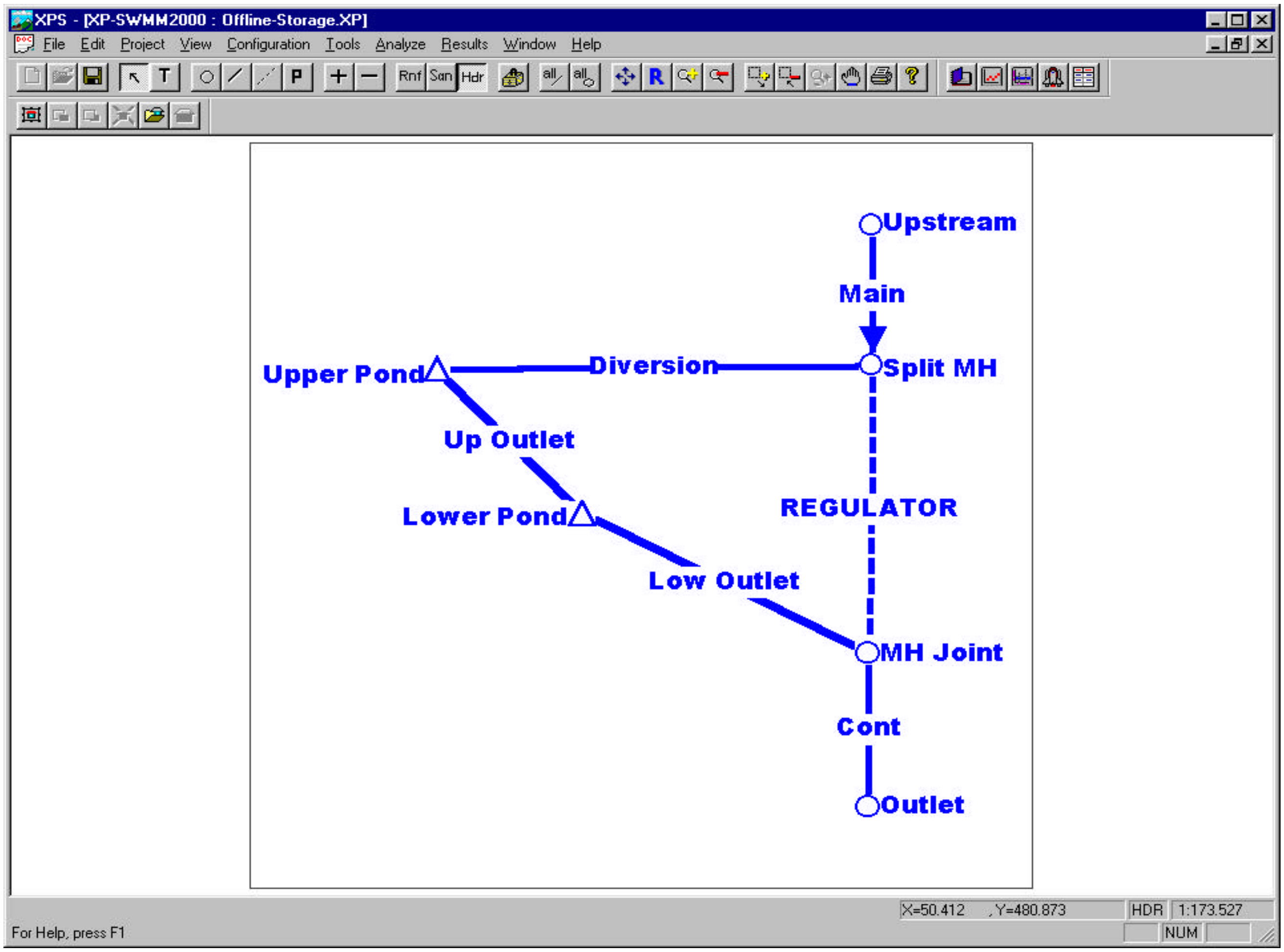
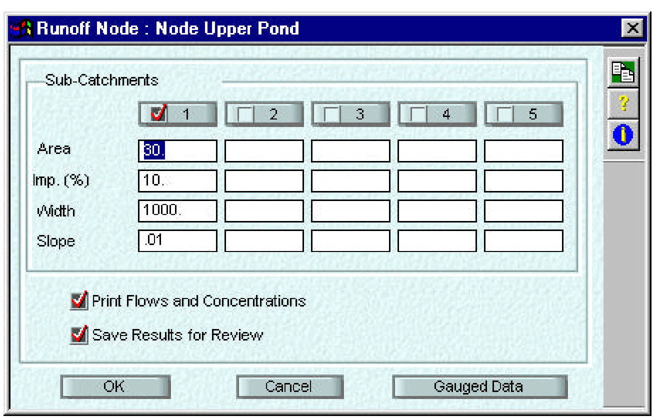
# *Module 55: Offline Storage with Real Time Control Regulator*

