
Application of different NAPI values to accommodate different soil types when using the New UK runoff model in InfoWorks ICM

Introduction

In the New UK runoff model was calibrated against a variety of urban catchments in the UK. It uses a value of the antecedent wetness conditions (NAPI) which can vary depending on the soil type. The soil type is defined as part of the subcatchment data or as part of the user defined defaults. In the UK, the soil type classification is derived from Maps. There are 5 different soil types although commonly soil type 5 is not used. The soil type effects the value of a constant which is used in the calculation of NAPI. It is common to set an initial value of NAPI which as above can vary depending on the soil type.

A feature of InfoWorks ICM which has been inherited from InfoWorks CS and its predecessor HydroWorks, is that it is only possible to use one value of NAPI with any one rainfall profile. This is a problem in catchments with different soil types where a different value of NAPI is needed for each soil type. This blog describes how it is possible to represent the effect of different soil types on NAPI values within subcatchments. This blog complements the blog on the New UK runoff model which is at <http://blog.innovyze.com/2012/06/06/implementation-of-the-new-pr-equation/>.

Rainfall Event Data and Catchment Runoff Data

One way to apply different NAPI values is to use different rain gauge records for each area of the catchment that is underlain by a different soil type. Different values of NAPI can then be defined by adding different values to each of the rainfall profile properties in the Rainfall Event Data (RED). For synthetic or observed rainfall events the rainfall can simply be repeated several times as if from different rain-gauges.

Unfortunately this is cannot be done automatically in the design rainfall generator which produces only a single profile. An alternative is to use the Catchment Runoff Data (CRD) files to define initial runoff conditions for different surface types. This would require defining a separate surface type (runoff index) for similar surfaces with a different soil type.

The following sections outline the practical implementation of different NAPI values in InfoWorks ICM.

Observed/Synthetic Rainfall

The following network has 4 subcatchments all of which are made up of the same 3 runoff surfaces, these are roads, roofs and pervious surfaces (Runoff Surfaces 10, 20, and 21).

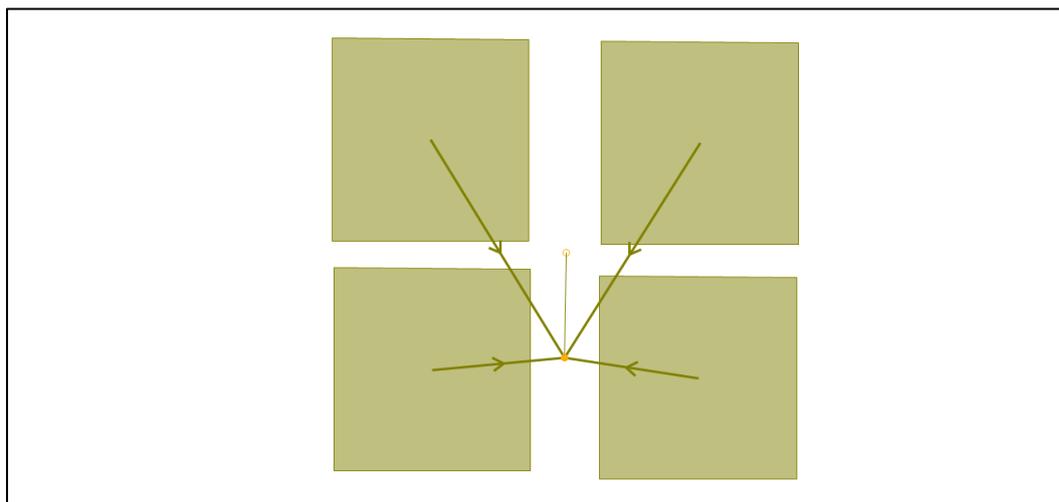


Figure 1: Example Network with 4 Subcatchments

If we assume that each subcatchment has a different underlying soil type, there is a potential need to provide a different NAPI value for each subcatchment. When undertaking modelling with observed or synthetic rainfall events, this can be carried out using the Rain gauge functionality. Rain gauge polygons can be defined for each soil type region. In the below example these are simply defined using the available rain gauge boundary creation tools in InfoWorks ICM to create Thiessen polygons representing a simple delineation of the soil type. However, for more complex boundaries these can be imported in from GIS.

