MAGNET-StormNET

Modeling an Urban Watershed

The goal of this document is to help users understand the underlying methodology for modeling an urban watershed (subcatchment) in MAGNET-StormNET. The process is illustrated through application to a simple watershed involving a subcatchment and outfall as its outlet.

This document does include specific details for *all* options, settings, parameters, etc. that may be involved in some aspect of modeling a watershed. Readers are referred to the '?' realtime help pages embedded in the StormNET interface system, as well as other online resources on the magnet4water website and elsewhere.

Conceptual Model

Watershed modeling in StormNET is essentially a subcatchment-by-subcatchment water balance: inflows minus outflows equals the rate of storage (interception or depression storage).

The hydrologic processes involved include precipitation and snowmelt (inflows), as well as evaporation, infiltration, and overland runoff (outflows)

Watershed runoff is represented as an effective sheet flow. The sheet outflow is based on an "effective" Manning's equation. Runoff depths are computed from water balance analysis (see Figure 1).

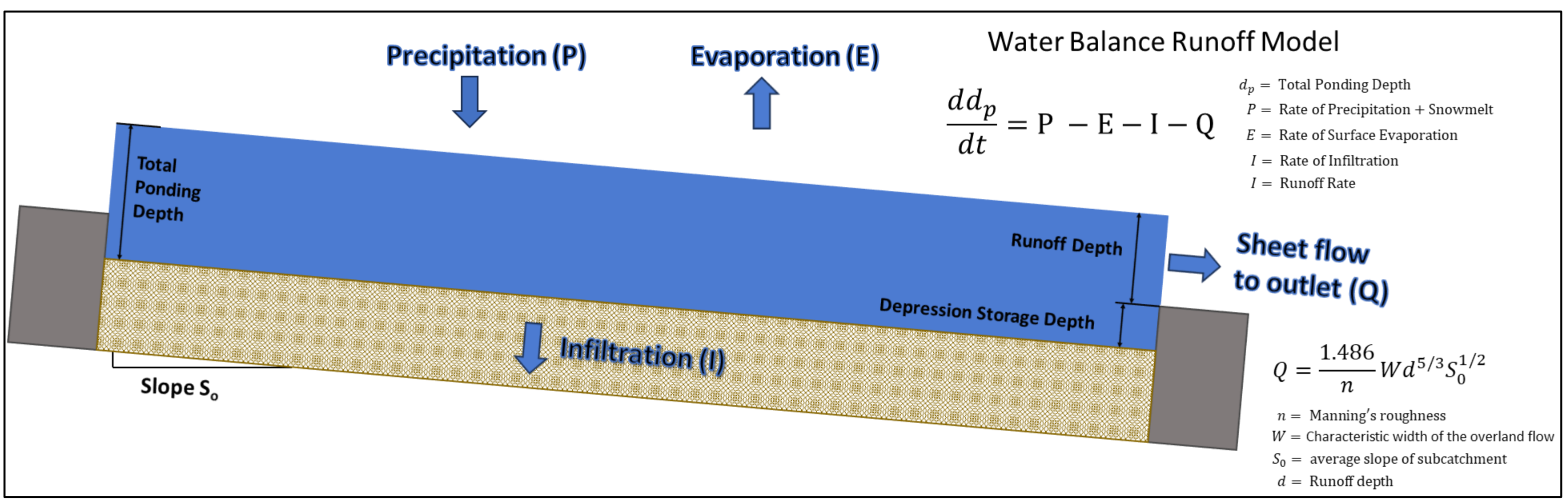


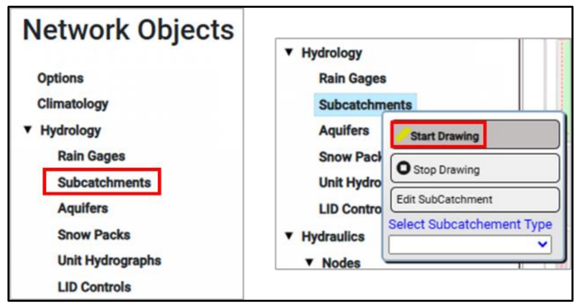
Figure 1:Water Balance Runoff Model.

Modeling Steps

Define Subcatchment Geometry

The subcatchment geometry helps to define the subcatchment area and characteristic width, wich help to control runoff. Subcatchment area is automatically calculated from the georeferenced map display. Characteristic width should be computed/estimated by the user (see more below in Define Runoff Characteristics.

The first step is to draw the subcatchment in the map display:



- Navigate to: Network Objects > Hydrology > Subcatchments > Right-click and select 'Start Drawing'
- Click on the map to add vertices of the subcatchment polygon. For this example, a rectangular subcatchment is added along a stretch of the Grand River in southwest Lansing, Michigan, USA (see Figure 2).
- Double-click to close the subcatchment.
- Click 'Stop Drawing' in the Subcatchments submenu

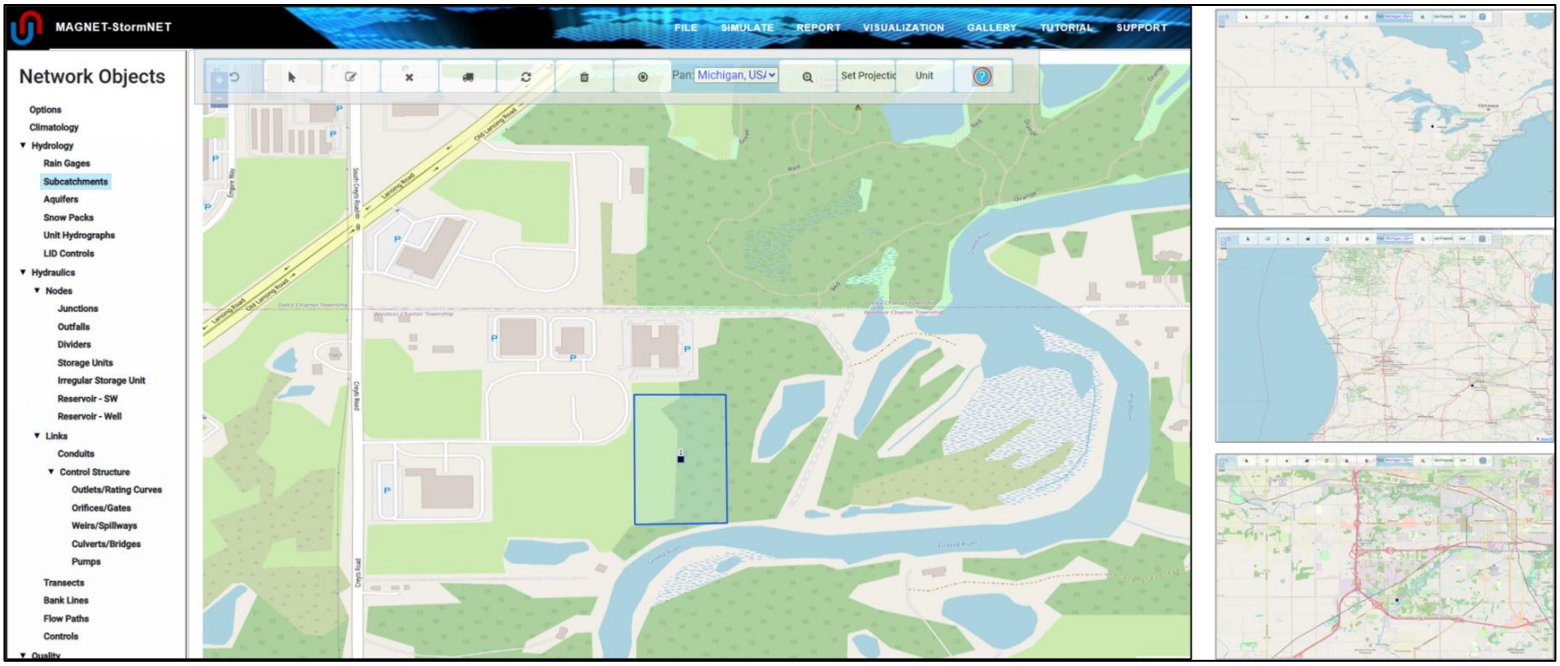


Figure 2: Drawn subcatchment in the StormNET environment. This hypothetical development is situated along the Grand River in southwest Lansing, Michigan, USA.

Define Runoff Characteristics

Runoff is computed in the following manner: first, precipitation "losses" are calculated (interception/depression storage, surface evaporation, and infiltration), and the remaining (or "excess") precipitation dictates the amount of additional water that becomes runoff. The runoff depth (d) is used to compute runoff flow (Q) via Manning's equation:

$$Q = \frac{1.486}{n} W d^{5/3} S_0^{1/2}$$

The underlying conceptual model for runoff sheet flow assumes a rectangular subcatchment defined by a width (W), flow path length (L), and effective (uniform) slope (S_o). The one-dimensional runoff flow is aligned along the length axis and move towards a "collection channel" that instantaneously routes water to the subcatchment outlet (see Figure 3). The relationship between the characteristic width, subcatchment area, and average flow path length depends on the assumed position of the outlet:

- A "single-sided" subcatchment (Scenario A) gives the typical relationship between width, area and length: W=A/L.
- A "double-sided" subcatchment (Scenario B) yield: W=A/(L/2)=2A/L

In reality, subcatchments are often not rectangular. In that case, an average flow path length (computed or approximated from real, variable lengths) should be substituted for the uniform flow path length.

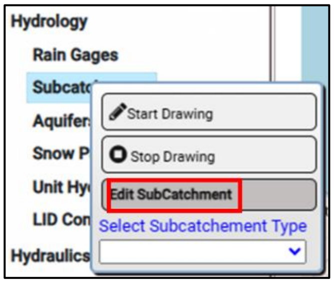
Note that stormnet allows modeling the mix of pervious and impervious land covers within a subcatchment, e.g., an impervious parking lot surrounded by pervious area of grass and other vegetation. Runoff is calculated separately for each subarea, and total combined runoff is routed to the subcatchment outlet.

Assign Slope, Width, and Manning's Roughness

In StormNET, the following parameters are needed as input to compute runoff with Manning's equation: subcatchment area (A), characteristic width (W), slope, and Manning's roughness.

Users use the Subcatchment editor interface to define the subcatchments runoff characteristics:

- Network Objects > Hydrology > Subcatchments > Edit SubCatchments
- Or, click within an existing subcatchment



Use the drop-down menu at the top of the menu to select/change the Subcatchment to be edited (see Figure 4).

StormNET computes subcatchment *area* based on its drawn extent in the georeferenced map display. The computed area is automatically populated as the default value in the editor (but can be overwritten, if desired). See Figure 5

The area and estimated average flow path length should be used to calculate the subcatchment *width*. A default value of 500ft is provided (Figure 5).

In this example, the outlet will be placed at the bottom-right corner of the subcatchment - essentially the same configuration as shown in Scenario A of Figure 3. Therefore, W=A/L=(7.5acres)/(365ft)=895ft

The effective *slope* should be specified by the user (default: 0.5%).

Manning's roughness is assigned for pervious portions and impervious portions of the subcatchment (Figure 6). (Recall that Stormnet allows modeling the mixing of different land covers within subcatchment based on percentage of area covered). Default values of 0.01 and 0.1 are used for impervious and pervious area, respectively. The default values are applied in this example.

Click the '?' help button to view a table of typical values of n for different surfaces (see Figure 7).

Assign Percent Pervious / Impervious

Use the "% imperv" field to control the percentage of impervious cover in the subcatchment (not including LIDs) – see Figure 8. Percentage pervious cover is calculated automatically for using in water balance and runoff calculations.

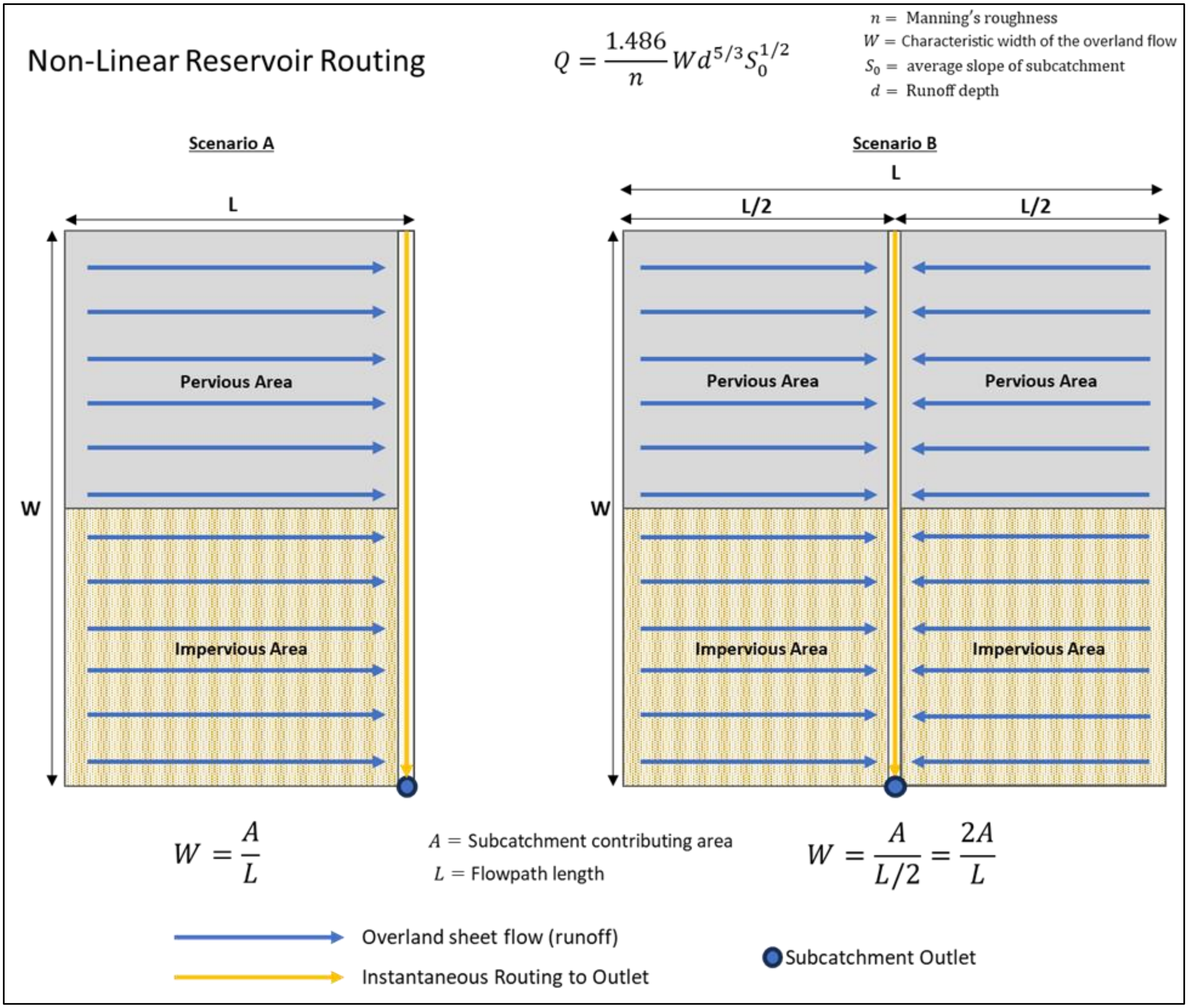


Figure 3: Non-linear reservoir routing or effective sheet flow runoff.

