Metric Tutorial 6 - Sizing of Treatment System

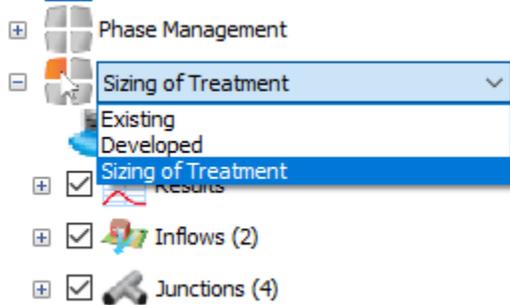| File/s needed: |
| --- |
| Click to download the **METRIC model files**. |

1. Continue with your previous file or open **XP_Tutorial5.xpdx**

2. Check that the **Sizing of Treatment** Phase is selected in 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. Also, we are getting flooding in our pipe network which we do not want. We have not yet used the built in sizing tools, therefore we will now use these 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. We can either do this by manually altering pipes individually, or we can use the **Pipe Sizing Wizard** found within 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. The **Pipe Sizing Wizard** reads the IDF curve for the time of concentration of an individual pipe and then a rainfall intensity is generated. This rainfall intensity 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.
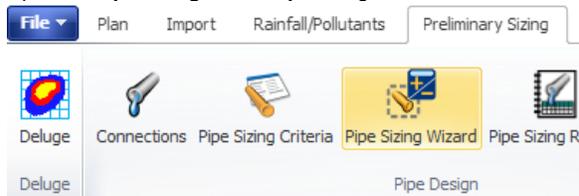
The **Pipe Sizing Wizard** should open and show the first step of the wizard, selecting the flow path to size. The only flow path in our system should be specified on opening the wizard. However, there is the ability to also select the flow path from the **Select Flow Path** drop-down menu. Make sure our flow path is selected and then click **Next**.
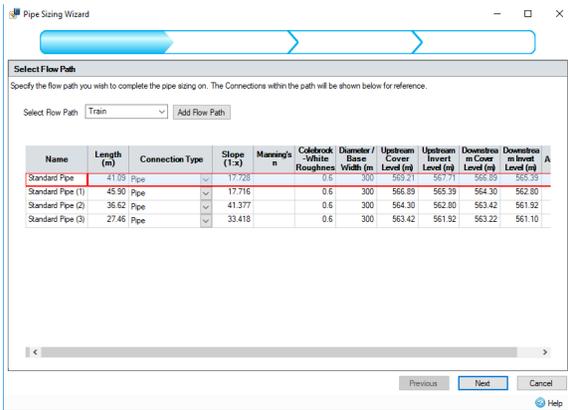
2. The second stage of the **Pipe Sizing Wizard** allows us to enter the Pipe Sizing Criteria, within here are a variety of conditions that can be specified for our pipes to be designed to. We will be using the **(UK) Modified Rational Method** (as mentioned above), combined with the **FSR 2** Rainfall Source, the two-year return period FSR data from Oxford (UK) as the basis for our pipe design.
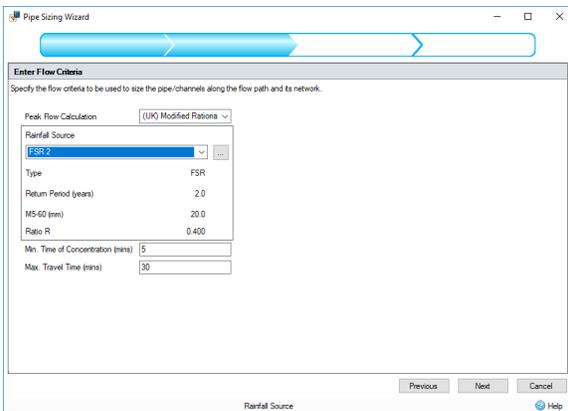

