaway drainage incorporating any of these options shall also embrace the design principles described in Chapter 3.

2.4 As described in Section 1.1, this guidance focuses on soakaway structures that essentially provide discharge to the ground at a single point, either through chambers or trenches or into open pit type structures.

2.5 There are a wide range of these soakaway types that have been put into use including, for example:

a) segmental concrete chambers within excavated pits (with the chamber used as storage);

b) pre-cast concrete perforated ring units;

c) brickwork within previously created excavations;

d) trenches;

e) open pits;

f) rubble/aggregate filled pits;

g) pits/trenches with proprietary 'geo-cellular' units.

2.6 Sections 2.6 to 2.11 provide typical design considerations for pre-cast and trench type soakaways, although the designer should consider those designs most suitable to ground conditions, space, discharge requirements and other site specific criteria.

2.7 Soakaways for draining roads will commonly service relatively large areas requiring significant storage volumes. Such soakaways may not, in themselves provide such storage capacity, although there are examples where large storage volumes comprise part of the soakaway.

Pre-cast Perforated Concrete Ring Type Soakaway

2.8 This system (see Figure 1) is commonly used for its simplicity of construction and ease with which compatible components can be supplied from various sources. An excavation to the required depth is made, a concrete footing formed and then segments lowered one on top of the other until the hole is filled. The area between the outside of the rings and the excavation can be backfilled with aggregate.

Trench Type Soakaway

2.9 Trench type soakaways shall be constructed with inspection tubes at regular intervals. These inspection tubes (observation wells) shall be connected by a horizontal perforated or porous distributor pipe laid in the top of the granular fill along the trench as shown in Figure 2 (BRE Digest 365). The extreme ends of the trenches shall be identified by inspection tube covers or other access covers.

2.10 Trenches are generally constructed with a horizontal base (CIRIA 156) and the volume between the structure and the excavation backfilled with granular material. Typically a minimum width of 300mm will be considered.

2.11 Trenches tend to require a lower volume of excavation and granular fill material for a given discharge capacity than a soakaway with a square profile. The narrower and longer the trench, the more efficient it is in terms of outflow performance and construction cost compared to wider and shorter trenches (CIRIA 522). A narrower trench, of for example, 0.3m width, requires a reduced storage volume relative to wider trenches, of 0.6m or 1.0m, because it has an enhanced outflow performance.

Contaminant Attenuation Processes

2.12 Once they enter the unsaturated zone around a soakaway, pollutants within road runoff are dependent upon ground conditions, subject to transport through various pathways prior to entering groundwater in the saturated zone. Such pathways are illustrated in Figure 3. Within these pathways, and with the unsaturated zone acting as a substrate, a number of contaminant attenuation processes occur which may act to reduce the concentration of pollutants arriving at the saturated zone.

2.13 Natural attenuation results from the combined impacts of physical processes (e.g. filtration), chemical reactions (e.g. oxidation of sulphides) and biochemical transformations (e.g. the degradation of compounds under aerobic or anaerobic conditions). The action of these various attenuation mechanisms may influence the design of a soakaway system for instance by maximising the contact with strata that may provide enhanced attenuation potential or preventing direct discharge into a strata that does not offer any potential.

Physical Attenuation Processes

2.14 The physical attenuation of contaminants may be by processes associated with adsorption onto the solid matrix through which flow takes place, or by filtration.

2.15 Adsorption retains contaminants within the matrix of the unsaturated zone. In general terms, materials of mixed mineralogy, especially those containing a proportion of clay minerals, provide greater opportunity for retention or retardation of particles by adsorption than formations composed principally of silica (e.g. clean sands and sandstones) or calcium carbonate (clean limestones).

2.16 Filtration removes suspended particles, trapping them within the pore spaces of the drainage medium. In general, shallow groundwater, protected by a thin unsaturated zone and composed generally of coarse grained or heavily fissured materials is likely to be more vulnerable to contamination by particulates (due to lesser potential filtration) than groundwater in finer grained, more massive materials and with a significant depth of unsaturated zone.

2.17 Volatilisation will allow partial attenuation of volatile organic compounds through venting to atmosphere from a porous matrix. The effectiveness of this process depends on the relative temperature of the ground with respect to ambient air and the depth of unsaturated zone.

Chemical and Biochemical Attenuation Processes

2.18 Chemical and biochemical processes of attenuation act mainly on organic contaminants such as hydrocarbons, although metals may be transformed through processes such as oxidation.

2.19 Biodegradation is typically the most important process acting to reduce contaminant mass. The process acts to reduce contamination levels by oxidation-reduction reactions and is dependent on groundwater geochemistry, microbial population, and contaminant properties. Biodegradation can occur under aerobic and/or anaerobic conditions and may ultimately result in complete degradation of many organic contaminants.

2.20 Abiotic degradation can result in partial or complete degradation of contaminants through chemical transformations. These reactions are dependent on the contaminant properties and groundwater geochemistry. Rates of degradation are typically much slower than those associated with biodegradation.

2.21 Recent research into the fate of contaminants in the unsaturated zone has highlighted the attenuation potential of organic rich layers within drainage systems, such as topsoil and other horizons. Field tests have shown significant reductions in contaminant concentrations, both organic and inorganic. This attenuation potential within the unsaturated zone shall be considered during the design stages of any soakaway system. Sediments with clay and silt particles provide greater attenuation capacity than coarser sands and gravels due to increased surface area and hence increased sorption potential. Organic matter present within soils can provide suitable environments for soil-borne microbes to provide a degradation mechanism for hydrocarbons. Care shall be taken not to bypass any such organic rich layers unless it is necessary to provide sufficient drainage capacity and consideration shall be made for incorporating soils or other sub-surface strata with high attenuation capacity into the overall soakaway design.

2.22 On this basis, preferred designs should comprise soakaway systems that are broad and shallow, such as infiltration ponds rather than deep and narrow systems. Guidance on the design of infiltration basins is provided in NRA HD 103.

