GEOPAK Drainage V8*i*
Course Manual

Tennessee Department of Transportation
Roadway Design Division

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The information in this manual is based on the following software versions:
MicroStation V8i - SELECT Series 2 Edition (08.11.07.443)
GEOPAK V8i – SELECT Series 2 Edition (08.11.07.615).

Resources

Tennessee Department of Transportation Drainage Manual:

https://www.tn.gov/content/tn/tdot/roadway-design/design-standards/drainage-manual.html

Tennessee Department of Transportation Design Guidelines and Instructional Bulletins:

https://www.tn.gov/tdot/roadway-design/design-standards/instructional-bulletins.html

Tennessee Department of Transportation Design V8 CADD Standards and Downloads:

https://www.tn.gov/tdot/roadway-design/design-standards/design-cadd-files.html

Tennessee Department of Transportation Standard Drawings Library:

https://www.tn.gov/tdot/roadway-design/standard-drawings-library.html

Federal Highway Administration Hydraulic Engineering Circular NO. 22, Second Edition Urban Drainage Design Manual:

https://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf

GEOPAK Drainage V8*i* Course Manual

Table of Contents

1. Getting Started

This exercise introduces the GEOPAK Drainage workflow to complete the setup required for a new project. The user will review the project information and set the preferences.

GEOPAK Drainage gives you the best design and analysis based on the input that you enter. Engineering judgment must be used to evaluate the output that the program produces. Refer to the TDOT Roadway Design Division Drainage Manual for additional guidance.

1.1 Project Workflow

The GEOPAK Drainage workflow mirrors a conventional design process beginning with the design of the surface collection system (inlets, drainage areas) followed by the design of the conveyance system (subsurface pipes, channels).

Roadway alignments, vertical profiles, and digital terrain models (DTM) may be used throughout GEOPAK Drainage to provide pertinent information to the drainage design. All drainage components feature interactive *graphical placement tools* for easy definition of the drainage system.

Each of these components (inlets, areas, and pipes) is composed of two basic types of information:

- Spatial information describing its location, shape and connectivity.
- Hydraulic and Hydrologic information describing its properties, conventions and other associated attributes.

1.2 Drainage Components

GEOPAK Drainage organizes the components of a drainage system according to their spatial characteristics. Spatial information is stored as **Nodes**, **Links** and **Networks**. This information is stored in a *.gdf file – GEOPAK Drainage File.

Nodes: A node (inlets, manholes, etc.) is a point with a user-defined location. The location may be in Cartesian coordinates (x,y) or in curvilinear coordinates (station, offset).

Links: A Link represents a linear feature depicting a path connecting two nodes, traversing upstream to downstream. The path may be straight line or curvilinear (along a graphic element).

Networks: A network is a system of interconnected nodes and links that form a system through which water can flow to a single outlet node. A drainage project accommodates any number of Networks.

Other associated components in GEOPAK Drainage include:

Areas: A drainage area can be represented by a closed boundary or simply keyed-in (acres or hectares). All flows from a single drainage area are tributary to a single Node. There is a *one to one* correspondence between a node and an area. Therefore areas and nodes share the same name (ID). A drainage area may contain multiple subareas representing homogeneous features such as soil types and land uses (“C” values), thereby allowing composite "C" value calculations.

Profiles: A profile represents a linear feature depicting a path connecting two nodes, it is different than a link in that a path may span multiple links and traverse upstream, downstream, or any combinations. The primary purpose of a profile is to allow visualization of a profile view between any two nodes in a drainage network.

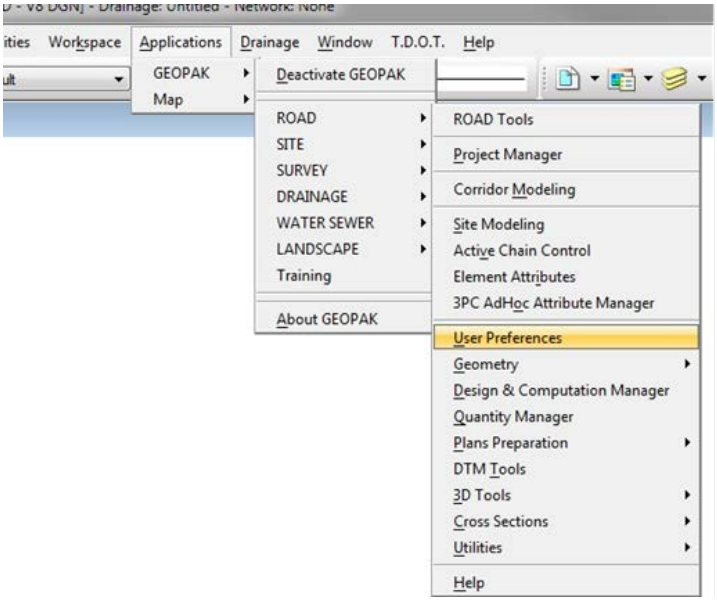
1.3 Directory Information

Class files are located in the directory c:\Projects\Drainage*.*

1.4 GEOPAK User Preferences

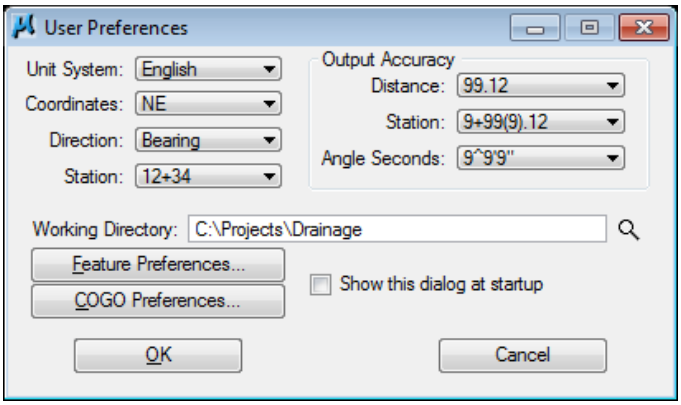
a) Utilizing MicroStation, open DVSR1proposed.dgn using the tdot interface.

b) Activate GEOPAK by going to Applications > GEOPAK > Activate GEOPAK. The GEOPAK User Preferences control the output format of data produced using GEOPAK. Access the **User Preferences** by selecting **Applications > GEOPAK> Road > User Preferences**.



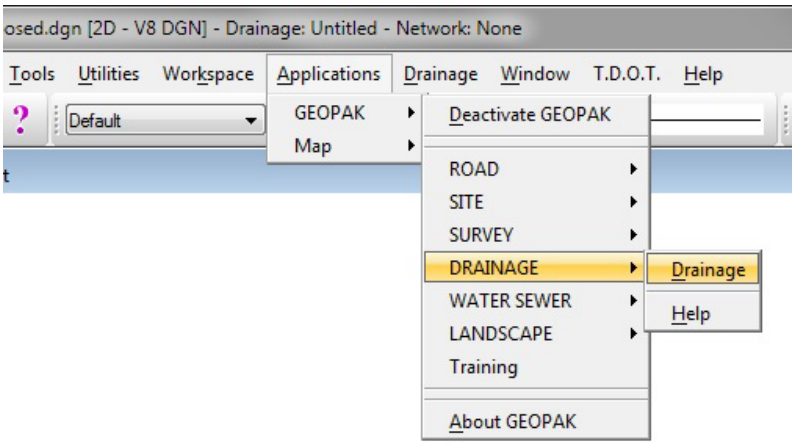
c) Set the Units to **English**, Stationing to **12+34**, and Working Directory to **C:\Projects\Drainage** and click **OK**.

NOTE: For your project, this would be your working directory.

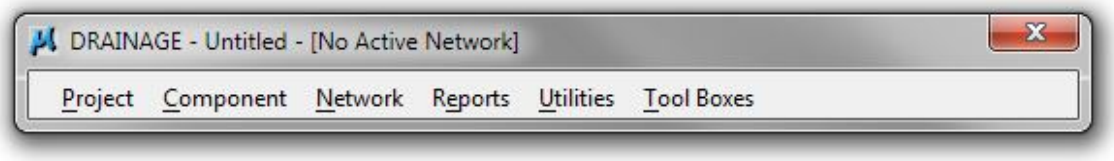


1.5 GEOPAK Drainage Menu

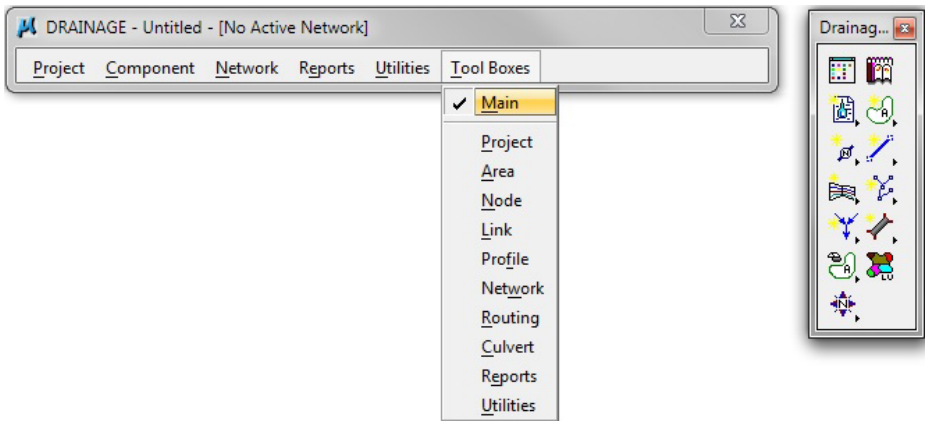
a) Access GEOPAK Drainage from MicroStation's **Applications** menu:



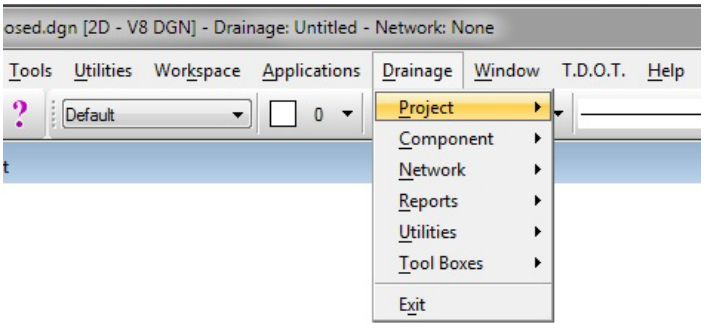
All items in Drainage can be accessed through this main GEOPAK DRAINAGE Menu Bar:



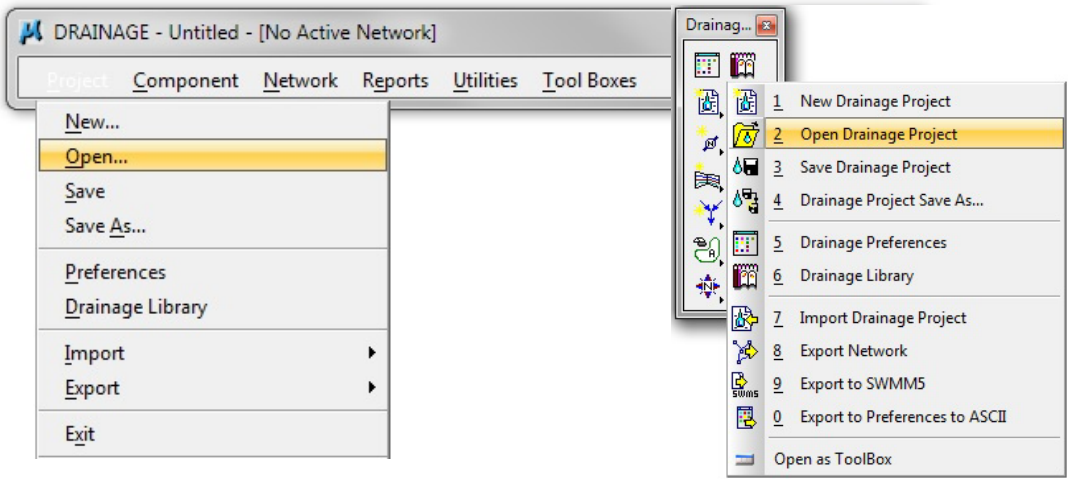
Or by invoking the GEOPAK Drainage **Main Tool Box** from **Tool Boxes>Main**:



Or they can be accessed through the Drainage Menu which has been added to the main menu bar once you load GEOPAK Drainage.



b) Open GEOPAK Drainage project file **DrainageProject.gdf** that was copied into the project directory: **C:\Projects\Drainage\.**

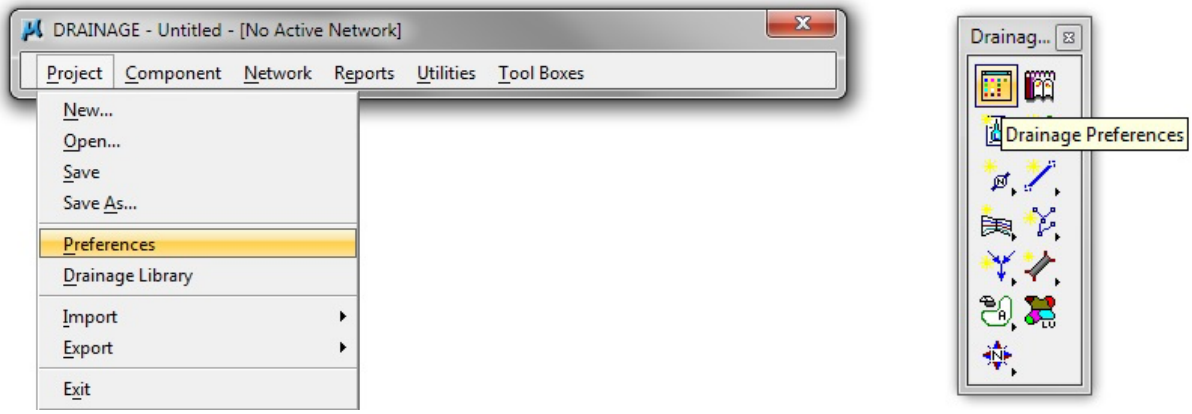


NOTE: Every time that you open GEOPAK Drainage, an untitled project will open. Therefore, you must go to **Project>Open** and select your project .gdf file every time you want to edit or continue working on a project.

1.6 Project Preferences

The Project Preferences control the *graphic and computational* options of the drainage system. The Project Preferences may be changed at any time and the system can then be redesigned or analyzed utilizing the new preferences.

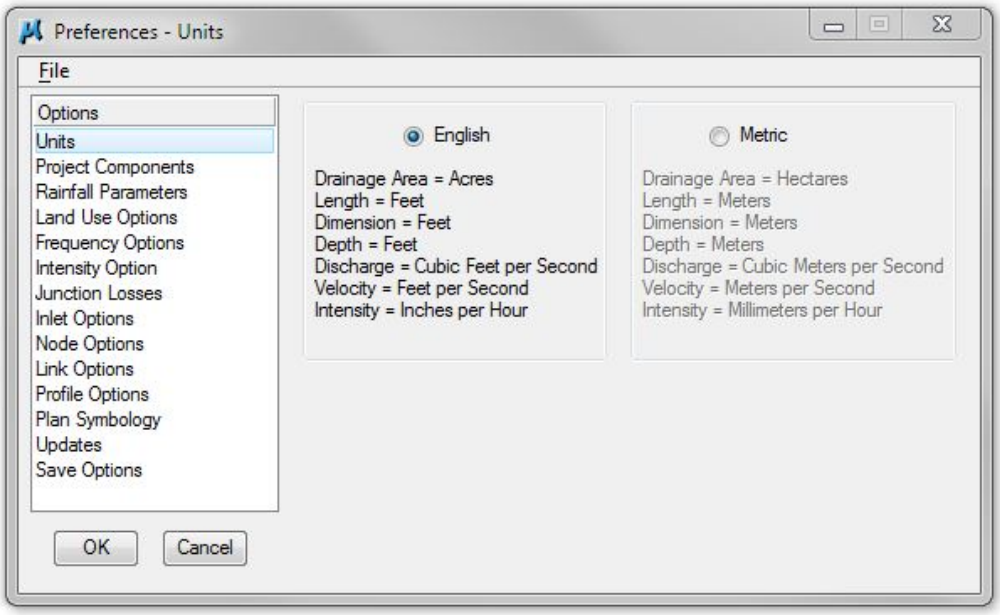
a) Select **Project > Preferences**.



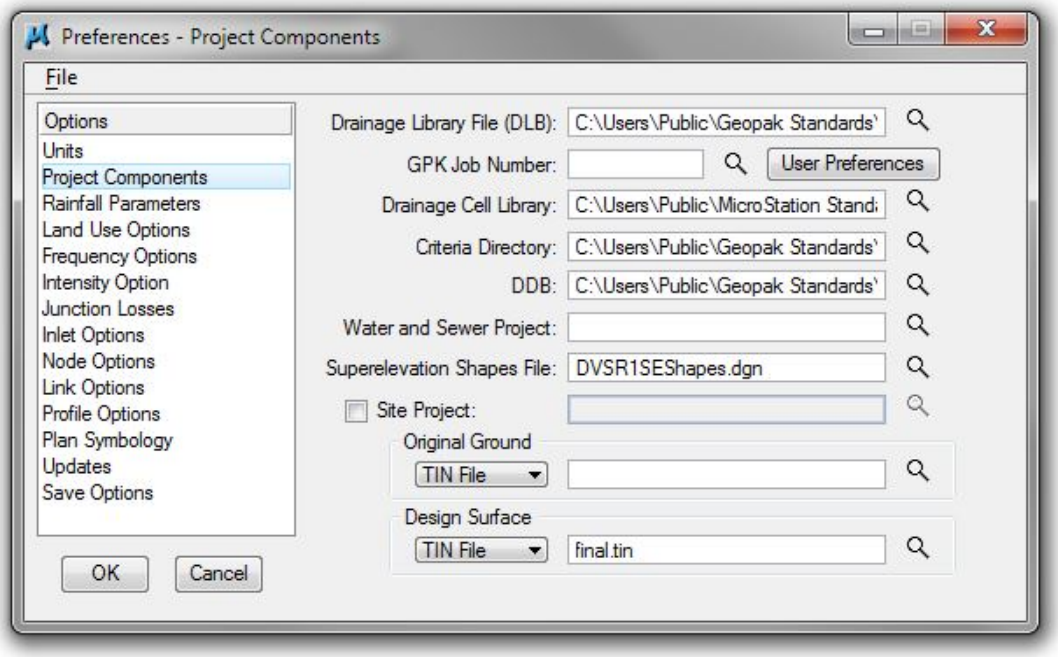
NOTE: Each Drainage Project should begin by copying the file **DrainageProject.**gdf from **C:\Users\Public\GeoPak Standards** into the project folder. This step automatically imports all needed preferences. If this step is missed, TDOT Standard Preferences may be loaded **after opening** the Preferences window and going to **File > Open** and navigating to the following file: **C:\Users\Public\Geopak Standards\TDOTdrainageprefs.dpf**

Review the Preferences by selecting each option in the column and reviewing the various options.

b) Units:



c) Project Components:



The following items are set to the defaults and NO CHANGES need to be made:

Drainage Library File (DLB) – C:\Users\Public\Geopak Standards\TDOTEnglish.dlb

User Preferences – These settings are already set for you for this exercise.

Drainage Cell Library - C:\Users\Public\MicroStation Standards\cell\STDS.CEL

Criteria Directory - C:\Users\Public\Geopak Standards\Criteria

GEOPAK DDB: C:\Users\Public\Geopak Standards\tdot.ddb

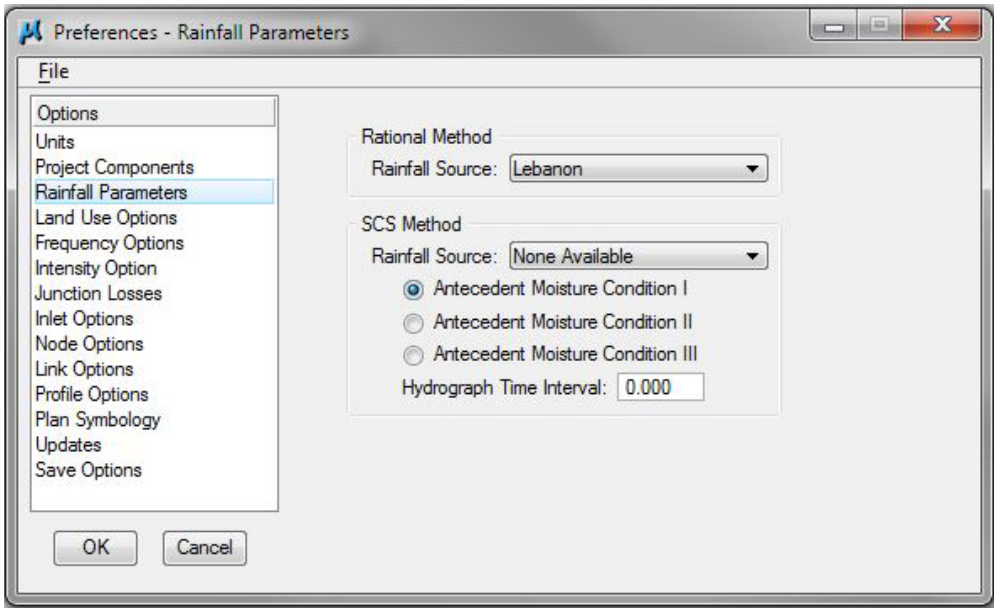
For each Library and Directory file location, select the explorer button and go to the following file locations:

GPK Job Number – Pick the GPK file and it will automatically set the correct number (this only happens if it goes to the correct User Preferences)

Superelevation Shapes File – Choose DVSR1SEShapes.dgn from the project directory

Design Surface – Choose final.tin from the project directory. This final tin is a combination of the proposed tin and existing tin. The final tin includes the proposed areas inside the slopes and the existing area outside the slopes. The tin file has been created for your use in class. Refer to the Geopak Road Course Guide Chapter 22 for instruction on how to create a final tin file for your project.

d) Rainfall Parameters:

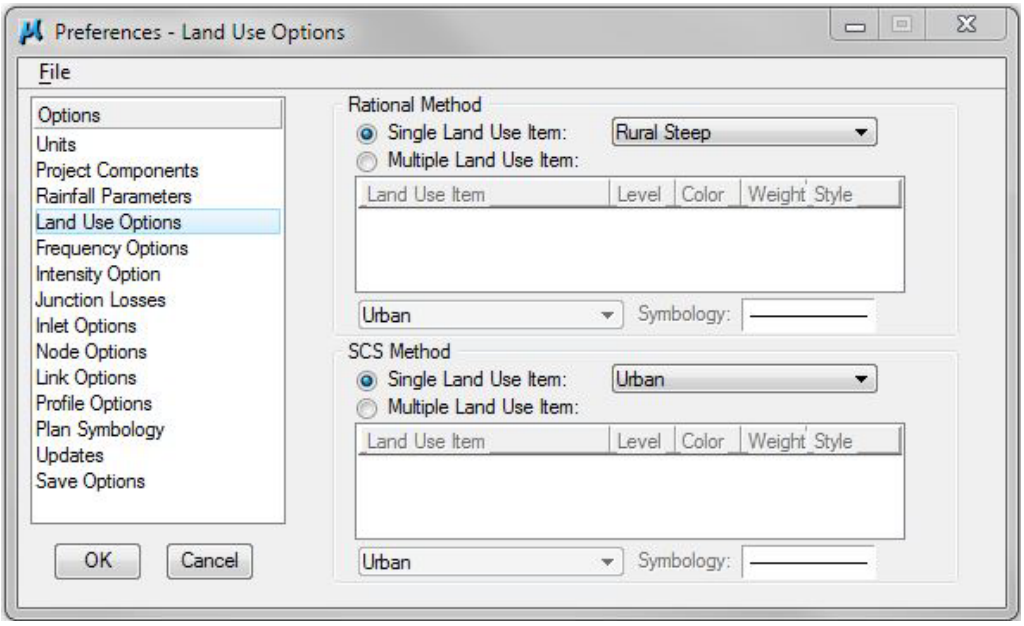


Select the appropriate rainfall source for the city closest to the project site.

See the TDOT Drainage Manual, Chapter 4, Figure 4A-1 or Appendix I.

