

How do I define a new ReFH2 Unit in Flood Modeller?

The ReFH2 boundary unit utilises the ReFH2 (Revitalised Flood Hydrograph 2) software to derive an inflow hydrograph for a catchment or sub-catchment. The ReFH2 method can be applied to both rural and urbanised catchments and can utilise either the FEH 1999 or the FEH 2013 rainfall models. ReFH2 is an updated version of the original ReFH method and was released by Wallingford HydroSolutions (www.hydrosolutions.co.uk) in 2015. Information on the theory adopted within the ReFH2 method can be found on the Wallingford Hydrosolutions website, e.g. the ReFH2 [Technical Guidance Document](#), or in the user guide that accompanies the ReFH2 software.

The hydrograph produced by the method is utilised in Flood Modeller as a boundary condition, equivalent to a Flow Time Boundary. It can therefore form inputs to a hydrodynamic or routing 1D model. This inflow can be applied at the upstream end of a reach or may be distributed over a reach in conjunction with the Lateral Inflow unit. When run in boundary mode, the resultant hydrograph may be viewed using the Graphical or Tabular postprocessors; furthermore, summary hydrograph (*.zzh) and data input (*.zzb) files may be viewed prior to running a full simulation; this preview functionality is also available within the Flood Modeller interface.

Alternatively, the rainfall component of the ReFH2 Boundary can be used as a direct rainfall boundary (equivalent to an REBDY), when used in conjunction with a Lateral Inflow unit, by selecting the Hyetograph Boundary type option.

ReFH2 boundaries can also be utilised to provide boundary data for Flood Modeller 2D models. Use the 1D hydrology tools to define ReFH2 node(s) in a new (empty) network and then save these data as a separate 1D event file (.ied text file). This can then be associated to a 2D boundary shapefile.

Note that you **must** have the Wallingford Hydrosolutions ReFH2 software installed on your system to be able to run simulations or review input time series of models that include ReFH2 boundary units. However, if you don't have ReFH2 installed, you can still load models that include ReFH2 units to review the ReFH2 catchment parameters

The following explains how to include a ReFH2 boundary in your 1D network and how to run the ReFH2 calculation process to generate data:

1. Make the relevant 1D Network active in the Flood Modeller interface. You have the option to load some background map data to help locate your nodes. If your model is georeferenced then you can add online base maps provided by Bing Maps and Open Street Map – use the Base Maps menu on the right-hand side of the Home tab in the main toolbar. However, you can also opt to build your model as a schematic with no background data (and hence no true georeferencing).

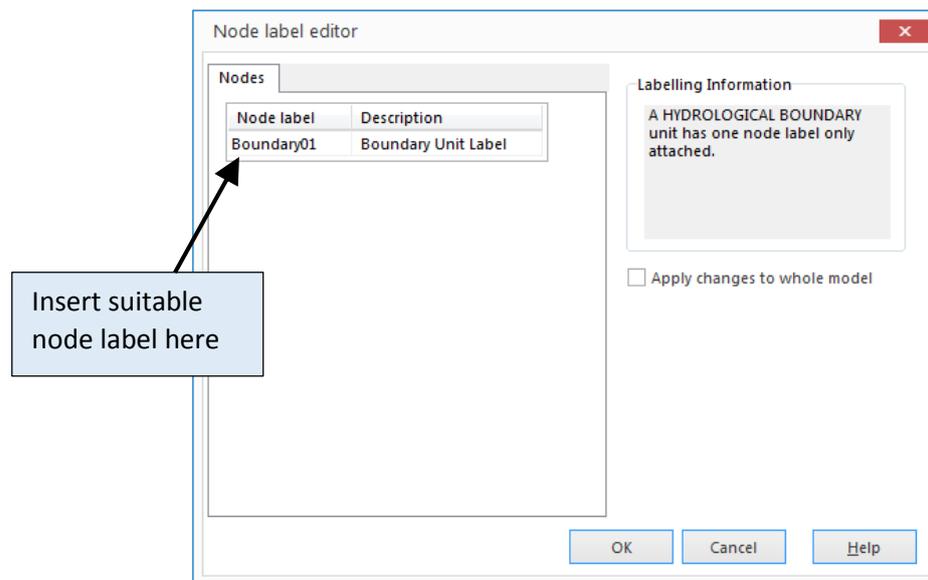
If you are generating boundary data for a 2D model start a new 1D event file (ied file) by right-clicking on the event section of the Project panel. Your new event file will automatically be made the active network within the map and Network table, thus allowing you to use the 1D build tools to add one or multiple ReFH2 units (in the same way as they are added to 1D networks).