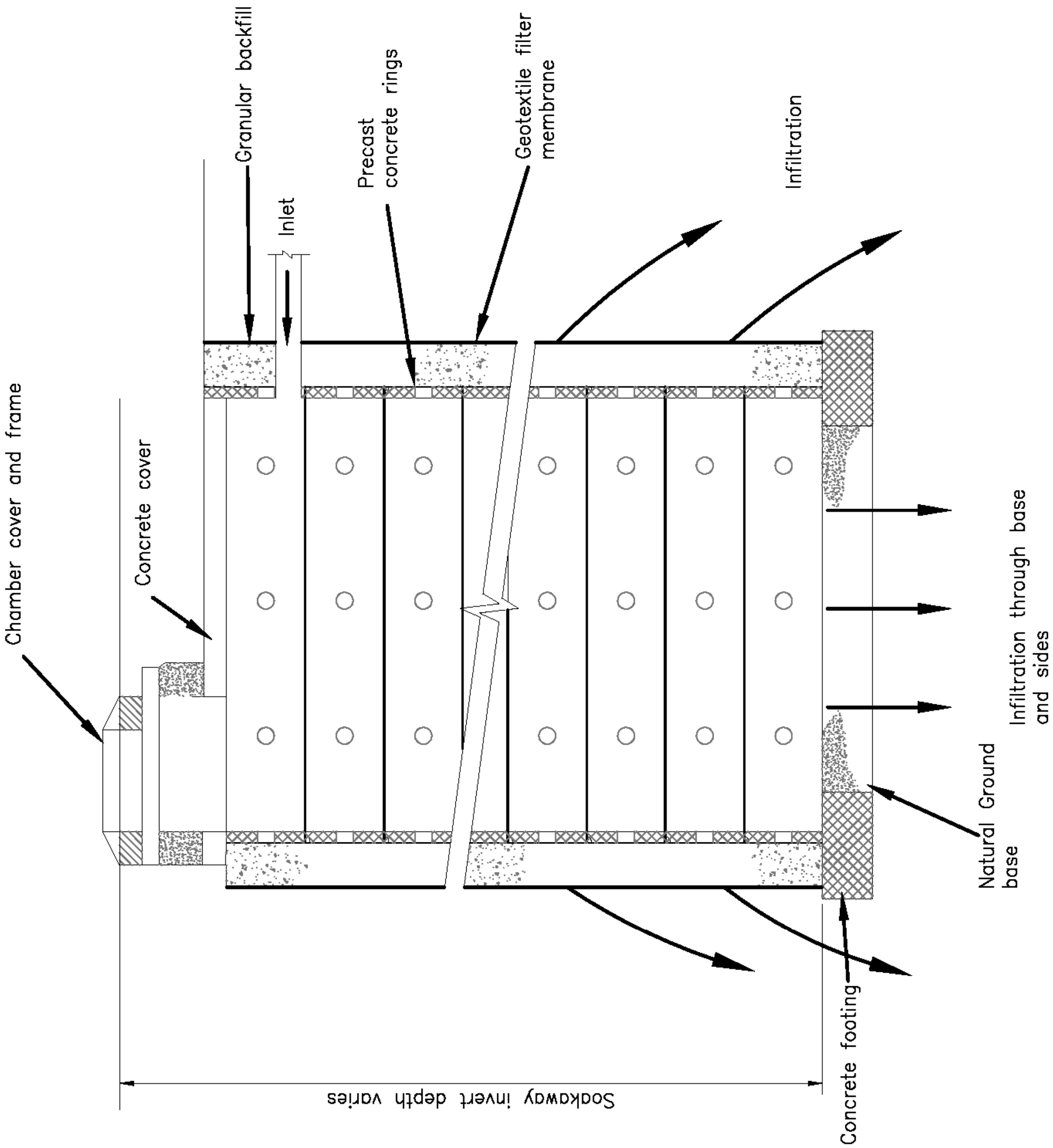

Figure 1: Pre-cast Perforated Concrete Rings Type Soakaway (After CIRIA C522)

