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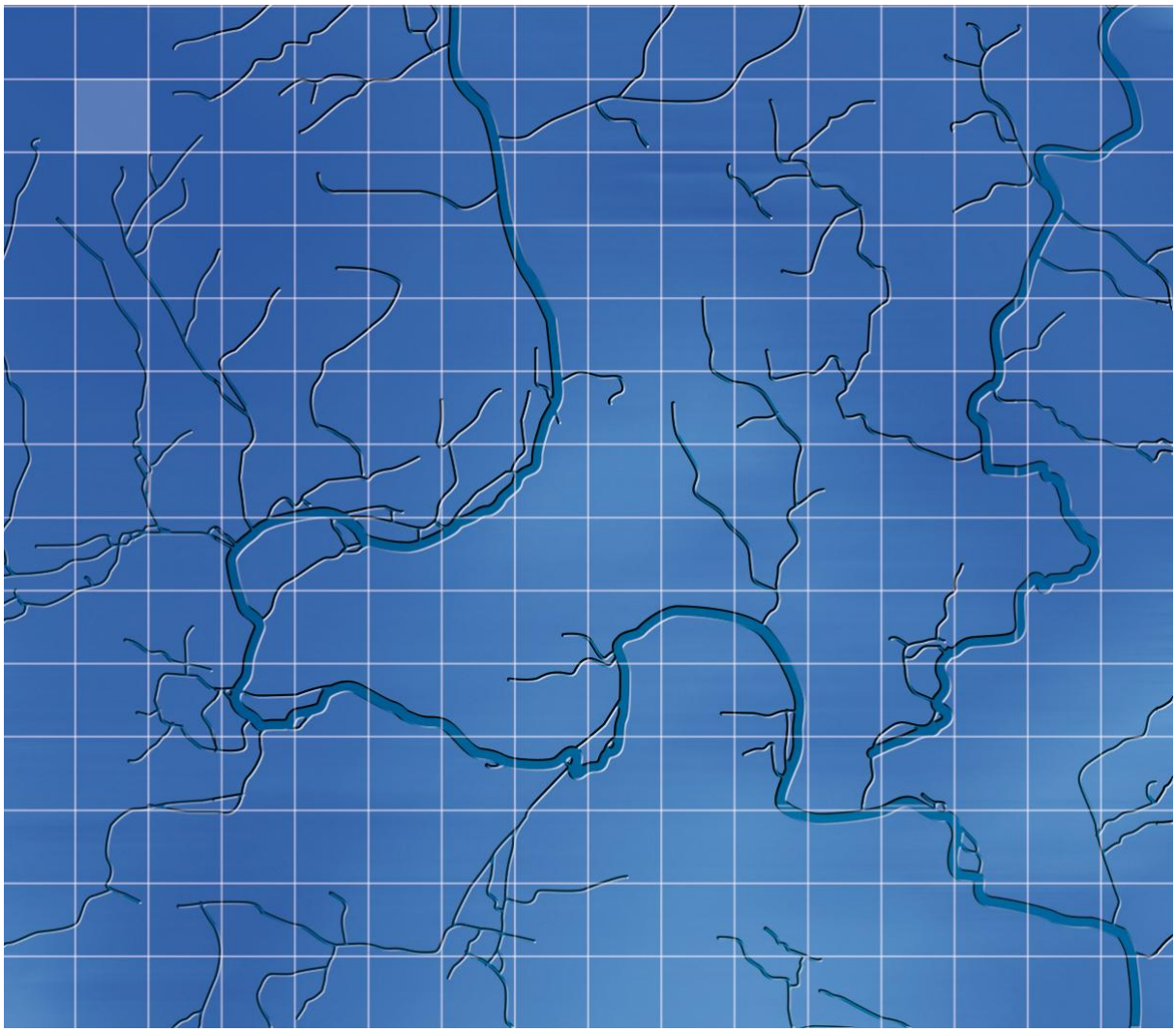
# WINFAP 5.3 Urbanisation



# WINFAP 5.3 Urbanisation

## Document issue details

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| 1 | 06/08/2025 | Final | Rishma Chengot (*Senior Consultant*) | Tracey Haxton (*Technical Director*) |

For and on behalf of Wallingford HydroSolutions Ltd.