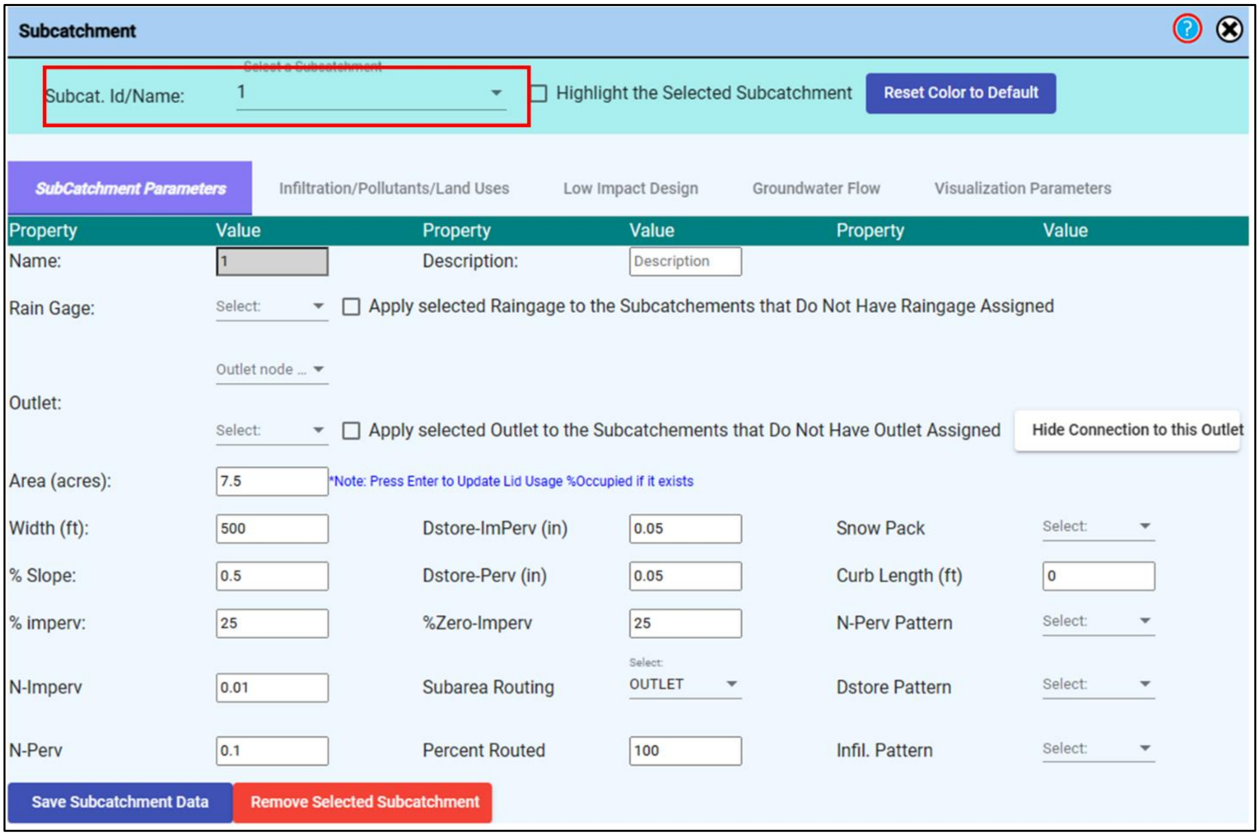


Figure 4: Subcatchment editor interface.

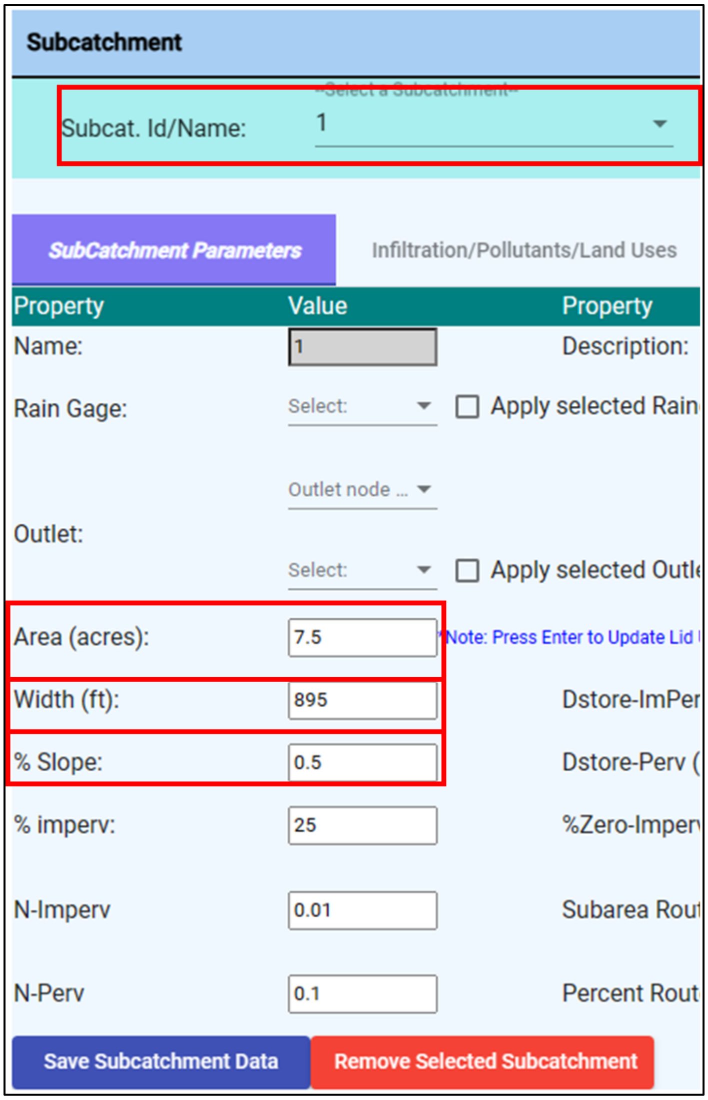


Figure 5:Input fields for subcatchment area, characteristic width, and slope.

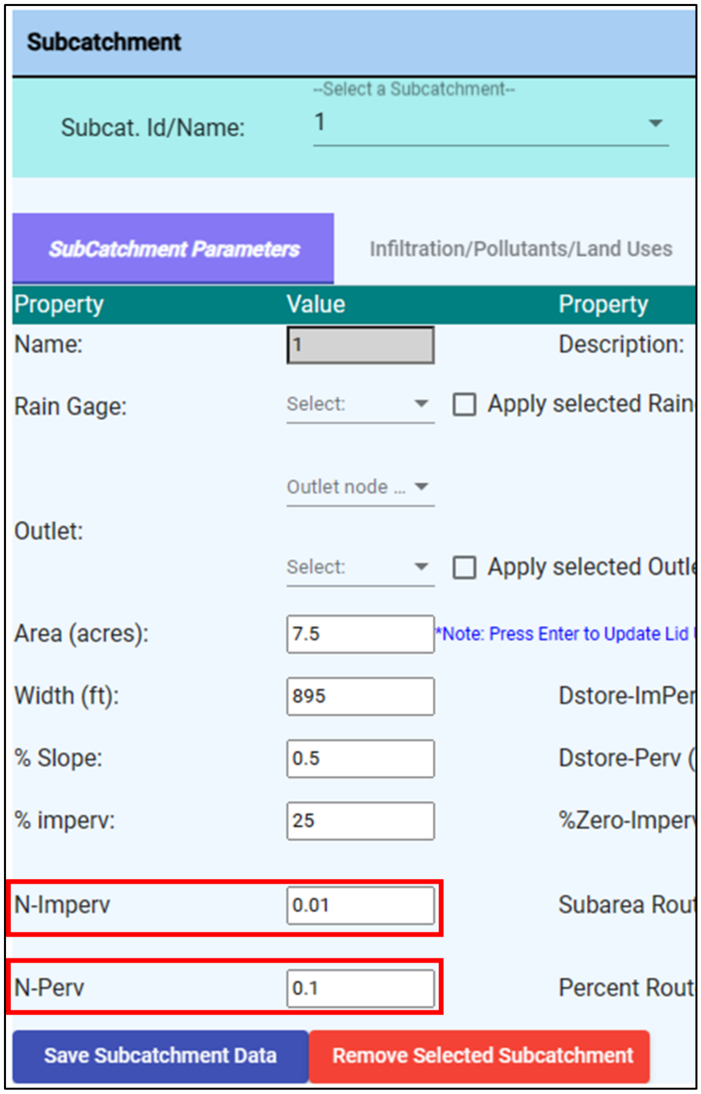
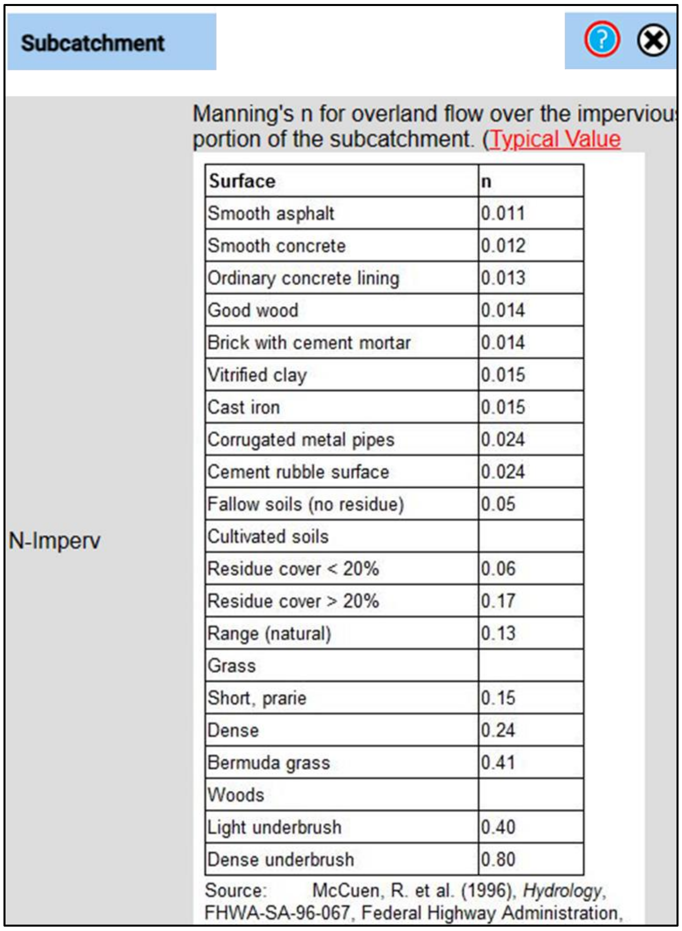


Figure 6:Input fields for Manning's roughness.



Subcatchment

N-Imperv

Manning's n for overland flow over the imperviou
portion of the subcatchment. (Typical Value

Surface	n
Smooth asphalt	0.011
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Brick with cement mortar	0.014
Vitrified clay	0.015
Cast iron	0.015
Corrugated metal pipes	0.024
Cement rubble surface	0.024
Fallow soils (no residue)	0.05
Cultivated soils	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Range (natural)	0.13
Grass	
Short, prarie	0.15
Dense	0.24
Bermuda grass	0.41
Woods	
Light underbrush	0.40
Dense underbrush	0.80

Source: McCuen, R. et al. (1996), *Hydrology*,
FHWA-SA-96-067, Federal Highway Administration,

Figure 7: Typical values of Manning's roughness in the StormNET realtime help page.

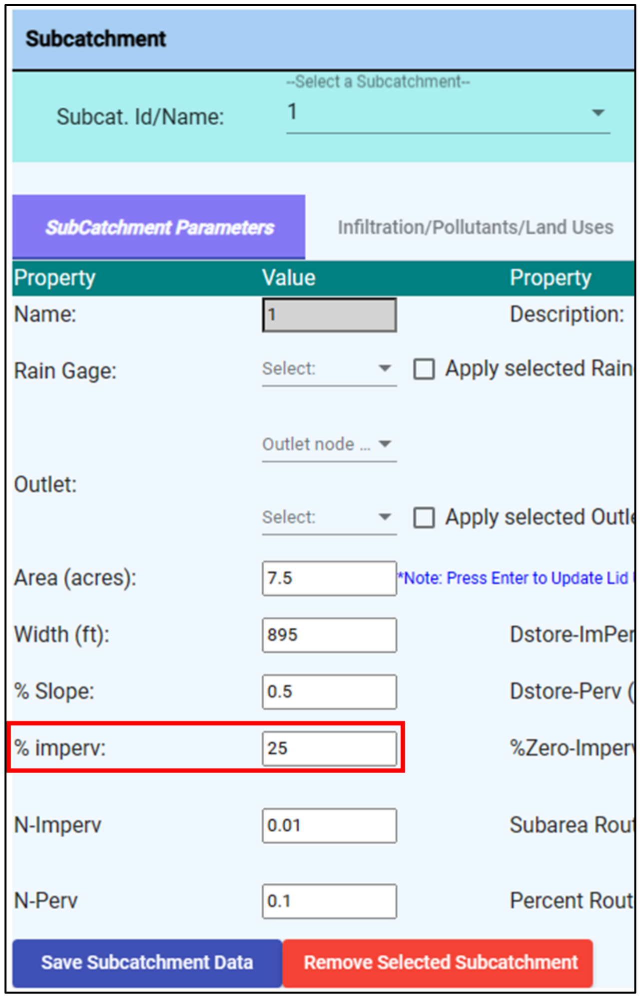


Figure 8:Input field for percentage impervious cover.

Define Rain Input

StormNET enables automatic generation of spatially explicit rainfall time series based on 1) historical data, 2) future projections; and 3) design storm events or historical storm statistics.

In this example, we apply a pre-defined design storm as an illustration.

