Norwich Western Link

Drainage Strategy Report Appendix 11 : Topsoil for Infiltration Basins Technical Note

Author: Ramboll

Document Reference: 4.04.11

Version Number: 00

Date: March 2024

Contents

1 Introduction

The build-up of drainage basins includes a lining of 200mm of topsoil as shown on planning drawings. This technical note describes the need for topsoil in infiltration basins and comments on the nature of topsoil with respect to its permeability capability within the basin. The permeability issue was raised in a letter from LLFA dated 4 April 2023 ref FW2023_0259.

This technical note describes the justification for use of topsoil in drainage basins and includes reference to technical guidance, topsoil properties and proposed specification for topsoil to be included in the NWL design.

2 Need statement

Topsoil is required to enable the establishment of proposed vegetation within all the basins, contributing to the amenity and biodiversity value of the drainage design and acting as a bird deterrent. For infiltration basins in the NWL, topsoil provides a further measure in the treatment train in filtering out highway run-off pollution from entering a sensitive aquifer in the source protection zone 2. The desired thickness of topsoil is 200mm.

3 What topsoil to use

A topsoil with a good texture is required to line the base and sides of basins and the proposal is to use a selected site-won material, or an engineered soil. This is in line with guidance contained within the CIRIA SUDS Manual, as shown below:

3.1 SuDS Manual recommendations

Reference	Description
Chapter 13 Figures	Figure 13.4 refers to infiltration basins with “flat basin floor planted with mix of grass and deep-rooted plants” and figure 13.5 shows an “Engineered soil mix to improve durability (200mm layer)”.

Reference	Description
Section 13.6	“Engineered soils on the surface are less likely to be adversely affected and lose infiltration capacity. Planting trees and shrubs rather than just grass, and mulching the surface layers will also help maintain the infiltration rates”
Section 13.8	“Topsoils or engineered soils used in infiltration basins should be sufficiently permeable. The minimum permeability assumed in the design should be stated, and the material should be tested after it has been placed in accordance with the method described for bioretention soils in Chapter 18.”
Section 13.10	“Vegetation also increases the effectiveness of infiltration by slowing the flows across the basin and by maintaining or enhancing the pore space in the underlying soils via deeper rooting systems. Dense vegetation such as shrubs and mulching will also minimise the risk of clogging of surface soils (Emerson and Traver, 2008).”
Section 13.11.2	“The surface soils within the basin should not be smeared or compacted during construction. After final grading, the basin floor should be tilled to a depth of 150 mm to provide a well-aerated, porous surface texture”

Reference	Description
Section 30.4.2	Engineered soils use on the base of basins: 30.4.2 Engineered soils A suitable depth of engineered soil can be used over the bottom of the basins, filter strips or swales to reduce waterlogging an improve the drainage characteristics of the basin. (Note that in BS 3882:2007, multipurpose topsoil can still be specified for banks of swales and basins, where planting is desired.) The engineered soil will tend to be a greater depth than typical topsoil depths- potentially replacing some of the subsoil depth, where appropriate. The important properties of this engineered soil are as follows: • Sufficiently permeable to allow to allow water to drain easily • Having suitable properties and organic content to support plant growth An engineered soil will tend to be sand-based medium with narrow particle size distribution, high permeability and porosity, and reasonable reserves of organic matter and available plant nutrients. The example specification of a bioretention filter medium provided in **Chapter 18, Box 18.3** is suitable soil type that could be considered. Root zone materials, that is a mix of sand and topsoil or green compost (similar) to that used in construction of sports pitches), can often also be suitable. Any specification that is used should be fully verified to ensure that it meets site-specific requirements in terms of drainage performance and its function as growing media. In particular, the saturated hydraulic conductivity of the soil should meet the design requirements for the drainage function.
Box 18.1	The example specification for a bioretention filter medium as shown in Box 18.1 (not 18.3 as noted above) is suitable for an Engineered soil:

<table>
<tr><th>Reference</th><th>Description</th></tr>
<tr><td>Box 18.1</td><td>Box 18.1
Example specification for a bioretention filter medium

Saturated hydraulic conductivity (permeability)
The saturated hydraulic conductivity should be between 100 mm/h and 300 mm/h. This should be checked in situ, using the single ring infiltration test method as described in BS EN 22282-5:2012.