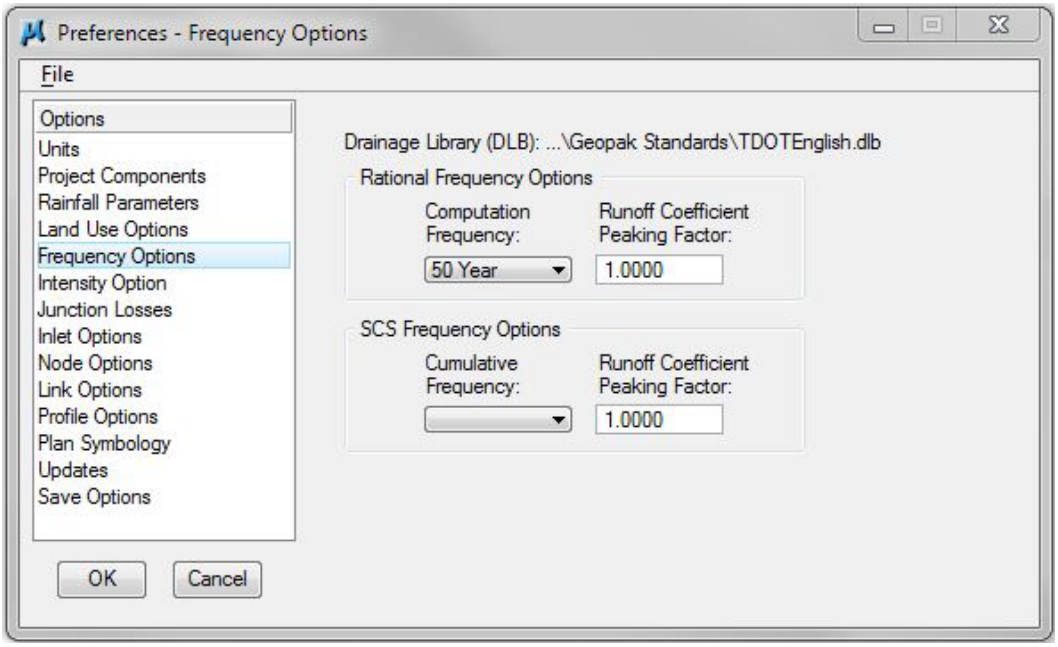
NOTE: The Tennessee Department of Transportation Roadway Design Division uses the Rational Method for drainage design.

e) Land Use Options:

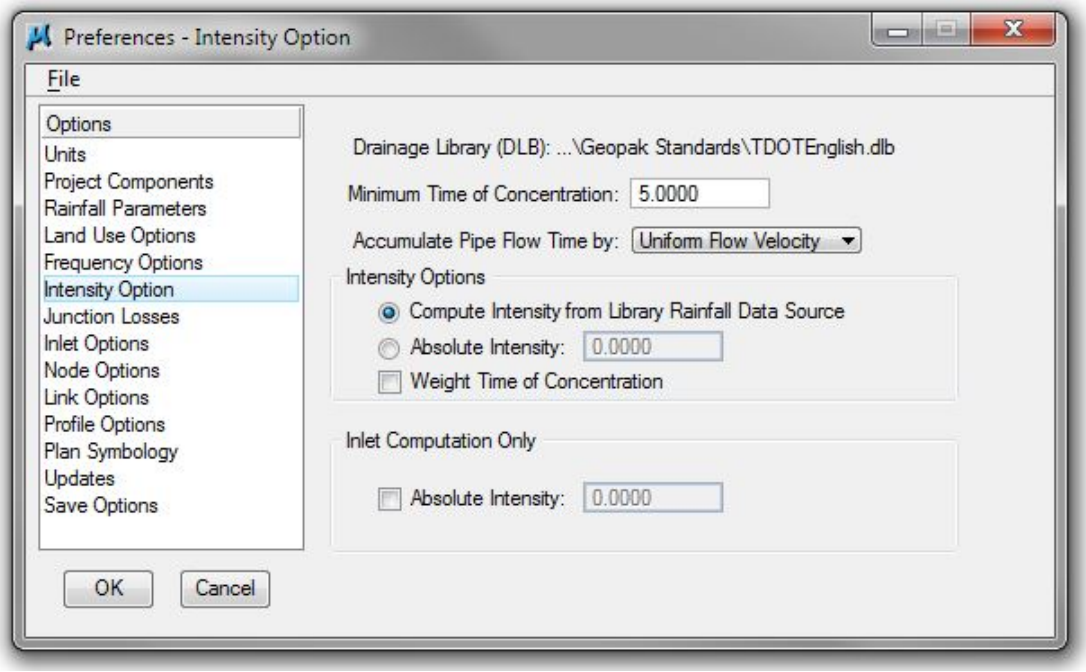


Set the Land Use Option to **Single Land Use Item: Rural Steep** for this class. The Roadway Design Division **does not** use the option for Multiple Land Use Items. All definitions for land use must come from a specific category.

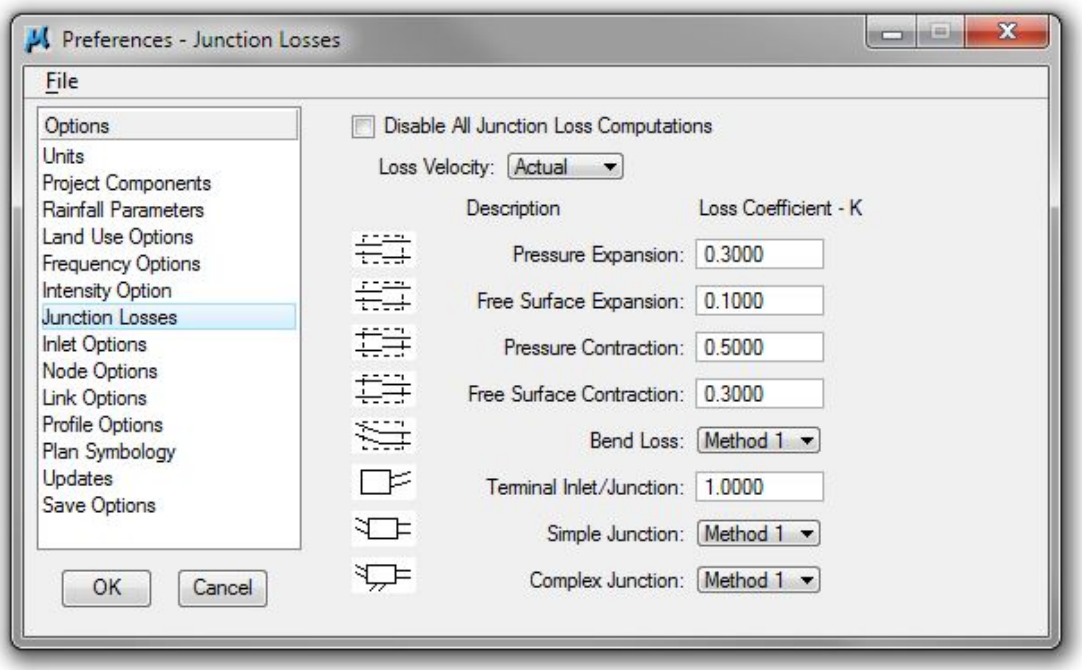
f) Frequency Options:



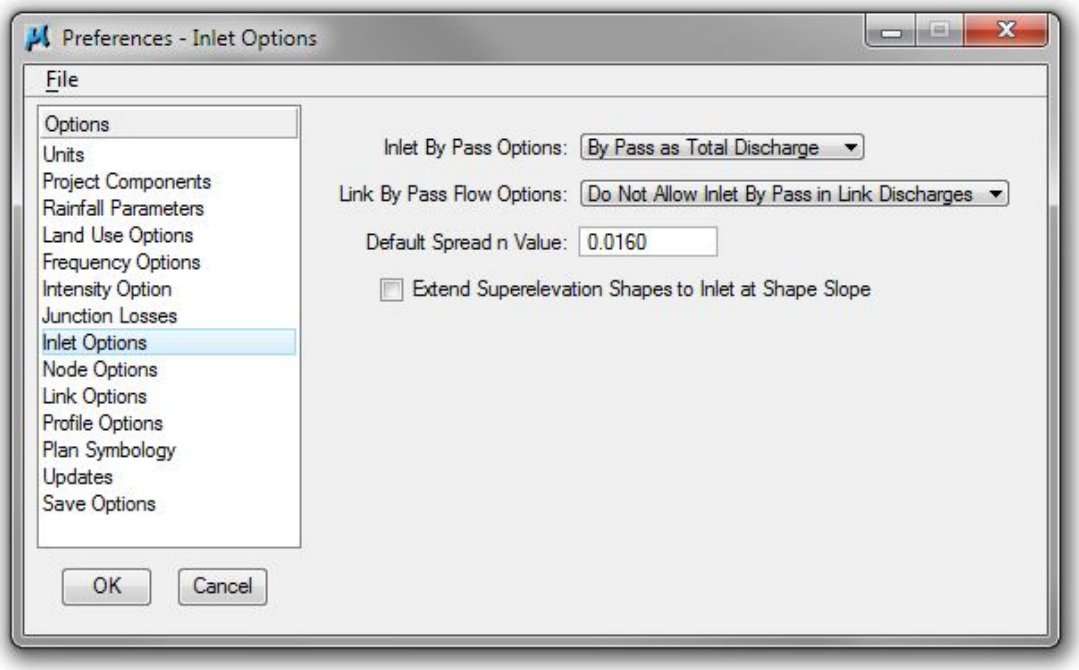
g) Intensity Options:



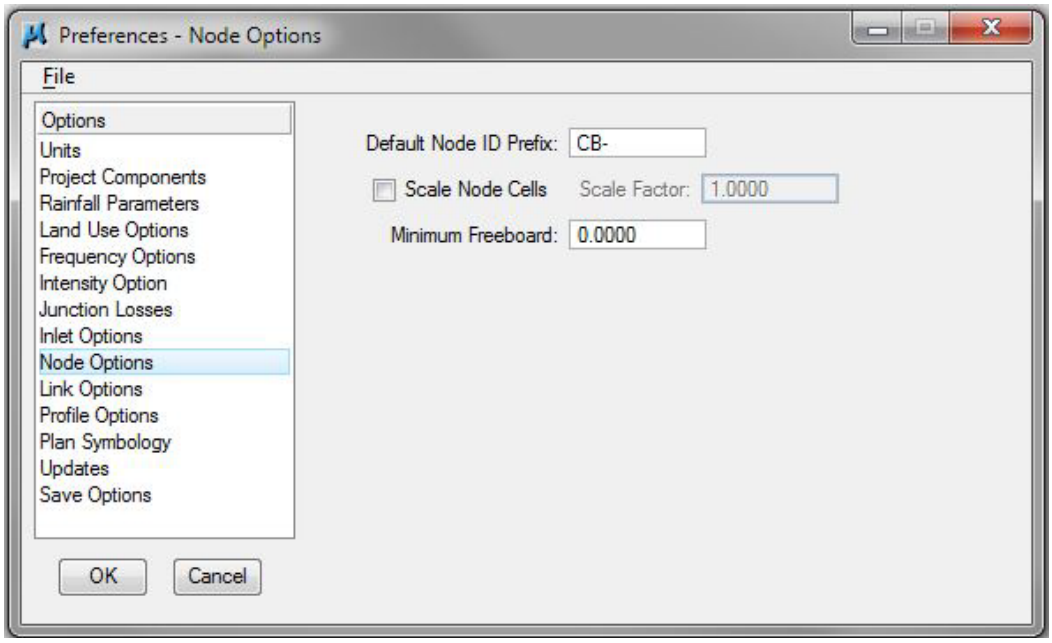
h) Junction Losses Options:



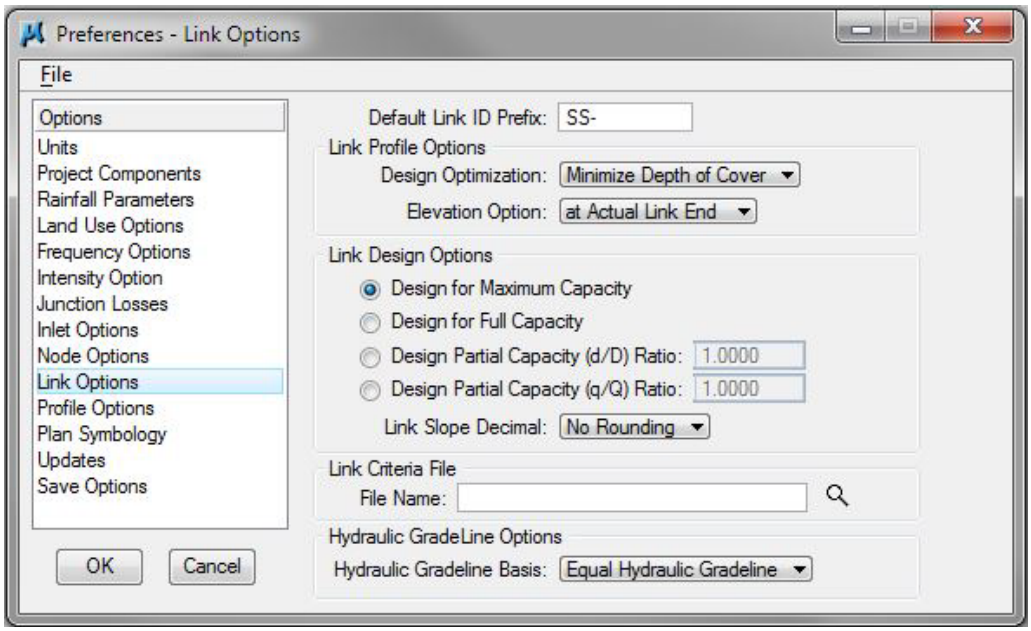
i) Inlet Options:



j) Node Options:



k) Link Options:



NOTE: Do **not** set the **Link Slope Decimal** to rounding. This setting is for control of Pipe Design not annotation. If set it will be impossible to design for minimum depth drainage structures.

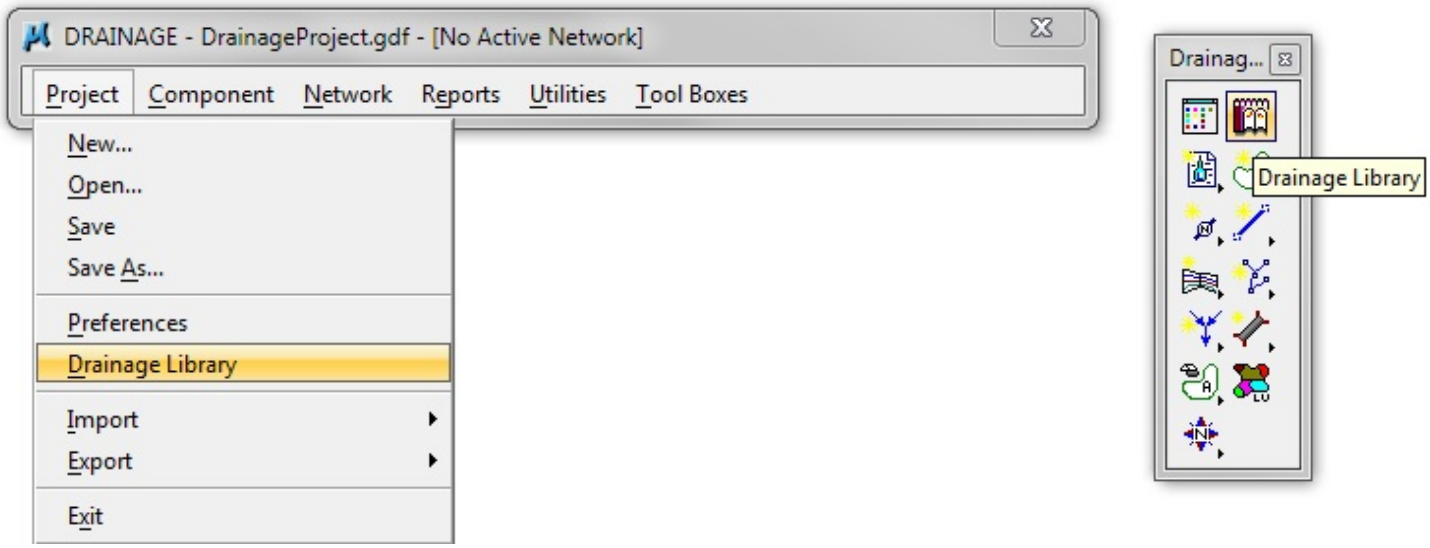
l) Profile Options, Plan Symbology, Updates and Save Options should be kept at the default settings. Do not make any changes.

m) Click **OK** to save changes and dismiss the dialog.

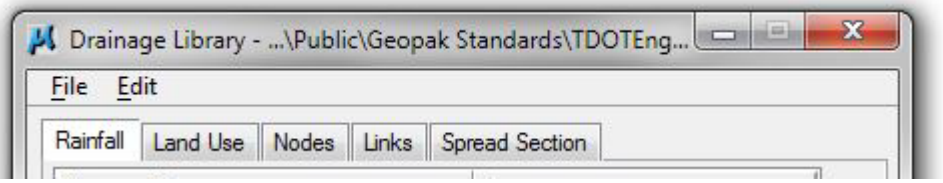
1.7 Drainage Library

The Drainage Library is used to store hydraulic, hydrologic, and construction standards, which may be shared by different projects and designers. Each GEOPAK Drainage project accesses items from the *Drainage Library* for use on the specific project.

a) Select **Project > Drainage Library**. The library stored in the Preferences will be opened by default.



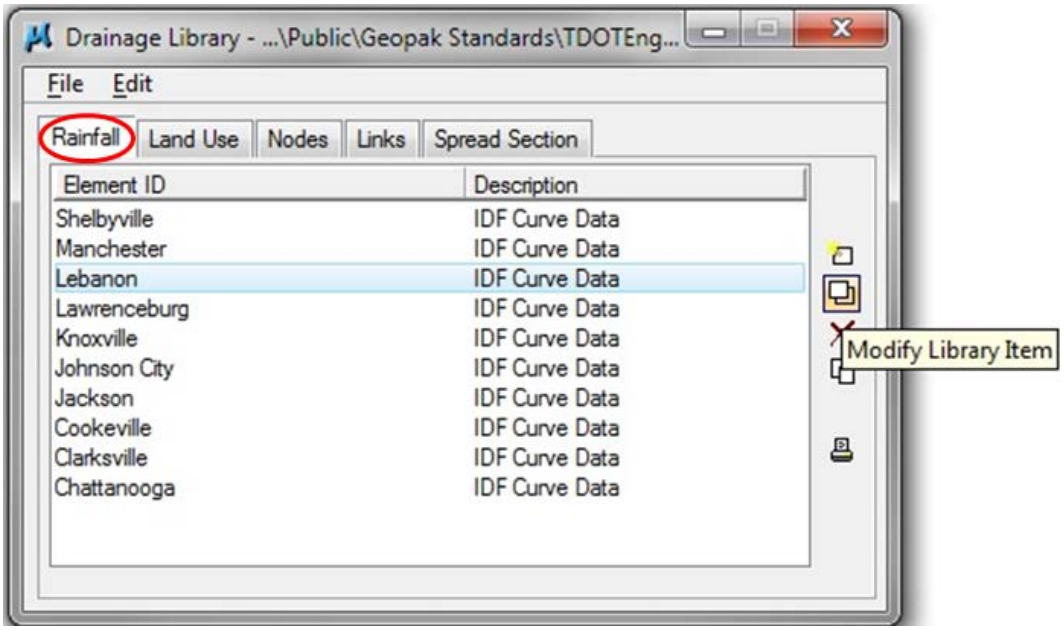
The Drainage Library currently contains five (5) tabs as shown below:



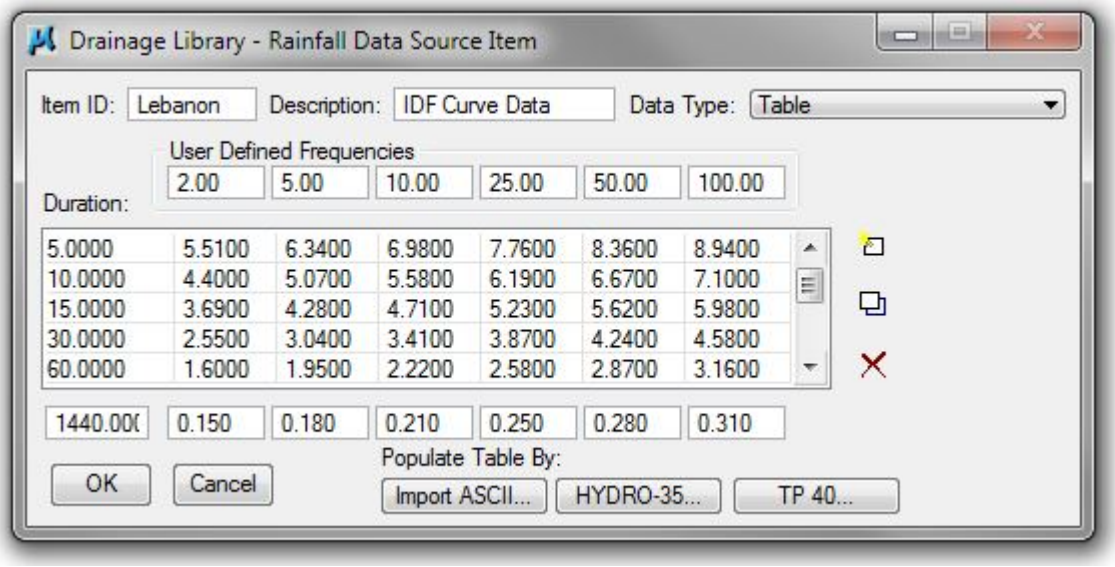
- **Rainfall** .. .. Rainfall Data Source
- **Land Use** ..... Land Uses, their corresponding “C” values and symbology
- **Nodes** ..... Inlets, Junctions, Manholes, Outlets, etc.
- **Links** ..... Circular Pipes, Elliptical Pipes, Pipe-Arch pipes, Boxes, etc.
- **Spread Section** ..... Inventory of varying Spread Cross Sections

The **Rainfall** tab stores the rainfall data information to be used on GEOPAK Drainage Projects. GEOPAK Drainage supports rainfall sources in the form of intensity duration frequency (IDF) tables, or as coefficients for intensity-duration-equation formats.

b) Select the **Rainfall** tab, highlight Lebanon, and select **Modify** to review the various options:



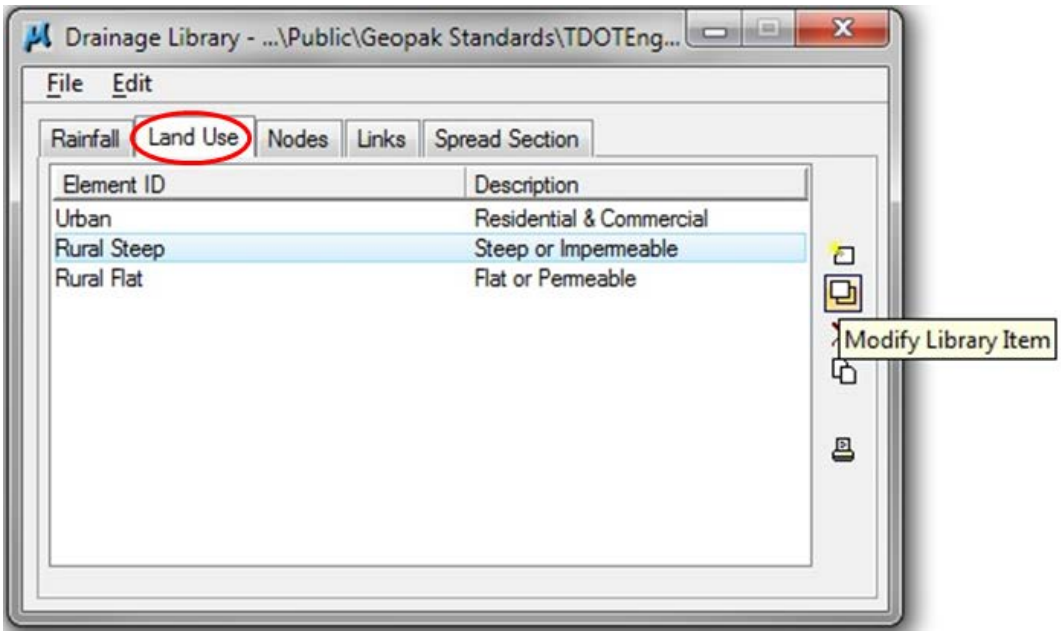
NOTE: See Appendix I for IDF Zone Location Map.

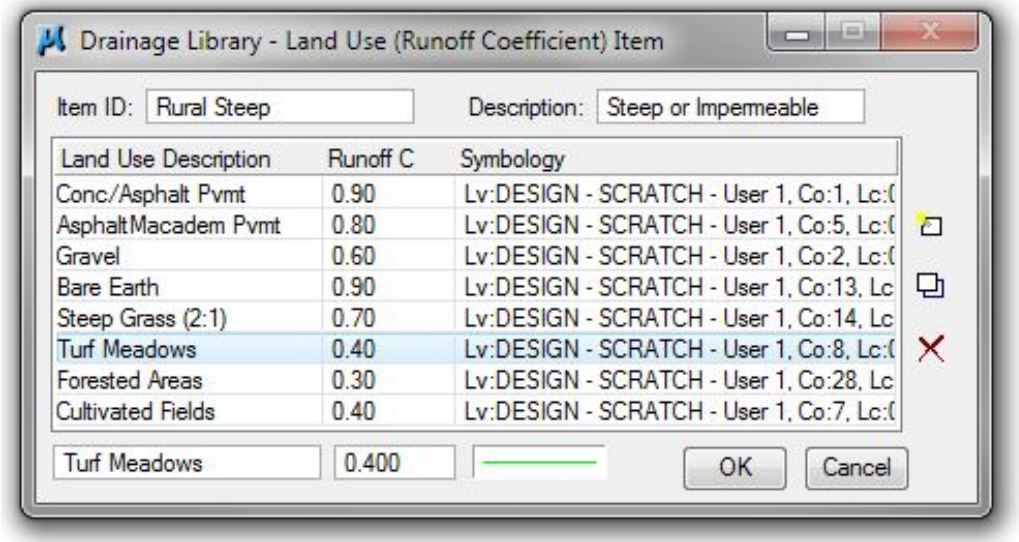


The table contains the Duration-Frequency Table for the Lebanon area.

