British Geological Survey
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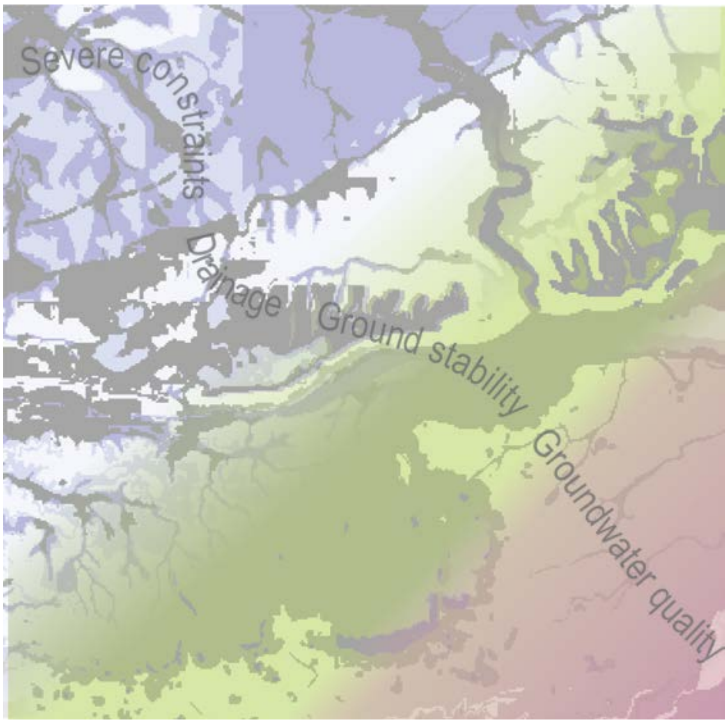
User Guide for the Infiltration SuDS Map: Detailed

Open Report OR/16/009



BRITISH GEOLOGICAL SURVEY

OPEN REPORT OR/16/009

User Guide for the Infiltration SuDS Map: Detailed

R Dearden

Keywords

infiltration SuDS map, SuDS, sustainable drainage, infiltration to the ground.

Front cover

Data from the Infiltration SuDS Map

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Summary

This report presents a description of the *Infiltration SuDS Map: Detailed* developed by the British Geological Survey (BGS). The dataset provides subsurface information enabling preliminary assessment of the ground for infiltration sustainable drainage systems (SuDS). The map can be used in relation to any type of infiltration SuDS including soakaways, infiltration basins and permeable pavements. The map is designed to be used by those interested in the properties of the ground for the installation of infiltration SuDS, but it is not an alternative to a ground investigation. It may be particularly valuable for developers, planners and local authority SuDS approval officers, who need to either assess the properties of the ground directly, or assess planning application for SuDS.

The *Infiltration SuDS Map: Detailed* comprises of twenty-four individual GIS (geographical information system) layers, which are structured under the following headings: infiltration constraints, drainage potential, ground instability and groundwater protection. The GIS layers under each heading include up to seven individual data layers showing the properties of the ground and a summary layer, which provides an overview of the information contained within those data layers highlighting overall suitability.

More information about pricing and licensing the Infiltration SuDS Map is provided at http://www.bgs.ac.uk/products/hydrogeology/infiltrationSuds.html.

For those involved in the strategic assessment of ground conditions for the installation of infiltration SuDS, the *Infiltration SuDS Map: Summary* may be more appropriate. This map provides an indication of the suitability of the subsurface for infiltration SuDS, but does not provide any specific information about the properties of the ground.

The methodology employed in creating this dataset has been critically assessed by Dr. V. Banks and Dr. D. Aldiss who specialise in hydrogeology and in geological derived products at BGS. The dataset has also been reviewed by seven external experts and improvements have been made based on their suggestions. The purpose of this user guide is to enable those licensing the *Infiltration SuDS Map: Detailed* to have a better appreciation of how the dataset has been created and therefore a better understanding of its potential applications and limitations.

Acknowledgements

A number of individuals in the Information Products and Derived Products Programmes have contributed to the project and helped compile this report. This assistance has been received at all stages of the study. In addition to the collection and processing of data, many individuals have freely given their advice, and provided the local knowledge. In particular, we thank Don Aldiss, Vanessa Banks, Stephanie Bricker, Rose Hargreaves, Kate Royse and Gerry Wildman. We are also grateful to Mike Barker, Paul Davies, Llew Hancock, Nick Orman, Martin Osborne, Steve Wilson and Bridget Woods-Ballard, who peer-reviewed the Infiltration SuDS Map from an external perspective and provided valuable feedback.

1 Introduction

Founded in 1835, the British Geological Survey (BGS) is the world's oldest national geological survey and the United Kingdom's premier centre for earth science information and expertise. The BGS provides expert services and impartial advice in all areas of geosciences and has a client base that is drawn from the public and private sectors both in the UK and internationally.

Our innovative digital data products aim to help describe the ground surface and subsurface across the whole of Great Britain. These digital products are based on the outputs of the BGS survey and research programmes and our substantial national data holdings. This data coupled with our in-house geoscientific knowledge are combined to provide products relevant to a wide range of users in central and local government, insurance and housing, engineering and environmental business, and the British public.

Further information on all the digital data provided by the BGS can be found on our website at http://www.bgs.ac.uk/data/home.html or by contacting:

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2 About the Infiltration SuDS Map

2.1 BACKGROUND

Following extensive flooding in 2007 across much of the UK, the Government launched a review to determine the causes and consequences of the flood events and to establish the most appropriate course of action to reduce future flooding (Pitt, 2008). The review found that intense rainfall and overland flow on impervious surfaces resulted in flooding particularly in urban areas where the piped drainage networks were overwhelmed. The impacts were not restricted to flooding; storm water flow through combined sewers (that carry both foul and surface water) overflowed to watercourses during storm events, resulting in a deterioration of water quality. To reduce the intensity and magnitude of such impacts during flood events, the review recommended that our reliance on the existing piped drainage network should be decreased. The recommendations were further considered in the *Making Space for Water* strategy (DEFRA, 2005) and were then enacted to law by the Floods and Water Management Act 2010 (HMSO, 2010).

One of the recommendations, enacted to law via Schedule 3 of the Floods and Water Management Act, was the specific provision for the implementation of sustainable drainage systems (SuDS) in all new developments (excluding single dwellings). To promote the use of SuDS, the Act withdraws Section 106 of the Water Industry Act 1991, thereby removing the automatic right for developers to connect to the drainage network (HMSO, 2010). An exception applies to single dwellings, which are excluded from this requirement in law. However, even for single dwellings, there are significant advantages to using SuDS in practice, for example they require reduced drainage infrastructure and attract disconnection rebates for homeowners.

Sustainable drainage aims to reduce the reliance on traditional piped drainage networks by draining surface water in a way that mimics the natural water cycle, thereby decreasing flow rates and reducing peak flows to rivers. In addition, SuDS remove pollutants near to source and thereby play a key role in improving catchment water quality. Benefits for amenity and biodiversity are also associated with installing SuDS instead of traditional drains (Woods-Ballard et al., 2007).

Sustainable drainage includes surface water management techniques such as:

- rainwater re-use (water butts, rainwater harvesting systems)
- rainwater storage with discharge to watercourses (detention basins/ponds/subsurface chambers), and
- infiltration to the ground (soakaways, infiltration basins, permeable pavements)

Systems often incorporate two or more SuDS techniques connected in series. This enables an incremental reduction in pollutants, flow rates and volumes along the drainage flow path. The connection of systems in this way is termed the *management train*.

The design, construction, operation and maintenance of SuDS have been the subject of numerous documents since the release of the draft SuDS National Standards (DEFRA, 2011). Since then, the standards have become focused on controlling the rate and quantity of flow (DEFRA, 2015). The National Planning Policy Framework has published further Planning Practice Guidance that supports sustainable drainage and suggests the following order of preference for the runoff destination:

- discharge to the ground
- discharge to a surface water body
- discharge to a surface water sewer
- discharge to a combined sewer

To determine whether SuDS that infiltrate to the ground are compatible with the subsurface, the ground conditions at each individual site need to be assessed.

The British Geological Survey has developed two series of maps that provide information on the suitability of the subsurface for infiltration SuDS:

a. *Infiltration SuDS Map: Summary*
b. *Infiltration SuDS Map: Detailed*

The *Infiltration SuDS Map: Summary* comprises of four maps that provide an overview of ground suitability for infiltration SuDS. It does not provide any information about the properties of the subsurface. It is purely intended as a dataset for strategic planning.

This user guide describes the *Infiltration SuDS Map: Detailed.* This map comprises the four summary layers included within the *Infiltration SuDS Map: Summary*, plus an additional twenty data layers, containing a wealth of subsurface property information that can be used to make a preliminary assessment of the suitability of the subsurface for infiltration SuDS.

> The *Infiltration SuDS Map: Detailed* provides data that will enable a preliminary assessment of the subsurface for infiltration SuDS.
>
> The Infiltration SuDS Map facilitates efficient and scientifically defensible decision making.
>
> The map is not a replacement for a soakaway test or site investigation.

2.2 WHAT ARE INFILTRATION SUDS?

Infiltration SuDS is a term that covers a number of infiltration techniques including:

- soakaways
- infiltration trenches
- infiltration basins
- permeable pavements
- wetlands
- unlined ponds, and
- unlined swales

These systems facilitate the infiltration of surface water into the ground. Once in the ground, the water percolates through the subsurface to the groundwater.

Infiltration SuDS are appropriate in a wide variety of ground conditions, but the design must be compatible with the properties of the subsurface, in particular, the infiltration rate. Infiltration SuDS are commonly installed within freely draining ground, but they can also be used in less permeable deposits, if they are designed to incorporate larger infiltration areas (e.g. permeable pavements), or the capacity to store water (e.g. infiltration basins). By increasing the surface area or volume of the infiltration system, the amount of water infiltrated and the time over which infiltration can occur are increased. This allows infiltration SuDS to be installed in ground that would not otherwise be suitable for the installation of soakaways. In such ground conditions, infiltration may not provide the whole drainage solution, but may form part of the drainage strategy alongside SuDS that store and re-use water.

Figure 1 illustrates three types of infiltration SuDS and Table 1 summaries the characteristics of infiltration SuDS in terms of typical storage capacity, surface area for infiltration, pollutant attenuation capacity, land take requirement, and amenity value.