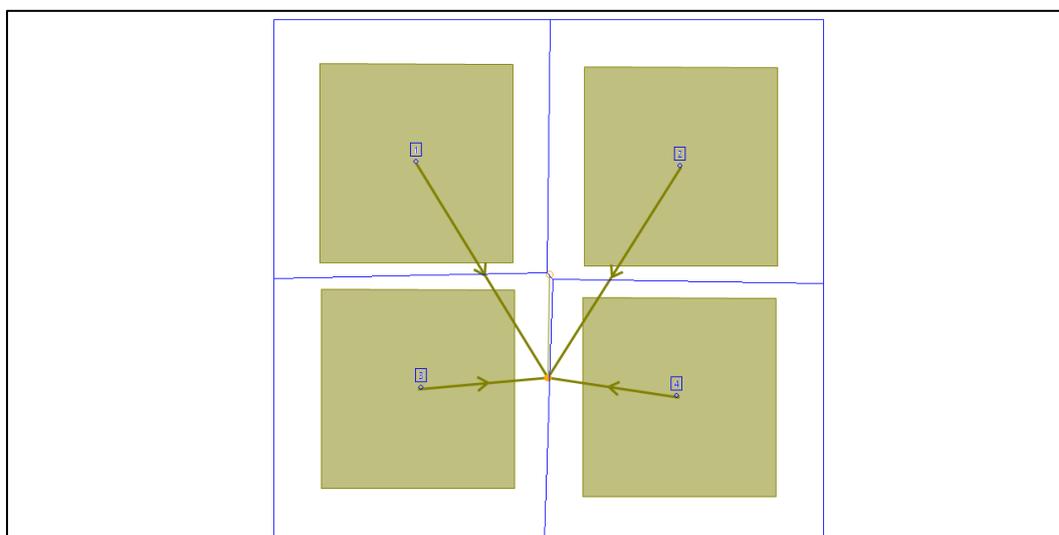


Figure 2: 4 Rain Gauge Boundaries Representing the 4 Different Soil Types underlying the 4 Subcatchments

Once the rain gauge boundaries have been set up, a separate profile can be set up for each rain gauge boundary. The observed or synthetic rainfall event can then be duplicated, or in this case quadruplicated for each rain gauge. It is possible if required, to have different rainfall time-varying data in each profile if real rain gauge data is available.

Rainfall ev				
Time	1 (mm/hr)	2 (mm/hr)	3 (mm/hr)	4 (mm/hr)
SUB-EVENT 1				
00::00:00	10.876390	10.876390	10.876390	10.876390
00::00:01	11.440110	11.440110	11.440110	11.440110
00::00:02	12.003820	12.003820	12.003820	12.003820
00::00:03	12.534380	12.534380	12.534380	12.534380
00::00:04	13.429690	13.429690	13.429690	13.429690
00::00:05	14.523970	14.523970	14.523970	14.523970
00::00:06	15.916670	15.916670	15.916670	15.916670
00::00:07	17.640980	17.640980	17.640980	17.640980
00::00:08	20.061650	20.061650	20.061650	20.061650
00::00:09	24.471880	24.471880	24.471880	24.471880
00::00:10	31.767060	31.767060	31.767060	31.767060
00::00:11	44.533530	44.533530	44.533530	44.533530
00::00:12	63.865730	63.865730	63.865730	63.865730
00::00:13	87.143780	87.143780	87.143780	87.143780
00::00:14	117.186500	117.186500	117.186500	117.186500
00::00:15	117.186500	117.186500	117.186500	117.186500
00::00:16	87.143780	87.143780	87.143780	87.143780
00::00:17	63.865730	63.865730	63.865730	63.865730
00::00:18	44.533530	44.533530	44.533530	44.533530
00::00:19	31.767060	31.767060	31.767060	31.767060
00::00:20	24.471880	24.471880	24.471880	24.471880
00::00:21	20.061650	20.061650	20.061650	20.061650
00::00:22	17.640980	17.640980	17.640980	17.640980
00::00:23	15.916670	15.916670	15.916670	15.916670
00::00:24	14.523970	14.523970	14.523970	14.523970
00::00:25	13.429690	13.429690	13.429690	13.429690
00::00:26	12.534380	12.534380	12.534380	12.534380

Figure 3: Rainfall Grid Editor with the same profile for each rain gauge boundary

Each profile properties can then be edited to provide a different NAPI value for each profile.