3. The third stage of the **Pipe Sizing Wizard** allows us to enter the **Pipe Sizing Criteria**. Click the ellipses next to the **Pipe Size Library** and then select **Default**. You will be asked if you want to save existing data, select **No** and the default sizes will be entered. Click **OK** to close the form. We want to use the **Lock** drop-down menu to maintain our slopes by selecting **Slopes**. We also want to tick on **Min. Cover Depth** and **Synchronise Manhole Invert Levels**.
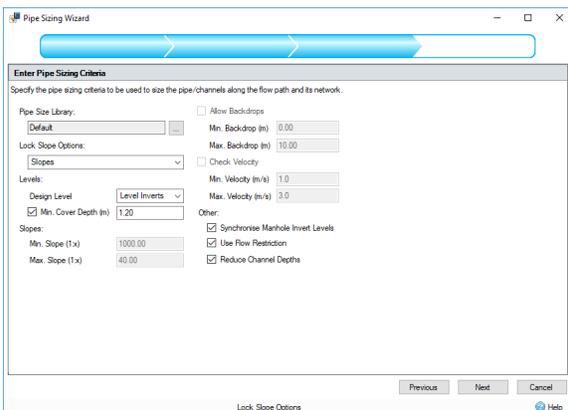

4. Now that we have completed our criteria specifications, we can now click **Next** to see what changes the wizard has made. Highlighted in yellow are any changes that have automatically been made. Anything that remains with a white background has not been altered by the wizard, as shown by our pipe slopes since we locked them previously. Hovering your mouse over the highlighted fields will display the original values before the wizard made alterations, allowing a comparison between the two values.
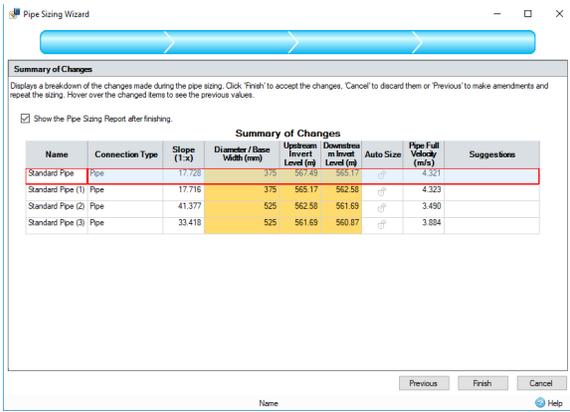
5. Make sure that **Show the Pipe Sizing Report after finishing** is selected, then click **Finish** to save and apply the changes that the wizard has made. Upon the wizard closing, the **Pipe Sizing Report** now shows. Here we can select the flow path we want to see the report for as well as the layout of the pipe sizing report. Furthermore, we can also export this Pipe Sizing Report to PDF by clicking the icon. This pipe sizing report can be extremely useful in showing us total areas, predicted flows, and depths within our pipes based off the pipe sizing wizard results. Additional toolbar options exist to change **Pipe Sizing Criteria**, **Recalculate Rational Results** and **Audit changes against Pipe Sizing Criteria**.
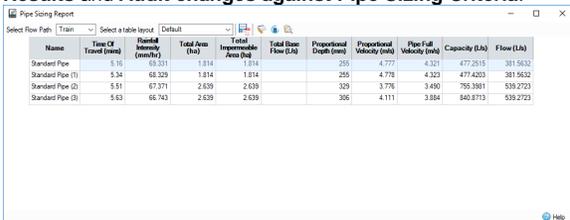
6. Now that the connections have been up-sized we can also go back to the **Profile** view to see how the system has been altered. The **Cover Depth Line** in magenta shows that due to a drop in the surface between manholes we have a breech in Cover Depth. We could consider adjusting the pipe levels, doing some earthworks to prevent this or another engineered solution.
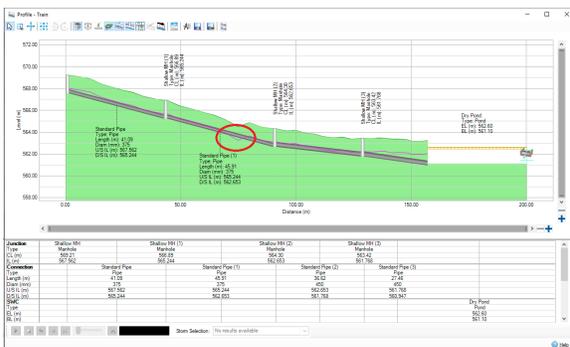