The **Land Use** tab is used to store runoff coefficients ("C" values) and corresponding graphic symbology for each land use. Land uses can then be delineated automatically using the selected symbology.

c) Select the **Land Use** tab, highlight the Rural Steep item and select **Modify** to review the various options:

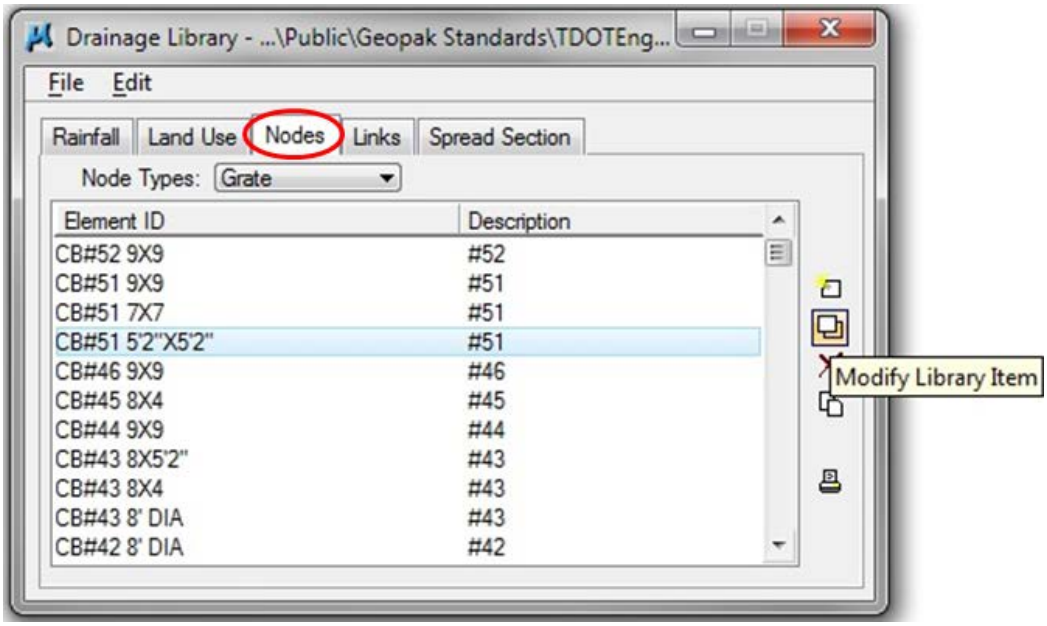


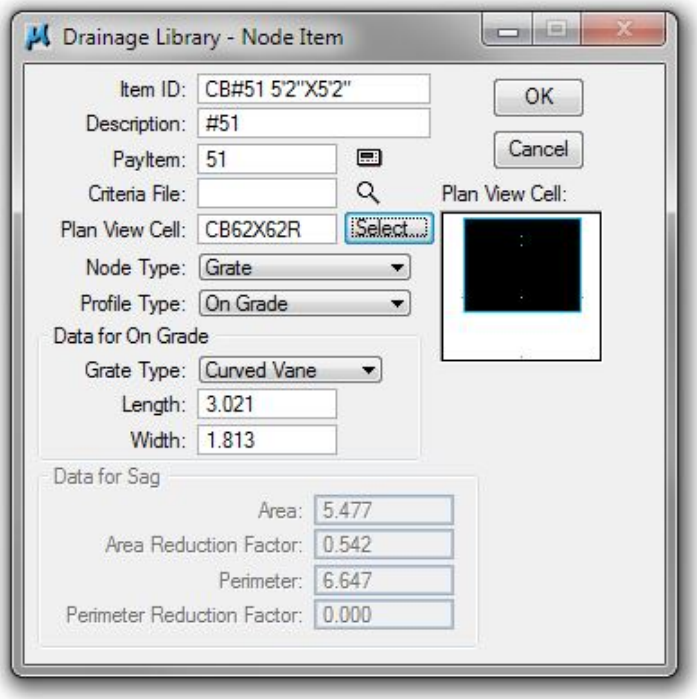


Note the various land uses and their associated symbology. Chapter 2 will discuss how to make a land use file.

The **Nodes** tab contains standard configurations for Grates, Curbs and Slotted drain inlets, as well as Junctions, Outlets and Other nodes. The description, plan view representation and dimensional information are stored for each node.

d) Select the **Nodes** tab, highlight a Grate inlet and select **Modify** to review the various options:

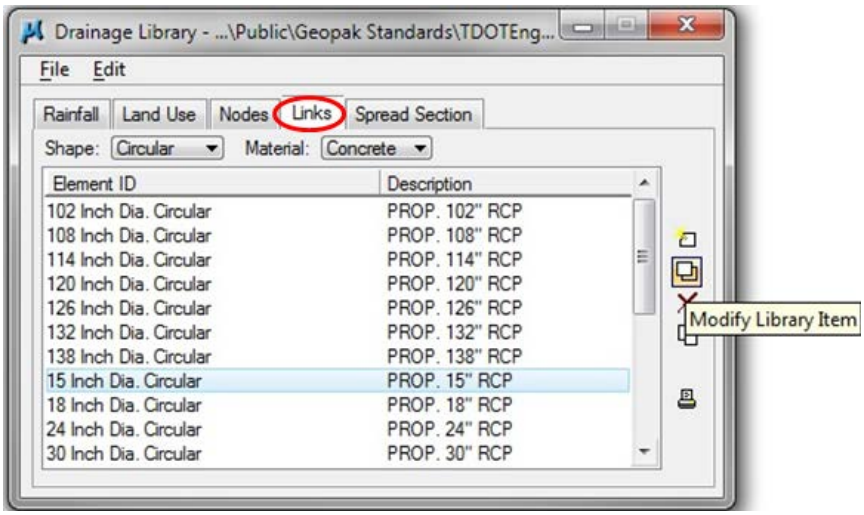


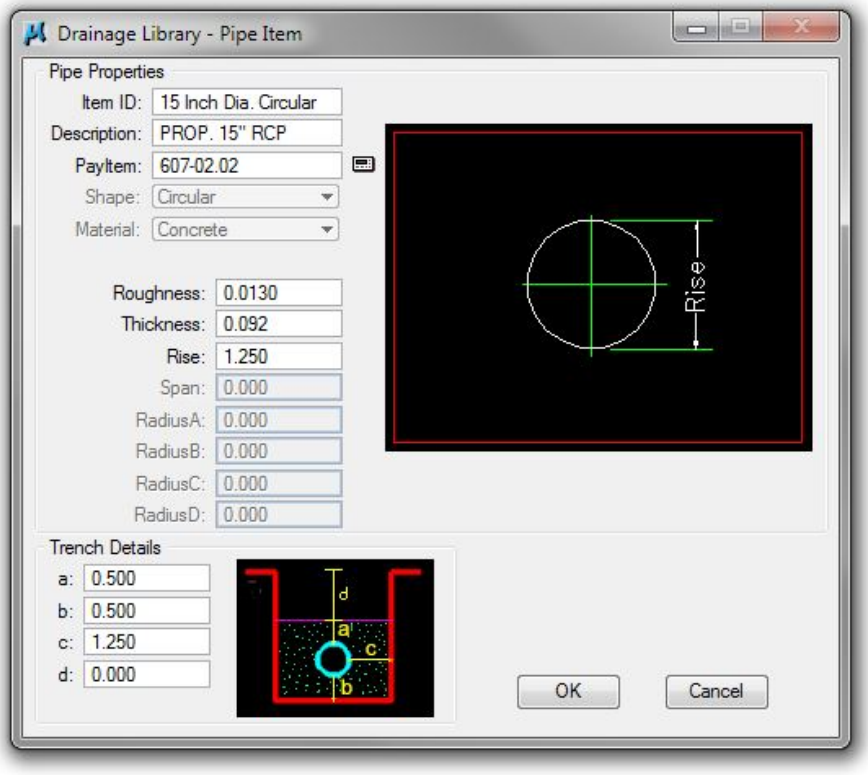


Note the various geometric values required for the nodes.

The **Links** tab contains all culverts to be used on drainage projects. Each link type is categorized by three properties: Shape, Material and Type (for some combinations of Shape & Material); and contains information regarding specific culvert geometry, default roughness coefficient and material combination.

e) Select the **Links** tab, select **Circular** from the Shape dialog box and **Concrete** from the Material dialog box. Highlight the first Circular Concrete pipe, and select **Modify** to review the various options:

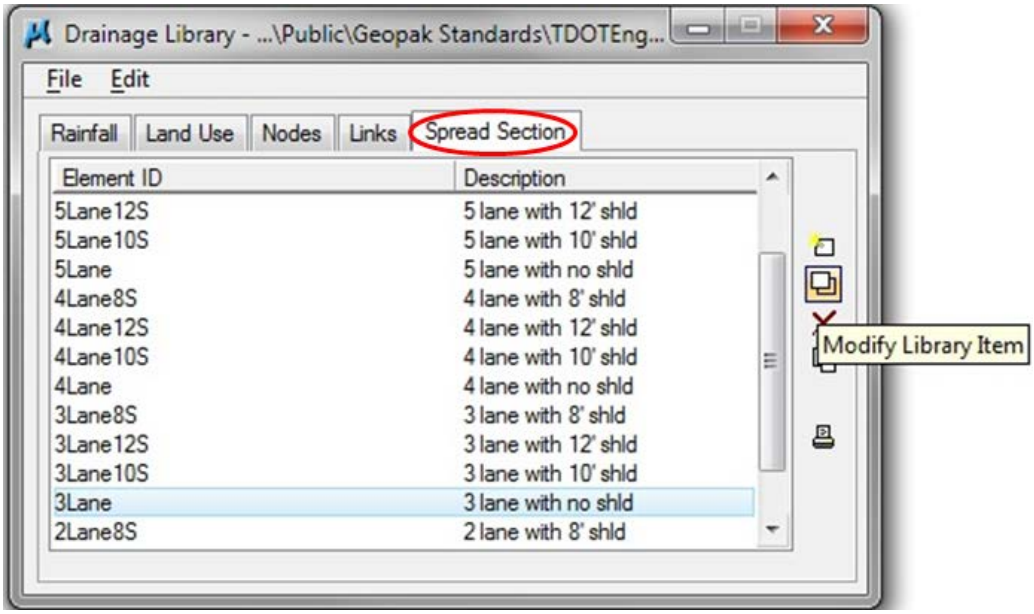


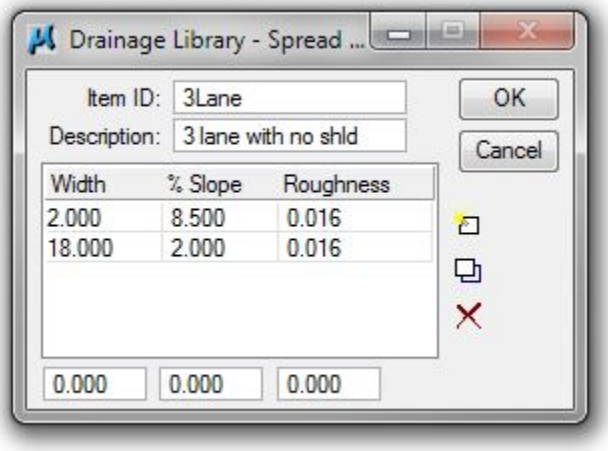


Note the various geometric values required for the links.

The **Spread Section** tab stores standard spread cross sections for roadway, shoulders and gutter that can be used on drainage projects.

f) Select the **Spread Section** tab, highlight any section, and select **Modify** to review the various options:





Note the spread cross section characteristics for the spread item.

2. Land Use DGN Files

This chapter is provided for REFERENCE ONLY. We have provided the land use file for you so that all class participants will have the same areas.

For your own project, these exercises would have to be done prior to beginning GEOPAK drainage.

This exercise allows the user to create a Land Use file.

2.1 Land Use DGN Creation

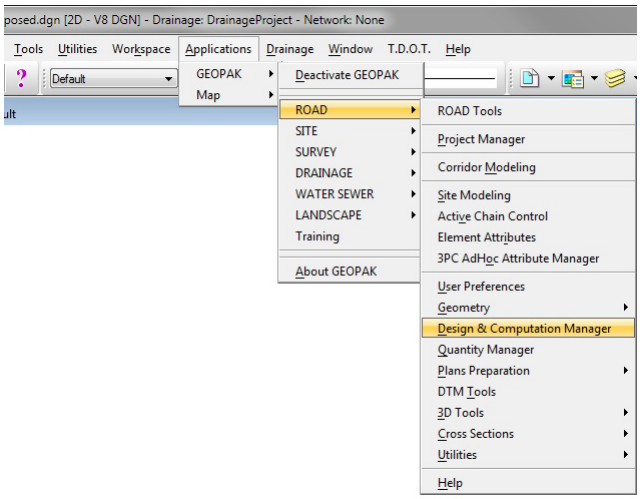
The shapes created in the land use DGN file are used to specify run-off coefficients (C value) for different land use areas. These values are then used to calculate the composite run-off coefficient. This composite value is used in conjunction with rainfall data in the rational formula to calculate the Q discharge for the drainage area. This composite run-off coefficient can be manually calculated and entered as a value but by creating these shapes this can be done automatically for any drainage area specified on your project.

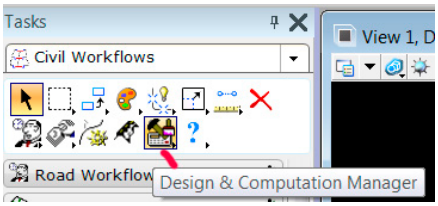
a) Create a new DGN file for placement of land use shape elements from DGN seed file SEED2D.DGN and open it. Reference your proposed file, which contains proposed edges of pavement and slope lines. Also reference your survey topo file.

- Land use.dgn

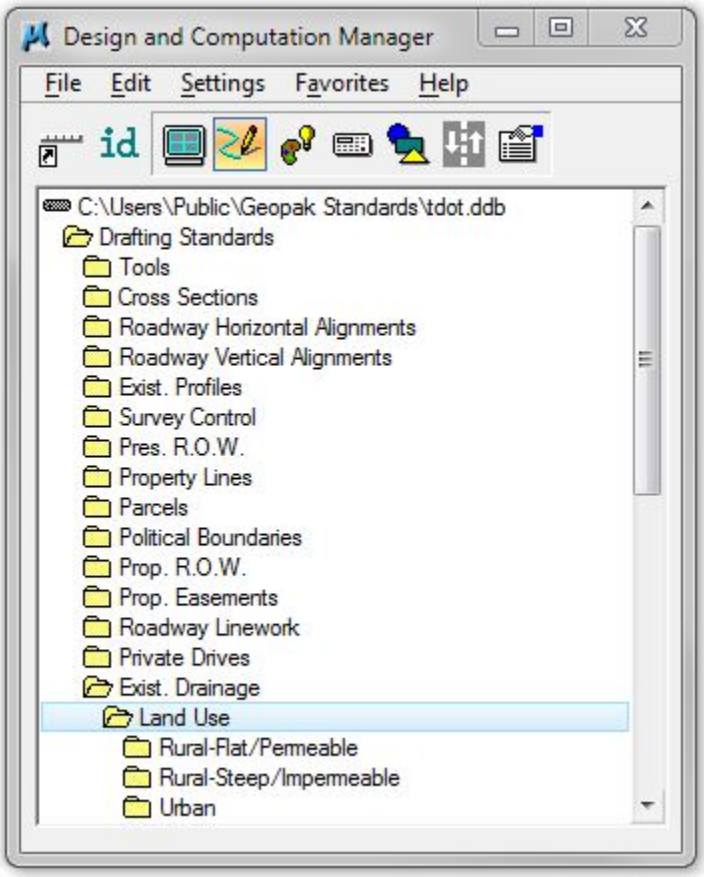
NOTE: For further guidance in creating a new DGN file see **Exercise 2** of the MicroStation V8 Manual

b) Access **D & C Manager** from the MicroStation menu bar drop down location **Applications>GEOPAK> Road>Design & Computation Manager** or from task navigation with Geopak's **Civil Workflows**, it is the second icon from the end on the right.

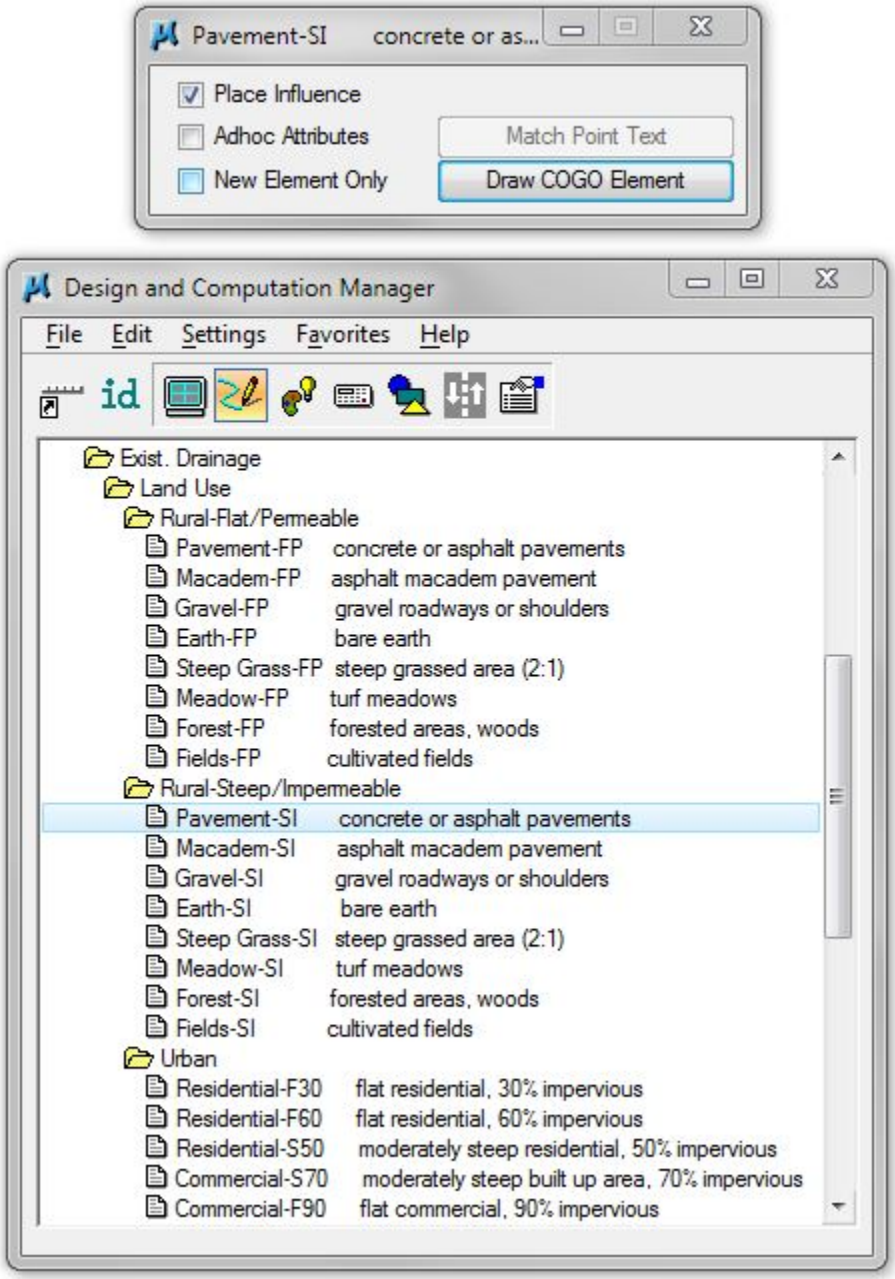




c) In **D & C Manager** go to the land use category under **Drafting Standards\Exist. Drainage\Land Use**.
There you will see the three categories of land use items used by T.D.O.T.



d) Open the desired category and click on the land use item you wish to define on the project. Click on **Place Influence** in the D & C Manager control strip.



NOTE: You should only use types from one section (i.e. Rural-Flat/Permeable or Urban).

e) Use any MicroStation shape command to draw shapes around the areas. You may wish to copy graphics from the reference files to create complex shapes. This could be the proposed edge of pavement lines from the proposed file to shape the pavement area or perhaps the edge lines from a parking lot or woods area from the survey topo file. Anytime you wish to change to a different land use type just click on it in **D & C Manager**. If you have shapes already defined simply use the MicroStation **Change Element Attributes** command to change their symbology.

NOTES:
Shapes must be continuous and closed. Set fill type to None.

It is not necessary to place shapes to cover all areas absolutely. Any areas not delineated by a land use shape will use the **Base C value** entered in the **Drainage Area Definition** dialog.

f) Once shapes have been set up simply reference the DGN file to your proposed DGN file and they will be read when you use **Delineate Subareas** in the **Drainage Area Definition** dialog.

3. DTM Drainage Tools

GEOPAK supports a wide range of tools that allows you to analyze and evaluate the drainage patterns of a GEOPAK Digital Terrain Model or TIN file. These tools are useful for delineating and distinguishing watersheds, flow paths, flow directions, and hydrographic features.

This exercise allows the user to become familiar with the Digital Terrain Model (or DTM) Drainage Tools.

See Exercise 22 in the TDOT GEOPAK Road Course Guide for guidance in creating a final merged TIN file.

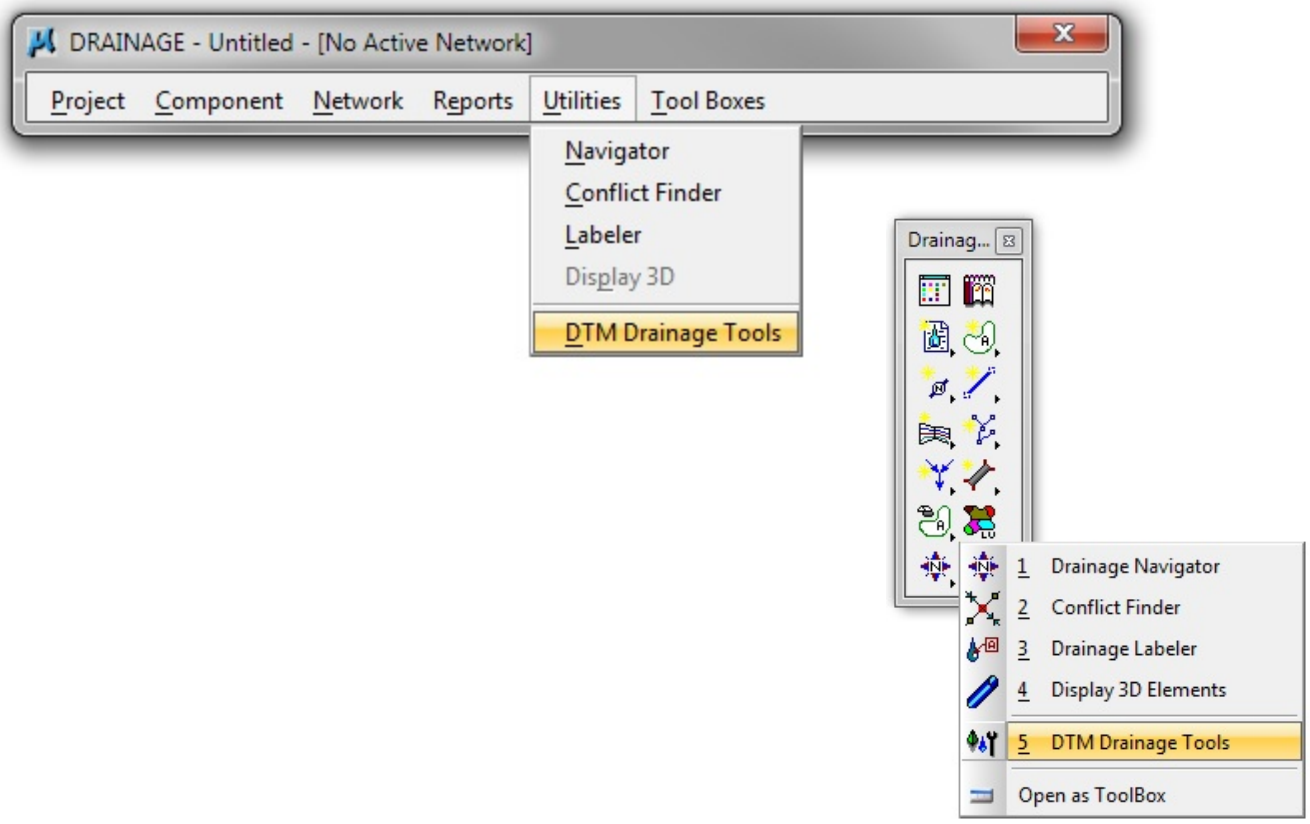
3.1 Accessing DTM Drainage Tools

a) Open the file **DVSR1proposed.dgn file**.