NOTE: In InfoWorks ICM, each runoff model initial state value has its own property field. In InfoWorks CS, the property fields were shared for a number of runoff model initial states.

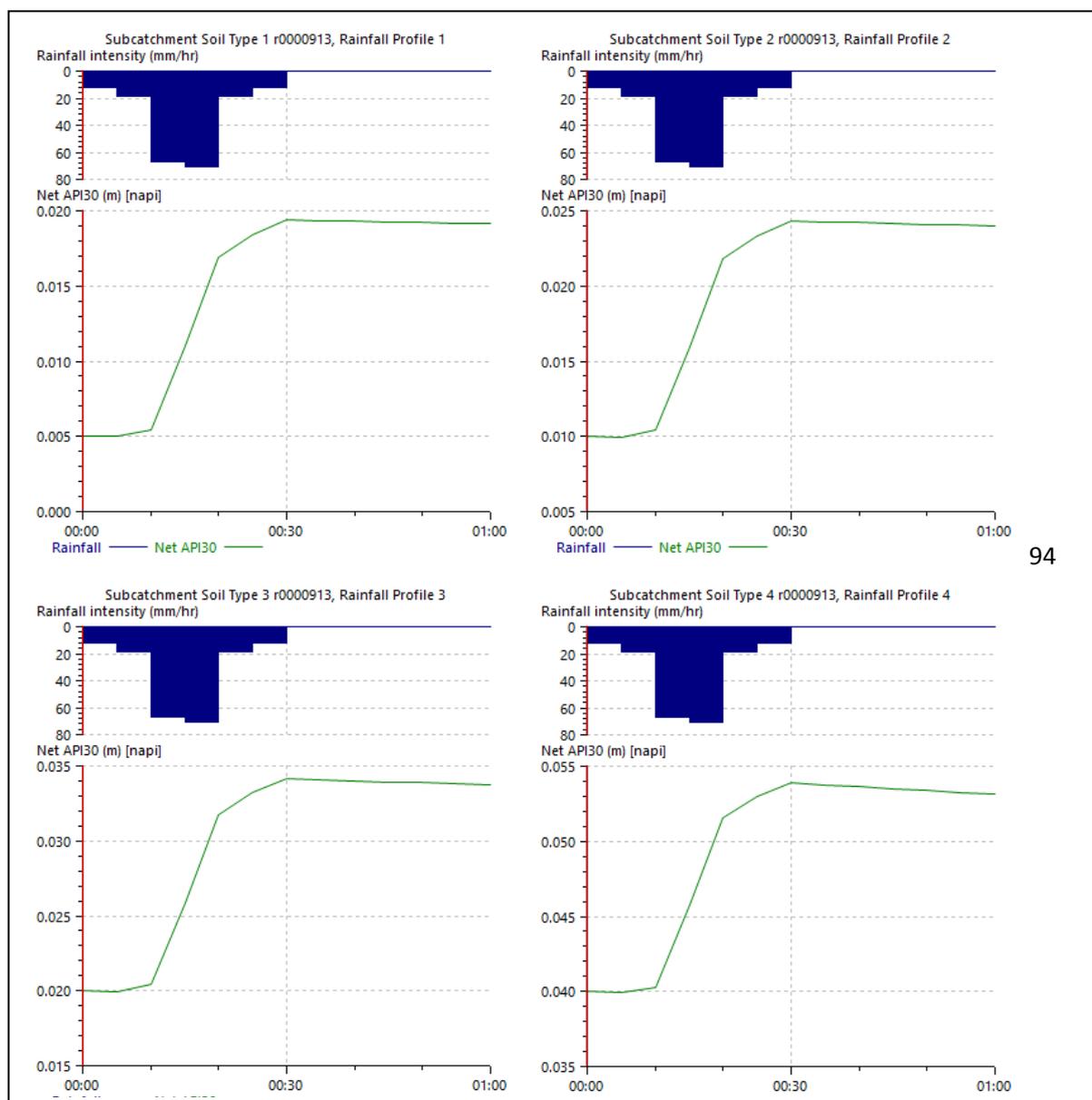
Rainfall event 1 (Read Only)	
Properties	
Parameter	Value
Calibration / areal reduction	0.00
Local antecedent depth (mm)	0.0
Local Evaporation (mm/day)	0.0
Local U C W I	0.000
Local New PR API30 (mm)	10.000
Local Horton SMS (mm)	0.000
Local Green-Ampt SMD (%)	0.000
Local SCS index	0
Local ReFH soil moisture (mm)	0.000
Local ReFH baseflow (m3/s)	0.000
Profile title	1
Profile description	
Gauge data	REGION=5,-627.537009,433.779354,-222.214005,433.
ReFH ACF	1.000
Snowmelt SCF	1.000