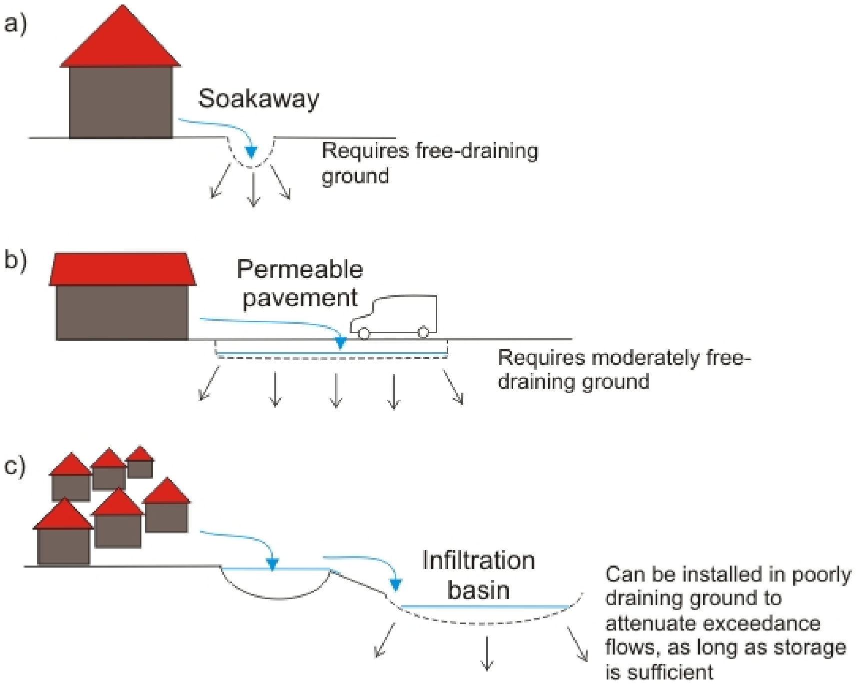

Figure 1. Diagram to show versatility of infiltration SuDS, for example: a) soakaways in free-draining ground; b) permeable pavements incorporating water storage in moderately free-draining ground, and c) infiltration basins with large storage volumes in poorly draining ground

Table 1. Common infiltration SuDS types. Values derived from Woods-Ballard et al. (2007)

Technique	Description	Typical storage capacity	Surface area for infiltration	Pollutant attenuation capacity	Land-take requirements	Amenity value
Infiltration basin	Comprises a depression in the ground, where water can be stored during gradual infiltration through the permeable base	High	Moderate to high	Medium to high	High, but dual use possible	Potentially high
Infiltration trench	Comprises a gravel-filled trench with a permeable base through which water can infiltrate the ground	Moderate	Moderate	Low to high	Low	Low
Permeable pavement	A durable permeable surface, through which water can infiltrate. Systems may allow infiltration directly to the ground, or may be constructed with a subbase providing storage capacity, allowing more gradual infiltration to the ground	Low to high	Low to high	High	High, but dual use normal	Potentially high
Soakaway	Metre-scale pit in the ground, that stores water during gradual infiltration	Low to moderate	Low to moderate	Low to medium	Low	Low
Wetland	Comprises a natural or man-made swampy or boggy area with a permeable base	Moderate	Moderate to high	Medium to high	High	Potentially high

2.3 WHO MIGHT REQUIRE THIS MAP?

The Infiltration SuDS Map developed by BGS is relevant to professionals who make decisions on SuDS design, construction, and approval. The maps will help:

- make preliminary decisions on the suitability of the subsurface for infiltration SuDS
- make preliminary decisions on the type of infiltration SuDS that will likely be appropriate.
- assess SuDS planning applications to determine whether the necessary factors have been considered.
- determine whether infiltration SuDS could be appropriate where a non-infiltrating SuDS technique has been proposed.

The dataset is relevant to professionals throughout construction, including those involved with planning, land surveying, architecture, landscape design, construction, SuDS design, SuDS approval and regulation. It may also be of interest to solicitors, loss adjusters, and the insurance industry.

2.4 ABOUT THE DATASET

The *Infiltration SuDS Map: Detailed* comprises a GIS in four thematic sections, which together provide answers to four key questions.

The intention is that the user will work through these questions sequentially, using the data included in the map to guide decisions. For each question, a summary map provides an overview of the subsurface properties, whilst multiple component data layers provide more detailed information about the subsurface characteristics. Figure 2 illustrates the form of the summary and component data layers within the GIS.

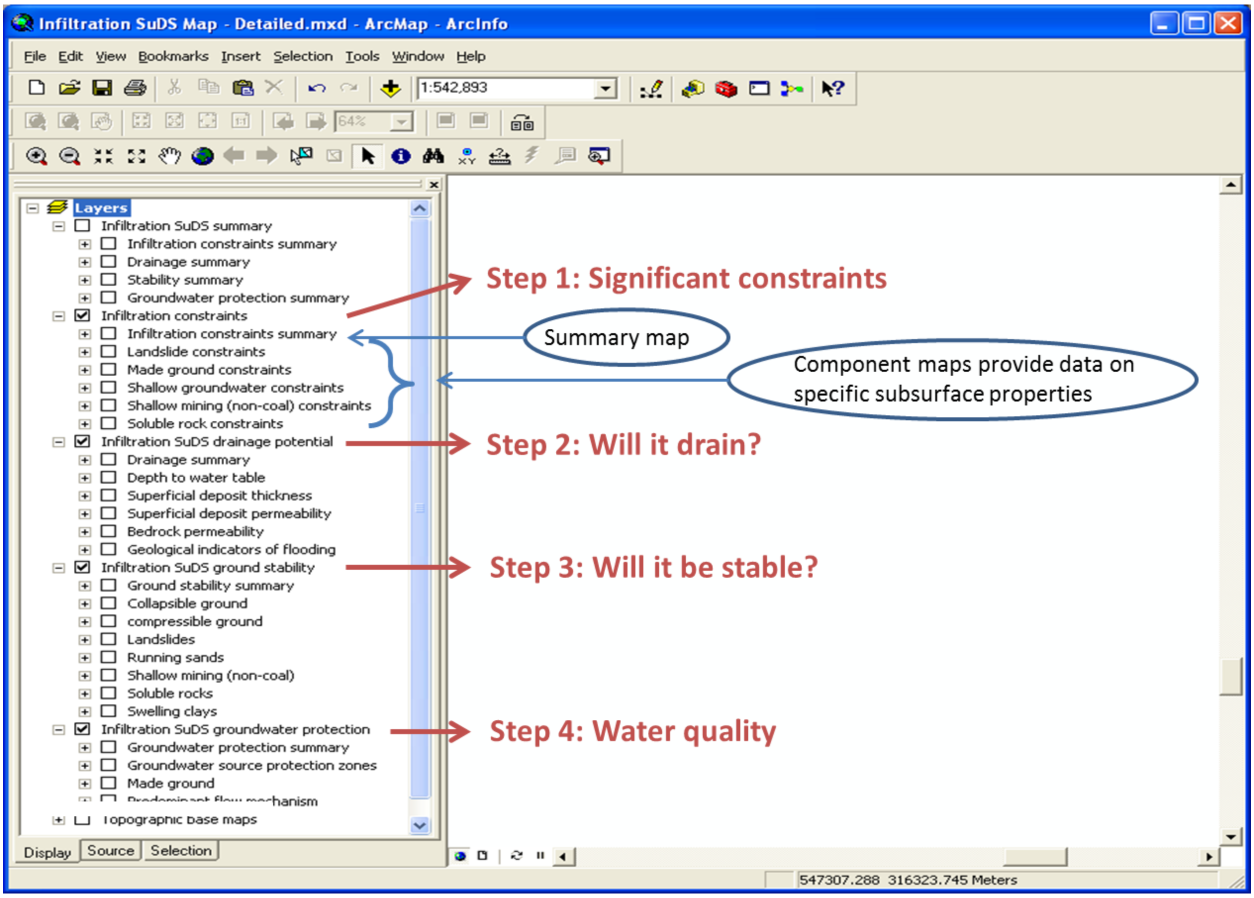

Figure 2. An illustration of the GIS workspace showing the set-up of the summary and component data layers structured in four thematic sections.

The four questions are:

- **Question 1. Are there any constraints that mean infiltration SuDS should only be used if the potential for, and consequences of flooding and geohazards are known?**
  This step addresses the potential presence of geological and hydrogeological hazards that could be initiated or worsened by infiltrating water to the ground. In such areas, infiltration is not recommended unless a full appraisal of the potential for and consequences of infiltration has been undertaken. Possible hazards include:

  i) ground instability resulting from the infiltration of water into rocks that are highly susceptible to landslide or collapse associated with dissolution or shallow mining;
  ii) flooding resulting from infiltration into deposits where the water table is shallow and potentially able to rise causing inundation of soakaways or emergence of groundwater at the ground surface, and
  iii) made ground of unknown characteristics that may be unstable or potentially contaminated.

- **Question 2. What is the drainage potential of the subsurface?**
  The drainage potential of the ground depends on the geology and hydrogeology of the subsurface. This step provides information on the depth to water table, the permeability of superficial deposits, the thickness of superficial deposits and the permeability of the bedrock. Data are also provided on the presence of deposits that lie on a floodplain; in such deposits, groundwater level may respond rapidly to rises in river level causing inundation of subsurface systems.

- **Question 3. Are there any ground stability considerations?**
  Not all ground instability hazards will preclude the installation of infiltration SuDS, but if present, those hazards should be taken into account during design and construction. Where such hazards are thought to be present, they are highlighted in this step. Hazards considered include soluble rocks, landslides, compressible ground, collapsible ground, shrink-swell clays, running sand, and shallow mining (excluding coal mining).

- **Question 4. Is the groundwater susceptible to deterioration in quality?**
  When designing SuDS installations the potential impact on groundwater quality should be considered. This step provides information on the Environment Agency, and Natural Resources Wales source protection zone classification, the predominant flow mechanism through the unsaturated zone and on the presence of made ground, which may be contaminated. This information can be used, in part, to determine likely pre-treatment requirements.

The dataset is intended to provide the information required to make a preliminary decision on the extent to which the subsurface at a site is suitable for the installation of infiltration SuDS. The data is NOT an alternative for a site investigation or an infiltration test.

3 Quick start guide

3.1 OVERVIEW

This section is aimed at those users who are familiar with GIS software and wish to rapidly start using the dataset. More detailed explanations of how the dataset should be set up and used are presented in Sections 5 and 6.

3.2 GIS SET-UP

Load the layer files/shape files into the GIS software. The GIS should appear as shown in Figure 3.

