

## Modeling Detention Ponds – Malaysian Example (v2009)

This tutorial demonstrates the usability of xpswmm and xpstorm for simulating detention basins in urban areas. This fictitious example includes the use of background images and surface data that enhance the modeling experience. A comparison of **pre and post** is also provided in the tutorial as engineers often reduce peak flows of developed sites to pre existing peak flows.

In addition the example uses the Global Storms capability to show the ease that the critical storm can be determined and the results displayed for many events.

### Files Used:

Detentionpond.xp – sample model with most of the data entered for this tutorial

Malaysian\_Detention\_Pond\_Example.dwg –background drawing for this tutorial

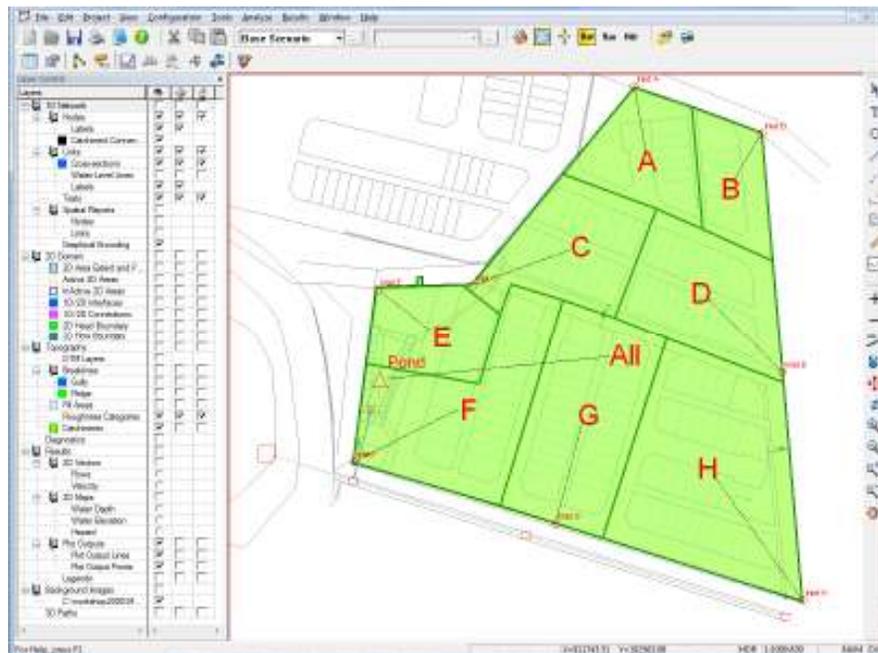
Preexisting-10yr.dat – File of gauged flows for comparison in Review Results

OpenDrain.jpg – digital picture of roadside open drain

Pond.jpg - digital picture of pond

Riser outlet.jpg - digital picture of weir

### Load the model Detentionpond.xp.



### Model Description

This model uses the time area method for hydrology which requires % impervious, subcatchment slope, time of concentration (Tc) and infiltration parameters in addition to the subcatchment area. The watershed slope is % as opposed to the **default** of m/m by using the configuration parameter **CATSLOPE=%**. The infiltration method is Initial and Proportional losses.

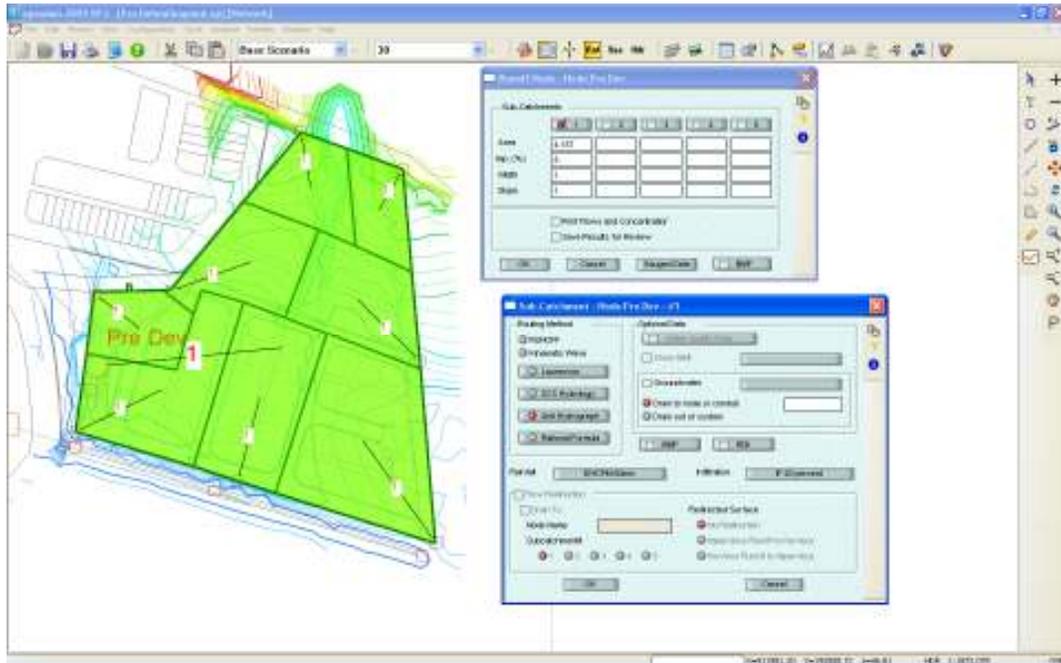
To model the pre development hydrologic condition the subcatchment representing the total area was assigned a **5%** impervious value and a Tc of **35 min**.

The post development hydrology breaks up the total site area in to **8** subcatchments with **65%** impervious and a Tc of **5 min** is used.

The 10-yr storm with a total of about 84 mm in 1 hr is already applied to each of the subcatchments.

