Metric Tutorial 6 - Sizing of Treatment System

File/s needed:
Click to download the **METRIC model files**.

Open **XP_Tutorial5.xpdx**

You can carry on from the previous Chapter or switch to the **Sizing of Treatment** Phase by selecting from the drop-down list on the left **Tree View** panel if you have not already done so.
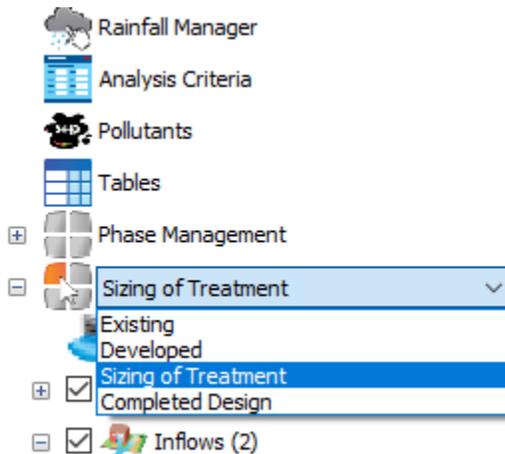

As you saw from reviewing the results, the treatment train is successfully mitigating the volume of water discharging from the site. However, the flow rate is still too great compared to the existing site, and we are still getting flooding in our pipe networks which we do not want. Therefore, we will now carry out a sizing of the treatment system to fix these issues.

Pipe Auto Sizing

We are going to size our pipes in line with the Sewers for Adoption (SfA) UK guidance specifications. To meet these requirements we need to make sure that our network will not surcharge for a 1:2 year event and will not flood for a 1:30 year event. As we have already discovered, we have broken this rule for both cases so we will need to redesign our network. We can do this by either manually altering pipes individually, or we can use the **Pipe Sizing Wizard** found in the **Preliminary Sizing** ribbon**.**

The **Pipe Sizing Wizard** works by using an Intensity Duration Frequency (IDF) curve for a particular storm event for a particular area. We will specify this using FSR data. With the IDF curve a time of concentration and rainfall intensity is generated for individual pipes, which generates the expected flow the pipe will have to deal with (in the UK this is done using the **Modified Rational Method**). The connection is then sized accordingly. This is related to the Wallingford Procedure for the UK, and enables pipes to meet the Sewers for Adoption criteria or similar guidance documents in other countries on pipe surcharging and flooding for various events, as stated above.

1. Open the **Pipe Sizing Wizard** by clicking the icon in the **Preliminary Sizing** ribbon.
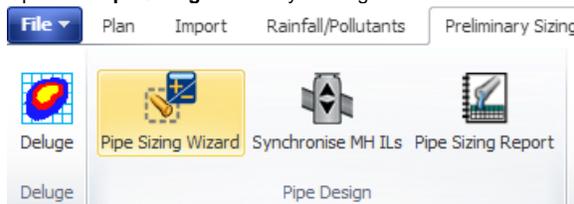