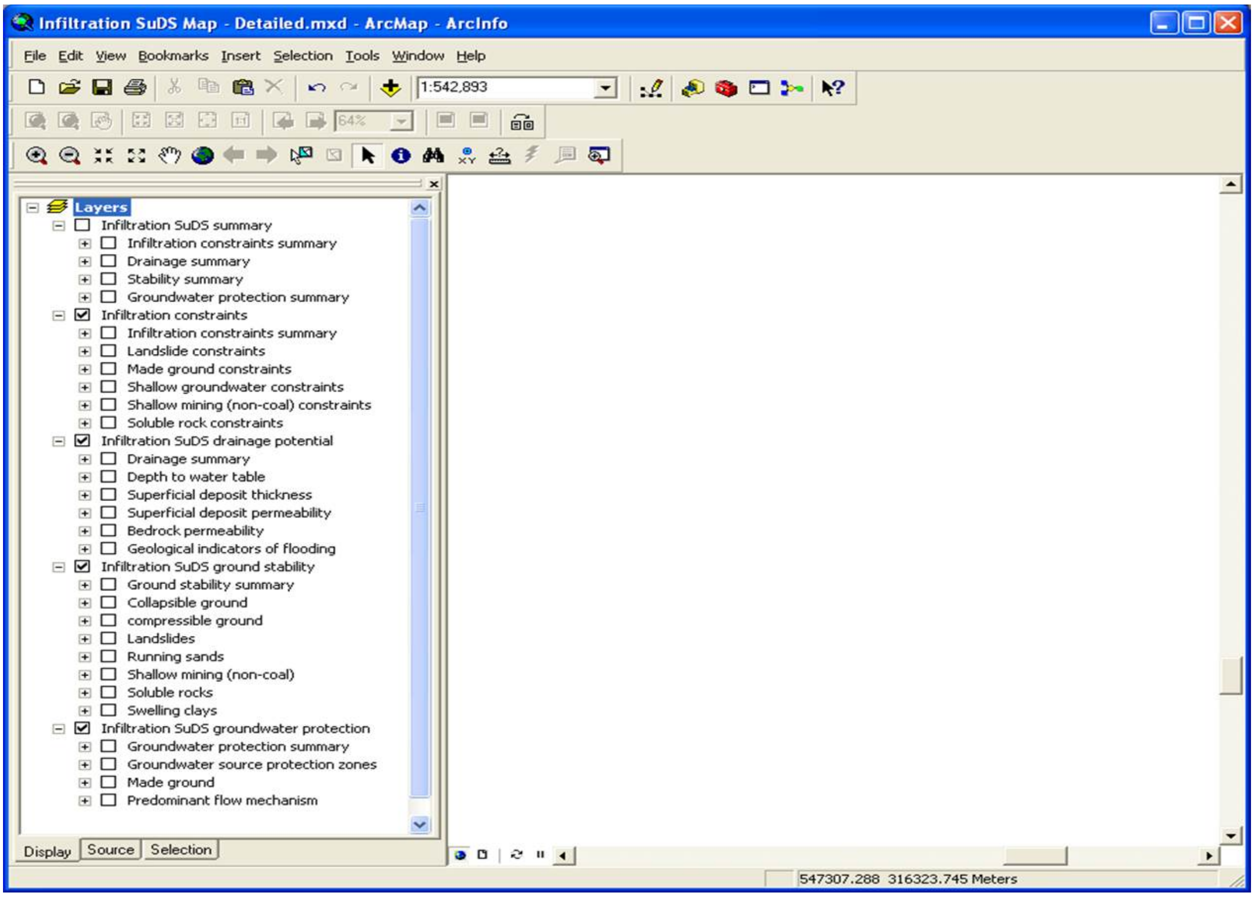

Figure 3. ***Infiltration SuDS Map: Detailed*** **loaded into ESRI ArcGIS**

Pan to a location of interest and view each dataset sequentially, following the flow charts shown in Figures 4, 5 and 6. The flow chart in Figure 4 shows how to use the summary layers to support strategic planning. Figures 5 and 6 show how to use the summary and property-specific layers when making preliminary assessments of ground suitability at the local level.

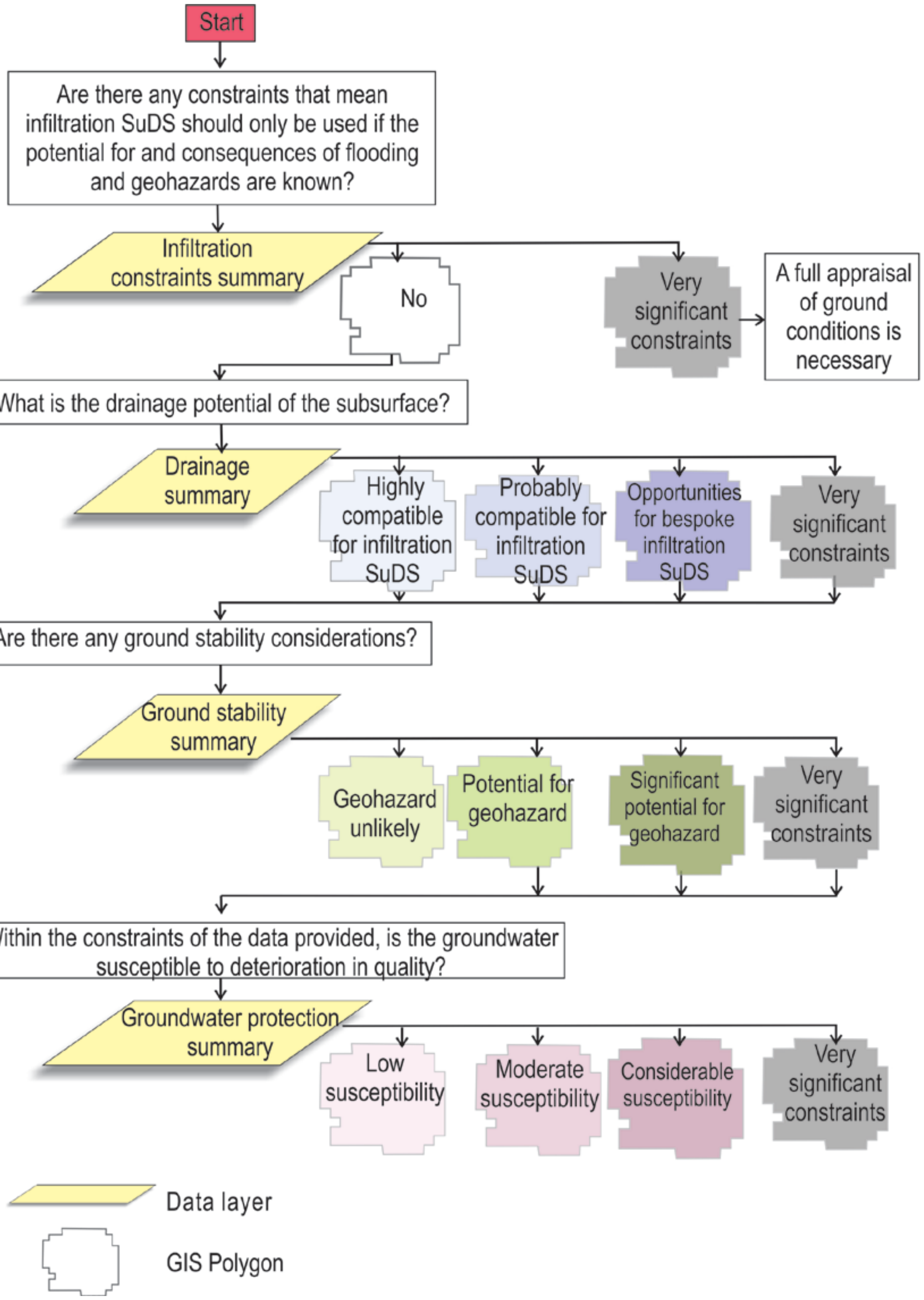

Figure 4. Quick start flow chart: A rapid guide to using the Infiltration SuDS Map: Summary layers

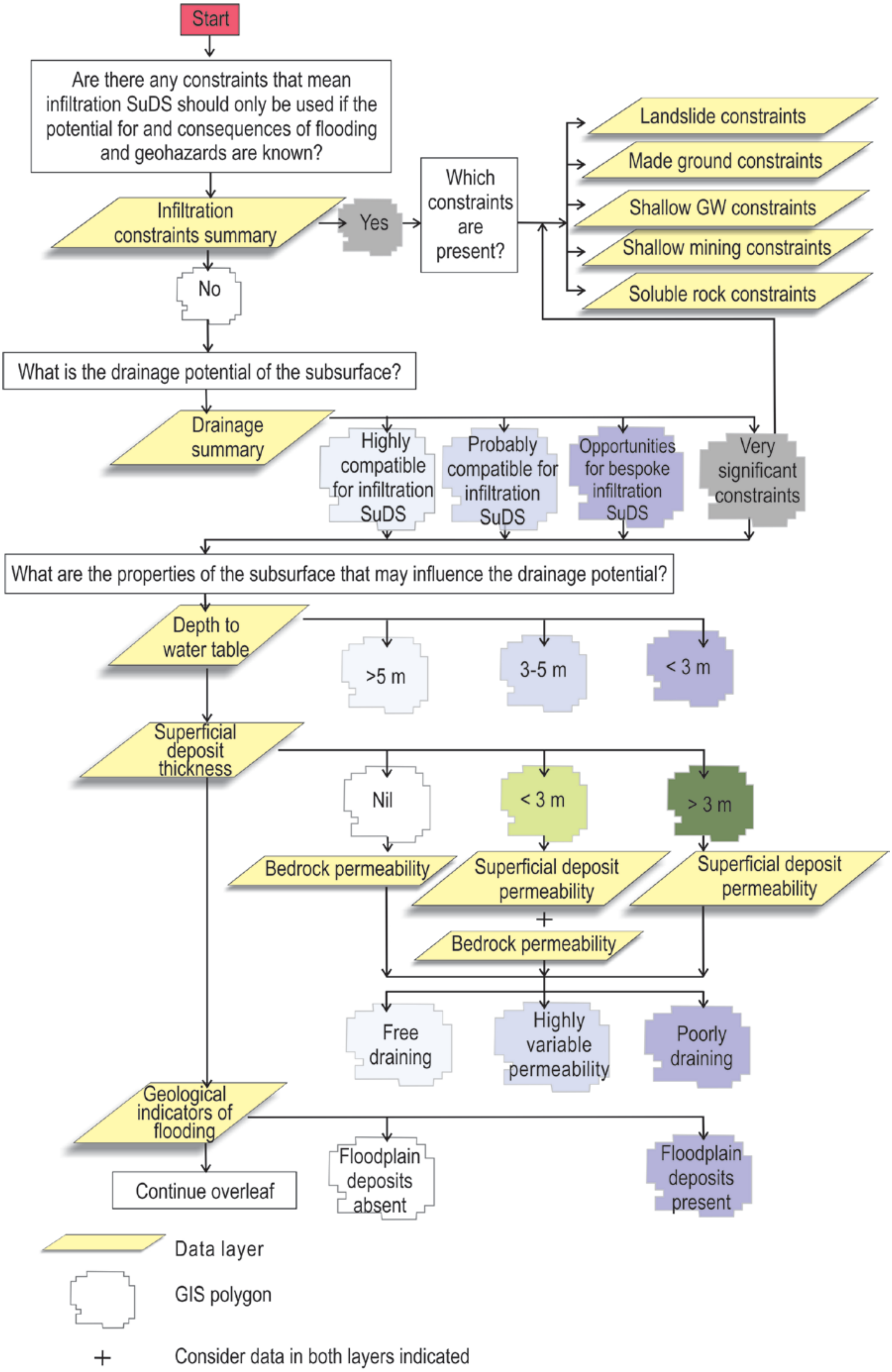

Figure 5. Quick start flow chart I: A rapid guide to using the infiltration constraints and drainage sections of the *Infiltration SuDS Map: Detailed*