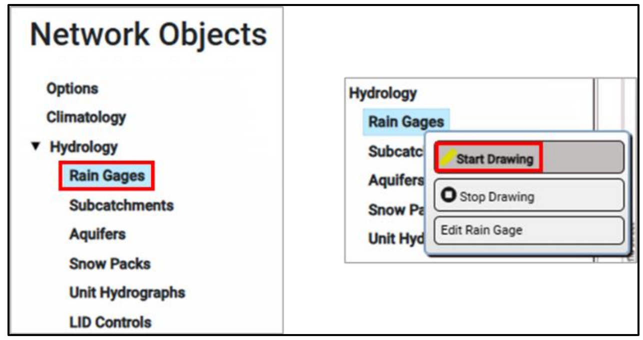
Users can interactively generate time series data based on a statistical temporal distribution for a design storm of a given depth, duration, and return period. Users may utilize a variety of standard deign storm distributions and use Intensity-Duration-Frequency curve information (if available). The results are automatically used as input into a Stormnet model.

Add a Rain Gage and Assign Storm Event (Rain Time-Series)

Modeling precipitation in StormNET requires 1) adding a rain gage to the model; 2) assigning the rain gage to a precipitation time-series; and 3) linking the subcatchment to the rain gage.

To add a rain gage to the model:

- Network Objects > Hydrology > Rain Gages > Right-click and select 'Start Drawing'
- Click in the map display to add a rain gage
- Select 'Stop Drawing' from Rain Gages submenu

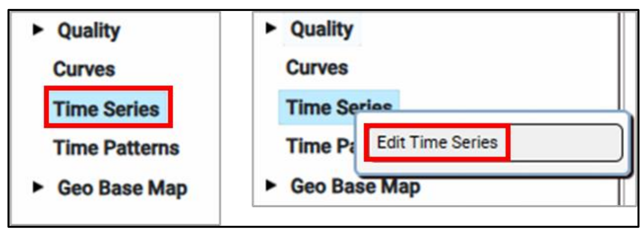


To edit the rain gage:

- Click on the rain gage map icon; this opens the Rain Gage editor (see Figure 10) (or select 'Edit Rain Gage from the Rain Gage submenu)
- Define a rain data format (intensity, volume, or cumulative); in this example we use 'VOLUME'.
- Select the 2hr-Volume as the Series Name (default series) – this is the time-series that will be used to compute precipitation input during simulation.
- Click 'Show Plot' to preview the rain time-series

Note: to edit the time-series:

- Network Objects > Time Series > Right-click and select 'Edit Time Series'; this opens the Time Series Editor interface (see Figure 11)



To link the rain gage to the subcatchment:

- Open the Subcatchment editor interface, SubCatchment Parameters subtab (see Figure 12).
- Select the rain gage ID from the drop-down menu next to 'Rain Gage'
- Save the changes

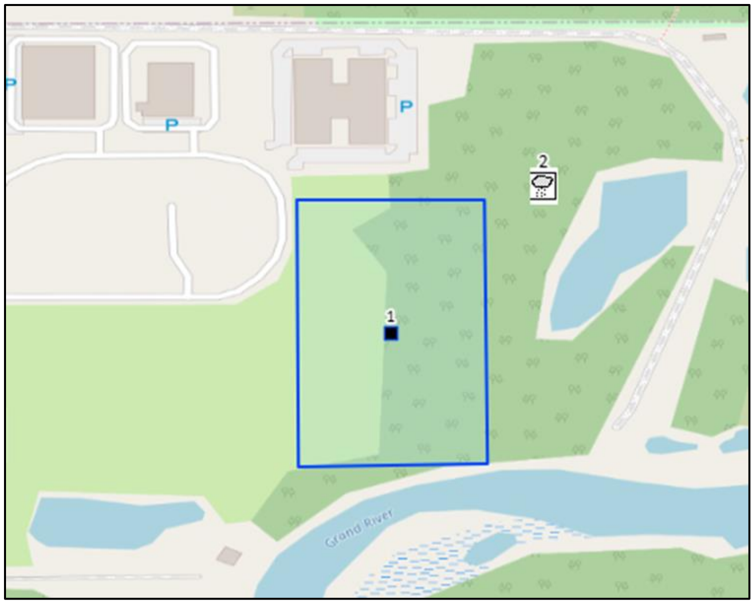


Figure 9: Rain gage added to the model.

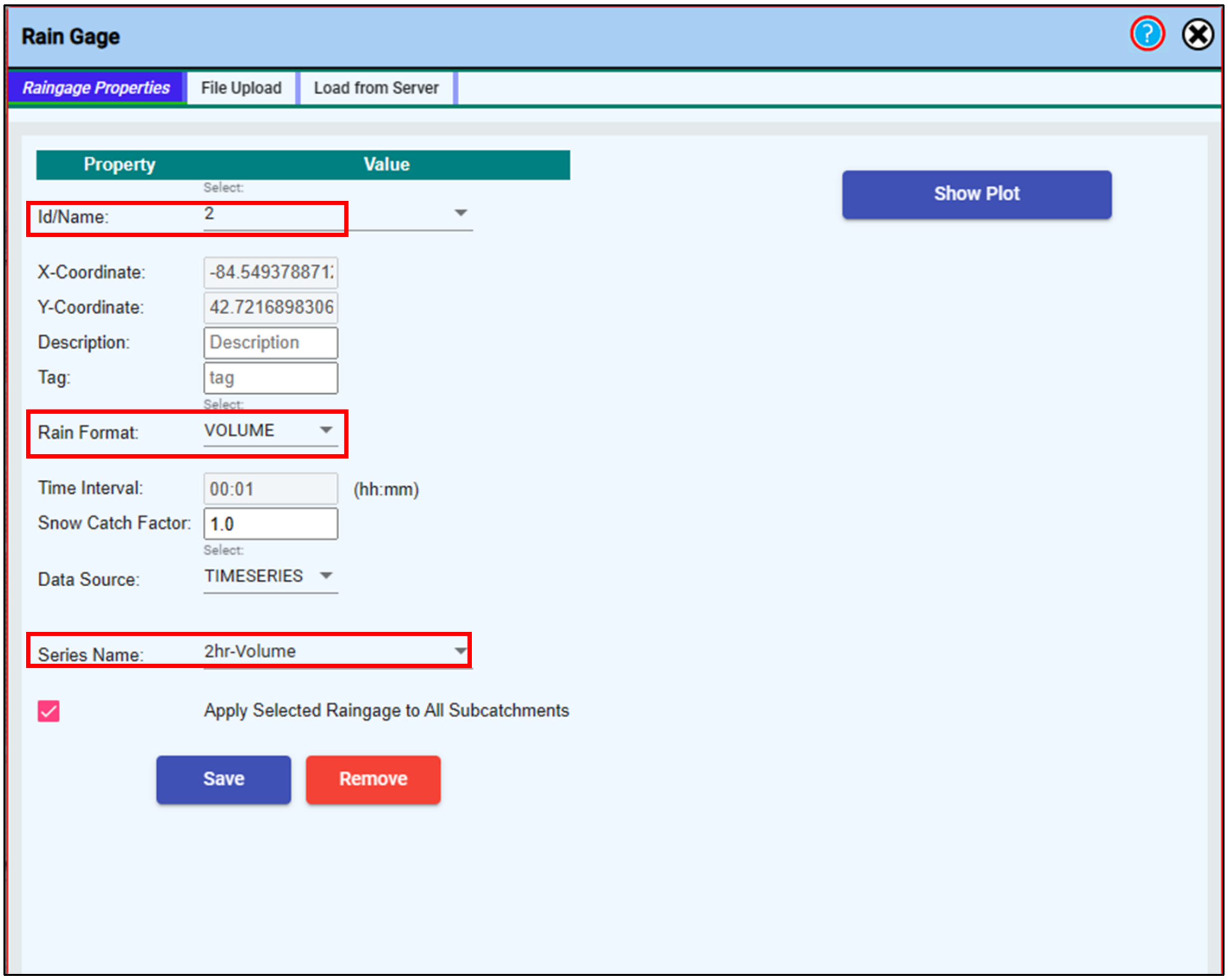


Figure 10: Rain Gage editor interface.

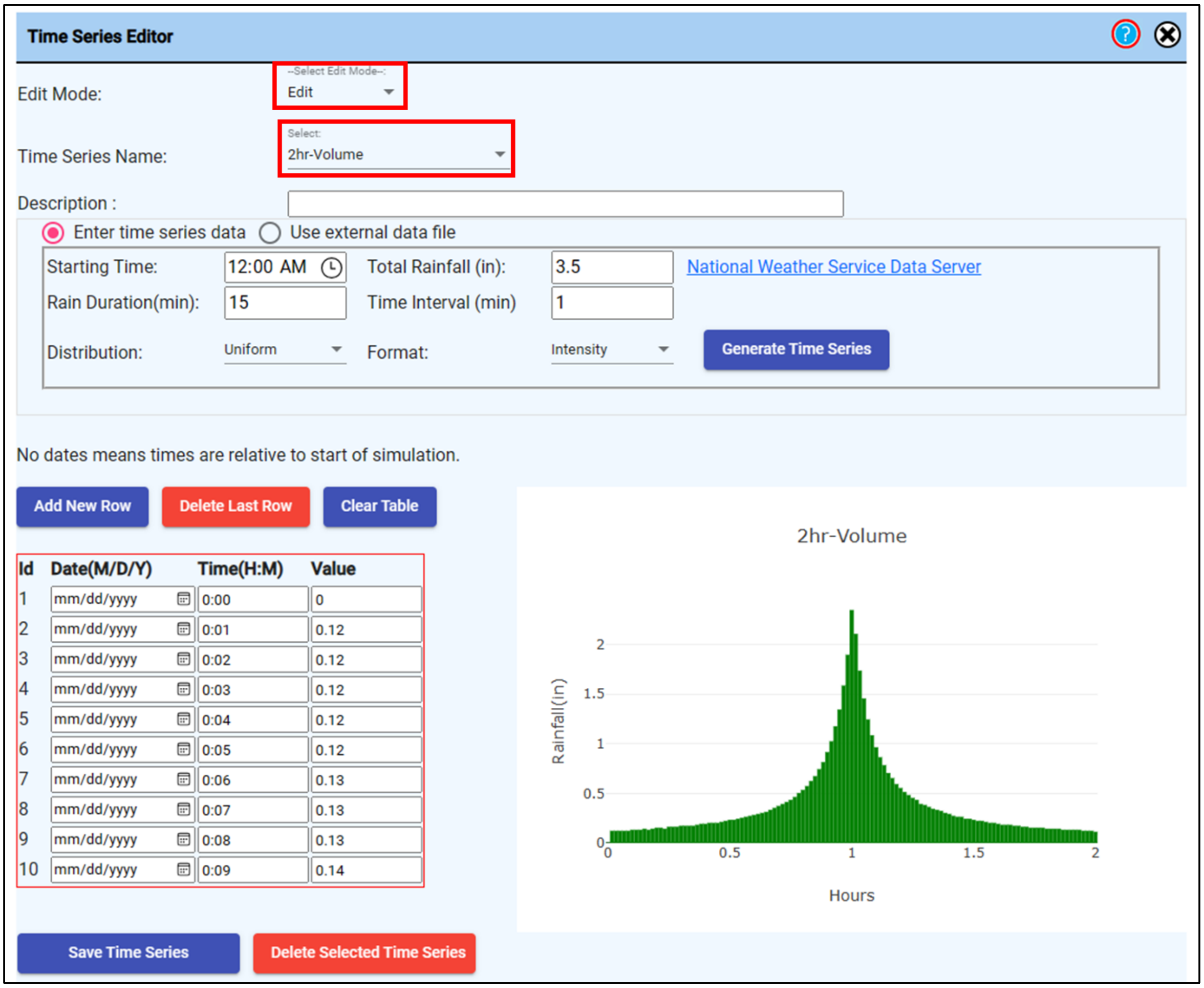


Figure 11:Time Series Editor interface for defining a storm event (rain time-series).

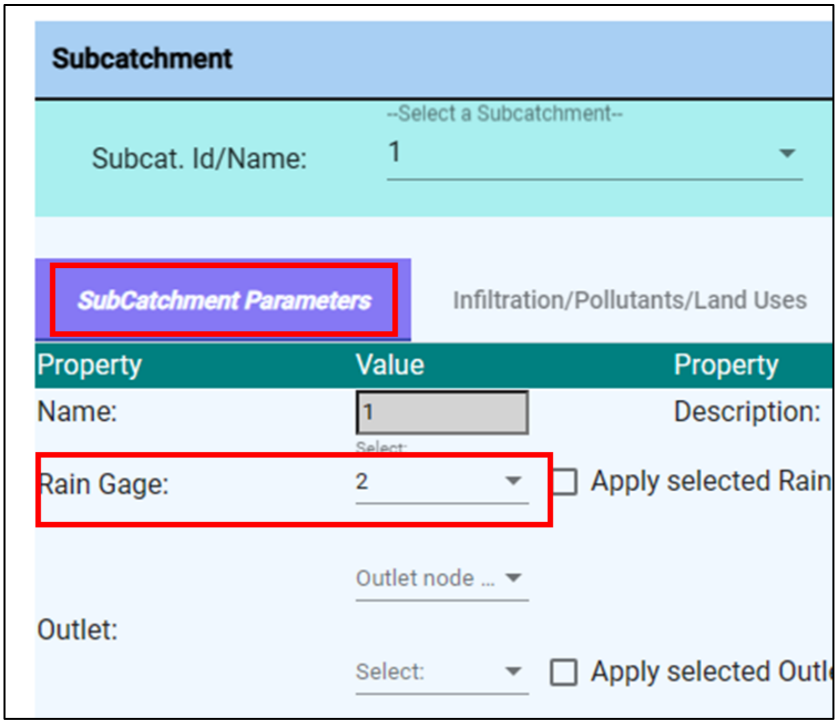


Figure 12: Linking a rain gage to a subcatchment.

Define Interception

Interception or depression storage is the amount of input water (precipitation and/or snowmelt) that can accumulate before runoff occurs – no runoff can occur until the subcatchment water depth is greater than the depression storage depth (refer to Figure 1).

Different depression storage depth can be specified for impervious and pervious subareas of the subcatchment.

To assign depth of depression storage depths:

- Open the Subcatchment editor interface, SubCatchment Parameters subtab.
- Update the input in 'Dstore-Imperv' (depth of depression storage in impervious subarea) - see Figure 13). This example uses the default value
- Update the input in 'Dstore-Perv' (depth of depression storage in impervious subarea). This example uses 0.15 in

Refer to typical values of depth of depression storage in the realtime help page.

