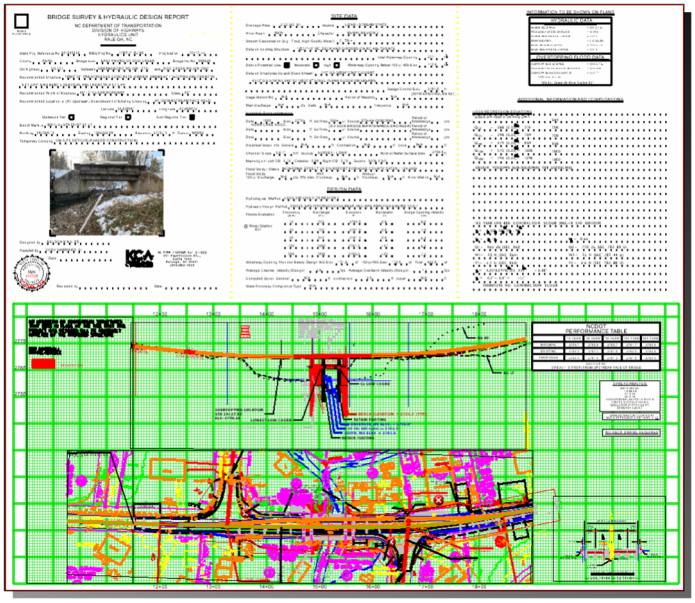
Draft Hydraulic Structure Report
ORD Production Guide

Prepared for: North Carolina Department of Transportation Hydraulics Design Unit

Utilizing: OpenRoads Designer CE 2022 Release 3 (ORD 10.12)



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1.0 Introduction

The intent of this document is to present a passable workflow for creating a Bridge Survey Report (BSR) and Culvert Survey Report (CSR) sheet in Open Roads Designer (ORD). This production manual is a draft and, due to the nonstandard layout of a Hydraulic Structure Report (HSR) sheet, will include current known workarounds to allow for the creation of the HSR sheet. Only the items required to create a HSR sheet will be covered within this guide. Modeling, drainage design, and general drafting will not be covered. It is highly recommended that whether a user desires to create a BSR or CSR for a particular project, this guide should be read in its entirety before drafting a BSR or CSR, as some instructions within the BSR guidance will need to be applied for creating a CSR. Future versions of this guide will further explain the development of each report type in more detail as workflows are refined.

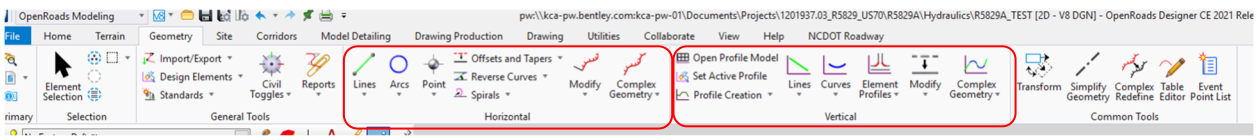
This production guide was originally written utilizing *OpenRoads Designer CE 2022 Release 3* (ORD 10.12) and the *NCDOT_CONNECT_WORKSPACE* (10.12.NC.23.12). This guide has been updated utilizing *OpenRoads Designer 2023* and the *NCDOT_CONNECT_WORKSPACE*(2023). This guide is to be used in conjunction with the latest NCDOT ORD production Module documents located on the NCDOT Connect site.

1.1 Introduction to Geometry Elements

ORD linear geometry elements consist of two parts, a horizontal element, and a vertical element. Together these elements store the three-dimensional positioning of a linear element. Geometry elements are the basis for many other tools within ORD, including named boundary and sheet creation.

- Horizontal Geometry – Linear elements housed in the 2D design view. Sets the X and Y positioning and can be dynamically ruled.
- Vertical Geometry – Profile elements housed in the profile view (*Attached Long Section*) of a linear element. Sets the Z positioning and can be dynamically ruled.
- Profile View – Each horizontal geometry element has a profile view that can be opened with the “Open Profile Model” tool.
- Rule Based Elements- Geometry information that determines the position of an element. There are various ways to rule elements. Few examples: Snap rules, Offset, projected profile, etc. The type of rule created depends on the specific design tool used to create it and how it was created.

Linear Geometry elements are created using the geometry ribbon tab.



There are various ways to create, edit and use geometry elements in ORD. For more information on the tools see *NCDOT ORD Module 3 and 6* and OpenRoads Designer Geometry Section.

1.2 Introduction to Feature Definitions

Before beginning with the design and drafting tools one of the concepts that will be new to the ORD user are feature definitions.

Feature Definitions are included in the NCDOT workspace. They are used to control symbology, and various other properties that are applied to ORD elements.

The Feature Definition Toolbar is a way to easily activate and deactivate the Feature Definition settings. Using the Feature Definition Toolbar is not a requirement, but most users will find it helpful. It is important to choose the correct Feature Definition when placing elements in the design because that Feature Definition will control the properties not only of that element during that step but also how it looks and interacts with other design elements in later steps during the design process.

To activate the Feature Definition Toolbar, use the search bar in the top right corner of ORD.

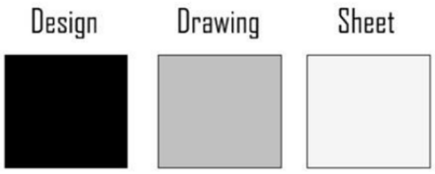
With the "Use Active Feature" Toggle set to on any tool that creates a featured element will automatically be set to the feature that is set in the Feature Definition Drop Down.

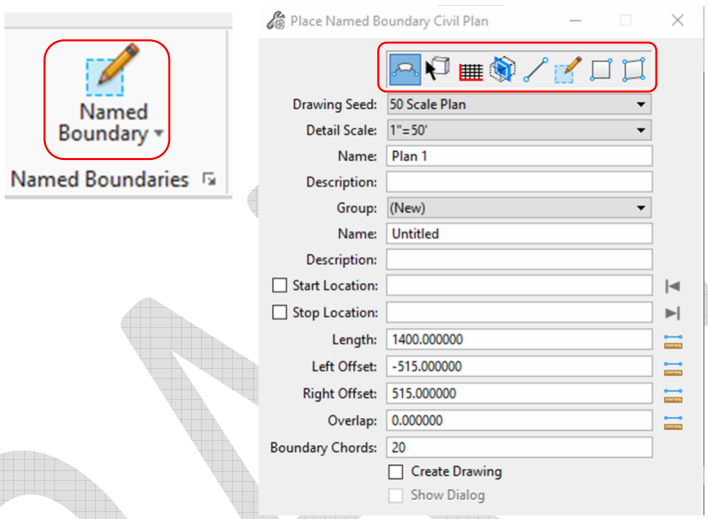
1.3 Introduction to Named Boundaries and Sheet Models

In ORD there are three model types: Design, Drawing, and Sheet Models.

- **Design Model:** Is where you will do most of your drafting and manual labeling.
- **Drawing Model:** Output by the named boundary and determines the clip area. This is where auto annotations and some manual annotations are held.

- **Sheet Model:** Output by the named boundary and is set to true 1:1 paper size. The only elements that are live in this file are the sheet border elements and sheet specific components such as the sheet number.





A **Named Boundary** is a created element that stores view and sheet properties and is used for automating drawing and sheet model production. This element is created and stored in the design model. Named Boundaries are created with the named boundary tool using different methods and formats depending on the type of sheet you would like to create such as: Plan by element, Plan by shape, Profile, Cross section, etc.

For more information on the use of named boundaries see *NCDOT ORD Module 13 – Sheeting* and OpenRoads Designer Named Boundaries Section.

2.0 BSR Production

In accordance with Section 8.5 of the 2022 Guidelines for Drainage Studies and the published BSR_Guide Key, the following will be needed to set up a BSR sheet:

- BSR Cell
- Plan View
- Profile View
- Typical Section
- Details (where applicable)
- Supplemental Profiles (where applicable)
- Design Data

2.1 File Structure

This section outlines the general file structure for setting up a BSR. This file structure can be adapted for project-specific circumstances. For more information see NCDOT ORD Module - 1 File Management.

BSR Design Model

File Naming Convention: *TIP#_HYD_BSR.dgn*
Contents*:*

- BSR Cell
- Referenced design files
- Referenced survey file

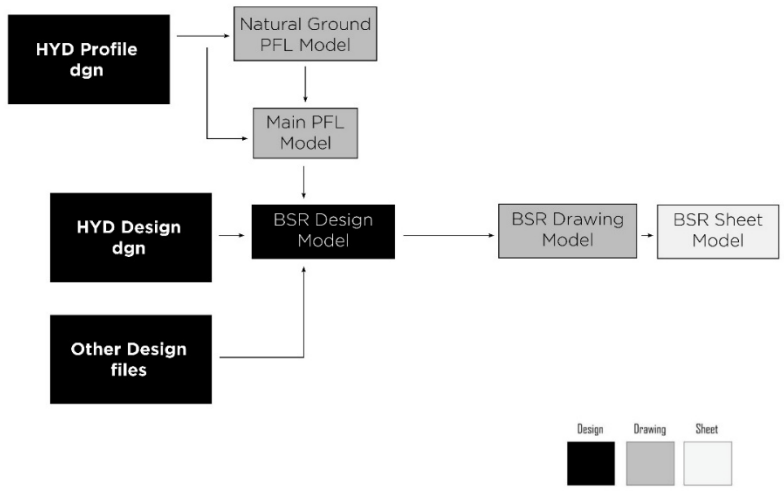
  NOTE: If survey was done in V8i set line style scale to “Reference” or “none” to fix annotations.
- All BSR labels not provided in design labels.
- Named boundary used to create the drawing and sheet model.

HYD Profile

File Naming Convention: *TIP#_HYD_PFL.dgn / TIP#_HYD_BSR_PFL.dgn*
Contents:

- Profile named boundary associated with the roadway alignment.
- Profile drawing model.
- Centerline and offset elements for natural ground left and right.
- Centerline element drawing model.
- Profile linework for bridge, abutments, excavation, etc.

BSR File Structure Diagram:

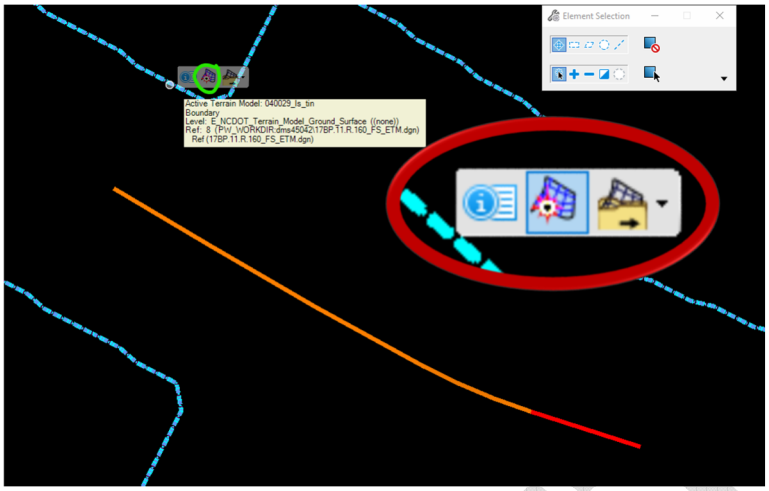


2.2 Profile Creation

Profiles in ORD are handled very differently than how they were in geopak. ORD profiles are stored within the horizontal geometric element. To obtain a referenceable view of a profile, you must first create a drawing model using the Named Boundary Tool.

