CES322352

Under Pressure: Pressure Networks in AutoCAD Civil 3D

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Learning Objectives

- Discover the different parts of a pressure network in AutoCAD Civil 3D
- Learn how to lay out a pressure network both horizontally and vertically
- Learn how to edit pressure networks to account for design changes such as crossing utilities
- Learn how to analyze the pressure network to find faults in the layout of the model

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Description

Modeling water distribution systems has always been a tedious process. AutoCAD Civil 3D offers tools that will greatly assist you with this process. For horizontal and vertical layouts, AutoCAD Civil 3D can model just about any situation you'll run into. In this class, we see how to create a 3D model of a water distribution system, edit the system to account for those design changes, and analyze it for design errors. Note that this class does not get into hydraulic analysis.

Speaker(s)

In 1998, armed with a Bachelor of Science in Civil Engineering from Colorado State University, I began my career working at a general civil engineering firm using Land Desktop LDT. Within a short time, I became the resident self-taught expert in LDT and AutoCAD and then learned AutoCAD Civil 3D upon its release. I then spent 13 years in the Autodesk reseller channel as a technical specialist delivering best-in-class training and support using AutoCAD Civil 3D, InfraWorks, and other Autodesk solutions. Currently, as CAD Manager and licensed profession engineer at GEI Consultants, I provide training and support to the engineers and designers on staff as well as implement new technologies to enable us to provide better designs on time and under budget. To that end, I am professionally certified in Autodesk software, have taught at Autodesk University ten times since 2007, am a member of the Autodesk Expert Elite program, and won the AUGI Top DAUG competition at AU 2011.

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Introduction

Pressure networks are an integral part to most civil engineering designs, from utility replacement to new design. Pressure networks were introduced into Civil 3D 2013 and improved in Civil 3D 2014 and then again in Civil 3D 2020.1. Pressure networks are very similar to pipe networks but are not compatible or interchangeable with the pipe networks.

The basic workflow for modeling pressure networks in Civil 3D is to first create the parts list. The parts list is made with the types of parts that will be used in the design. This allows you to limit the options you'll see as you are laying out the network. Next, layout the network. You can do this either by using the layout tools or converting an existing polyline into the pressure network. When laying out the network, you can specify the type of pipe, the cover over the pipe, the bends, and the appurtenances. Once the network is laid out horizontally, you display the pipe in a profile view and then adjust the elevations of the network. Most of the time during the design process, changes need to be made to the network. Accounting for interferences with the network can be one of the most time consuming portions of modeling a pressure system. The tools in Civil 3D greatly increase the speed in which you can model a lowering of one utility under another. Finally, you can run an analysis on the network to make sure that none of the parts are in violation of the design requirements. This analysis can check things such as making sure there is sufficient cover over the pipe, that a 16" pipe doesn't connect into a 6" fitting, and that the pipes and fittings are within the design criteria for deflection.

The different parts of a pressure network in Civil 3D

Before creating a pressure network, it's nice to understand its different parts. As with pipe networks, pressure networks have parts lists. The parts lists basically allow you to create a list of parts that you will be using while designing this particular design. For example, when creating a network for pressurized gas, there is no need to add fire hydrants so, in your parts list for the gas network, only include the parts you need.

Within the parts list, there are three different components you'll need to set up: Pipes, Fittings, and Appurtenances. Pipes are pretty much self-explanatory; they are the pipes you will be putting in the ground. The fittings are used when you are changing something in the pipe such as pipe size, direction, connecting multiple pipes, etc. Appurtenances are used in line when there is no change in the pipe. Examples of appurtenances are valves, hydrants, etc.
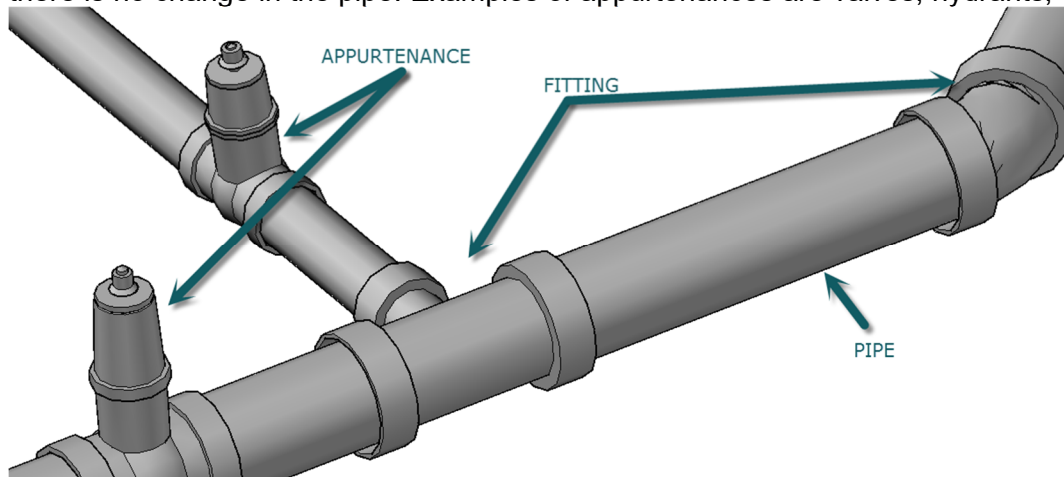
Parts List

Similar to the older Pipe Networks that have been in Civil 3D for quite a long time, the Pressure Networks require a parts list. Basically, you create a parts list that contains the parts that you are going to use for this particular type of design. You can create different parts lists for the different types of pressure networks you'll use (water, gas, sanitary force main, etc.) or you can get even more detailed and create different parts lists for the different types of parts in the individual utilities (PVC water distribution vs. ductile iron water distribution).

Setting Catalog

Prior to creating a parts list, you must specify the catalog that the parts list will be referencing. The catalog contains all the data for the parts that will be added to the parts list. The catalog is a .sqlite file with supporting files in a similarly named folder.

| Name	Date	Type	Size
Imperial_AWWA_Flanged	4/14/2019 9:00 AM	File folder	
Imperial_AWWA_HDPE	4/14/2019 9:00 AM	File folder	
Imperial_AWWA_Mechanical	4/14/2019 9:00 AM	File folder	
Imperial_AWWA_PushOn	4/14/2019 9:00 AM	File folder	
Imperial_AWWA_PVC	4/14/2019 9:00 AM	File folder	
Imperial_AWWA_Steel	4/14/2019 9:00 AM	File folder	
Imperial_AWWA_Flanged.sqlite	11/22/2017 10:16 ...	SQLite Spatial Dat...	4,800 KB
Imperial_AWWA_HDPE.sqlite	11/22/2017 10:16 ...	SQLite Spatial Dat...	3,488 KB
Imperial_AWWA_Mechanical.sqlite	1/5/2016 2:27 AM	SQLite Spatial Dat...	6,528 KB
Imperial_AWWA_PushOn.sqlite	1/25/2013 6:15 PM	SQLite Spatial Dat...	3,552 KB
Imperial_AWWA_PVC.sqlite	11/22/2017 10:16 ...	SQLite Spatial Dat...	4,832 KB
Imperial_AWWA_Steel.sqlite	11/22/2017 10:16 ...	SQLite Spatial Dat...	5,792 KB