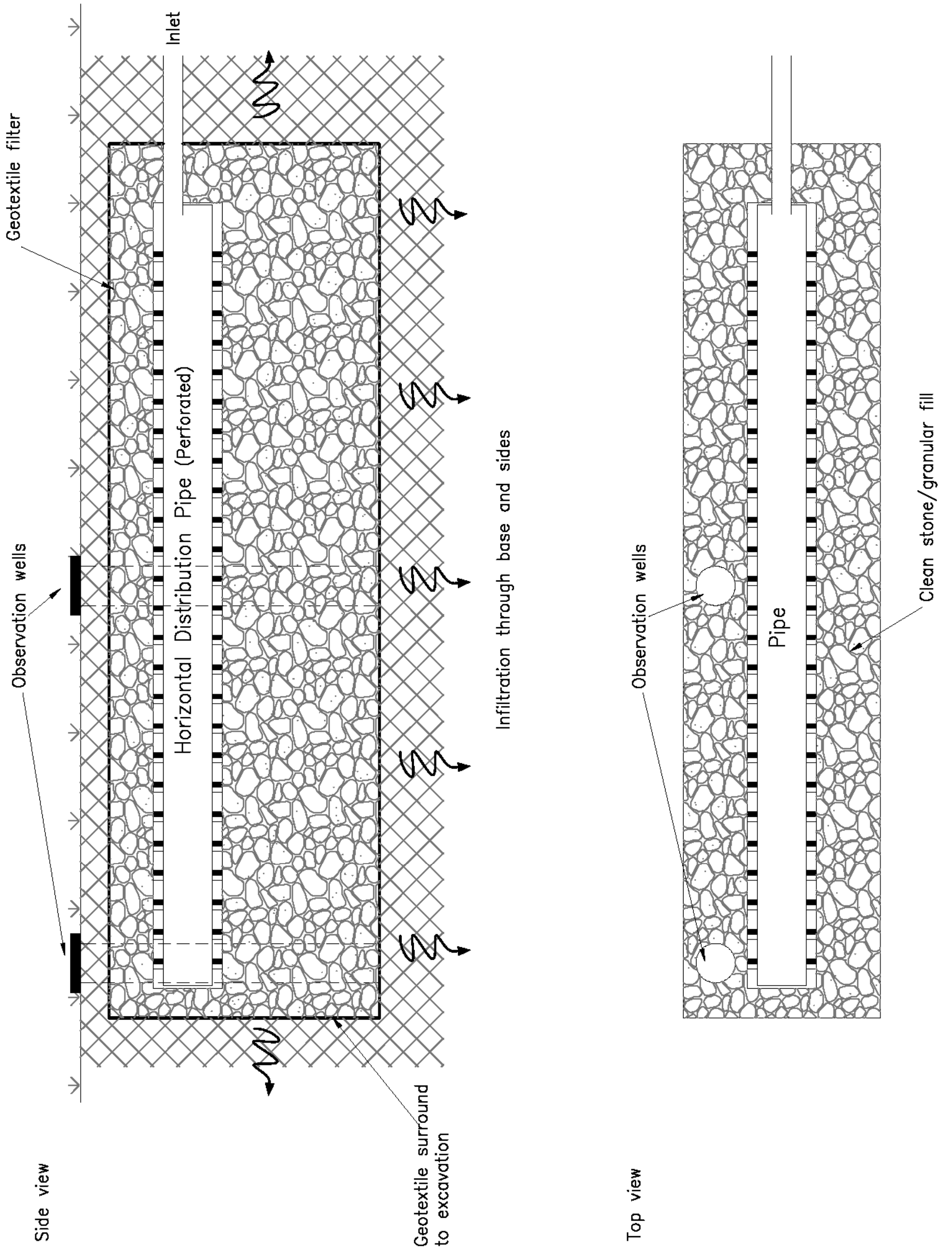

Figure 2: Trench Type Soakaway with Horizontal Distributor Pipe (After Figure 4 of BRE DG 365 © IHS. Reproduced with permission).

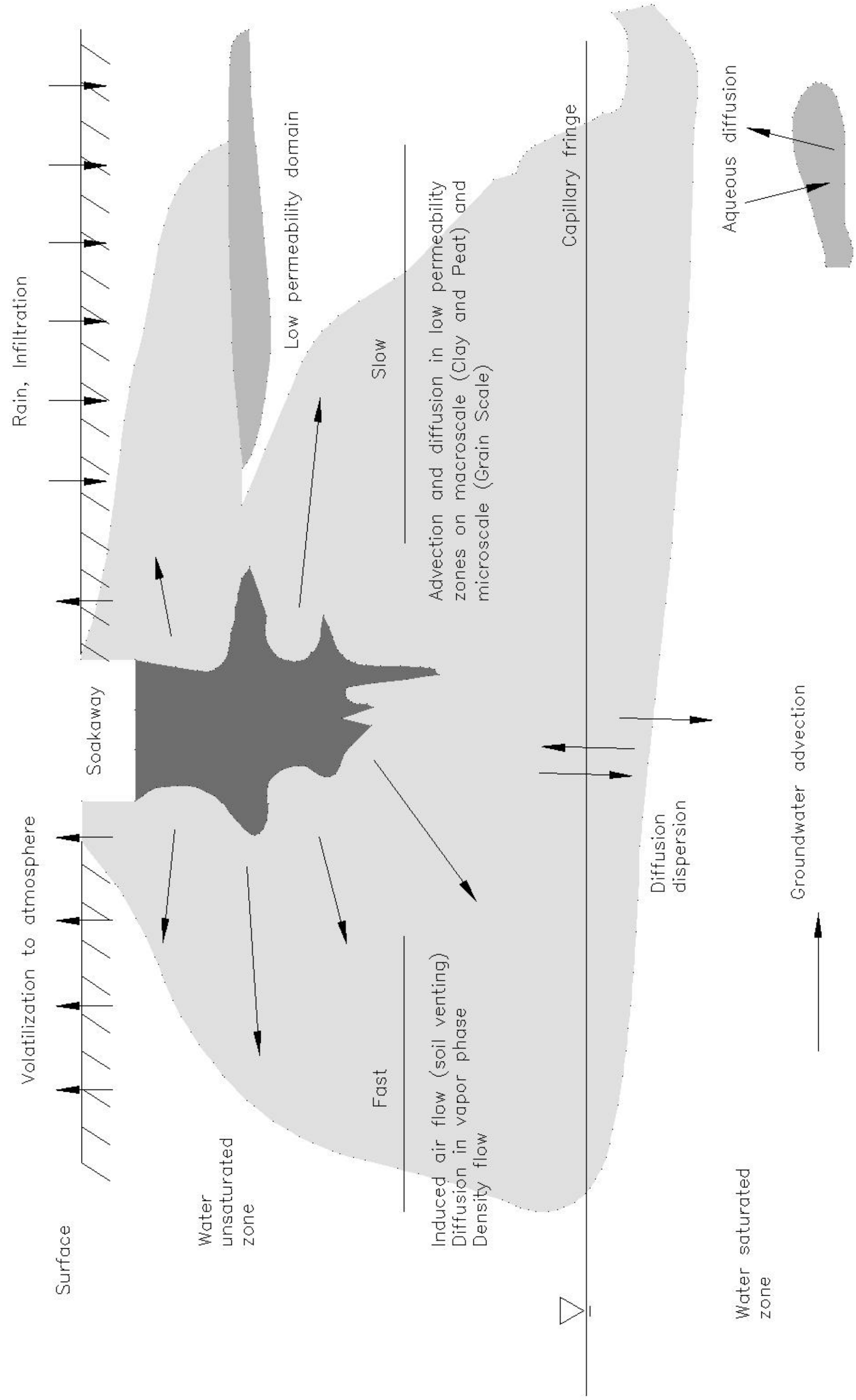

Figure 3: Schematic Showing Attenuation Processes Active in Subsurface

3. DESIGN AND CONSTRUCTION OF SOAKAWAY SYSTEMS

General

3.1 In the past soakaways have been designed primarily on hydraulic grounds; i.e. simply to transmit runoff efficiently and facilitate drainage into the underlying unsaturated zone using 1 in 10 year return periods for volume requirements. Previous designs of soakaway chambers have even incorporated boreholes to by-pass the unsaturated zone once the storage capacity of the chambers has been reached, ensuring that the roadway remains clear of water but potentially allowing contaminants to enter the saturated zone with little impedance. Under the current legislative regime and with the introduction of tighter controls within the Water Framework Directive, allowing direct discharge to groundwater through structures such as boreholes is considered inappropriate and shall not be used within a soakaway system design. NRA HD 45 provides mandatory requirements with respect to such direct discharges while NRA HD 33 provides guidance on the allowance for climate change in the hydraulic design of the drainage system.

