UK Sustainable Drainage Guidance & Tools

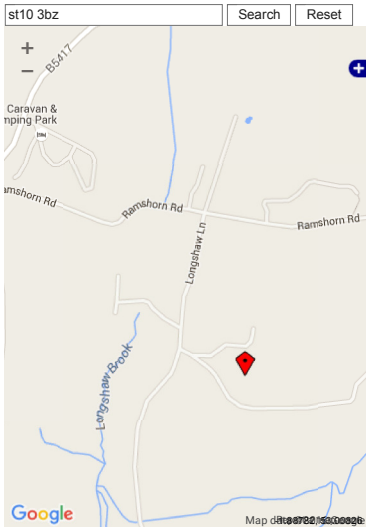
HR Wallingford
Working with water

Greenfield Runoff Estimation for Sites

Use the map to find your site location and then click on your site to extract the hydrological characteristics. If you wish to produce a report of findings, please ensure that you have switched off any Pop-up blockers that are enabled in your browser.

Please note that due to licensing restrictions, we cannot automatically provide the HOST class for your site directly from the map click. We have however recently digitised our own map of Winter Rainfall Acceptance Potential (WRAP) from the Wallingford Procedure, and are pleased to be able to provide the SOIL value for your site from the map click from this. If you still require the HOST class for your site then please consult the FEH CD ROM.

st10 3bz Search Reset



Site Details

Site Name	Cote Farm
Site Location	ST10 3BZ
Latitude of site	53.00272° N
Longitude of site	1.89283° W

Site Characteristics

Total Site Area (ha)	3
Significant public open space (ha)	2.8
Area positively drained (ha)	0.2

IH124 Method | FEH Method

Derivation of QBar

Specify how QBar should be derived	Calculate from SPR and SAAR	
Specify how SPR should be derived	Calculate from SOIL type	
Specify SOIL Type	1	1
SPR	0.10	0.10

Hydrological Characteristics	Editable values	Map value
SAAR (mm)	1299	1299
M5-60 Rainfall Depth (mm)	20	20
'r' Ratio M5-60 / M5-2 day	0.3	0.3
FEH/FSR conversion factor	0.92	0.92
Hydrological region	10	10
Growth curve factor: 1 year	0.87	0.87
Growth curve factor: 10 year	1.38	1.38
Growth curve factor: 30 year	1.7	1.7
Growth curve factor: 100 year	2.08	2.08

Results Estimated Site Discharges	IH124 Results User values	IH124 Results Map values	FEH Results User Values	FEH Results Map values
Qbar (l/s)	0.07	0.07	---	---
1 in 1 year (l/s)	5.00	5.00	---	---
1 in 30 years (l/s)	5.00	5.00	---	---
1 in 100 years (l/s)	5.00	5.00	---	---

Generate report

Please note that a minimum flow of 5 l/s applies to any site

Help Information

Greenfield Runoff Estimation for Sites
The aim of the tool is to provide flow rate information based on a minimum amount of data so that anybody can use the tool.

The methodology is built around the concept that a flow rate discharge constraint is needed for storm water runoff from a site, resulting in attenuation volume being needed. In addition, current drainage criteria include the requirement for the 100 year 6hr volume to be controlled.

The tool is based on the results of simple model analysis and correlating the results against key known site parameters. As such the results need to be treated as providing indicative information only and should not be used to produce final designs of drainage systems without additional modelling being carried out.

The peak flow estimation can now be estimated using two different formulae.
1) the formula developed in IH124 (IH 1994) and use of the FSSR growth curve information for regions of the UK (FSSR 14),
2) The use of FEH statistical correlation equation revised in 2008.

However, only the IH124 method can be used without providing specific parameter values. The FEH based method requires the use of the parameter BFIHOST which needs to be entered manually for this version.

Direct input of a value for Qbar to over-ride the calculated value can also be made.

The FSSR 14 growth curves are applied to both methods.

The greenfield runoff estimation tool is based on work initially carried out for the Environment Agency by HR Wallingford (HRW 2004) to provide a simple nationally available consistent methodology for estimating limiting discharges for drainage systems. The methodology (which is a manual system designed to avoid the need for any software tools) is also available in the Defra/ Environment Agency document 'Preliminary rainfall runoff management for developments' (2011), W5-074/A/TR/1 rev. E.