Note: The landuse.dgn file has already been referenced into this file for your use. Refer to the previous exercise (Exercise 2) or to the Land Use DGN Creation document for instructions on creating the land use file.

b) Open GEOPAK Drainage and select from the Drainage Menu Bar:

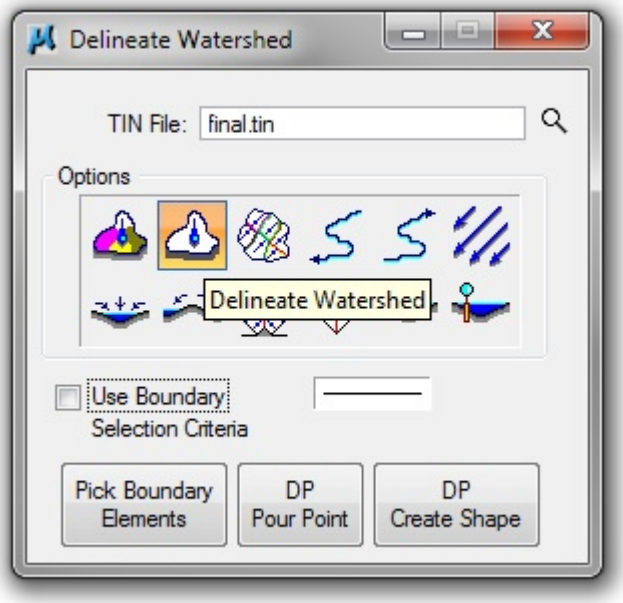
Utilities > DTM Drainage Tools



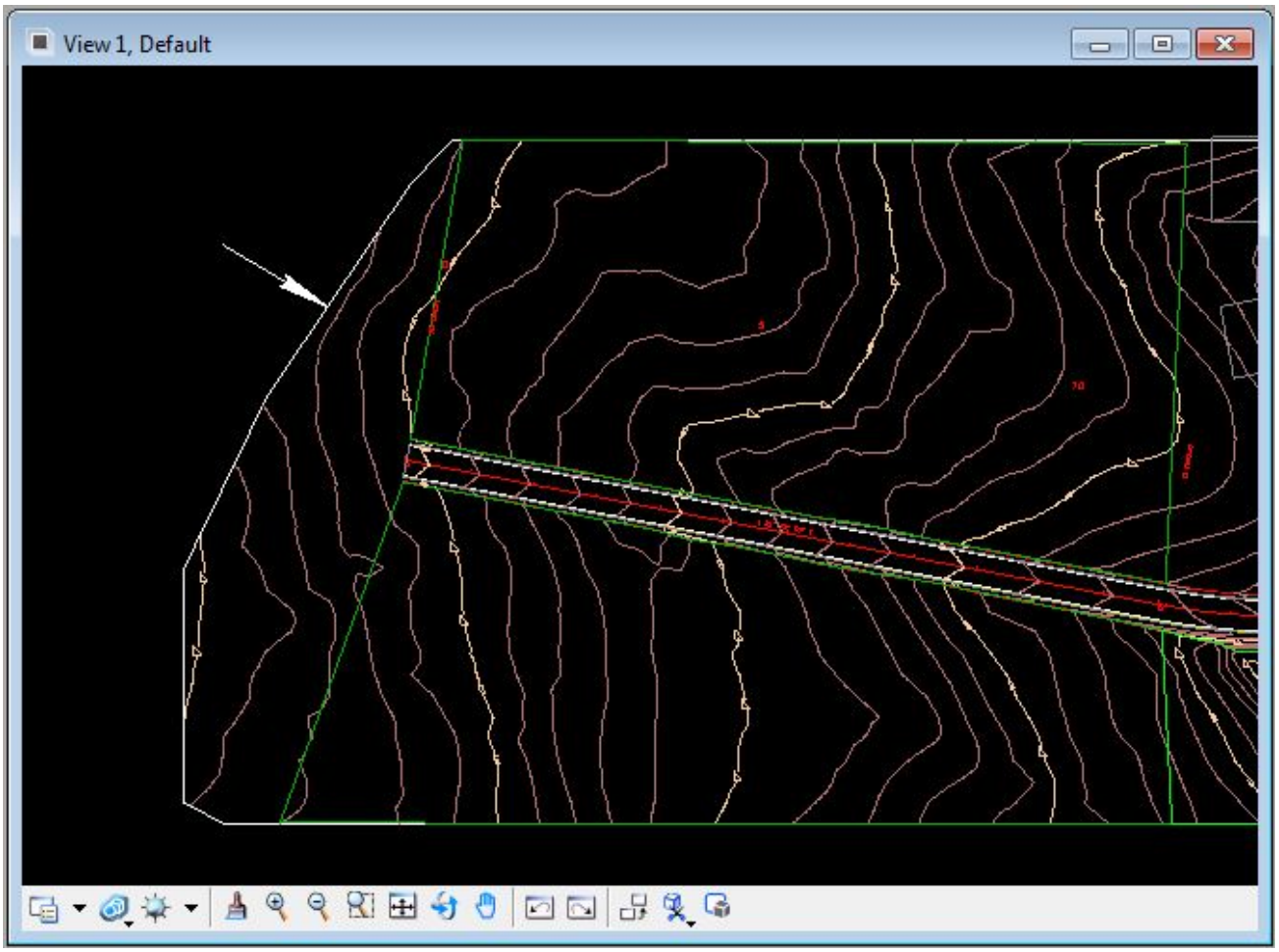
3.2 Delineate Watershed

The Delineate Watershed tool outlines and defines a watershed at any location within the TIN surface. The pour point of the watershed is the most downstream point of a desired watershed. Once a data point representing the pour point of the watershed is indicated the contributing watershed area is computed and delineated. Pour points must be located near sumps (i.e. low points) in the terrain since a point lying on the side of a hill does not actually have a contributing area.

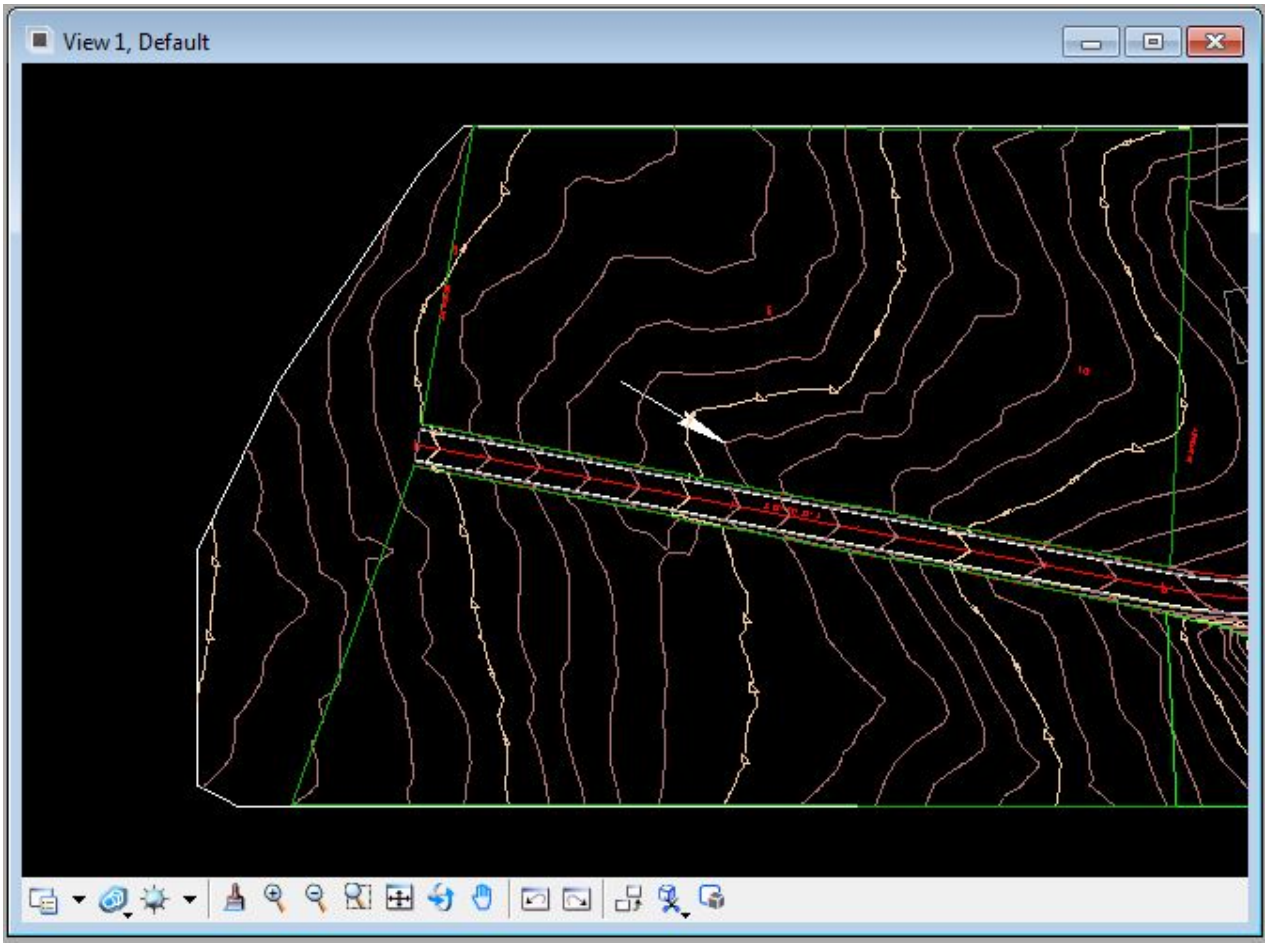
a) Use the Select File button to select the final merged TIN for the project. Then select the DTM Drainage Icon **Delineate Watershed**.



b) Click the **Pick Boundary Elements** button and select the element representing the tin hull (the boundary of the TIN file) as shown in the screenshot below. Data Point to accept. Make sure **Graphic Group Lock** is **OFF**.

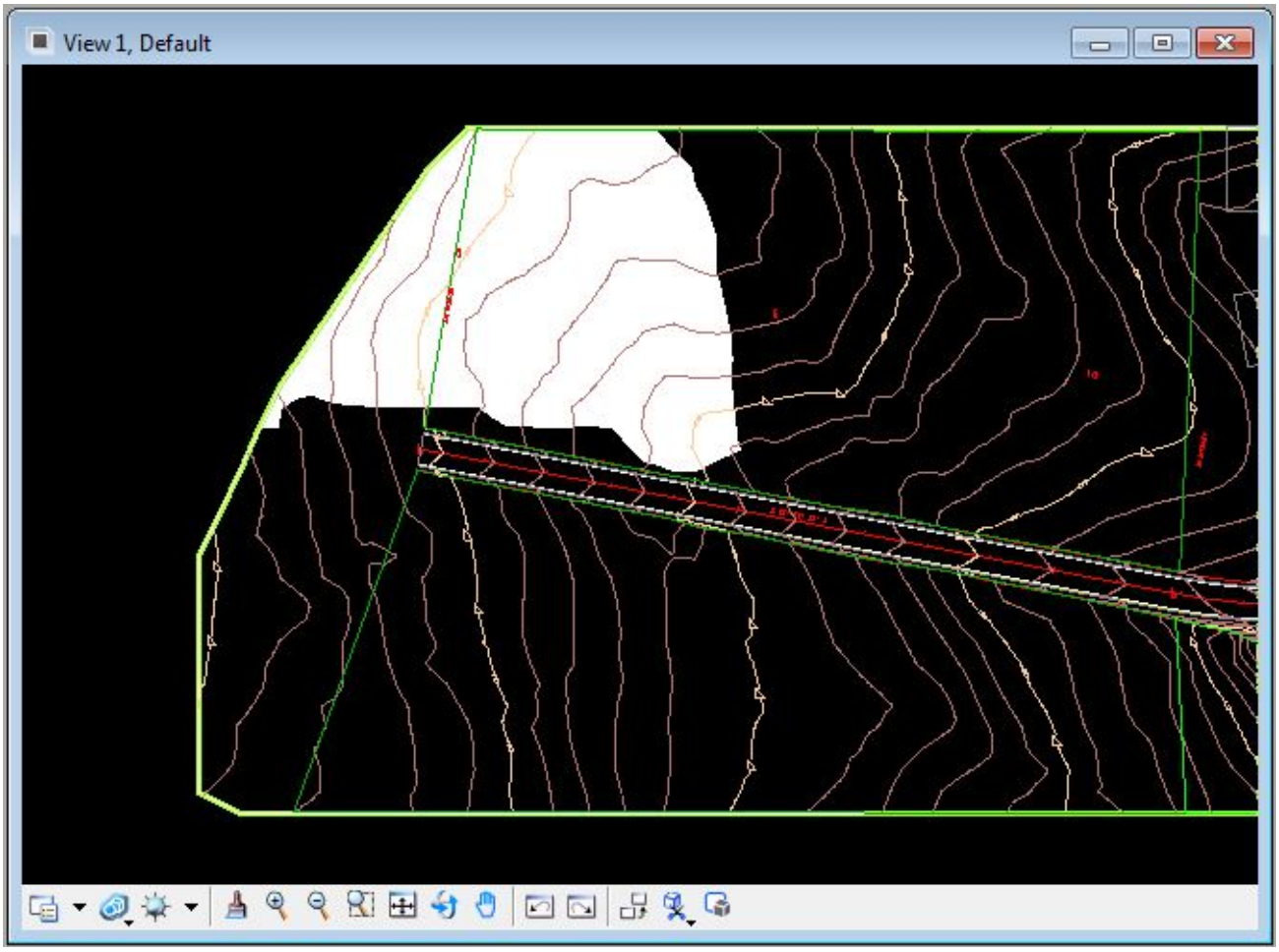


c) Click the **DP Pour Point**. Data Point in the dgn file in the approximate location shown below:



d) Click the **DP Create Shape** button and data point inside the drainage area delineation from the previous step. This procedure will place a temporary fill in the drainage area. Data Point to accept this shape and Update the Microstation View to remove the temporary fill. The Drainage Area Shape has been drawn in the dgn file.

NOTE: Scrolling or zooming between Step (c) and Step (d) will cause the temporary watershed delineation to disappear. However, the information is still present and following Step (d) will still create the Drainage Area Shape.

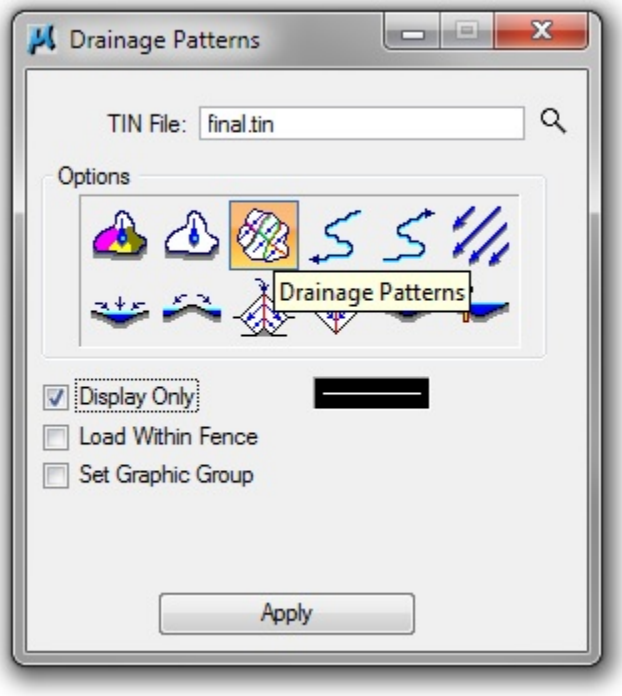


3.3 Drainage Patterns

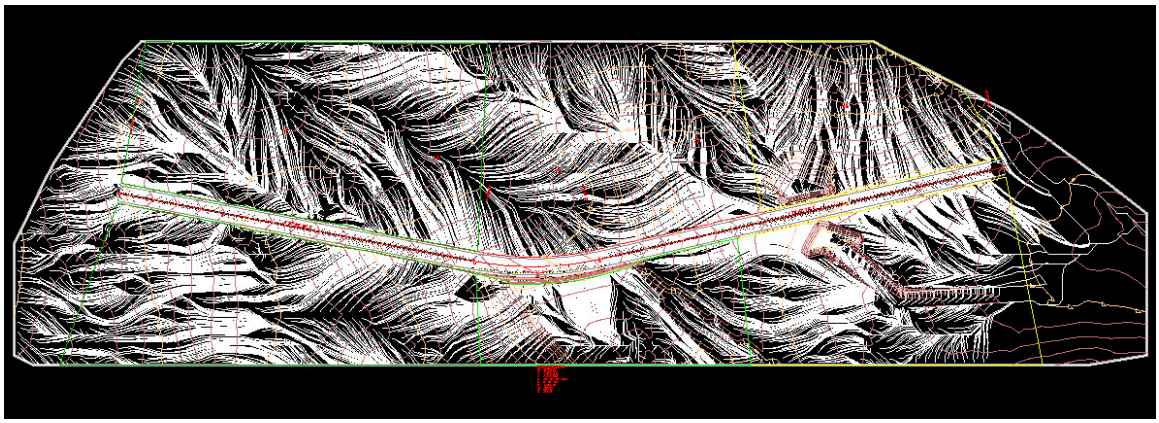
The Drainage Patterns tool evaluates the flow paths contained within the TIN. This tool performs a downstream trace from the centroid of each triangle.

a) Select the DTM Drainage Icon **Drainage Patterns**. Toggle ON Display Only and click the **Apply** button to exhibit the Drainage Patterns for the tin file.

NOTE: Throughout this exercise, Display Only will be chosen (except where noted), so that the graphics will delete when the view is refreshed.



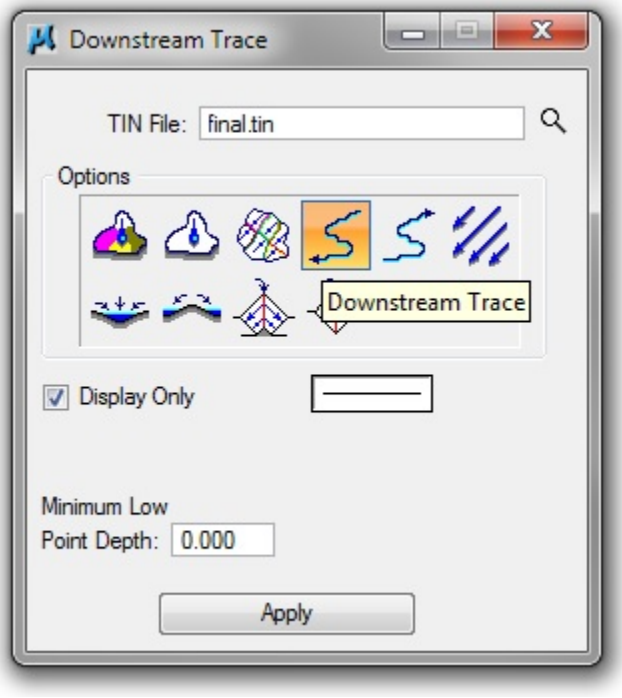
NOTE: Pressing the Escape button (on the keyboard) will terminate the current process before completion.



3.4 Downstream Trace

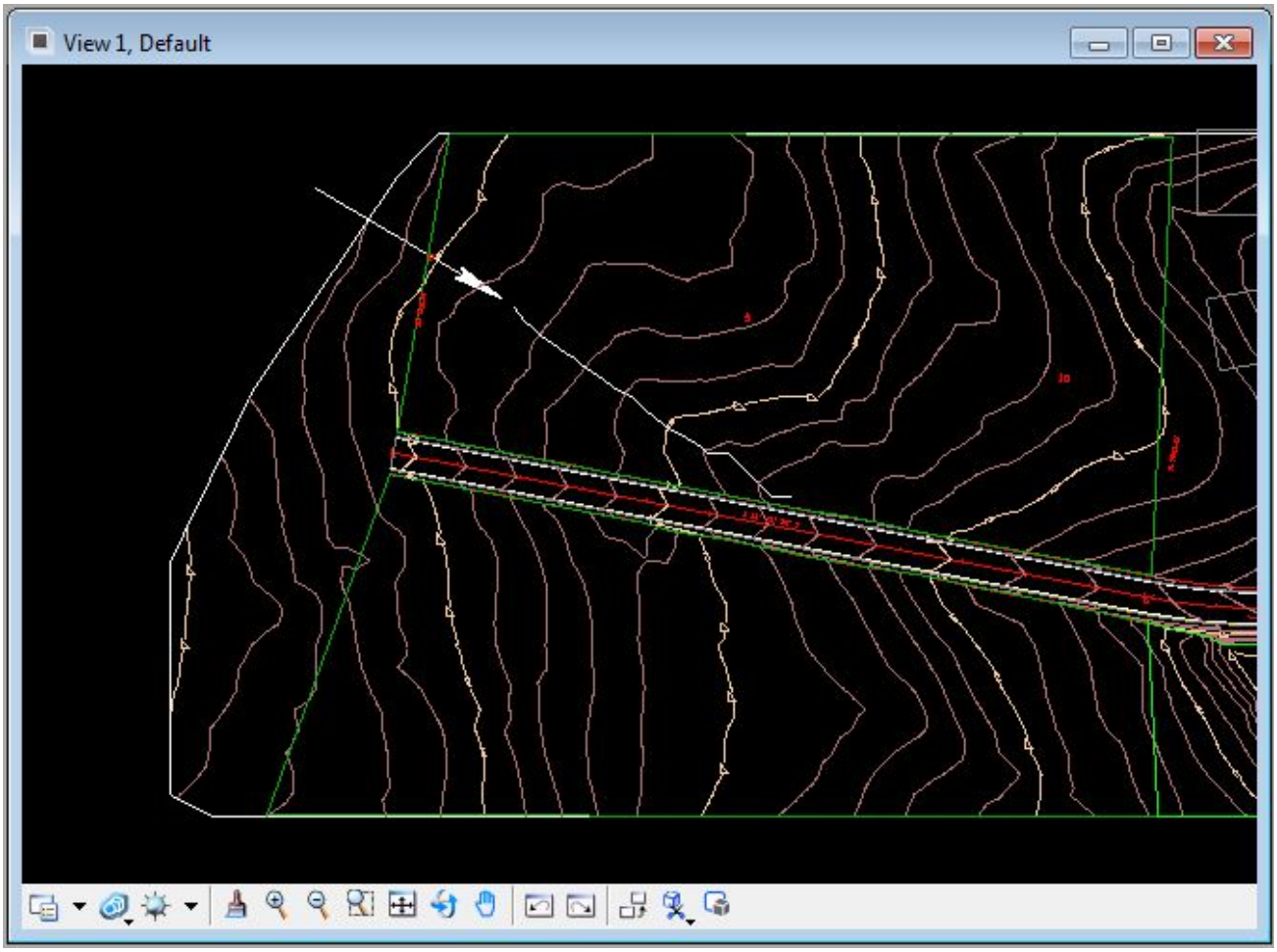
The Downstream Trace tool delineates the flow path downstream from a given point in the TIN. The indicated path follows the steepest descent from the point through the TIN terminating at a low point or the edge of the TIN.

a) Select the DTM Drainage Icon **Downstream Trace**. Toggle ON Display Only and click the **Apply** button.



NOTE: Setting the Minimum Low Point Depth to a value above 0.00 will allow the downstream trace to pass through small, localized depressions and continue downstream.

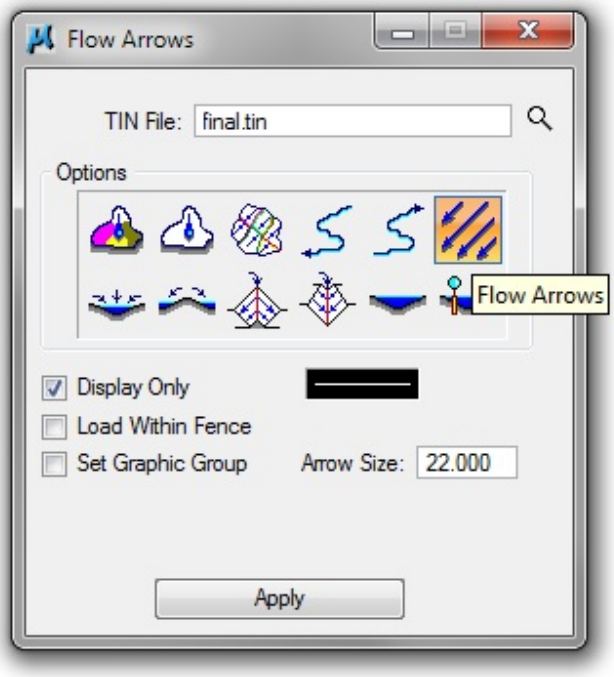
b) Click in the design file within the limits of the tin hull. A downstream trace will appear from the cursor data point location to the nearest low point to which the water will drain.



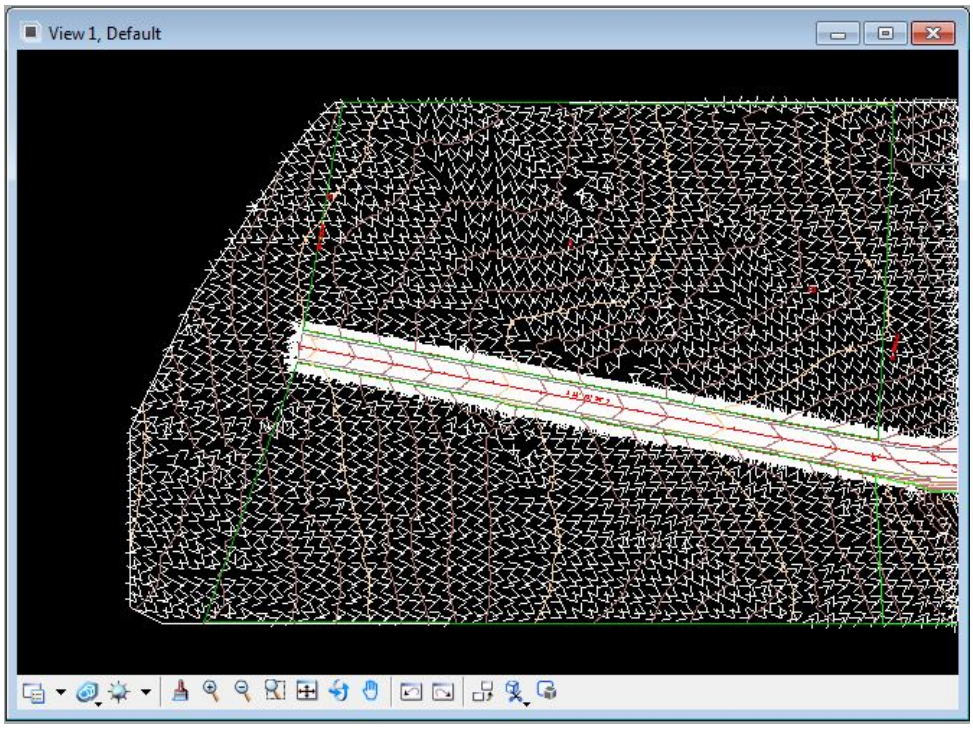
3.5 Flow Arrows

The Flow Arrows tool indicates the direction of flow within the triangles of the TIN.

a) Select the DTM Drainage Icon **Flow Arrows**. Toggle ON Display Only, set the arrow size as shown, and click the **Apply** button.



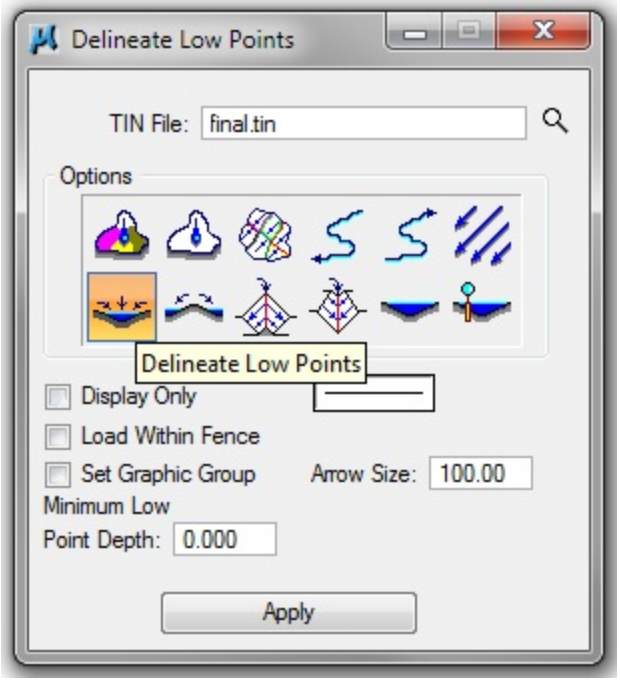
The Drainage Flow Arrows are drawn in the design file.