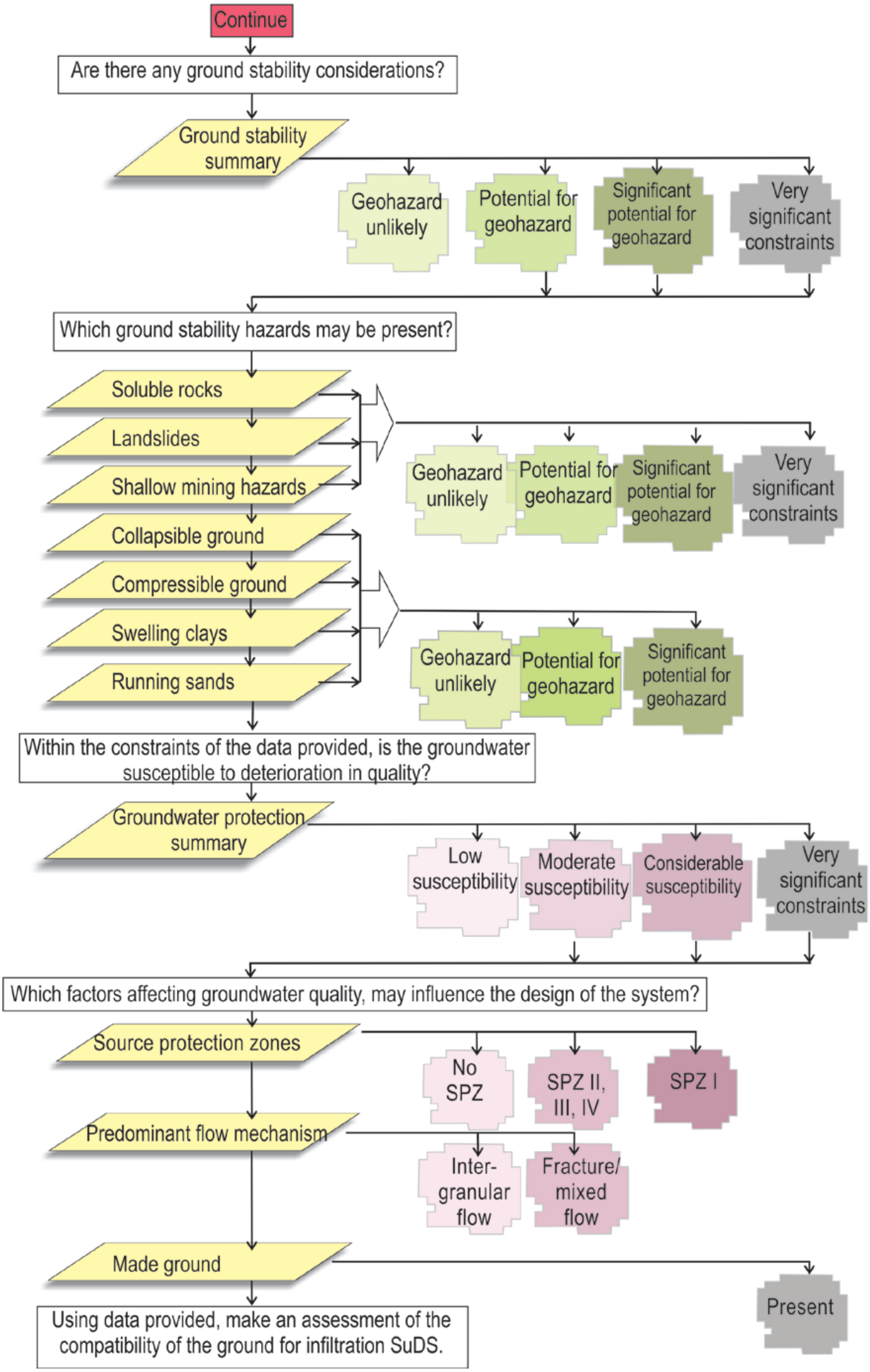

Figure 6. Quick start flow chart II: A rapid guide to using the ground stability and groundwater quality protection sections of the *Infiltration SuDS Map: Detailed*

4 What information does the dataset provide?

4.1 OVERVIEW

This section describes in detail the subsurface property datasets included in each of the four questions discussed in Section 2.4.

- Section 4.2 focuses on question 1 in Section 2.4, and is called: 'Infiltration SuDS Constraints',
- section 4.3 focuses on question 2 and is called 'Infiltration SuDS drainage potential',
- section 4.4 focuses on question 3 and is called 'Infiltration SuDS ground stability', and
- section 4.5 focuses on question 4 and is called 'Infiltration SuDS groundwater protection'.

4.2 INFILTRATION SUDS CONSTRAINTS

4.2.1 Infiltration SuDS constraints summary layer

The *Infiltration Constraints Summary* layer highlights all areas where there is potential for a significant constraint. Constraints include those described in Section 4.2.2 to 4.2.6 below. In these areas, infiltration SuDS should only be installed if the potential for, or the consequences of, the constraint are considered not to be significant. Table 2 shows the attributes used in this summary layer.

Table 2. Description of attribute score for the *Infiltration Constraints Summary* layer

Score	Short description	Detailed description
4*	Very significant constraints are indicated	There is a very significant potential for one or more geohazards associated with infiltration

* Polygons with the highest score (4) are shown independently in the *'Infiltration Constraints Summary'* layer to provide an overview of where hazards may occur if water is infiltrated to the ground.

4.2.2 Soluble rocks constraints

Some types of ground contain layers of material that can dissolve in underground water. This can cause underground cavities to develop. Cavities created by dissolution of soluble rocks can collapse, resulting in subsidence of the land above. More commonly, changes in ground or surface water flow can flush away unconsolidated sediment, potentially leading to the collapse of overlying materials leading to subsidence at the surface. Infiltration may exacerbate this problem causing acute collapse around infiltration SuDS. Therefore the installation of infiltration SuDS should proceed only after a full appraisal of the ground conditions.

This component data layer is derived from the soluble rocks layer in the BGS GeoSure dataset. The dataset has been reclassified to show only those areas where collapse poses a significant hazard if water is infiltrated to the ground. Information about the original dataset can be viewed at: http://www.bgs.ac.uk/products/geosure/soluble.html.

4.2.3 Landslide constraints

A landslide is a relatively rapid outward and downward movement of material on a slope, due to the force of gravity. A slope is under stress from gravity but will not move if its strength is greater than this stress. If the balance is altered so that the stress exceeds the strength, then movement will occur. In deposits that are highly susceptible to landslide, the infiltration of water to the ground may decrease the 'strength' of the deposit, resulting in slope instability. This may occur if water is infiltrated to the ground on or above the susceptible area. In such deposits, the installation of infiltration SuDS should proceed only following a full appraisal of the ground conditions.

This component data layer is derived from the landslide layer in the BGS GeoSure dataset. The dataset has been reclassified to show only those areas where landslide poses a significant hazard if water is infiltrated to the ground. Information about the original dataset can be viewed at: http://www.bgs.ac.uk/products/geosure/landslides.html. Landslide hazards present along the coastline may be under-represented in this dataset. Where the installation of infiltration SuDS are considered on the coastline, the ground investigation should consider the potential for and the consequences of landslide.

4.2.4 Shallow mining (non-coal) constraints

In areas where current or past underground mining has resulted in cavities at shallow depths, the infiltration of water may destabilise material above or within a cavity potentially resulting in ground collapse in highly susceptible areas. In such areas, infiltration of water to the ground may initiate or exacerbate the instability of material leading to collapse around the infiltration system. This dataset considers only mining for commodities other than coal.

This component data layer is derived from the BGS Mining Hazards (not including coal) dataset. The dataset has been reclassified to show only those areas where shallow mining represents a potentially significant hazard if water is infiltrated to the ground. This dataset was created, or interpreted, from a wide variety of data sources. Hazards that may be under-represented in the 2012 version, include those present in geological units that would not typically be mined, for example hazards associated with archaeological workings, and those in deposits where artisan mining has occurred historically in urban areas, for example Norwich and Bury St Edmunds. Information about the original dataset can be viewed at:
http://www.bgs.ac.uk/products/geohazards/miningHazard.html.

4.2.5 Made ground constraints

Made ground, including ground that has been infilled or landscaped has an unknown composition and structure. Infiltration through such material may result in ground instability or in the remobilisation of contaminants from within that ground.

This component dataset is derived from DiGMapGB-50 which shows the occurrence of made ground where mapped and over 1 m in thickness. Information about the original dataset can be viewed at: http://www.bgs.ac.uk/products/digitalmaps/digmapgb_art.html.

4.2.6 Shallow groundwater constraints

In areas where the water table is shallow either persistently or seasonally, the installation of infiltration SuDS requires further consideration for several reasons:

- At least 1 m of unsaturated zone thickness should exist between the base of the infiltration system and the groundwater to allow filtration and removal of surface water pollutants before they reach the groundwater. Where shallow groundwater occurs, this may not be possible.
- Increased infiltration may result in a temporary rise in groundwater level, which may cause the inundation of subsurface storage chambers.

- Increased infiltration may result in a rise in groundwater level, causing the emergence of groundwater at the ground surface (termed groundwater flooding).

This component dataset is derived from the BGS Susceptibility to Groundwater Flooding dataset. The susceptibility map seeks to identify areas where the geological conditions and water table level indicate that groundwater may be present at shallow depths and could rise at certain times of the year. A classification of high susceptibility in this dataset does not mean that groundwater flooding has occurred in the past, or will do so in the future, as susceptibility maps do not contain information on how often flooding may occur and to what depth. Very shallow groundwater and the potential for groundwater flooding is a relatively rare event and not easily distinguishable from other types of flooding. Therefore the susceptibility to groundwater flooding has been determined by a computer model, which uses: geological maps; information from boreholes and wells, and relationships between groundwater and surface water. Artificial lowering of the water table is not taken into account, so in places where groundwater is abstracted, the susceptibility to groundwater flooding may be less than that predicted by the model. Information about the original dataset can be viewed at:
http://www.bgs.ac.uk/products/hydrogeology/groundwaterFlooding.html.

The dataset has been reclassified to show only those areas where a shallow water table is likely to restrict the installation of infiltration SuDS.

4.3 INFILTRATION SUDS DRAINAGE POTENTIAL

4.3.1 Drainage Summary

The *Drainage Summary* layer provides an overview of the extent to which the ground will drain. It is derived from the datasets described in Section 4.3.2 to 4.3.6 and is overlain with the *Infiltration SuDS Constraints Summary* layer discussed in Section 4.2.1. The summary layer indicates the likely design constraints associated with installing an infiltration system at a given location. Table 3 shows the four categories used in this summary layer.

Table 3. Description of attribute scores for the *Drainage Summary* layer.