**Registered Office** Stables 4, Howbery Business Park, Wallingford, OX10 8BA
**www.hydrosolutions.co.uk**

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# 1 Introduction

Within flood estimation it is generally perceived that urbanisation can result in a higher risk of flooding within a catchment. Peak flows and volumes can increase due to greater percentage runoff values, due to the greater degree of impervious surfaces, and a decrease in catchment response times, due to enhanced routing through urban surface water management systems.

The 2025[1] statistical method incorporates urbanisation in two ways (using the new catchment descriptors; URBEXT2015 and BFIHOST19scaled):

- Scaling of an as rural estimate of the rural QMED index flood by the Urban Adjustment Factor (UAF). The lowest value of UAF, where there is no urbanisation within a catchment is 1.
- Scaling of the rural pooled mean estimate of the L-moments, L-CV. The highest scaling factor of 1 is present for a catchment with no urbanisation.

The revised equations are presented in Equation 1 and Equation 2.

$$UAF = (1 + URBEXT_{2015})^{1.8838}\left(1 + 0.3URBEXT_{2015}\left(\frac{70}{67.0674 - 63.82BFIHOST_{19scaled}}\right) - 1\right)^{3.52} \quad \text{Equation 1.}$$

Note that in application the UAF can be large for very permeable catchments. Based on analysis of observed datasets (the NRFA Peak Flow Dataset v12) and model parameterisation this will be limited to 10.

$$LCV_{urban} = 0.5269^{URBEXT2015} LCV_{rural} \quad \text{Equation 2.}$$

The implementation within WINFAP 5.2 is described within WHS, 2016[2]. Within WINFAP 5.2 and ReFH2.3 urbanisation is incorporated through the use of URBAN, the urban fraction based on the 1:50k OS mapping. This was previously estimated based on the URBEXT2000 (Bayliss et al., 2006[3]) using the following equation: $URBAN = 1.567 * URBEXT2000$

Equation 3.

The advantages of this approach are that:

- There is consistency across the two main methods as applied within WINFAP and ReFH. The latter explicitly requires the proportion of pervious and impervious fractions to be calculated (based on an urban area) rather than an URBEXT index.
- Users can update the URBAN proportion or area based on mapped data. This is necessary as it is difficult to directly update the URBEXT2000 as this is based on a specific LCM model and how cells were assigned of cells as suburban and urban.

[1] Vesuviano, G., Griffin, A. 2025. The FEH 2025 Statistical Method Update . UK Centre for Ecology & Hydrology, Wallingford, UK.
[2] WHS. 2016. Urban Adjustment Procedure Technical Note. http://software.hydrosolutions.co.uk/winfap4/Urban-Adjustment-Procedure-Technical-Note.pdf
[3] Bayliss, A. C., Black, K. B., Fava-Verde, A. and Kjeldsen, T.R. 2006. URBEXT2000 – a new FEH catchment descriptor. R&D Technical Report FD1919/TR, Department of Food, Agriculture and Rural Affairs (DEFRA), London.

However, the main disadvantage is that:

- The URBAN equation is regionalised and based on relatively few datapoints (approx. 25). Thus, information in the URBEXT index is lost through the transformation.

For application in WINFAP 5.3 the following approach is taken:

- The adjustment to QMED and L-moments are incorporated through URBEXT2015, as derived within Vesuviano et al., 2025[4].
- Users will be able to update urbanisation within selected catchments using readily available datasets such as the 1:50k OS map (URBAN), or OS Open Built Up Areas (built up extents) dataset, hereafter referred to as OS Open Built Up Extents. The LCM (on which the URBEXT2015 dataset is based) will also be updated more frequently and consistently moving forward which means that direct updates to the URBEXT index will also be able to be completed with greater ease.

The main disadvantage to this approach is:

- The implementation within ReFH will not be wholly consistent with that within WINFAP, in that a conversion to an urban area will still be necessary due to the form of the urbanised model in ReFH.

For use within WINFAP5.3 the following tasks were completed:

1. Development of a model to estimate URBEXT2015 based on URBAN.
2. Development of a model to estimate URBEXT2015 based on the OS Open Built Up Extents dataset.

The NRFA Peak Flow 14 Beta dataset was provided by UKCEH. This represents a beta dataset of the new descriptors which will be used in the NRFA Peak Flow 14 dataset to be released in Summer 2025.

# 2 Urban Datasets

For application in WINFAP 5.3 it is necessary to develop relationships between URBEXT2015 and URBAN, and OS Built Up Extents.