Name	Date	Type	Size
Metric_AWWA_PushOn	4/14/2019 9:00 AM	File folder	
Metric_Ductile_Iron	4/14/2019 9:00 AM	File folder	
Metric_PE	4/14/2019 9:00 AM	File folder	
Metric_PVC	4/14/2019 9:00 AM	File folder	
Metric_Steel	4/14/2019 9:00 AM	File folder	
Metric_AWWA_PushOn.sqlite	1/25/2013 6:15 PM	SQLite Spatial Dat...	3,552 KB
Metric_Ductile_Iron.sqlite	1/2/2018 3:12 AM	SQLite Spatial Dat...	3,968 KB
Metric_PE.sqlite	1/2/2018 3:12 AM	SQLite Spatial Dat...	4,480 KB
Metric_PVC.sqlite	1/2/2018 3:12 AM	SQLite Spatial Dat...	4,064 KB
Metric_Steel.sqlite	1/2/2018 3:12 AM	SQLite Spatial Dat...	4,064 KB

Autodesk Civil 3D 2020 ships with eleven catalogs, five metric and six imperial. If installed to the default location, the catalogs are located at "C:\ProgramData\Autodesk\C3D 2020\enu\Pressure Pipes Catalog". To switch to a different catalog, expand out the "Create Design" panel on the

"Home" tab of the ribbon and choose, "Set Pressure Network Catalog"
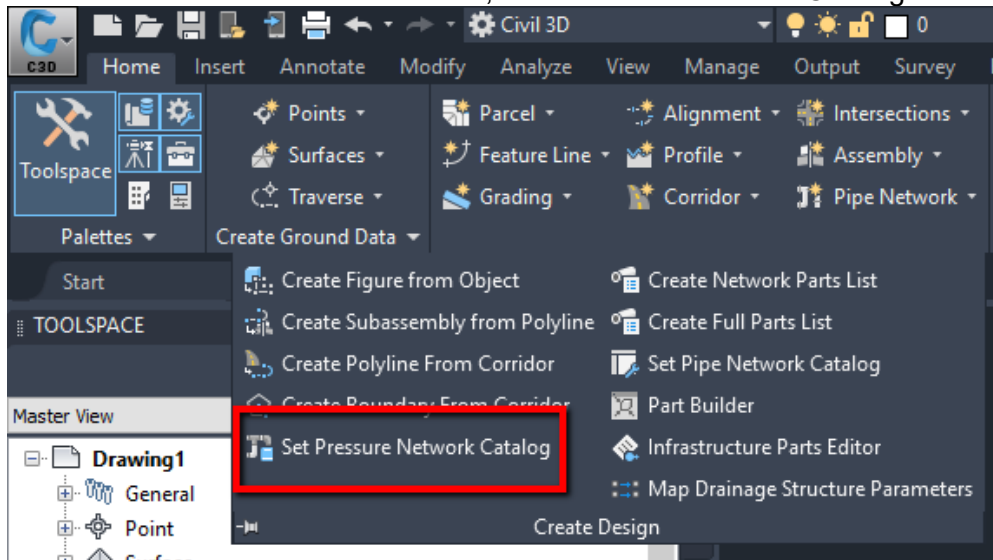
Available catalogs
The eleven catalogs available in Civil 3D 2020 are as follows:
Metric_AWWA_PushOn
Metric_Ductile_Iron
Metric_PE
Metric_PVC
Metric_Steel
Imperial_AWWA_Flanged
Imperial_AWWA_HDPE
Imperial_AWWA_Mechanical
Imperial_AWWA_PushOn
Imperial_AWWA_PVC
Imperial_AWWA_Steel

Many fittings that you will need can be found in one of these catalogs however it is limited. If you need additional parts, materials, and/or sizes, you'll need to create the parts for that. Civil 3D 2020 comes with instructions for creating your own parts. By default it's installed at "C:\Program Files\Autodesk\AutoCAD 2020\C3D\Sample\Civil 3D API\Part Publishing Wizard\PartPublishingWizardUsersGuide.docx".

Creating Parts Lists

To create a parts list for your pressure network, go to the settings tab of the Prospector, expand out Pressure Networks, right click on Parts List, and select New
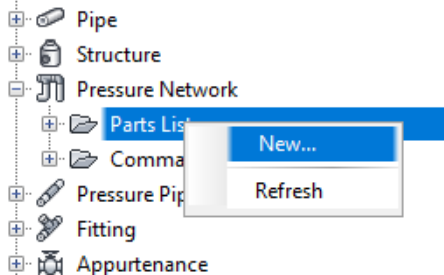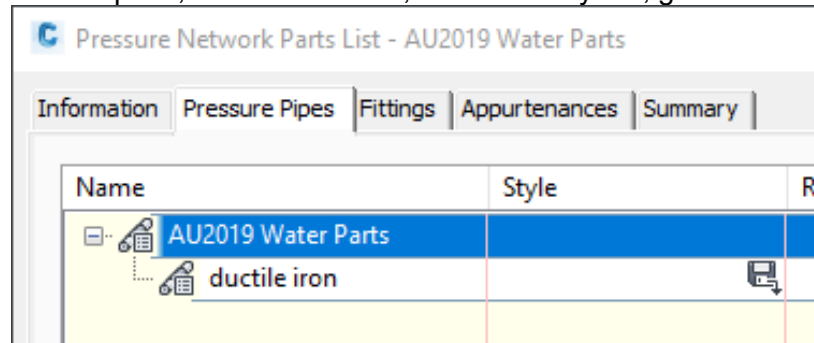

The information tab is basically the same as everything else in Civil 3D, you can name it, give it a description, etc. The last tab, the Summary tab, gives an overview of everything.

Adding parts

To add a part to a network, simply right click on the Parts List name under the section you want to add the part to (pipes, fittings, or appurtenances) and choose Add Material… (for pipes) or Add Type… (for fittings and appurtenances). Once the material or type has been added, right click on it and choose Add Size…
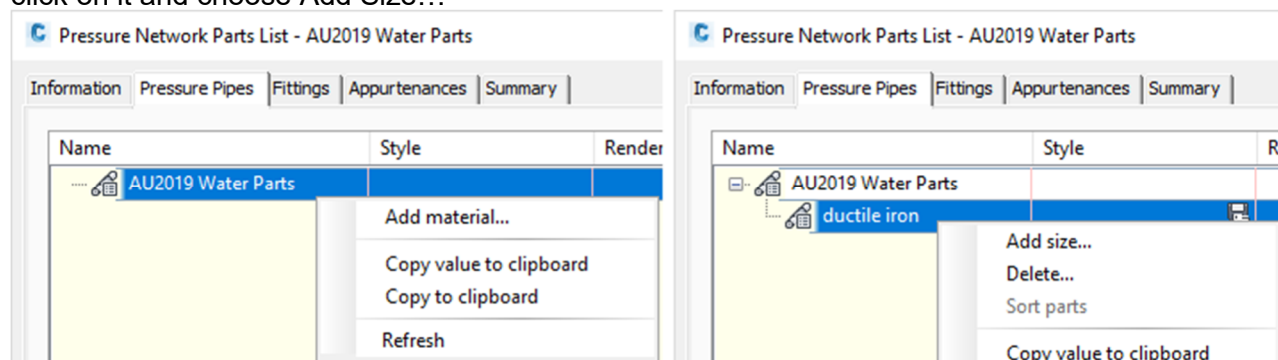
Once the sizes have been added to the parts list, you can then assign styles, render materials, and pay items to the parts for visualization and quantity take off purposes.