3.2 Traditionally little regard has been made to the effects the soakaway may have in particular hydrogeological situations, although more recently designs have been influenced by the need to meet requirements set by the regulators.

Overall Requirements

3.3 There are three fundamental principles that shall be applied to soakaway discharge system design, which are to:

a) ensure that the hydraulic performance of the soakaway ‘outfall’ allows sufficient storage and infiltration capacity such that the system will have the capacity to drain the ‘design storm’ (and hence prevent flooding of the carriageway);

b) ensure protection of receiving groundwater; and

c) provide measures to prevent the possibility of an accidental spillage passing through the discharge system. The level of control provided shall be commensurate with the risk identified at a soakaway.

Guidance on the risk of pollution from accidental spillages is provided in the NRA HD 45.

3.4 The most fundamental hydraulic design principle for soakaway discharge systems for roads applications is to provide sufficient storage capacity to allow the removal of storm runoff from the carriageway, quickly and effectively. The principal hydraulic design criterion is therefore to provide sufficient capacity within the system to cover peak runoff. This is generally achieved by constructing large detention ponds, to temporarily store the water discharging from the road, upstream of the soakaways or by constructing underground chambers with porous sides or bases that also have sufficient internal capacity to store the runoff. The size and number of retention ponds or chambers shall be determined to provide the required capacity of the drainage system within the design constraints of the location.

3.5 The requirement to provide effective drainage cannot, however, override the need to protect groundwater, which is an explicit legal requirement. This applies to both pollutants carried by routine drainage (the focus of this Standard) and pollutants that may enter the system through accidental spillage.

3.6 As described in Section 1.9, the risk assessment methodology in NRA HD 45 provides a means to determine the level of risk to groundwater from chronic pollution derived from routine road runoff. This shall be carried out by a specialist and the potential risks discussed with the EPA (and Inland Fisheries Ireland, where relevant) prior to selection of the soakaway site. The assessment may demonstrate the requirement for pollution prevention measures to be incorporated in the design of the drainage system. These shall be incorporated upstream of the soakaway discharge.

3.7 The soakaway design shall take into consideration potential impacts on ecology, habitats and biodiversity. These could arise from, for example, potential effects of soakaway drainage on the quality of receiving groundwaters which subsequently emerge at the surface (e.g. providing flow to wetlands).

3.8 Certain soakaway designs (e.g. open pits) could encourage the development of new habitats. The implications of any such developments shall be evaluated both with respect to the potential for providing new habitats for protected species and with respect to the potential for encouraging invasive species.

3.9 Whilst the soakaway itself may have little manifestation at the surface, fencing, maintenance, access routes and signage may all have landscape impacts. Sympathetic design shall be adopted, particularly in sensitive locations.

Site Specific Factors

3.10 There are a number of potential limiting factors in the design of a soakaway. Refer to NRA HD 45 for further guidance. The GPR (NRA HD 45) provides an assessment to determine the risk to groundwater from routine runoff. The Highways Agency Water Risk Assessment Tool (HAWRAT) includes a tool for indicating the risk of an accidental spillage. Refer to NRA HD 45 for further details.

3.11 Note – the Water Framework Directive is such that it essentially treats all groundwater with equal weight – i.e. a certain ‘minimum level’ of protection is required. Where source protection areas may be impacted, additional protection may be warranted with respect to the protection of human health. These concepts are explained in more depth in NRA HD 45.

Site-Specific Design

3.12 Once the general area where a soakaway is to be situated is identified, the detailed specific design is required. In the past designs have tended to be general for a whole scheme with no variations to take into account differences in ground conditions along the route. As a road generally traverses a wide range of ground conditions the design of the discharge system shall also change to reflect this. Subject to the results of the GPR (NRA HD 45), in low lying areas near rivers there may be little unsaturated zone available and a soakaway should be broad and flat in configuration whereas on high ground, the depth of unsaturated zone is large enough for smaller deeper structures, reducing the amount of land take.

3.13 The pre-treatment of drainage water shall also be considered as a means of reducing or removing some potential contaminants, as well as possibly providing some short-term storage capacity within the drainage system. Treatment systems may require periodic maintenance to remove accumulated pollutants before the capacity is exceeded. As an example, the use of vegetative treatment systems in road drainage is discussed in NRA HD 103.

3.14 There are a number of factors to be considered when selecting a soakaway for a specific location. The key factors are the topography and the shape of the area available adjacent to the road. The design shall ensure that the:

a) soakaway selected suits the site dimensions;

b) soakaway is not within 3-6m of a building, to meet practices nationally (see note below);

c) road sub-base remains unsaturated when the soakaway is at its maximum design capacity;

d) vertical distance between the soakaway and the groundwater is maximised;

e) soakaway does not lead to (harmful) groundwater emergence down gradient;

f) soakaway does not surcharge groundwater leading to (harmful) waterlogging or exacerbate groundwater flooding;

g) soakaway does not lead to the washing out of fines or lead to (harmful) dissolution of the sub-surface or otherwise lead to instability of the sub-surface;

h) soakaway does not lead to discharges into old mine workings or into areas of known landslip hazard.

Some of these aspects of soakaway design are critical to minimise impacts on nearby structures and the water environment. NRA HD 33 provides mandatory guidance with respect to a number of these design elements.

<u>Note:</u>

According to I.S. EN 752: “If drainage is to be a soakaway, the subsoil and the general level of the groundwater should be investigated. It is not desirable to locate a soakaway closer than 3m to 6m from a building’s foundations, nor in any other position such that the ground below foundations is likely to be adversely affected.”

BRE Digest 365 recommends that: “Soakaways should not normally be constructed closer than 5m to building foundations.”

Similar recommendation is made in Irish Building Regulations which state: “Soakaways should not be built within 5 m of a building or road or in areas of unstable land.”

Given the potentially high discharge volumes and rates that may be generated by road run-off, designers must consider the proximity of buildings on a site specific basis, particularly with respect to ground conditions.