1. Create a new blank.dgn named *TIP#_HYD_PFL.dgn or TIP#_HYD_BSR_PFL.dgn*
   a. Use the NCDOT seed file located in the workspace.
2. Reference the following:
   a. Roadway alignment file.
   b. Survey terrain file. This will be provided either within the FS file or as a standalone ETM file.

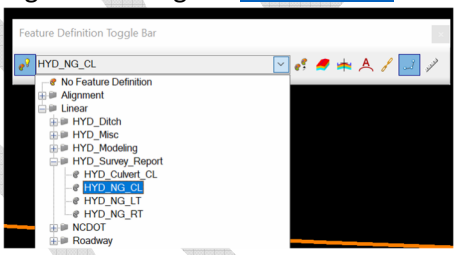
   NOTE: Other files may be added for preference and viewing purpose but at a minimum the above files are required.
3. Set the existing terrain as active. This will set the file to automatically display the existing ground along any element in profile view.

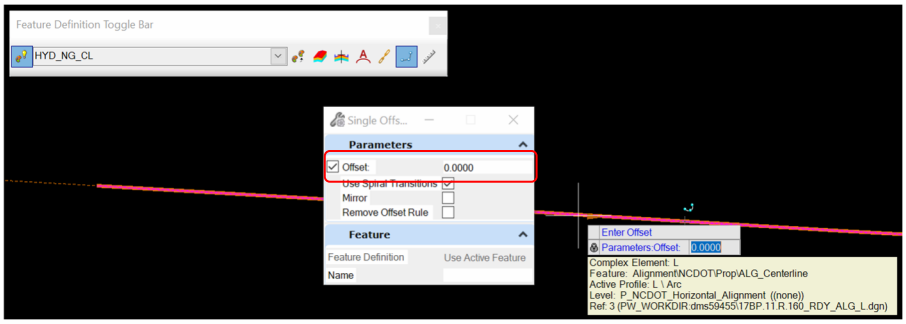


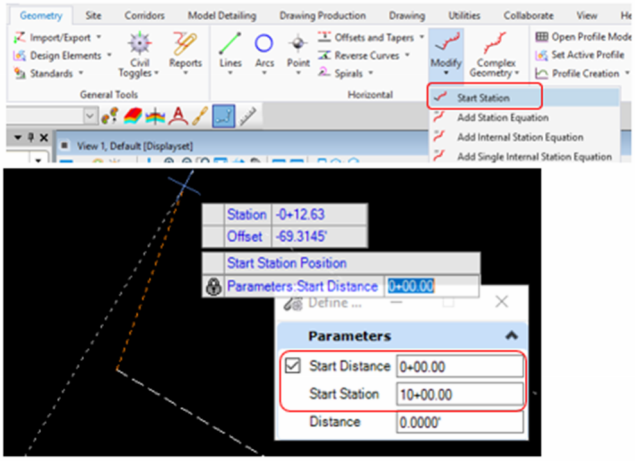
4. Create three (3) horizontal alignments, NG_CL, NG_LT, and NG_RT, based off the roadway alignment using the **Single Offset Entire Element** Tool. Using this geometry tool will ensure the geometry and profile views remained ruled to roadway's horizontal geometry. Should roadway change the alignment, the lines ruled to it will update accordingly.

   NOTE: The reasoning for creating a NG_CL element is to have an element that matches stationing and position of roadway's alignment to project the NG_LT and NG_RT onto. The project tool cannot project onto a referenced element only one that is live in the file.

   a. A Natural Ground Centerline (NG_CL) element with an offset of zero (0) feet, using the feature definition HYD_NG_CL.
      i. Modify the start station of this element to match the stationing of the roadway alignment using the **Start Station** tool.

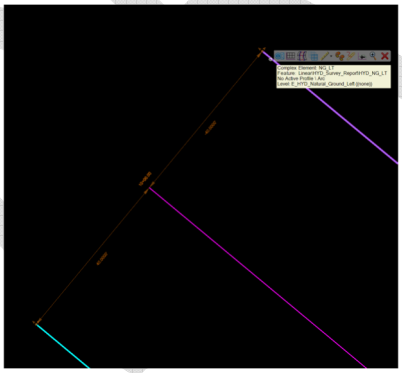




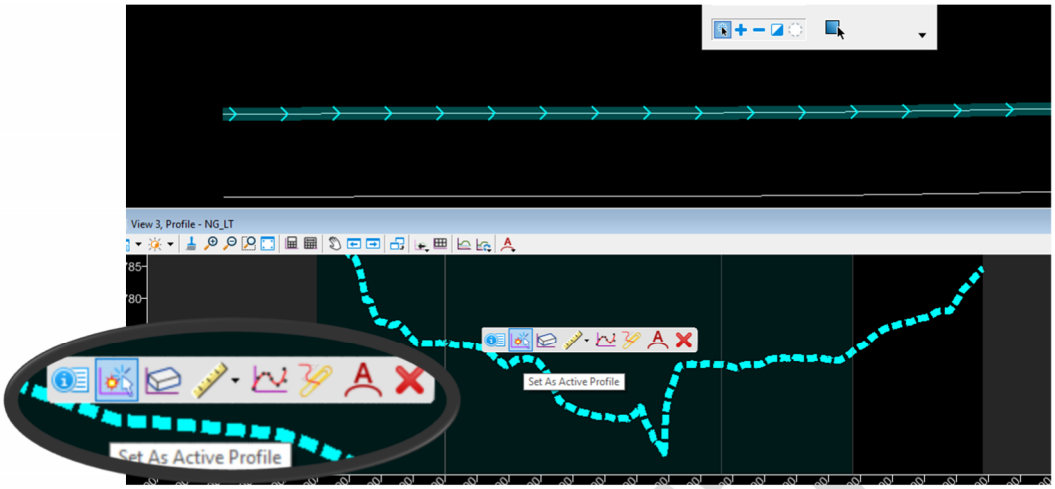


b. A Natural Ground Left (NG_LT) element with an appropriate negative offset to get a snapshot of LT floodplain, using the feature definition HYD_NG_LT.

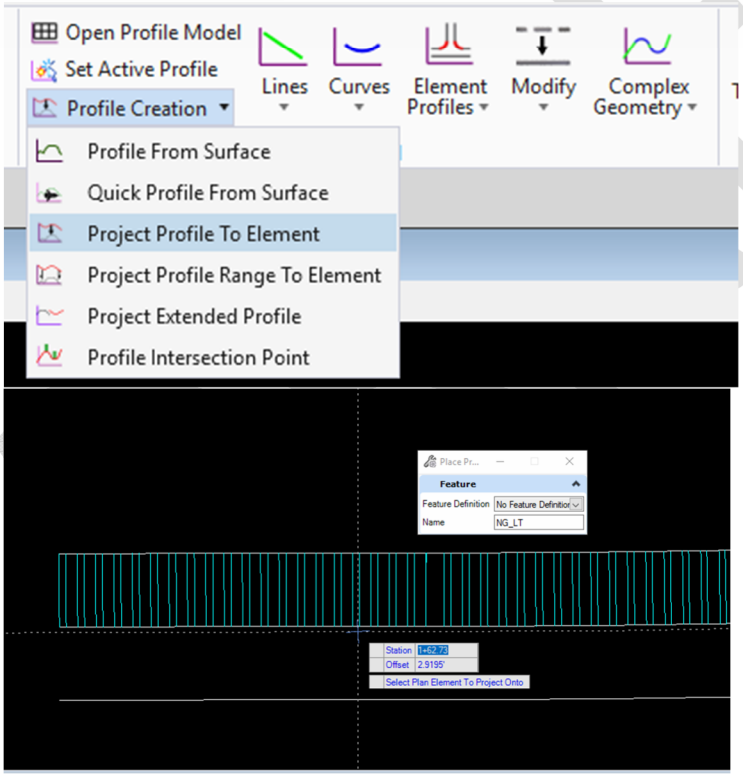
c. A Natural Ground Right (NG_RT) element with an appropriate positive offset to get a snapshot of RT floodplain, using the feature definition HYD_NG_RT.



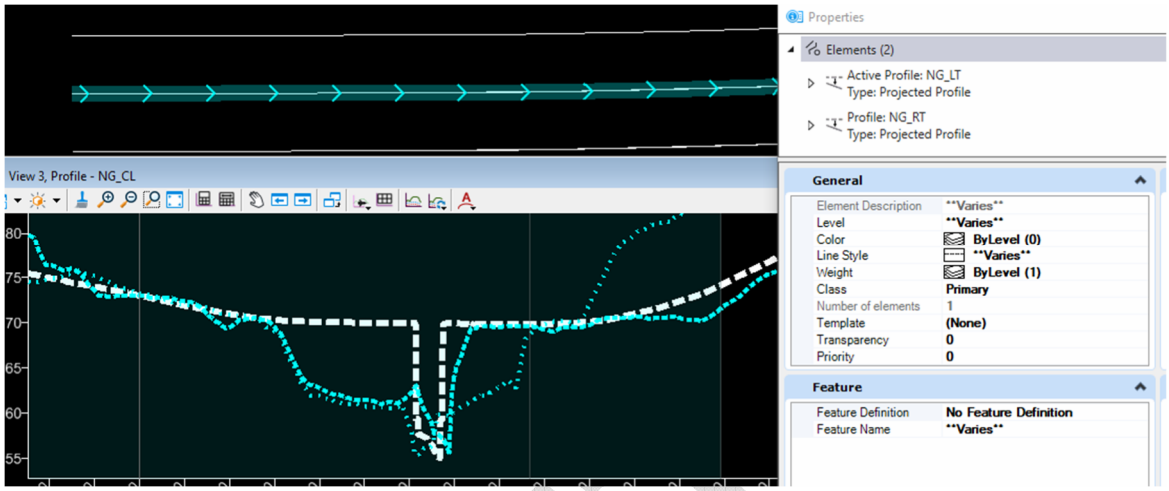
5. Open the profile view of the NG_LT and set the existing terrain line as the active profile. This existing terrain line represents the existing ground along the element and will update if the element is adjusted.



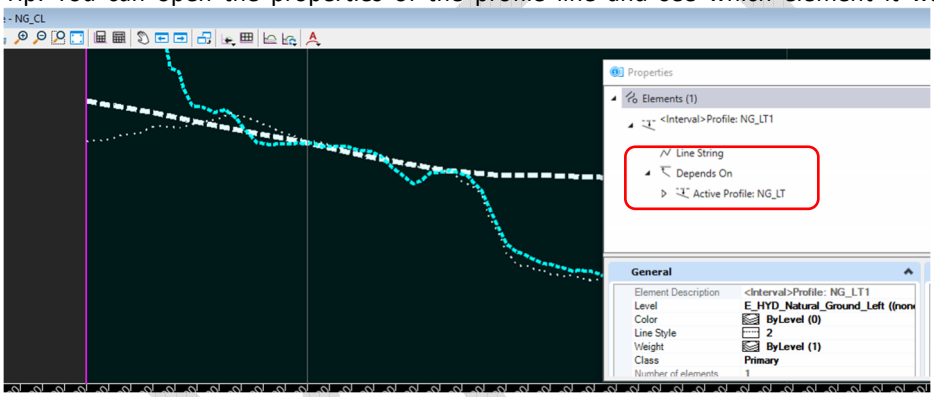
6. Set the active feature definition to HYD_NG_LT and use the **Project Profile to Element** tool to project the NG_LT onto the NG_CL element so that the profile shows up in the NG_CL profile view.