Figure 4: The Profile Properties page. Note the addition of Gauge data and the specification of the Local New PR API30 (mm) value.

For the purpose of the described model, the various subcatchments had the following NAPI values applied to them in the Profile properties page.

- Subcatchment **Soil Type 1** Rainfall Profile **1** NAPI=**5mm**
- Subcatchment **Soil Type 2** Rainfall Profile **1** NAPI=**10mm**
- Subcatchment **Soil Type 3** Rainfall Profile **1** NAPI=**20mm**
- Subcatchment **Soil Type 4** Rainfall Profile **1** NAPI=**40mm**

Once the model has been simulated, it is then possible to graph the NAPI values, as can be seen each



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subcatchment has a different value of initial NAPI assigned to it, as defined above.

Figure 5: The results from the simulation showing different initial NAPI Values for each of the subcatchment as defined by the profile properties.

Design Rainfall

When using the design rainfall generator, only one profile is created and therefore it is only possible to specify one value of NAPI. By default this is the value specified in the Dialogue Editor.

FEH Rain Event Generator Parameters - Rainfall event

Catchments

ID	C	D1	D2	D3	E	F
*	-0.024	0.340	0.308	0.278	0.292	2.471

Initial conditions

Antecedent depth (mm) Green-Ampt SMD (%)

Evaporation (mm/day) Wetness index

UCWI ReFH Cini (mm)

NAPI (mm) ReFH BF0 (m3/s)

Horton SMS (mm)

Event

'Return period' and 'Duration' may contain multiple, comma-separated values.

Return period Return period type Annual maximum Peaks-over-threshold

Duration

Profile

Multiplying

Figure 6: The Design Rainfall Dialogue for the FEH Rainfall Generator

Once generated design rainfall is created, the Rainfall Event (Time Varying Data) is read-only and therefore cannot be edited to add more profiles. One potential approach around this is to create the design rainfall and then copy the time-varying values into a non-generated observed rainfall event. This will then allow the user to follow the steps in the 'Observed/Synthetic Rainfall Event' section above to spatially distribute the NAPI value.

However, another approach does exist and this is to use the Catchment Runoff Data (CRD) which does not use the spatial rain functionality. Once the generated rainfall is created, although the time-varying data (TVD) is read-only the CRD can still be edited. There are a number of tabs in the rainfall grid editor which can be used to define different NAPI values. The CRD consists of data on the Globals (Catchment Runoff Data), Runoff Surface, Runoff Subcatchment and Unit Runoff Subcatchment as well as tabs for other runoff models. If you define any CRD it overrides any initial conditions on the TVD tabs.

Note: Any values added to the CRD will override those added to the RED. This can only be changed by ticking the option to 'Read subevent NAPI (New UK method) in the run dialogue.

Globals Tab

The first tab is the 'Globals' tab. This allows the user to specify a global value for NAPI.