The current national procedure for estimating rainfall and river flow in the UK is the Flood Estimation Handbook (FEH) software package and subsequently the more recent ReFH (2007). This package superseded FSR when it came out in 1999. FEH is a digitally based methodology and has 7 unique data values for parameters at approximately one kilometre resolution across the country. It is aimed at providing tools for hydrologists to use and its use by engineers who are unfamiliar with the package is not recommended. FEH subdivides the country into catchments and uses an average of the data values to generate flow rate information rather than calculating a value from the parameter values at a specific point, thus aiming at providing river flow information rather than runoff from a specific site.

FSR is a paper map based system delivered in 1975 and rainfall is a simple function of two principal parameters, M560 and Rainfall Ratio 'r'. When using FSR based information it allows for a correction factor (which is location specific) to take account of the difference in rainfall depth between FSR and FEH where this is known.

References:

- IH124 Flood Estimation for Small Catchments(IH 1994).
- HR Wallingford (2011). Preliminary rainfall runoff management for developments.
- Defra/EA report WS-074A/TR/1 rev.E.
- Flood Estimation Handbook(CEH 1999).
- Improvements to FEH statistical method 940, 08(EA, 2008).
- KELLAGHER R. Preliminary rainfall runoff management for developments – Technical Report. W5-074/A/TR/1, Revision E. Bristol: Environment Agency / Defra, 2013.

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Site Name
Please provide a name for the site. The site name will be recorded in the generated report.

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Site Location
Please provide an approximate location for your site, such as the town within which the site is located, as it will be recorded in the generated report.

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Site coordinates
The location of your site, as determined by the location of the cursor when you clicked on the map, represented in degrees Latitude and Longitude.

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Total site area (ha)
The area, in hectares, of the whole development site including any large parkland areas and public open space.

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Significant public open space (ha)
The area, in hectares, of any large parkland areas or public open space situated within the site which remains largely unchanged and is not provided with positive drainage.

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Area positively drained (ha)
This is the total development area that is served by the drainage system. It is the difference between the total site area and the significant public open space.

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Greenfield runoff method
The user can choose between two methods to calculate greenfield runoff: IH 124, or the correlation equation of the statistical method of the FEH method.

IH 124 (1994):
The Institute of Hydrology carried out a number of further studies on revising the runoff equations produced in the original Flood Studies Report (1975). IH124 was specifically produced to address the runoff from small catchments. Institute of Hydrology (1994). Although shown to be slightly less accurate than the more recent FEH based methods, it is still considered to be an acceptable approach for assessing greenfield runoff rates.

$Qbar_{rural} = 0.00108 \times (0.01 \times AREA)^{0.89} \times SAAR^{1.17} \times SPR^{2.17}$, m^3/s

where:
$Qbar_{rural}$ is the mean annual flood flow from a rural catchment (approximately 2.3 year return period).
AREA is the area of the catchment in ha.

SAAR is the standard average annual rainfall for the period 1941 to 1970 in mm (SAAR 41-70). SAAR 61-90, which was analysed from 1961 - 1990 for FEH, is virtually the same and can also be used.
SPR is Standard Percentage Runoff coefficient for the SOIL category.

FEH (1999):
The Flood Estimation Handbook, produced by the Institute of Hydrology in 1999 effectively replaced Flood Studies Report in the UK. The following QMED equation is from a revision to the statistical approach in Kjeldsen et al., 2008.

$Qmed = 8.3062 \times (0.01 \times AREA)^{0.851} \times 0.1536^{(1000 / SAAR)} \times FARL^{3.4451} \times 0.0460^{(BFIHOST \times BFIHOST)}$, m^3/s

where:

Qmed is the median annual flow rate; the 1:2 year event.
AREA is the area of the catchment in ha.
SAAR is the standard average annual rainfall for the period 1961 to 1990 in mm.
FARL is a reservoir attenuation function and is set at 1.0 and therefore has effectively been ignored. This means that areas with water bodies which attenuate the runoff will over-predict the greenfield runoff rate.
BFIHOST is the base flow index derived using the HOST classification

It should be noted that SPRHOST, a parameter of the 29 HOST classes used in FEH, is derived differently to SPR from SOIL (from FSR). However in principle they are attempting to measure much the same thing. In using SPRHOST for the IH124 formula this allows GIS data to be used along with a more accurate higher resolution breakdown of the types of soil. It is important to note that the values of SPR are from the predominant soil classes data, rather than those reported in IH126 and used by FEH. Some HOST classes have very different values for SPR. An analysis was made comparing the values of Qbar with Qmed, which showed that the SPR values from the predominant soil data gave a much closer fit for Qbar using IH124 values to values of Qmed (after factoring appropriately).