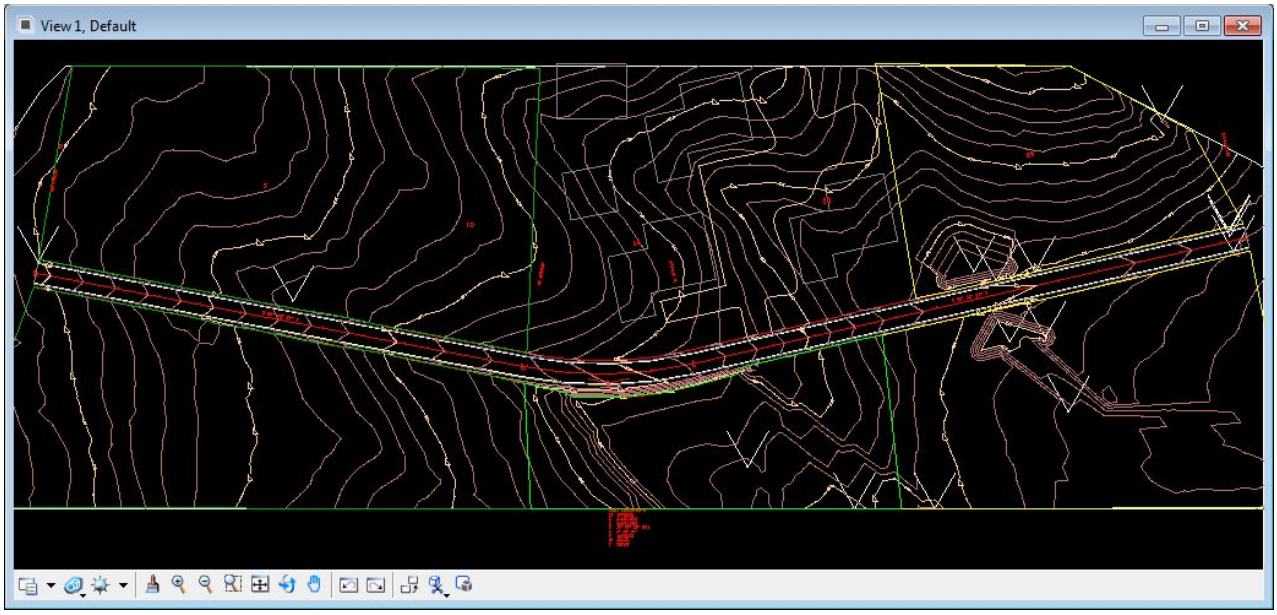
3.6 Delineate Low Points

The Delineate Low Points tool locates all low points within a region of a TIN. A flow arrow is placed and the text "LP" is placed at the triangle vertex. This is an excellent tool to use when choosing an initial location for catch basins on sag points as well as locations in ponding areas.

a) Select the DTM Drainage Icon **Delineate Low Points**. **Toggle OFF Display Only**, **set the arrow size as shown**, and **click** the **Apply** button.



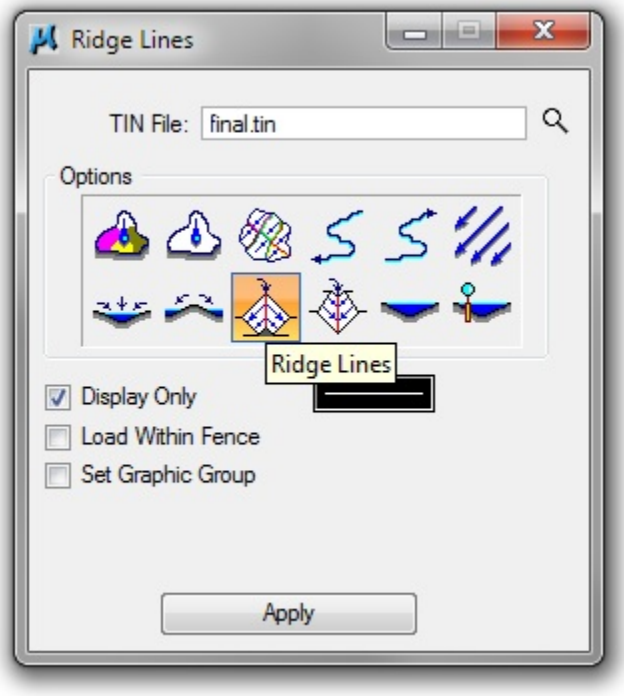
The Low Points are drawn in the design file.



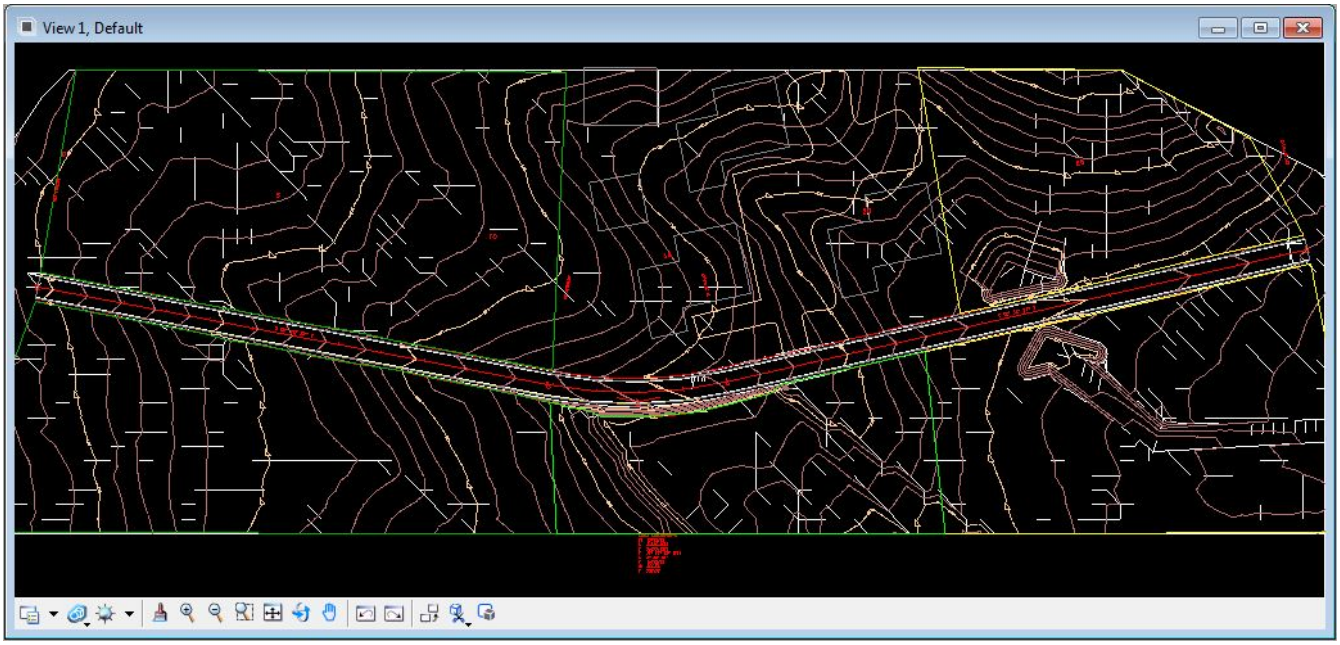
3.7 Ridge Lines

The Ridge Lines tool indicates the ridgelines within a TIN. A ridge line is defined as a triangle edge where the flow on each side of the edge is away from the edge

a) Select the DTM Drainage Icon **Ridge Lines**. Toggle ON Display Only, and click the **Apply** button.



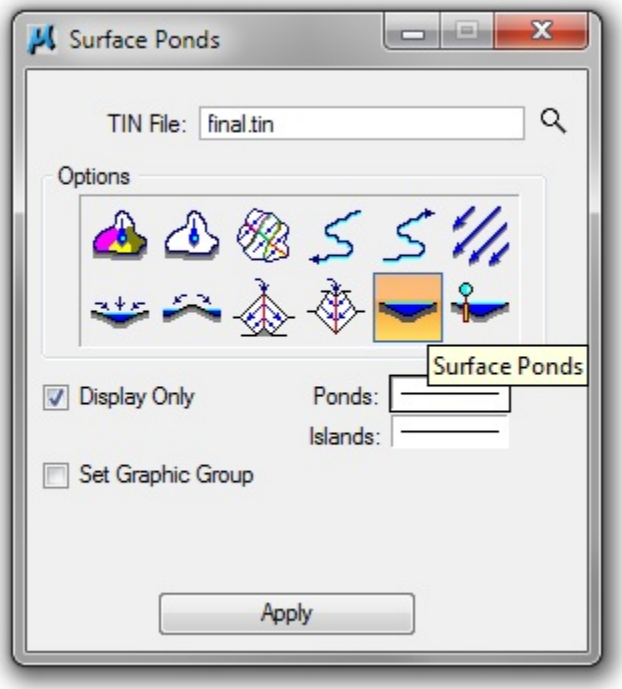
The Ridge Lines are drawn in the design file.



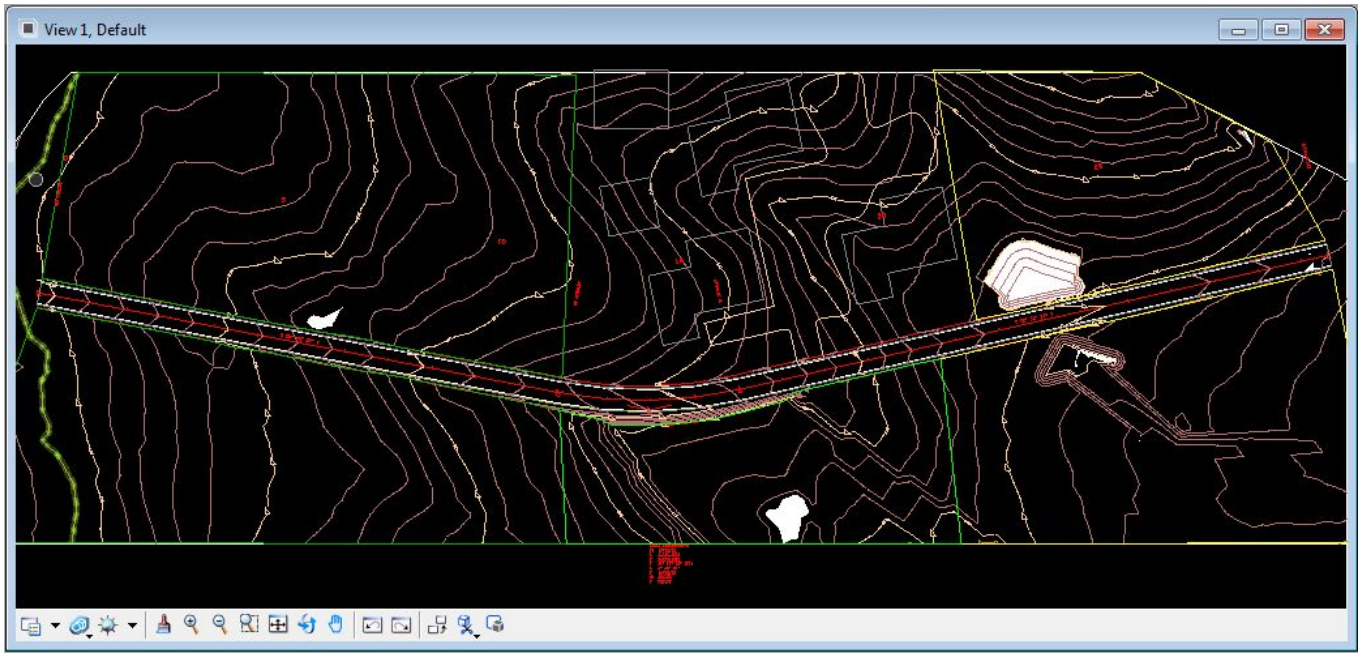
3.8 Surface Ponds

The Surface Ponds tool delineates the area(s) of ponded water within the specified TIN.

a) Select the DTM Drainage Icon **Surface Ponds**. Toggle ON Display Only, and click the **Apply** button.



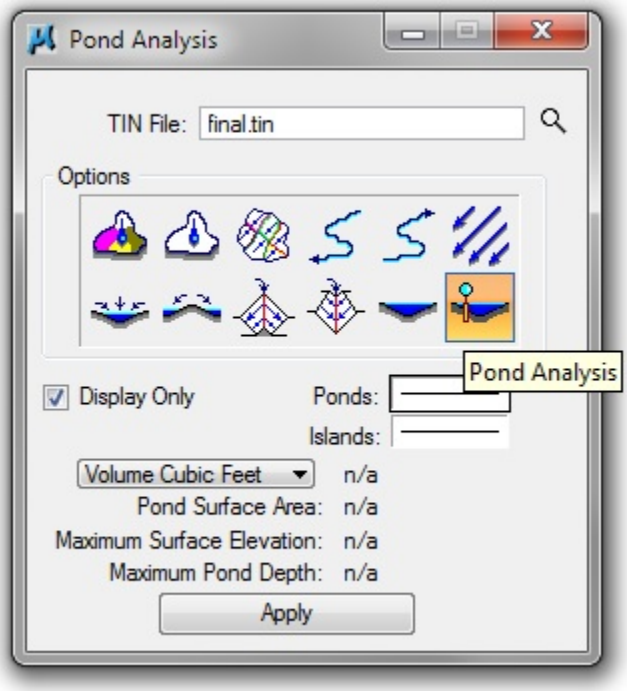
The surface ponds are drawn in temporary fill as shown below:



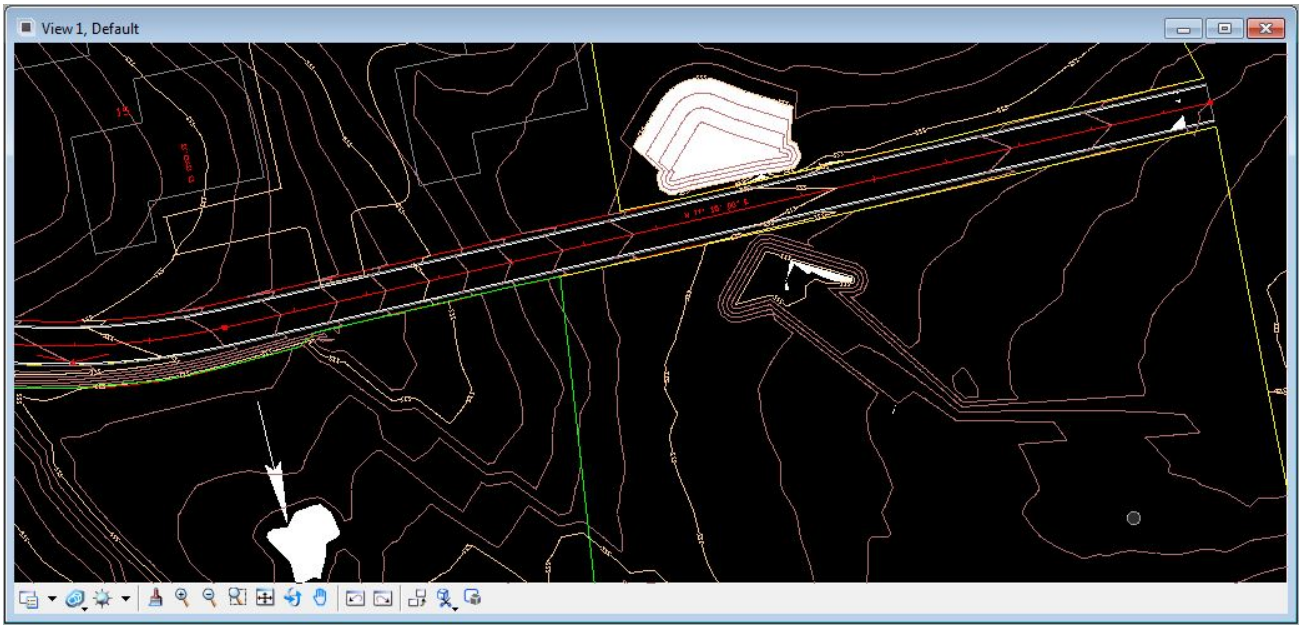
3.9 Pond Analysis

The Pond Analysis tool traces a point downstream to a low point and fills it giving the volume, maximum depth, and maximum elevation. In addition, the pond delineation is graphically displayed

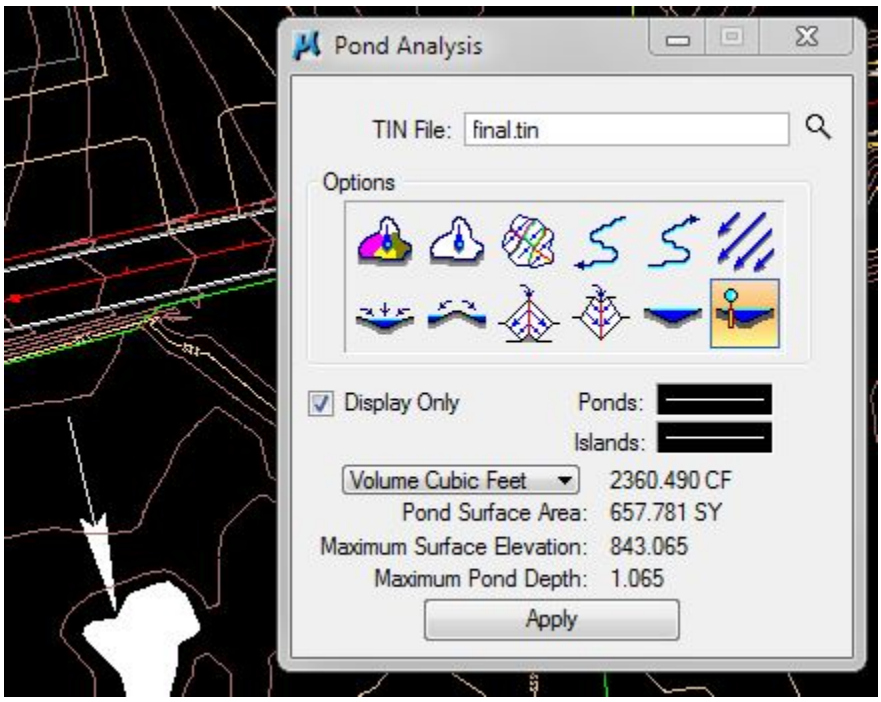
a) Select the DTM Drainage Icon **Pond Analysis**. Toggle ON Display Only, and click the **Apply** button.



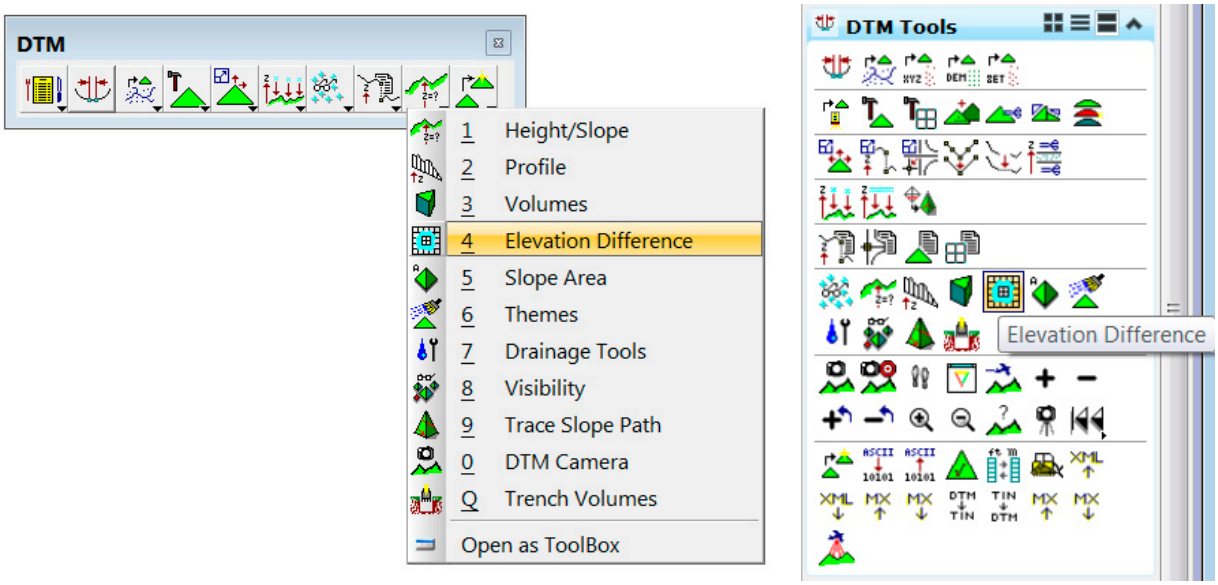
b) Data Point near the location shown below:



c) The Pond is filled and pond characteristics computations performed:



NOTE: Other DTM Tools are available from **Applications> GEOPAK> ROAD>DTM TOOLS**. Surface analysis tools are the second from the end. All of these tools are available under task navigation through **DTM Tools** when Geopak's Civil Workflows is active.



4. Culverts

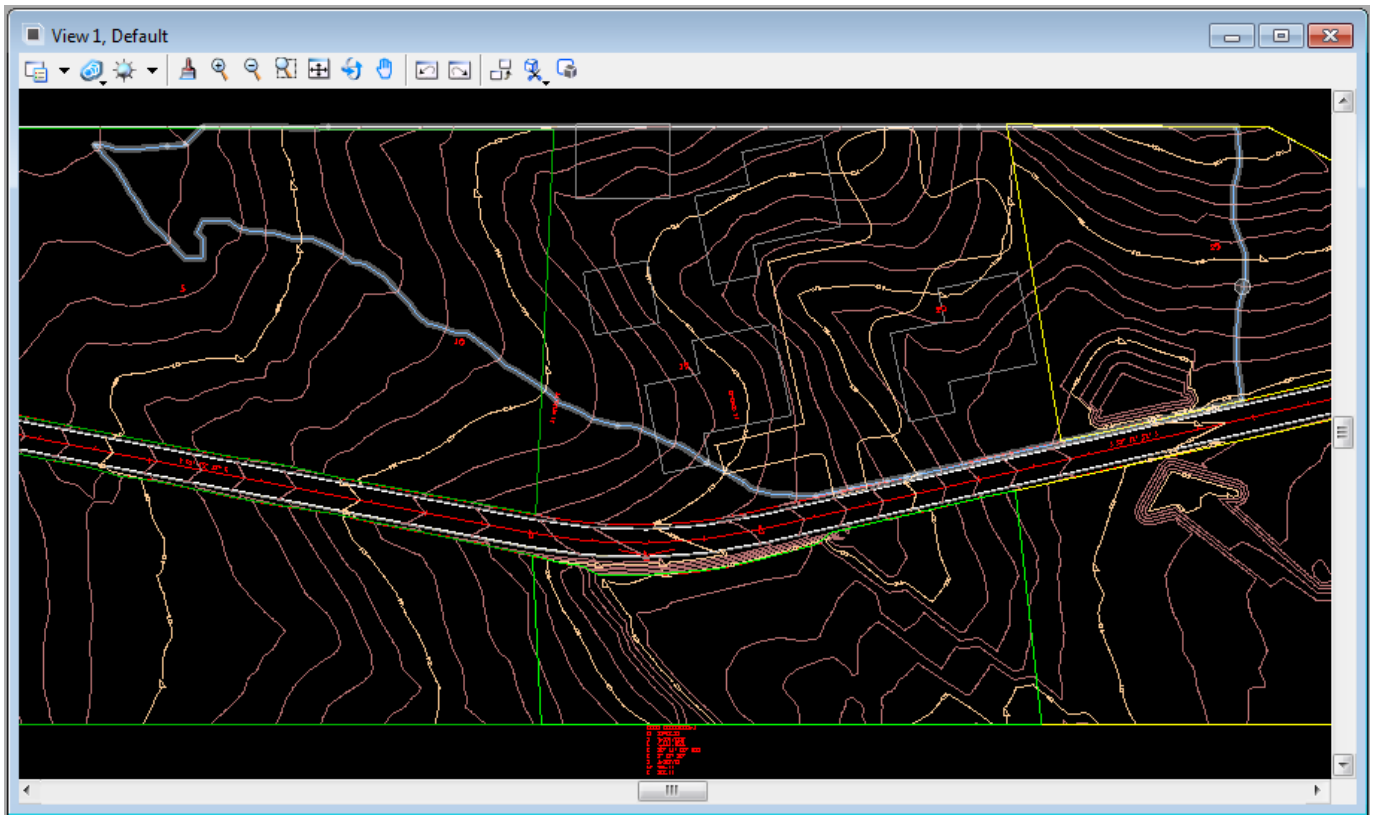
This exercise shows the user how to use the culvert module to design a culvert. The culvert module acts as a standalone component of GEOPAK Drainage, meaning it does not directly interact with Drainage Areas, Nodes, Links or Networks.