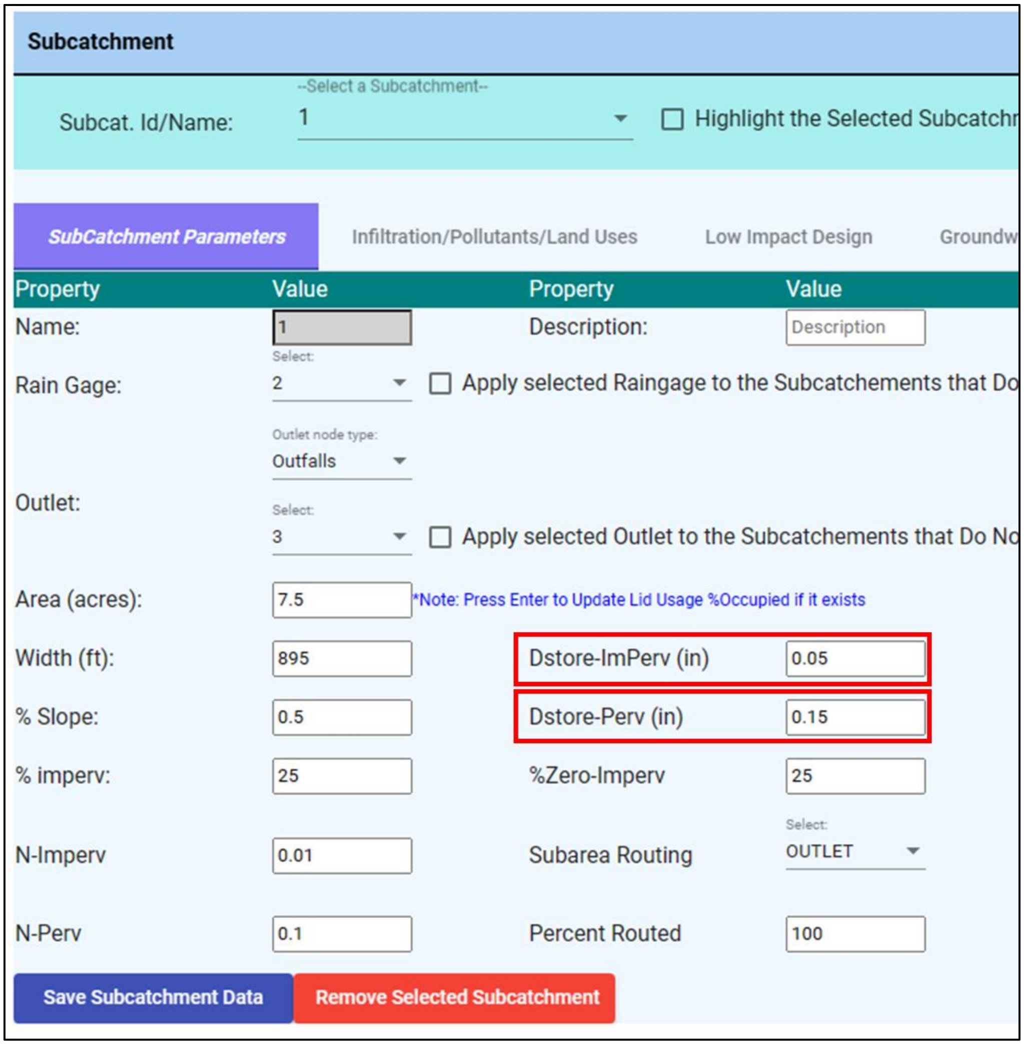


Figure 13:Input fields for specifying depression storage depth in impervious and pervious subareas of the subcatchment.

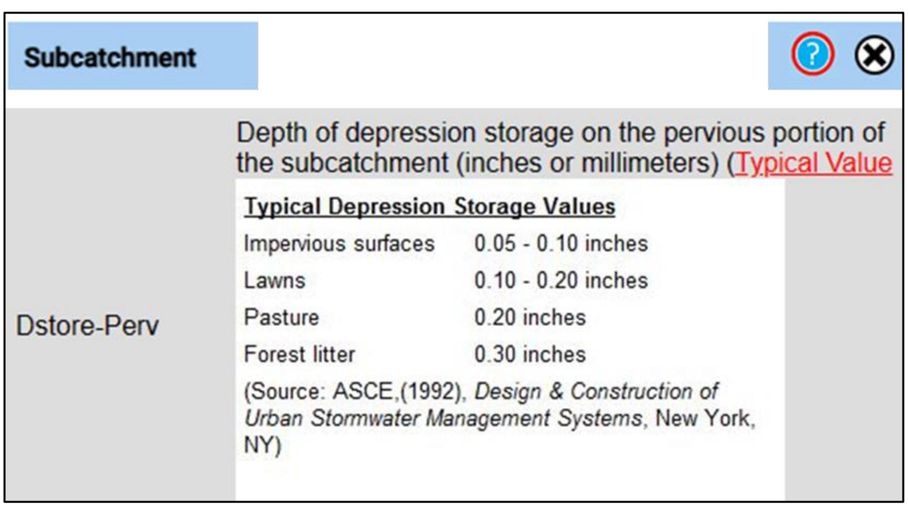


Figure 14: Typical values of Manning's roughness in the StormNET realtime help page.

Define Infiltration Characteristics

Within pervious areas, StormNET models infiltration into unsaturated soils using one of the following methods: 1) the Horton method, 2) the Modified Horton method, 3) the Green and Ampt methods, 4) the SCS Curve Number method. Infiltration is not modeled within impervious subareas.

Here we will illustrate modeling infiltration with the SCS Curve Number method. The Curve Number method calculates runoff resulting from a given precipitation input and the hydrologic soil group, land use, and hydrologic condition. The difference between input precipitation and calculated runoff is the infiltration amount.

Assign Infiltration Method and Infiltration Parameters

Navigate to the Infiltration / Pollutants / Landuse subtab of the Subcatchment editor interface. The left-panel is used to assign the infiltration method and infiltration parameters (Figure 15).

Select ‘CURVE_NUMBER’ from the drop-down menu next to ‘Infil._Method’.

For this example, we will utilize the default values for curve number, conductivity, and drying time. Refer to the ‘?’ (realtime help) for a table of typical values of curve number and saturated conductivity based on land use and hydrologic soil group Figure 17.

Note: users may examine the land use and soil type/soil properties at their site by mapping Big Data live-linked to the StormNET platform (not shown here; this is detailed in another tutorial):

- Navigate to VISUALIZATION (header menu) > Data Mapping > Draw Model area
- Follow the resulting interface to define a mapping area and which parameters to extract and display: DEM, soil, and/or land use and derived parameters, e.g., Curve Number

Alternatively, users may directly extract the Curve Number from Big Data :

- Navigate to: SIMULATE (header menu) > Add Spatial Data
- Click ‘ Get Spatial Data’ in the interface that appears (see Figure 18)
- When the task is finished, notice that the Curve Number is updated in the Subcatchment editor interface (see Figure 19).

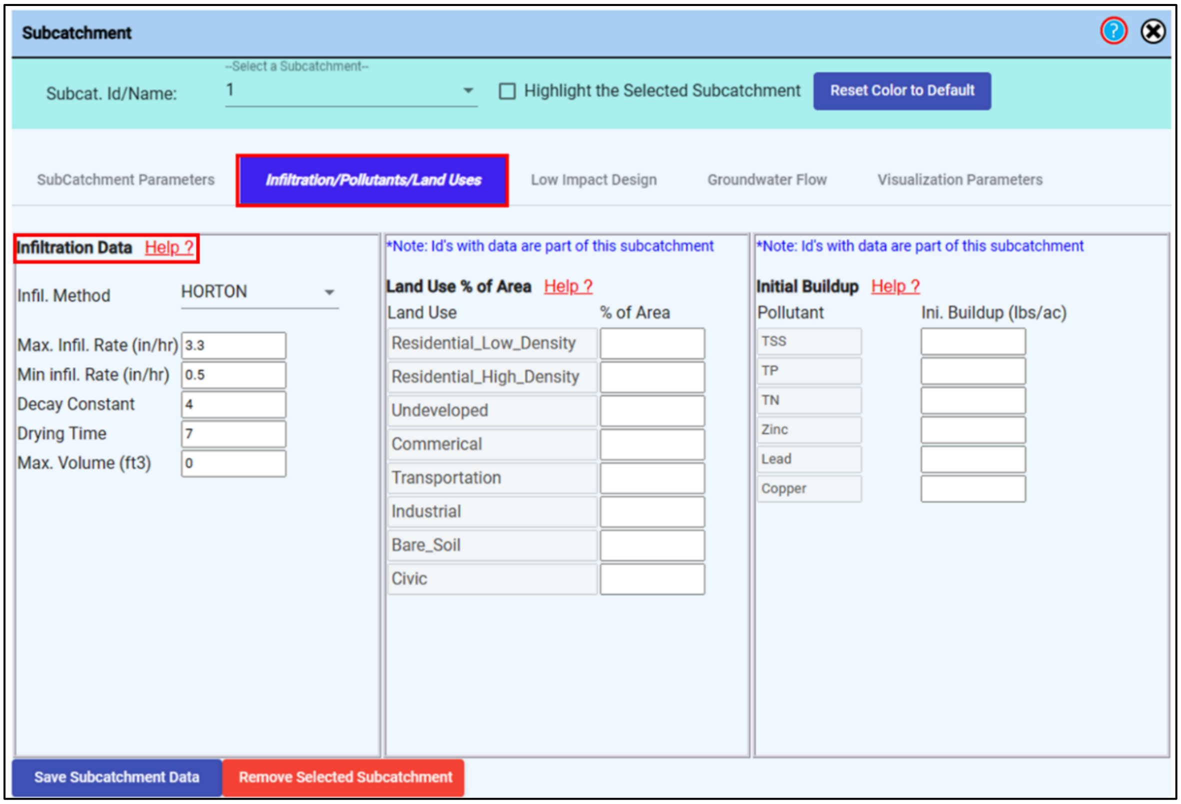


Figure 15: Infiltration Data tab of the Subcatchment editor interface.

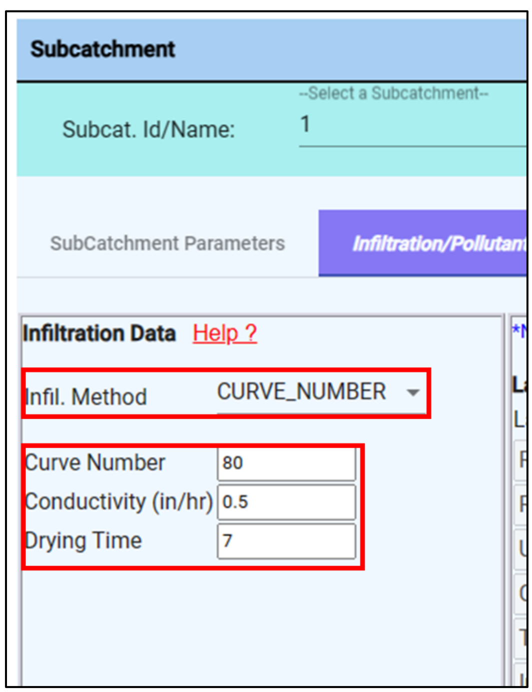
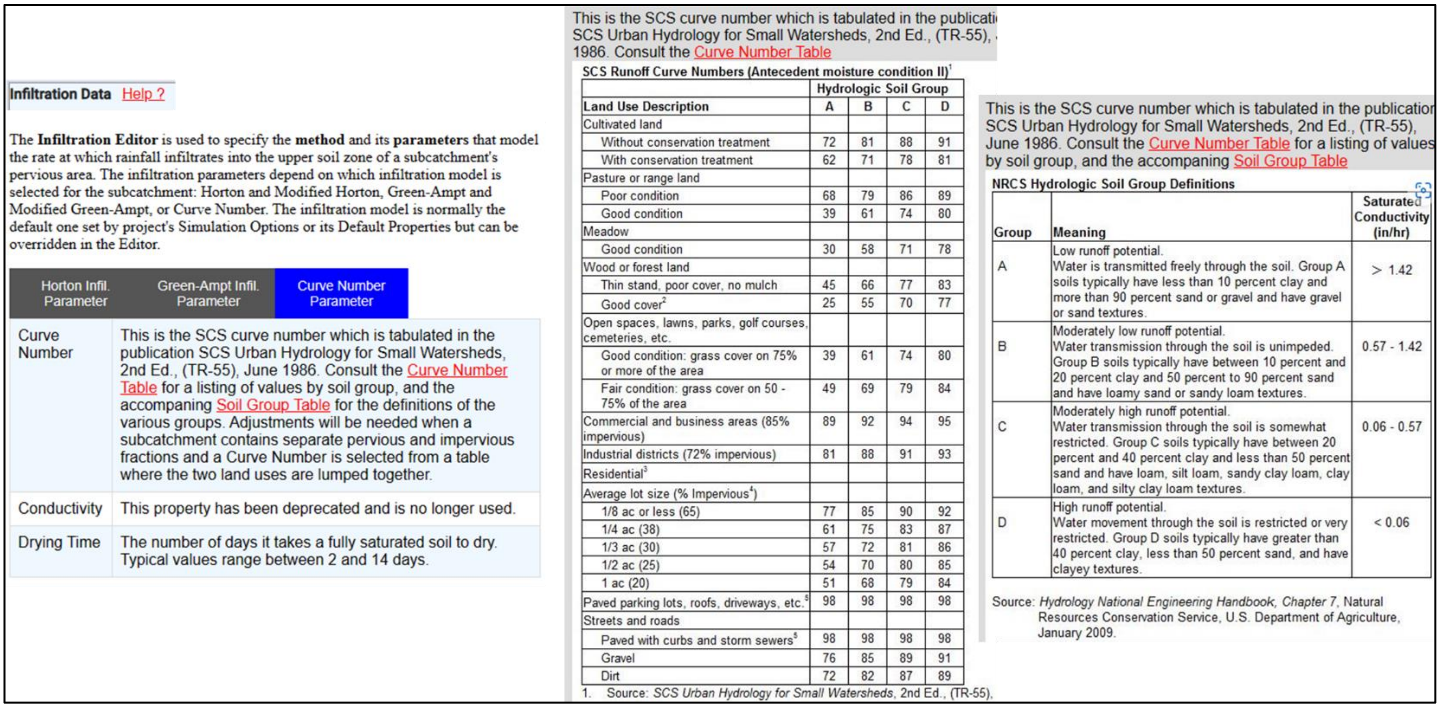


Figure 16: Example of selecting the Curve Number method for modeling infiltration within the subcatchment.



Infiltration Data Help ?

The **Infiltration Editor** is used to specify the **method** and its **parameters** that model the rate at which rainfall infiltrates into the upper soil zone of a subcatchment's pervious area. The infiltration parameters depend on which infiltration model is selected for the subcatchment: Horton and Modified Horton, Green-Ampt and Modified Green-Ampt, or Curve Number. The infiltration model is normally the default one set by project's Simulation Options or its Default Properties but can be overridden in the Editor.