Creating the Network

There are three different methods to create a network: Pressure Network Creation Tools, Create Pressure Network from Object, and Create Pressure Network from Industry Model. This course will focus primarily on the first method. If you have a simple network (i.e. one run with no

branches) the object method works well. The Industry Model will take a Map 3D Industry Model and make a pressure network out of it (most design firms will not have one of these created but if you do, it makes it really easy to get that network created).
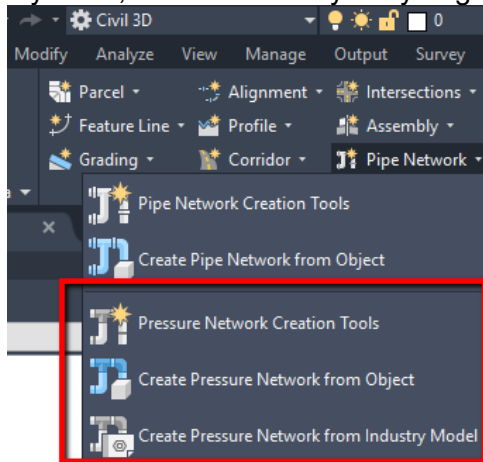
Layout a pressure network both horizontally and vertically

When laying out a pressure network, designers have to consider where it's going to go both horizontally as well as vertically. Civil 3D includes tools that will help with both aspects of the design. Once the network has been created, design the horizontal portion of the network. After creating the pressure network, the ribbon will change to show the Pressure Network Plan Layout tools.
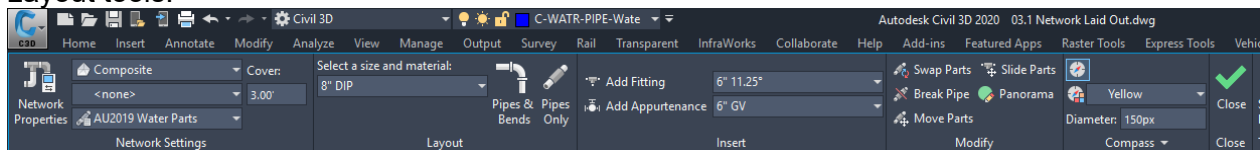
Horizontal Tools

A typical workflow for laying out pressure pipes is to determine the horizontal location of the pipes first. Civil 3D has several options for laying out the pipes. After creating the network, the Pressure Network Plan Layout tools are displayed on the ribbon. On the far left you can change things such as the reference surface, the reference alignment, the parts list, the default cover of the pipe, and other network properties.
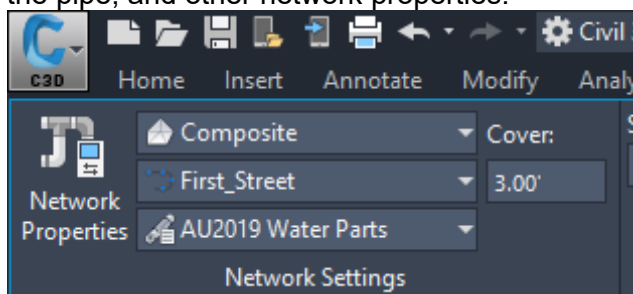
As you are laying out the initial pipe location, use the tools on the Layout panel. Choose the appropriate pipe size for the design and then choose either Pipes & Bends or Pipes Only. If you choose Pipes & Bends, Civil 3D will only allow you to put in the bends that are available in the selected parts list. If you don't get the option to put in any bends, check your parts list and make

sure there are bends. Unfortunately, you are restricted to exactly the angle of the bends in the parts list. If you use the Pipes Only option, as you layout the pipes, you can change the direction of the pipes within the allowable deflection as defined in the parts list.
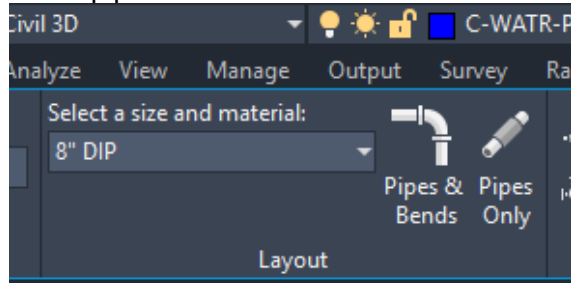
After parts are added to the drawing, fittings and appurtenances can be inserted into the model. Simply select the appropriate part and then select which part of the model you want to add the part to. As you move your mouse over the different pressure parts in the drawing you'll see a series of glyphs appear near your crosshairs.
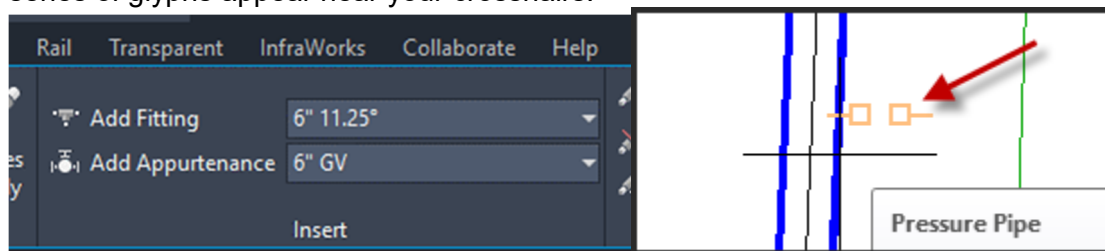
Compass

When using the Pipes & Bends method of laying out the network, a compass is used to present the available bends in the parts list. The compass is designed to assist in the layout of the network. If the deflections desired are not being displayed, change the parts list to one that has bends defined in it.

CORRECT PARTS LIST   INCORRECT PARTS LIST
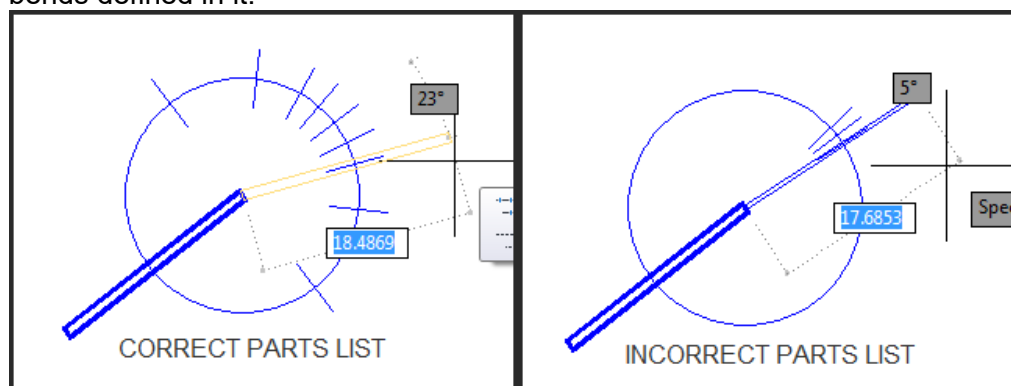
Unfortunately, when using the compass, the design is restricted to exactly the angle of the bends as represented in the parts list. If that is the goal of the design, (i.e. EXACTLY a 45° bend) then the compass works just great. If you need to put in a 42° bend, the compass doesn't allow you to do that. One way of accomplishing this is to put in the 45° bend and then, prior to putting in the next fitting, adjust the pipe accordingly. To adjust the pipe, select it and then pick