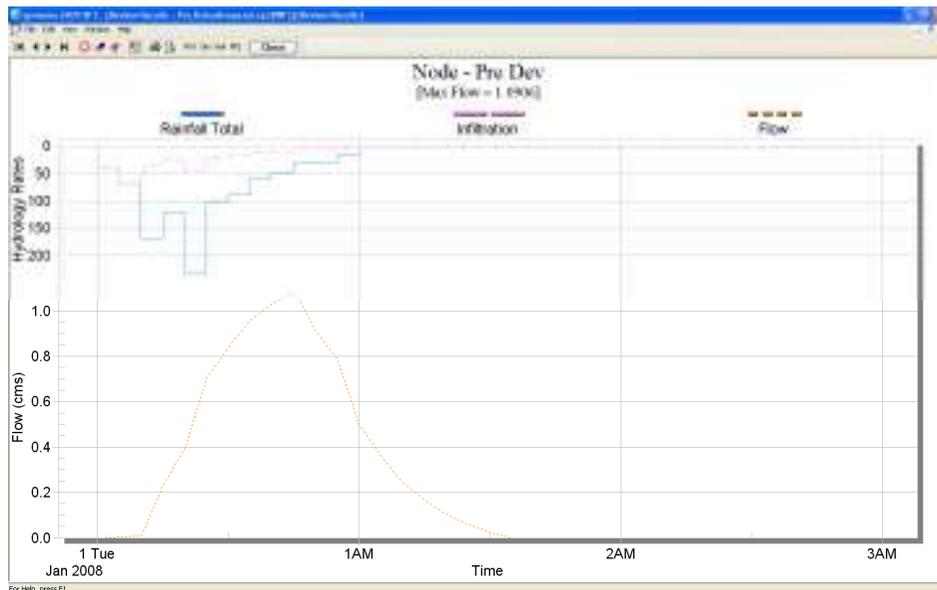
## Pre Existing Flow Case

A single subcatchment has been drawn for the entire site and it drains to the node "Pre Dev". The centroid of this polygon is at the centre of the whole catchment. The thin dashed line is the catchment connection showing the node to which this area drains.



Execute the model to have this area produce runoff for the 10-year storm. To solve the model choose Solve from the Analyze menu or press the F5 key on the keyboard.

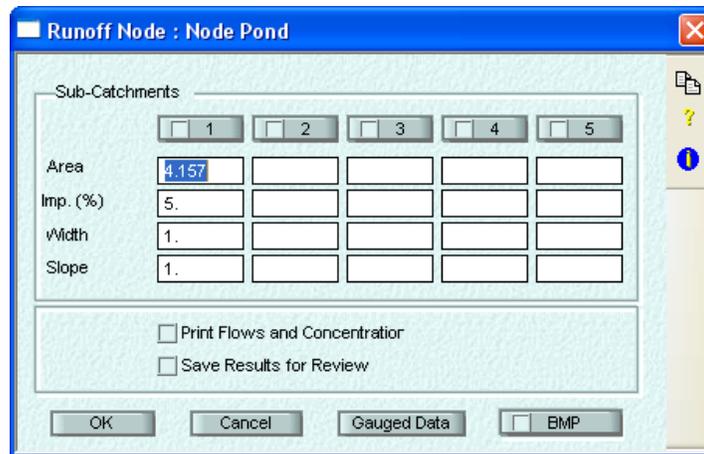
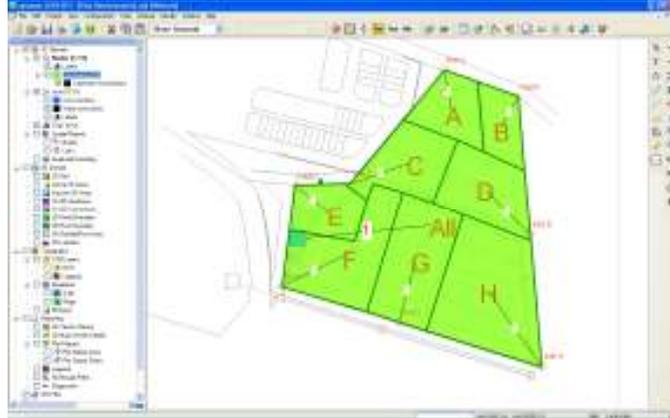
Select the node with the pointer tool and choose the Review Results tool from the toolstrip. The maximum flow for this area before the development with the Pond is about 1.1 cms.



This hydrograph has been previously saved to a text file by exporting the text/data only from the export dialog. This will be used later in the tutorial as a comparison to the post development condition.

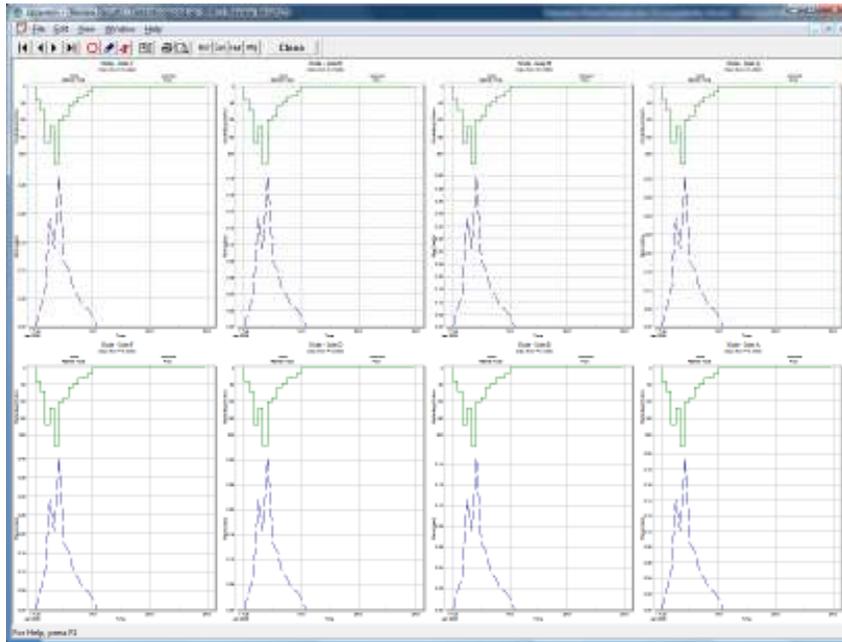
## Post Development Model

The post development model is configured by inactive the node called Pre Dev (in post development model it was changed to Pond) or selecting the checkbox for the 1<sup>st</sup> sub catchment. This will turn off the subcatchment and remove the check in the box.

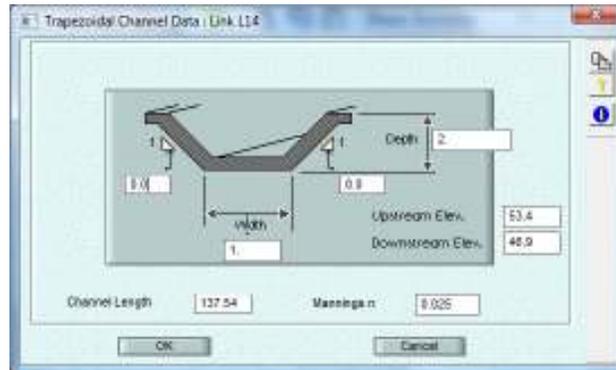


The model can now be run by selecting Solve from the Analyze menu or simply press the F5 key on the keyboard. In this run we have all of the subcatchments contributing fast responding hydrographs because of the high percent impervious and the small time of concentration.