   The **Pipe Sizing Wizard** whould open and show the first step of the wizard, selecting the flow path to size. The only flow path in our system should be specified on opening the wizard. However, there is also the ability to select the flow path from the **Select Flow Path** drop down menu. Make sure our flow path is selected and then click **Next**.
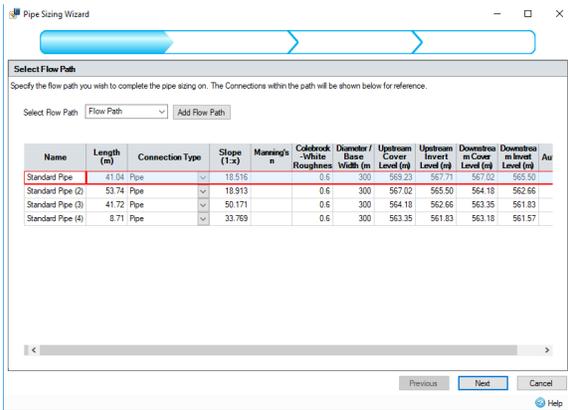
2. The second stage of the **Pipe Sizing Wizard** allows us to enter the **Pipe Sizing Criteria**, where you can specify a variety of conditions for the design of our pipes. We will be using the Modified Rational Method (as mentioned above), combined with the two-year return period FSR data from Oxford (UK) as the basis for our pipe design. The other factors have default values set, which we will leave as they are.
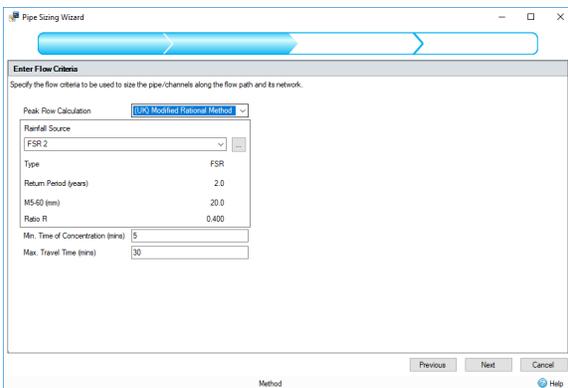

3. In the third stage, we want to tick **Min. Cover Depth** and **Synchronise Manhole Invert Levels**. We can leave the other values as default values. **Use Flow Restriction** would enable to automatically reduce the size of pipes downstream of the flow controls specified but in this case, this is the outfall of our network.
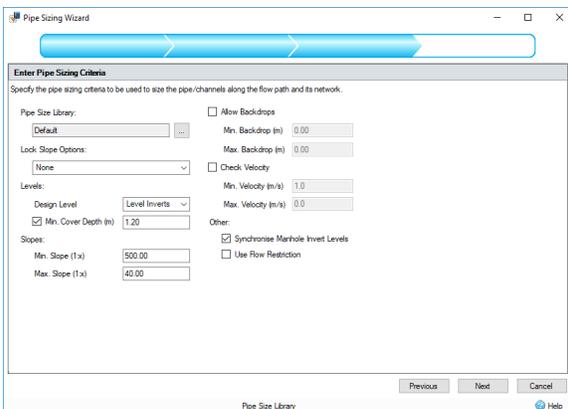