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Soil classes HOST / SOIL

Soil type can be SOIL from FSR, or HOST. The HOST class indices are detailed in report IH126 (1996).

HOST, i.e. Hydrology Of Soil Types, classifies the soils of the United Kingdom into 29 categories. These classes are based on a series of conceptual models that simulate the hydrological behaviours associated with the soils and it interprets soils physical properties and their effects on the development of soil water.

SOIL indices (1 to 5) are defined in the Flood Studies Report (NERC, 1975). The index broadly describes the maximum runoff potential and was derived by a consideration of soil permeability and topographic slope.

SOIL type 1 is sandy highly permeable material with permeability reducing as the SOIL value increases. SOIL type 4 is heavy clay and 5 (which is rarely applied) is exposed rock. For each of these categories there is a value of SPR which is used in the IH124 equation. These were 0.1, 0.3, 0.4, 0.47, 0.53 respectively. The SPRHOST values used in this tool are constrained to the same range as SOIL (0.1 - 0.53) as this is the range over which the IH124 equation was developed.


The Winter rain acceptance potential map for the UK, produced by the Wallingford Procedure is provided within the Wallingford Procedure data available here.

Alternative maps are available from the original FSR document. There is a soil category referred to as urban on the FSR map that is used for city areas. It is assumed that the SOIL value is 4 for the purposes of storage analysis.

Where it is possible to obtain information from the site, the soil type selected should reflect the results from field investigation.

Alternatively SPR can be estimated from the HOST class. These values, known as SPRHOST, are derived in report IH126. In this tool, the SPRHOST values are constrained to the same lower limit as those from SOIL (0.1) as this is the range over which the IH124 equation was developed. SPRHOST values are used by default in this tool as the SPRHOST values are deemed to provide greater accuracy, even though the IH124 equation was not derived using HOST classes.

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HOST
HOST, i.e. Hydrology Of Soil Types, classifies the soils of the United Kingdom into 29 categories. These classes are based on a series of conceptual models that simulate the hydrological behaviours associated with the soils and it interprets soils physical properties and their effects on the development of soil water.

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SPR (%)
SPR is a parameter which is used by FSR. Standard Percentage Runoff, is the percentage of rainfall that contributes to the increase of surface runoff. Based on analysis of data from flood events, and adjusted for rainfall and catchment properties.

SPR can be extracted from the map click and it also allows over-ride by the user.

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SPRHOST (%)
SPRHOST is HOST (Hydrology Of Soil Types) related SPR (Standard Percentage Runoff). SPRHOST is normally an averaged value over a catchment when applying the FEH or ReFH methods. Its derivation is similar but not the same as the parameter SPR derived by FSR research.

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BFIHOST
BFI, i.e. Base Flow Index, is the baseflow proportion of the flow on average. It is calculated based on the daily mean flow data. It is a term used by FEH techniques.

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Qmed (m^3/s)
Qmed means median annual maximum flood, whose annual exceedance probability is 0.5, and return period is 2 years. This tool uses the FEH statistical equation (Kjeldsen et al., 2008) to predict Qmed:

$Qmed = 8.3062 \times (0.01 \times AREA)^{0.851} \times 0.1536^{(1000 / SAAR)} \times FARL^{3.4451} \times 0.0460^{(BFIHOST \times BFIHOST)}$, m^3/s

where:

Qmed is the median annual flow rate; the 1:2 year event.
AREA is the area of the catchment in ha.
SAAR is the standard average annual rainfall for the period 1941 to 1970 in mm.
FARL is a reservoir attenuation function and is set at 1.0 and therefore has effectively been ignored. This means that areas with water bodies which attenuate the runoff will over-

predict the greenfield runoff rate.
BFIHOST is the base flow index derived using the HOST classification.

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Qbar/Qmed conversion factor
Qbar is the Mean Annual Flood flow rate for a river. It is equivalent to an approximate return period of 2.3 years. An equivalent value of Qbar is obtained from FSSR 14 when the FEH formula is used in developing the storage volume results.

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SAAR (mm)
Standard average annual rainfall in mm (1941-1970). This value is derived from the Flood Studies Report (NERC, 1975). The AAR used in FEH (1961-1990) gives very similar values for nearly all coordinates in the UK.