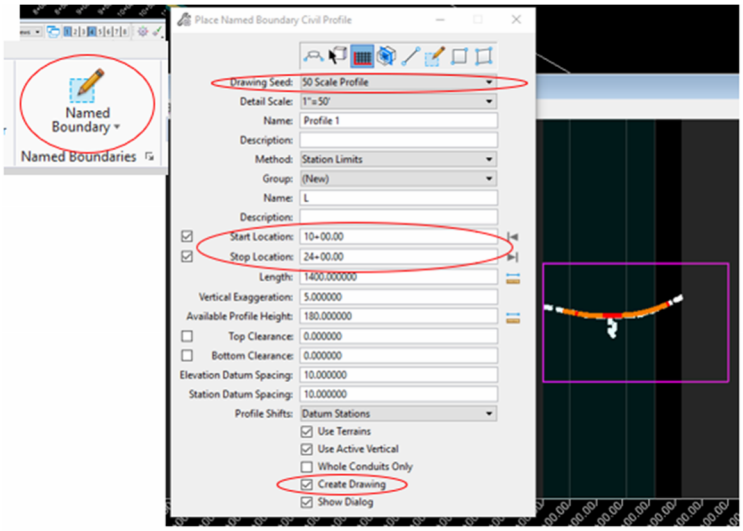
7. Repeat Steps 5 and 6 for the NG_RT using the HYD_NG_RT feature definition.
8. Open the NG_CL element profile view and check the level of the projected profiles are on the "E_HYD_Natural_Ground_[right or left]" so that the symbology is correct.



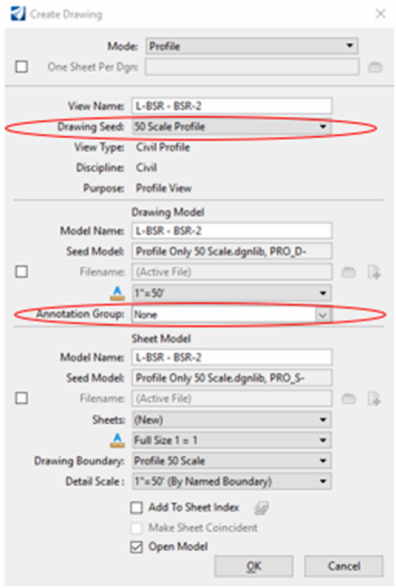
Tip: You can open the properties of the profile line and see which element it was projected from.



9. Create a named boundary and output a profile drawing model for the roadway alignment.
    a. Open the profile view of the Roadway alignment.
    b. Use the **Create Named Boundary** tool set to **Civil Profile Named Boundary** to place a 50 scale profile named boundary centered on the bridge location.
        i. Note: A 50-scale profile is 1400 feet long. One method to set the limits of the named boundary is to take the bridge ID station and subtract 700’ to set the start station of the named boundary.
        ii. It is not necessary for the named boundary to be perfectly centered on the bridge. However, it does make bringing this into the BSR sheet easier if it is reasonably close to the center.
        iii. The rest of the named boundary settings should be populated by the seed selected and typically do not need to be changed.

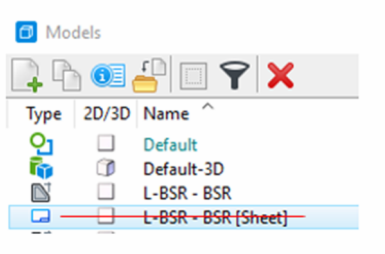


c. Output the named boundary to a drawing model.
   i. Set the annotation group to none. The default setting is to place grid line work. This is not needed since the BSR sheet Cell already provides the grid. Use the **Remove Drawing Annotation** tool in the drawing model if grids are output by mistake.

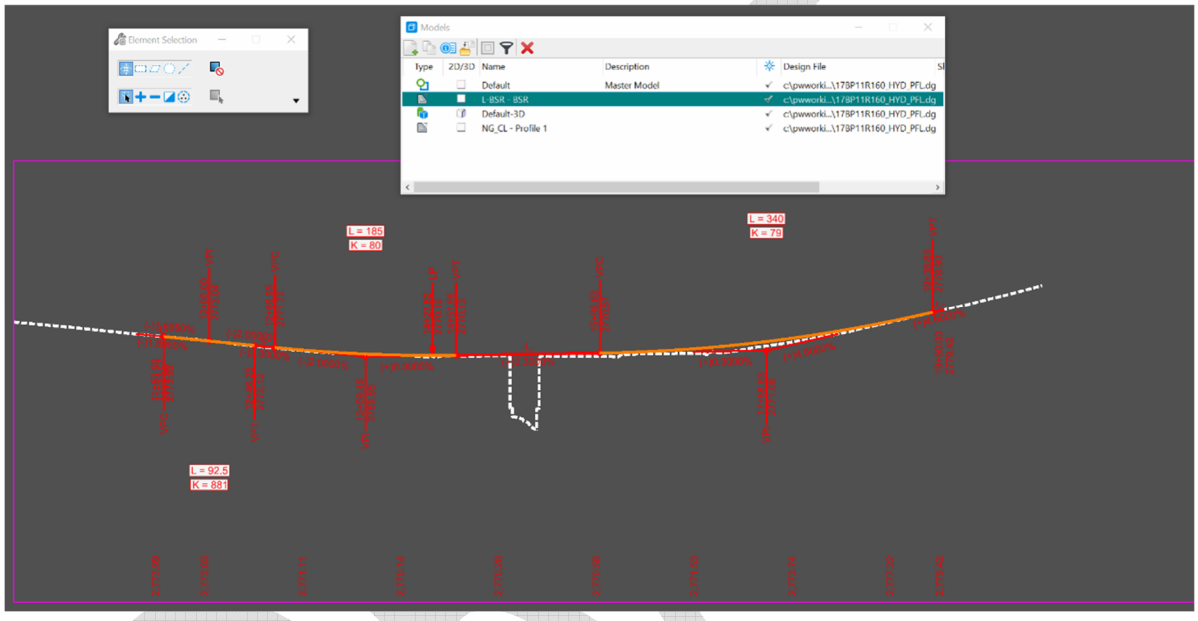


NOTE: Optionally you can set the annotation group to output the grid lines. These grid lines can be helpful in lining up the profile on the BSR sheet cell. However, be sure to either remove them later or turn the level off to prevent from printing double grids.

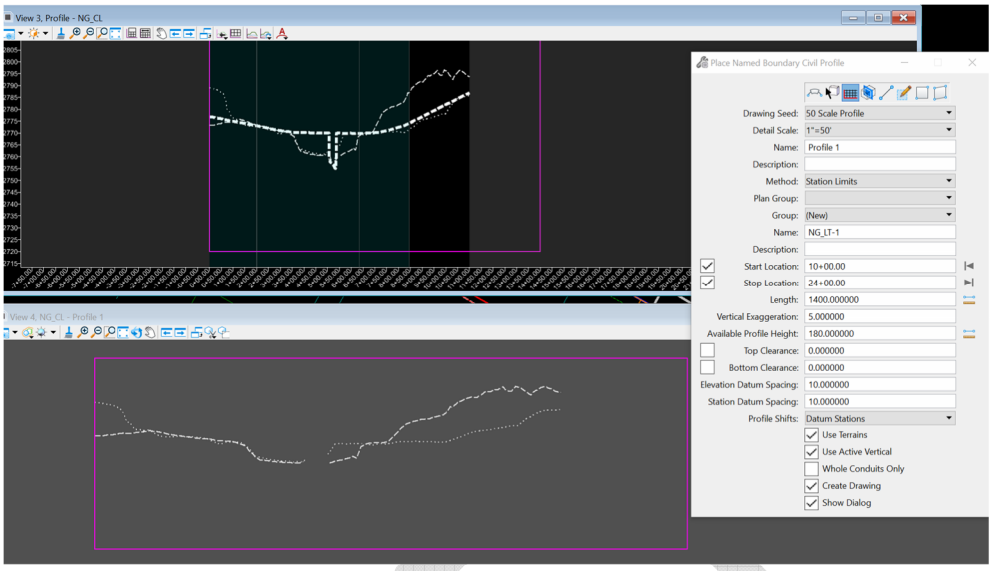
d. Delete the sheet model that gets output along with the drawing model.
   NOTE: Future update to ORD will allow for the creation of drawing models without the sheet model.



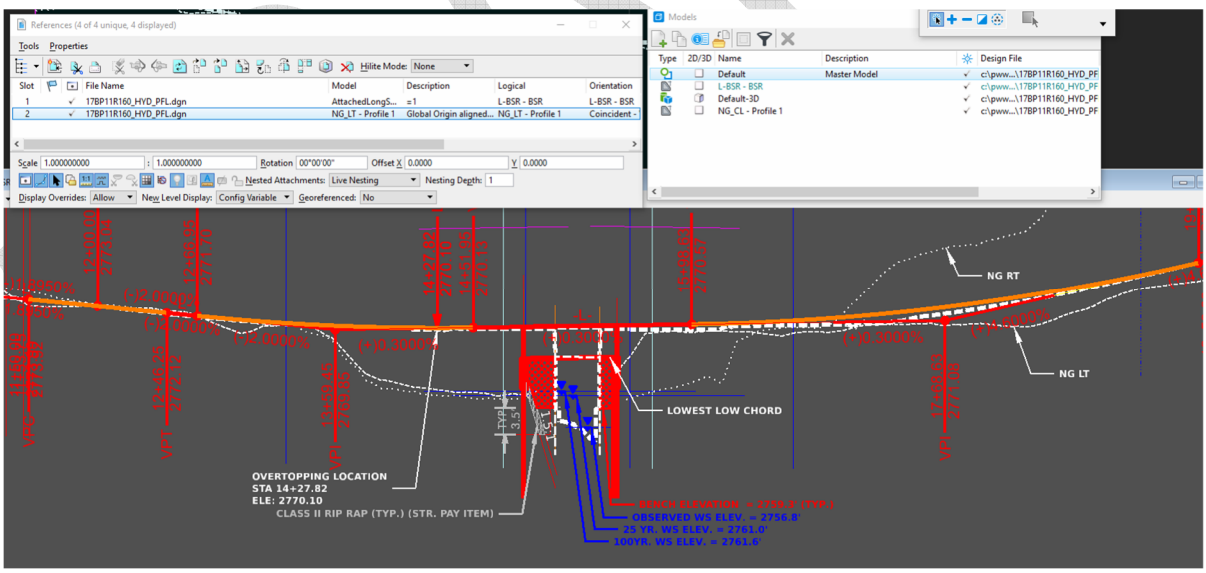
This should leave you with a drawing model of the main line profile with the basic element annotations of the roadway alignment.