Horton Infil. Parameter	Green-Ampt Infil. Parameter	Curve Number Parameter

Curve Number	This is the SCS curve number which is tabulated in the publication SCS Urban Hydrology for Small Watersheds, 2nd Ed., (TR-55), June 1986. Consult the Curve Number Table for a listing of values by soil group, and the accompaning Soil Group Table for the definitions of the various groups. Adjustments will be needed when a subcatchment contains separate pervious and impervious fractions and a Curve Number is selected from a table where the two land uses are lumped together.
Conductivity	This property has been deprecated and is no longer used.
Drying Time	The number of days it takes a fully saturated soil to dry. Typical values range between 2 and 14 days.

This is the SCS curve number which is tabulated in the publicati SCS Urban Hydrology for Small Watersheds, 2nd Ed., (TR-55), 1986. Consult the Curve Number Table

SCS Runoff Curve Numbers (Antecedent moisture condition II)[1]

	Hydrologic Soil Group			
Land Use Description	**A**	**B**	**C**	**D**
Cultivated land				
Without conservation treatment	72	81	88	91
With conservation treatment	62	71	78	81
Pasture or range land				
Poor condition	68	79	86	89
Good condition	39	61	74	80
Meadow				
Good condition	30	58	71	78
Wood or forest land				
Thin stand, poor cover, no mulch	45	66	77	83
Good cover[2]	25	55	70	77
Open spaces, lawns, parks, golf courses, cemeteries, etc.				
Good condition: grass cover on 75% or more of the area	39	61	74	80
Fair condition: grass cover on 50 - 75% of the area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious)	81	88	91	93
Residential[3]				
Average lot size (% Impervious[4])				
1/8 ac or less (65)	77	85	90	92
1/4 ac (38)	61	75	83	87
1/3 ac (30)	57	72	81	86
1/2 ac (25)	54	70	80	85
1 ac (20)	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]	98	98	98	98
Streets and roads				
Paved with curbs and storm sewers[5]	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89

1. Source: *SCS Urban Hydrology for Small Watersheds*, 2nd Ed., (TR-55),

This is the SCS curve number which is tabulated in the publicatio SCS Urban Hydrology for Small Watersheds, 2nd Ed., (TR-55), June 1986. Consult the Curve Number Table for a listing of values by soil group, and the accompaning Soil Group Table

NRCS Hydrologic Soil Group Definitions

Group	Meaning	Saturated Conductivity (in/hr)
A	Low runoff potential. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures.	> 1.42
B	Moderately low runoff potential. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures.	0.57 - 1.42
C	Moderately high runoff potential. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures.	0.06 - 0.57
D	High runoff potential. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures.	< 0.06

Source: *Hydrology National Engineering Handbook, Chapter 7*, Natural Resources Conservation Service, U.S. Department of Agriculture, January 2009.

Figure 17: Realtime help page for Infiltration Data, including tables of typical values for curve number and saturated conductivity.

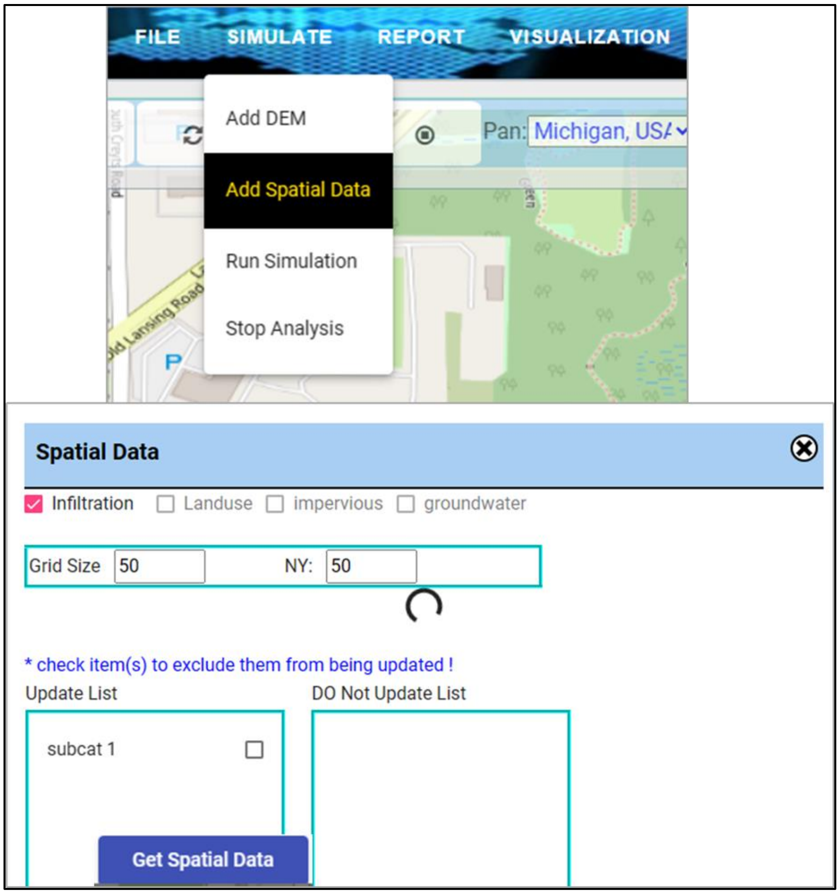


Figure 18: Steps for assigning infiltration parameters from Big Data live-linked to Stormnet.

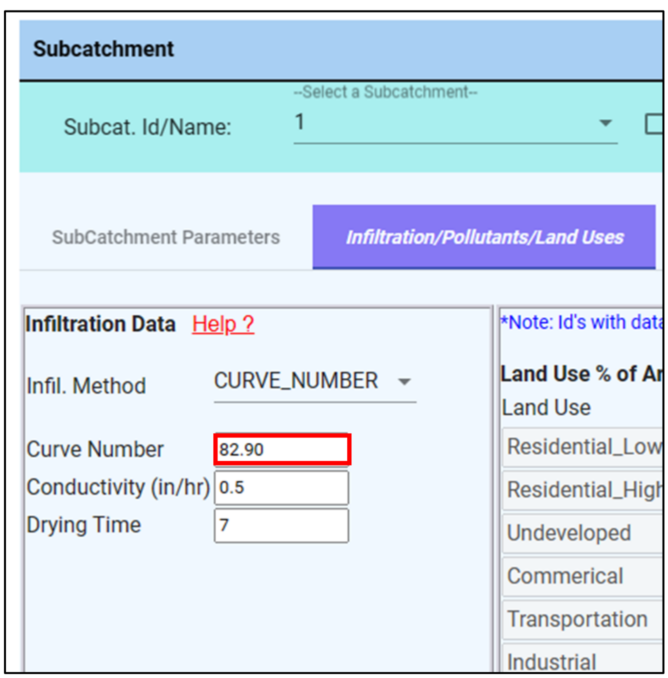


Figure 19: Updated Curve Number in Subcatchment editor interface after extracting from Big Data server.

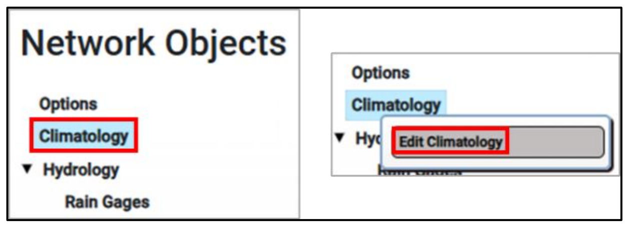
Define Evaporation

Evaporation can be specified as constant daily rate or as monthly averages throughout the year (e.g., for long-term simulation). Evaporation can also follow a time series (similar to rain time-series data), climate file, or users can apply the relatively simple temperature relationship (Hargreaves approach) with automated, instant extraction of maximum and minimum air temperature from:

- the global CFSR climate generator database (about 38km resolution) containing temperature for the period 1979 to 2018.
- the NOAA PRISM database containing seamless USA-wide temperature datasets, from 1981 to 6 months ago, at 4km-resolution (with 800m coming soon).

In this example, a constant evaporation rate is applied throughout the half-day simulation of a single (design) storm event is utilized to compute evaporation during simulation.

Assign Evaporation Rate



Navigate to: Network Objects > Climatology > Edit Climatology. This opens the Climatology editor interface (Figure 20).

The default subtab is ‘Temperature’ where users can specify/import temperature data which can be used to compute evaporation. Click on the ‘Evaporation’ subtab and assign a constant daily evaporation rate of 0.05in./day (see Figure 21).

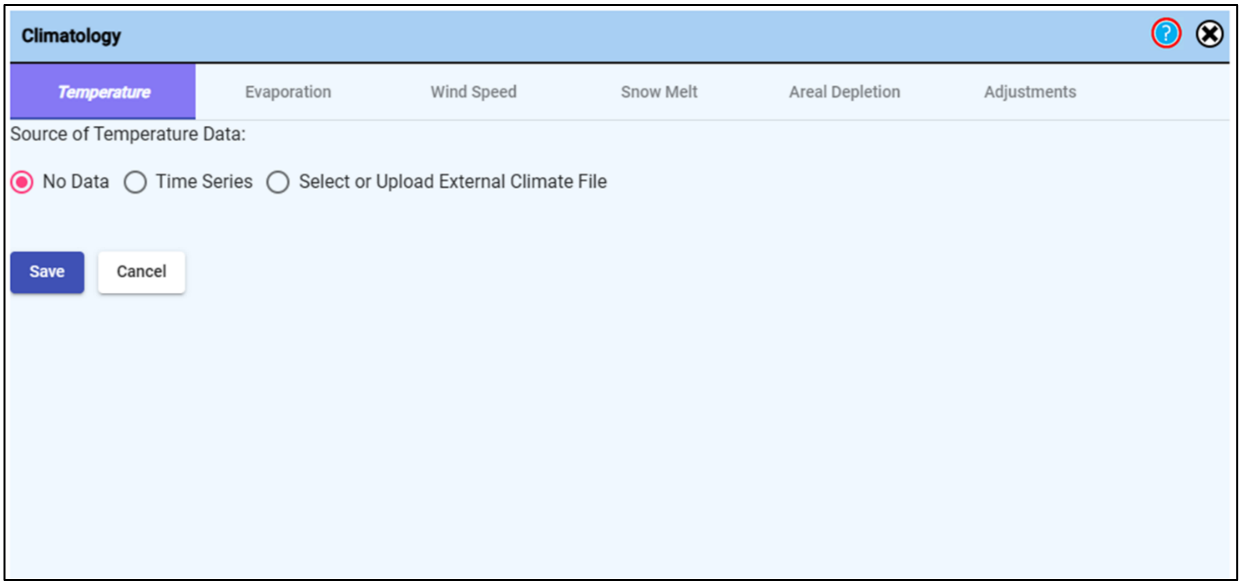


Figure 20: Climatology editor interface.

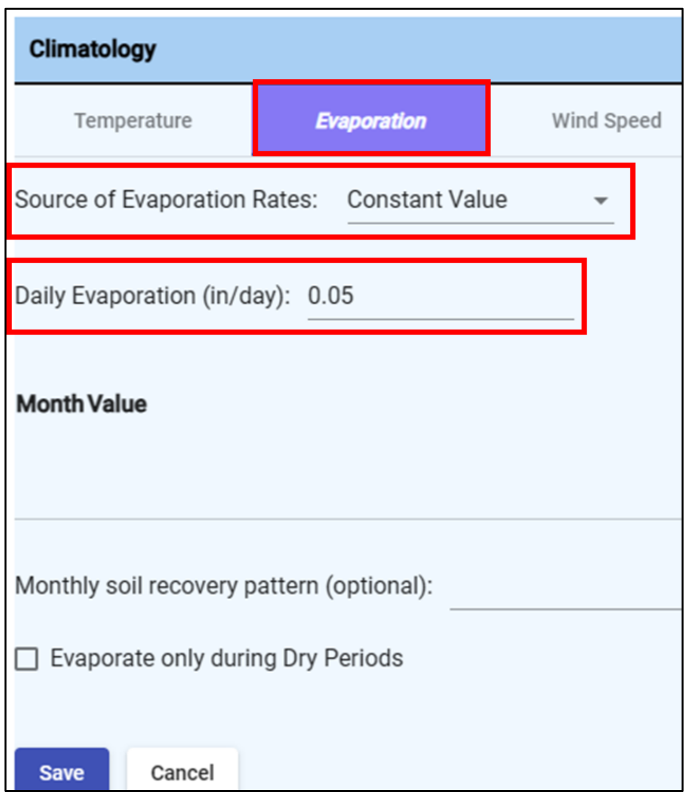


Figure 21: Assigning a constant daily evaporation rate to be applied throughout simulation.

Define Subcatchment Outlet

The outlet of a subcatchment is the location/network feature that receives the runoff. The outlet can be a node (e.g., a junction, divider, or storage unit), an outfall (special node), or another subcatchment.

In this example, an outfall is utilized. An outfall represents the 'end-point'; water at an outfall essentially leaves the model network. Outfalls can represent free outflow (i.e., water leaves freely with no tailwater effects), or they can involve user defined tailwater effects (e.g., fixed stage, temporally variable elevations, etc.

Add an Outfall and Assign as Subcatchment Outlet

First, add an Outfall to the bottom-right corner of the subcatchment (Figure 22):

- Network Objects > Hydrology > Nodes > Outfalls > Start Drawing
- Click on the map to add the Outfall node
- Select 'Stop Drawing' in the Outfalls submenu

Next, edit the Outfall in the Outfall Editor (Figure 23):

- We will use the default Type: 'FREE' (free outflow)

Note that invert elevation (Invert El) is, by default, zero. To add an invert elevation based on DEM:

- SIMULATE (header menu) > Add DEM (Figure 24)
- After a few moments, the extracted DEM at the outfall location will be used to compute the invert elevation.
- The invert elevation is computed based on a DEM offset (DEM minus offset equals invert elevation. The offset used here is 5ft (Figure 25).
- Note the updated value in the Outfall Editor interface.