## *Synopsis*

In this module we will look at a Runoff – Hydraulics (EXTRAN) surface pond system with a regulator that will control the flow in a conduit based on the depth of water at node "upper pond"  This model depicts a method of controlling water levels in sensitive offline storage facilities such as wetlands.

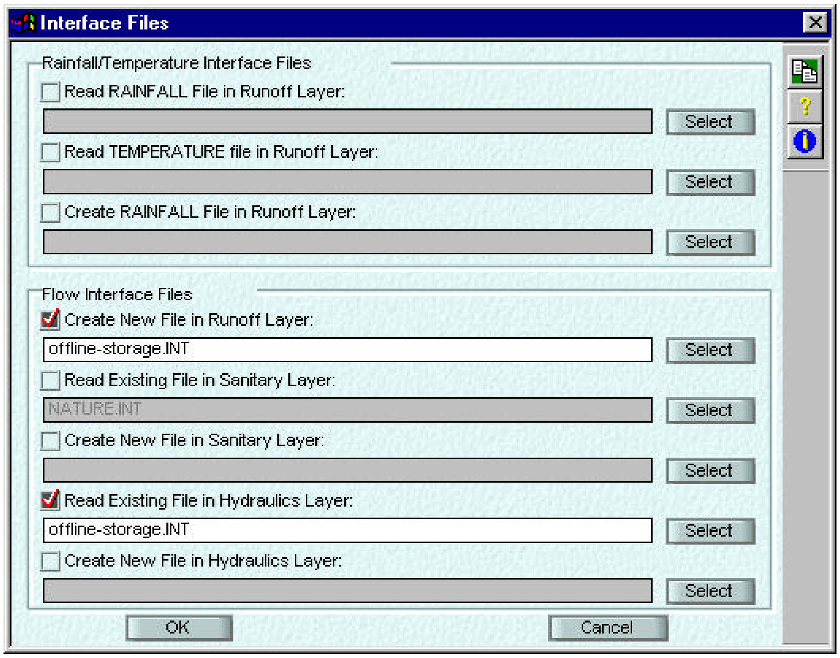
Open up the file ***Offline-Storage.XP*** in your work directory. There are two subcatchments in the Runoff layer at nodes "Upstream" and "Upper Pond". The Runoff and Hydraulics layers are connected together with an interface file.



