A NEW HYDROLOGY FOR THE WALLINGFORD PROCEDURE

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Introduction

One of the features of the Wallingford Procedure is that it incorporates a hydrology model which requires very few parameters and yet gives reasonably good answers. However like all simple models it has limitations, and we are now looking to improve its abilities. This paper briefly explains some of the limitations of the existing model, the interim improvements which we have made in WALLRUS, and new models which we would like to develop fully.

The existing model

Runoff volume

The existing model uses a regression equation to predict the proportion of the rainfall which runs off from the catchment. This depends on the density of development in the catchment, the soil type, and the antecedent wetness of the catchment.

The runoff is calculated at the start of the storm as an average for the catchment, and does not change during the storm.

The runoff is adjusted throughout the catchment depending on the local density of development.

Speed of travel of runoff

The speed of travel of runoff from the catchment is calculated for a series of 10 standard surfaces of different slopes and areas. The calculations are done using a non linear reservoir routing model.

Limitations of the existing model

The main limitations on calculating runoff volume are:

> The proportion of runoff does not change during the storm as the catchment wetness changes. runoff from catchments with substantial unpaved areas is therefore not predicted correctly.
>
> The variation in runoff across the catchment and between impervious and pervious surfaces is handled in a very simple manner.

The main limitations on calculating speed of travel are:

> The 10 standard surfaces are all for very small areas; much smaller than normally used in WASSP models.
>
> The standard surfaces do not give a wide range of slopes.
>
> The routing treats impervious and pervious surfaces the same, neglecting any difference in the speed of travel of the runoff.

Interim changes for WALLRUS

Runoff volume

The runoff is calculated separately for each contributing area. This gives a better representation of the variation across the catchment. The same regression equation is used as in WASSP.

Depression storage can be defined to be partly full at the start of the storm rather than simply full or empty as in WASSP. Depression storage is subtracted as a loss in volume rather than being treated as merely a delay to the runoff.

Runoff rate

The speed of travel is calculated using a simpler quasi linear reservoir model. This can therefore be applied separately for each area rather than using 10 standard surfaces. This allows a greater range of areas and slopes.

The runoff from pervious and impervious areas can be routed at different speeds.

Limitations of the WALLRUS model

The proportion of runoff still does not vary during the storm.

The different way of treating depression storage will give slightly lower runoff for small storms falling on a dry catchment than predicted using WASSP. It has no effect on design storms.

Although we can route runoff from pervious and impervious surfaces separately the runoff is still calculated as one value and we do not have a proper way of dividing it between the different surface types; we use a simple proportion.

The speed of runoff still does not allow for very large surface areas.

The next stage

We have defined the new requirements for a model as:

Calculate runoff from pervious and impervious surfaces separately.

Update the calculations of runoff continuously throughout the event to allow for increasing wetness. This should be done in such a manner that we can start calculating at different points in the event, or divide it into two sub events and still get the same answers.

Improve the reservoir model to allow for large catchment areas.

Use similar parameters to the existing model.

Be calibrated in the same manner as the existing model.

Allow for inclusion of features such as limiting gully inflows and permeable pavements.

The most difficult aspect is to use similar parameters to the existing model and to calibrate it in the same way.

Proposed models

Impervious areas

An initial loss of rainfall to depression storage which may be partly or completely full at the start of the storm. The depression storage depends on surface type and slope.

A continuing loss as a proportion of the rainfall. This will depend on the surface type and previous rainfall (probably using the five day rainfall index API_5). The calculation will be updated as API_5 changes during the event.

A reservoir routing model which is applicable to large catchment areas.

Pervious areas

A depression storage model similar to that for impervious areas.

A continuing loss calculated from an infiltration model. This calculates an infiltration rate depending on the soil type, the soil moisture and the land use. The soil moisture is updated throughout the storm with infiltration reducing as the catchment gets wetter. If the rainfall intensity is greater than the current infiltration rate then the excess runs off. This can model a wide range of surfaces including pervious pavements.

The model may also include a baseflow calculated using an inverse of the infiltration model. In this case the exfiltration increases as the catchment becomes wetter. The baseflow would continue after the rainfall had stopped if the catchment was still wet.

A reservoir routing model similar to that for impervious surfaces, but with different routing coefficients.

Other features to be added to the model are the ability to limit the flow into the drainage system at any point, and to divert any excess flow onto other surfaces.

Although the proposed model will have a much better handling of pervious surface runoff it will still not necessarily give the same runoff as the Flood Studies Methods because of the different data sets used in calibration. We may therefore have to include the FSR percentage runoff equation as an alternative to allow this to be used in special cases.

The current position

At present we have ideas for several different ways of developing the models. To decide between then we have to calibrate them against the available data, and see which works best. To do this we need to collate all of the available runoff data, and then to analyses it using the proposed models. By the time this paper is presented, I hope that we will have sorted out the money and people to do this.

Discussion on Martin Osborne's Paper

1 D Walters (Bolton MBC)

Q Do the changes result in better accuracy ?

A Overall little change from WASSP. Better accuracy on individual pipes as PR evaluated individually instead of globally.

2 A Eadon (Severn Trent Water)

Q Is there sufficient data available to justify the changes ?

A The same data as available for WASSP was used - will have to make comparisons with good quality flow surveys - there has been no collection of data since circa 1978.

3 R Allitt (Trevor Crocker & Partners)

Q Staff generally grasped WASSP fairly quickly - will this change cause problems with WALLRUS ?

A HR intend to use the same familiar parameters and so no extra data or information needed.