3.15 CIRIA 156 includes a number of flowcharts to aid the design process, including the selection of a suitable system.

Soakaway Design

3.16 The GPR process described in NRA HD 45 includes evaluation of the geological setting of the site, which shall be a fundamental consideration in the development of the design.

3.17 Based on the criteria detailed in the following sections, and subject to the GPR, the key elements in the design and construction of an effective soakaway are:

a) where identified as necessary through the spillage risk assessment (NRA HD 45), the introduction of containment and control measures for potential pollution from accidental spillage;

b) where identified as necessary, pre-treatment to remove non-soluble and particulate contaminants;

c) sufficient capacity to accommodate the quantity of design runoff;

d) sufficient drainage paths/ports within soakaway and sufficient hydraulic conductivity of the surrounding ground material to allow unimpeded infiltration to groundwater table;

e) filter or settlement mechanisms to prevent the blockage or siltation of the drainage paths and the surrounding ground;

f) maximising depth of unsaturated zone;

g) outlets/ overflows will be required to make allowance for the controlled overflow of extreme storm events in excess of the 1 in 10 year design storm and any discharge from these overflows must be routed safely to avoid flooding the road and minimise impact upon adjacent land;

h) the drainage system as a whole must be assessed for the consequences up to and including the 1 in 100 year storm event. Where the consequences of any identified flooding are unacceptable, the National Roads Authority must be consulted;

i) the provision of observation wells/pipes (inspection tubes/chambers) to allow inspection and maintenance.

Infiltration Capacity

3.18 The performance of a soakaway system will depend to a large extent on the ability of water to infiltrate through the unsaturated zone, which is in turn dependent on the physical properties of the ground and the surface area in contact with the soakaway. The site specific infiltration capacity shall be confirmed on site through soakaway testing. The base of all soakaway tests shall be placed at the invert level of the proposed drainage. The ability of a soakaway to transmit water will be influenced by a number of factors, such as the number and size of drainage ports, the amount of sediment allowed to settle and remain in the chambers and the degree of choking that occurs immediately outside the chamber in the surrounding ground. For example, special soakaway manhole rings are available from pre-cast concrete suppliers. These have sufficient outlets to allow the water to infiltrate into the ground. If non-standard pre-cast concrete units are used, or a site-specific design for the soakaway chamber is undertaken, then the capacity to discharge into the ground shall be considered.

Vertical and Horizontal Drainage

3.19 The permeability of a rock formation may vary between the horizontal and vertical, dependent upon the precise lithology and structure. In sedimentary formations consisting of interbedded layers, the horizontal (along bedding) component may be significantly higher than the vertical. The effectiveness of soakaways in layered systems will be heavily influenced by the degree of interconnection between layers of high transmissivity, through fractures and fissures.

3.20 In areas of significant fracturing, for example in some sandstones or granite, in an otherwise homogenous lithology, the soakaway performance will be determined largely through interception of one or more fracture systems.

3.21 Natural geological systems may be complex, with a variety of flow components contributing to drainage capacity around the soakaway. Site specific information such as infiltration rates obtained through soakaway testing will be required to optimise soakaway design to local flow conditions.

Aspect Ratio

3.22 It is considered good practice to maximise the depth of unsaturated zone below a soakaway device to allow the maximum attenuation of pollutants to occur. This may mean that the depth and size of chambers needs to be varied so that in areas with less unsaturated depth, the soakaway system comprises a number of shallow interconnected chambers to provide sufficient short-term storage, whilst maximising the depth of unsaturated zone. In areas with a deeper unsaturated zone the soakaway may comprise fewer deeper chambers, so requiring less land, whilst still maintaining sufficient attenuation capacity. This is illustrated schematically in Figure 4. It should be noted, however, that further land may be necessary for access and maintenance. Requirements for groundwater water protection shall be adhered to in accordance with NRA HD 45.

3.23 Surface infiltration systems (e.g. infiltration basins etc.) also depend on surface area to provide sufficient drainage capacity, so that a large shallow infiltration basin will allow rapid dispersal of water through the semi-permeable base whereas a deep narrow pond will retain water for much longer.

Storage

3.24 The drainage system must provide a balance between sufficient infiltration rate and storage capacity to allow the fast and efficient removal of water from the surface of the road. The storage capacity must be designed to cope with peak runoff from the maximum design storm events defined, for no flooding of the road surface without the drainage network backing up. Storage is thus essential where the discharge rate from the road exceeds the infiltration capacity of the soakaway. The rate of runoff from the road surface shall be calculated using an appropriate design methodology/drainage modelling programme using the actual design rainfall values. The calculated outflows from the drainage system shall be utilised in the design of the soakaway instead of following the methods given in the published design guidance (BRE 365 and CIRIA 156). This will ensure that the soakaways are designed to suit the actual road or section thereof under consideration.

Spillages

3.25 Measures to control and contain spillage shall be installed where the combination of the probability of the occurrence of a major spillage and risk to the receiving waters is sufficient to justify them. Such measures will enable polluting material to be intercepted before it reaches the soakaway or infiltration zone, providing sufficient time for emergency spill responses to be implemented. Guidance on the necessity for the provision of spillage control and containment is provided in NRA HD 45.

Design Procedures

3.26 Soakaways store storm water runoff and provide for its infiltration into the surrounding soil. The infiltration must occur sufficiently quickly to provide the necessary capacity within the drainage system to cope with the expected runoff, based on expected rainfall intensity and frequency or the outflow calculations from the use of modelling as described earlier in Section 3.24. Providing adequate storage volume and subsequent discharge are the two design parameters that govern the calculations for soakaway design. Design of soakaways and infiltration trenches shall be undertaken in accordance with published good practice (BRE 365 and CIRIA 156).

3.27 It is also possible to determine information relating to the capacity for a given lithology to transmit water through a falling or rising head test using a groundwater monitoring standpipe or borehole. This test is generally carried out by surcharging a piezometer with water and monitoring the fall in head as the column of water equilibrates with the water table over time. A procedure for undertaking this test is provided in I.S. EN ISO 22282-2. This test may potentially be useful at initial design stages as many road schemes will have borehole coverage along the length of the proposed route and calculations of the aquifer permeability can be made at each location.