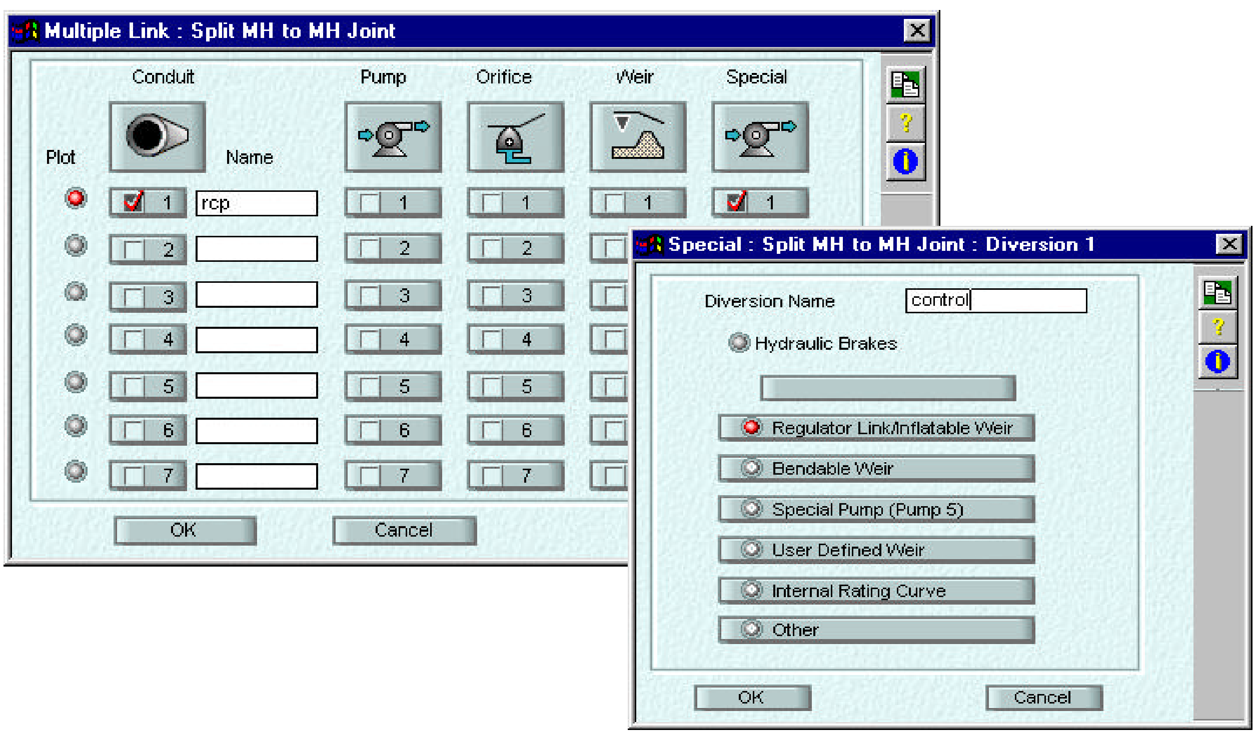

The two subcatchments have four physical parameters, use the EPA Runoff Hydrology, and are connected to two global databases for rainfall and infiltration.  This data can be viewed by double-clicking on the nodes "Upstream" and "Upper Pond" and on the selected subcatchment buttons.

The interface file from the Runoff layer is named as the "Create New File in Runoff Layer" section of the Interface File dialog.  This dialog is accessed under the Configuration menu in the interface. The same named interface file should be entered in the "Read Existing File in Hydraulics Layer". Two locations will be saved to the Runoff interface file; these are nodes "Upper Pond" and "Upstream".

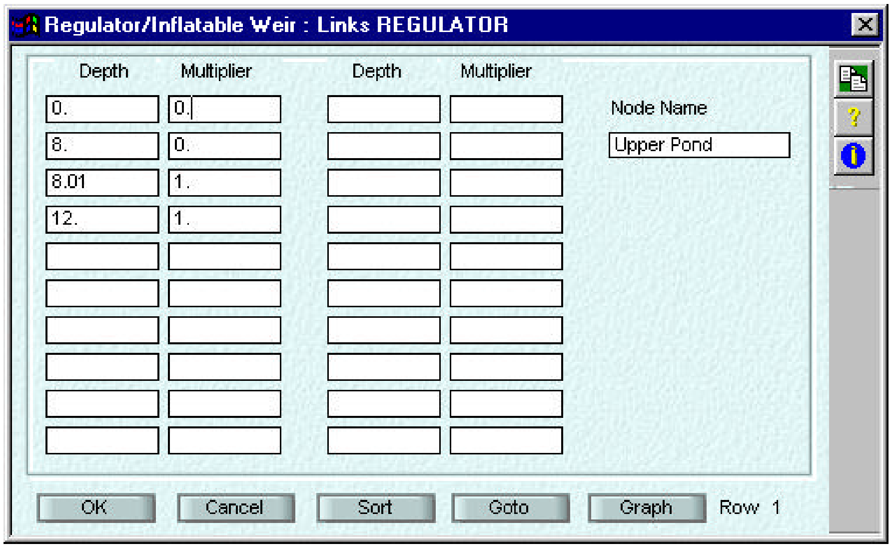



The two flow time series will be read by Hydraulics and routed through the open and closed conduit network shown in the network. Click on the "Hyd" icon to move to the Hydraulics layer of XP-SWMM2000. The low flow will be diverted down the conduit diversion to the Upper pond and Lower pond storage nodes. The regulator will control the flow down the regulator link dependent on the depth of water in node.