The following datasets were used:

- The NRFA Peak Flow 14 Beta dataset was provided by UKCEH. This represents a beta dataset of the new descriptors which will be used in the NRFA Peak Flow 14 dataset to be released in Summer 2025. The NRFA Peak Flow 14 Beta dataset includes *URBEXT2000* and *URBEXT2015* as well as $BFIHOST_{19scaled}$.
- Catchment shapefiles were derived using the FEH designated DTM x and y coordinates.
- *OS Open Built Up Extents proportion:* The built-up area and its proportion within each catchment were estimated using the derived catchments and the Ordnance Survey (OS) Open Built Up Areas[5] dataset, using the built up extents only.

[4] Vesuviano, G., Wallbank, J., Griffin, A., Miller, J. 2025. New FEH Catchment Descriptors 2025: Updates to FARL, SAAR, URBEXT and BFIHOST . UK Centre for Ecology & Hydrology, Wallingford, UK.
[5] https://www.ordnancesurvey.co.uk/products/os-open-built-up-areas. Accessed January 2025.

- *LCM Change in built-up proportion*: The Land Cover Change dataset[6] consists of a 25m raster product that tracks land cover changes in Great Britain between 1990 and 2015. The LCM dataset consists of five bands, of which Band 4 and Band 5 were used:

  **Band 4:** Represents the "change from" class.

  **Band 5:** Represents the "change to" class.

  The built-up area, identified as class number 5

Within each catchment the proportion of Band 4 and 5 were derived. The change in built-up proportion is then calculated as:

Proportion difference = Abs((Proportion of Band 5 = Class 5) - (Proportion of Band 4 = Class 5))

# 3 Estimating URBEXT2015 based on URBAN2015

If there has been little or no change in urbanisation between 1990 and 2015 it is assumed that the estimate of URBAN remains the same as that based on URBEXT2000 (Equation 1) i.e. the assumption is that URBAN2015 is the same as URBAN and this can be used to establish a relationship between URBAN2015 and URBEXT2015.

Development of the model uses a pragmatic approach. Catchments which have larger degrees of change tend to be those that have relatively high levels of urbanisation. However, if all those with larger changes are removed there are few with high URBEXT2015 values and this decreases the ability to be able to capture these within the model. A compromise is therefore made between providing a large number of catchments (with enough variability in urbanisation) and providing a dataset for which the URBEXT2015 is well estimated i.e. there has been little change hence URBAN2015 can be assumed to be represented by URBAN2015.

For these reasons, catchments where the proportion change is less than 5% of the catchment are selected to develop the model.

Figure 1 presents the model where URBEXT2015 is estimated based on URBAN2015. The URBAN2015 estimates are based on a linear model (based on URBEXT2000) so the form of the model, a simple linear approach, was retained.

[6] https://catalogue.ceh.ac.uk/documents/07b6e5e9-b766-48e5-a28c-5b3e35abecc0 Accessed in January 2025.