10. Create a drawing model for the NG_CL element by repeating step 9 within the NG_CL Profile view. Use the **SAME** station range for the named boundary that you used in the previous step.

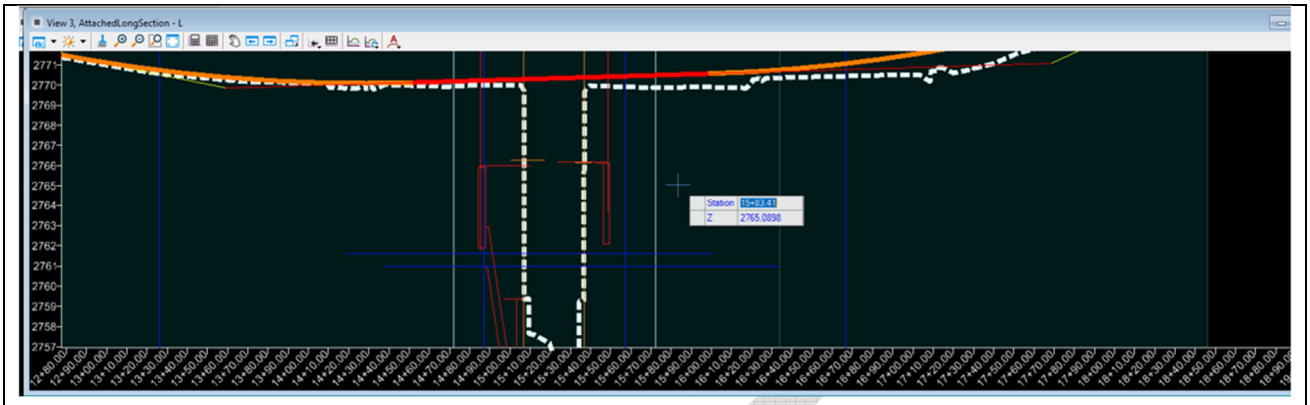
a. 

11. Reference the NG_CL Drawing model (created in step 10) into the alignment profile drawing model (created in step 9).
    a. Sometimes the elevations of the two will be off slightly so you may need to move the reference up or down to match up correctly. The horizontal should be correct if the station ranges where set to the same values during the named boundary creation.
12. Now you may add all the necessary line work for the bridge and any labels needed.

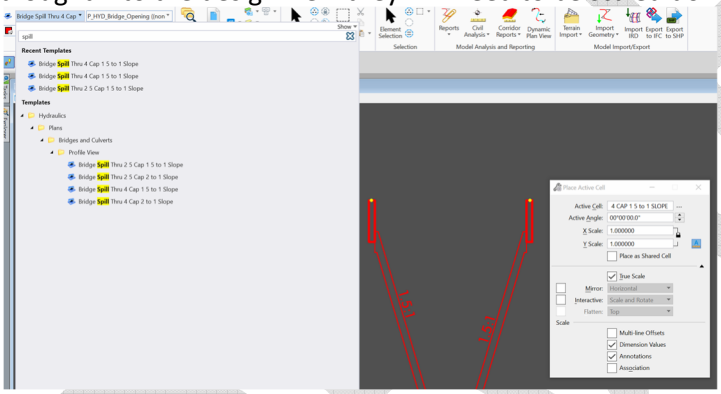


Profile drawing tips:

- **Do NOT** label or hatch in the profile design view (AttachedLongSection). Actions done in this view will always be at a 1:1 scale, anything placed in this view will have the vertical exaggeration applied to it in the drawing and sheet model.
- Use the profile design view to draw scratch lines with the civil accudraw station elevation tool.

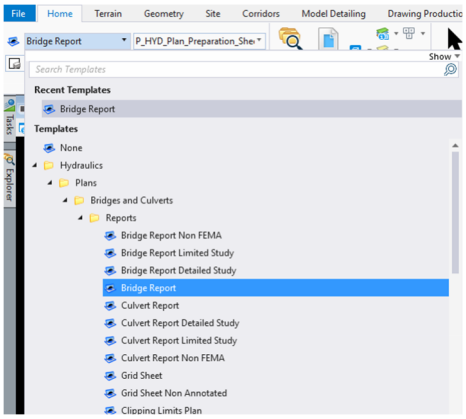


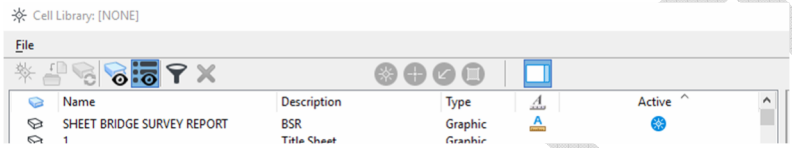
- **Break Element By Two Points** can be used to remove NG_LT and RT from the bridge opening. This tool can also be used to remove the existing ground line to be replaced with sounding elevation data if needed.
- Element Templates with associated Cells have been set up to easily draw the standard abutments. The cells have been set up for a 5x vertical exaggeration to be able to bring into the drawing models. If brought into the design view they will need to be scaled down vertically.



2.3 BSR Design Model Creation

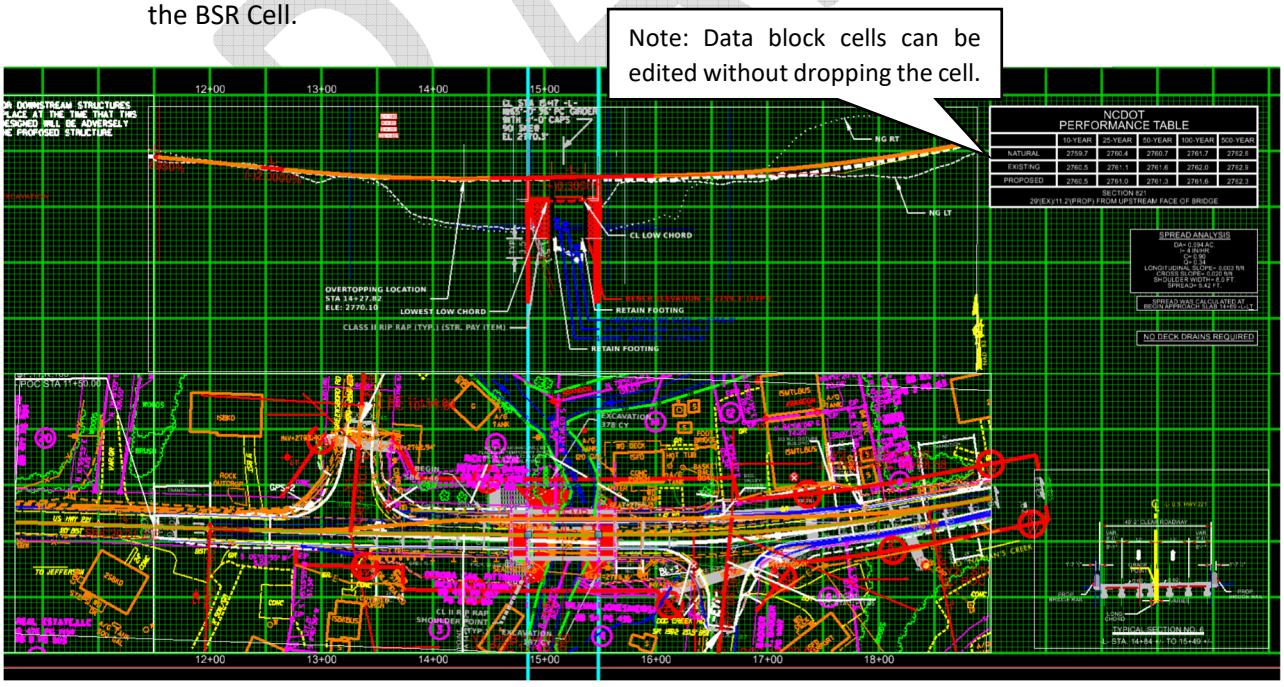
1. Create a new dgn file named *TIP#_HYD_BSR.dgn*
2. Reference in any plan view design files. (i.e., alignment, survey, dsn, drn, etc.)
3. Insert the BSR cell. This can be done by navigating to it in the cell library or setting the element template to Bridge Report and using the **Place Active Cell** tool. The Report sheet cells are set up to be the correct size for 50 scale and should be place with a scale value of 1.





a. Position the cell so that the bridge is aligned horizontally with the grid and roughly centered in the designated plan view area and an even station lines up with a major grid line.
b. Clip the plan view references to the plan view area. Adjust as needed.

4. Reference the Profile Drawing model created in section 2.1 and set the live nesting to 3.
   a. Move and rotate the reference to be positioned correctly in the profile view section of the BSR Cell.



5. Reference the bridge typical section and place in the designated area.

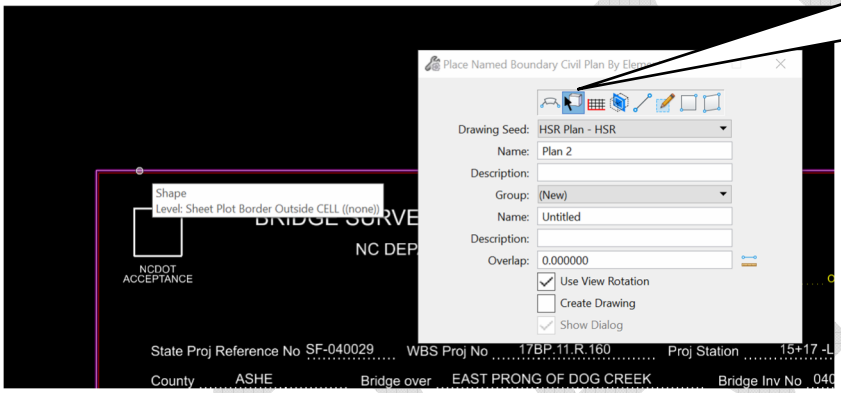
2.4 BSR Sheet Model Creation

There are two methods for creating the Sheet model that is used to print. One is to utilize the named boundary tools within ORD to generate a drawing and sheet model based on the border element of the BSR Cell. The other is to manually create a sheet model from seed and attach the BSR design model as a reference. (NOTE: I have personally started defaulting to method 2 of this section.)

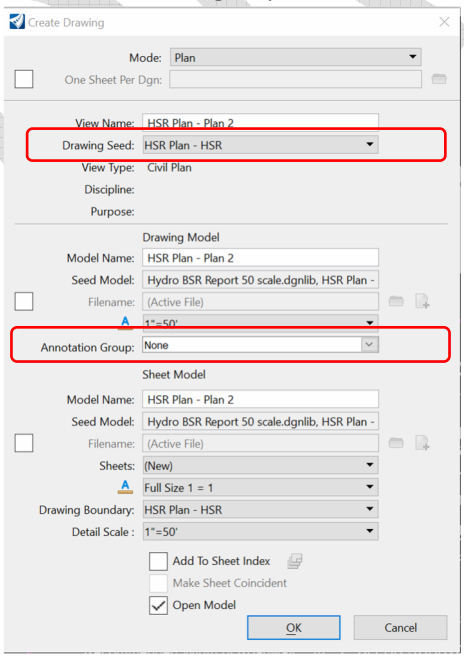
2.4.1 Named Boundary Method

1. Create a named boundary out of the cell border.
    a. Use the **Create Named Boundary** tool set to **Civil Plan by Element**
    b. Set the drawing seed to "HSR Plan - HSR"
    c. Select the Outside Border shape

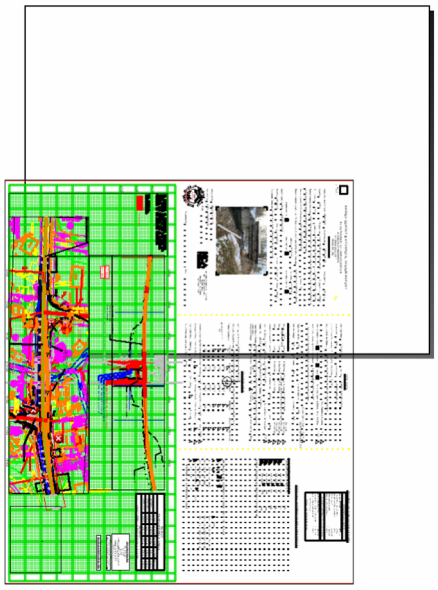
Note: In order to select the border element the sheet cell needs to be dropped first. Alternatively you can draw a new shape based on the border.