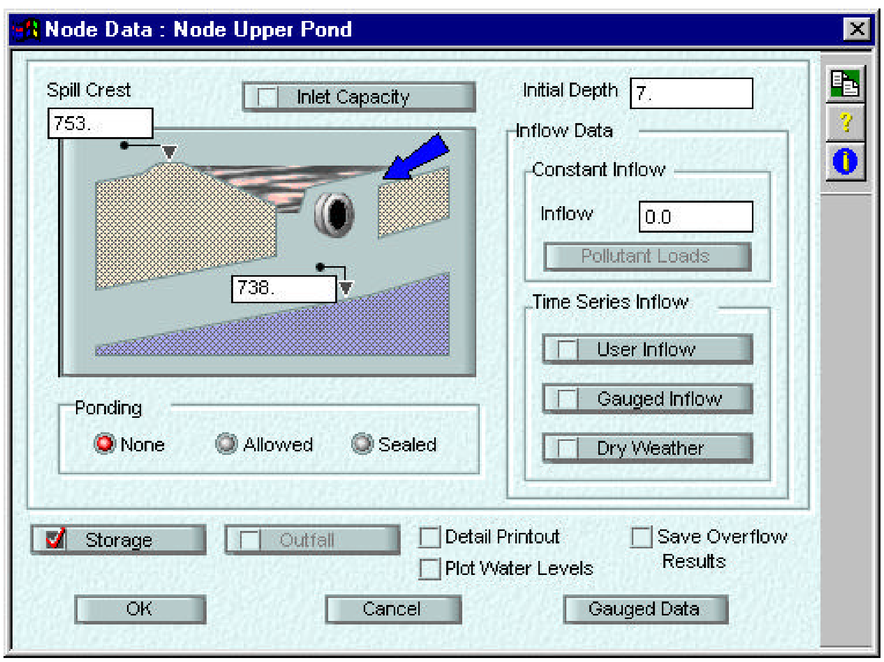
A regulator is defined in a multi-link under the Special list of conduits.  The regulator in a row modifies the behavior of a conduit in that row.  Double-click on the Special conduit in the first row to look at the regulator.



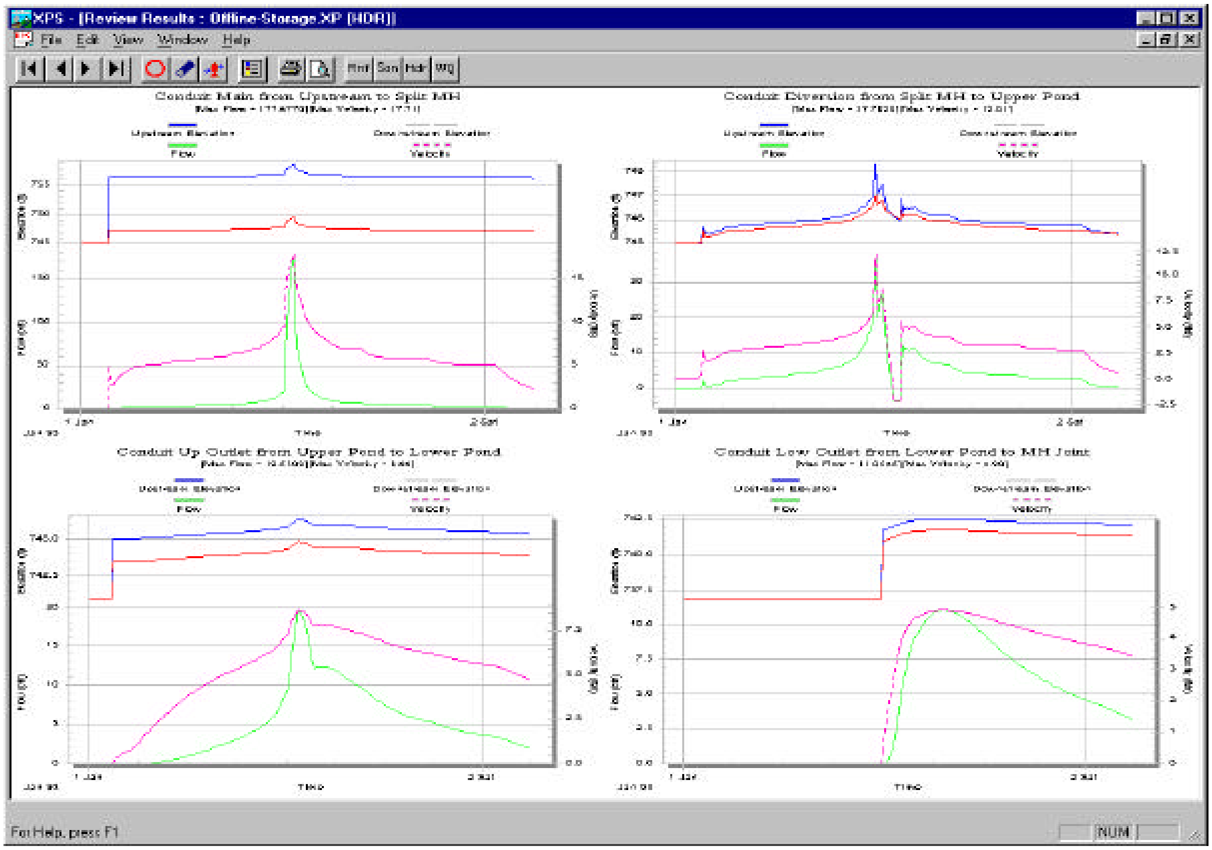
The regulator data is set up in the following way: A table of depth versus flow multiplier is entered in the data fields. A multiplier of zero means that no flow will go through conduit “rcp”. In the above table until the depth of water in node “Upper Pond” exceeds 8 feet there will be no flow in conduit “rcp”.