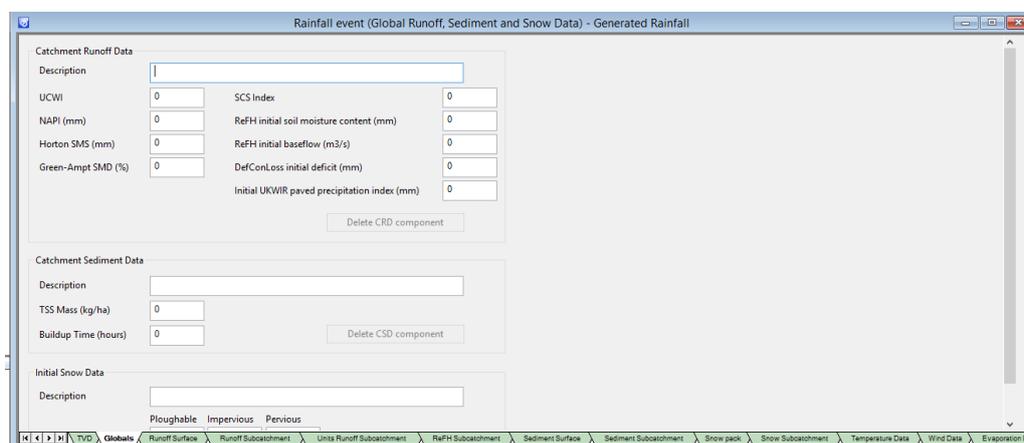


Figure 7: The Globals Tab of the Rainfall Grid Editor

The value defined in the CRD globals tab will override that specified in the generated rainfall dialogue editor and carried through to the profile.

Runoff Surfaces Tab

The 2nd tab is the 'Runoff Surfaces' tab. This allows us to define NAPI for each runoff surface. A runoff condition specified for surface type 1, for example, will apply to all subcatchments that use that surface type, unless overridden by a value specified elsewhere. For this, there is a requirement to duplicate those runoff surfaces which you would like to apply in each soil type area within the network. In this example there are now 6 runoff surfaces, these are the roads and roofs runoff surfaces that were present previously and 1 pervious runoff surface for each of the 4 soil types. The runoff surface ID has been given a new number to represent the soil type it corresponds to as well as a description added.

Grid [Runoff surface] - Model network (Scenario Different Runoff Surfaces)							
Runoff surface ID	Description	Runoff routing type	Runoff routing value	Runoff volume type	Surface type	Ground slope (m/m)	
1		Rel	1.000	Fixed	Impervious	0.000000	
10	Roads	Rel	1.000	Fixed	Impervious	0.000000	
20	Roofs	Rel	1.000	Fixed	Impervious	0.050000	
121	Pervious-Soil Type 1	Rel	4.000	NewUK	Pervious	0.000000	
221	Pervious-Soil Type 2	Rel	4.000	NewUK	Pervious	0.000000	
321	Pervious-Soil Type 3	Rel	4.000	NewUK	Pervious	0.000000	
421	Pervious-Soil Type 4	Rel	4.000	NewUK	Pervious	0.000000	