4.1 Delineate the Drainage Area

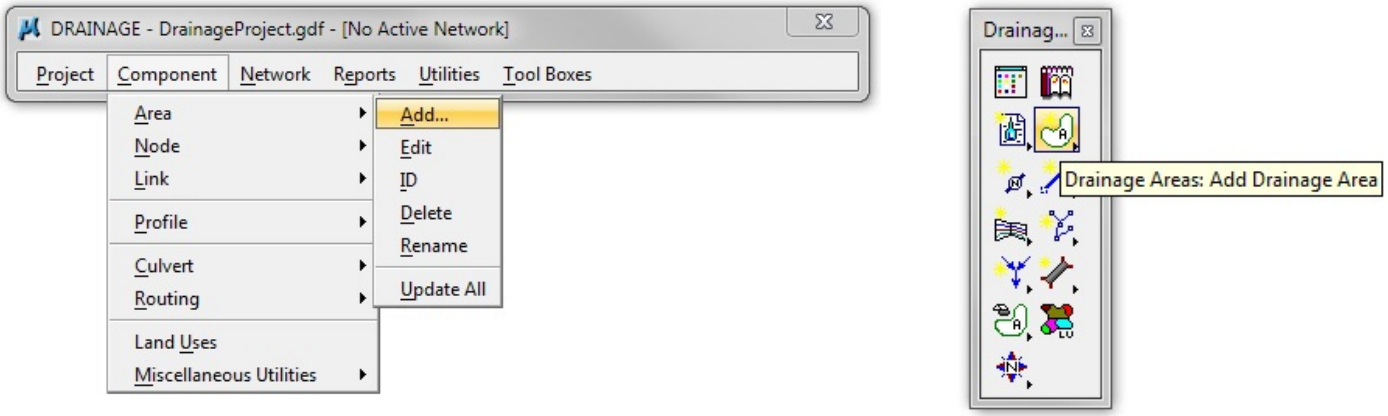
a) Use DTM tool Delineate Watershed to create the drainage area shown below. If necessary, refer back to exercise 3.2 to create the drainage area.

The following shape will be used below as the drainage area for this exercise.

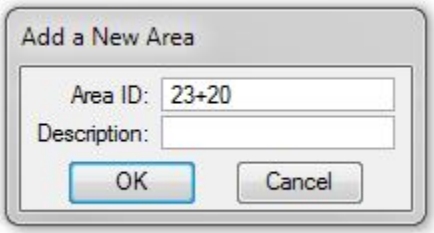
NOTE: The area shown below on level SURVEY - DRAINAGE - Area Shapes extends to the limits of the current TIN file. Inspection of the contours will reveal that the drainage area most likely extends beyond these limits. **Appendix B** will discuss options to approximate the full extent of the drainage area.



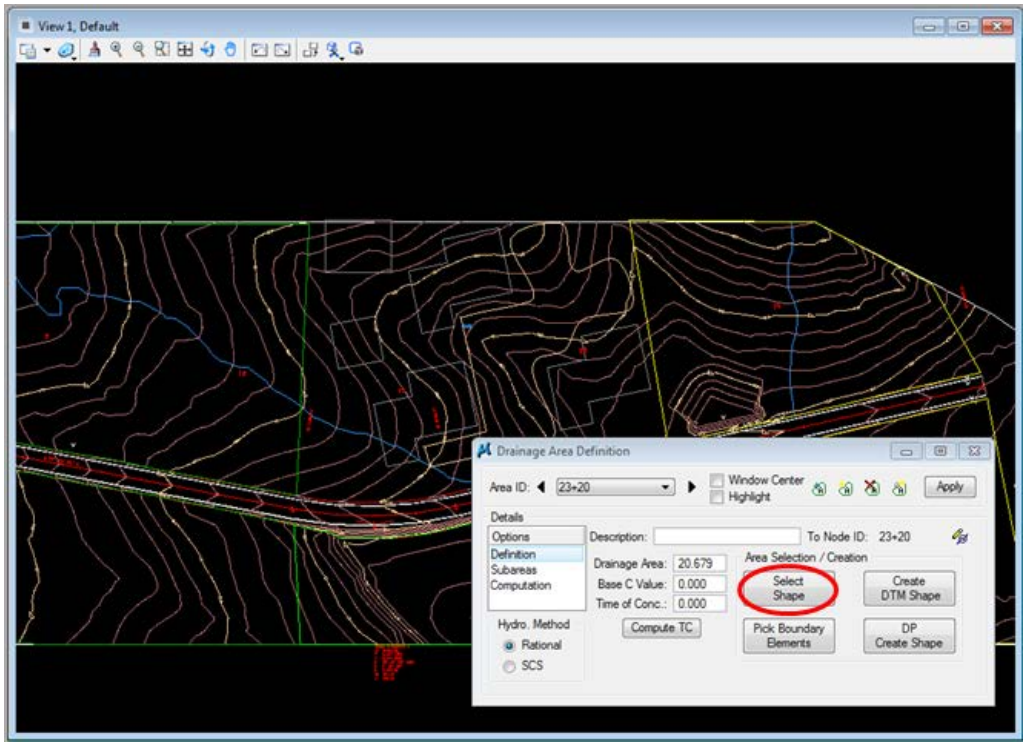
b) From the GEOPAK Drainage menu bar select **Component>Area>Add.**



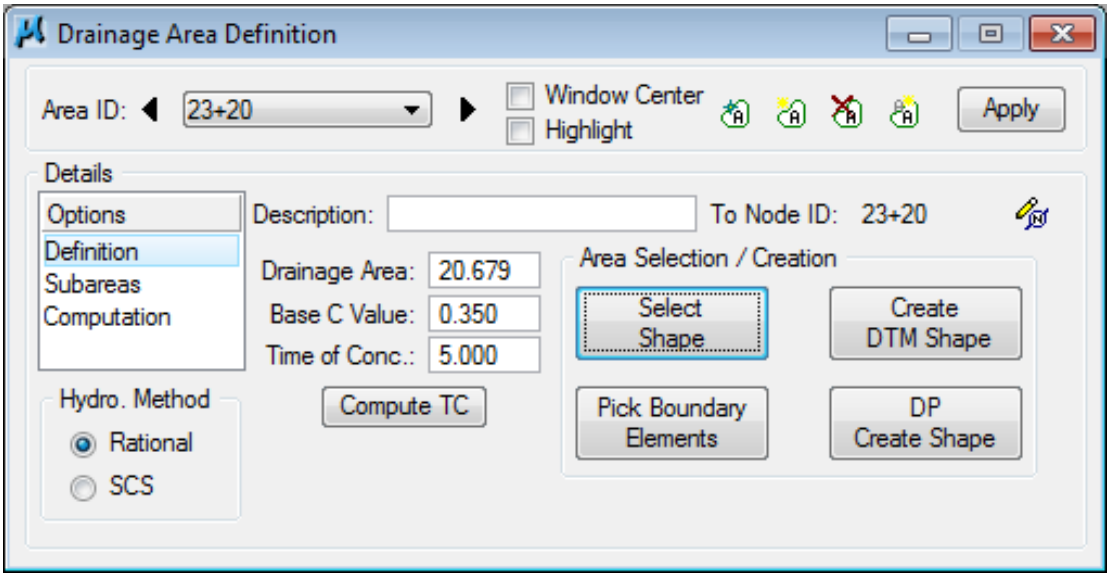
Type in **23+20** for the **Area ID.** Click OK.



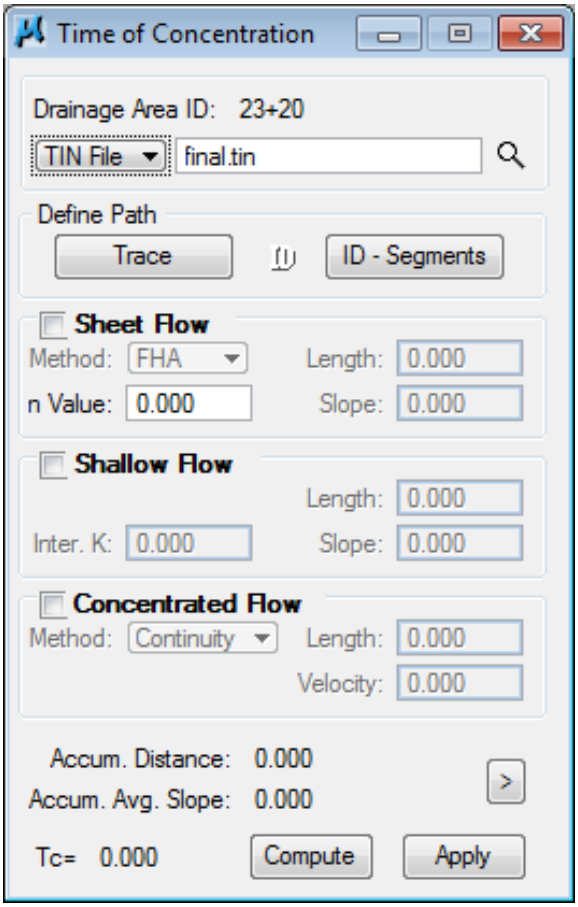
c) Click the Select Shape button. Select and data point to accept the shape shown in the first step. The area is automatically calculated.



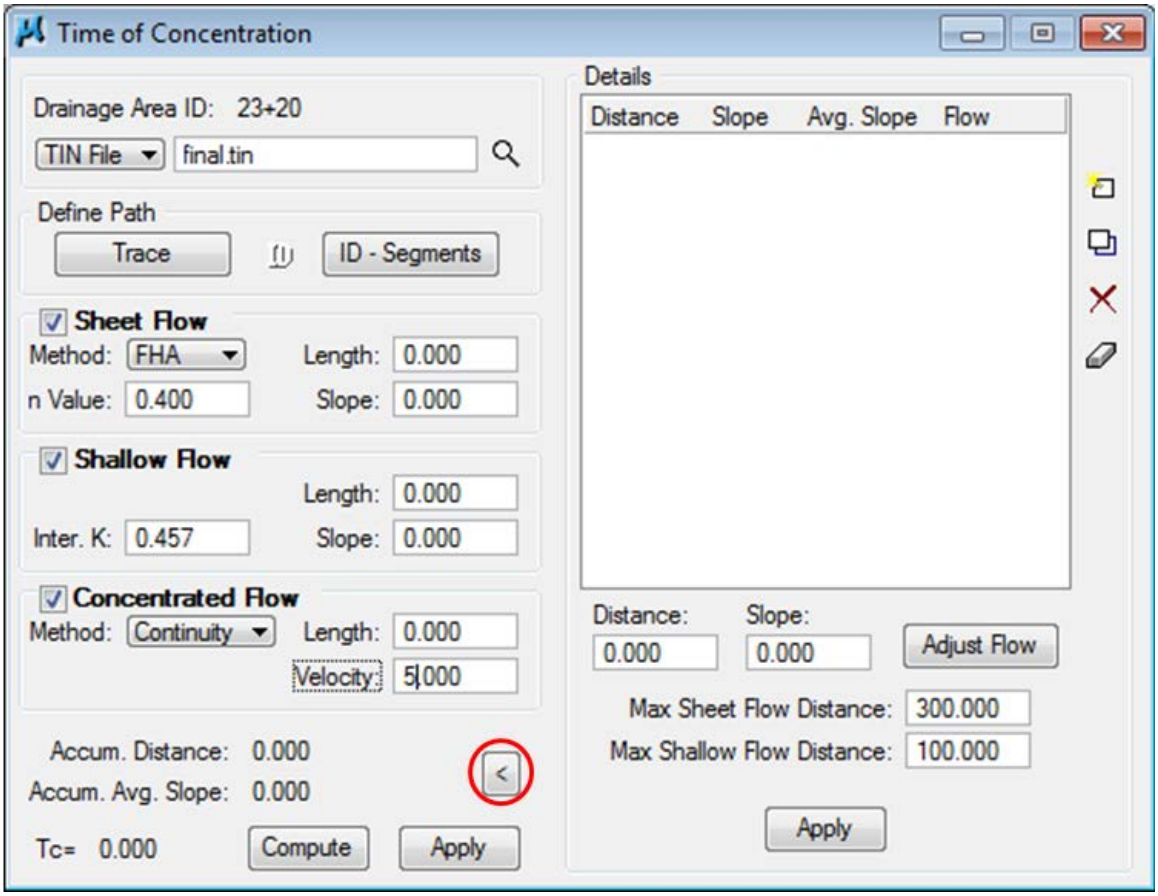
d) Set the **Base C Value** to 0.350 and click on **Compute TC**



When the following Dialog will appears, use the explorer button to select the correct TIN file.



e) Expand window to show details and set Max Sheet Flow Distance to 300' and Max Shallow Flow Distance to 100'.



Collapse the window, toggle ON Sheet Flow, Shallow Flow and Concentrated Flow and fill in the values as follows:

n Value: 0.400

Inter. K: 0.457

Velocity: 5.000

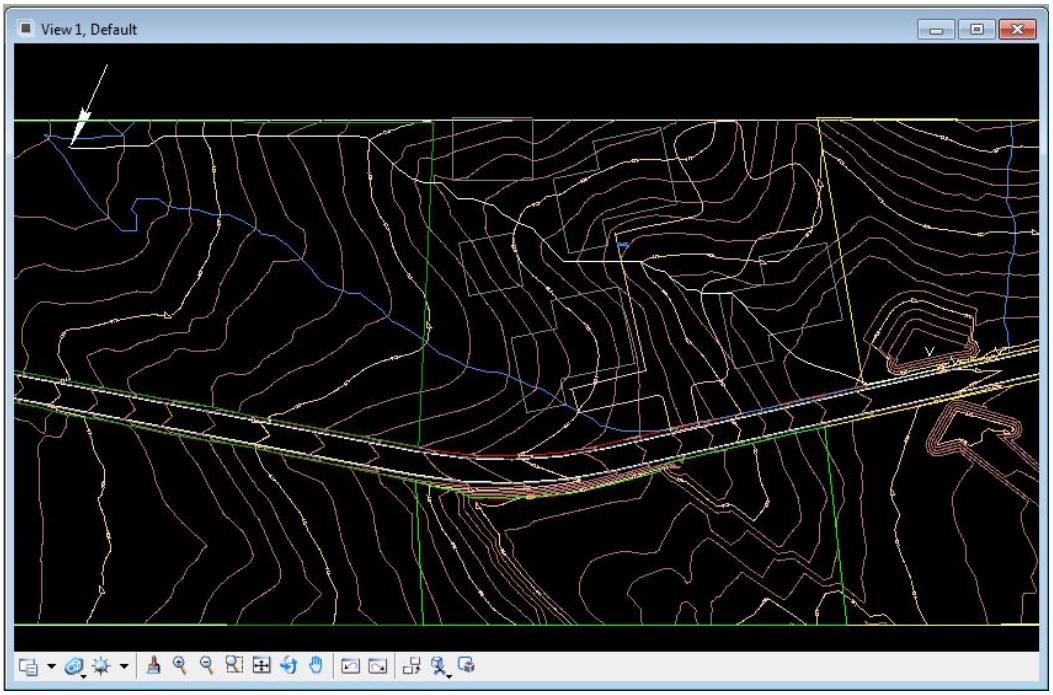
n Values for different surface types are available in the TDOT Drainage Manual, Table 4-3 *Manning's n Values for Overland Flow*

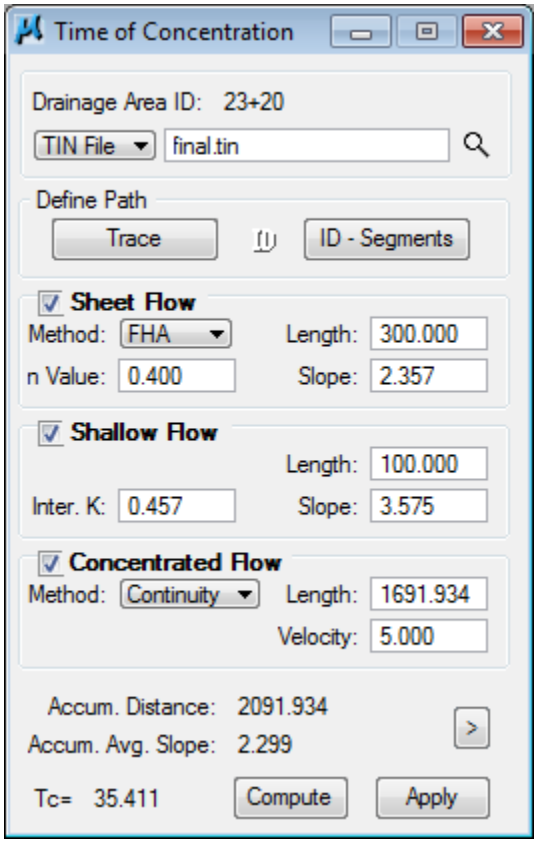
Intercept K values are below:

Land Cover / Flow Regime	**k**
Grassed waterway (shallow concentrated flow)	0.457
Unpaved (shallow concentrated flow)	0.491
Paved area (shallow concentrated flow); small upland gullies	0.619

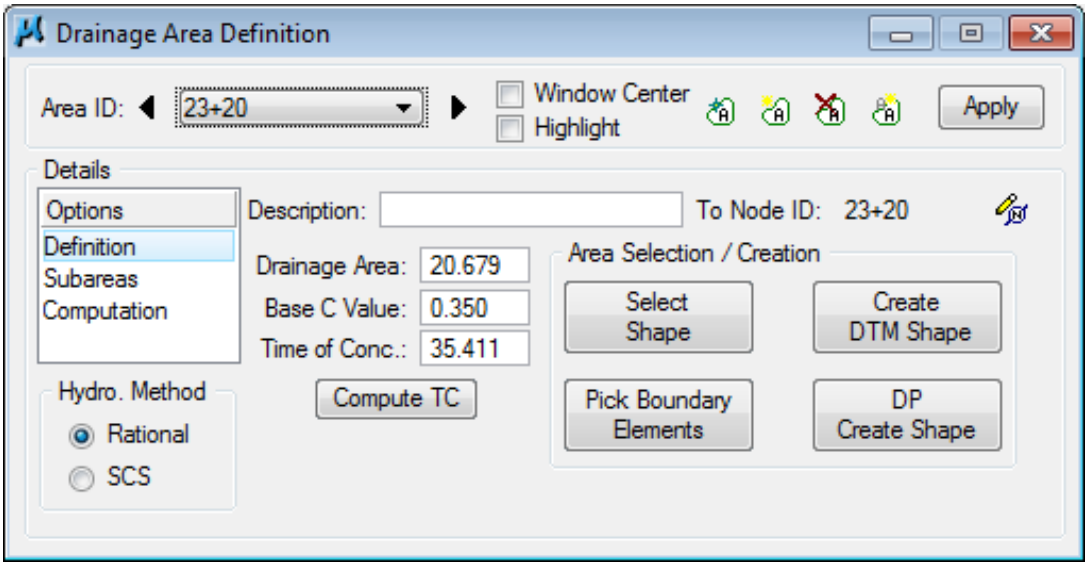
NOTE: See Appendix D for additional Manning's N and Intercept K Values.

f) Click Trace and data point at the furthest hydraulic point. Once values are calculated, click Compute. Then click Apply.





The Drainage Area Definition is now filled out.

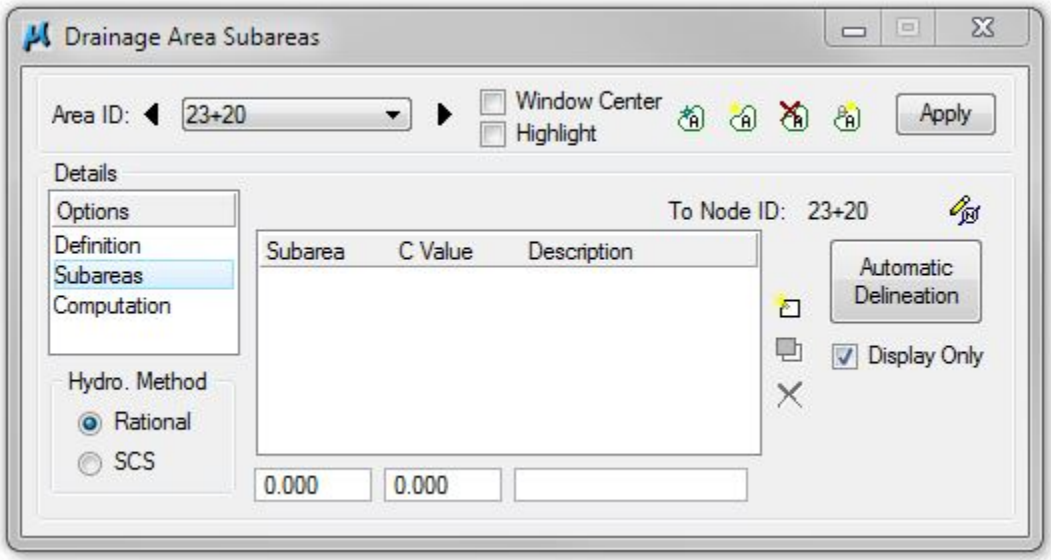


NOTES:
Minimum Time of Concentration is 5 minutes. If computed time is less than **5 minutes** input 5 manually.

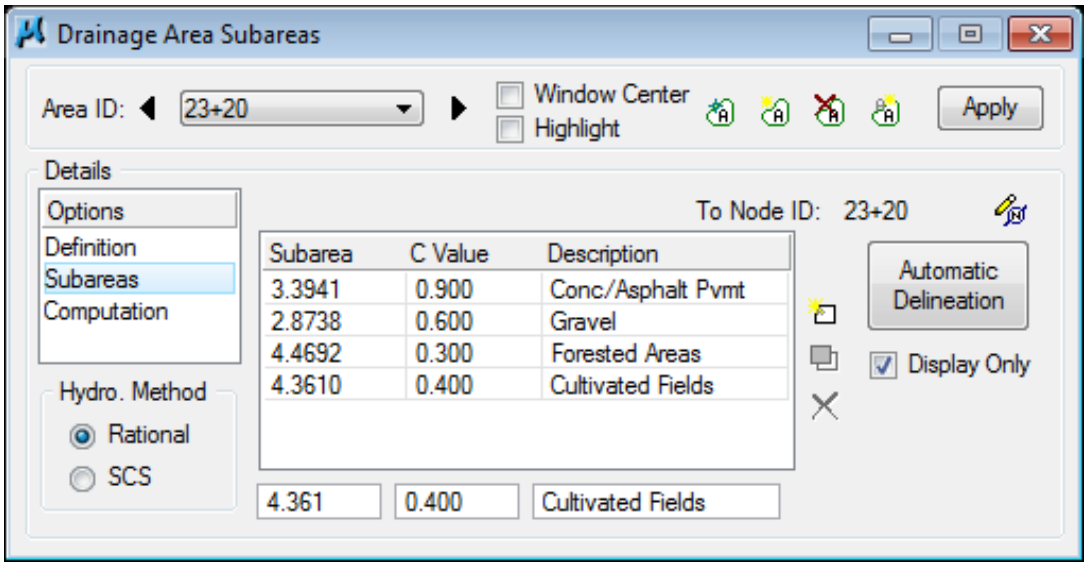
For urban areas adjust maximum sheet flow as required.

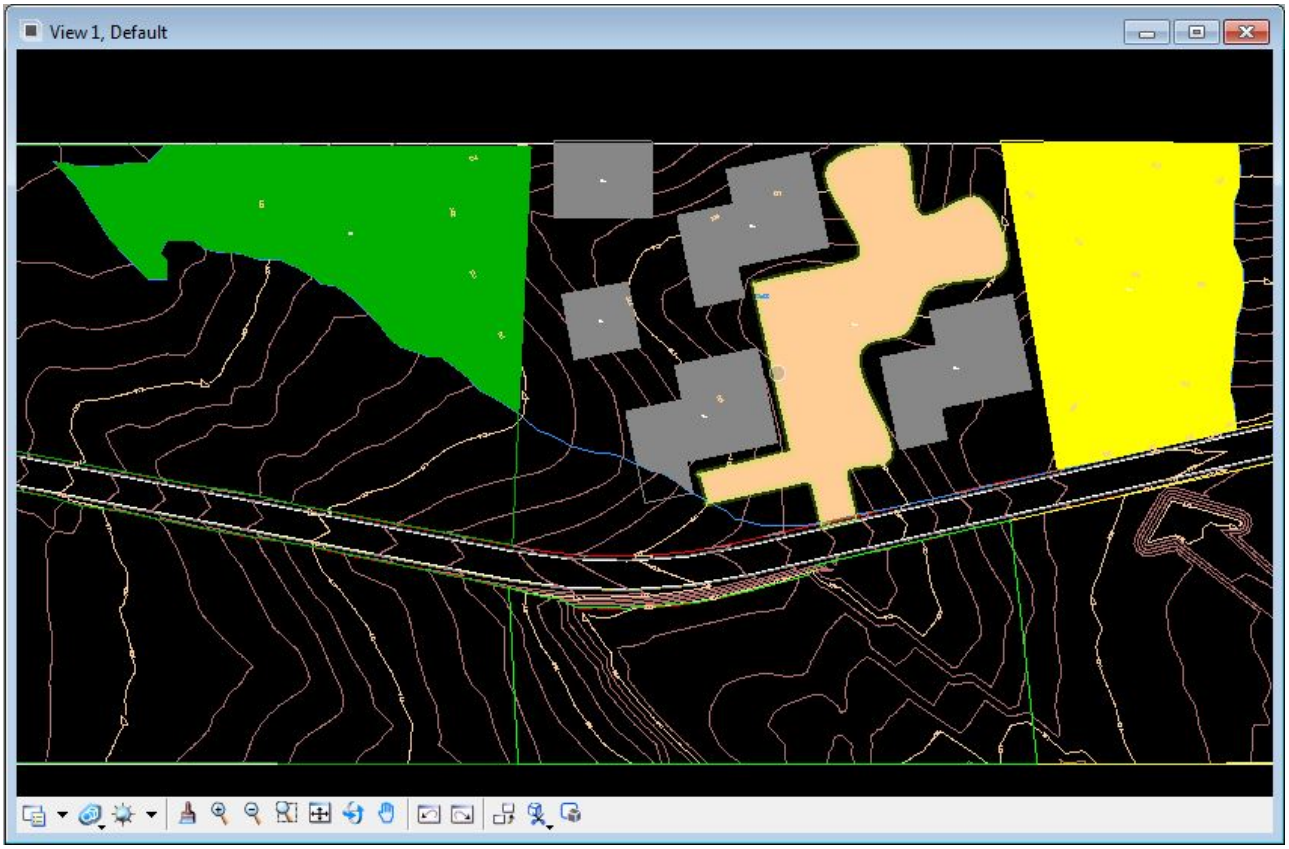
For areas that drain directly from sheet flow to concentrated flow, uncheck the Shallow Flow box. Leaving this box checked and setting it to zero will not allow TC to be calculated correctly.