4. Now that we have completed our criteria specifications, we can click **Next** to see what changes the wizard has made. The changes that have automatically been made are highlighted in yellow. Anything that remains with a white background has not been modified by the wizard, as shown by our pipe slopes since we locked them previously. Hovering your mouse over the highlighted fields will display the original values before the wizard made modifications, allowing a comparison between the two values. Hovering over the warning triangle will show the reason for anything that breaks the Design Criteria where there are conflicting conditions, the suggestions column may help with finding a solution. In this case, the pipes are following the ground slope which is quite steep as can be seen on the Profile View in a later step.
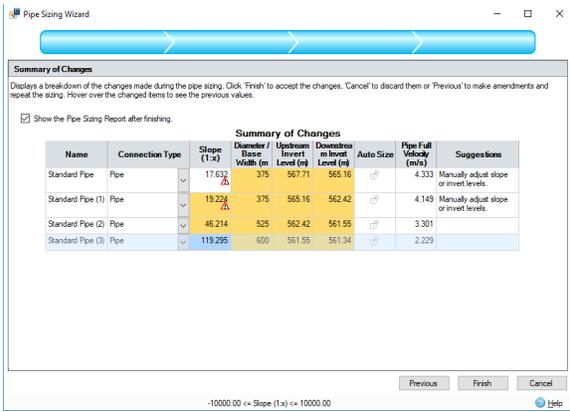
5. Make sure that **Show the Pipe Sizing Report after finishing** is selected, then click **Finish** to save and apply the changes that the wizard has made. Upon the wizard closing, the **Pipe Sizing Report** now shows. Here we can select the flow path that we want to see the report for, as well as the layout of the pipe sizing report. Furthermore, we can export this **Pipe Sizing Report** to PDF by clicking the icon. This pipe sizing report can be extremely useful in showing the total areas, predicted flows, and depths in our pipes based on the pipe sizing wizard results.
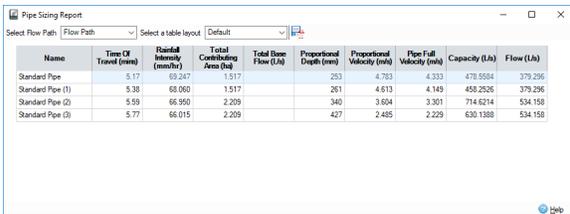
6. Now that the connections have been modified, we can also go back to the **Profile** view to see how the system has been altered.
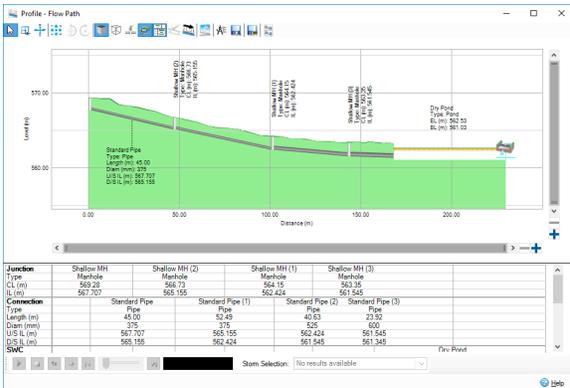
7. The simulation can now be re-run by selecting **Go** from the **Analysis** ribbon to show how the pipe sizing function has successfully modified the pipes so that they now do not surcharge for 1:2 year storms except immediately upstream of the pond. To check that the pipes do not flood for 1:30 year storms open, the **Analysis Criteria** in the **Analysis** ribbon and change the rainfall to FSR 30 then rerun the analysis.

⚠️ Depending on your exact placement of items there may be surcharging in the lower pipe for the 1:2 year critical storm due to the water depth in the pond being greater than the soffit of the pipe.

Pond Sizing

Now that we have resized our pipes, we want to modify our **Dry Pond** so that we are meeting the same discharge flow rate as the **Existing** site. As we saw from our phases report for the **Developed** site, we are discharging at higher rates than the existing site. To successfully decrease the flow rates, we will modify the outflow control and also the pond size, as reducing the flow rate will lead to a higher storage volume required.

1. In the **Dry Pond** window, open the **Sizing Calculator**. In the **Sizing Calculator,** select **Quick Storage Estimate** from the **Method** drop-down menu and change the **Design Level** to **Freeboard.** Click the calculator button next to **Volume (m^3)** to open the Quick Storage Estimate window. Input the data as shown below, then press **Calculate**. This produces a storage volume estimate based on our desired discharge rate.
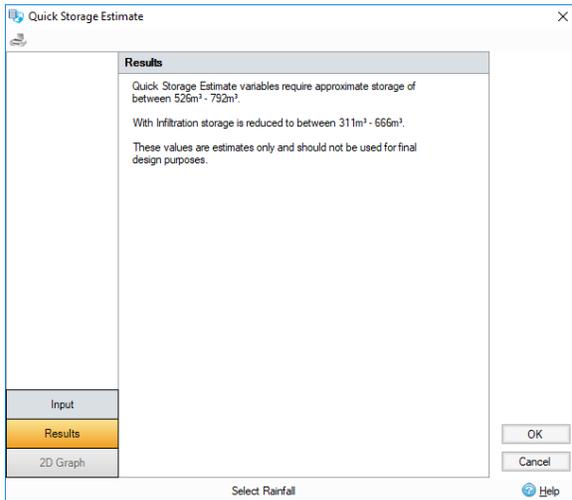
Displayed is the quick storage estimate that xpdrainage has provided from the parameters that we used in the **Input** tab. We can see that the software has estimated that we require **526 m^3** to **792 m^3** of storage to manage the volume of water effectively. You will also notice that due to us specifying an infiltration rate in the pond, we are given a second estimate, **311 m^3** to **666 m^3**, this is the storage required if we have an effective infiltration rate