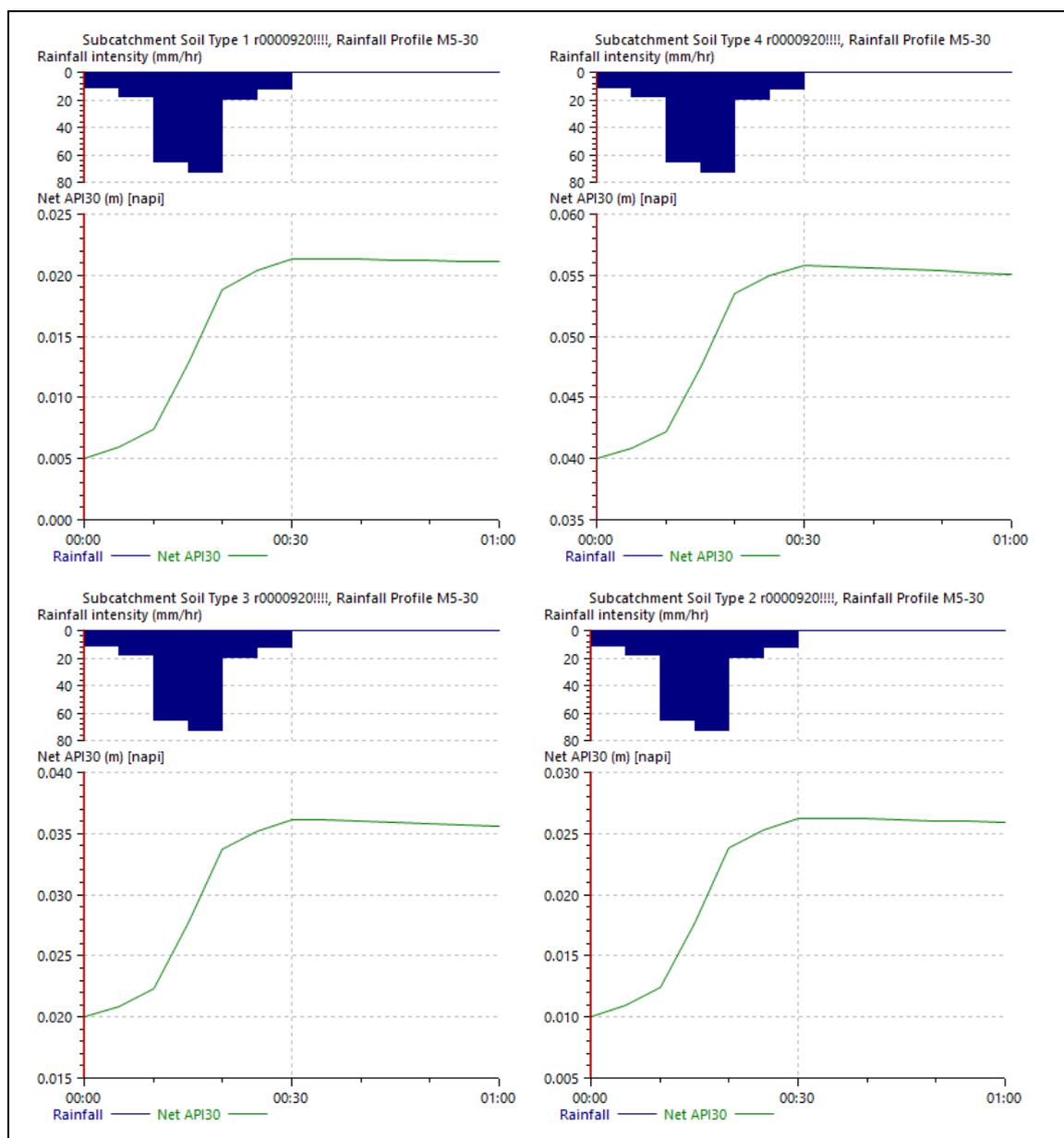
Figure 8: The Runoff Surfaces used within the network. Note that there are 4 new UK surfaces to represent the pervious surface on 4 different soil types.

The NAPI value can then be defined for each runoff surface in the rainfall grid editor CRD section. In the below, the NAPI values for Runoff Surfaces 121, 221, 321 and 421 have been set up to those values described earlier. The NAPI value defined in the Globals tab remains at 50mm.

Rainfall event (Runoff Surface - initial conditions) - Runoff Surfaces (Read Only)						
Runoff Index	UCWI	NAPI / Pipv (mm)	Horton SMS (mm)	Green-Ampt SMD (%)	SCS Index	DefConLoss initial deficit (mm)
121		5.0000				
221		10.0000				
321		20.0000				
421	0.0000	40.0000	0.0000			

Figure 9: The Runoff Surface Tab of the Rainfall Grid Editor

The results show that the NAPI value has been picked up from the Runoff Surfaces tab of the CRD



section of the rainfall grid editor, overriding the globals value.

Figure 10: The results from the simulation showing different initial NAPI Values for each of the subcatchment as defined in the runoff surfaces tab in the rainfall grid editor.