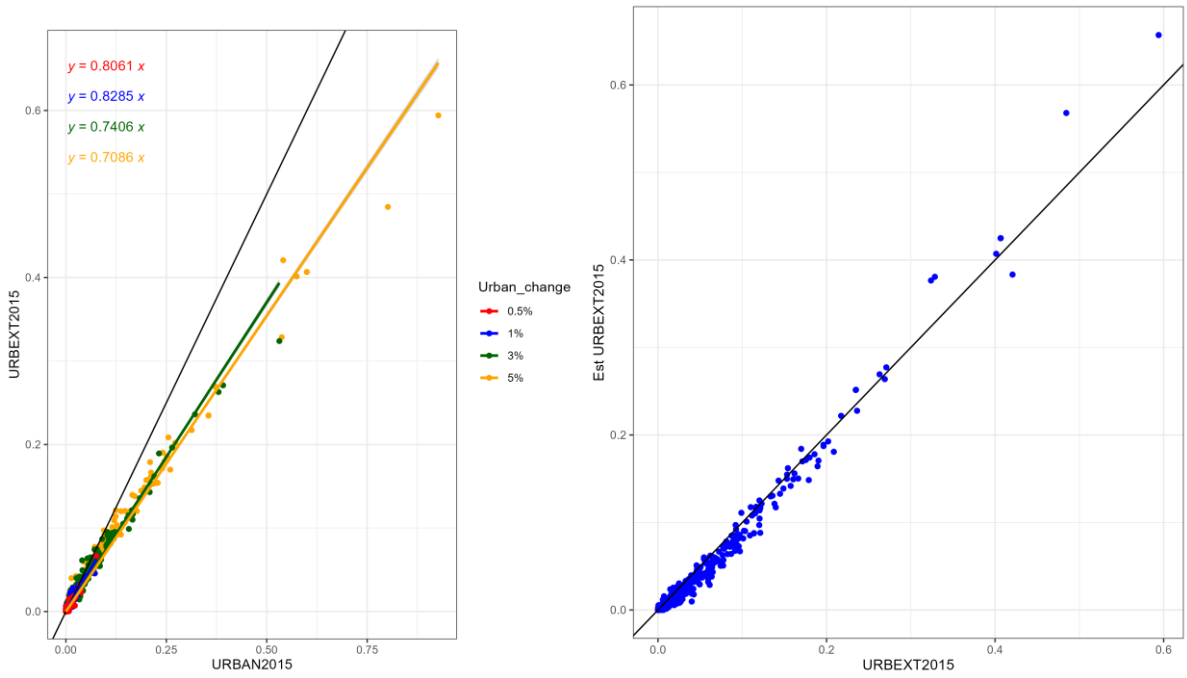


Figure 1. Estimating the URBEXT2015 based on URBAN2015. a) Relationship between URBAN2015 and URBEXT2015. b) Model estimate of URBEXT2015 and URBEXT2015.

The final relationship is presented in Equation 4.

$$URBEXT2015 = 0.7806 URBAN2015 \qquad \text{Rsq} = 0.9817 \qquad \text{Equation 4.}$$

URBAN2015 can be assumed to be equivalent to URBAN*XXXX*, the URBAN proportion for any year, in application within WINFAP 5.3.

# 4 Estimating URBEXT2015 based on OS Open Built Up Areas proportion

A relationship between URBEXT2015 and the OS Open Built Up Extents proportion was developed by establishing a linear model between the two datasets. In contrast to the relationship with URBAN (which was assumed to be the same as URBAN2000) the dataset is not limited, and it is assumed that the most recent OS Open Built Up Areas dataset proportions can be associated with the urbanisation as represented by URBEXT2015 (a necessary assumption since the LCM change dataset only provides change between 1990 and 2015).

The relationship and model are presented in Figure 2. Whilst other forms of equation were explored, a linear approach provided the best performance. The equation is presented below.

$$URBEXT2015 = 0.6469 * OS\ Built\ Up\ Extents\ Proportion \qquad \text{Rsq} = 0.9823 \qquad \text{Equation 5.}$$

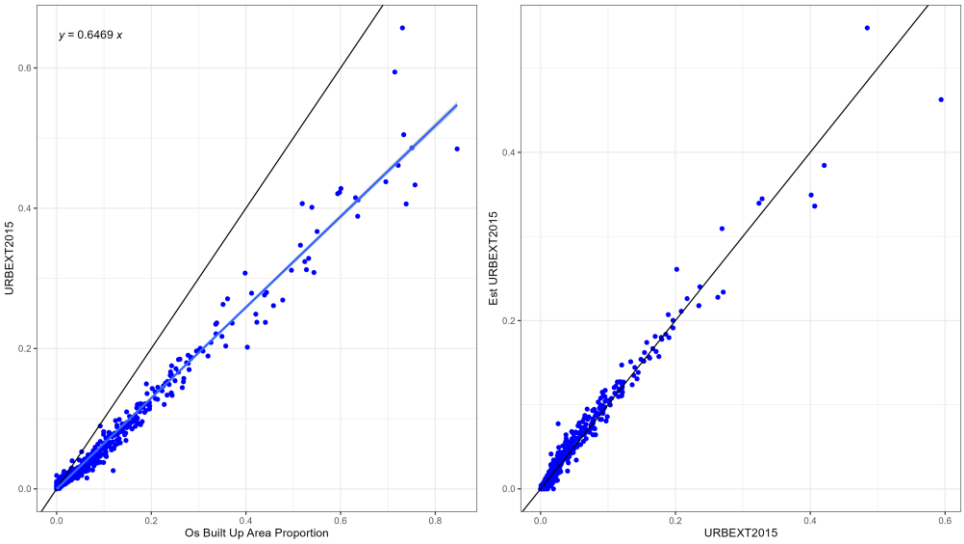


Figure 2. Relationship between URBEXT2015 and OS Built Up Area proportion. a) Relationship between OS Built up Area. b) Model estimate of URBEXT2015 and URBEXT2015.