2. Click **OK** to close and apply the volume. The software will automatically take the average of the infiltration storage value, we will manually change this to **700 m^3** to provide a more conservative approach.
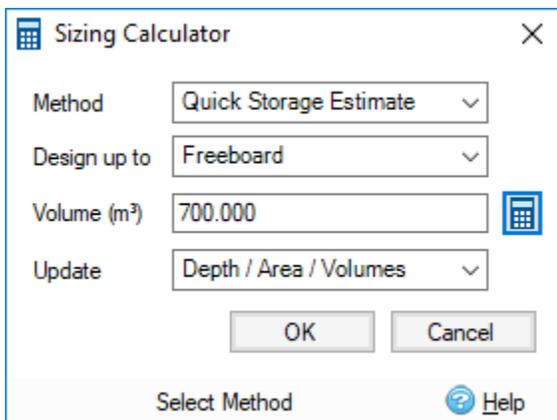
Click OK and we can now see that the pond has updated its areas and volume based on these values.

3. Now that we have sized our pond, we will also modify the outflow in our system to better mitigate the flow running off of our **Developed** site. To do this, we will go to the **Outlets** tab.

Select **Edit**, select the [>] button and change the flow of the lower orifice to **23.3 l/s**. Highlight the lower Orifice and click the **Change Templates** icon then choose the **Orifice** and click **OK.** C hange the values to **0.9** for the depth and **43.6 l/s** for the Flow, then click the **Solved for displayed controls** calculator button to alter the diameters. Click **OK** to close the form.
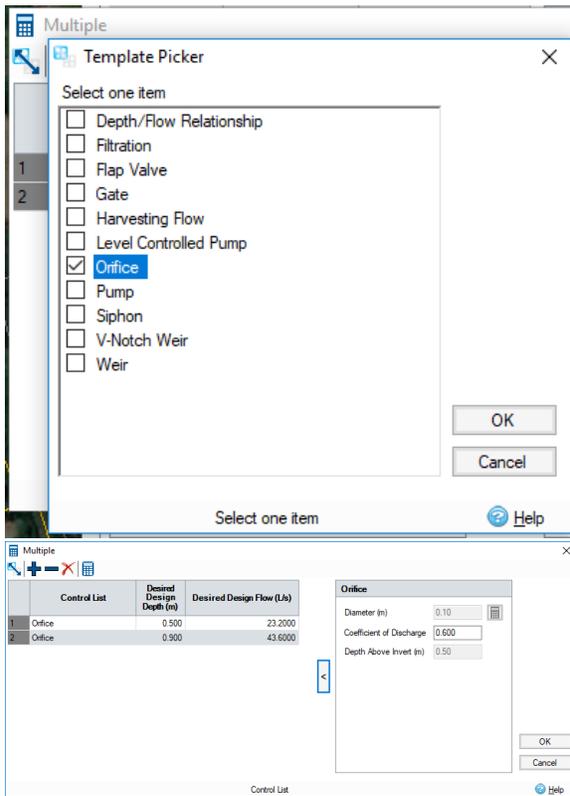
4. Click **OK** to all the forms to apply the changes and close the pond form.