After the drainage area has been set up, runoff coefficients can be automatically computed with the use of *Land Use Items* from the Drainage Library. Click on **Subareas** in the Details list on the left.



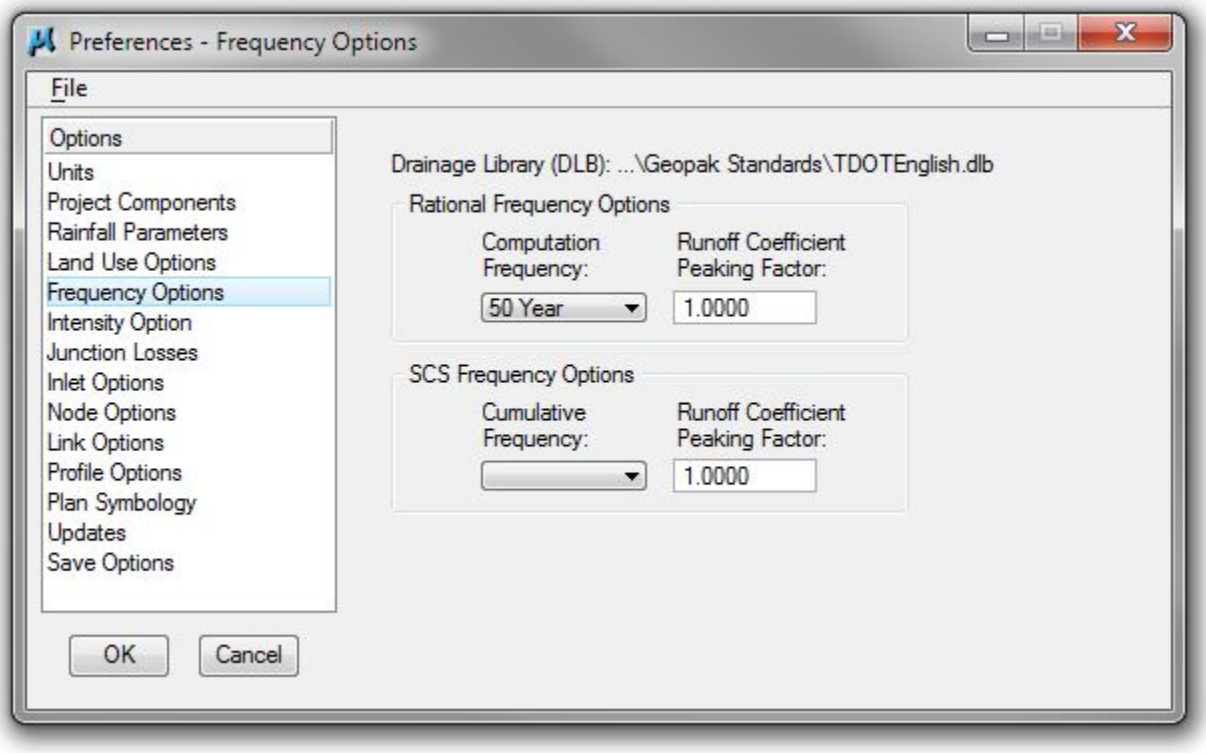
g) Toggle ON **Display Only** and then click the **Automatic Delineation** button. The file is scanned for closed shapes matching the Land Use symbology specified in the Drainage Library (Land Use Tab).



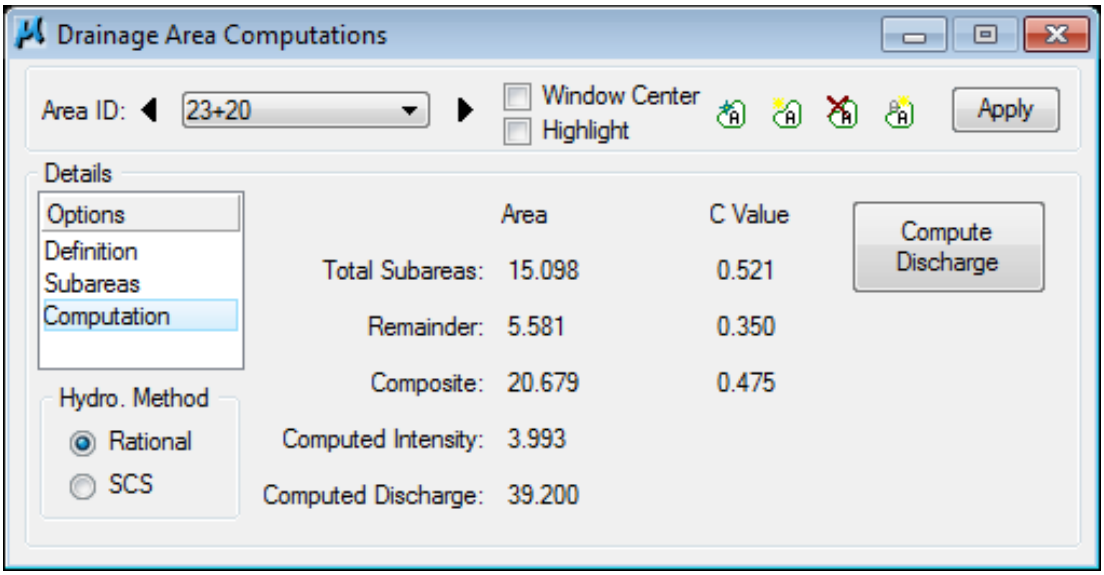


h) Click the **Apply** button to apply the land uses (and their "C" values) to the Drainage Area.

i) We want to compute the discharge for a 50-year storm so if that is not already set; select **Project>Preferences>Frequency Options** and change the Frequency to the 50-year storm. Click the **OK** button to accept the new preference setting.



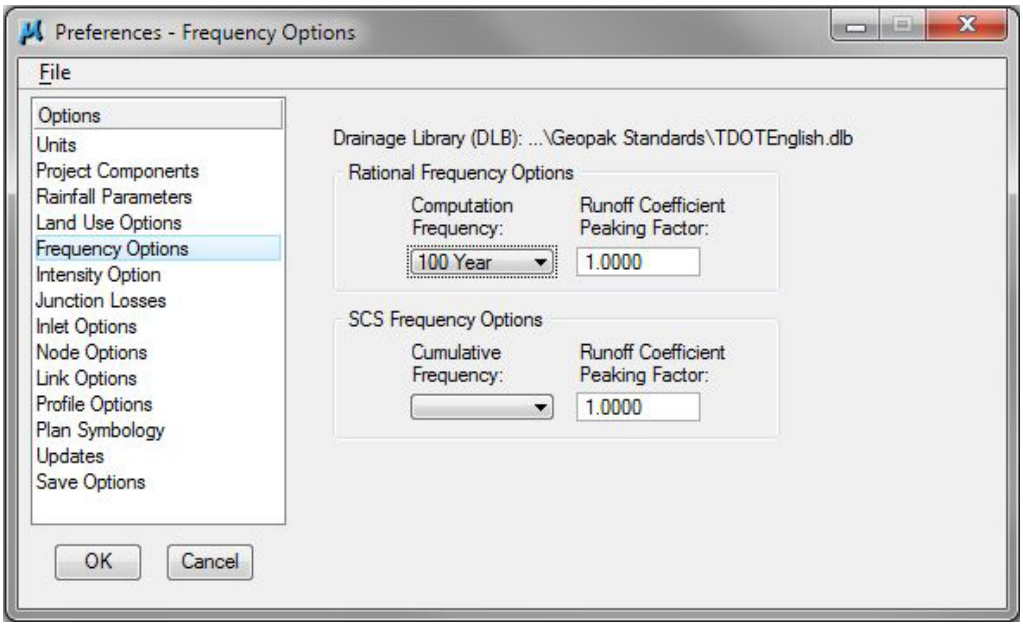
j) Return to the **Drainage Area Computations>Computation** dialog box and click the **Compute Discharge** button:



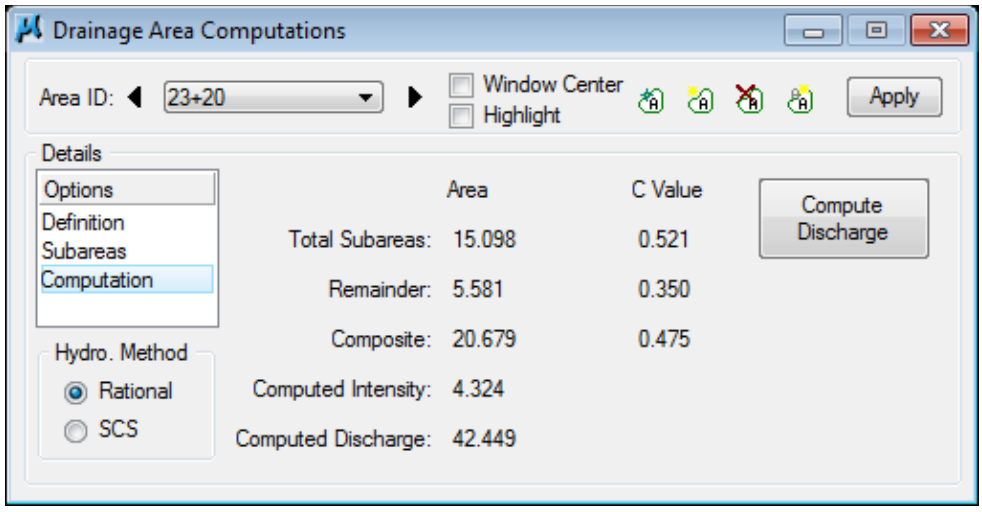
Verify the Computations; then click **Apply** to add the Area to the Project.

k) Jot down the Computed Discharge from the 50-year storm computed in the step above here: _____

l) Recompute the drainage area discharge for the 100 Year storm. Select **Project>Preferences>Frequency Options** and change the Frequency to the 100 year storm. Click the **OK** button to accept the new preference setting.



m) Return to the Drainage Area Definition dialog box and click the **Compute Discharge** button:



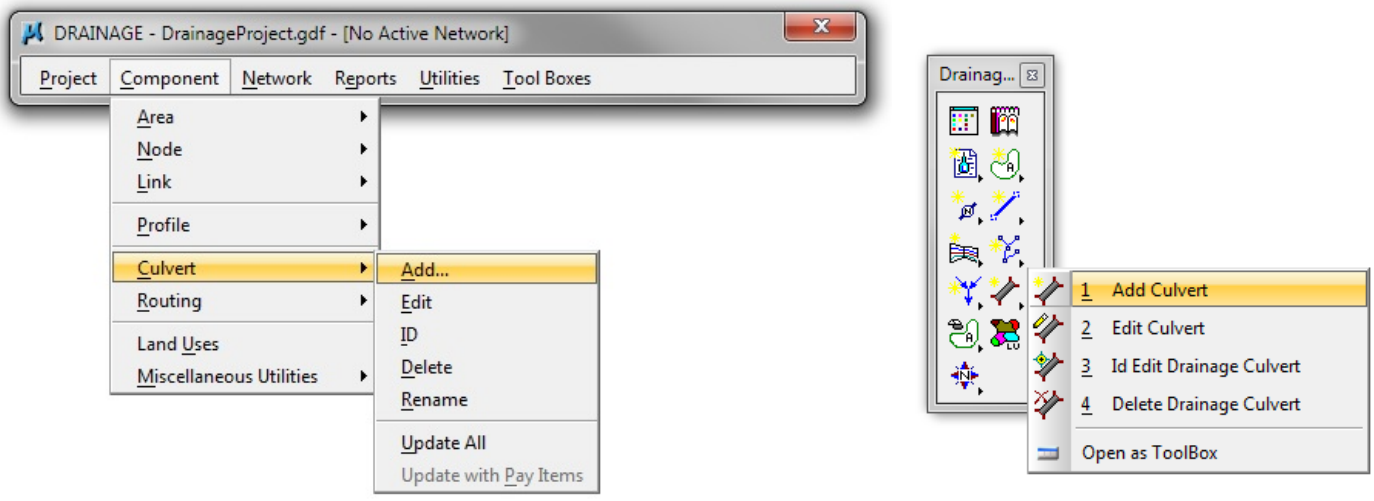
n) Jot down the Computed Discharge from the 100-year storm computed in the step above here: _____

o) Close the **Drainage Area Definition** dialog box.

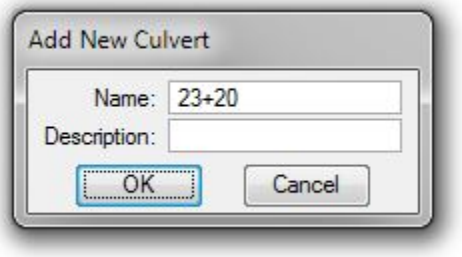
p) Change the Frequency back to the 50 Year storm

4.2 Design the Culvert

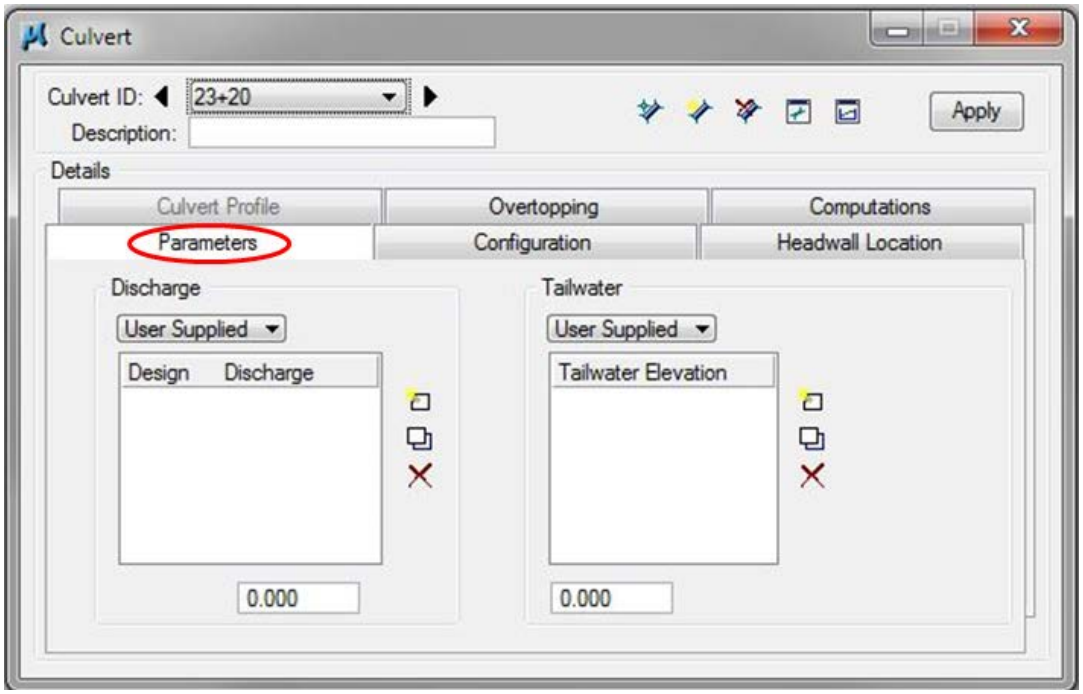
a) From the Drainage main menu, select **Component > Culvert> Add**.



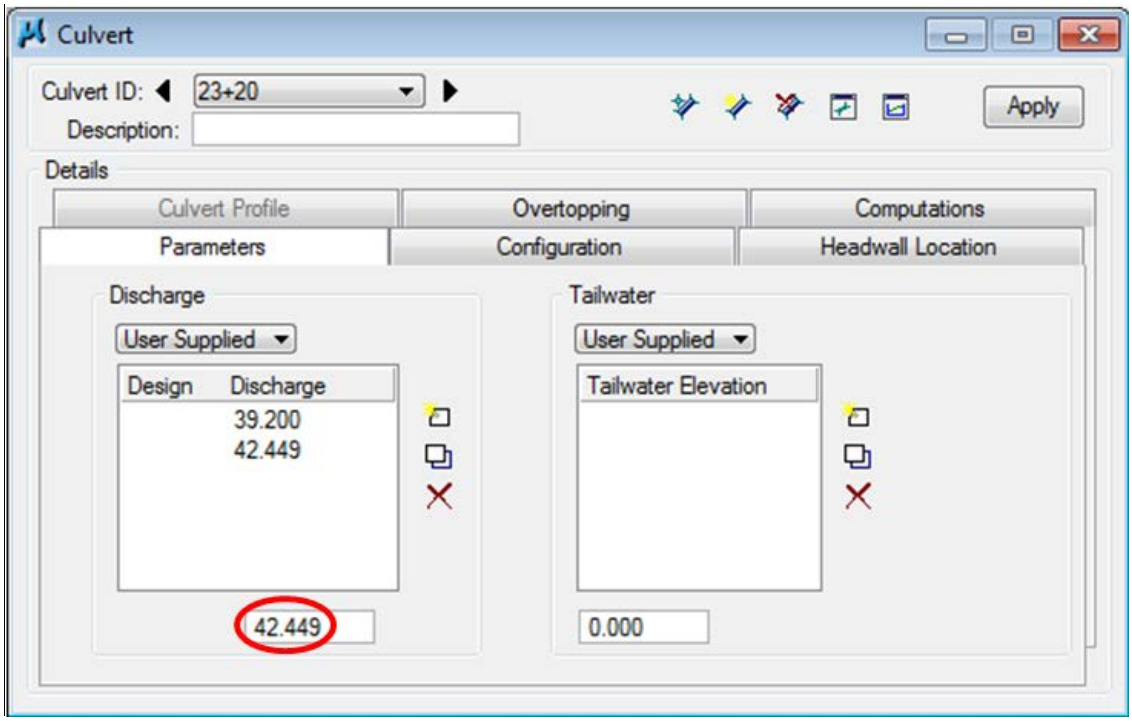
b) Click on the Add button to add a new culvert. Enter the Culvert Name as **23+20** (station of the culvert) and Click **OK**.



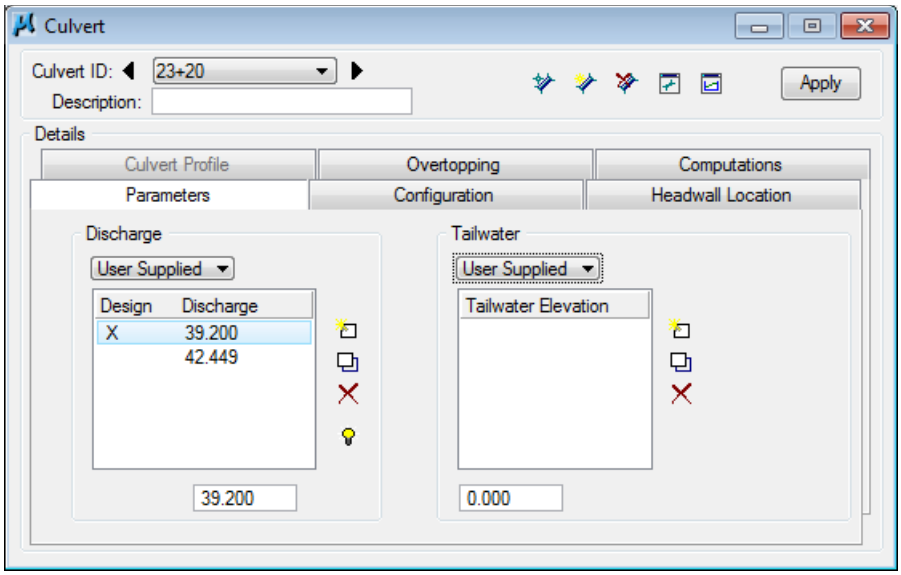
c) The **Culvert** dialog will open as seen below:



d) Enter the culvert discharges from Steps 11 and 14 in the previous exercise. Key-in the discharges in the key-in field and click the **Add List Item** button for each discharge



e) Highlight the 50-yr storm and click **Select Discharge**. This will be the Discharge that the culvert is designed for.

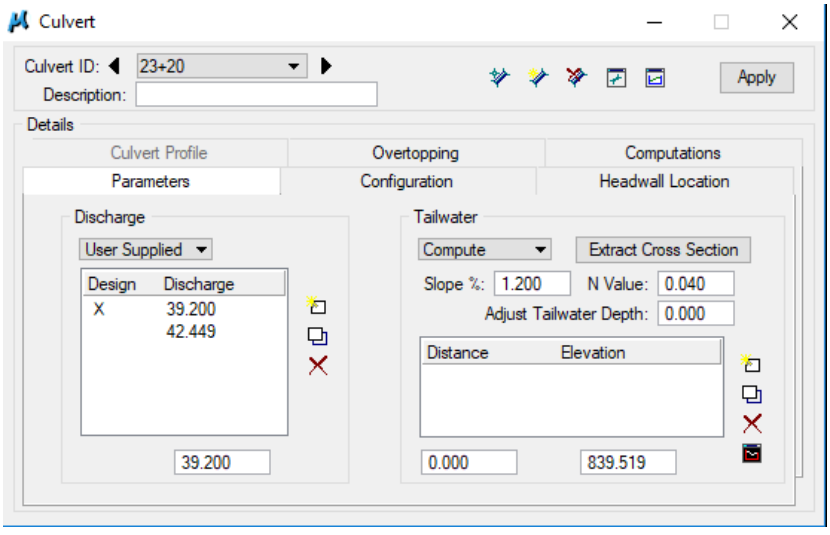


You could also just double **click** to set the desired Design Discharge that the culvert is designed for.

f) Define the tailwater. Set the **Tailwater** option to **Compute** and key-in the slope and N Value.

NOTES:
This slope is the longitudinal slope of the downstream channel. This slope can be determine utilizing the **Analysis** tool: **Height/Slope** located in **Applications>GEOPAK>ROAD>DTM Tools**

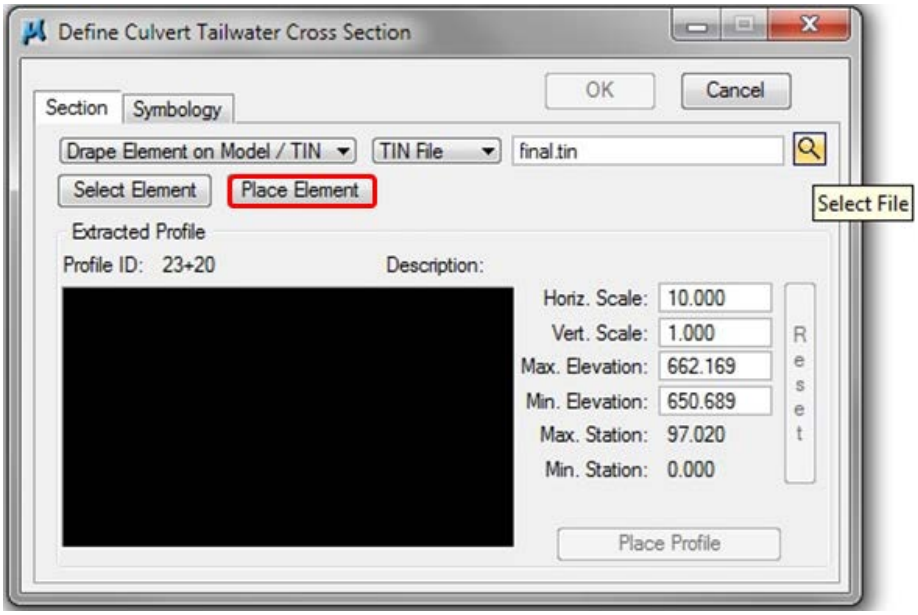
N Values for different surface channels are available in the TDOT Drainage Manual, Table 5A-1 *Values of Roughness* (See Appendix E).



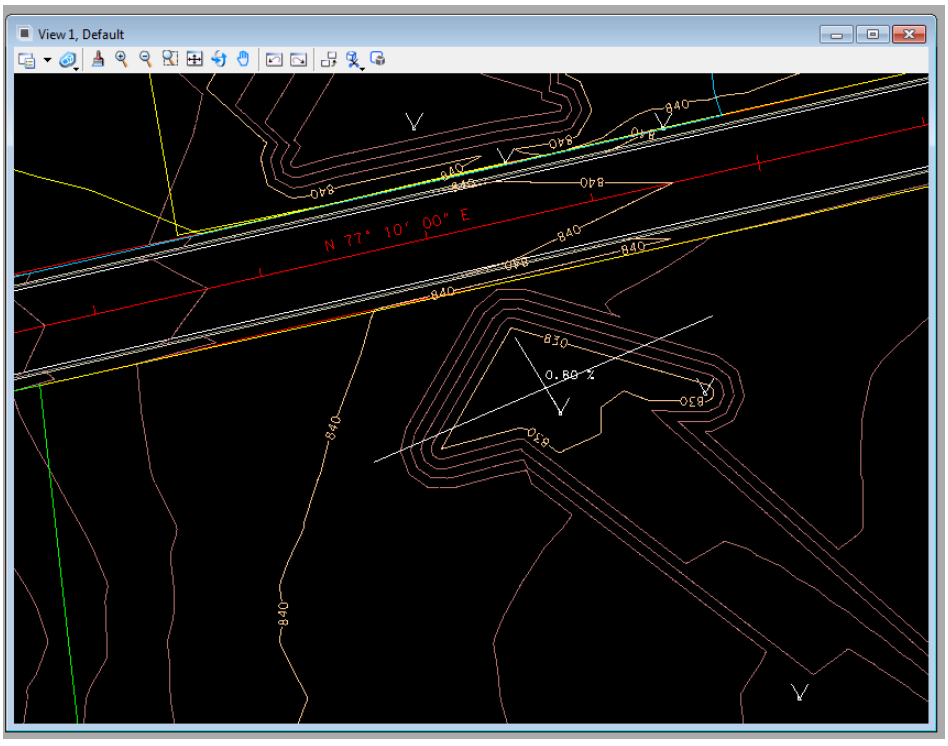
Set the **Slope %** to **1.200** and the **N Value** to **0.040** and click the **Extract Cross Section** button.

g) The **Define Culvert Tailwater Cross Section** dialog will open. Set to **Drape Element on Model/TIN** and **TIN File**.