After the model is run select all the subcatchments using the "Select All Nodes" icon from the right hand toolbar and exclude the node Pond by holding the <Ctrl> key and selecting it. This will avoid a warning message that no results exist for the node Pond since we unchecked the subcatchment for that node. Now Select Review results to view the hydrographs. These 8 hydrograph represent the hydrologic response that is sent to various nodes on open drains.



Switch to the Hydraulics mode by selecting the Hdr icon on the toolbar. The links which are active in this mode now show with their labels and take on their attributes. In the Runoff mode where they were inactive they showed as hidden dashed lines. The links labeled Lx where x is a number such as L14 are open drains that are approximately 2 m deep and 1 m wide. They are created by using the trapezoidal conduit shape with zero side slopes as shown in the dialog below.

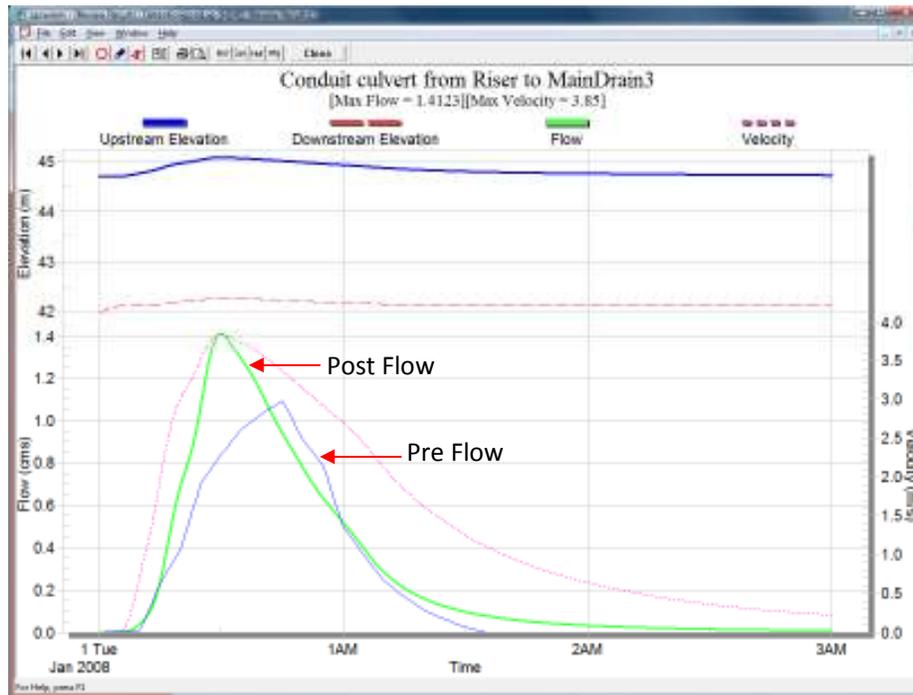


These open drains have the same roughness value but vary in slope and inverts as they follow the land and drain to the Pond. At roadways and in high traffic areas they would be covered. A photo of a typical open drain covered in a traffic area is shown below.



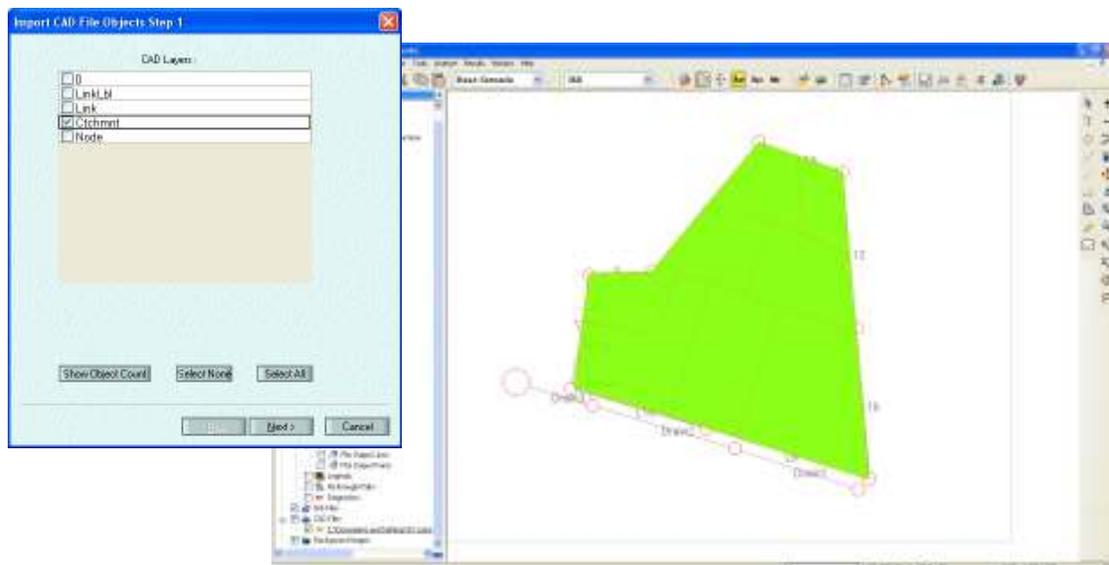
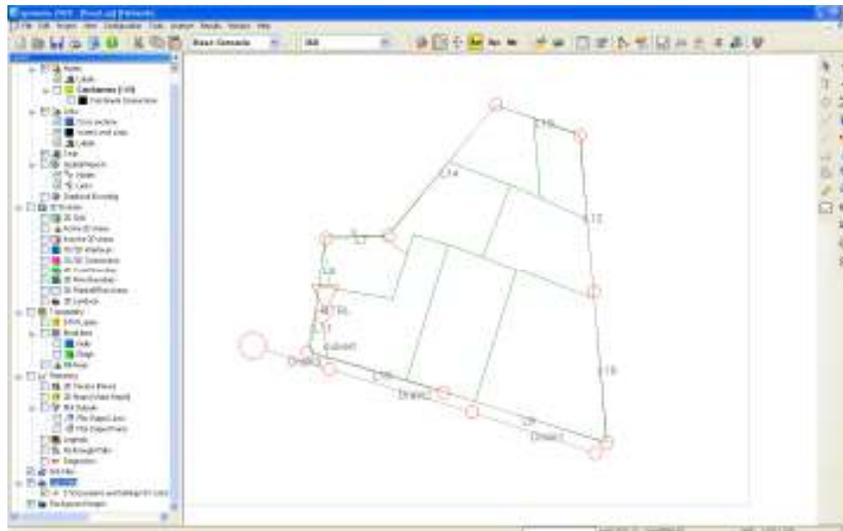
Select the link “culvert” then Review Results to see the hydrograph for the developed case. The thin blue line is the gauged flows which were created previously by exporting the hydrograph from the Pre Dev node. This hydrograph is the pre development flow for the 10-year storm.