the double arrow (or diamond) grip. This grip will allow you to adjust the angle of the pipe but not the length. Once the pipe is adjust to the desired location, select the + button at the end of the pipe (visible after selecting the pipe) to allow you to continue with the Pipes & Bends command.
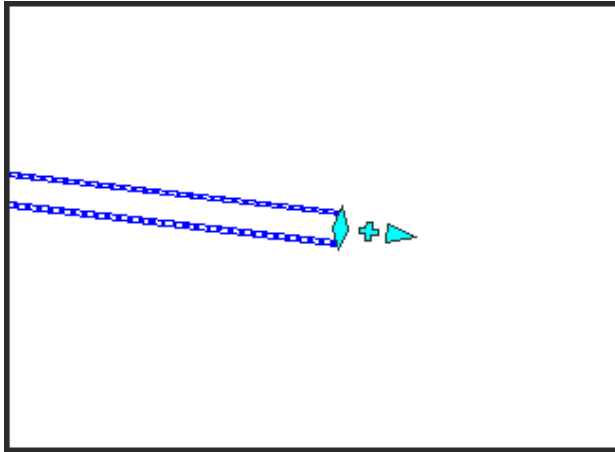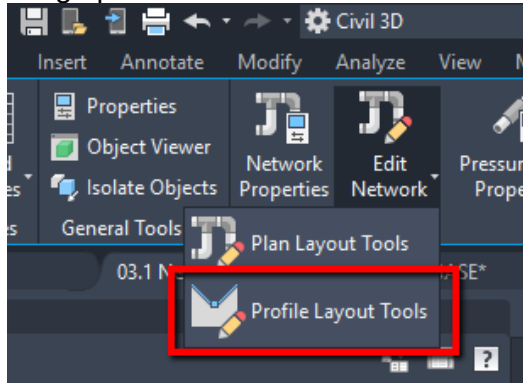

Vertical Tools

Once the horizontal layout of the network is completed, it's time to do the vertical design. Most people find the easiest way to do this is within a profile view. Civil 3D has tools to automate the creation of profiles for your network and, if these tools are used, they make it so you can even add pipes in your profile.

To create a profile for a run of pressure network, use the "Create Alignment from Pressure Network" command. Follow the prompts and continue through the command until you have a profile view with the network parts used to create the alignment displayed in it.
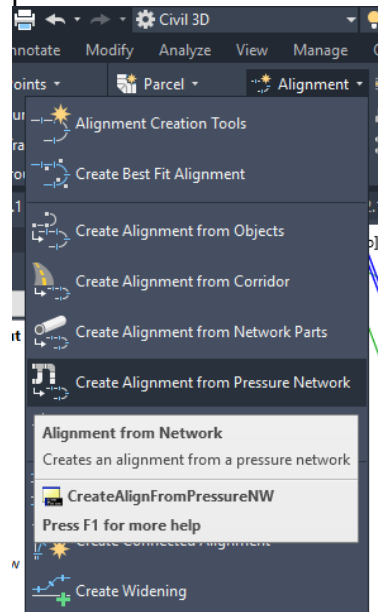

Once the pipes are displayed in the profile view, you can edit the elevations of them. Select one of the parts of the network you wish to edit vertically (it doesn't matter if it's in plan or profile)

and on the ribbon choose the, "Profile Layout Tools" on the Edit Network pull down. This will bring up the tools that will be used to edit the elevations in the profile view.

The Profile Layout Tools are very similar to the Plan Layout tools. There are tools to add pipe, fittings, and appurtenances. Curve Pipe and Follow Surface are additional tools that are available.
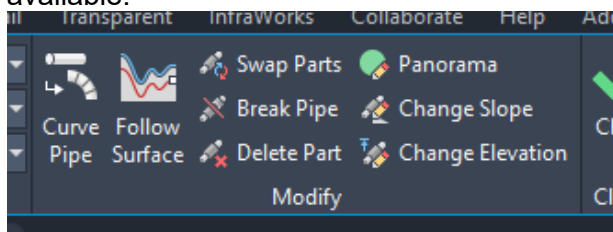
Curve Pipe
To put a vertical curve in the pipe, use the Curve Pipe command on the Profile Layout tools. The vertical curve on the pipe is only circular and is not intended to follow along a parabolic vertical curve that is typically used in roadway design.

Follow Surface
If the pipe needs to follow the existing ground such as within a vertical curve of a road (i.e. parabolic road curve), use the Follow Surface command. This will edit the pipe and place vertices on the pipe as well as set the elevations of the vertices to a set distance below the

target surface.
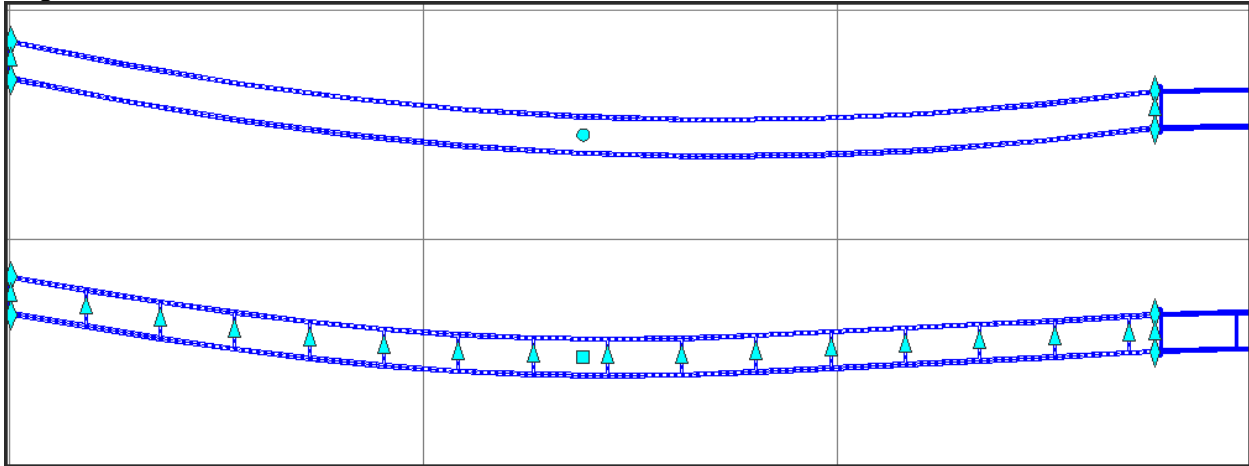
Can the Pipe be Straightened?

So your pipe is curved or following the surface and you want to straighten it back out. Perhaps it curved and you want it to follow the surface now. Unfortunately, there aren't any commands to straighten the pipe back out vertically. There are two option to get a straight pipe back: 1) Grip edit it so the midpoint grip is exactly half way between the ends of the pipe or 2) Delete the pipe and recreate it in either plan or profile. If you are working in the profile view, simply hitting the delete key or using the erase command won't remove the pipe from the model, it will only set it so that pipe (or fitting or appurtenance) is no longer displayed in the profile view. To delete a part from the profile view, use the Delete Part command on the Profile Layout Tools and then use the Pipes & Bends command to recreate the pipe.