Runoff Subcatchments/Unit Runoff Subcatchment Tab

The 3rd and 4th Tabs are the Runoff Subcatchment and Units Runoff Subcatchment tab. These allow different initial conditions to be defined for specific subcatchments that use the same runoff surface.

Note that depending on the Runoff volume model being used, the initial condition may be set in the 'Runoff Subcatchment' tab. This is set up differently in IWCS where both types of runoff volume model initial conditions are set in the 'Runoff Subcatchment tab. The 'Units Runoff Subcatchment' tab does not exist in IWCS.

Those runoff volume model initial conditions which do not have units (ie, indices) are specified in the 'Runoff Subcatchment' tab. These are:-

- Wallingford (UCWI)
- CN/SCS (AMC)
- Green-Ampt (SMD)

Those runoff volume models which use a metric with units (such as NAPI) are specified in the 'Units Runoff Subcatchment' Tab. These are:-

- Horton (SMS)
- New UK (NAPI)
- UKWIR Paved and Pervious (PI)

In the Units Runoff Subcatchment tab we define the subcatchment ID and then define the NAPI value for each subcatchment. In the example model, Surface 3 is the one that corresponds to the pervious surface and therefore a value is defined for runoff surface 3. In this example Surface 3 corresponds to the same Runoff Surface 21 with exactly the same parameters for all subcatchments.

Subcatchment	Surface 1 (mm)	Surface 2 (mm)	Surface 3 (mm)	Surface 4 (mm)	Surface 5 (mm)	Surface 6 (mm)	Surface 7 (mm)	Surface 8 (mm)	Surface 9 (mm)	Surface 10 (mm)
Soil Type 1			50.0000							
Soil Type 2			25.0000							
Soil Type 3			12.0000							
Soil Type 4			6.0000							

Figure 11: The Units Runoff Subcatchment Tab of the Rainfall Grid Editor

The Units Runoff Subcatchment tab is used to set the NAPI values as follows:-

- Subcatchment **Soil Type 1** Runoff Surface **21** NAPI=**50mm**
- Subcatchment **Soil Type 1** Runoff Surface **21** NAPI=**25mm**
- Subcatchment **Soil Type 1** Runoff Surface **21** NAPI=**12mm**
- Subcatchment **Soil Type 1** Runoff Surface **21** NAPI=**6mm**