This hydrograph from Review Results is shown below.

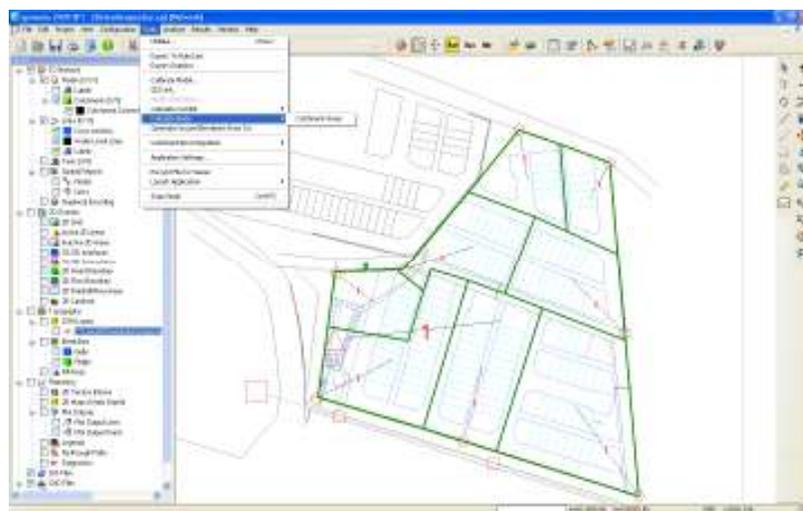


Notice that the new peak flow (thick green line) is **higher** than the pre existing condition (thin blue line) and that the peak is earlier. These effects are generally due to the increased impervious percentage and the smaller time of concentration.

In xpswmm2009, you can Import catchment, links & nodes from CAD file to xpswmm model

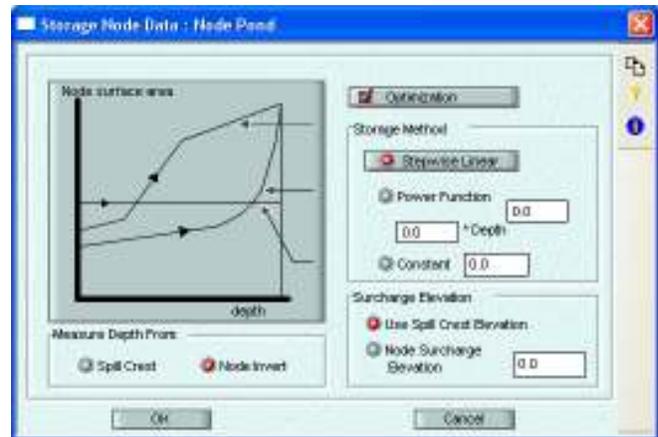
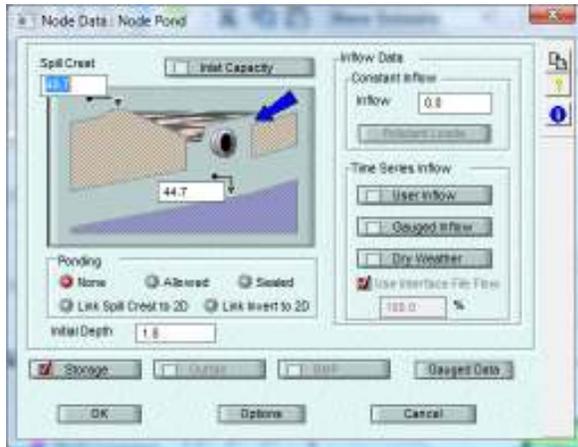


After import the catchment from CAD, you can assign catchment to a particular node by drag the centroid of the catchment to a node. xpswmm calculate catchment areas using calculation tool under Tools, Calculate Node, Catchment Area. You can use the Calculate Link Tool to calculate Conduit slopes, Lengths & Cross Sections.



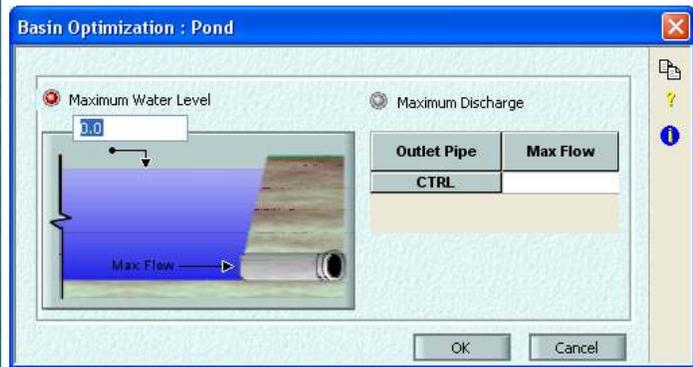
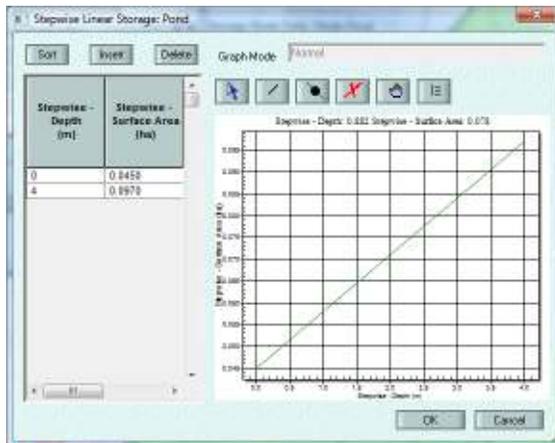
## Detention Description

The proposed model has the hydrographs routed in the open drains to the proposed detention pond. The detention pond is created by adding storage to a node. All nodes have a default surface area of 1.2 m<sup>2</sup>. The default is approximately the size of a typical manhole and the default can be modified in the Hydraulics mode Job Control. The default is overwritten by selecting Storage in the node dialog.