Combination Horizontal and Vertical Layout

Sometimes it's necessary to put in a fitting (such as a 45° bend) that is angled along both the horizontal and vertical planes of the design. To accomplish this, change your drawing to a 3D view and then continue the layout by pressing the plus symbol (+) at the end of the pipe.
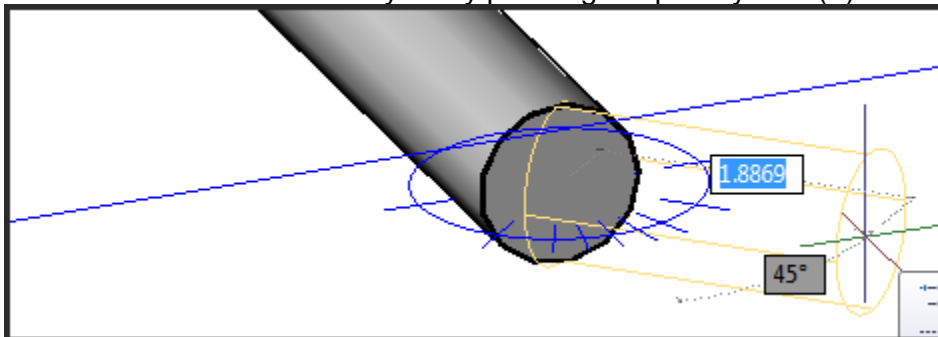
If the fitting needs to be at a different angle vertically (i.e. not on the horizontal plane) pressing the P key on the keyboard will rotate the compass and allow different angles.
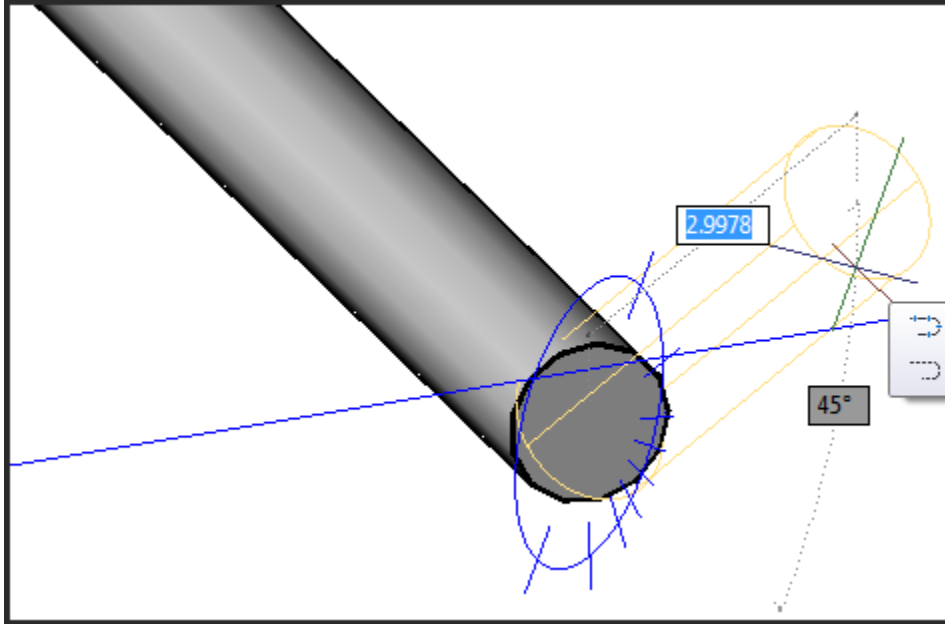
If there is already a fitting at the end of the pipe that needs to be rotated about the end of the pipe, select the fitting (while in a 3D view) and grab the rotate grip (this can be difficult to find in some visualization styles so changing to wireframe may help). The rotation of the fitting will automatically snap to a predefined angle.
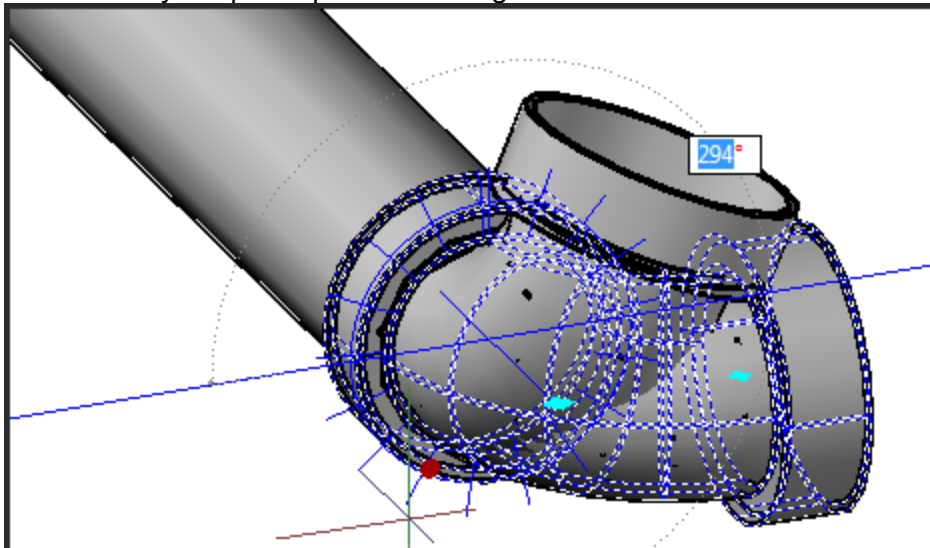
To control the angle at which the P key rotates the compass, expand out the Compass panel on either the Plan Layout Tools or the Profile Layout Tools and adjust the value for 3D Plane. To control the angle at which the fitting rotation is snapped to, change the value for 3D Snap.
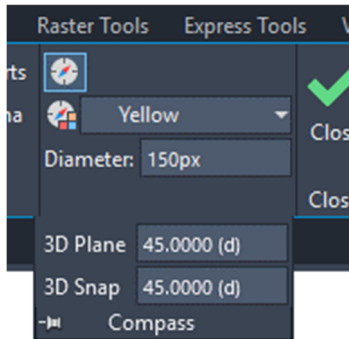
Edit pressure networks to account for design changes such as crossing utilities

Often times the initial design will change as the project progresses or conflicts between the pressure network and another utility will be found. Sometimes simple edits horizontally and/or vertically will suffice but sometimes more drastic measures are required.

Move fittings/appurtenances

Fittings and appurtenances can be moved both horizontally in the plan view and vertically in the profile view. Selecting the "Panorama" button on the Pressure Network Layout Tools Ribbon (available on both the plan and profile tools), will allow you to change most of the properties of the pressure network parts. The elevations of the ends of the pipes, the northing and easting of fittings, styles, and surface/alignment references can all be changed in the Panorama.

Name	Descripti...	Style	Render ...	Nominal ...	Referenc...	Referenc...	Station	Offset	Insertion ...	Insertion ...	Insertion ...
Fitting -	8" 22.5°	Fitting	ByLayer	8 in x 8 in		Composite			1024467.725	77948.9374'	141.96'
Fitting -	8" 22.5°	Fitting	ByLayer	8 in x 8 in		Composite			1024542.216	77860.8966'	145.01'
Fitting -	8" 22.5°	Fitting	ByLayer	8 in x 8 in		Composite			1024676.246	77497.7231'	151.90'
Fitting -	8" 22.5°	Fitting	ByLayer	8 in x 8 in		Composite			1024668.761	77401.5774'	153.29'
Fitting -	8" 22.5°	Fitting	ByLayer	8 in x 8 in		Composite			1024623.292	77316.5332'	154.51'
Fitting -	8" 11.25°	Fitting	ByLayer	8 in x 8 in		Composite			1024444.949	77176.2530'	156.75'

Any piece of data that is in a white cell can be changed and any that is in a greyed out cell is for reference only.