Score	Short description	Detailed description
1	Highly compatible for infiltration SuDS	The subsurface is likely to be suitable for free-draining infiltration SuDS.
2	Probably compatible for infiltration SuDS	The subsurface is probably suitable for infiltration SuDs although the design may be influenced by the ground conditions.
3	Opportunities for bespoke infiltration SuDS	The subsurface is potentially suitable for infiltration SuDS although the design will be influenced by the ground conditions.
4	Very significant constraints are indicated	There is a very significant potential for one or more geohazards associated with infiltration.

If a site scores a value of 1, the subsurface is likely to be highly permeable, with a deep water table and not underlain by floodplain deposits that may respond rapidly to changes in river levels. In this environment, the installation of infiltration SuDS is likely to be straightforward. Sites that score a value of 2 may be characterised by a spatially variable permeability or a water table that may be within 1 m of the base of the infiltration system, or both. The design of infiltration SuDS in these areas should take account of the local ground conditions. Sites that score a value of 3 may be poorly draining, or have a shallow water table, or are located on floodplain deposits, or have some combination of these characters. In these areas, the subsurface may potentially be suitable for infiltration SuDS, but the design will be strongly dependent on the local ground conditions. Sites that score a value of 4 have a severe constraint that needs investigation to determine whether the potential for or the consequences of the constraint are likely to be significant.

4.3.2 Superficial deposit permeability

Superficial deposits mostly comprise unconsolidated gravel, sand, silt and clay in some combination. They are present beneath the pedological soil in patches or larger spreads over much of Britain. Infiltration systems are generally installed beneath the soil layer and hence the infiltration rate is dependent on the deposit that lies beneath. Where superficial deposits are present, the infiltration rate varies widely depending on the composition of the deposits.

This data layer reports the range of permeability predictions for the superficial deposits thereby indicating the type of infiltration system that might be suitable.

This component data layer is derived from the BGS Permeability Index dataset. The dataset has been reclassified to include a score field, but retains the original qualitative estimates of the predicted permeability range (minimum and maximum permeability). Information about the original dataset can be viewed at:
http://www.bgs.ac.uk/products/hydrogeology/permeability.html.

4.3.3 Superficial deposit thickness

In some areas, the superficial deposits are thin or absent and hence the permeability of the subsurface may be controlled either by the superficial deposits and bedrock in combination or by the bedrock alone. To determine whether or not the bedrock permeability should be considered a model of the superficial thickness is provided.

This component data layer is derived from the BGS Basic Superficial Thickness Model (BSTM). The thickness model has been reclassified to denote areas where the superficial deposits are absent, less than 3 m thick, or more than 3 m thick. Where the superficial deposits are less than 3 m thick or absent, the bedrock permeability should also be taken into consideration. Information about the original dataset can be viewed at:
http://www.bgs.ac.uk/products/onshore/superficialThickness.html

4.3.4 Bedrock permeability

Bedrock forms the main mass of rock forming the subsurface. Where superficial deposits are thin or absent, the ease with which water will infiltrate into the ground depends on the permeability of the bedrock. The infiltration rate into the bedrock depends on its permeability, which is largely determined by the rock type.

This data layer provides a qualitative indication of the predicted permeability range, which may indicate the type of infiltration system that might be suitable.

This component data layer is derived from the BGS Permeability Index. The dataset has been reclassified to include a score field, but retains the original qualitative estimates of the predicted permeability range (minimum and maximum permeability). Information about the original dataset can be viewed at:
http://www.bgs.ac.uk/products/hydrogeology/permeability.html.

4.3.5 Depth to water table

Guidance states that there should be a minimum unsaturated zone thickness of 1 m between the base of the infiltration system and the groundwater table. This ensures that there is sufficient space in the unsaturated zone to accommodate temporary rises in groundwater level resulting from infiltration. The depth to the water table is difficult to estimate, however by extrapolating river elevation levels, this dataset provides an estimate of the depth to water level. It is likely to be most accurate when applied at sites in close proximity to rivers. The dataset does not consider the presence of perched water tables, which may form above layers of low permeability material, causing a water strike above the level of the regional water table. The dataset provides an estimate of the natural water table not depressed by abstraction or dewatering. Prior to the installation of infiltration SuDS, the groundwater level should ideally be monitored for a period of one year to determine the likely seasonal variation. The infiltration SuDS system should be designed using the seasonal high groundwater level.

This component data layer has been derived specifically for the Infiltration SuDS Map. The dataset is classified into three zones; those where the water table is expected to be < 3 m, between 3 and 5 m and > 5 m deep.

4.3.6 Proximity to floodplains

On floodplains, the water table may respond rapidly to changes in river level. In times of high river level, a groundwater rise as a result of a rise in river stage may result in inundation of subsurface infiltration systems.

This component data layer is derived from the BGS Geological Indicators of Flooding dataset. The dataset has been subject to reclassification, such that the polygons highlighted in this component dataset represent those areas where floodplain deposits occur. Information about the original dataset can be viewed at:
http://www.bgs.ac.uk/products/hydrogeology/indicatorsOfFlooding.html.

4.4 INFILTRATION SUDS GROUND STABILITY

4.4.1 Ground Stability Summary

The *Ground Stability Summary* layer provides an overview of ground stability issues that should be considered during the planning and design of infiltration SuDS. The summary layer is derived from the reclassified GeoSure datasets described in sections 4.4.2 to 4.4.8 below. These datasets have been reclassified, such that the polygons highlighted in each component dataset represent the hazards associated with infiltrating water to the ground.

To provide a spatial overview of the geological hazards associated with infiltration to the ground, polygons within the individual datasets are scored from 1 to 4 (Table 4). These scores indicate the potential for ground stability associated with installing infiltration SuDS at a given location. The summary layer reports the maximum score, thereby representing the potential for ground instability.

Table 4. Description of attribute scores for the *Ground Stability Summary* layer.

Score	Short definition	Detailed definition
1	Geohazard unlikely	Increased infiltration is very unlikely to result in ground instability
2	Potential for geohazard	Ground instability problems may be present or anticipated. Increased infiltration is unlikely to result in ground instability
3	Significant potential for geohazard	Ground instability problems are probably present. Increased infiltration may result in ground instability
4	Very significant constraints are indicated	There is a very significant potential for one or more geohazards associated with infiltration

The stability of an area with a score of 1 is not anticipated to be impacted as a result of infiltration. Areas with a score of 2 or 3 may need investigation prior to infiltration, however the hazards present should not prevent infiltration SuDS from being used. For areas with a score of 4, the potential for and consequences of the identified hazard should be fully appraised. The impacts of infiltration on ground stability may be influenced by the infiltration system design. Systems designed for high volume infiltration over small areas may have a greater impact on ground stability than those that are designed to infiltrate small volumes of water over more extensive surface areas. Where ground instability hazards are present, the infiltration system design should take such considerations into account.

The ground stability component data layers in this section are derived from the BGS GeoSure dataset. The dataset has been reclassified to show only those areas where the geohazard represents a significant hazard if water is infiltrated to the ground.

4.4.2 Soluble rocks

As discussed in Section 4.2.2, infiltration may result in ground collapse where the geological deposits are susceptible to dissolution.

This data layer provides an indication of the potential for a hazard to occur as a result of infiltration and suggests the relevant action. The presence of soluble rocks may prevent infiltration SuDS from being installed, however in many areas, infiltration systems can be used as long as the hazard from soluble rocks is taken into account during planning and design.

4.4.3 Landslide hazards

As discussed in Section 4.2.3, the infiltration of water into deposits that are susceptible to landslide, may decrease the ‘strength’ of the deposit, resulting in slope instability

This data layer provides an indication of the potential for a hazard to occur as a result of infiltration and suggests the relevant action. On some landslides the installation of infiltration SuDS is not recommended, but on many susceptible slopes, infiltration systems can be used as long as the hazards are taken into account during planning and design.

4.4.4 Compressible ground

Many geological deposits contain water-filled pores. When the ground is compressed by a building or other load, the water in the pore space can be squeezed out, causing the ground to compress. This may cause uniform or non-uniform settling, resulting in tilting, cracking or distortion to buildings. If water is added to the ground through an infiltration system, the compressibility may alter, possibly initiating settlement.

This data layer provides an indication of the potential for settlement to occur as a result of infiltration and provides relevant advice. Compressible ground is unlikely to prevent infiltration SuDS from being installed, but it should be considered during planning and design to ensure that the installation or nearby structures are not affected. Information about the original dataset can be viewed at: http://www.bgs.ac.uk/products/geosure/compressible.html.

4.4.5 Swelling clays

Clays that are susceptible to shrink and swell change volume significantly according to how much water they contain. All clay deposits change volume as their water content varies, typically swelling in winter and shrinking in summer, but some do so to a greater extent than others. Contributory circumstances include the change in moisture content brought about by drought, leaking pipes, tree roots drying out the ground, or changes to local drainage patterns, such as the creation of soakaways. Shrinkage may remove the support from the foundations of buildings and structures, whereas clay expansion may lead to uplift or lateral stress on part or all of a structure; any such movement may cause cracking and distortion. If water is added to the ground through an infiltration system, susceptible clays may swell with the increase in moisture content, possibly introducing differential uplift.

Clay-rich deposits may be considered unsuitable for infiltration. This is likely to be true for systems that require rapid drainage such as soakaways, however infiltration systems that have an extensive infiltration area or that have provision for water storage may be appropriate. Such systems are often utilised for high-return period storm events and utilise land that has a different primary use (e.g. recreation).

This data layer provides an indication of the potential for ground movement to occur as a result of infiltration and provides relevant advice. Swelling clays are unlikely to prevent infiltration SuDS from being installed, but they should be considered during planning and design to ensure that the installation or nearby structures are not impacted. Information about the original dataset can be viewed at: http://www.bgs.ac.uk/products/geosure/shrink_swell.html.

4.4.6 Running sands

Running sand conditions occur when loosely-packed sand, saturated with water, flows into an excavation or other type of void. The pressure of the water filling the spaces between the sand grains reduces the contact between the grains and they are carried along by the flow. This can lead to subsidence of the surrounding ground. Running sand is potentially hazardous during the installation of infiltration SuDS. The excavation of ground may create a space into which sand can flow, potentially causing subsidence of surrounding ground.

This data layer provides an indication of the potential for running sand. Running sand is unlikely to prevent infiltration SuDS from being installed, but it should be considered during planning and design to ensure that the installation or nearby structures are not impacted.

The dataset has been reclassified to show only those areas where running sand represents a significant hazard if water is infiltrated to the ground. Information about the original dataset can be viewed at: http://www.bgs.ac.uk/products/geosure/running_sand.html.

4.4.7 Shallow mining hazards (non-coal)

As discussed in Section 4.2.4, the infiltration of water may destabilise material bridging above or within a mined cavity, potentially resulting in ground collapse.