7. If we zoom in on the Profile, it shows that our **Standard Pipe (4)** invert level and **Dry Pond** invert level no longer match the connection invert levels. This is further confirmed by the values shown in the summary table at the base. To correct this, we will manually alter the base level of our pond to that of the **Downstream Invert Level** of **Standard Pipe (3)**. Double-click the value in the table, highlight it and use "Ctrl + C" to copy it.

| Connection	Standard Pipe (3)
Type	Pipe
Length (m)	25.48
Diam (mm)	450
U/S IL (m)	561.734
D/S IL (m)	560.927
SWC	

8. Within the Profile view, double-click the **Dry Pond** to open the pond form. In the dimensions tab, we can now manually edit the **Base Level** to match that of the preceding pipe DS IL. If the **Base Level** is greyed out, then we can fix this by using the radio button to set the **Depth** to automatically calculate as opposed to the **Base Level**. We can now type in our new **Base Level**,

which in this case is **560.927**. This has now extended the depth to 1.65 metres, resulting in a deeper pond and therefore providing more capacity for storage which we will review again later.
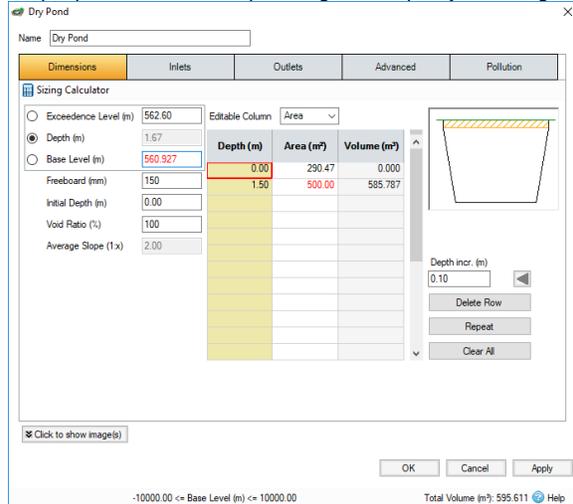
9. Now that we have altered our pond **Invert Level**, we also want to make sure that our outflow control Invert Level is also correct. As discussed in an earlier Chapter, the outlets are set at 300 mm above the base to allow infiltration to occur. Simply go into our **Outlets** tab and alter the **Invert Level** of the control so that it sits 300 mm above the Pond Invert Level at 561.247 m. Click **OK** to close the form and apply the changes. The profile will be updated to show the levels matching.

10. The simulation can now be re-run by selecting **Go** from the **Analysis** ribbon to show how the pipe sizing function has successfully altered the pipes so that they now do not surcharge for 1:2 year storms except immediately upstream of the pond.
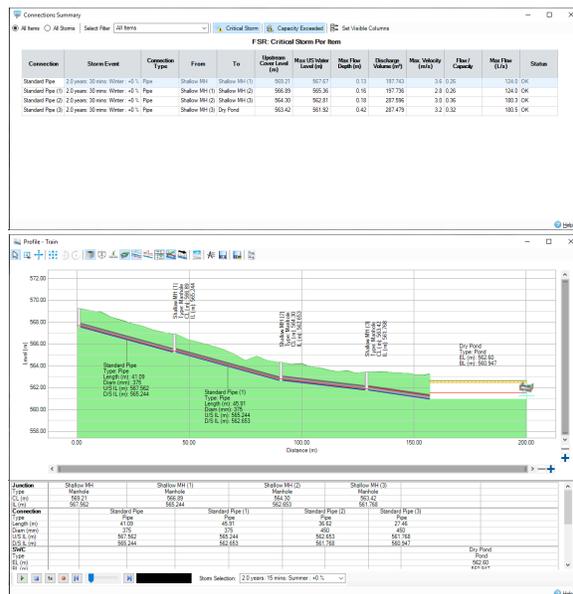
11. To check that the pipes do not Flood for 1:30 year storms, you can open the **Analysis Criteria** on the **Analysis** ribbon and change the rainfall to **FSR 30** then rerun the Analysis but we'll be making some more amendments to the pond below.