5. Save the file as **XP_Tutorial6.xpdx**

Results and Fine Tuning

You can carry on from the previous Chapter or open **XP_Tutorial6.xpdx** and switch to the **Completed Design** phase by selecting from the drop-down list on the left T**ree View** panel if you have not already done so.
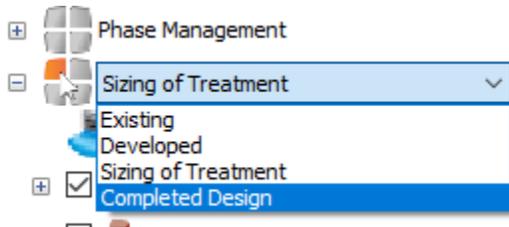
1. Now that we have finished the sizing of our network, we can run an analysis to compare the results between the **Existing** and **Completed Design**. We will re-run the simulation to see how effective our changes have been. Open **Analysis Criteria** and make sure the fields are as below, then run the simulation.
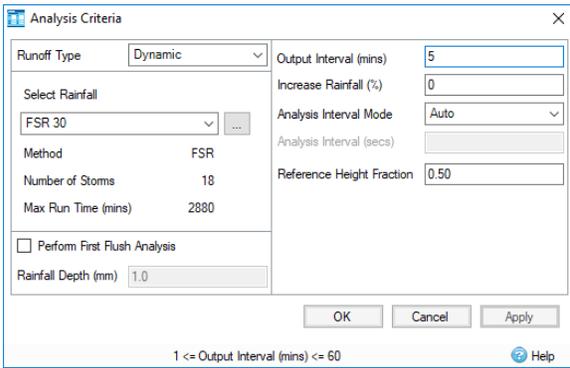
2. Just as with previous simulations the **Stormwater Controls Summary** will be the first window we see. Select **Critical Storm** to show the worst event experienced by the **Dry Pond**, which will allow us to see if our storage upsizing has been effective.


As we can see from the **Stormwater Controls Summary** window, we have no flooding from the pond, with very little excess storage available, as stated in the **Percentage Available (%)** column.

3. Open the **Connections Summary** from the **Results** ribbon to see if our pipes were able to take the flow of the 1:30 year events without flooding. Click the **Critical Storm** icon again.


As we can see from this window, our pipes are only experiencing surcharged conditions and are not flooding for the critical 1:30 year storm. This means that we are meeting the UK standard Sewers for Adoption criteria for drainage design.

4. You can also navigate to the profile view for any storm to visually inspect how our updated system is coping with the critical storms. The 240 mins Winter storm is critical for the **Dry Pond**. The different storms can be selected using the **Storm Selection** menu at the base of this window.
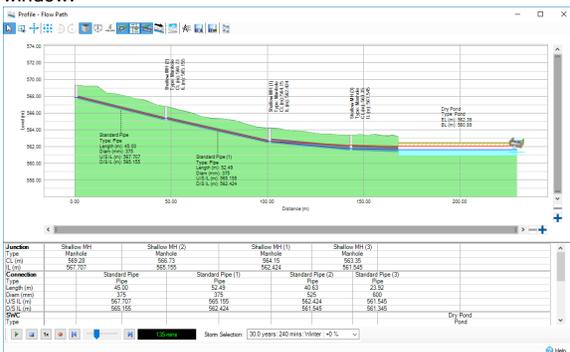
5. We can also view the **Phases Report** to make sure that our flow rates and outflow volumes are now satisfactory when compared to the **Existing Site** conditions. Open **Phases Report** from the **Results** ribbon and select the options as shown below, then select **Update Preview**. You may need to drag the box around the legend to expand it to show the legend for both phases.
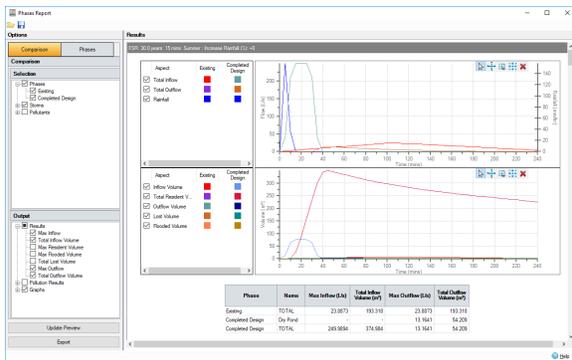
6. The effect of our storage and flow control mean that we are not initially capturing the peak of the hydrograph or the whole drain down for the shorter duration storms in the **Completed Design** Phase. We have extended the **Run Time** for the shorter duration storms in the **Rainfall Manager**.
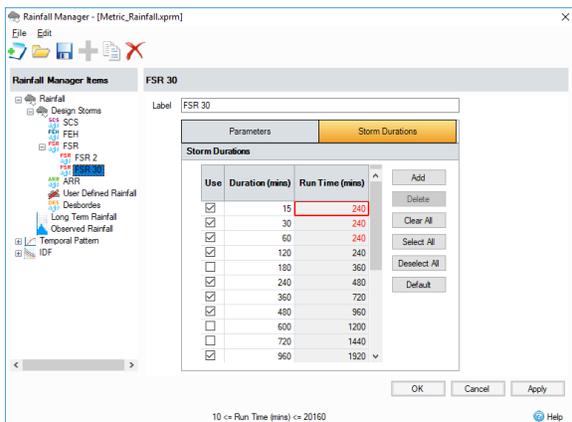
7. We can check all storms in the **Phase Report** and see we are successfully mitigating the run-off from this **Developed** site. With further refinement, the treatment train is possible by altering the size of our outlets and the size of the pond, as we have some leeway between our runoff rates and volumes. For the purpose of this tutorial, we will not be editing the treatment train any further. However, you can refine the results comparison to the **Existing Phase** flows if desired.