This data layer provides an indication of the potential for shallow mining collapse to occur as a result of infiltration. The installation of infiltration SuDS is possible in many areas that are affected by shallow mining as long as the potential for stability (and water quality) hazards are considered. The dataset considers only non-coal mining hazards. For information regarding underground and opencast coal mining and matters relating to subsidence or other ground movement induced by coal mining, please contact the Coal Authority, Mining Reports, 200 Lichfield Lane, Mansfield, Nottinghamshire, NG18 4RG; telephone 0845 762 6848 or at www.coal.gov.uk.

4.4.8 Collapsible ground

Collapsible ground comprises certain fine-grained materials with large pore spaces. Such deposits can collapse when they have been loaded and then become saturated by water. If the ground below a building collapses it may cause the building to sink. If the collapsible ground is variable in thickness or distribution, different parts of the building may sink by different amounts, possibly causing tilting, cracking or distortion. Infiltration will result in an increase in water content, which may affect the strength of the ground.

This data layer provides an indication of the potential for the ground to collapse. Collapsible ground is unlikely to prevent infiltration SuDS from being installed, but it should be considered during planning and design to ensure that the installation or nearby structures are not impacted.

The dataset has been reclassified to show only those areas where collapsible ground represents a significant hazard if water is infiltrated to the ground. Information about the original dataset can be viewed at:
http://www.bgs.ac.uk/products/geosure/collapsible.html.

4.5 INFILTRATION SUDS GROUNDWATER PROTECTION

4.5.1 Groundwater Protection Summary

The *Groundwater Protection Summary* layer provides an overview of subsurface factors that may impact the planning and design of infiltration SuDS in respect of protecting groundwater quality. The data will be useful when determining whether pre-treatment of surface water prior to infiltration is necessary. The summary layer is derived from the datasets described in sections 0 and 4.5.3. The site investigation should include a full risk-based assessment of the potential for groundwater quality deterioration. The data included in the Infiltration SuDS Map only provides preliminary data, for example it does not consider the presence of contaminated land, through which infiltration could result in the remobilisation of contaminants.

To provide a spatial overview of the extent to which precaution is required, polygons within the individual datasets are scored from 1 to 4 (Table 5). These scores indicate the extent to which the groundwater may be susceptible to contamination. The summary layer reports the maximum score, thereby representing the likely level of precaution required.

Table 5. Description of attribute scores for the *Groundwater Protection Summary* layer

Score	Short description	Detailed description
1	Low susceptibility	The groundwater is not expected to be especially vulnerable to contamination. Infiltrating water should be free of contaminants
2	Moderate susceptibility	The groundwater may be vulnerable to contamination. Infiltrating water should be free of contaminants
3	Considerable susceptibility	The groundwater is likely to be vulnerable to contaminants. Infiltrating water should be free of contaminants
4	Very significant constraints are indicated	Made ground is present at the surface. Infiltration may increase the possibility of remobilising pollutants

4.5.2 Groundwater source protection zones

The source protection zone datasets sourced from the Environment Agency, and Natural Resources Wales, define zones around public water supply abstraction points where additional protection is required to safeguard drinking water quality. In these areas, activities that may affect the quality of the drinking water abstraction may be restricted. It is included here to show where restrictions on the installation of infiltration SuDS may apply.

Source protection zones are delineated only in England and Wales. Four source protection zone classifications are used, each defined by groundwater travel time to the abstraction point. Zone 1 areas are defined by a travel time of 50 days or less from any point within the zone, at or below the water table. Zone 2 is defined by a 400-day travel time from a point below the water table, with a minimum radius of 250 or 500 m. Zone 3 is defined as the whole of the area that supports the abstraction or discharge from the protected groundwater source. Zone 4 highlights areas (mainly on non-aquifers) where known local conditions mean that potentially polluting activities could impact a groundwater source. The source protection zone dataset provides only a partial indication of the sensitivity of the groundwater and should be used as the basis for risk-led decisions on the appropriateness of infiltration (for more information consult the Environment Agency publication, Groundwater Protection: Policy and Practice, Document GP3). It is important to prevent the transport of contaminants into the groundwater at all sites. This includes contaminants that are potentially introduced to the surface water and also contaminants that may be re-mobilised within the subsurface by infiltrating water.

4.5.3 Predominant flow mechanism

Some geological deposits will attenuate surface water pollutants more than others. The predominant flow mechanism in the unsaturated zone is one proxy for determining whether such attenuation is likely. There are three types of flow mechanism in the unsaturated zone: intergranular flow occurring through otherwise air-filled pore spaces, fracture flow occurring through cracks, or a combination of both. Where flow is intergranular, the residence time of the infiltrating water will be long and contact with the mineral surfaces large, so attenuation is likely to be maximised. Conversely, where flow is through fractures, the residence time will tend to be short and contact with surfaces low, and so attenuation will be minimised.

This component data layer is derived from the BGS' Permeability Index dataset. The dataset has been re-attributed to include a score field, but retains the original descriptions of predominant flow mechanisms. Information about the original dataset can be viewed at:
http://www.bgs.ac.uk/products/hydrogeology/permeability.html.

4.5.4 Made ground

As discussed in Section 4.2.5, infiltration through made ground may impact groundwater quality as such anthropogenic deposits can contain contaminants that may be remobilised from the unsaturated zone into the groundwater. Made ground is shown on the geological maps only where it has been recorded, and it may be present elsewhere.

4.6 DATA SUMMARY

The original datasets used in the creation of the Infiltration SuDS Map are detailed in Table 6.

Table 6. Details of the original datasets used in the infiltration SuDS map

Data layer	Layer ID	Original dataset	Dataset owner	Scale
Infiltration SuDS constraints				
Infiltration constraints summary	SuDS_infiltrationconstraints_screen_2016	N/A	BGS	
Soluble rock constraints	SuDS_infiltrationconstraints_solublerocks_2016	GeoSure v7	BGS	1:50 000
Landslide constraints	SuDS_infiltrationconstraints_landslides_2016	GeoSure v7	BGS	1:50 000
Shallow groundwater constraints	SuDS_infiltrationconstraints_shallowGW_2016	Groundwater Flooding Susceptibility v6.1	BGS	1:50 000
Made ground constraints	SuDS_infiltrationconstraints_madeground_2016	DiGMapGB-50 v7	BGS	1:50 000
Shallow mining constraints	SuDS_infiltrationconstraints_shallowmining(non-coal)_2016	Mining hazard (non-coal) GB v7	BGS	1:50 000
Infiltration SuDS drainage potential				
Drainage summary	SuDS_drain_screen_2016	N/A	BGS	
Depth to water table	SuDS_drain_depthtowater_2016	gwlevelgb (2016)	BGS	---
Superficial deposit thickness	SuDS_drain_superficialthickness_2016	Basic superficial thickness model, version 2.1, GI_SDTM v2.1	BGS	1:50 000
Superficial deposit permeability	SuDS_drain_superficialpermeability_2016	Permeability indices v7	BGS	1:50 000
Bedrock permeability	SuDS_drain_bedrockpermeability_2016	Permeability indices v7	BGS	1:50 000
Floodplains	SuDS_drain_geologicalindicatorsofflooding_2016	Geological indicators of flooding v6	BGS	1:50 000
Infiltration SuDS ground stability				
Ground stability summary	SuDS_stability_screen_2016	N/A	BGS	1:50 000
Soluble rocks	SuDS_stability_solublerocks_2016	GeoSure v7	BGS	1:50 000
Landslides	SuDS_stability_landslides_2016	GeoSure v7	BGS	1:50 000
Compressible ground	SuDS_stability_compressibles_2016	GeoSure v7	BGS	1:50 000
Swelling clay	SuDS_stability_swellingclay_2016	GeoSure v7	BGS	1:50 000
Running sand	SuDS_stability_runningsand_2016	GeoSure v7	BGS	1:50 000
Shallow mining	SuDS_stability_shallowmining_2016	Mining hazard (non- coal) GB v7	BGS	1:50 000
Collapsible ground	SuDS_stability_collapsibles_2016	GeoSure v7	BGS	1:50 000
Infiltration SuDS groundwater protection				
Groundwater protection summary	SuDS_waterquality_screen_2012	N/A	BGS	
Source protection zones	SuDS_waterquality_sourceprotectionzone_2012	Downloaded 2015	EA	--
Predominant flow mechanism	SuDS_waterquality_predominantflowmechanism_2012	Permeability indices v7	BGS	1:50 000
Made ground	SuDS_waterquality_madeground_2012	DiGMapGB-50 v7	BGS	1:50 000

5 Technical Information

5.1 PRE-REQUISITE REQUIREMENTS

To use the Infiltration SuDS Map, a computer with vector-based GIS software is required.

It is highly beneficial to have a topographic GIS layer. If unavailable, see the Ordnance Survey website (http://www.ordnancesurvey.co.uk/) for the provision of OpenData.

5.2 CREATION OF THE DATASET

The component datasets are directly derived from the datasets listed in Table 6. The original datasets were modified to create the component datasets in one or more of the following ways:

a) polygons were reclassified with SuDS scores (scores used are stated in Tables 2 to 5) and those with identical attributes were merged
b) raster datasets with continuous numerical values were classified into intervals
c) polygons that were not relevant were not incorporated in the map

Resulting polygons were attributed with a score, a short description, a detailed description, an advice description, layer identification (ID), and where relevant, further information about the dataset. The only exception was the superficial thickness data layer, which was not attributed with a score classification.

The four summary maps were derived from the rasterised component datasets as shown in Figure 7. For each raster cell, the maximum score from the individual datasets was calculated and used to create the summary map.

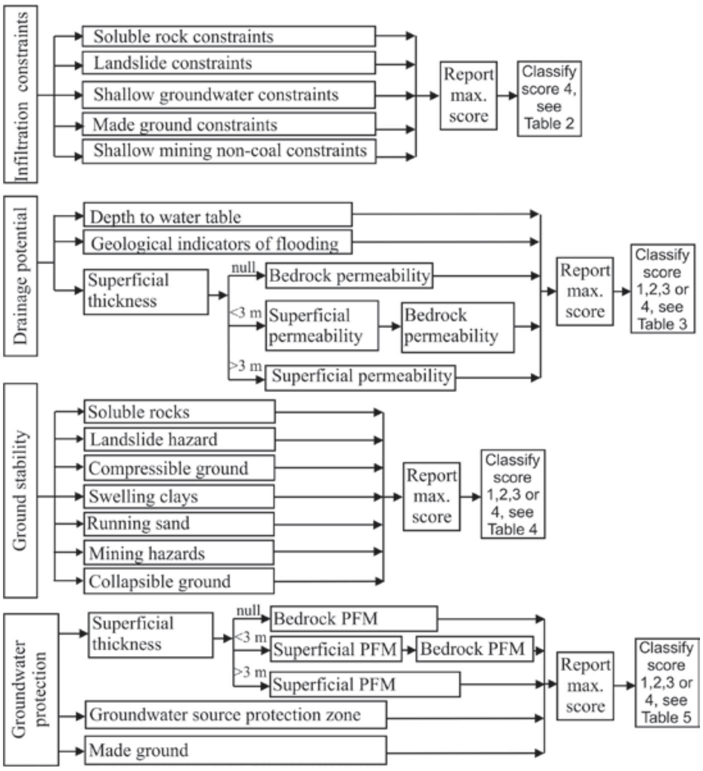

Figure 7. Flow diagram showing how data was used to create summary maps. PFM: Predominant flow mechanism.