Pond Sizing

Now that we have resized our pipes we want to alter 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 alter the outflow control and also the pond size, as reducing the flow rate will lead to a higher storage volume required.

1. Open the Dry Pond by double-clicking the icon in plan view. Before we size the pond we want to alter the depth column in the table, so that it now matches the depth of the pond (in our example

this is 1.65 m). This depth change is due to us altering the pond in the previous section to make sure the upstream pipe connected invert to invert.
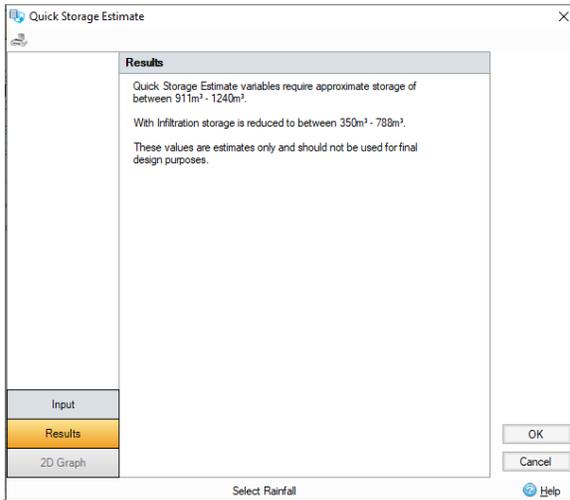
2. Within the **Dry Pond** window, open the **Sizing Calculator**. Within the **Sizing Calculator**, select **Quick Storage Estimate** from the **Method** drop-down menu and change the **Design Level** to **Exceedence**.
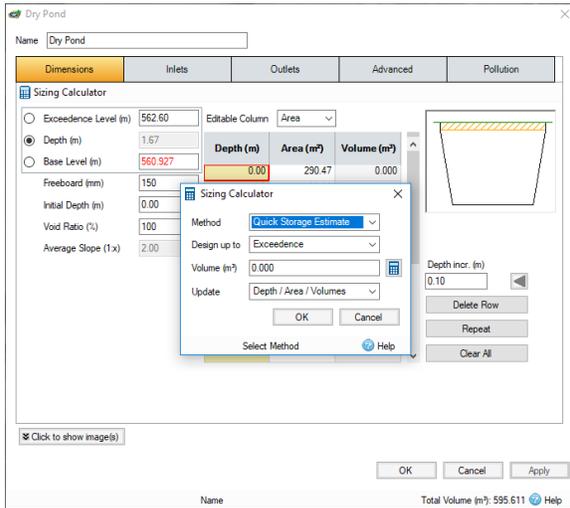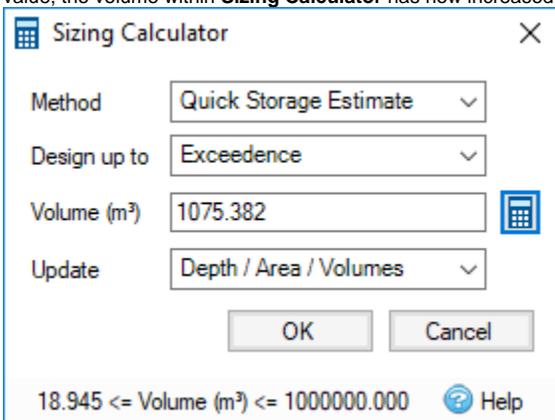