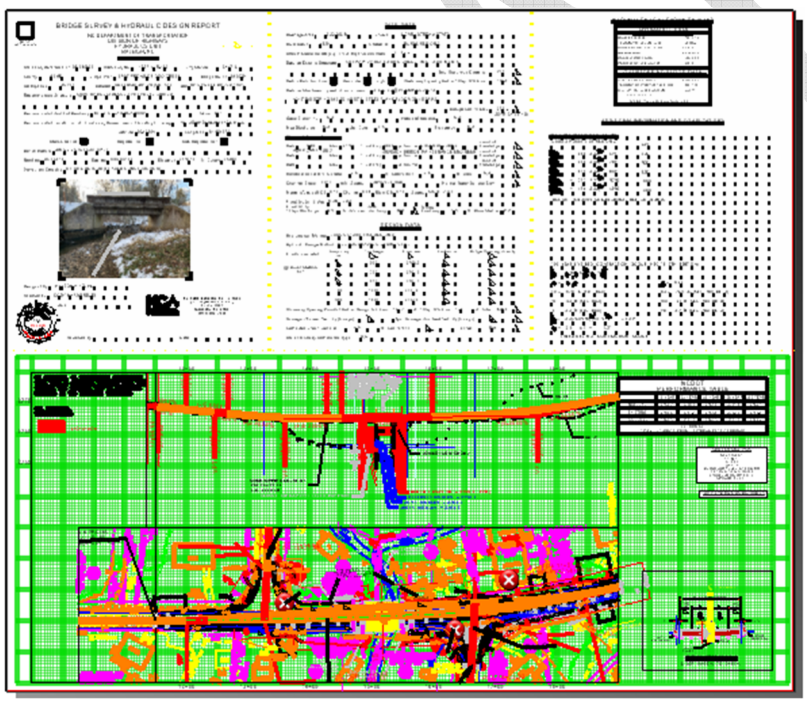
2. Output the drawing and sheet models from the named boundary.
    a. Leave drawing seed set to "HSR Plan - HSR"
    b. Leave annotation group set to "None"



3. If the reference comes in not matching the sheet boundary then adjust by moving and rotating as needed. This is an issue with using the create named boundary by element not orienting correctly.



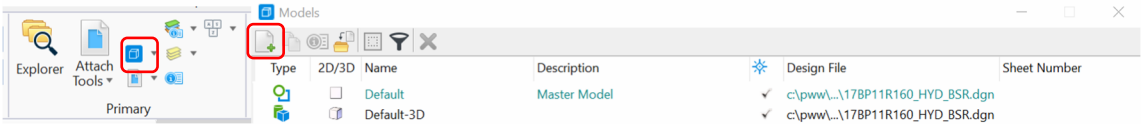
4. From here the sheet model can be printed or added to a .pset



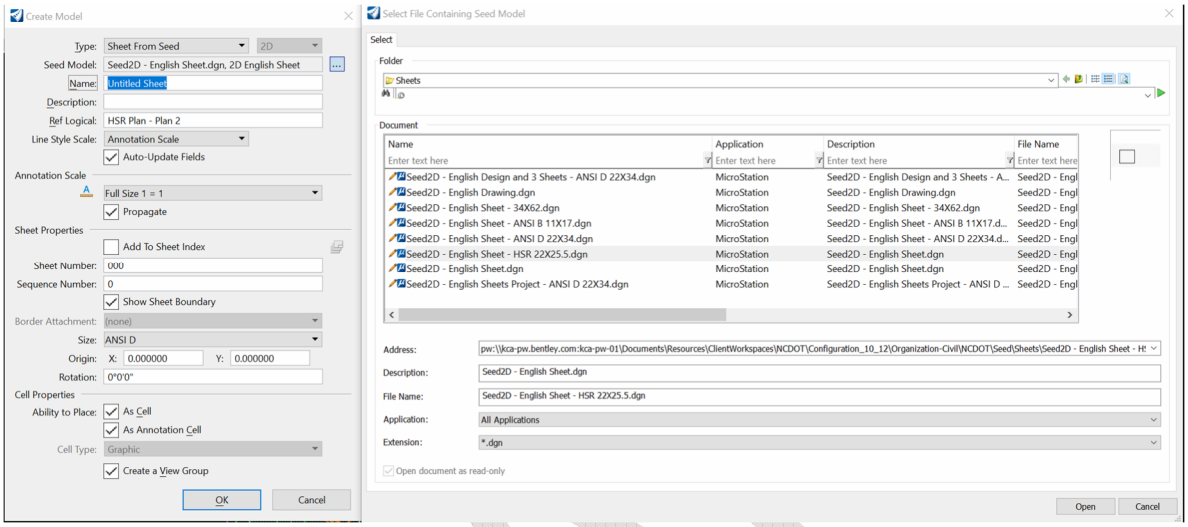
5. Return to the BSR design model to finish inputting the necessary data.

2.4.2 Manual Sheet Model Method

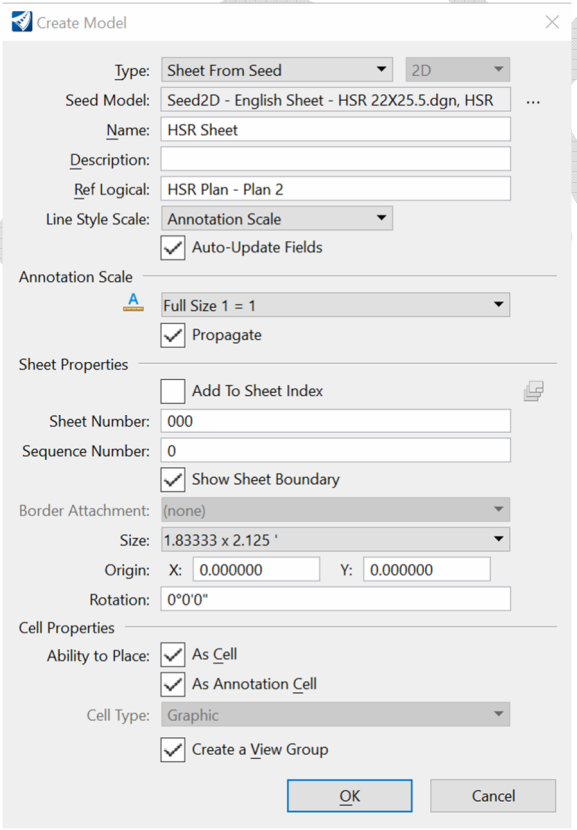
1. Open the Models window and select create new model.



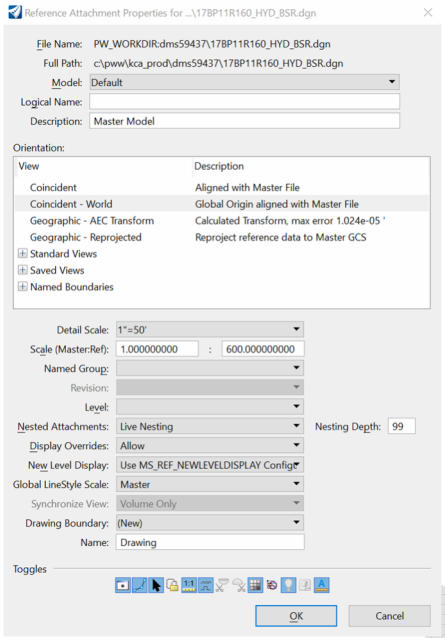
2. Set the type to “Sheet From Seed” and hit the elipse to select the HSR 22X25.5 sheet seed dgn



3. Name the Sheet and hit Ok



4. In the newly created Sheet Model reference the default model of the BSR file. Check that the Scale is set to 1:600 and change the live nesting to 99.



5. The reference will come in far from the sheet boundary. Move and rotate the reference so that the BSR fits into the sheet boundary.
6. From here the sheet model can be printed or added to a .pset
7. Return to the BSR design model to finish inputting the necessary data.

3.0 CSR

CSR sheets will follow the similar set up methodology for the BSR profile and plan view. The one key difference for CSR sheets is the addition of a cross section cut along the culvert. See Section 9.3 of the 2022 Guidelines for Drainage Studies and the published CSR_Guide Key for further information on CSRs. The following will be needed to set up a CSR sheet:

- CSR Cell
- Plan View
- Profile View
- Cross Section
- Details (where applicable)
- Supplemental Profiles (where applicable)
- Design Data

3.1 File Structure

This section outlines the general file structure for setting up a CSR. This file structure can be adapted for project-specific circumstances. For more information see NCDOT ORD Module - 1 File Management.

CSR Design Model

File Naming Convention: *TIP#_HYD_CSR.dgn*

Contents:

- CSR Cell
- Referenced design files
- Referenced survey file

  NOTE: If survey was done in V8i set line style scale to "Reference" or "none" to fix annotations.

- All CSR labels not provided in design labels.
- Named boundary used to create the drawing and sheet model.

HYD Profile

File Naming Convention: *TIP#_HYD_PFL.dgn / TIP#_HYD_CSR_PFL.dgn*
Contents:

- Profile named boundary associated with the roadway alignment.
- Profile drawing model.
- Centerline and offset elements for natural ground left and right.
- Centerline element drawing model.
- Profile linework for culvert

Culvert Cross Section

File Naming Convention: *TIP#_HYD_XSC.dgn / TIP#_HYD_CSR_XSC.dgn*
Contents:

- Culvert Center Line Element
- Profile named boundary associated with the Culvert Center Line.
- Culvert Profile drawing model.
- Top of bank elements for natural ground.
- Cross section linework for culvert

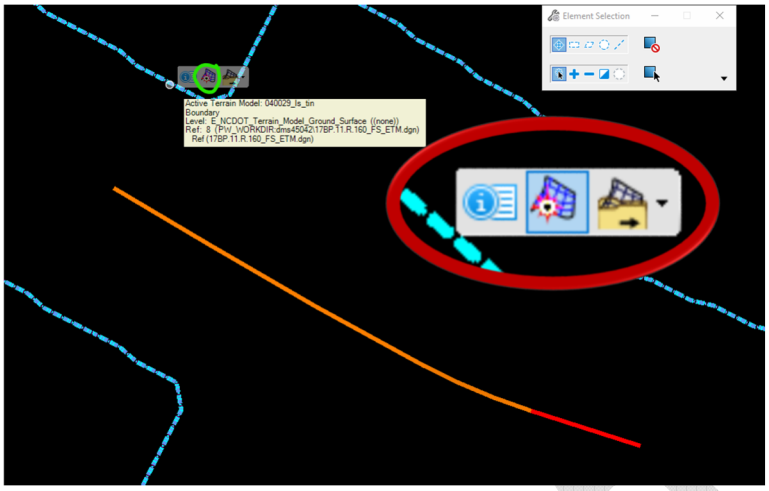
3.2 Profile Creation

Profiles in ORD are handled very differently than how they were in geopak. ORD profiles are stored within the horizontal geometric element. To obtain a referenceable view of a profile, you must first create a drawing model using the Named Boundary Tool.