Add in crossing

A very time consuming and often a very common task is to model a vertical lowering of a pressure pipe under an existing utility.
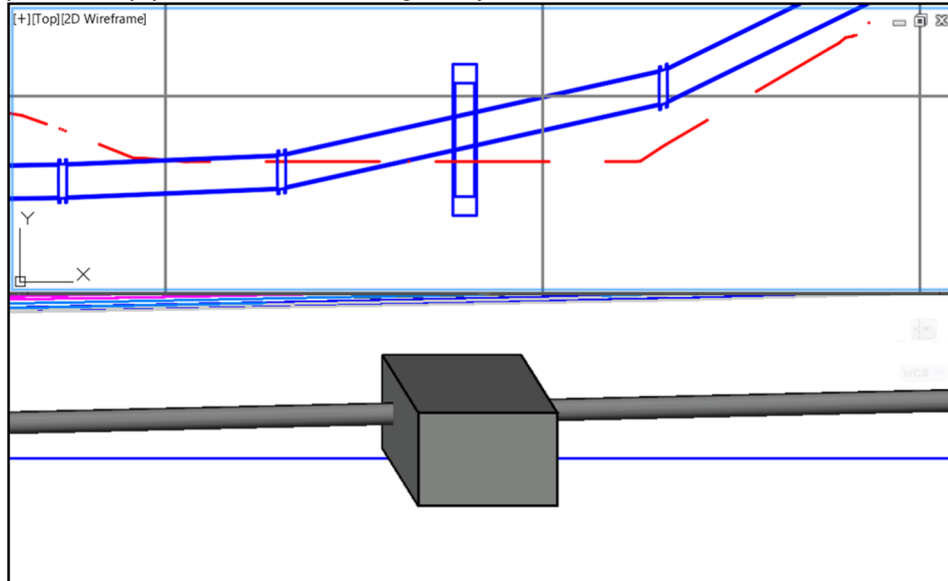

In this case, a pressure pipe is interfering with a box culvert. Rather than lowering the entire length of pipe, it's decided to put in a utility lowering at this location (four 45º bends to bring the pipe under the culvert). One thing that will make this much easier is to first work in a profile view that does not vertically exaggerate the elevations. This makes it much easier to see the angles of the bends and pipes as well as to draw construction geometry.

First thing to do is to draw in lowering where you need it to be. Depending on the design constraints and the reviewing agency, this can be different than what is being used here. In this example, the pipe needs to have 18" of clearance from outside of pipe to outside of culvert and the bends need to be 18" away from the culvert horizontally. Here is the layout of the top of the

pipe for the lowering:
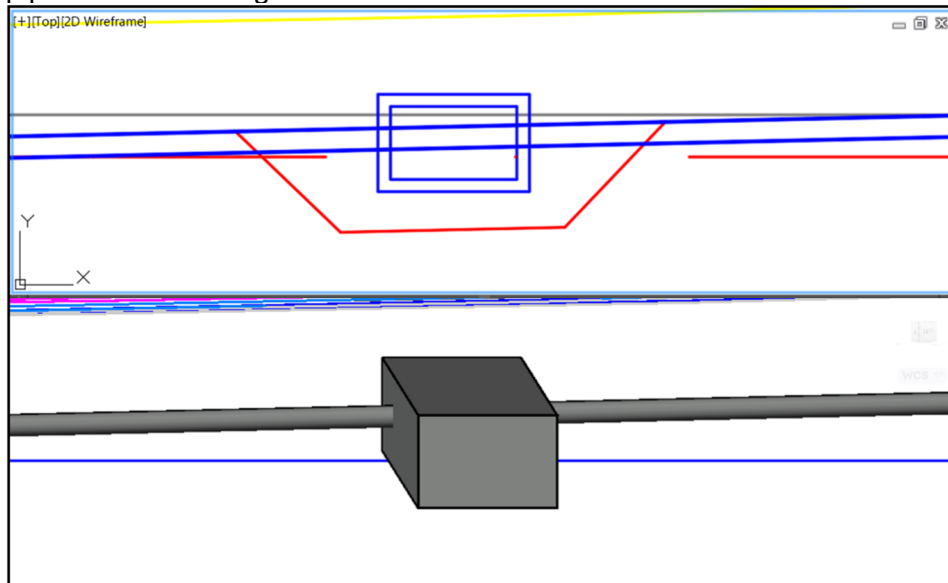
Once the lowering has been determined, remove the piece of the pipe that will be lowered. Use the Break Pipe command on the Pressure Network Profile Layout tools to break the pipe at the locations of the top bends and then use the Delete Part command to remove the middle piece of the pipe. The erase command doesn't work in a profile view. If you select the part in profile and use the erase command (or the delete key), the part isn't erased, it is just no longer displayed in the profile.
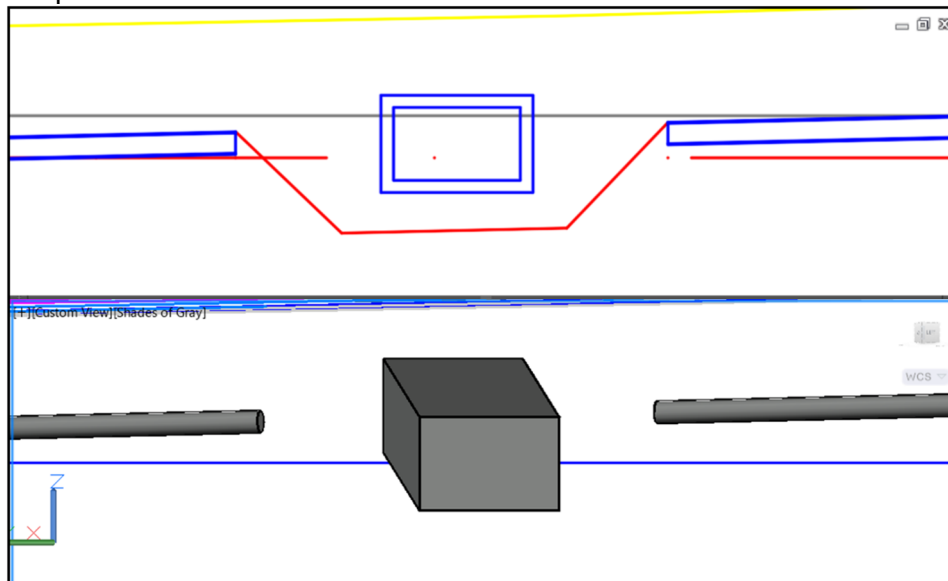