3. Now click on the calculator button next to **Volume (m^3)** to open the **Quick Storage Estimate** window. Input the data as shown below, then press **Calculate**. This produces a storage volume estimate based on our desired discharge rate.
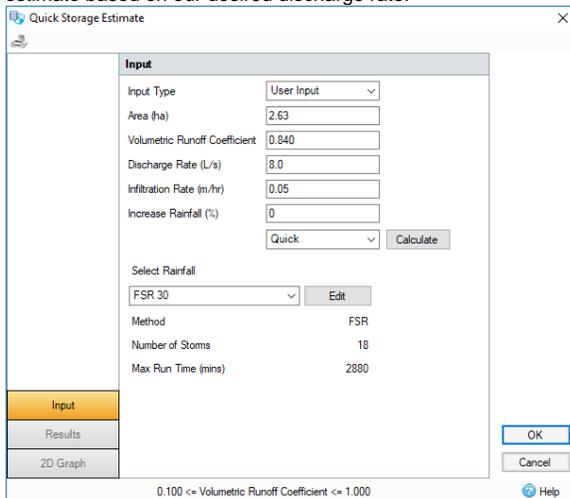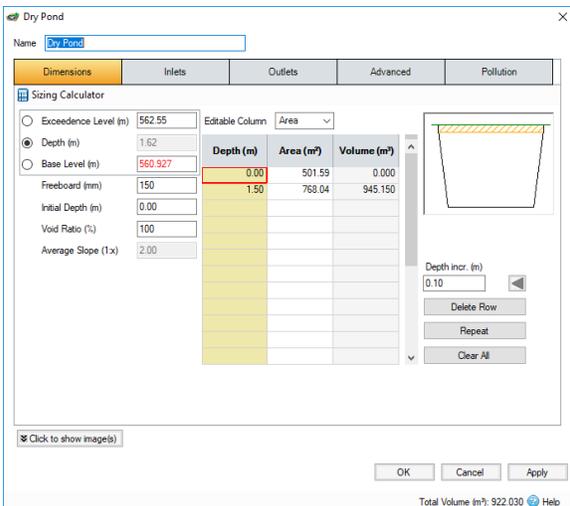

Displayed is the quick storage estimate that XPDrainage has provided from the parameters that we used in the **Input** tab. We can see that the software has estimated that we require **911m^3 to 1240m^3** of storage to manage the volume of water effectively. You will also notice that due to us specifying an infiltration rate in the pond, we are given a second estimate, **350m^3 to 788m^3**, this is the storage required if we have an effective infiltration rate.

Quick Storage Estimate

Results

Quick Storage Estimate variables require approximate storage of between 911m³ - 1240m³.

With Infiltration storage is reduced to between 350m³ - 788m³.

These values are estimates only and should not be used for final design purposes.

Input

Results

2D Graph

Select Rainfall

OK

Cancel

Help

4. Click **OK** to the calculator form, the software will automatically take the average of the storage value, the volume within **Sizing Calculator** has now increased to 1075 m³.

Sizing Calculator

Method	Quick Storage Estimate
Design up to	Exceedence
Volume (m³)	1075.382
Update	Depth / Area / Volumes

OK   Cancel

18.945 <= Volume (m³) <= 1000000.000   Help

5. Click **OK** to close and apply the volume. We can now see that the pond has updated its areas and volume based on what was specified in the **Sizing Calculator.**


Dry Pond

Name: Dry Pond

| Dimensions | Inlets | Outlets | Advanced | Pollution |

Sizing Calculator

Exceedence Level (m) 562.55   Editable Column Area

Depth (m) 1.62

Base Level (m) 560.927

Depth (m)	Area (m²)	Volume (m³)
0.00	501.59	0.000
1.50	768.04	945.150

Freeboard (mm) 150

Initial Depth (m) 0.00

Void Ratio (%) 100

Average Slope (1:x) 2.00

Depth incr. (m) 0.10

Delete Row

Repeat

Clear All

≫ Click to show image(s)

OK   Cancel   Apply

Total Volume (m³): 922.030   Help

(i) **Note**

The **Total Volume** shown in the toolbar at the base of the Pond form is calculated up to the Freeboard. In this case the Freeboard is set 150 mm below the Exceedence Level, hence it is different to the total volume measured up to the Exceedence Level as set but the Quick Storage Estimate Calculator.

6. Now that we have sized our pond, we will also alter the outflow on 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**, then select the [>] button and change the flow of the orifice to 15 l/s, and weir to 22.5 l/s, then click the **Solved for displayed controls** calculator button to alter the diameters. Click **OK** to close the form.
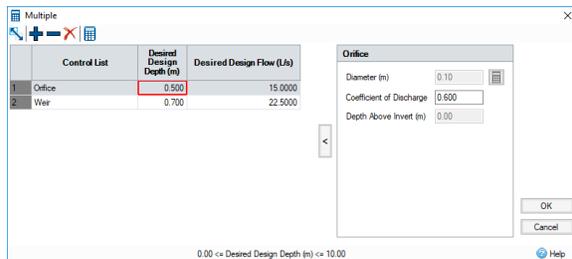