(Note that where larger volumes of engineered sol are to be used, it is wise to test the hydraulic conductivity before delivery to site using a laboratory test. ASTM F1815-06 is commonly used in other application such as sports pitches.)

Porosity
The total porosity should be > 30% when tested in accordance with BS 1377-2:1990).

Particle size distribution
Particle size distribution (PSD) is of secondary importance compared with saturated hydraulic conductivity. A material whose PSD falls within the following recommended range does not preclude the need for hydraulic conductivity testing, that is it does not guarantee that the material will have a suitable hydraulic conductivity. However, the grading in Table 18.2 provides a useful guide for selecting an appropriate material. The grading needs to be readily understood by both drainage and landscape/horticultural professionals, and each use different standard format for presenting grading information. The grading in Table 18.2 is presented in a standard engineering format.

Table 18.2 Example grading for a bioretention filter medium
<table>
<tr><th>Sieve size (mm)</th><th>% passing</th></tr>
<tr><td>6</td><td>100</td></tr>
<tr><td>2.0</td><td>90 -100</td></tr>
<tr><td>0.6</td><td>40 – 70</td></tr>
<tr><td>0.2</td><td>5 – 20</td></tr>
<tr><td>0.063</td><td>< 5</td></tr>
</table>
</td></tr>
</table>

Reference	Description
Box 18.1 Continued	The specification could also be presented as follows (which may be more relevant to landscape practitioners): • Clay and silt (< 0.063 mm) <5% • Fine sand (0.063-0.2 mm) <20% • Medium sand (0.2-0.6mm) 35% to 65% • Coarse sand (0.60-2 mm) 50% to 60% • Fine gravel (2.0-6.0 mm) <10% The filter medium should be well-graded, and the composition should contain limited particle size range. **Organic matter content** Organic matter content should be 3-5% (w/w). **pH** pH should be 5.5-8.5 (1:2.5 soil/water extract) **Electrical conductivity (salinity)** Electrical conductivity (EC) should be < 3300 µS/cm (1:25 soil/$CaSO_4$ extract) **Major plant nutrients** Total nitrogen should be 0.10-0.30% Extractable phosphorus should be 16-100 mg/l Extractable potassium should be 120-900 mg/l (Methods of analysis in accordance with BS 3882:2015, unless otherwise stated.) **Horticultural assessment** Potential bioretention soils and test results should generally be assessed by a horticulturalist to ensure that they are capable of supporting a healthy vegetation community. This assessment should take into consideration delivery of nutrients to the system by surface water runoff. Any component or soil found to contain high levels of salt (as determined by EC measurements), high levels of clay or silt particles (exceeding the particle size limits listed above), or any other extremes which may be considered retardant to plant growth should be rejected.

The guidance describes how topsoil contributes to maintaining the infiltration of the basin (if not even increases the effectiveness).

Site-won topsoil

Site Investigation results (Report dated October 2022) for topsoil classification gave the following description in para. 7.1.1. and table 7.7 abstracted below.

7.1.1 Topsoil

The ground surface at the exploratory hole locations typically comprised stubble fields or lightly cultivated agricultural land , with areas of the floodplain comprising rough grassland

Topsoil was encountered in most of the exploratory holes across the site. The stratum is typically 0.30. to 0.50. m. thick. However. That are isolated locations where topsoil was encountered up to 0.80 to 1.00 m. The material is predominantly granular and generally described as 'slightly gravelly clayey fine to medium SAND. Gravel is sub-angular to sub–rounded fine to coarse flint. Occasional fine rootlets.'