13. Create a new blank.dgn named *TIP#_HYD_PFL.dgn or TIP#_HYD_CSR_PFL.dgn*
    a. Use the NCDOT seed file located in the workspace.
14. Reference the following:
    a. Roadway alignment file.
    b. Survey terrain file. This will be provided either within the FS file or as a standalone ETM file.

    NOTE: Other files may be added for preference and viewing purpose but at a minimum the above files are required.

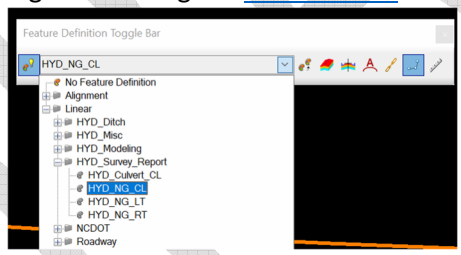
15. Set the existing terrain as active. This will set the file to automatically display the existing ground along any element in profile view.

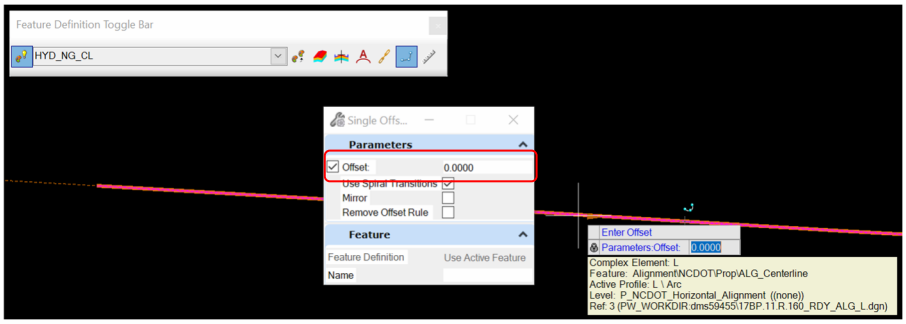


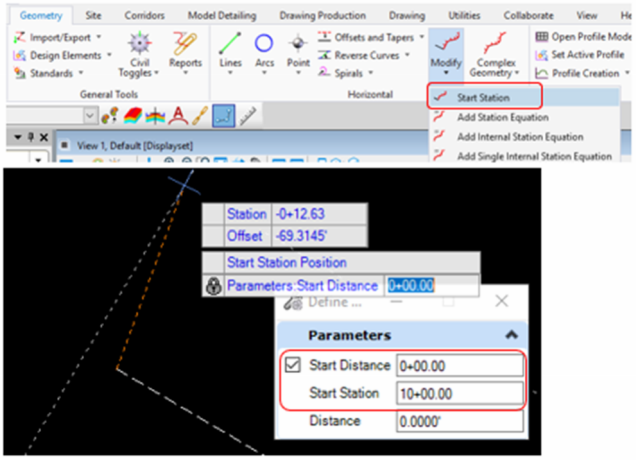
16. Create three (3) horizontal alignments, NG_CL, NG_LT, and NG_RT, based off the roadway alignment using the **Single Offset Entire Element** Tool. Using this geometry tool will ensure the geometry and profile views remained ruled to roadway's horizontal geometry. Should roadway change the alignment, the lines ruled to it will update accordingly.

    NOTE: The reasoning for creating a NG_CL element is to have an element that matches stationing and position of roadway's alignment to project the NG_LT and NG_RT onto. The project tool cannot project onto a referenced element only one that is live in the file.

    a. A Natural Ground Centerline (NG_CL) element with an offset of zero (0) feet, using the feature definition HYD_NG_CL.
        i. Modify the start station of this element to match the stationing of the roadway alignment using the **Start Station** tool.

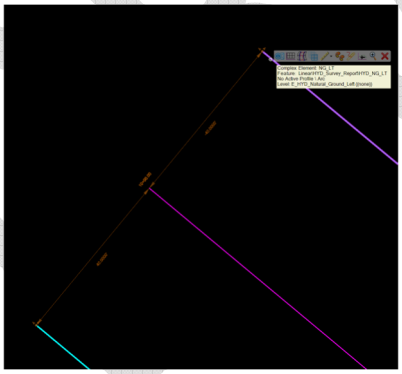




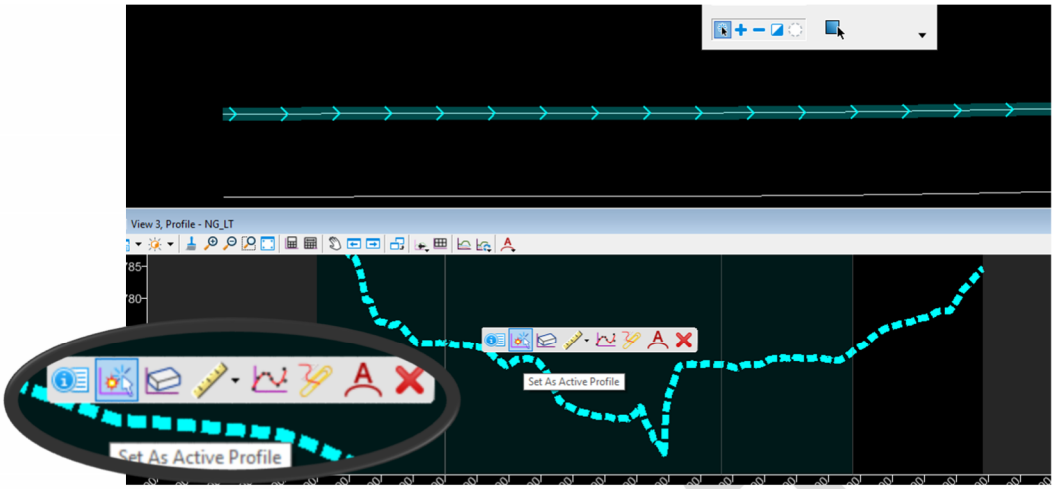


b. A Natural Ground Left (NG_LT) element with an appropriate negative offset to get a snapshot of LT floodplain, using the feature definition HYD_NG_LT.

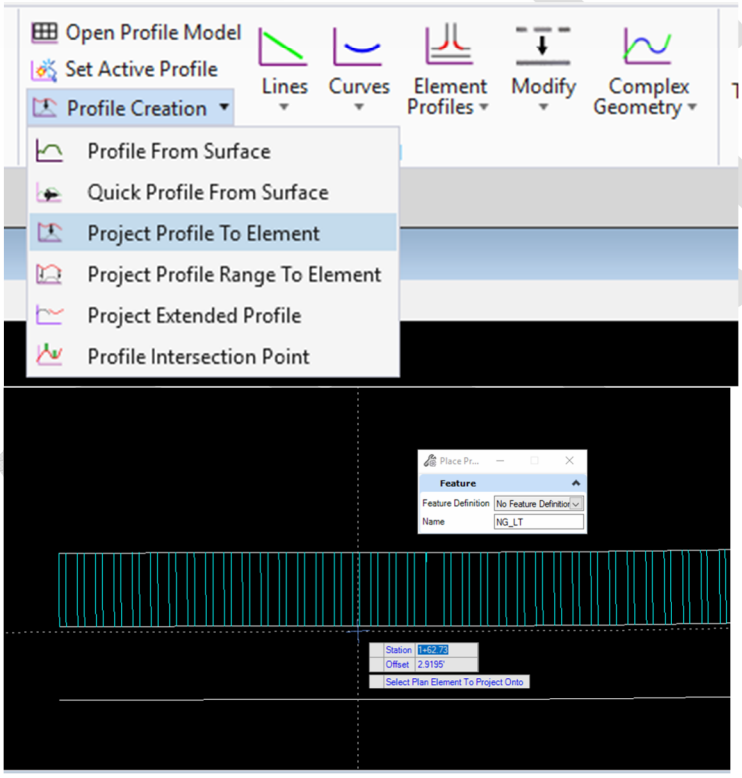
c. A Natural Ground Right (NG_RT) element with an appropriate positive offset to get a snapshot of RT floodplain, using the feature definition HYD_NG_RT.



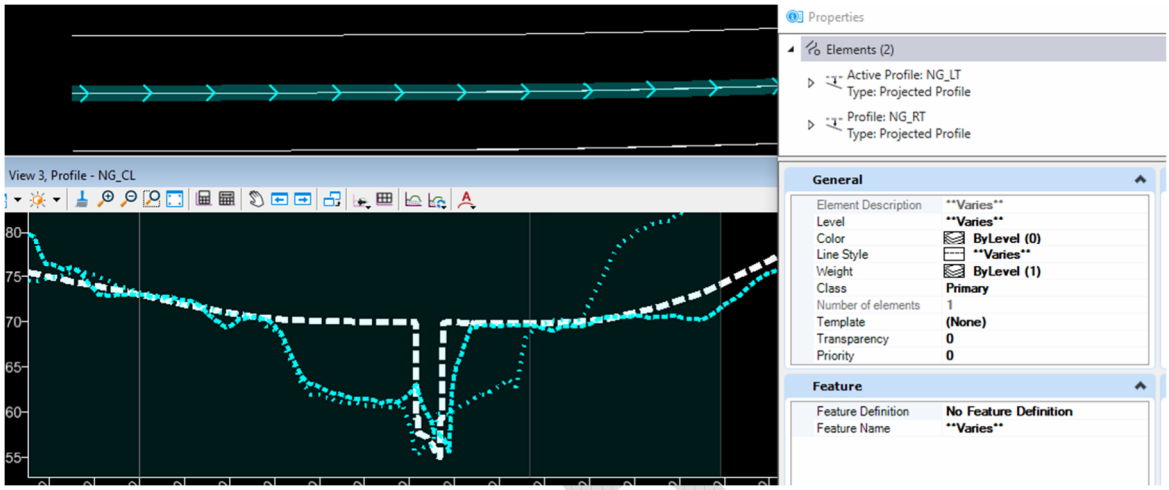
17. Open the profile view of the NG_LT and set the existing terrain line as the active profile. This existing terrain line represents the existing ground along the element and will update if the element is adjusted.