Now link the Outfall to the Subcatchment as its outlet:

- Navigate to Subcatchment Editor interface, SubCatchment Parameters interface
- Select 'Outfalls' from the Outlet node type drop-down menu, and select Outfall 3 (ID from this example) – see Figure 26.
- Click Save. Notice the linkage is now represented in the map display (Figure 27)

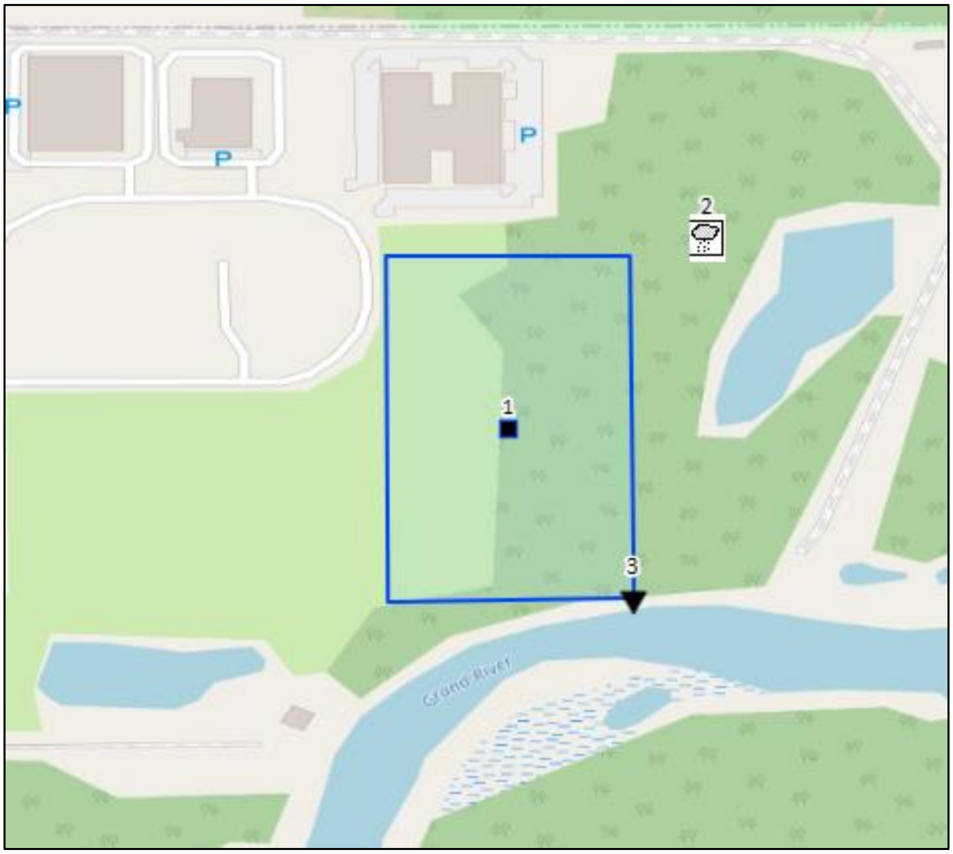


Figure 22: Rain gage added to the model at bottom-right corner of subcatchment (essentially the configuration shown in Figure 3).

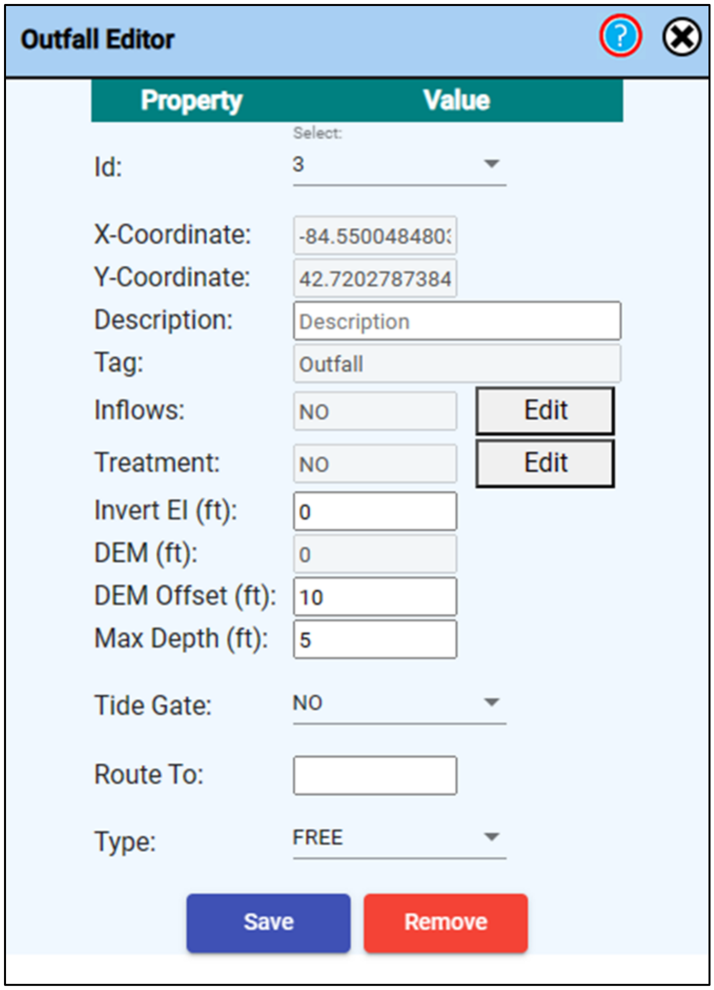


Figure 23: Outfall Editor interface.

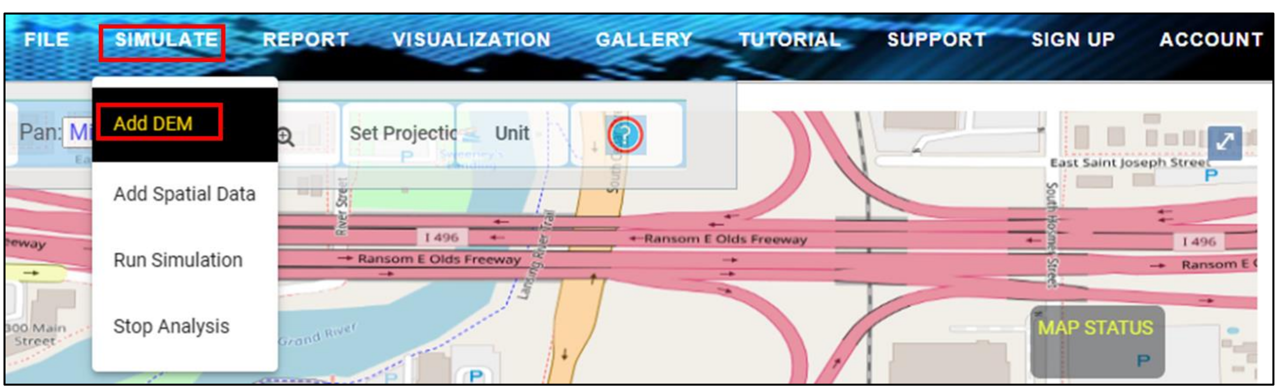


Figure 24: Utilizing the 'Add DEM' tool to assign invert elevations based on DEM to the nodes in the model.

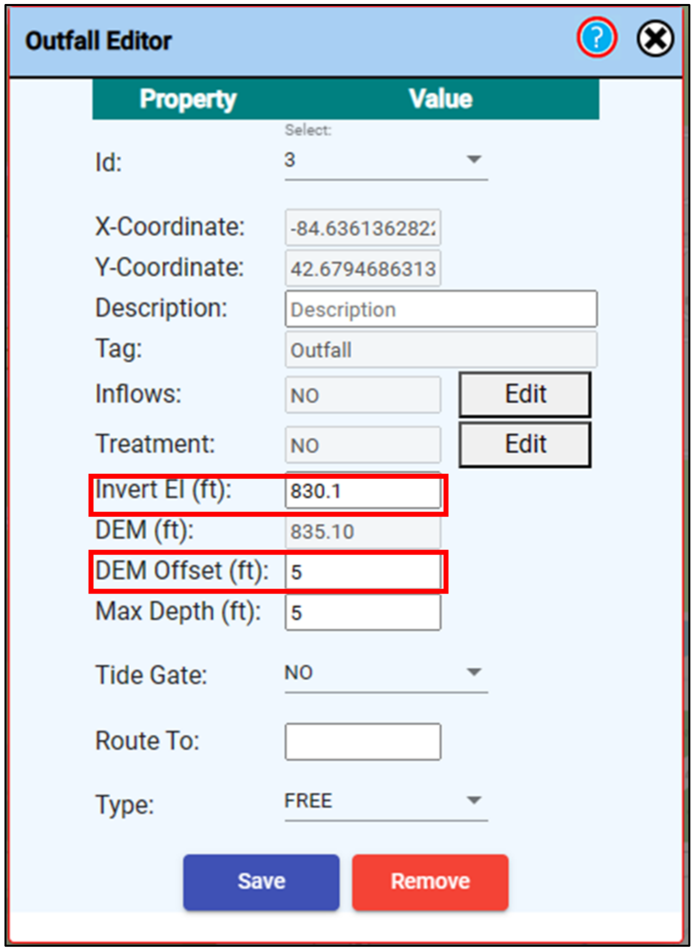


Figure 25:Updates to the Outfall Editor interface after utilizing the 'Add DEM' tool.

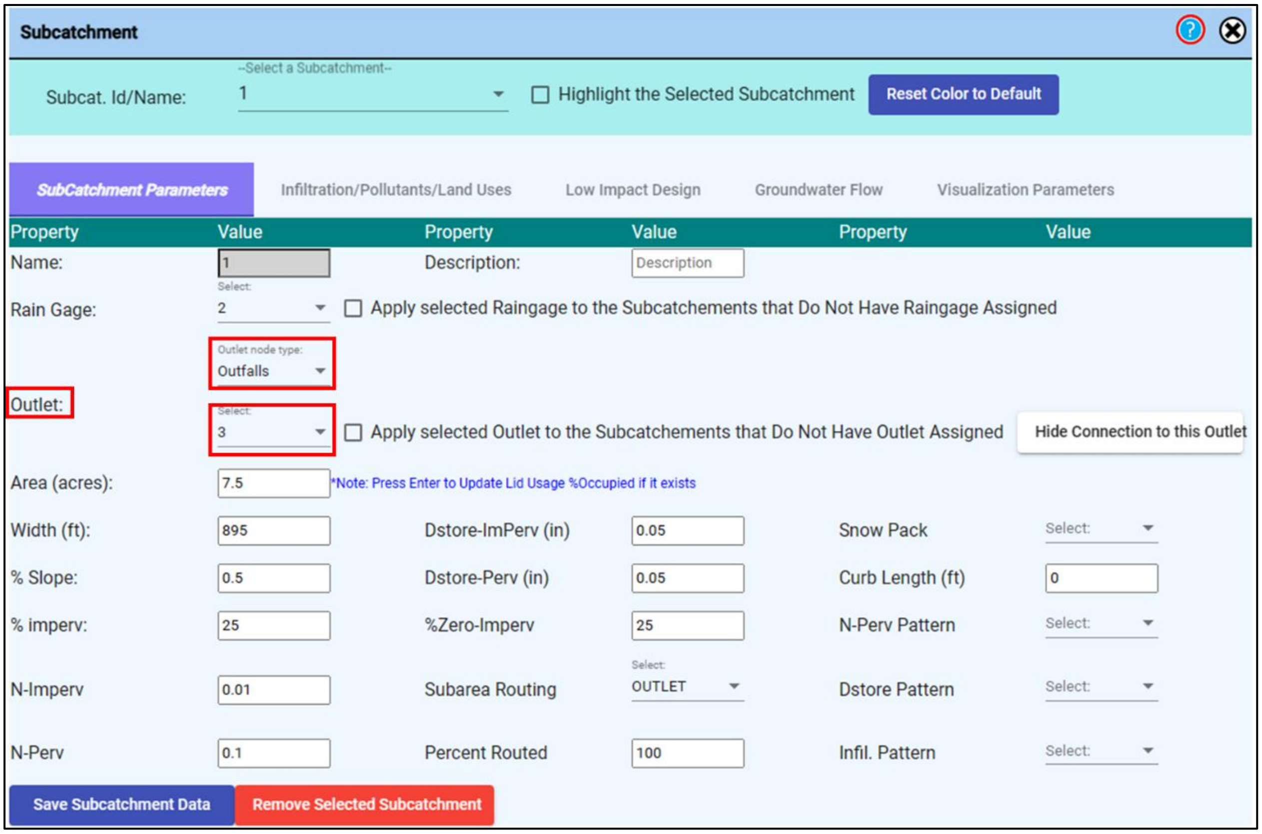


Figure 26: Assigning the outfall node as the subcatchment outlet.

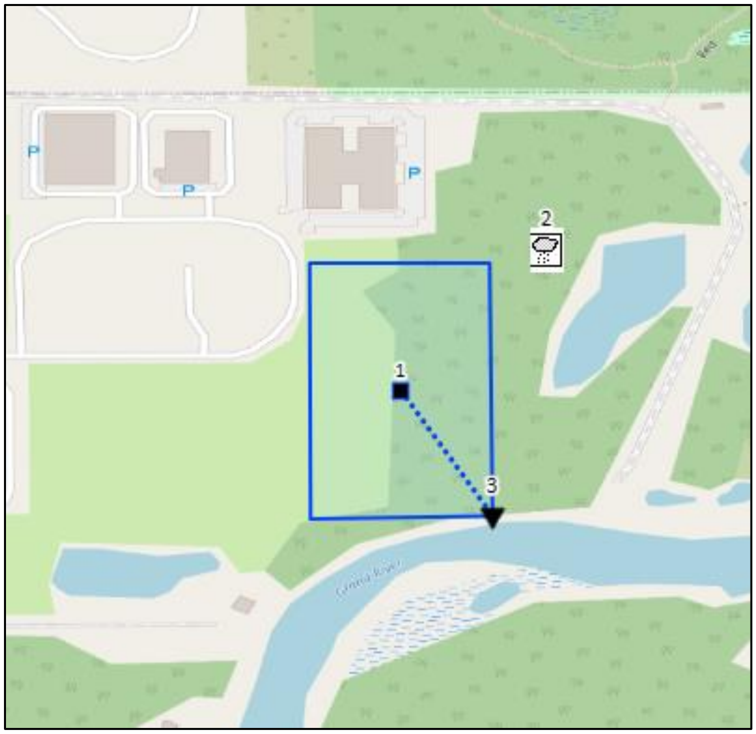


Figure 27: Map display after assigning the outfall node as the subcatchment outlet.

Simulate Water Balance, Runoff Depth, and Runoff Hydrograph

StormNET simulates / solves the water balance, runoff depth, and runoff outflow at each time-step of over a simulation spanning a specified length (simulation period).

Assign Simulation Length (Start and End Date & Time)

- Navigate to: Network Objects > Options > Dates subtab of Simulation Options subtab
- The simulation length is by default: 48 hours, but our storm event is 2hr
- Reduce the simulation length to 6 hours by making the End Analysis Time: 6:00pm of the same date as Start Analysis (see Figure 28).

Run Simulation

All aspects of setup and parameterization of relevant hydrological processes has been completed, as the model is ready for simulation, i.e., solving the subcatchment water balance (runoff depth) and simulating the runoff hydrograph for 2-hour storm event.