Next, adjust the construction line so it represents the middle of the new pipe and use the Pipes & Bends command on the Pressure Network Profile Layout ribbon tab to put in the new pipe starting at both ends. Leave a gap in one of the lines as you do this as shown in the image

below. Make sure all four fittings are placed in the crossing.
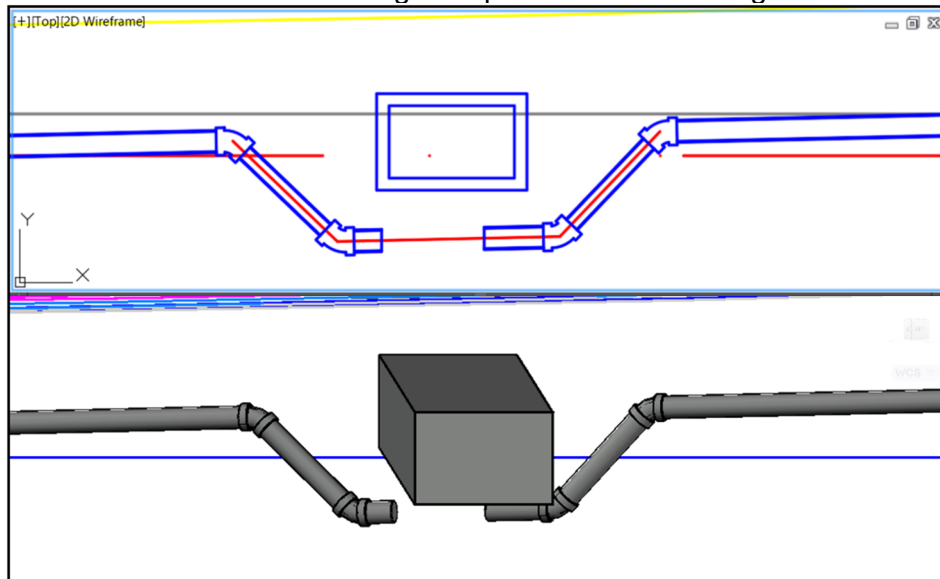
There will be two pipes along one of the lines with a gap between them. Delete one of the extra pipes and then use the grips to adjust the end of the other pipe and connect it to the other fitting.
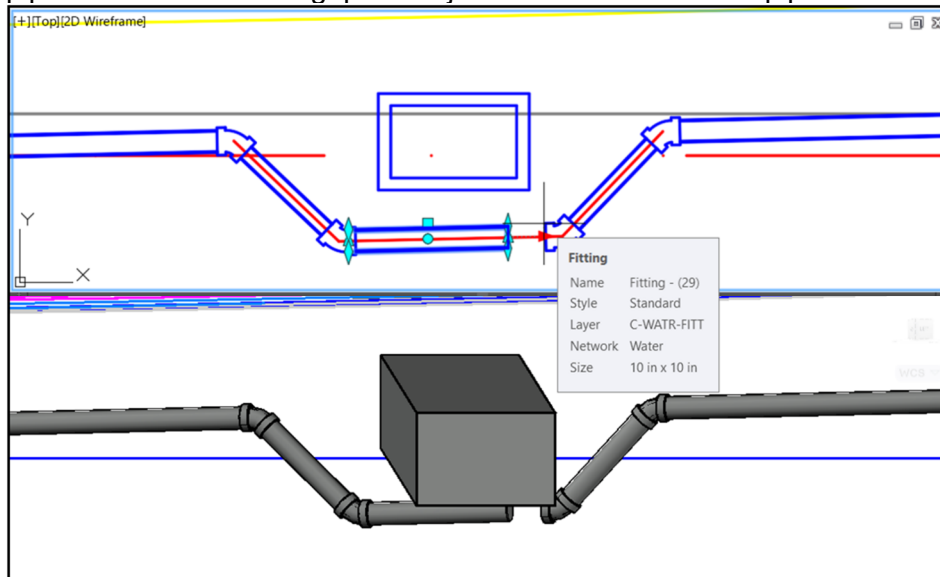
Adding a lowering isn't quite as automated as some of the other features within the program (perhaps in a future release?) but once you figure out the steps, it's not too bad.
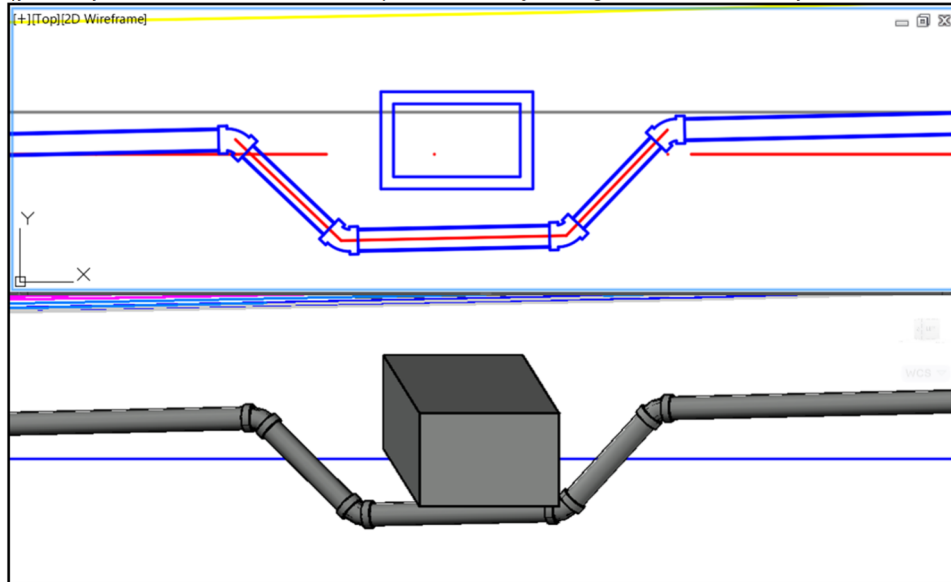

Analyze the pressure network to find faults in the layout of the model
Just because Civil 3D will allow you to create the network, that doesn't necessarily mean the network can actually be built. Civil 3D will allow you to model the network in a fashion that shouldn't or even can't be built.
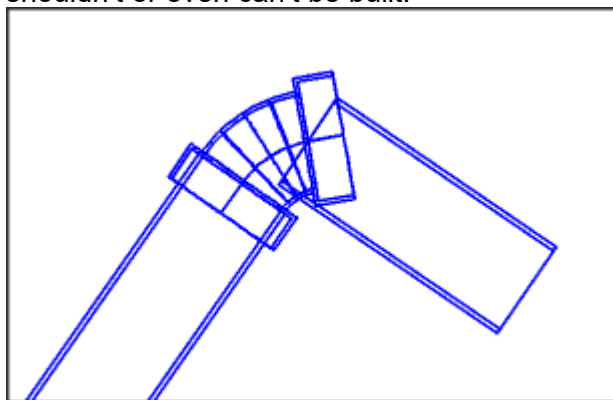

Even though the above image is quite obviously an error, some errors are very small and difficult to locate. Civil 3D provides two tools that will analyze the network and look for errors: Design Check and Depth Check. To access these tools, go to the Modify tab on the ribbon, expand out the Design panel and select Pressure Pipe Network. This will bring up the Pressure Network contextual tab but without needing to have a part selected.
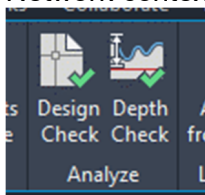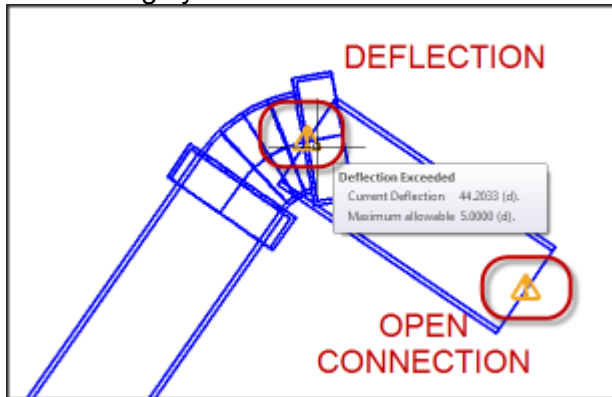
Design Check