The data that creates the Pond's storage characteristics are found in the Stepwise Linear storage option.

Select Stepwise Linear to view the data for the storage in the retention basin.



It is good modeling practice to define the storage from the bottom of the pond all the way to the Spillcrest elevation of the node. This node has a spillcrest of 48.7 and an invert of 44.7 for a difference of 4 m. The storage data shown above is from depth of 0 to depth of 4 m which covers the entire height of the node.

You will also notice that the initial depth in the node is set to 1.8 m. This initial depth starts the node at the control elevation of 46.5 m which is equal to the elevation of the lowest item in the control structure.

### Basin optimization option

If you set the max allowable Q in Culvert --> Program will allow only up to user defined max Q through culvert (not more than that) and will adjust the basin Level accordingly. No pipe design will happen.

If you set the target HGL at basin --> program will upsize (design) the pipe if required to maintain the user defined target HGL at basin. Pipe design never happen for downsizing, it's always for up sizing.

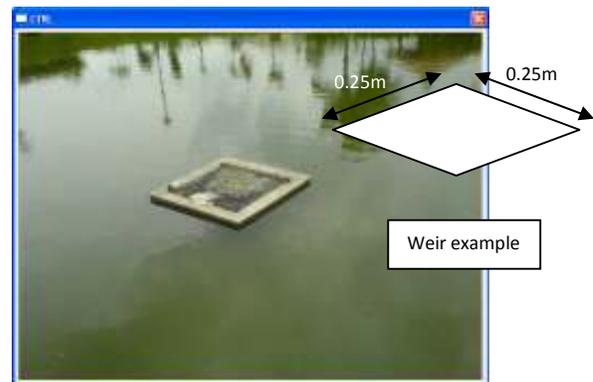
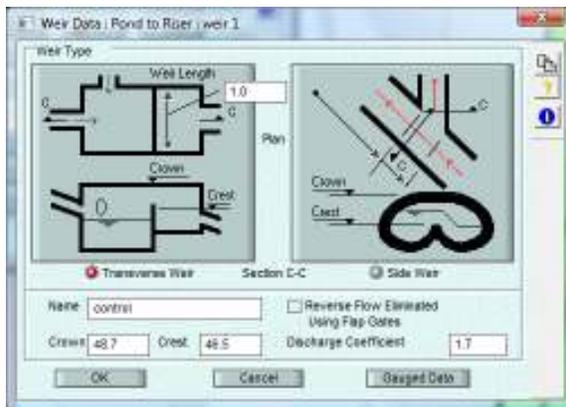
## Control Structure

The control structure is contained in the multilink (dashed line) named "CTRL" leaving the Pond and draining to the node called "Riser". The multilink allows multiple conduits in parallel but also is the object where pumps, orifices, weirs and special conduits can be entered.



In this model we have a weir selected as the only exit for the detention basin.

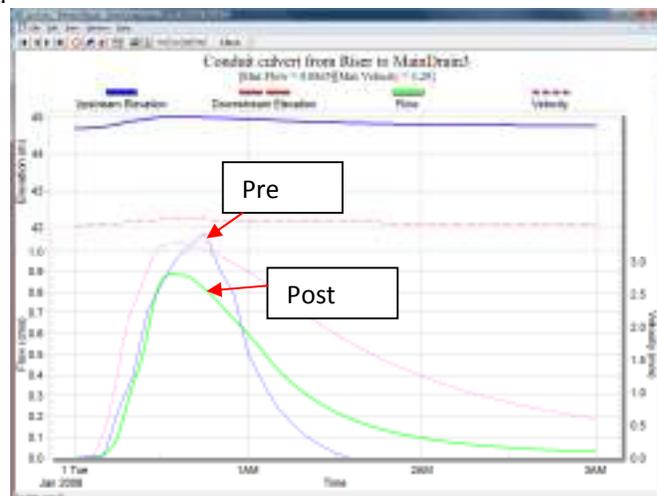
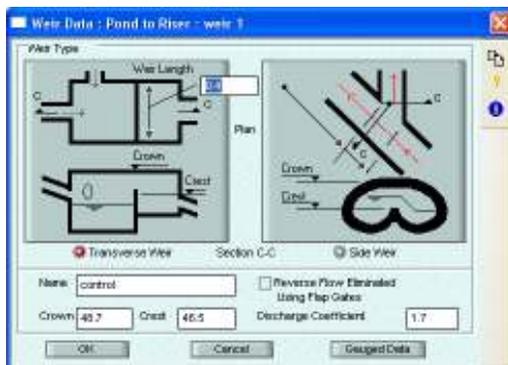
Select the weir #1 to see the weir data.



The weir has a length of 1.0 m and a crest of 46.5 m. Changing the weir length will alter the flow out of the detention basin. Selecting appropriate storage characteristics and control structure will allow an optimization of the system and permit the post condition model to have a peak flow that does not exceed the pre existing condition.

## Reducing the Peak Flow

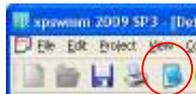
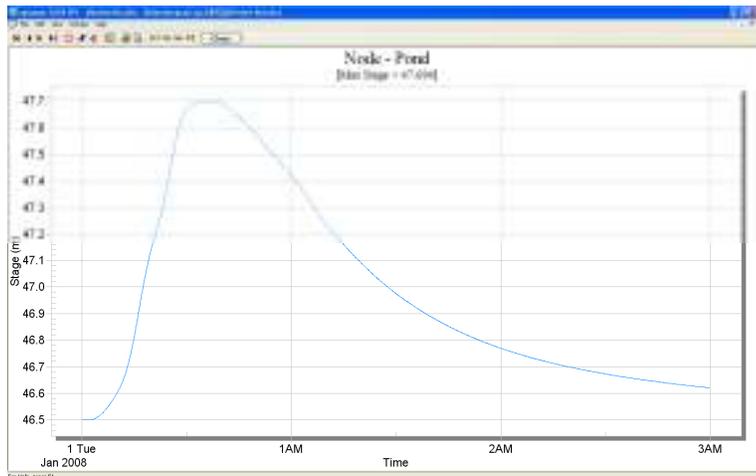
Change the weir length to **0.4 m** and rerun the model.



Use Review Results to see the hydrograph for the culvert link.

By reducing the flow out of the detention basin we have also raised the peak water level in the detention basin. This higher water level could have an impact on the model by raising the water level due to backwater effects.