- Navigate to: SIMULATE (header menu) > Run Simulation (Figure 29).
- When the simulation is complete, a summary update report will appear. Also shown is a map display editor that allows users to explore the model outputs or inputs at different times (see Figure 30). Map-based visualization is covered in detail in other tutorials.

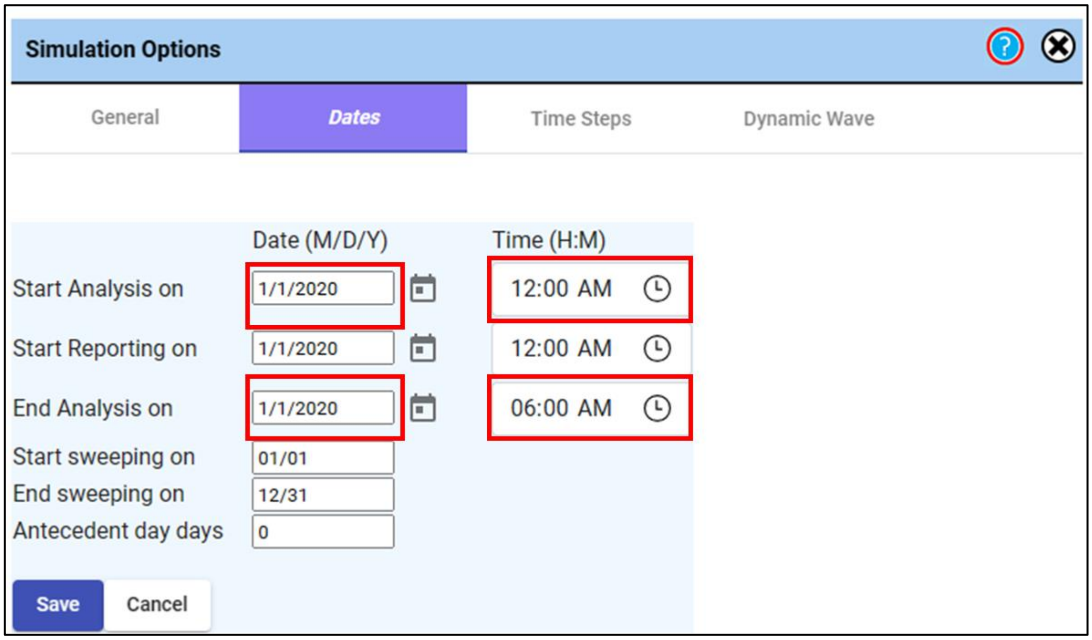


Figure 28: Adjusting the simulation length: 'Start Analysis on' and 'End Analysis on' options.

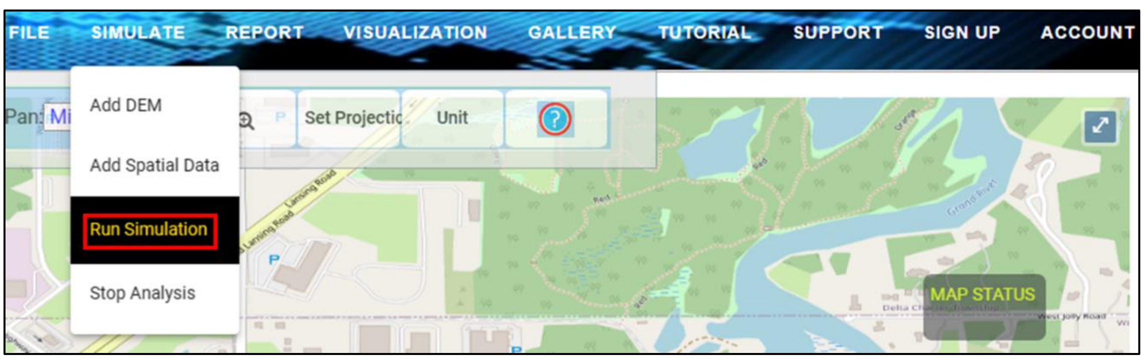


Figure 29: Run Simulation.

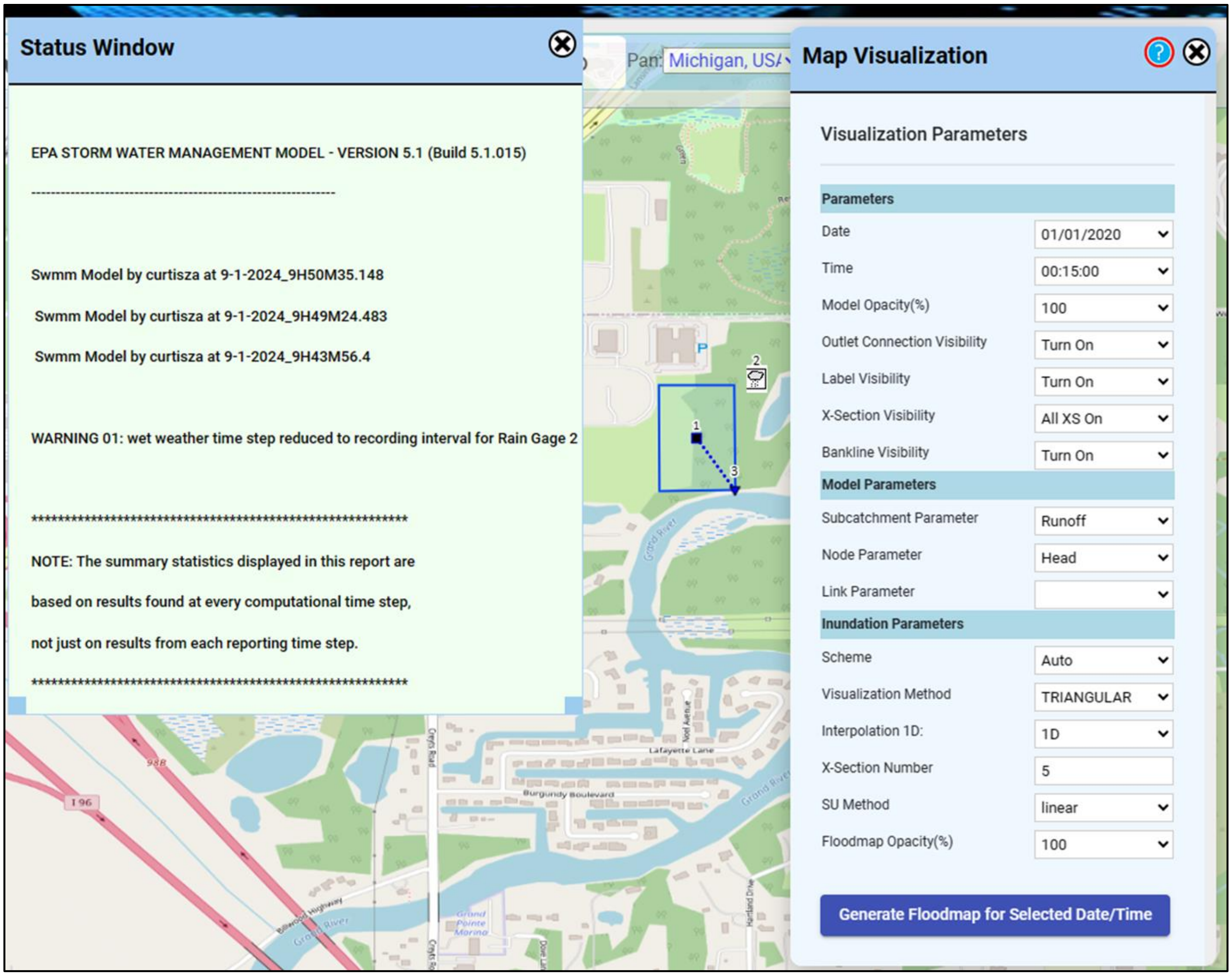


Figure 30: Status Report and Map Visualization interface, post-simulation.

Visualizing Runoff

There are a number of ways to map, chart, visualize, and analyze the results of the StormNET model. For this example, we are interested in visualizing the runoff hydrograph (time-series) for the simple subcatchment.

To view the runoff hydrograph (runoff time-series):

- Navigate to: VISUALIZATIONS (header menu) > Simulation > Basic Model > Time Series
- In the interface that appears, select ‘Subcatchment’ as Object Type, ‘Runoff’ as Parameter (see
- Double-click in the subcatchment and then click the ‘+’ next to Feature ID
- Click ‘Show Timeseries Plot’

A graph of runoff over simulation time will appear (see Figure 32). Note that peak runoff occurs at about the same time as peak precipitation.

The user can change the parameter to be plotted, e.g., to “losses” (evaporation, infiltration, storage).

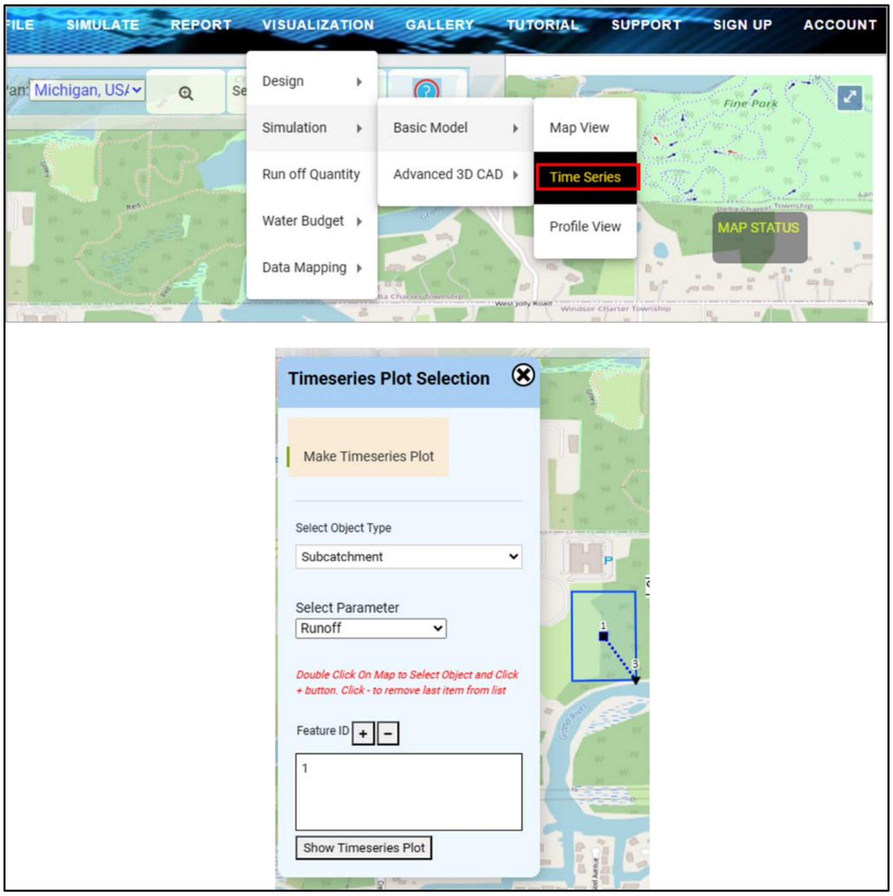


Figure 31: Creating a runoff hydrograph.

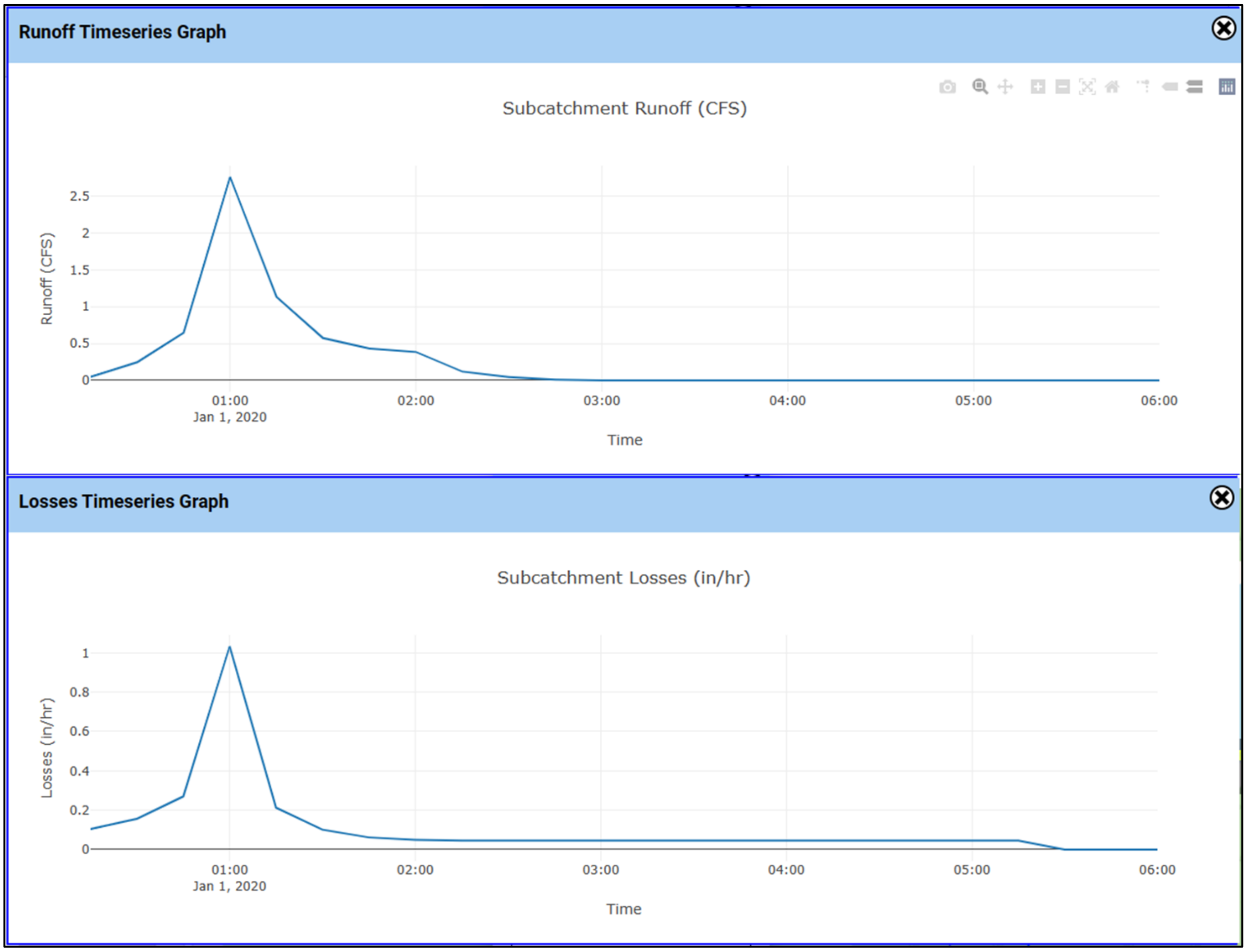


Figure 32: Runoff Hydrograph and a "Losses Hydrograph" for the subcatchment.