Cohesive Topsoil was occasionally encountered in the exploratory holes on the River Wensum floodplain and between mainline CH5250 to CH5550. On the floodplain, it has been described as slightly gravelly sandy CLAY. Towards the southern end of the scheme, it has been described as a sandy gravelly CLAY.

Topsoil sampled at the NWL site is derived from the mean particle size distribution test results and values input to figure 26.2 extracted from the SuDS Manual to classify the soil type.

Thirty one PSD tests were undertaken on samples of the Topsoil. The results are summarised in table 7-7 and figure A6 in appendix 2. Granular Topsoil is typically found across the site and can be described as a slightly gravelly clayey SAND. Cohesive Topsoil can be encountered in exploratory holes on the floodplain and between mainline CH5250 to CH5550. It can generally be described as a slightly sandy slightly gravelly organic CLAY and a sandy very gravelly Clay, respectively.

Results of PSD tests

N/A	Sample Details	Sample Details	Soil Fraction (%)	Soil Fraction (%)	Soil Fraction (%)	Soil Fraction (%)	Soil Fraction (%)	Soil Fraction (%)	N/A
Statistic	**Depth (mbgl)**	**Elevation (mOD)**	**Cobbles**	**Gravel**	**Sand**	**Silt**	**Clay**	**Fines**	**Cu**
No. samples	31	31	31	31	31	10	10	31	8
Range	0 to 0.5	51.9 to 8.98	0 to 0	0 to 44	0 to 83	8 to 33	1 to 22	5 to 44	3.5 to 70
Mean	0.15	36.7	0	14	57	21	8	23	32.5
Median	0.20	38.3	0	12	57	17	4	21	31.0
Standard Deviation	0.10	12.0	0	10	19	9	7	11	24.7