Pond level = 47.694m



From Output File

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*=====
|           Storage Junction Data           |
*=====

```

STORAGE JUNCTION NUMBER OR NAME	JUNCTION TYPE	MAXIMUM OR CONSTANT SURFACE AREA (M2)	PEAK OR CONSTANT VOLUME (CUBIC MET.)	CROWN ELEVATION (M)	DEPTH STARTS FROM
Pond	Stage/Area	970.0000	2838.9602	48.7000	Node Invert

```

*=====
| Variable storage data for node |Pond
*=====

```

Data Point	Elevation meters	Depth meters	Area m^2	Volume m^3
1	44.7000	0.0000	450.0000	0.0000
2	45.2000	0.5000	515.0000	241.0674
3	45.7000	1.0000	580.0000	514.6565
4	46.2000	1.5000	645.0000	820.7626
5	46.7000	2.0000	710.0000	1159.3827
6	47.2000	2.5000	775.0000	1530.5140
7	47.7000	3.0000	840.0000	1934.1550
8	48.2000	3.5000	905.0000	2370.3041
9	48.7000	4.0000	970.0000	2838.9602

Available storage  
= 2838.96 - 1934.16  
= 904.8m3

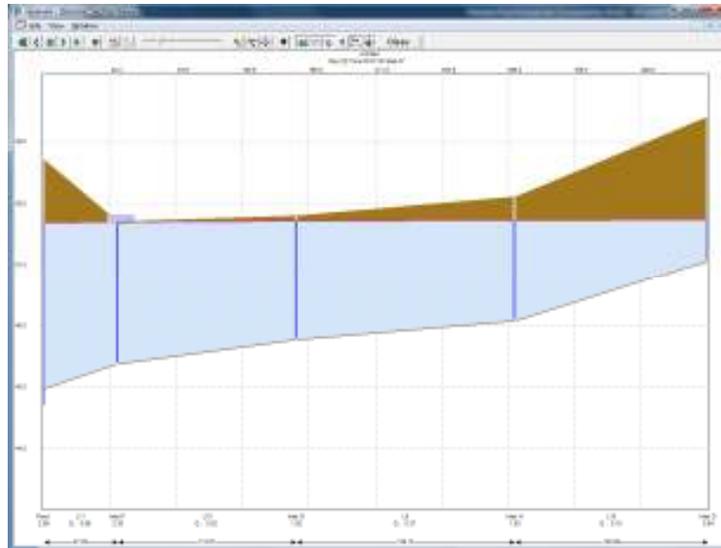
**Note:**

**If you feel that the pond is too big, you can readjust the pond size & rerun the model to check all requirements are fulfill.**

### Dynamic Long Section Animation of the HGL

The hydraulic grade line (HGL) can be animated over time by selecting the Dynamic Long Section View from the Results menu, or the F9 key on the keyboard or by selecting the icon from the toolbar.

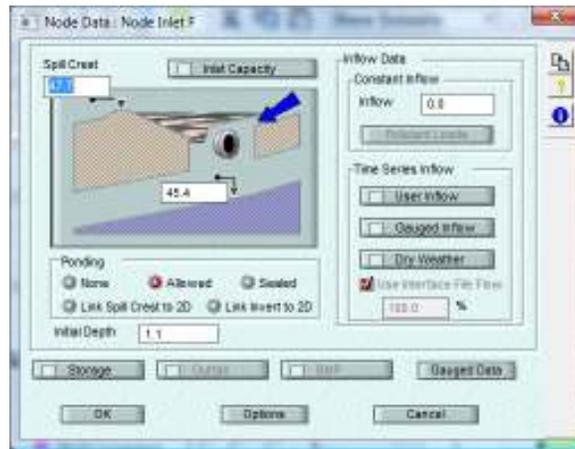
Select the node "Pond" then while holding the Shift key select the node "Inlet D". Using the Shift key while selecting nodes allows xpswmm to select from the first point to the next selection. After selecting this string of links and nodes choose Dynamic Long Section View. Press the solid triangle icon on the toolbar to play the simulation. Stop the simulation using the pause or stop button when you see the flooded symbol at inlet F. When the HGL reaches the ground water can escape the system out of the top of the node. This water can be lost from the system, stored locally, or linked to a 2D simulation of overland flows. In the default case the water is lost from the system and reported as flooded losses.



This flooding at Inlet F is a result of creating **too small of a weir** and causing a **high water level** in the detention basin. Selecting a **slightly larger weir would remove** this small amount of flooding.

### Preventing Flood Losses at Nodes

Select the node Inlet F. Choose the Ponding Allowed option. This option stores water above the Spillcrest and return it to the same node as capacity increases. No water is lost from the system in this case and the model operates close to the real world where water would pond then return to the system.



Rerun the model with the new setting of ponding allowed at node "Inlet F".

### Using XP-Tables to Review Model Results

Select XP-Tables by choosing XP-Tables from the results menu, by pressing the F2 key on the keyboard or selecting the XP-Tables icon on the toolbar. Select the table Node Flooding using the tab in the lower right corner if it is not the current table in the window.