Sensitivity Analysis (Design Experimentation/Optimization)

StormNET's integrated modeling and design environment enables users to experiment with different scenarios/configurations/parameters and almost instantly visualize the impact of their modifications. This is critical for model sensitivity analysis (i.e., how different parameters/processes control the water dynamics) and model optimization (how the system is best configured to meet compliance requirements).

In this example, it is interesting to consider how runoff routing and degree of imperviousness impacts the subcatchment runoff hydrograph.

Route Runoff to the Pervious Subarea

Let's first look at the impact of routing runoff from the impervious subarea to the pervious subarea (as opposed to routing impervious directly to the subcatchment outlet, as was done earlier).

- Navigate to the Subcatchment editor interface, SubCatchment Parameters subtab
- Choose 'PERVIOUS' from the drop-down menu next to Subarea Routing (Figure 33).
- Run Simulation (SIMULATE > Run Simulation)
- View the subcatchment runoff time-series (VISUALIZATIONS > Simulation > Basic Model > Time Series)

The resulting time-series is shown in Figure 34. Note that the peak flow is reducing, and the onset of runoff (and its peak flow) is delayed relative to the 'baseline' case where runoff from the impervious areas is routed directly to the subcatchment outlet. This is because the runoff routing allows for more infiltration of water in the pervious area that would have otherwise contributed to direct runoff to the subcatchment outlet.

Model a Completely Impervious Subcatchment

Now let's consider the case of an 100% *impervious* subcatchment.

- Navigate to the Subcatchment editor interface, SubCatchment Parameters subtab
- Change '% imperv' to 100 (Figure 35)
- Choose 'OUTLET' from the drop-down menu next to Subarea Routing
- Run Simulation
- View the subcatchment runoff time-series

The resulting time-series is shown in Figure 36. Note that the peak runoff is much higher than in the case of a mixed subcatchment (25% impervious, 75% pervious). This is expected, as there is no longer any infiltration in the model (now converted to runoff).

Model a Completely Pervious Subcatchment

Finally, consider the case of an 100% *pervious* subcatchment.

- Navigate to the Subcatchment editor interface, SubCatchment Parameters subtab
- Change '% imperv' to 0 (Figure 37Figure 35)
- Run Simulation
- View the subcatchment runoff time-series

The resulting time-series is shown in Figure 38. Note that the peak runoff is significantly less than in the case of a mixed subcatchment (25% impervious, 75% pervious) or impervious subcatchment. Also, the timing of the onset of runoff to the outlet and its peak flow is delayed (as was seen before in the runoff routing example). Again, this is expected, as the entire subcatchment area is available for more infiltration (and therefore less runoff).

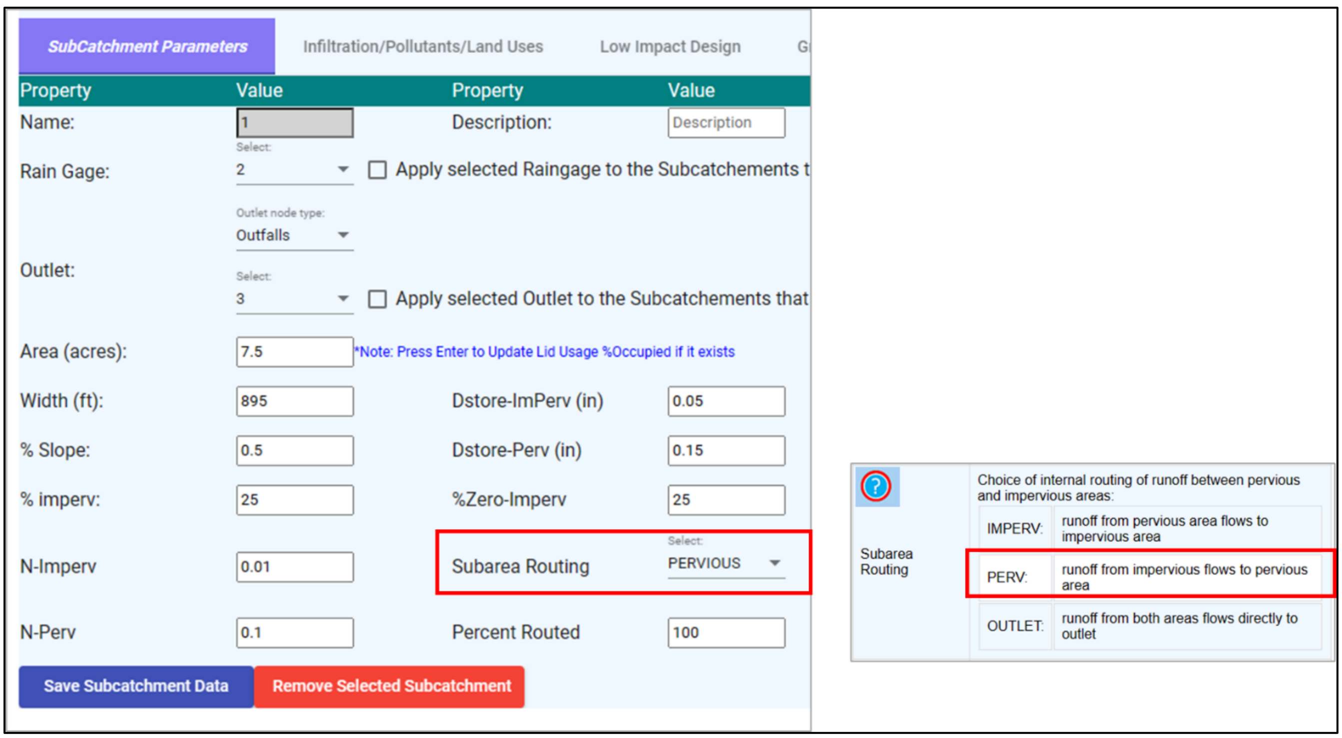


Figure 33: Routing runoff from the impervious subarea to the pervious subarea.

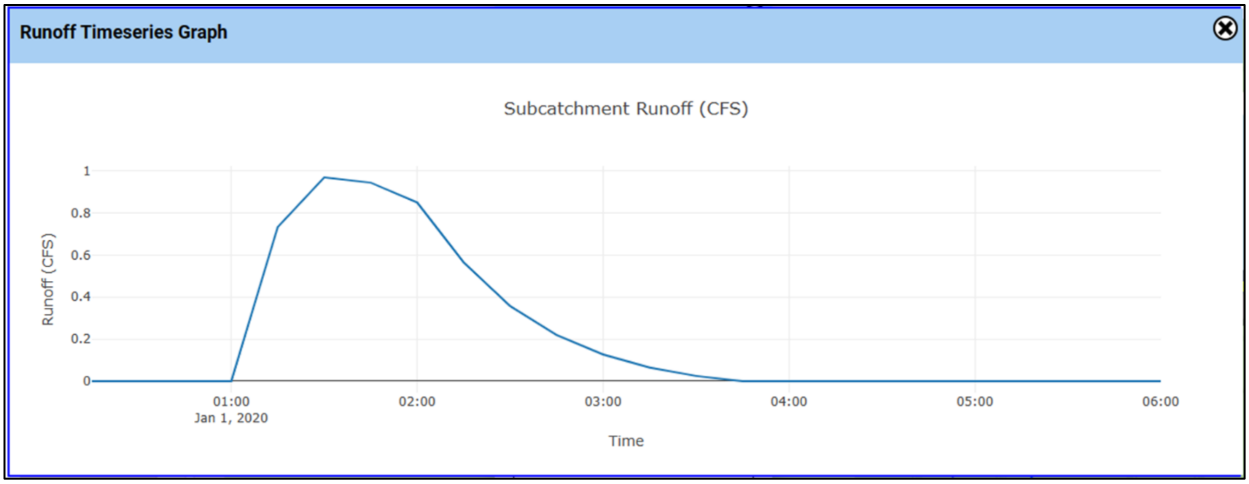


Figure 34: Runoff hydrograph for the case of runoff routing from impervious subarea into pervious subarea.

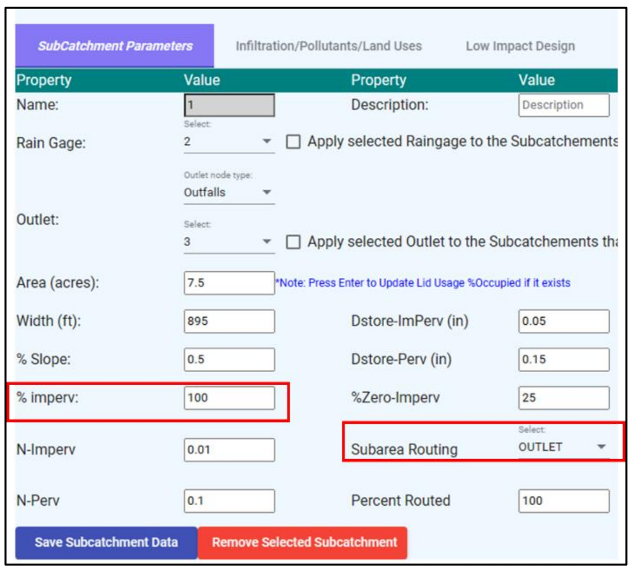


Figure 35: Assigning the subcatchment as 100% impervious cover.

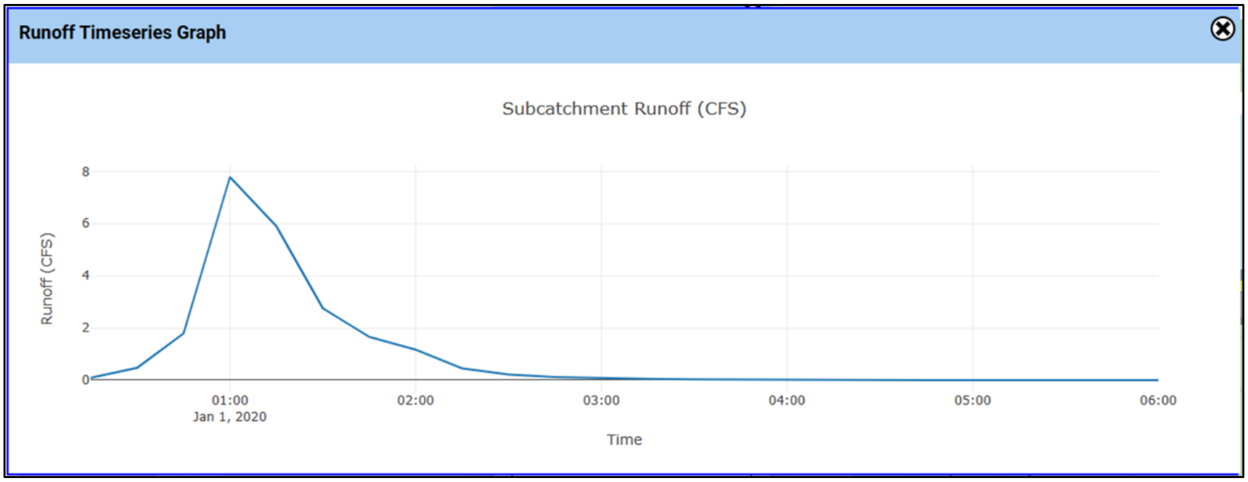


Figure 36: Runoff hydrograph for the case of 100% impervious cover in the subcatchment.

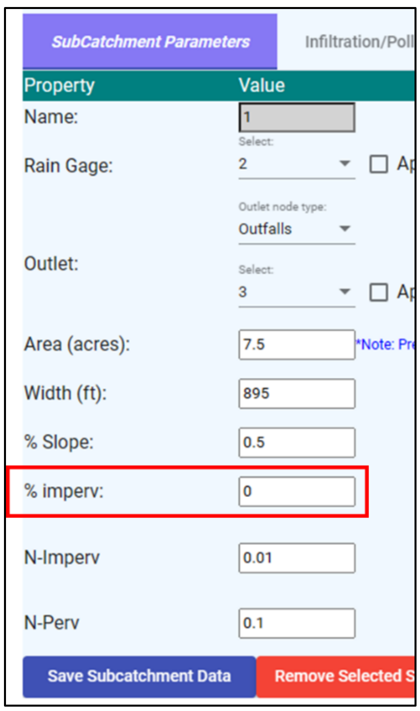


Figure 37: Assigning the subcatchment as 100% pervious cover.

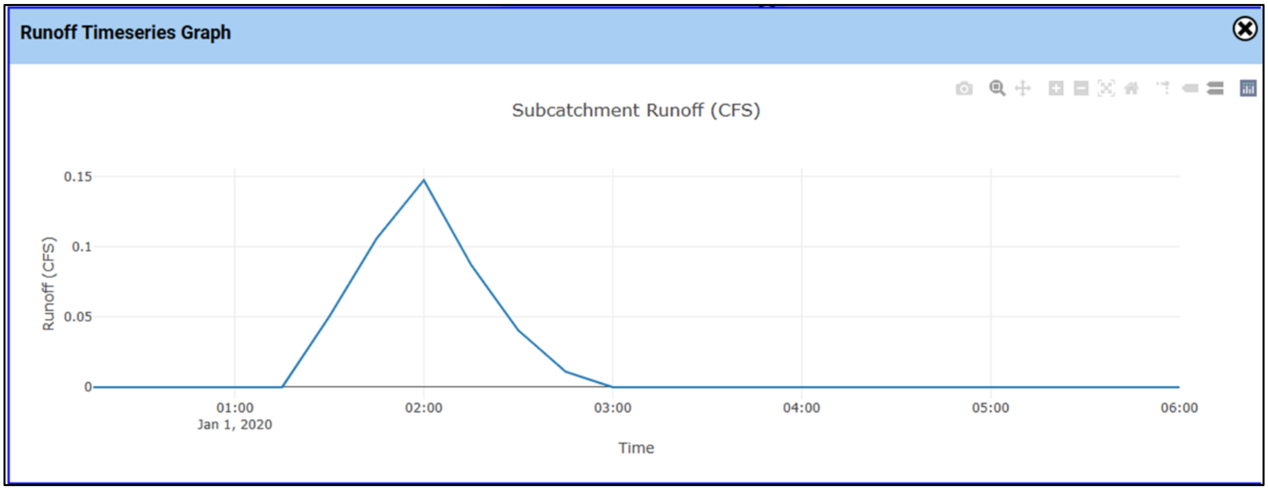


Figure 38: Runoff hydrograph for the case of 100% pervious cover in the subcatchment.