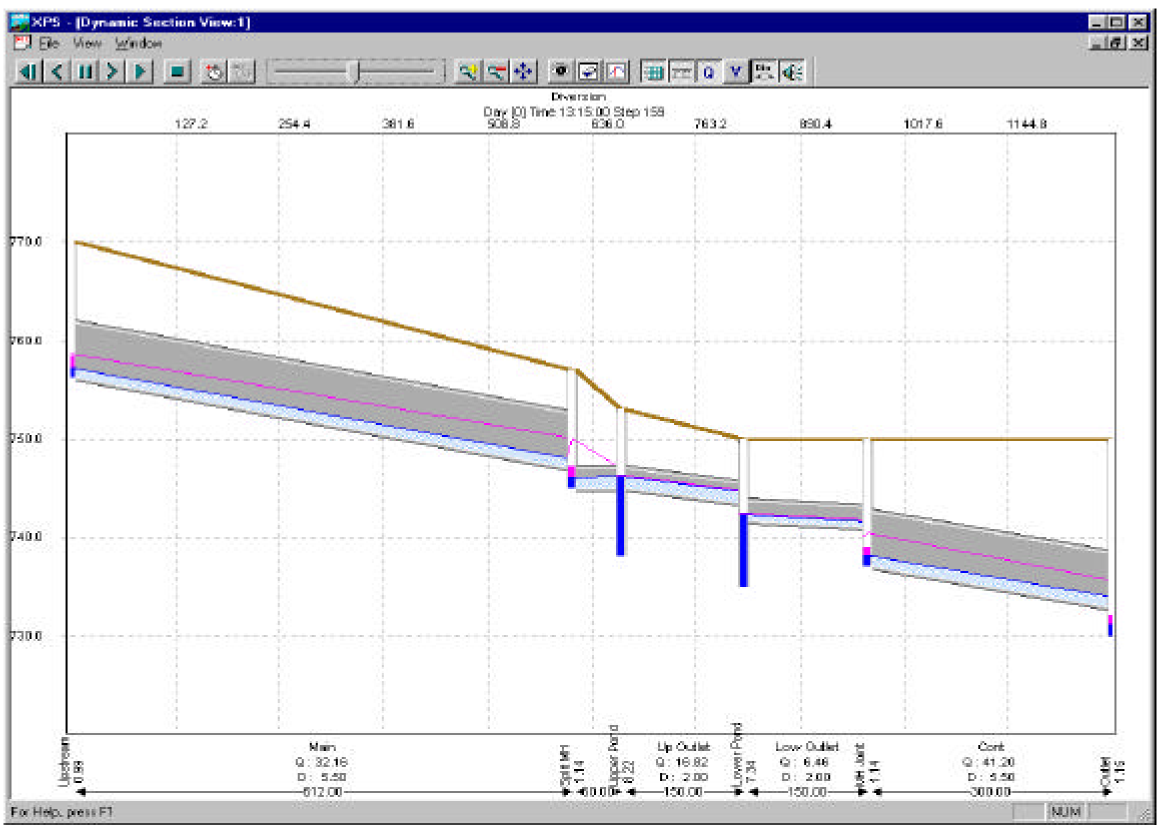

Also note that “Upper Pond” is initialized at a depth of 7 feet. This leaves a maximum 1 foot of bounce (difference between control and the maximum water surface elevation) before the regulator will open.




Solve the model and look at the results using Review Results. You can see the influence of the regulator and the delayed hydrograph through the two ponds. Notice the time that the water surface elevation in “Upper Pond” is above 746 ft. This is the same time frame that there is flow in “rcp” as we would expect from our *rule* in the regulator.




Highlight the “Upstream” through “Outlet” set of conduits. To accomplish this you could highlight the whole model and then using the shift key and the left mouse button deselect link “regulator”. The long section plot can only show straight runs of links. Next use the long section icon and look at the long section plot. You can see the dead storage in the two ponds. Experiment and try to zoom in on the center section of the network.



An important table in the output file is Table E5a, which lists the internal time step for each conduit during the simulation. The conduit in the above table with the most control over the internal time step is link “Up Outlet”.

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*===========================================================*
|       Table E5a - Conduit Explicit Condition Summary      |
|       Courant   =         Conduit Length                  |
|       Time step = --------------------------------        |
|                      Velocity + sqrt(g*depth)             |
|                                                           |
|                  Conduit Implicit Condition Summary       |
|       Courant   =         Conduit Length                  |
|       Time step = --------------------------------        |
|                             Velocity                      |
*===========================================================*
|  The 3rd column is the Explicit time step times the       |
|      minimum courant time step factor                     |
|                                                           |
|  Minimum Conduit Time Step in seconds in the 4th column   |