3.28 The BRE Digest 365 provides advice on the design of soakaways in urban environments, which, whilst not strictly applicable to roads, does provide methods for determining the size of the soakaway required to deal with anticipated levels of runoff. The methodology uses a 10 year return period for a 15 minute duration storm to determine the required storm flow capacity. This may not be appropriate for roads design.

3.29 The BRE's methodology does not allow for attenuation of flow within the drainage system itself. Road drainage systems will very often comprise long drain runs which run to a low point in the road to where the soakaway drainage is provided. A significant amount of water will be attenuated as it flows through the drainage run, effectively reducing the peak flow at the soakaway. The BRE's methodology, therefore, over designs the required soakaway capacity based on inflow volume from the road and in order to accurately calculate the required soakaway size the inflow calculation used in the guidance should be replaced with the design flows calculated for the road based on guidance in NRA HD 33.

3.30 CIRIA 156 provides brief guidance on designs of drainage systems to remove pollutants, based on physical and biological systems, such as sediment traps, interceptors, soakaways and vegetative treatment systems for a range of drainage scenarios, including roads. This report provides methods for determining the required size for a drainage system based on the amount of rainfall and infiltration characteristics of the ground. In terms of groundwater protection this report relies upon the UK Environment Agency's Policy and Practice for the Protection of Groundwater, which provides basic guidance on the suitability of discharges to soakaway in terms of providing protection to water abstraction sources and groundwater resources in general. The report concentrates on source protection and does not provide detailed advice on treatment systems. Implementation of the Water Framework Directive requires a different approach whereby all groundwater is protected regardless of use.

3.31 The methodology within CIRIA 156 uses the lower portion of the chamber walls plus the base of the soakaway to calculate the infiltration rate into the ground and hence the required storage capacity. It should be noted that over time the base of a soakaway can become silted, unless adequate maintenance or upstream protective measures are implemented. Incorporating the base into the contact area can thus lead to overestimating the rate of infiltration and underestimating the volume of storage. This method can therefore under estimate the size of soakaway required for a given inflow runoff rate.

3.32 The design guidelines in BRE 365 and CIRIA 156 may not always give similar results for a specific circumstance because the two methods treat the factor of safety in different ways. CIRIA 697 reference both methods as applicable without favouring either one.

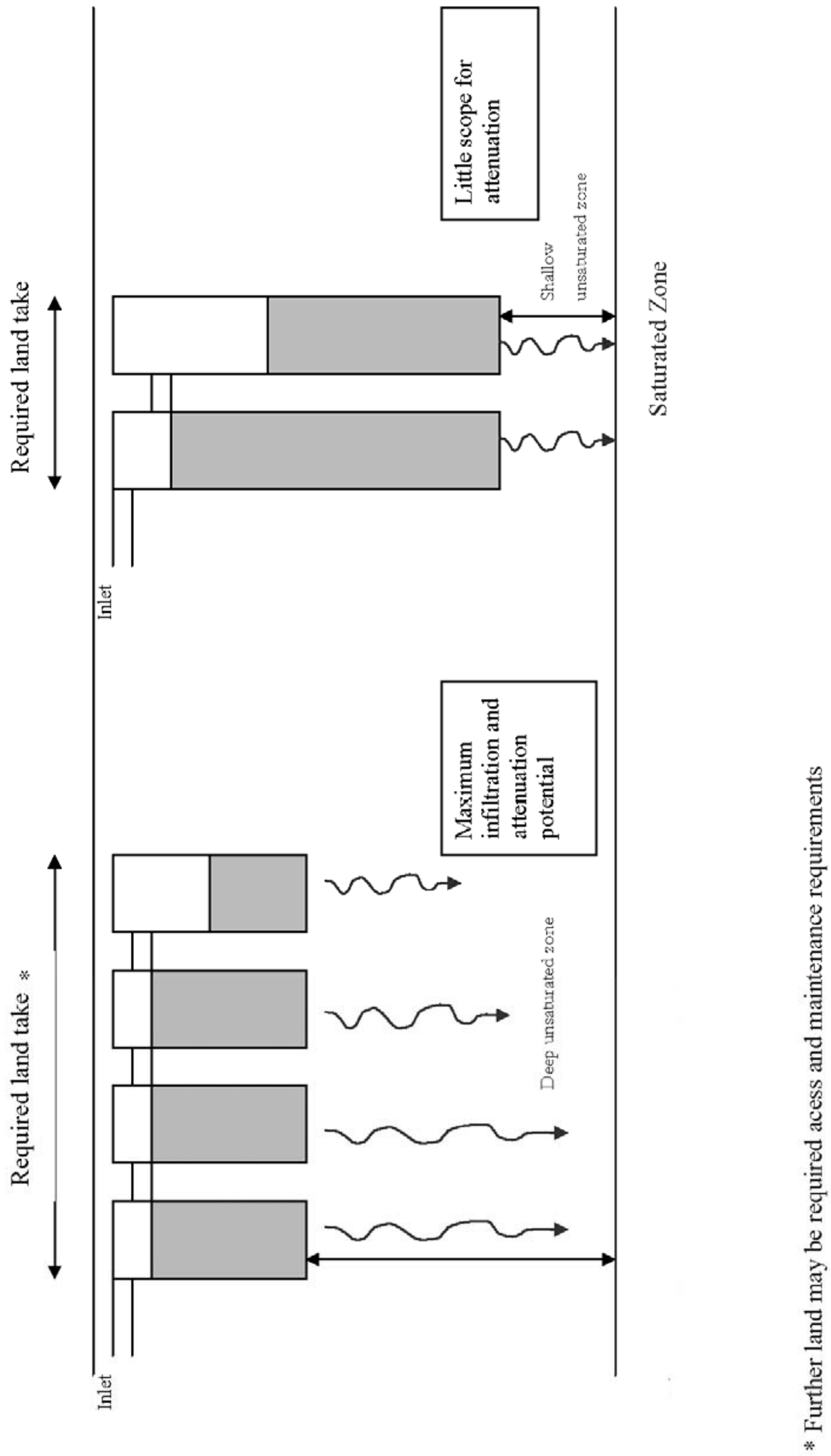

Figure 4: Maximising the Depth of Unsaturated Zone

4. CONSTRUCTION PRACTICES

General Construction Guidelines

4.1 Soakaways shall be constructed sufficiently far away from buildings or other structures such as bridges in order to prevent the risk of undermining foundations. Building practices recommend that a minimum distance of 3-6m between a sub-surface drainage system and a building should be adopted, depending on ground conditions (see Section 3.14).