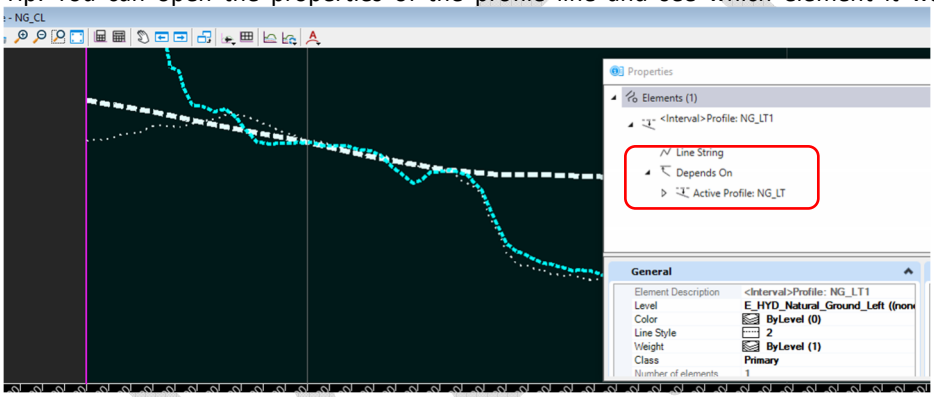
18. Set the active feature definition to HYD_NG_LT and use the **Project Profile to Element** tool to project the NG_LT onto the NG_CL element so that the profile shows up in the NG_CL profile view.



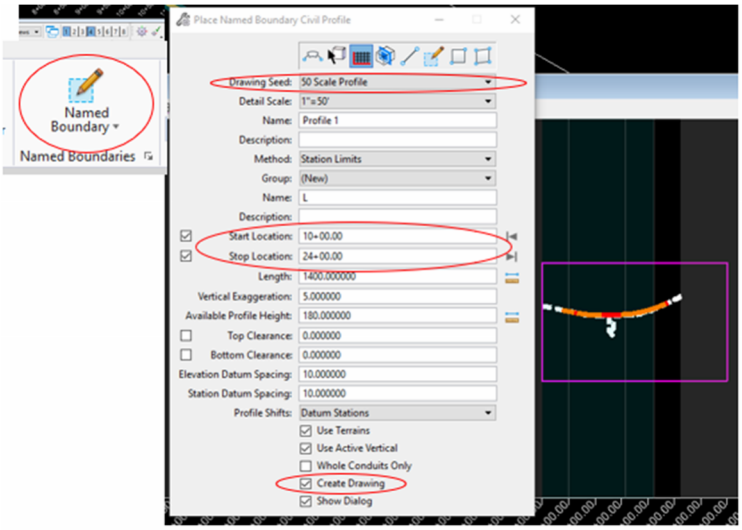
19. Repeat Steps 17 and 18 for the NG_RT using the HYD_NG_RT feature definition.
20. Open the NG_CL element profile view and check the level of the projected profiles are on the "E_HYD_Natural_Ground_[right or left]" so that the symbology is correct.



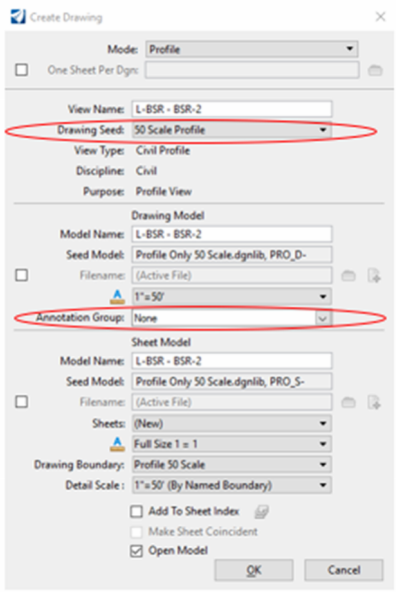
Tip: You can open the properties of the profile line and see which element it was projected from.



21. Create a named boundary and output a profile drawing model for the roadway alignment.
    a. Open the profile view of the Roadway alignment.
    b. Use the **Create Named Boundary** tool set to **Civil Profile Named Boundary** to place a 50 scale profile named boundary centered on the culvert location.
        i. Note: A 50-scale profile is 1400 feet long. One method to set the limits of the named boundary is to take the culvert ID station and subtract 700’ to set the start station of the named boundary.
        ii. It is not necessary for the named boundary to be perfectly centered on the bridge. However, it does make bringing this into the CSR sheet easier if it is reasonably close to the center.
        iii. The rest of the named boundary settings should be populated by the seed selected and typically do not need to be changed.

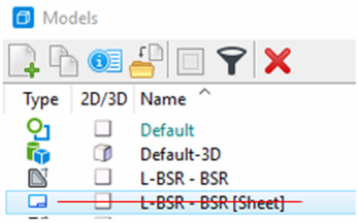


c. Output the named boundary to a drawing model.
   i. Set the annotation group to none. The default setting is to place grid line work. This is not needed since the CSR sheet Cell already provides the grid. Use the **Remove Drawing Annotation** tool in the drawing model if grids are output by mistake.

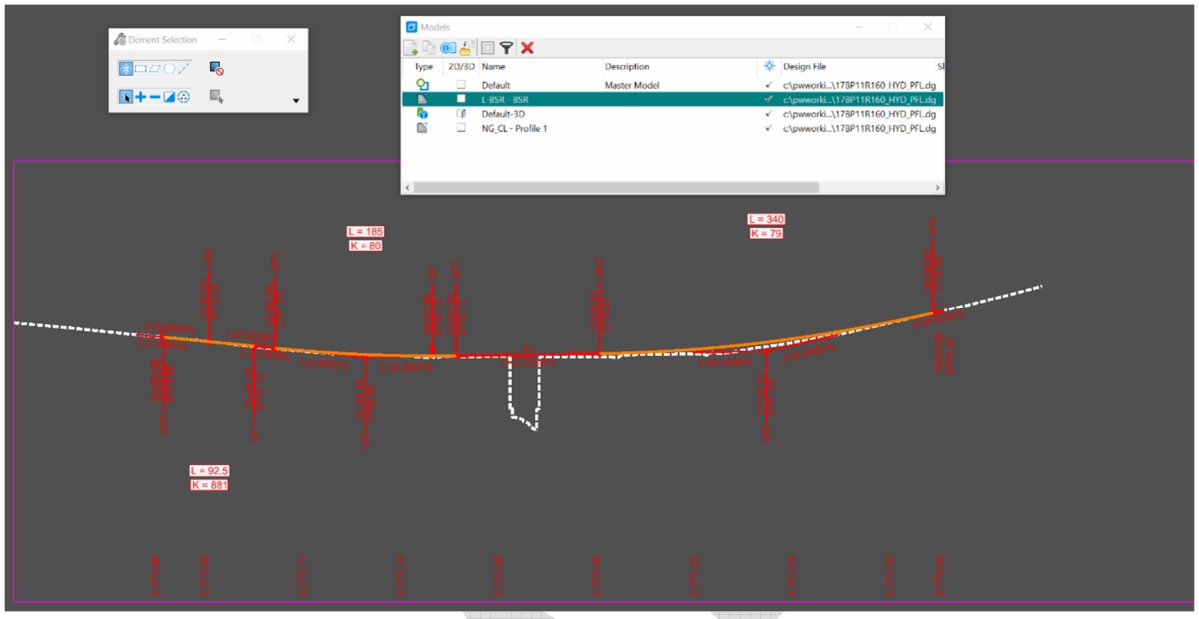


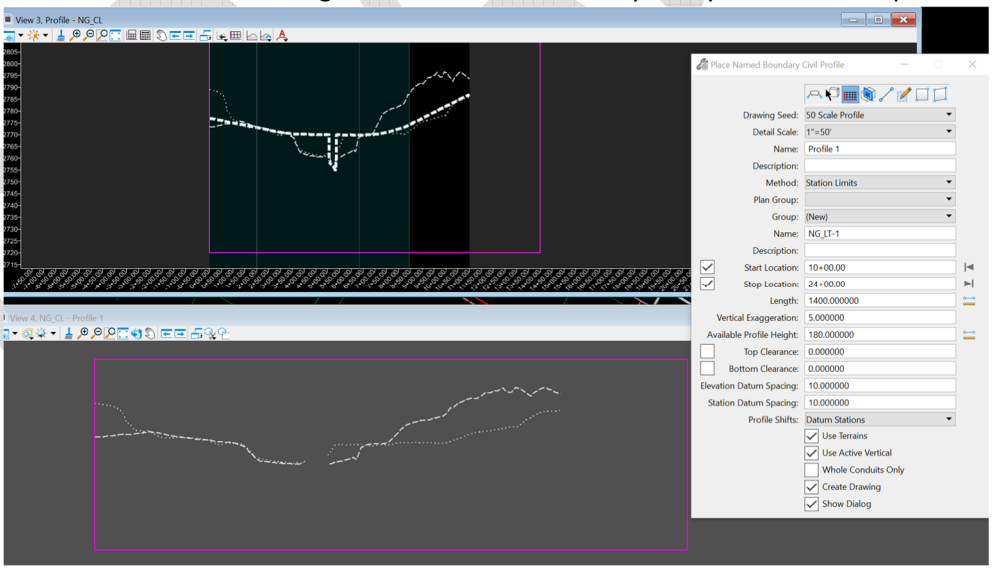
NOTE: Optionally you can set the annotation group to output the grid lines. These grid lines can be helpful in lining up the profile on the CSR sheet cell. However, be sure to either remove them later or turn the level off to prevent from printing double grids.

d. Delete the sheet model that gets output along with the drawing model.
   NOTE: Future update to ORD will allow for the creation of drawing models without the sheet model.



This should leave you with a drawing model of the main line profile with the basic element annotations of the roadway alignment.



22. Create a drawing model for the NG_CL element by repeating step 21 within the NG_CL Profile view. Use the **SAME** station range for the named boundary that you used in the previous step.
    a. 

23. Reference the NG_CL Drawing model (created in step 10) into the alignment profile drawing model (created in step 9).
    a. Sometimes the elevations of the two will be off slightly so you may need to move the reference up or down to match up correctly. The horizontal should be correct if the station ranges where set to the same values during the named boundary creation.

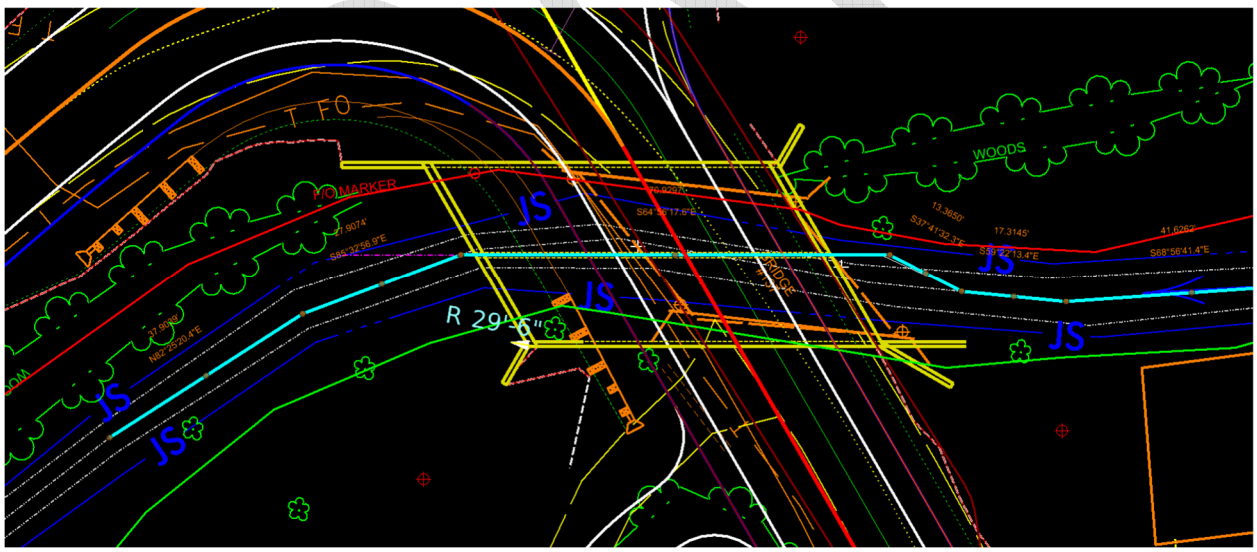
Now you may add all the necessary line work for the bridge and any labels needed.