5.3 SCALE

The Infiltration SuDS Map is produced for use at 1:50 000 scale providing 50 m ground resolution. A cell size of 50 m is deemed reasonable given that 1:50 000 geological linework has a cartographic accuracy of 50 m. The mapping scales on which the original geological linework are based are shown in Appendix 1.

5.4 FIELD DESCRIPTIONS

Table 7 describes the attributes attached to each dataset.

Table 7. Attribute table field descriptions

FIELD NAME	FIELD TYPE	DESCRIPTION
LayerID	String	Layer identification
Score	Integer	SuDS score
Short description	String	Short description of polygon attribute
Detailed description	String	Detailed description of polygon attribute
Advice	String	Advice on action necessary
Minimum*	String	The minimum value of a data range is reported
Maximum*	String	The maximum value of a data range is reported
Source protection zone*	String	The classification of source protection zone is reported
Predominant flow mechanism*	String	The flow mechanism is reported

*fields not found in every dataset feature layer

5.5 DATASET HISTORY

The Infiltration SuDS Map was originally created and released in 2012. This report describes the second version of the map released in 2016. The methodology used to create the map remains the same; however a number of the source datasets have been re-released since the Infiltration SuDS Map was released and thus the new versions of these datasets are now incorporated. The changes to these datasets (permeability, predominant flow mechanism, geohazards, groundwater flooding and artificial ground) are a result of changes to the underlying DigMapGB-50 and other advances in methodology/understanding. A new version of the depth to water table dataset has been incorporated. This dataset has been completely revised and as a result you may notice some differences compared to the old dataset. Since the last release, the Environment Agency, and Natural Resources Wales, have released new versions of the source protection zone datasets and these are now incorporated.

5.6 COVERAGE

The data covers Great Britain, but not the Isle of Man. The source protection zone dataset does not extend over Scotland and hence queries will not return any data.

5.7 DATA FORMAT

The Infiltration SuDS Map has been created as vector polygons, which are available in a range of GIS formats, including ArcGIS (.shp) and MapInfo (.tab).

A sample of the map is available at
http://www.bgs.ac.uk/products/hydrogeology/infiltrationSuds.html.

5.8 LIMITATIONS

- The Infiltration SuDS Map has been developed at 1:50 000 scale and must not be used at larger scales.
- The Infiltration SuDS Map is based on, and limited to, an interpretation of the records in the possession of the British Geological Survey at the time the dataset was created.
- The search does NOT consider the suitability of sites with regard to previous land use, for example with regard to water quality issues that might arise as a result of infiltration through contaminated land and associated mobilisation of surface or subsurface contaminants.
- This dataset is NOT an alternative for a site investigation or for infiltration testing, either of which may reach a different conclusion.
- Site observations represent the properties of the ground more accurately than the data provided by the Infiltration SuDS Map.
- This dataset must NOT be used to justify the disposal of foul waste or grey water.
- This dataset considers only the subsurface beneath the search area and does NOT consider potential surface or subsurface impacts outside of that area.
- Other more specific and detailed ground instability information may be held by BGS, and an assessment of this could result in a different outcome.
- An indication of potential natural ground instability does not necessarily mean that a location will be affected by ground movement or subsidence. Such an assessment can only be made by inspection of the area by a qualified professional.
- Limitations associated with the individual datasets are highlighted in Section 4.
- The dataset does not represent a complete list of factors that should be considered when designing infiltration SuDS. In particular, the dataset does not consider:
    - presence of contaminated land
    - potential for perched water tables
    - shallow mining hazards relating to coal mining
    - made ground, where not recorded, and
    - zones around private water supply boreholes that are susceptible to groundwater contamination
- The dataset may under-represent some hazards, in particular:

- o shallow mining hazards in areas that are not typically mined, or are subject to historical artisan mining
- o Landslide hazards in some coastal areas

6 Using the data

6.1 SETTING UP THE GIS

To ensure that the dataset is used as designed, follow the proceedings steps to set-up the map:

a) Make sure the required data layers, as shown below, are present.
   - Infiltration_constraints_summary
   - Soluble_rock_constraints
   - Landslide_constraints
   - Shallow_mining_constraints
   - Shallow_groundwater_constraints
   - Made_ground_constraints
   - Drainage_summary
   - Depth_to_water
   - Superficial_thickness
   - Superficial_permeability
   - Bedrock_permeability
   - Geological_indicators_of_flooding
   - Ground_stability_summary
   - Soluble_rocks
   - Landslides
   - Shallow_mining
   - Collapsible_ground
   - Compressible_ground
   - Running_sand
   - Swelling_clay
   - Groundwater_protection_summary
   - Groundwater_source_protection_zones
   - Predominant_flow_mechanism
   - Made_ground

If you have licensed data as a MapInfo .tab file and some of the infiltration constraint files are missing, this may be because the chosen area is not affected by those infiltration constraints (i.e. there is no data). MapInfo cannot create a file without data, conversely, ArcGIS shape files can be created regardless and so there should not be any .shp files missing.

To set-up the GIS to reflect Figure 3, the *Infiltration Constraints Summary*, *Drainage Summary*, *Ground Stability Summary* and the *Groundwater Protection Summary* layers need to be imported twice.

b) Import the data layers into the GIS software such that they appear in the order shown in Figure 3.

If you're using ESRI ArcGIS, the GIS can be set-up simply by using the single group layer file called *Infiltration_ SuDS_Map_Detailed.lyr*. Either import this into an existing ArcGIS document, or double click on the file to open a new GIS document.

Alternatively, import the layer files (.lyr) from the *Severe_Constraints*, *Drain*, *Stability*, and *Water_Quality* folders provided. By using layer files, the polygons will be imported with the correct symbology. The map should be coloured via the *short description* attribute as shown in Table 8, such that it mirrors that shown in Figure 8 for the *Drainage Summary* layer.

If you import the individual layer files, please note the following:

- Where the data layer appears twice in the above list, e.g. soluble rocks appears in the first and third questions, the data layer was reclassified in two different ways to provide answers to both questions. Ensure that these layers are positioned in the correct position.
- If possible, arrange the data layers in five sub-folders entitled 'Infiltration SuDS Summary', 'Infiltration Constraints', 'Infiltration SuDS Drainage Potential', Infiltration SuDS Ground Stability' and Infiltration SuDS Groundwater Protection', as shown in Figure 3.

If additional data on internationally designated sites is required (special areas of conservation, special protection areas and Ramsar sites) this can be downloaded from the Joint Nature Conservation Committee's website, http://jncc.defra.gov.uk/.

Table 8. RGB colours to be assigned to score classes

Datasets	Score			
	1	2	3	4
Infiltration_constraints_summary Soluble_rock_constraints Landslide_constraints Shallow_mining_constraints Shallow_groundwater_constraints Made_ground_constraints				R: 156 G: 156 B: 156
Drainage_summary Depth_to_water Superficial_permeability Bedrock_permeability Geological_indicators_of_flooding	R: 235 G: 240 B: 255	R: 199 G: 209 B: 255	R: 156 G: 156 B: 227	R: 156 G: 156 B: 156
Superficial_thickness	< 3 m R: 205 G: 255 B: 115		>3 m R: 76 G:115 B: 0	
Ground_stability_summary Soluble_rocks Landslides Shallow_mining Collapsible_ground Compressible_ground Running_sand Swelling_clay	R: 229 G: 245 B: 179	R: 198 G: 222 B: 133	R: 145 G: 163 B: 97	R: 156 G:156 B: 156
Groundwater_protection_summary Groundwater_source_protection_zones Predominant_flow_mechanism Made_ground	R: 245 G: 220 B: 229	R: 217 G: 169 B: 187	R: 179 G: 117 B: 143	R: 156 G: 156 B: 156

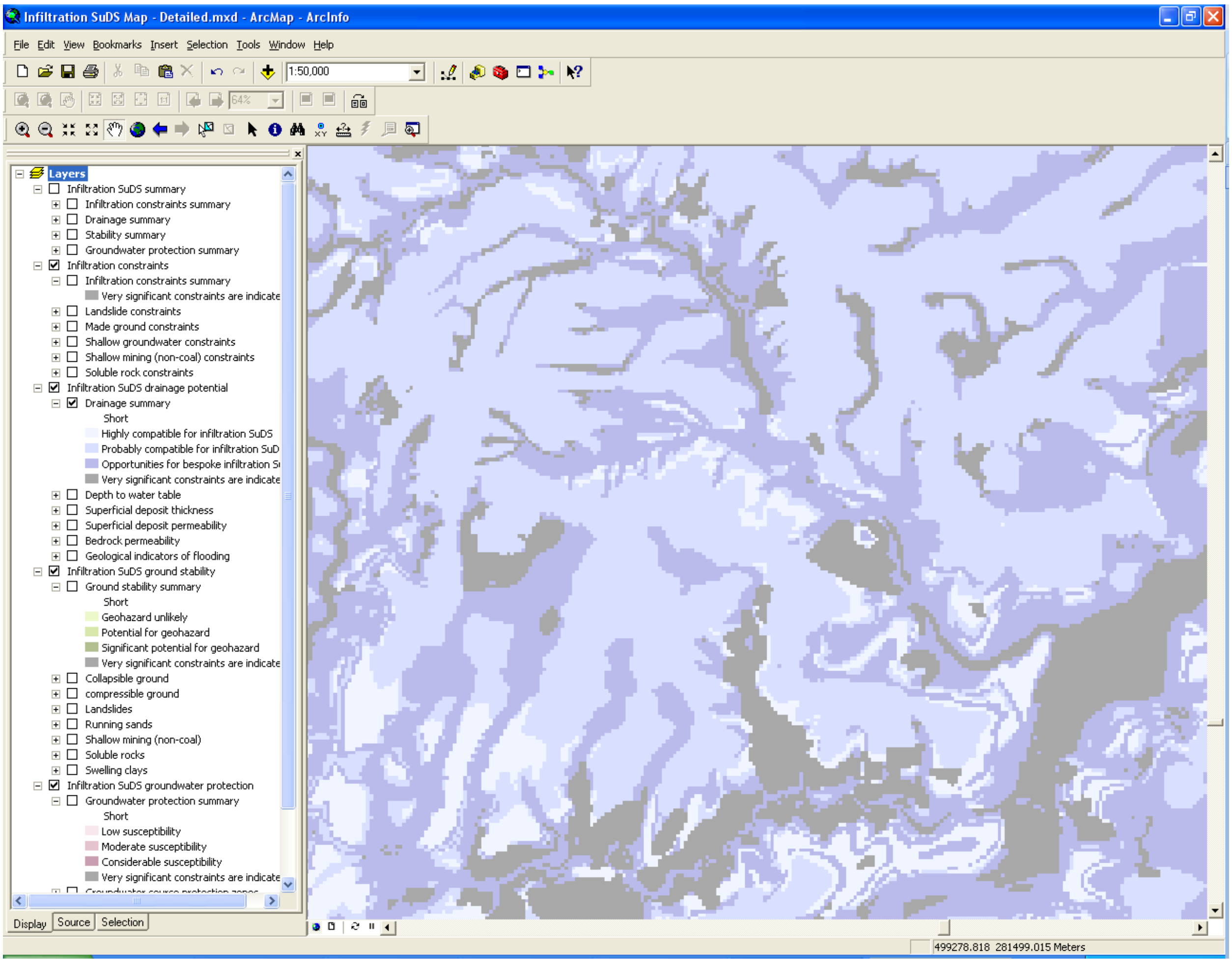

Figure 8. Infiltration SuDS map loaded into ArcGIS, showing legend colours

c) We recommend setting the polygon transparency to 30 per cent.