4.2 Soakaways shall not normally be deeper than 3 to 4m in order to maximise the length of the flowpath to the water table through the unsaturated zone. The greater the thickness of unsaturated zone available, the greater the potential for pollutant attenuation. The issue of fate and transport of pollutants from road drainage is discussed fully in NRA HD 45.

4.3 The long term performance of the soakaway depends on maintaining the initial storage volume by keeping the pores clear within the granular fill. Any material that is likely to clog the pores of the drainage material or seal the interface between the storage and the adjacent soil shall be intercepted before discharge to the soakaway (CIRIA 522) in order to maximise the effective life of the soakaway between cleaning. An assessment of the risk of pollution and need for pre-treatment is discussed in NRA HD 45. Consideration of the need for sediment traps and, where appropriate, oil interceptors to treat the surface water prior to discharge to soakaways may be required (CIRIA 156) based on an assessment of the risks. Vegetative systems are discussed in NRA HD 103 and treatment efficiencies for various drainage systems are provided in NRA HD 33 for a range of common pollutants. Physical process systems, such as vortex separators, can also be used to pre-treat run-off.

4.4 Whilst the interception of sediments prior to entry into the soakaway is an essential pre-requisite to good design, some soakaway designs may incorporate the use of geotextiles to prevent the migration of fine materials. Geotextiles may be used to:

a) separate granular backfill materials from ground material in the walls of excavated pits;

b) prevent fines within the soakaway from migrating outward into granular surround materials hence reducing clogging of those materials;

c) lay over the top surface of a granular fill to prevent downward ingress of backfill material during and after surface reinstatement.

The requirements for the use of geotextiles will be specific to the type of soakaway design adopted.

Health and Safety Considerations

4.5 Designers and specifiers should be aware of the risks to the public, road maintainers and those implementing the design. A risk assessment should be undertaken at the time the systems are designed or specified.

4.6 Ease of access for maintenance is important, not only to encourage regular maintenance, but also for the safety of the maintenance operatives. It will also aid emergency personnel in carrying out any measures to mitigate the effects of a spillage. Appropriate access to systems remote from the main carriageway is essential in all locations, and in many locations a gated access could be provided. Designers should ensure that there is adequate, safe access for both workers and plant and that provision is made for all maintenance operations to be carried out without disruption to the safety and free flow of traffic on the adjacent carriageway.

4.7 The mandatory implementation of appropriate Health and Safety procedure in the design, construction and maintenance of soakaway systems is described in NRA HD 33.

5. MAINTENANCE AND MANAGEMENT OF SOAKAWAY SYSTEMS

Routine Maintenance

5.1 Road runoff contains a significant amount of particulate material, in the form of road stone and tyre fragments, mud and dust. Without periodic removal of this, the discharge system will eventually become blocked. In designing a discharge system, an effective means of trapping sediment shall be provided, in an easily accessible area for periodic emptying and maintenance.

5.2 The frequency of inspection of soakaways shall be determined during the immediate post construction period. Maintenance requirements for each soakaway will be described within specific NRA maintenance requirements covering the construction and operation of the soakaway and will take precedence over any other guidance. Published guidance suggests that an initial period of frequent monitoring is carried out to determine the rate of accumulation of sediment in both soakaway and pre-discharge treatment devices (particularly silt traps in order to allow the long-term frequency of inspection/cleaning to be determined. Cleaning requirements and frequency will depend upon the size and type of area drained. A suggested maintenance schedule is set out below, although these requirements should not be interpreted rigidly, and a proactive approach based on site specific requirements, is to be encouraged:

a) removal of debris from the floor of chamber and sediment traps (minimum annual frequency);

b) check observation wells/inspection tubes for clogging and to ensure soakaway is emptying (annual);

c) inspect area around soakaway for ground settlement or sediment loss (annual);

d) removal and washing of exposed stones on the trench surface (annual);

e) trimming any roots that may be causing blockages (annual).

If annual inspections show significant performance deterioration, granular materials surrounding the soakaway may have become clogged – these may need replacement and or overhaul. The frequency for these more intrusive actions can only be assessed on a site specific basis and will be very variable.

5.3 Maintenance should be undertaken in accordance with the relevant NRA maintenance requirements and will usually require a suction tanker for debris removal. If maintenance is not undertaken for very long periods, deposits might become hard-packed and require considerable effort to remove, requiring care not to mobilise absorbed contaminants if solidified sediments are agitated.

5.4 The area draining to the infiltration device shall be regularly swept to prevent silt being washed off the surface.

5.5 A problem frequently encountered with drains and sewers is the ingress of tree roots through poor joints or cracks in the network. This occurs because roots are drawn to the presence of water and hence is a common problem with soakaways where a permeable structure is a design feature and roots can grow through the soakaway walls, reducing the passage of water.

5.6 In the maintenance and cleaning of open pit type soakaways, advice shall be sought from an ecologist, or other appropriately qualified environmental specialist, to ensure that the operation may be carried out with safeguards in place to protect protected species or breeding birds that may have colonised the pit. Similarly plant removal or trimming shall be undertaken following advice of both an ecologists and, as necessary landscape specialists. Further advice on these aspects of maintenance is provided in NRA HD 103.

5.7 It is essential to ensure that sediments cleaned out from one part of the system are not allowed to migrate further downstream in the drainage system or allowed to enter the water environment. Consideration must be given to the disposal of sediment and plant waste as these will retain contaminants from the road runoff. The disposal of the removed material shall be in compliance with relevant NRA maintenance management requirements and where disposal is to be to landfill, this waste will be subject to Landfill Directive (Council Directive 99/31/EC) and the specific waste licence conditions of the proposed receiving facility. Advice of the local authority (or EPA where relevant) shall be sought with respect to classification of any waste generated during maintenance and cleaning operations.