|  in the list. Maximum possible is 10 * maximum time step  |
|                                                           |
|  The 5th column is the maximum change at any time step    |
|  during the simulation. The 6th column is the wobble      |
|  value which is an indicator of the flow stability.       |
|                                                           |
|  You should use this section to find those conduits that  |
|  are slowing your model down.  Use modify conduits to     |
|  alter the length of the slow conduits to make your       |
|  simulation faster, or change the conduit name to         |
|  "CHME?????" where ????? are any characters, this will    |
|  lengthen the conduit based on the model time step,       |
|  not the value listed in modify conduits.                 |
*===========================================================*

   Conduit  Time(exp)  Expl*Cmin  Time(imp)  Time(min)  Max Qchange   Wobble  Type of Soln
  --------  ---------  ---------  ---------  ---------  -----------  -------  ------------
 Main          23.07      23.07      34.56     110.0         -4.965    0.803  Normal Soln
 Diversion      5.53       5.53       9.39     645.0         -1.775  154.067  Normal Soln
 Up Outlet     10.52      10.52      18.53     865.0          0.066    1.529  Normal Soln
 Low Outlet    32.91      32.91      66.49       0.0          0.013    0.508  Normal Soln
 Cont          11.98      11.98      18.16       0.0         35.895    1.494  Normal Soln
 rcp           16.99      16.99      28.53       0.0         -9.397    1.504  Normal Soln
 control     3000.00    3000.00    3000.00       0.0          0.000    0.000  Normal Soln

The conduit with the smallest time step limitation was..Up Outlet
The conduit with the largest wobble was.................Diversion
The conduit with the largest flow change in any
consecutive time step...................................Cont
```

The internal time step is controlled by the minimum courant time step factor. This model will run faster if the courant time step factor is 2 or 3. The selection of the time step factor should be based in the overall continuity error and the model efficiency. A low efficiency and low continuity error means that the model will run faster if the courant time step factor is increased.