Name	Node Name	Duration of Surcharge (min)	Duration of Flooding (min)	Flood Loss (m³)	Max Volume (m³)	Volume of Ponded Flow Stored (m³)
Inlet F	Inlet F	37.000	6.8	0.007	15.405	13.78
Inlet B	Inlet B	0.000	0.0	0.000	0.075	0.00
Inlet D	Inlet D	0.000	0.0	0.000	0.795	0.00
Inlet H	Inlet H	0.000	0.0	0.000	1.998	0.00
Inlet G	Inlet G	0.000	0.0	0.000	2.342	0.00
Inlet A	Inlet A	0.000	0.0	0.000	0.154	0.00
Inlet C	Inlet C	0.000	0.0	0.000	0.983	0.00
Inlet E	Inlet E	0.000	0.0	0.000	1.595	0.00
Pond	Pond	0.000	0.0	0.000	1501.135	0.00
Riser	Riser	0.000	0.0	0.000	0.371	0.00
MainDrain1	MainDrain1	0.000	0.0	0.000	0.525	0.00
MainDrain2	MainDrain2	0.000	0.0	0.000	0.462	0.00
MainDrain3	MainDrain3	0.000	0.0	0.000	0.500	0.00
Lake	Lake	0.000	0.0	0.000	2.440	0.00

This table shows that Inlet F stored about 13.78 m<sup>3</sup> in the ponding allowed storage starting from the spillcrest elevation. This surface flooding lasted about 7 minutes. No other flooding occurred. Select the other tables using the tabs to view their data and results. Selecting the XP-Tables icon on the toolbar will allow you to activate other tables or create new tables. The tables can contain a mixture of data and results and are completely user definable.

Table 1: Flood Info						
Name	Node Name	Duration of Surcharge (min)	Duration of Flooding (min) sec	Flood Loss m <sup>3</sup>	Max Volume m <sup>3</sup>	Volume of Ponded Flow Stored
MainDrain1	MainDrain1	0.000	0.0	0.000	0.525	0.00
MainDrain2	MainDrain2	0.000	0.0	0.000	0.462	0.00
Inlet B	Inlet B	0.000	0.0	0.000	0.075	0.00
Inlet D	Inlet D	0.000	0.0	0.000	0.795	0.00
Inlet H	Inlet H	0.000	0.0	0.000	1.998	0.00
Inlet G	Inlet G	0.000	0.0	0.000	2.342	0.00
Inlet F	Inlet F	37.000	6.8	0.007	15.405	13.78
Inlet A	Inlet A	0.000	0.0	0.000	0.154	0.00
Inlet C	Inlet C	0.000	0.0	0.000	0.983	0.00
Inlet E	Inlet E	0.000	0.0	0.000	1.586	0.00
Pond	Pond	0.000	0.0	0.000	1931.135	0.00
Riser	Riser	0.000	0.0	0.000	0.371	0.00
MainDrain3	MainDrain3	0.000	0.0	0.000	0.500	0.00
Lake	Lake	0.000	0.0	0.000	2.440	0.00

(Table 1 export out from XP Table)

**Flooded Volume Lost, ft<sup>3</sup> or m<sup>3</sup>**

The cumulative total of water lost caused by flooding at the node. This water is lost from the system and not routed any further. It is included in the continuity report as outflows just like an outfall and does not directly cause continuity error.

**Maximum Junction Volume, ft<sup>3</sup> or m<sup>3</sup>**

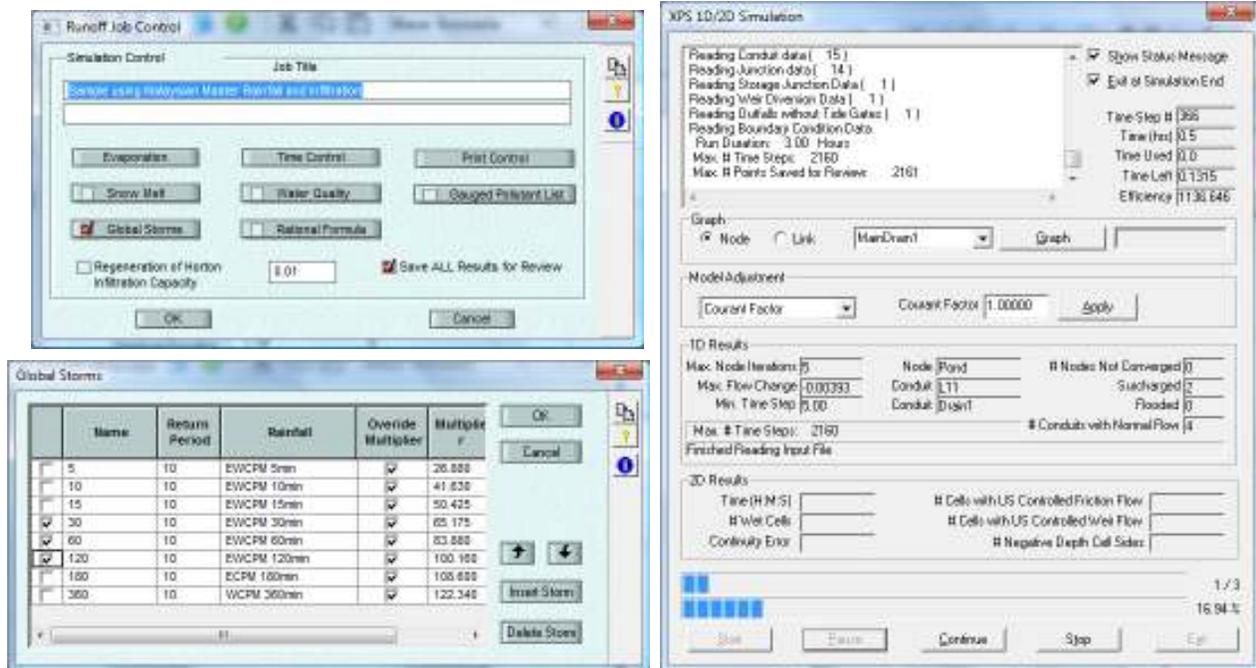
The maximum junction or node volume at any time during the simulation. It does not include the volume of connected conduits.