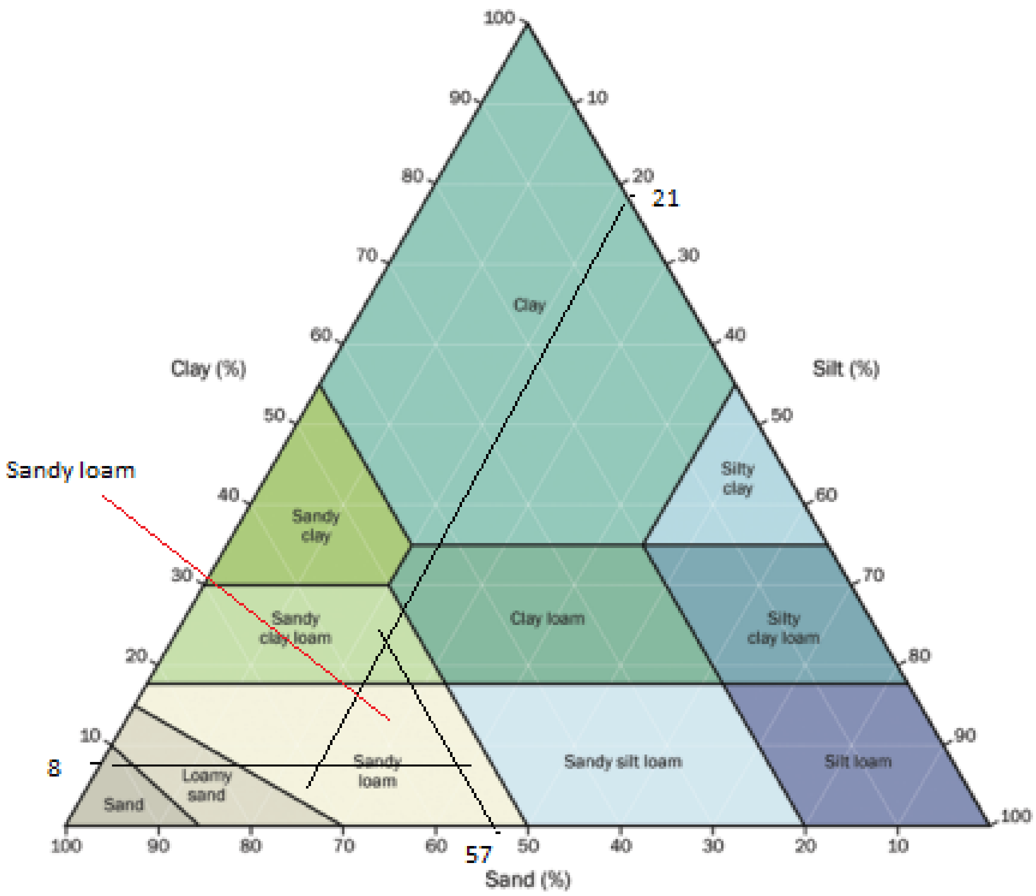

Figure 25.2 Soil texture classification (from LandIS, 2015)

The soil type is described from figure 25.2 as 'sandy loam'.

Permeability values

Typical infiltration rates for soil classifications is given in table 25.1 of the SuDS manual shown below.

TABLE 25.1 Typical infiltration coefficients based on soil texture (after Bettess, 1996)

Soil type/texture	ISO 14688-1 description (after Blake, 2010)	Typical infiltration coefficients (m/s)
Good infiltration media		
• gravel	Sandy GRAVEL	$3 \times 10^{-4} - 3 \times 10^{-2}$
• sand	Slightly silty slightly clayey SAND	$1 \times 10^{-5} - 5 \times 10^{-5}$
• loamy sand	Silty slightly clayey SAND	$1 \times 10^{-4} - 3 \times 10^{-5}$
• sandy loam	Silty clayey SAND	$1 \times 10^{-7} - 1 \times 10^{-5}$
Poor infiltration media		
• loam	Very silty clayey SAND	$1 \times 10^{-7} - 5 \times 10^{-6}$
• silt loam	Very sandy clayey SILT	$1 \times 10^{-7} - 1 \times 10^{-5}$
• chalk (structureless)	N/A	$3 \times 10^{-8} - 3 \times 10^{-6}$
• sandy clay loam	Very clayey silty SAND	$3 \times 10^{-10} - 3 \times 10^{-7}$
Very poor infiltration media	–	
• silty clay loam	–	$1 \times 10^{-8} - 1 \times 10^{-6}$
• clay	Can be any texture of soil	$< 3 \times 10^{-8}$
• till	described above	$3 \times 10^{-9} - 3 \times 10^{-6}$
Other		
• rock* (note mass infiltration capacity will depend on the type of rock and the extent and nature of discontinuities and any infill)	N/A	$3 \times 10^{-9} - 3 \times 10^{-5}$

Thus the anticipated permeability value k for site-won or engineered soils lies in the range $1x10^{-7}$ and $1X10^{-5}$ m/s. The range of design k values for the infiltration basins lie in the range $8.1x10^{-7}$ and $3.05X10^{-6}$ m/s. This indicates that site-won topsoil is suitable for use in lining the drainage basins and will be tested for permeability prior to placing within infiltration basins. Any shortfall in infiltration value can be addressed by mixing non-cohesive material for an engineered soil as described above.

Thus, the presence of topsoil lining to the infiltration basins will not affect the performance of the infiltration basin to percolate water to the subsoil.

4 Conclusions

1 Topsoil plays an important component of establishing and prolonging the planting regime in drainage basins and promoting good drainage within subsoil in infiltration basins;

2 Choice of grading of topsoil as sandy/ loaming in content will ensure good drainage with equal or better permeability value than the underlying subsoil;

3 The site investigation has confirmed that a suitable sandy, loamy topsoil material can be found on site; This soil subject to infiltration testing can be used to line infiltration basins.