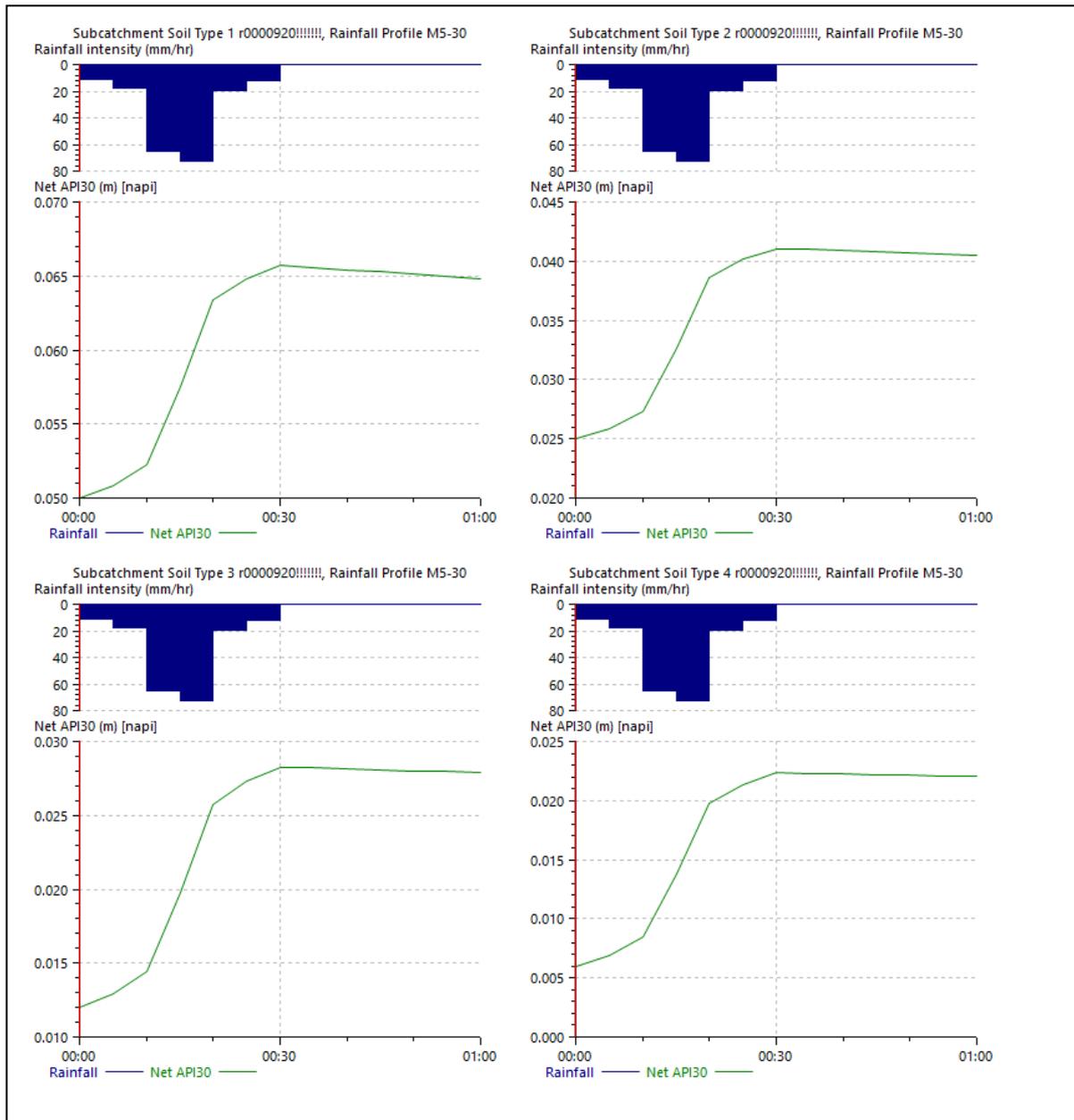
These values are different to those specified previously. This is to show those values specified in the Units Runoff Subcatchments tab override those specified in the Runoff Surfaces tab. The values for the runoff surfaces tab have been defined to a NAPI of 40mm for Runoff Surface 21.

Runoff Index	UCWI	NAPI / P/Ipv (mm)	Horton SMS (mm)	Green-Ampt SMD (%)	SCS Index	DefConLoss initial deficit (mm)
21		40.0000				

Figure 12: The Runoff Surface Tab of the Rainfall Grid Editor to show how the Units Runoff Subcatchment tab overrides values specified here.

The existing value of NAPI set in the Globals tab also remains set to 50mm.

The results from the simulation show that the values for NAPI in the results have been taken from the



Units Runoff Subcatchments tab.

Figure 13: The results from the simulation showing different initial NAPI Values for each of the subcatchment as defined in the Unit runoff subcatchment tab in the rainfall grid editor.

When using the CRD to represent spatially varying values of initial NAPI values, there is a hierarchy of precedence which is as follows:

- Unit Runoff Subcatchment/Runoff Subcatchment tab (if different initial NAPI values are required for individual subcatchments).
- Runoff Surface
- Globals Tab.

Summary

When using the NEW UK runoff model, it can be necessary to spatially vary the initial NAPI value to represent the effect of different soil types on the initial conditions. Depending on the different rainfall event and whether it is observed/synthetic rainfall or whether it is generated design rainfall there are a number of approaches to do this. The 2 main approaches are to edit the RED properties in the TVD profile properties or to edit the CRD properties. It is important to note that it is not possible to mix the RED and CRD values. If CRD is used then it will override any values in the RED as the globals tab will be exported to the simulation engine whenever any CRD data is used. The only way to override this behavior is to use the options to 'Read Sub Event UCWI and Evaporation' and 'Read subevent NAPI (New UK Method)' in which case the profile properties values will override the CRD values. Typically it is recommended that the CRD editor is used to set the catchment runoff initial conditions.