8. The finished layout can be exported to AutoCAD file (*.dxg or *.dxf). Go to the **Export** ribbon, and then select the **To CAD** button.
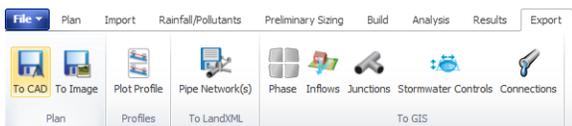
9. In xpdrainage, there is also the ability to export your completed pipe network. This can be done within the **Export** Ribbon, select **Export Pipe Network(s)** to save the network as a LandXML (*. xml) file. This allows the connections and junctions within the current phase to be shared with other applications, such as Autodesk® AutoCAD® Civil 3D®, as well as allowing networks designed outside of **xpdrainage** to be imported into the software for analysis and editing.

10. Within the **Import** ribbon you can also import pipe networks, if they are presented as a LandXML (*.xml) file.
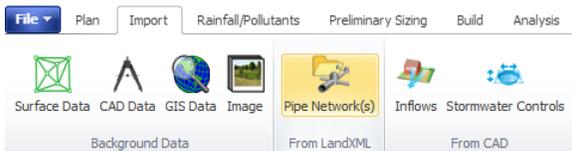
11. It is important to note that xpdrainage contains some information that is not supported by the LandXML file format. As such they are approximated within the LandXML file exported. These are:

Stormwater Controls:

1. These are not supported by LandXML so a simple structure (i.e. node with no volume) is provided at these locations with a label explaining what they are.
2. In addition to the Stormwater Control, the Inlet and Outlet attachment points shown on Plan cannot be represented. To maintain the layout the export will contain a 'connection', or null, structure for each of the inlet and outlet locations. Connections (pipes) will then be shown to /from these locations.

Connections:

1. Number of Barrels – If a value of more than 1 is specified the export will contain multiple versions of the same pipe/channel with the name post fixed with $\_X\_\varnothing$, where X is the number of the barrel.
2. Triangular Channels – These will be exported as an equivalent 'v' shaped channel.
3. Conceptual Connections (No Delay, Simple Time Delay and Lagged Flow) – These will be saved as a Circular Pipe with a nominal diameter, as specified on the Export Options.

For more information on the **Export Pipe Function**, to go Export Pipe Network.