The value of average annual rainfall is used in calculations of Qbar and Qmed.

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M5-60 Rainfall Depth (mm)
The rainfall depth for the 60 minutes 5 years return period event. M5-60 value is a parameter used in deriving rainfall depths for other return periods and durations. Flood Studies Report (NERC, 1975).

Due to assumption used in the tool, M5-60 values have been classified into 3 zones:
Zone 1 - 20mm for areas where M5-60 values are greater than 18.5mm;
Zone 2 - 17mm for M5-60 values ranging from 15.5mm to 18.5mm;
Zone 3 - 14mm for M5-60 values below 15.5mm.

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'r' Ratio M5-60/M5-2 day
Variable "r" represents the ratio of the rainfall depth of the 60 minute to the 2 day, 5 year rainfall event.

Due to assumption used in the tool, "r" ratio values have been classified into 3 zones:
Zone 1 - 0.4 for aeras where "r" values are greater than 0.35;
Zone 2 - 0.3 for "r" values ranging from 0.25 to 0.35;
Zone 3 - 0.2 for "r" values below 0.25.

Assigning alternative values will not modify the calculated storage volumes.

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FEH/FSR conversion factor
The methodology of this tool is based on the FSR parameters of M560 and "r" ratio and the rainfall depths generated. In general across UK extreme rainfall depths tend to be greater using the FEH package than that predicted by FSR. This difference varies with spatial location, duration and return period. In the south east of England it can be as high as +40% higher, though in most locations it is of the order of +20%. However in east Scotland it can slightly lower at around -10%.

The User can obtain some understanding of the differences in rainfall between FSR and FEH for any area by reference to the maps in the following link to the Preliminary Rainfall Runoff Management for Developments document, available here. The maps are in Appendix 1.

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Hydrological region
The UK is divided up into 10 hydrological regions which have different flood frequency growth curves. The tool automatically allows for the hydrological region. This is based on the work carried out by the Flood Studies research. The map is shown in Appendix 1 of the document available here. These factors are applied to either methodology for obtaining QBar (FEH or IH124).

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Growth curve factor
Growth curve factors have been derived for each of the 10 hydrological regions of the UK. This is based on the work carried out by the Flood Studies research (see FSSR 14). The map is shown in Appendix 1 of the document available here. The tool automatically allows for the hydrological region.

http://archive.defra.gov.uk/environment/flooding/documents/research/sc030219.pdf

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Qbar (m^3/s) (Mean annual greenfield peak flow)
The method of calculating the rate of greenfield runoff in this tool is based on Flood Estimation for Small Catchments, Report no. 124 (Institute of Hydrology, 1994) which is based on the investigation of 71 small rural catchments (<25 km2). A regression equation was produced to calculate $Qbar_{rural}$, the mean annual flood:

$$Qbar_{rural} = 0.00108 \times (0.01 \times AREA)^{0.89} \times SAAR^{1.17} \times SPR^{2.17}$$

where:
$Qbar_{rural}$ is the mean annual flood flow from a rural catchment in m^3/s (approximately 2.3 year return period).
AREA is the area of the positively drained site in ha.
SAAR is the standard average annual rainfall for the period 1941 to 1970 in mm.
SPR is Standard Percentage Runoff coefficient for the SOIL category.
Values of SAAR and SPR can be obtained from the Flood Studies Report.

The formula for determining the peak greenfield runoff rate should theoretically not be applied to areas less than 50 hectares. As many developments are smaller than this size this constraint is avoided by calculating $Qbar_{rural}$ for 50 hectares and linearly interpolating flow rates for smaller areas. The correlation equation for these areas therefore becomes:

$$Qbar_{rural} = (0.583 \times SAAR^{1.17} \times SPR^{2.17}) \times ((0.01 \times AREA)/50)$$

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Greenfield run-off rates: 1 in 1 year (l/s)/1 in 30 years (l/s)/1 in 100 years (l/s)
The principle applied in the design of storage is to limit the discharge rate of stormwater from the developed site for events of similar frequency of occurrence to the same peak rate of runoff as that which takes place from the greenfield site prior to development. Using a vortex control device and practical minimum pipe sizes it is not practical to control the discharge rate to below 5 l/s. The tool therefore defaults to 5 l/s where lesser values are calculated. SOIL types 1 and 2 can result in the mean annual flow rate being less than 2 l/s/ha. This can result in very large storage volumes if used, in these situations 2 l/s/ha is used as a minimum.

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