2. The ReFH2 unit is a hydrological boundary which is used to calculate inputs into your network due to rainfall in your catchment. Therefore, this unit should be positioned where you require an input, e.g. at the upstream end of a reach (inflow) or connected to a lateral inflow (direct rainfall).

Highlight the node in the network table or map below which the ReFH2 unit will be positioned (or highlight the 'General' row in the Network table to place this unit at the top). On the '1D Build' (Hydrographs list) or 'Hydrology' tabs of the main toolbar, click on the ReFH2 node type and then click on the map where you want to locate this node (the mouse cursor will change to a pencil icon to signify model building mode).

Note for 2D event file generation the georeferencing is not important (as the ReFH2 data will be associated to a 2D boundary shapefile to provide a location for inputs into a 2D model). Thus the node can be positioned anywhere on the map view when it is added to your active event file.

3. After adding a node, Flood Modeller will prompt you to provide a node label by displaying the following window:



After defining a name and clicking 'OK' the node will be added to the network table, nodes list table and map simultaneously. If you select a name that is already in use within your 1D network, e.g. a river cross section node into which the ReFH2 flows will pass into, the two nodes of the same name will be connected in your map view (in some cases you may need to right-click on the map and select the refresh option to 'draw' the connections).

4. The new ReFH2 node will now be displayed in your map view. The Home tab of the main toolbar provides options to also display the node labels for your 1D Network. By default the node icon is displayed as shown below (there is an option to turn off icons and show the node only as a point).



5. After you have filled in the details of each of your model network nodes, you should save the changes, by selecting the 'Network save' function in the 'Home' tab of the main toolbar. Saving should also refresh your network view, adding any links that have been defined. Note, you can refresh your network view at any time while constructing your network by right-clicking on the map and selecting 'Refresh' in the displayed menu.

6. If any nodes are placed in the wrong location, you can move them in the map view and the revised locations will be saved to your network. The procedure to move nodes is:
 - Activate the move nodes function by right-clicking on the map and selecting 'Move Nodes' from the displayed menu.
 - Select one or multiple nodes by depressing the left mouse button and dragging a rectangle around the appropriate node(s). Selected nodes will be displayed with a thicker, blue outline.
 - When the mouse hovers over your selected nodes, depress the left mouse button to pick up the node (or nodes) and drag to a new location. Release the mouse button when at the required location.
 - If you have selected multiple nodes, hold down the 'Ctrl' key with the left mouse button to drag individual nodes within the group.
 - The pan map function can be accessed while moving nodes. Clicking on the pan icon (on the on-map controls or the main toolbar) will pause the move nodes mode, allowing you to pan to a new location. When you turn off the pan function, you will be returned to move nodes mode.
 - You can exit the move nodes mode by right-clicking on the map and selecting the 'Move Nodes' menu item again.
 - When you next save your 1D network, the new locations of the moved nodes will also be saved.

7. To enter catchment and rainfall data to define your ReFH2 boundary you need to double-click on the appropriate unit icon on the map or on the unit entry in the Network table. The ReFH2 properties window is then displayed.

On opening a ReFH2 boundary unit within the Flood Modeller interface, you are presented with four tabs: Catchment, Rainfall, Options and Results.

REFH2BDY : Boundary01

Catchment | Rainfall | Options | Results

Node Label: Boundary01 [Edit...]

To use this unit in a model you must have WHS ReFH2 software installed on your system

Comment:

Map Reference: Easting: 221000, Northing: 49000

Physical Characteristics: Area: 6, Urban Extent (URBEXT): 0.000

Rainfall Characteristics: SAAR: 1191

Country: England, NI, Wales, Scotland

FEH 1999 DDF Model Parameters: c: -0.029, d1: 0.448, d2: 0.349, d3: 0.334, e: 0.296, f: 2.45

Model: Rural, Urbanised

Other descriptors	
altbar	0.000
aspbar	0.000
aspvar	0.000
farl	0.000
fpext	0.0000
fpdbar	0.000
fploc	0.000
ldn	0.000

Buttons: Photo..., Previous..., Next..., OK, Cancel, Help

REFH2BDY : Boundary01

Catchment | Rainfall | Options | Results

Options Tab (Left):

- Duration: 0.000, Time Step: 0.000
- Design Rainfall (FEH 1999), Design Rainfall (FEH 2013)
- Flood Return Period: 0.000
- Season: WINTER

Options Tab (Right):