3.3 Cross Section Creation

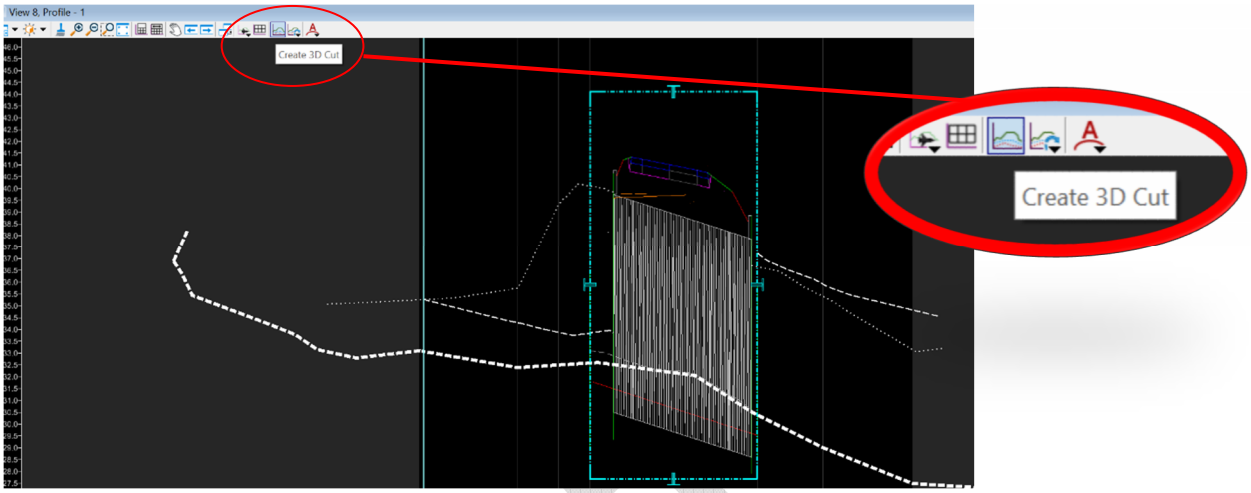
Similar to profiles, the only way to bring a cross section view into a model that can be referenced is to create a named boundary and output a drawing model. This can be done by one of two methods within ORD. The first way is to create a horizontal alignment and use its profile view along with a 3D cut to display the cross section, create and output a profile named boundary. The second way is to make a standard cross section named boundary using the named boundary tool. This is faster to set up but has a major limitation in that the cut line can only be straight between two points.

Method 1: Profile Named Boundary With 3D Cut

1. Create a new file named *TIP#_HYD_XSC.dgn*
2. Reference the following files:
    a. Existing terrain
    b. Roadway alignment
    c. Roadway corridor model
    d. Any other 3D design file you would like to show up in the cross section.
3. Create a horizontal element along the culvert (Culvert_CL).
    a. Recommend using **Complex by PI**
    b. Use the feature definition HYD_Culvert_CL
    c. Create the element along the stream centerline up until the culvert then follow along the center of the culvert and transition back to the stream after.

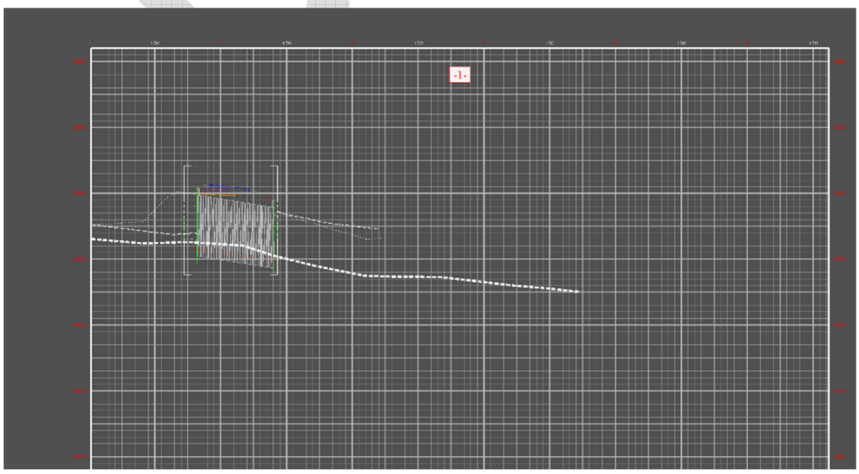


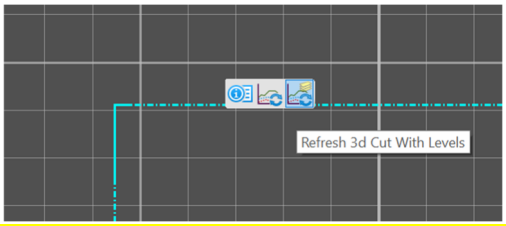
4. Open the profile view of PIPE_CL and use the **Create 3D cut** by two points to show the proposed cross section.



5. Create elements along the left and right top of banks. Assign the existing ground as the active profile and then project to the Culvert_CL element. Similar to how we did the Natural ground left and right for profile view.
6. Create a profile named boundary within the CL element and out put the drawing model. Not to worried about the extents of the named boundary or whether the culvert is centered or not. We only need this drawing model to reference into the CSR layout and will clip down from there.

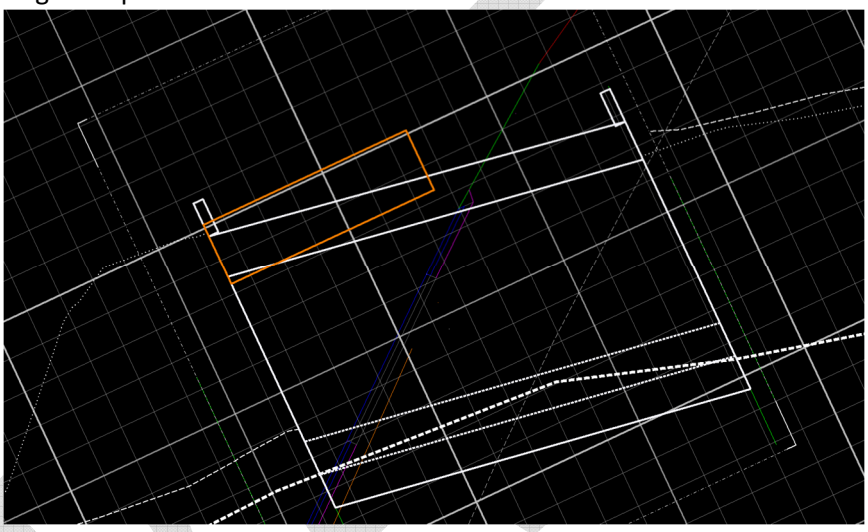
7. Within the drawing model make any manual drawing or labeling. The example screen shot is from a double barrel so the CL is cuting the wall of the culvert and showing a solid shape. So in the drawing model I would draw the culvert manually by tracing the 3D output then turning the culvert model levels off.
   a. To turn levels off in a 3D cut you must first turn the level off then hit the refresh 3D cut with levels on the fly out menu.



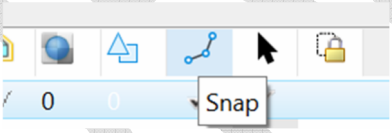


b. **There is a major bug with 3D cuts currently**. When referenced into another view the elements within the 3D cut get distorted and don't come in correctly. **If this bug is encountered**, easiest work around currently is to just trace the elements in the drawing model with manual linework then turn the 3D cut off.

i. Bug example:



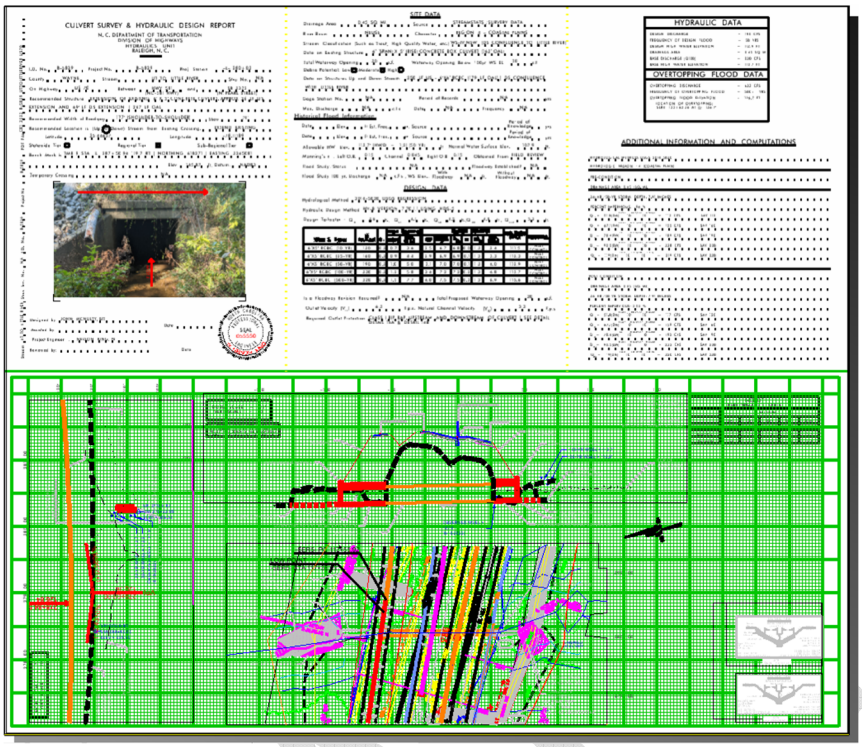
ii. Tip: within the profile design view (where the 3D cut exist) turn the snap to element option on in the reference dialogue. This option is defaulted to off for 3D cuts.



8. Reference this drawing model into the CSR design view

NOTE: In my experience, while useful, 3D cuts can be slow and cause stability issues with ORD. Use caution when utilizing this method and exercise patience. This has gotten much better with 10.12.

From here follow the BSR sections 2.2 and 2.3 (with the CSR cell) for setting up profile view, plan view, and sheet model.


CULVERT SURVEY & HYDRAULIC DESIGN REPORT
N.C. DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
HYDRAULICS UNIT
RALEIGH, N. C.
SITE DATA
HYDRAULIC DATA
OVERTOPPING FLOOD DATA
ADDITIONAL INFORMATION AND COMPUTATIONS
DESIGN DATA