If you need support setting up the GIS, please contact digitaldata@bgs.ac.uk.

6.2 HOW TO USE THE DATA

This section provides advice on how to use the dataset. Turn on each dataset individually, so that only one dataset and the topography layer is visible at any one time.

Using the data for spatial planning

a) Load the Infiltration SuDS Map into the preferred GIS software as described in Section 6.1. View the datasets in the ‘Infiltration SuDS Summary’ section, using the instructions below.

b) Pan to, or locate by coordinates, the location of interest.

c) View the *Infiltration Constraints Summary* layer

If an ‘infiltration constraints’ polygon is identified at the site it indicates that there is potential for a hazard if water is infiltrated to the ground. In such areas, infiltration SuDS should only be installed if the potential for, or the consequences of, the constraint are considered not to be significant.

d) View the *Drainage Summary* layer to obtain a spatial assessment of the drainage potential of the ground. At the location of interest, use the cursor in 'Identify' mode to determine the attributes of the polygon overlaying the site. The following attributes may be encountered:
   - Highly compatible for infiltration SuDS
   - Probably compatible for infiltration SuDS
   - Opportunities for bespoke infiltration SuDS
   - Very significant constraints are identified.

e) View the G*round Stability* S*ummary* layer to obtain a spatial assessment of the expected stability of the subsurface should water be infiltrated. At the location of interest, use the cursor in 'Identify' mode to determine the attributes of the polygon overlaying the site. The following attributes may be encountered:
   - Geohazard unlikely
   - Potential for geohazard
   - Significant potential for geohazard
   - Very significant constraints are identified.

f) View the *Groundwater Protection Summary* layer to obtain a spatial assessment of factors that may influence infiltration SuDS design with respect to protecting groundwater quality. At the location of interest, use the cursor in 'Identify' mode to determine the attributes of the polygon overlaying the site. The following attributes may be encountered:
   - Low susceptibility
   - Moderate susceptibility
   - Considerable susceptibility
   - Very significant constraints are indicated.

Using the data for local assessment

a) Pan to, or locate by coordinates, the location of interest.

b) View the *Infiltration Constraints Summary* layer in the *Infiltration SuDS Constraints* section. This layer is identical to that in the section above and is repeated for convenience.

   If an 'infiltration constraints' polygon is identified at the site, turn off the summary map and turn on the component layers one at a time (*soluble rock constraints, landslide constraints, made ground constraints, shallow groundwater constraints* and *shallow mining hazards constraints*) to determine from which dataset that polygon originates. Record the information obtained. If a constraint is identified, this factor will need specific investigation and verification during infiltration system planning and design.

   TIP for ArcGIS users: to easily determine the attributes of all layers within severe constraints, turn on all layers and use the 'Identify' tool in 'show all visible layers' mode when selecting the site location.

c) View the *Drainage Summary* layer in the *Infiltration SuDS Drainage Potential* section to obtain a rapid assessment of the drainage potential of the subsurface. This layer is identical to that in the section above and is repeated for convenience. This layer will give you an overview of the drainage potential of the ground, the next set of data layers identify the properties of the ground and can provide an indication of the likely limitations.

d) View the drainage component layers (*Depth to Water Table*, *Superficial Thickness, Superficial Deposit Permeability, Bedrock Permeability and Geological Indicators of Flooding)* in turn. Record the information obtained.

   TIP for ArcGIS users: to easily determine the attributes of all layers within severe constraints, turn on all layers and use the 'Identify' tool in 'show all visible layers' mode when selecting the site location.

e) View the *Ground Stability Summary* layer in the *Infiltration SuDS Ground Stability* section. This layer is identical to the *Ground Stability Summary* in the first section and is repeated for convenience. This layer will give you an overview of the potential for ground instability if water is infiltrated; the next set of data layers identifies which ground stability issues are possibly present.

f) View the seven ground stability component layers in turn and determine whether any stability issues are raised. Record the information obtained.

g) View the *Groundwater Protection* S*ummary* layer in the *Infiltration SuDS Groundwater Protection* section. This layer is identical to the *Groundwater Protection Summary* in the first section and is repeated for convenience. This layer provides an overview of the susceptibility of the groundwater to contamination if water is infiltrated (within the limitations of the data); the next set of data layers identifies which factors.

h) View the three groundwater protection component layers in turn and determine whether any water quality aspects are raised. Record the information obtained.

Worked examples

Table 9 summarises data outputs obtained from the *Infiltration SuDS Map: Detailed* for three locations; A, B and C, each of which represents a location where an infiltration system has been installed. The data does not state which type of infiltration system is appropriate, or, in any way, offer advice on appropriate infiltration systems, but does allow you to develop a conceptual model of the subsurface geology as shown in Figure 9.

The data outputs for Location A suggests that the site is suitable for a free-draining infiltration system, on condition that the minor stability concerns (landslides and running sand) are satisfactorily addressed. The water table is > 5 m deep and the superficial deposits (which are over 3 m thick) are freely draining. The impacts of infiltration on groundwater quality should be considered via a risk-based approach; however the Infiltration SuDS Map doesn't highlight any specific issues.

The data output for Location B suggests that the site is suitable for infiltration; however drainage is likely to be spatially variable, the water table is likely to be shallow (< 3 m) and the location is within a geologically-indicated floodplain. There is also potential for, or significant potential for, a number of ground stability hazards, in particular, running sand, compressible ground, landslides, and swelling clays. Because the drainage potential of the ground underlying this site is spatially variable, the infiltration rate is difficult to predict and hence the type of infiltration SuDS appropriate at this site is highly dependent on the specific site conditions. An infiltration basin or permeable pavement may be more appropriate than a soakaway, depending on the measured infiltration rate. The shallow water table at this site should be investigated to ensure that a 1 m thickness of unsaturated zone is present beneath the base of the infiltration system. In addition, it should be noted that the site is located on floodplain deposits. In such areas, the water table may rise in response to river levels, potentially resulting in inundation of the soakaway. The impacts of infiltration on groundwater quality should be considered via a risk-based approach; however the SuDS Map doesn't highlight any specific issues.

The data outputs for Location C suggests that the site is suitable for infiltration; however the ground is likely to be poorly draining and there are a few minor ground instability hazards that need to be addressed. At this site, the superficial deposits are anticipated to be less than 3 m thick and therefore the permeability of the bedrock should also be taken into account. At this location, both the superficial deposits and bedrock are relatively poorly draining and hence a system with an extensive surface area for infiltration, or capacity for water storage, may be appropriate depending on the measured infiltration rate. The impacts of infiltration on groundwater quality should be considered via a risk-based approach. At this site, water migrates through the unsaturated zone via fractures and intergranular flow; hence pollutant removal might be reduced compared to a case where intergranular flow predominates.

Table 9. Data for three locations, A, B, and C where infiltration devices (soakaway, permeable pavement and infiltration basins respectively) have been installed.

Data layer	Location A	Location B	Location C
System installed	**Soakaways**	**Permeable pavements**	**Infiltration basin**
Infiltration constraints			
Soluble rock constraints	**Null**	**Null**	**Null**
Landslide constraints	**Null**	**Null**	**Null**
Shallow groundwater constraints	**Null**	**Null**	**Null**
Made ground constraints	**Null**	**Null**	**Null**
Shallow mining constraints	**Null**	**Null**	**Null**
Will it drain?			
Depth to water table	**> 5 m**	**< 3 m**	**> 5 m**
Superficial thickness	**> 3 m**	**> 3 m**	**< 3 m**
Superficial permeability	**High to very high**	**Low to high**	**Low to very low**
Bedrock permeability	**High**	**Moderate to low**	**Moderate to low**
Geological indicators of flooding	**Null**	**Floodplain (sea)**	**Null**
Will it be stable?			
Soluble rocks	**Null**	**Null**	**Null**
Landslides	**2**	**2**	**2**
Compressible ground	**1**	**3**	**1**
Swelling clay	**1**	**2**	**1**
Running sand	**2**	**3**	**2**
Shallow mining	**Null**	**Null**	**Null**
Collapsible ground	**1**	**1**	**1**
Water quality precautions			
Source protection zones	**Null**	**Null**	**Null**
Predominant flow mechanism	**Intergranular**	**Intergranular**	**Superficial: Mixed**
Made ground	**Null**	**Null**	**Null**

All **red** text derived from Infiltration SuDS Map

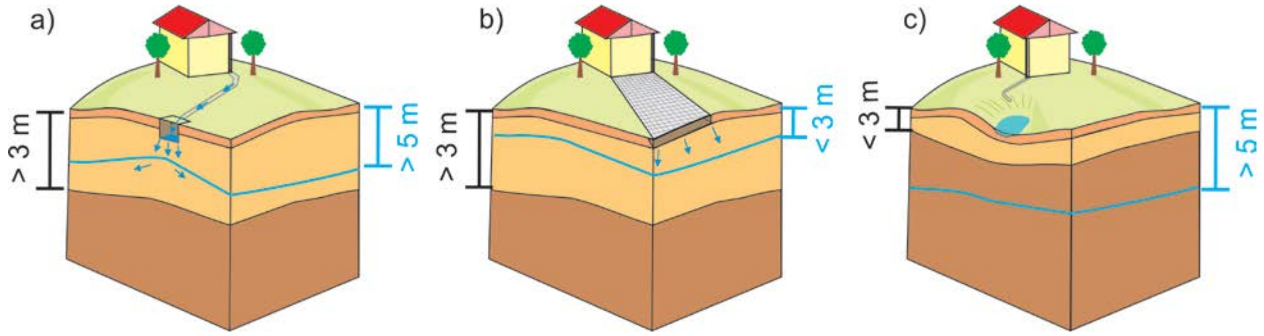

Figure 9. Conceptual models drawn using data in Table 9

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Appendix 1

Mapping scales