- Simulation Type: Full Hydrograph, Peak Flow, Baseflow Only
- Hydrograph scaling: Scale: Full, Method: By a factor of, Value: 1.000
- Minimum Flow: 0.000
- Time Delay: 0.000
- Boundary Type: Hydrograph (OT-type), Hydrograph (RE-type)
- Read descriptors directly from catchment descriptor file:
- Catchment descriptor (xml) file: []
- Generate report:
- Report output folder: []

Buttons: Photo..., Previous..., Next..., OK, Cancel, Help

The first two tabs specify the hydrological input data required for ReFH2; the Options tab allows for some model adjustment and the Results tab displays the values for the generated hydrograph and its intermediate constituent components. Note that selecting the Results tab effectively runs a 'mini' model simulation for just the boundary node to calculate the resultant ReFH2 inflows from your entered hydrological parameters (you can only view the Results tab if you have a licensed installation of the ReFH2 software).

Refer to the ReFH2 section in the Flood Modeller user guide to see definitions of all the data entries required on each tab of the ReFH2 properties window.

Generating Results

Prior to viewing the Results tab or running a simulation, the minimum input requirements are:

- The Catchment Descriptors (Catchment Tab)
- Storm Duration
- Data Interval
- Return Period (Rainfall Tab)

Although a recommended timestep range and storm duration are provided on the Results Tab, an estimate of these must still be provided initially.

Catchment descriptors may be imported from an xml file obtained from the FEH Web Service (note; this must be purchased), a csv file produced by the FEH CD-ROM (using the Import Catchment Descriptors button), or may be input manually. Note that only those descriptors used in the calculations are imported, in addition to the Easting and Northing grid reference, which are provided for information only (although may be used by post processing tools, e.g. TabularCSV, to extract coordinates).

The season (Rainfall Tab) has a default storm season setting of 'WINTER', but this can be changed to 'SUMMER'. An appropriate selection can be influenced by the degree of urbanisation in the catchment (for URBEXT > 0.125 a summer storm is recommended).

Note that unlike ReFH1 boundaries you cannot specify an observed rainfall time series for ReFH2. Thus, it may be better to adopt a ReFH1 boundary in catchments where you have observed data available to calibrate ReFH flow.

By clicking on the Results tab, the user is effectively launching a boundary mode simulation of Flood Modeller of a model containing the single ReFH2 unit. This produces the output hydrograph and its constituents in tabulated form, and many of the intermediate calculated parameters. Recommended values for design storm duration and timestep are given, which can be subsequently checked against those originally entered. N.B. if subsequently adjusting the storm duration or time interval, these should be rounded so that the duration divided by the interval is an odd integer. The hydrographs and hyetographs may also be viewed graphically via the Plot button. The hydrograph (*.zzh) and summary data (*.zzb) output files are also produced and are able to be viewed via the appropriate button on the tab. Occasionally, the simulation may fail, e.g. due to bad input data or an inappropriate licence, and like any Flood Modeller simulation, will generate a run error and produce diagnostic output in such instances. The user is advised to check this output (N.B. The error dialogue box may appear partially hidden behind the "Please Wait..." dialogue box).