When the Design Check command is run, it will ask you for the starting and ending parts to run the analysis on. This will not run the analysis for the entire network, just a run of the pipe. If the network has several branches or loops, there is a Command Line option to "Select entire Pressure Network" which will allow you to run it on the entire network. After running the command, a dialog box will open with options on which checks to perform.
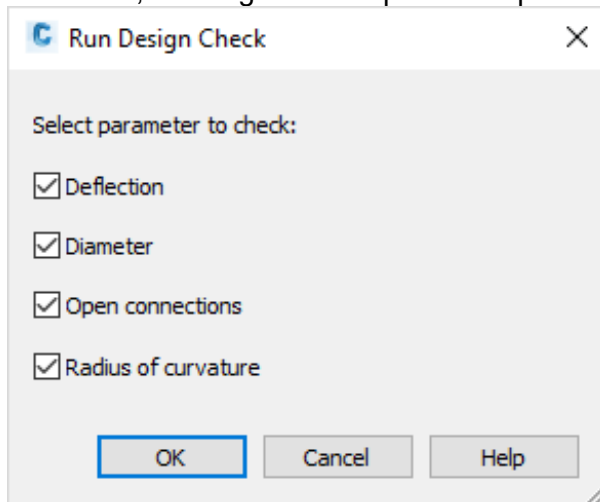

- **Deflection** – The parts list used to create the network sets an allowable deflection whenever a pipe connects to a fitting or another pipe. This will check the deflections and if any exceed the allowable deflection a warning will be displayed.
- **Diameter** – The pipes, fittings, and appurtenances all have a nominal diameter specified for each connection point. If a pipe and a fitting/appurtenance connection have different diameters, a warning will be displayed.
- **Open connections** – If a pipe doesn't end at a fitting or appurtenance, a warning will be displayed.
- **Radius of curvature** – The parts list used to create the network sets an allowable radius to be used when curving a pipe. If any of the pipes have a radius smaller than what's specified a warning will be displayed.

If any warnings are found in the network, warning symbols will be displayed in the drawing area at the location of the issue. To find out what the warning is for, simply hold the cross hairs over

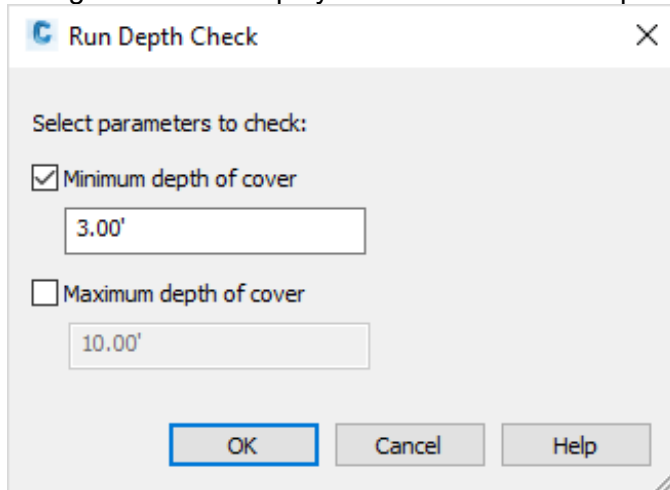the warning symbol and it will show what the warning is for.

Once the warnings are in the drawing, they may continue to be displayed even after the issue is resolved. Although, by default, the symbols won't plot, they can be rather annoying to have them still in the drawing. Rerunning the design check will remove any that have been resolved but there may be some that won't be resolved. To remove all the warning symbols, select one of the parts in the drawing, right click, and choose
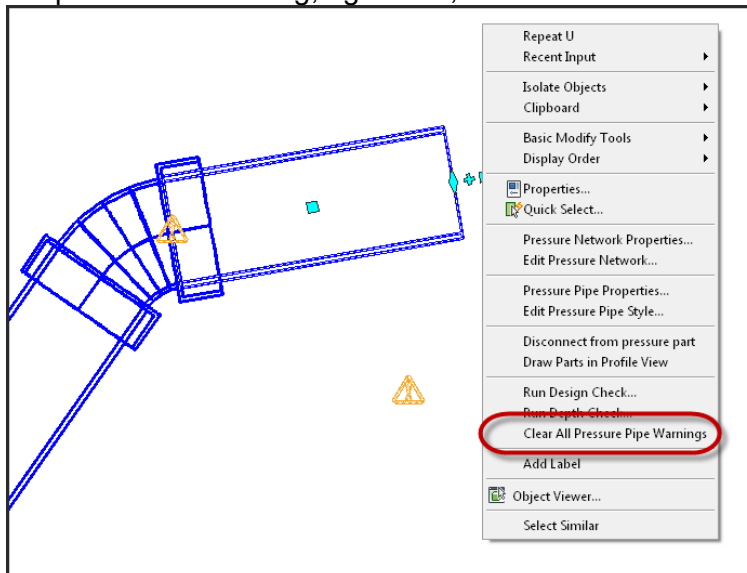

Depth Check

In a similar fashion to the Design Check command, the Depth Check command will analyze the network for locations that have a cover less then or greater then a specified depth. Unlike the Design Check, this can't be run on the entire network, it must be done on a single part or from one part to another part along a single path (either plan or profile). When the command is run, a

dialog box will be displayed with the available options of the command.

Choose the type of analysis desired and then the appropriate depths to check for. If any violations are found, a warning symbol will be displayed in the drawing. For additional information, mouse over the warning symbol and it will show the location where the violation is happening.
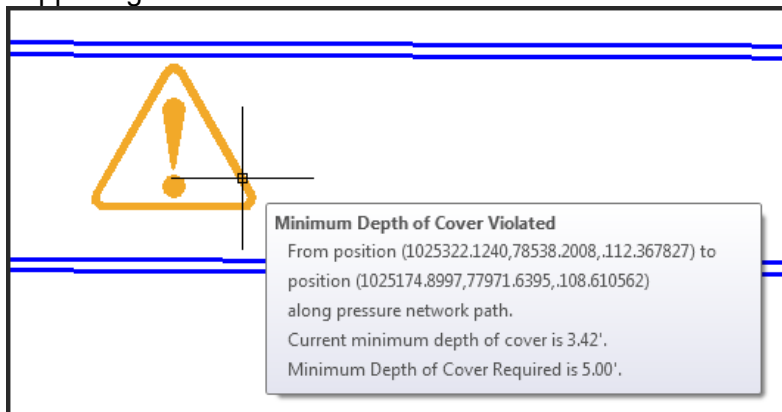
Conclusion

By now, you should have decent understanding of how Pressure Networks work in Civil 3D. You can explain the different parts of the Pressure Network as well as create a parts list for your design. You can use the different layout tools to create the network both horizontally as well as vertically. When design changes are required, you can edit the network and account for utility crossings. You can also analyze your network to find issues with the design. So, the next time you hear someone say, "I don't use Pressure Networks because they just can't do what I need", quietly chuckle and get to modeling your network.