5.8 Sediment and plant waste may require pre-treatment prior to disposal at a landfill site. This can take place either as the material is extracted, at a separate treatment centre or at the landfill site itself. The disposal of any waste is expensive and disposal facilities are limited. The benefits of testing, screening, separation and mechanical de-watering of the sediments using mobile plant or a dedicated treatment centre, shall be considered. This not only facilitates the separation of the materials into high and low contamination levels (thereby minimizing disposal costs) but also reduces the volume and weight of any material that has to be landfilled by removing excess water. The sand and pressed cake so produced is in a form that can be accepted by landfill sites in accordance with Landfill Directive (Council Directive 99/31/EC) and the specific waste licence conditions of the proposed receiving facility.

5.9 This maintenance guidance is primarily aimed at chamber and trench type soakaways. Procedures will need to be adapted to the particular soakaway design used. Guidance on maintaining vegetative systems for roads is provided in NRA HD 103 with suggested frequencies for inspections of different components of these drainage systems. Consideration can be given to consigning waste to permitted treatment sites for subsequent reuse elsewhere.

Spillage Control

5.10 It is important to prevent gross pollution, such as may occur following a major road accident, from entering a soakaway. NRA HD 33 discusses the provision of control systems, such as notched weirs or penstocks, to prevent drainage water that is grossly contaminated from moving down the drainage system. Any such pollution control devices incorporated within a drainage system will require signing to allow quick identification and location by emergency services so that control measures can be safely and effectively deployed as soon as possible.

6. REFERENCES

6.1 **NRA Manual of Contract Documents for Road Works (NRA MCDRW)**

a) NRA Specification for Road Works (SRW) (MCDRW 1)

b) Notes for Guidance on the Specification for Road Works (NGSRW) (MCDRW 2)

c) Road Construction Details (RCD) (MCDRW 4)

6.2 **NRA Design Manual for Roads and Bridges (NRA DMRB)**

a) NRA HD 33 Drainage Systems for National Roads

b) NRA HD 45 Road Drainage and the Water Environment

c) NRA HD 103 Vegetative Drainage Systems for Road Runoff

6.3 BRE (1991) Soakaway design, Digest 365, Buildings Research Establishment, London.

6.4 IS EN ISO 22282-2:2012: Geotechnical Investigation and Testing. Geohydraulic Testing. Water Permeability Tests in a Borehole using Open Systems.

6.5 Byrns, G and Brewin, L. 2010. Fate of Highway Contaminants in the Unsaturated Zone – Final Synthesis Report, March 2010, Scott Wilson Ltd for the Highways Consultancy Group/Highways Research Group. Commissioned by Highways Agency.

6.6 BETTESS, R (1996) *Infiltration drainage – manual of good practice,* R156, CIRIA, London (ISBN: 978-0-86017-457-8) Go to: www.ciria.org.

6.7 MARTIN, P, TURNER, B, DELL, J, PRATT, C, CAMPBELL, N, PAYNE, J and REED, B (2000) *Sustainable urban drainage systems – design manual for England and Wales,* C522, CIRIA, London (ISBN: 978-0-86017-522-3).Go to: www.ciria.org.

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6.9 WOODS-BALLARD, B, KELLAGHER, R, MARTIN, P, JEFFERIES, C, BRAY, R and SHAFFER, P (2007) The SuDS Manual, C697, CIRIA, London (ISBN: 978-0-86017-697-8). Go to: www.ciria.org.

6.10 Groundwater Protection. Policy and Practice (GP3). Parts 1-4, Environment Agency, 2008.

6.11 Guidance Manual for Constructed Wetlands. R&D Technical Report P2-159/TR2 Environment Agency. 2003.

6.12 Napier, F; D'Arcy, B; Jefferies, C; Fogg, P; Lowe, W and Clarke, R. Oil and SUDS: managing a priority urban pollutant. 12th International Conference on Integrated Diffuse Pollution Management. Research Center for Environmental and Hazardous Substance Management. Khon Kaen University, Thailand ; 25-29 August 2008.

6.13 I.S. EN 752:2008: Drain and Sewer Systems Outside Buildings.

6.14 European Communities Environmental Objectives (Groundwater) Regulations (S.I. 9 of 2010).

6.15 European Communities Environmental Objectives (Surface Water Regulations) (S.I. 272 of 2009).

6.16 European Communities (Drinking Water) (No.2) Regulations 2007 (S.I. No. 278 of 2007).

6.17 The Local Government (Water Pollution) Acts 1977 - 2007.

6.18 Landfill Directive (Council Directive 99/31/EC).

6.19 National Roads Authority. 2014. Drainage Design for National Road Schemes – Sustainable Drainage Options.

6.20 Highways Agency Water Risk Assessment Tool, Help Guide and Technical Manual. Available to download with the tool from www.haddms.com.

7. GLOSSARY

Aerobic	In the presence of oxygen (air).
Advection	The process by which solvents (e.g. dissolved 'pollutants') are transported by the bulk movement of flowing groundwater.
Adsorption	The uptake and retention of one substance onto the surface of a another.
Anaerobic	In the absence of oxygen (air).
Capillary fringe	The zone at the interface between the saturated and unsaturated zones where water is drawn upward by capillary force.
Controlled waters	In this document these represent groundwater and surface water.
Diffusion	(In groundwater) the dispersion of a solvent caused by the kinetic activity of the ionic or molecular constituents of the solvent and groundwater. (In vapour) – mixing caused by the kinetic activity of ionic or molecular constituents.
Dispersion	The spreading and mixing of chemical constituents in groundwater caused by differential velocities within and between the pore spaces in an aquifer.
Geo-cellular unit	Proprietary units, usually modular and of plastic construction, which may be used as infill to excavated soakaways of trenches. These provide high void space and surface perforations to allow both high water storage and rapid dispersal.
Infiltration	Herein used as synonymous with percolation – the generally downward flow of water through the unsaturated zone to the water table.
Permeability	A measure of an aquifer's capacity to transmit groundwater through a unit metre of its saturated thickness (units in m/day).
Unsaturated zone	The zone between the top of an aquifer (limited above by the ground surface) and the water table (i.e. the top of the saturated zone).
Volatilisation	Changing of liquid to gaseous phase.

8. ENQUIRIES

8.1 All technical enquiries or comments on this document, or any of the documents listed as forming part of the NRA DMRB, should be sent by e-mail to infoDMRB@nra.ie, addressed to the following:

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