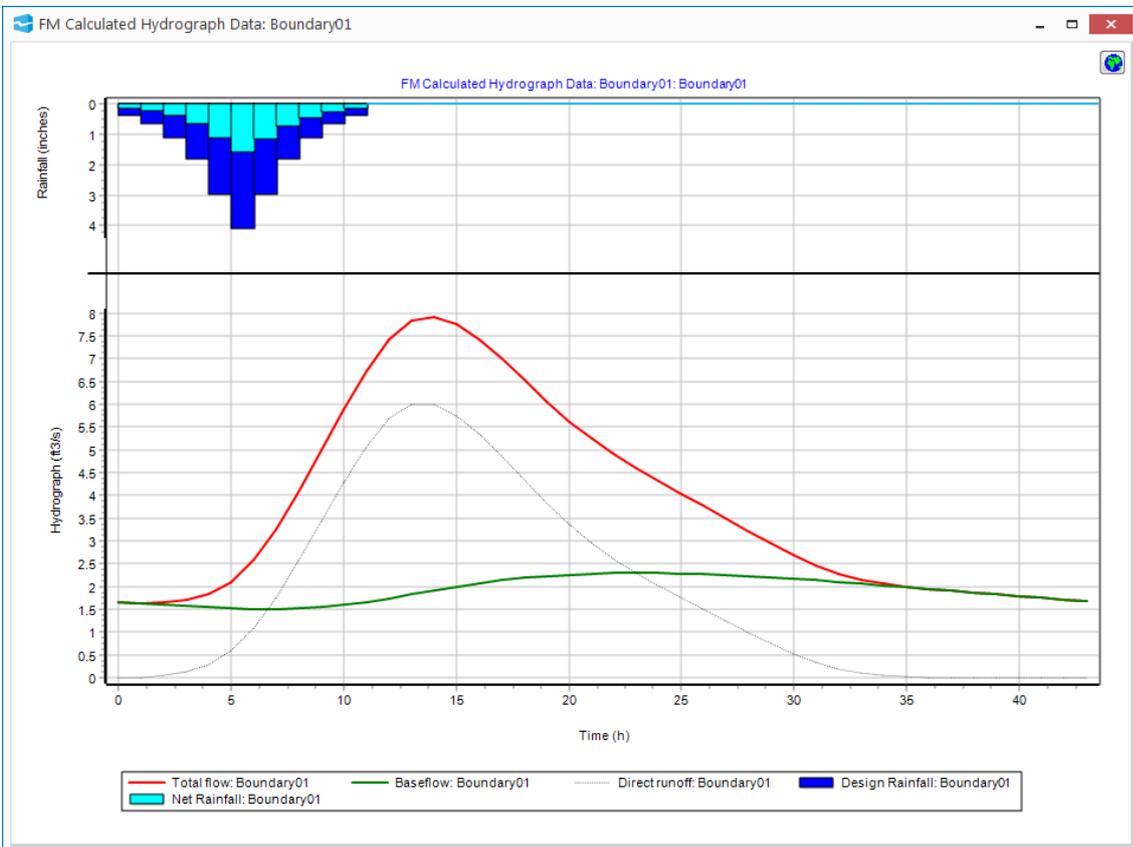
REFH2BDY : Boundary01

Catchment Rainfall Options Results

Report... Plot...

Time (hrs)	Design Rainfa	Net Rainfall	Direct Run Off	Baseflow	Total Flow
0.00000	0.39600	0.14100	0.00000	1.66200	1.66200
1.00000	0.66400	0.23800	0.01000	1.62900	1.63900
2.00000	1.10700	0.40000	0.04800	1.59600	1.64500
3.00000	1.83000	0.66800	0.13300	1.56600	1.69900
4.00000	2.97800	1.10800	0.29500	1.53900	1.83400
5.00000	4.10200	1.56800	0.58700	1.51700	2.10400
6.00000	2.97800	1.16800	1.07400	1.50300	2.57700
7.00000	1.83000	0.73000	1.76000	1.50200	3.26200
8.00000	1.10700	0.44600	2.57600	1.51700	4.09300
9.00000	0.66400	0.26900	3.44000	1.54900	4.98900
10.00000	0.39600	0.16100	4.29300	1.59800	5.89100
11.00000	0.00000	0.00000	5.06900	1.66300	6.73200
12.00000	0.00000	0.00000	5.67800	1.74100	7.41900
13.00000	0.00000	0.00000	6.00600	1.82700	7.83300
14.00000	0.00000	0.00000	6.00000	1.91500	7.91400
15.00000	0.00000	0.00000	5.74800	1.99800	7.74600
16.00000	0.00000	0.00000	5.34800	2.07300	7.42100
17.00000	0.00000	0.00000	4.86500	2.13700	7.00100
18.00000	0.00000	0.00000	4.34300	2.18900	6.53200
19.00000	0.00000	0.00000	3.82500	2.23000	6.05500
20.00000	0.00000	0.00000	3.35800	2.25900	5.61700
21.00000	0.00000	0.00000	2.96000	2.27900	5.23900

Photo... Previous... Next... OK Cancel Help



If the ReFH2 executable fails to run (E1797), there will be an accompanying message in the diagnostics (*.zsd) file of the format: "Error running ReFH2 executable; return code: *n*", where *n* is usually the return code specified in the ReFH2 documentation. In the first instance, the user is referred to this. However, there are other codes, not directly returned from the ReFH2 executable. If this is the case, usually these are error codes determined by the Windows system, e.g. refer to [https://msdn.microsoft.com/en-us/library/windows/desktop/ms681381\(v=vs.85\).aspx](https://msdn.microsoft.com/en-us/library/windows/desktop/ms681381(v=vs.85).aspx) for details. Specifically, the following two may be encountered:

- n=258 – ReFH2 executable timed out. By default, 30s is allowed for the ReFH2 executable to run and process the data. This should be much longer than ReFH2 software takes to run, and is introduced as an additional safety measure to Flood Modeller from hanging should an unexpected interruption occur in the ReFH2 software.
- n=9999 – [Non-Windows system code]. Unspecified return code. The ReFH2 executable process could not be launched for an undetermined reason.