## Using Global Storms to Model Multiple Rainfall Events

Multiple rainfall events can be simulated using a feature of xpswmm called Global Storms. Global Storms is accessed by selecting the Global Storms button from the Runoff Job Control as shown in the screen capture below.

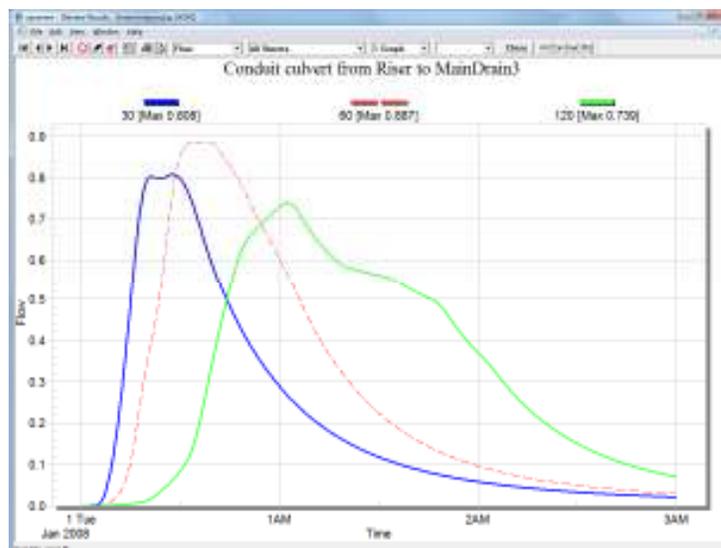
Select the Global Storms button from the Runoff Job Control. Then select the 3 storms named 30, 60 and 120 meaning the 30, 60 and 120 minute storms. The multipliers for each storm represent the total depth for each of the storm durations.

With 3 storms selected the model must solve each case for a total of 3 runs. These runs will be together in a batch with the Global Storms tool. The global storms also allow the model results to be compared side by side. The analysis engine shown to the right shows that multiple runs are being performed such as the 1/3 that is shown in this image.



When the run is complete view the hydrographs for the culvert link. With Global storm turned on the Review Results graph will show the results from all of the model runs.

Note: The Gauged data does not show in Review Results when multiple results are shown.



From the graph we can see that the most critical storm for this model is the 10-year 60-minute duration. It results in the highest outflow from the Pond.

The XP-Tables tool also compares results from multiple storms when the Global Storms is used. The table will create an additional row whenever results are to be displayed.

We can see from the results below that the only location with flooding is node Inlet F and the only occurrence of flooding is with the 60-minute duration storm.

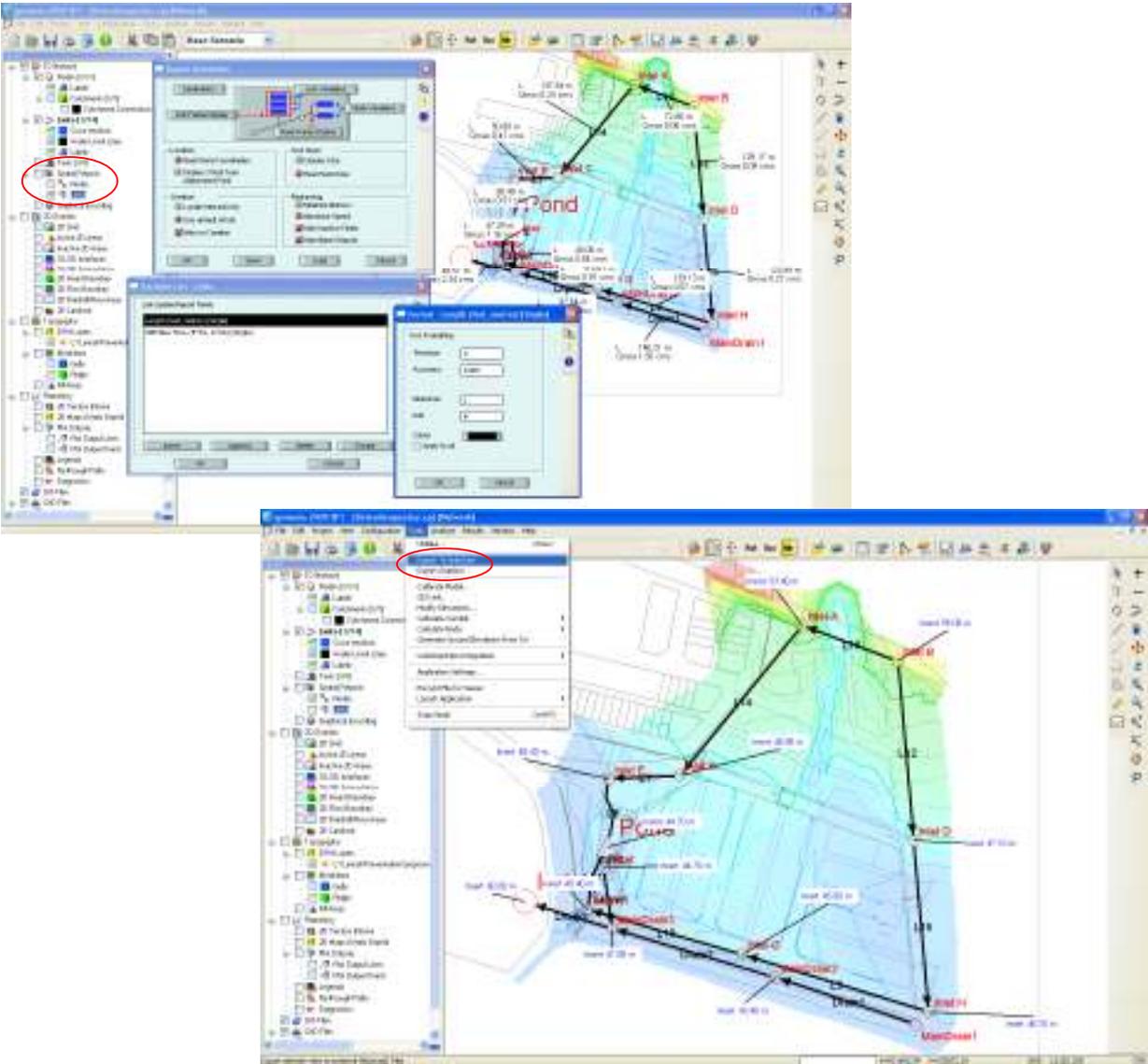
Name	Storm	Node Name	Duration of Surge (min)	Duration of Flooding (min)	Flood Loss (m³)	Max Volume (m³)	Volume of Ponded Flow (m³)
Inlet F	30	Inlet F	24.417	0.0	0.000	2.716	0.00
Inlet F	60	Inlet F	37.000	6.8	0.007	15.435	13.79
Inlet F	120	Inlet F	36.290	0.0	0.000	2.632	0.00

User can export Table below from XP- Table

Table 2: Data & Results							
Data						Results	
Name	Width m	Area ha	Impervious Perce	Slope	Infiltration Reference	Freeboard m	Flood Loss m <sup>3</sup>
MainDrain1					IP 20 percent	2.57	0
MainDrain2					IP 20 percent	3.02	0
Inlet B	1	0.243	65		1 IP 20 percent	2.84	0
Inlet D	1	0.506	65		1 IP 20 percent	1.65	0
Inlet H	1	0.993	65		1 IP 20 percent	0.36	0
Inlet G	1	0.678	65		1 IP 20 percent	0.08	0
Inlet F	1	0.668	65		1 IP 20 percent	0	0.007
Inlet A	1	0.324	65		1 IP 20 percent	1.87	0
Inlet C	1	0.442	65		1 IP 20 percent	1.19	0
Inlet E	1	0.303	65		1 IP 20 percent	0.7	0
Pond					IP 20 percent	1	0
Riser					IP 20 percent	3.7	0
MainDrain3					IP 20 percent	2.99	0
Lake					IP 20 percent	3.5	0

IP 20 percent = Initial and Proportion Loss of 20 percent

Set parameters like Conduit Length & Maximum Flow with Spatial Report. The results can export to dxf file via Export network via Dxf file



Superimpose dxf network file back to CAD background file.