7. Click **OK** to apply the changes and close the pond form.

Results and Fine Tuning

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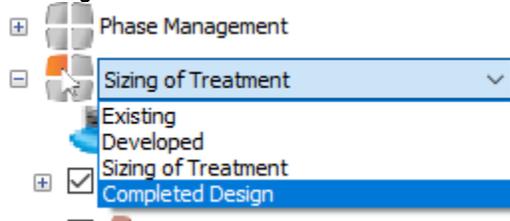
3. Now that we have finished the sizing of our network, we can run an analysis to compare results between the **Existing** and **Completed Design**. We will re-run the simulation to see how effective our changes have been. Open **Analysis Criteria** and make sure the fields are as below, then run the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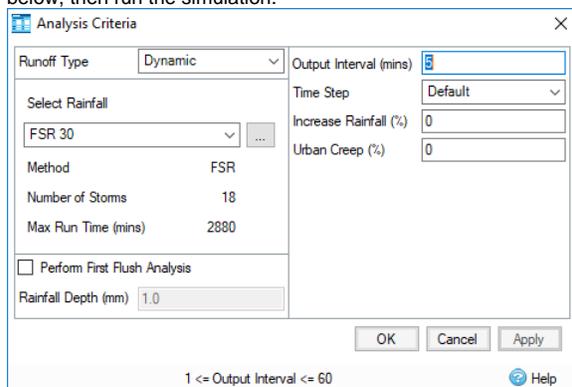
4. Just as with previous simulations, the **Stormwater Controls Summary** will be the first window we see, select **Critical Storm** to show the worst event experienced by the **Dry Pond**, this will allow us to see if our storage upsizing has been effective.

5. As we can see from the window above, we have no flooding from the pond. We could continue refining the design to downsize the pond to a smaller volume to decrease the area it takes up and save on construction costs. For the purpose of this tutorial, we will leave the pond as it is.

6. Further to this we can open the **Connections Summary** from the **Results** ribbon to see if our pipes are able to take the flow of the 1:30 year events without flooding. Click the **Critical Storm** i con 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.

7. 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.
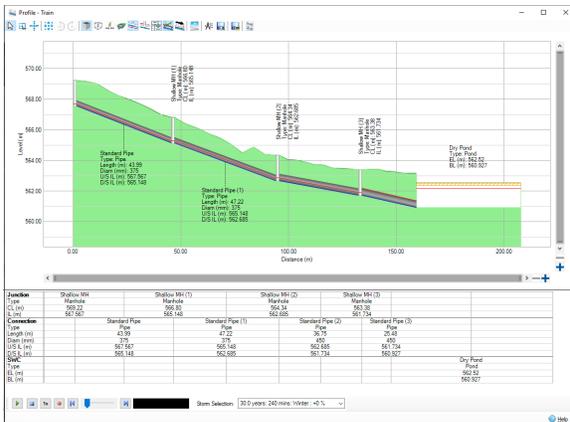
8. We can also view the Phases report to make sure that our flow rates and outflow volumes are now satisfactory when compared to the Existing Site conditions. Open **Comparison Report** from the **Results** ribbon and select the options as shown below, then select **Update Preview**. You may need to drag the box around the legend to expand it to show the legend for both phases.

9. The effect of our storage and flow control meant that we were 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**.

10. We can check all storms in the Phase Report and see we are successfully mitigating the run-off from this developed site. 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 the 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.

11. The finished layout can be exported to AutoCAD file (*.dxg or *.dxf). Go to the **Export** ribbon, and then select the **To CAD** button.

12. Within 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.

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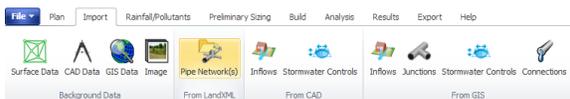
14. It is important to note that XPDrainage contains some information that is not supported by the LandXML file format. As such they are approximated within the LandXML file exported. These are:

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_Ø, 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.

More information on the **Export Pipe Function**, refer to Export Pipe Network.