Click on the **Select Files** button and select **final.tin .**

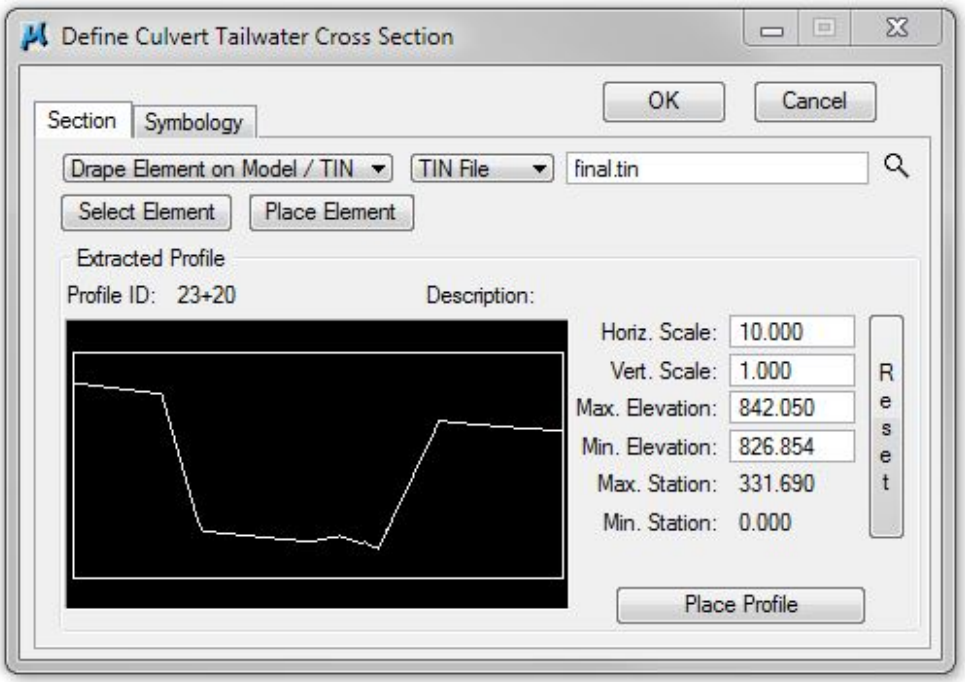


h) Click the Place Element button to locate the postion of the tailwater cross section that is to be extracted (this is notated as the 'Extracted Profile' on the dialog).

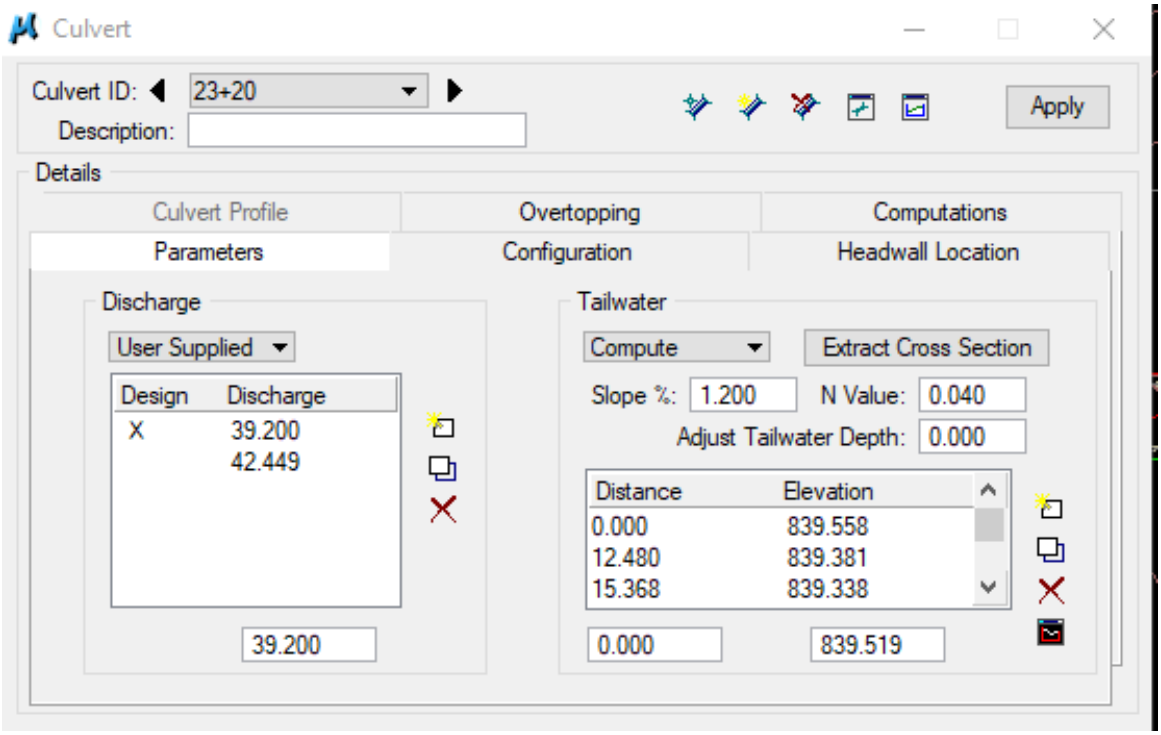


You can also place a line in MicroStation and click **Select Element.**

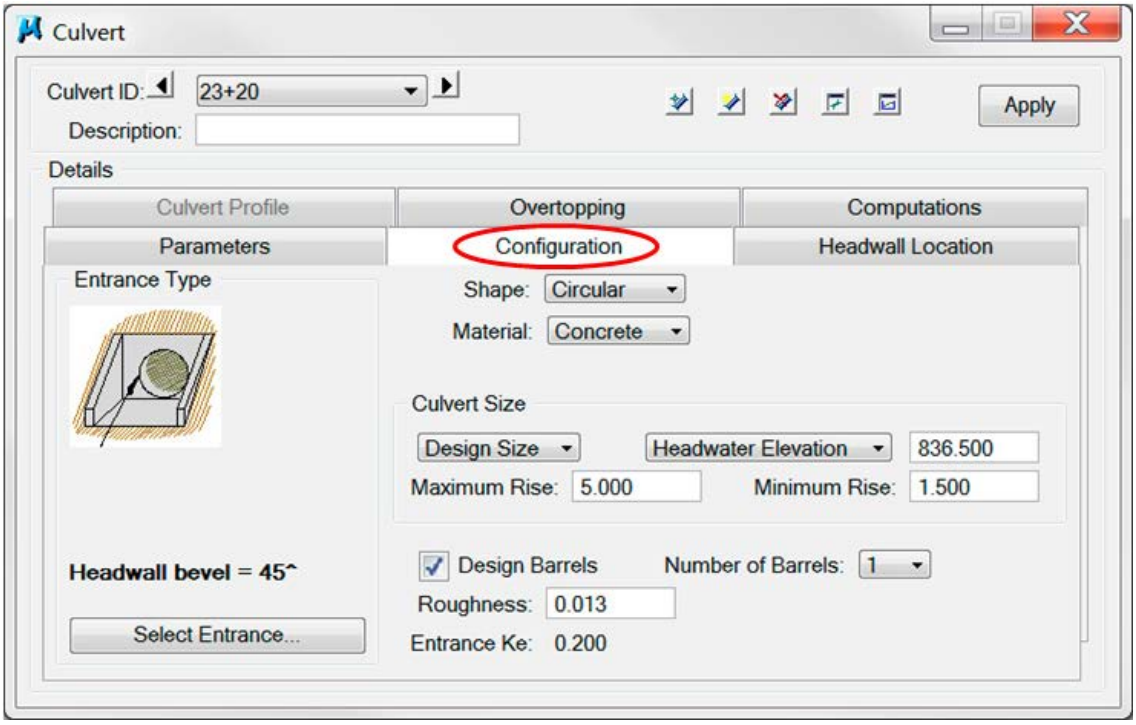
i) The **Define Culvert Tailwater Cross Section** dialog will now contain the profile along the element placed representing the channel cross section at this location.



j) Click the **OK** button and the main culvert dialog will open again. The values for the tailwater section will now be populated.



k) Select the **Configuration** tab to define the type of Culvert. Make settings as listed below.



Shape: Circular
(Culvert Shape: Circle, Box, Ellipse, Etc.)

Material: Concrete
(Culvert Material: Concrete, Steel, Plastic, Etc.)

Headwater Elevation: 836.50
(The maximum elevation the water can reach at the upstream end of the culvert). By default this option is set to Allowable Headwater which uses a height value, click to change to Headwater Elevation.

Maximum Rise: 5.000
(The maximum diameter, height of the culvert)

Minimum Rise: 1.500
(The minimum diameter, height of the culvert)

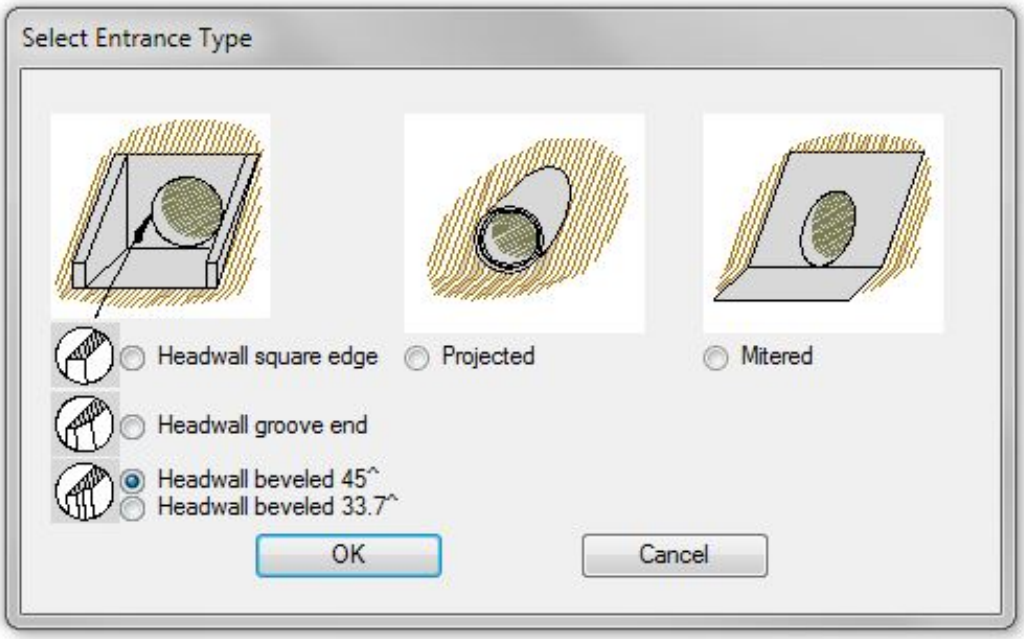
Design Barrels: Toggle ON
(Allows the program to design multiple barrels, if required)

Number of Barrels: 1

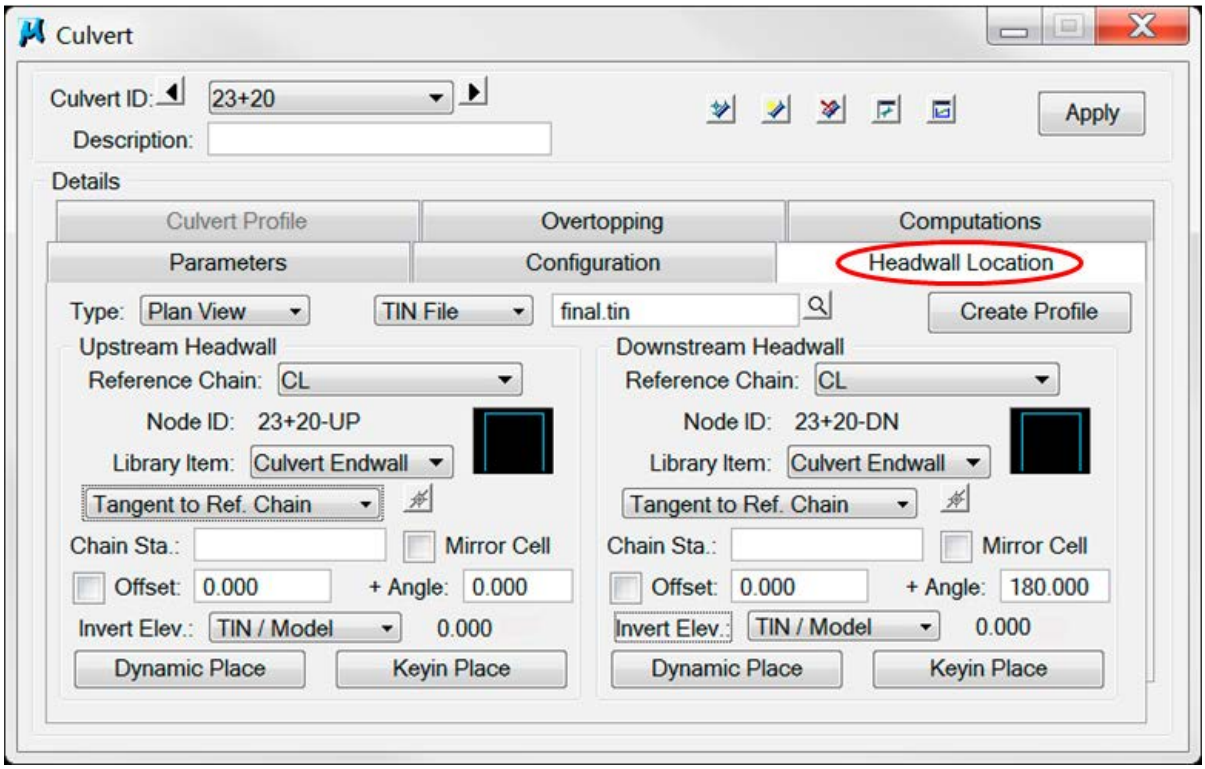
Roughness: 0.013
(Determined by the type of Material, See the TDOT Drainage Manual Section 6.04.2.4.3, *Culvert Roughness Coefficients*)

NOTE: If you know the size of culvert you need beforehand you may set Culvert Size to 'Library Item' and pick from the list of defined items.

l) Click **Select Entrance** and select the appropriate entrance condition. The most commonly used for TDOT projects is **Headwall beveled 45^**. Select this condition and click ok. This will automatically set the **Entrance Ke** value.



m) Select the **Headwall Location** tab to define the location of the **Upstream Headwall** and **Downstream Headwall** (nodes). Make settings as listed below.



Type: Plan View

Reference Chain: CL
(Roadway Centerline)

TIN File: final.tin

Library Item: Culvert Endwall

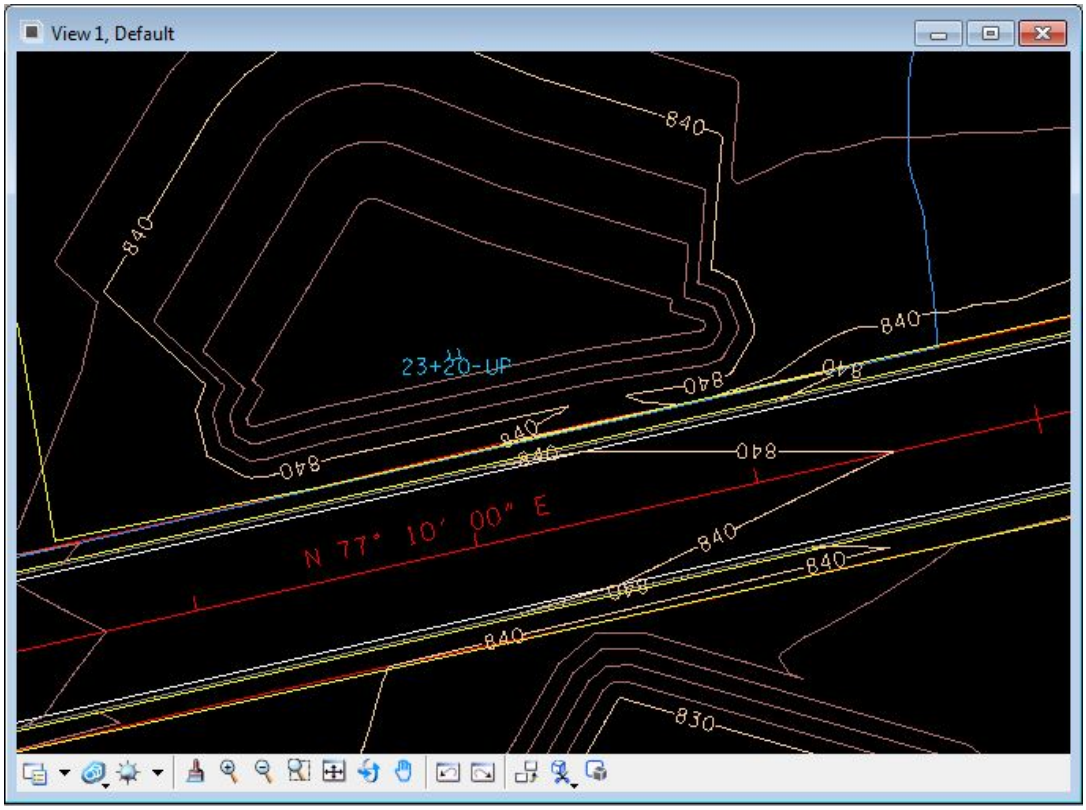
Alignment: Tangent to Ref. Chain

+ Angle.: 0 or 180
(For headwalls parallel to the roadway on the right side use an angle adjustment of 180 and on the left use 0. In this case the upstream is on left so that value should be set to 0.)

NOTE:.Another option is to use Mirror Cell. Set angles to 0 and Toggle ON for headwalls on the right of the roadway and Toggle Off for headwalls on the left of the roadway. Do NOT use Mirror Cell along with Angle Rotations as this adds confusion.

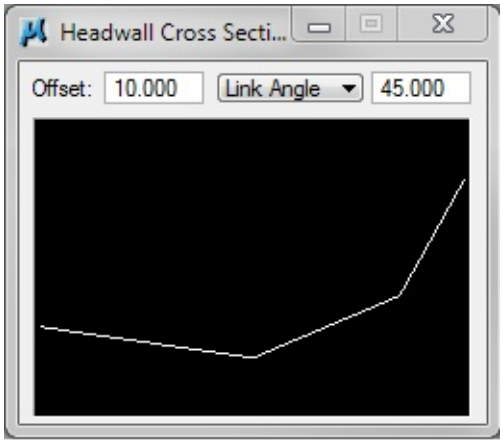
Invert Elev.: TIN / Model
(Reads TIN elevations. Use 'User Supplied' inverts are known or are different than TIN file.)

n) Locate the **Upstream Headwall** by clicking the **Dynamic Place** button and setting the upstream headwall at a location similar to that shown below:



Watch the **Headwall Cross Section** dialog box appear upon mouse-movement. Use this viewer to place the Headwall at the upstream **low point**.

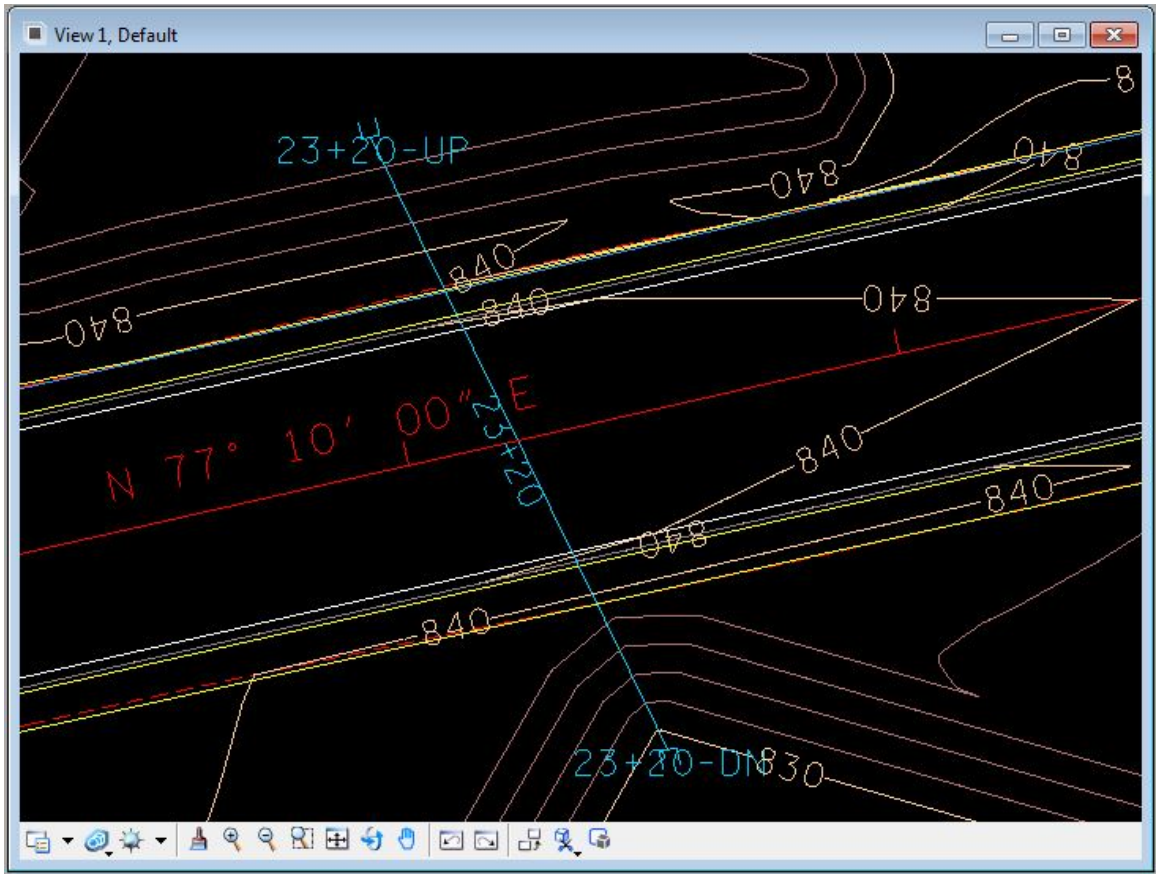
Station and offset values for the headwall location should change dynamically in the dialog as you move your mouse. If not, reset the chain name and try **Dynamic Place** again. It may be necessary to close the tool and reopen.

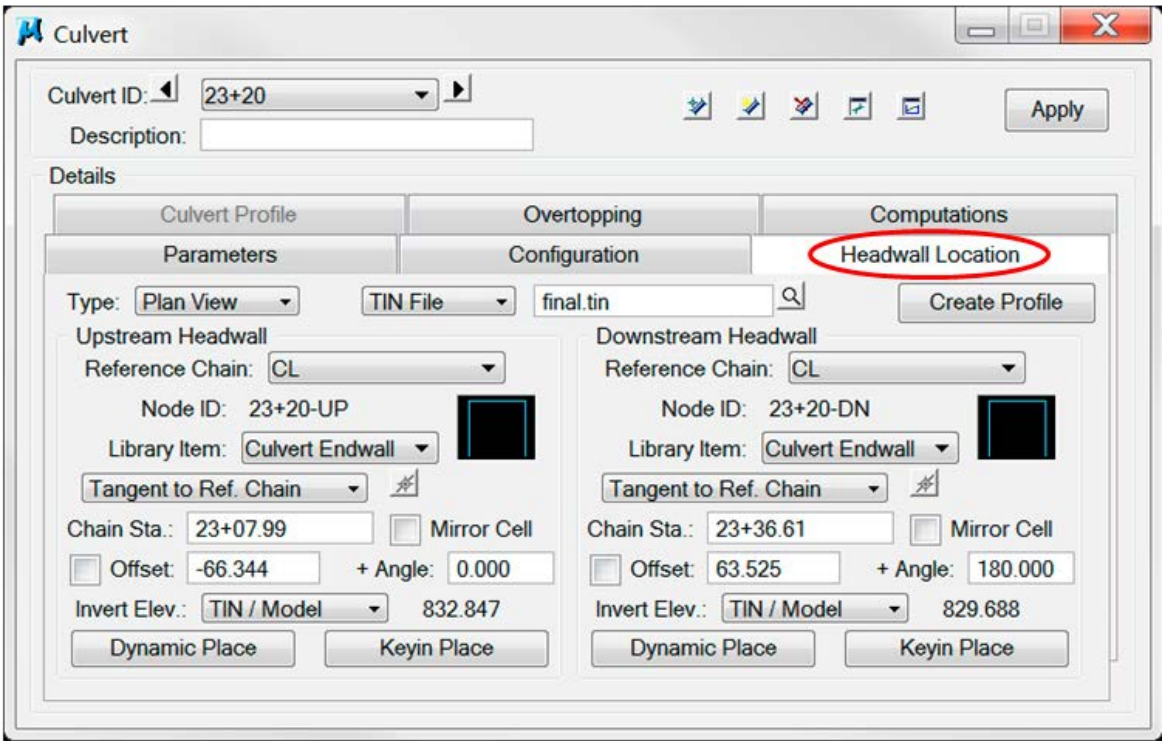


NOTES:
To set the headwall locations for 90 degree cross drains, you can enter the centerline crossing station with a given offset and click the Keyin Place button.

You may wish to utilize the **DTM Tools>Low Point Tool** as discussed in the DTM Tools Section 3 in order to predetermine the low point locations.

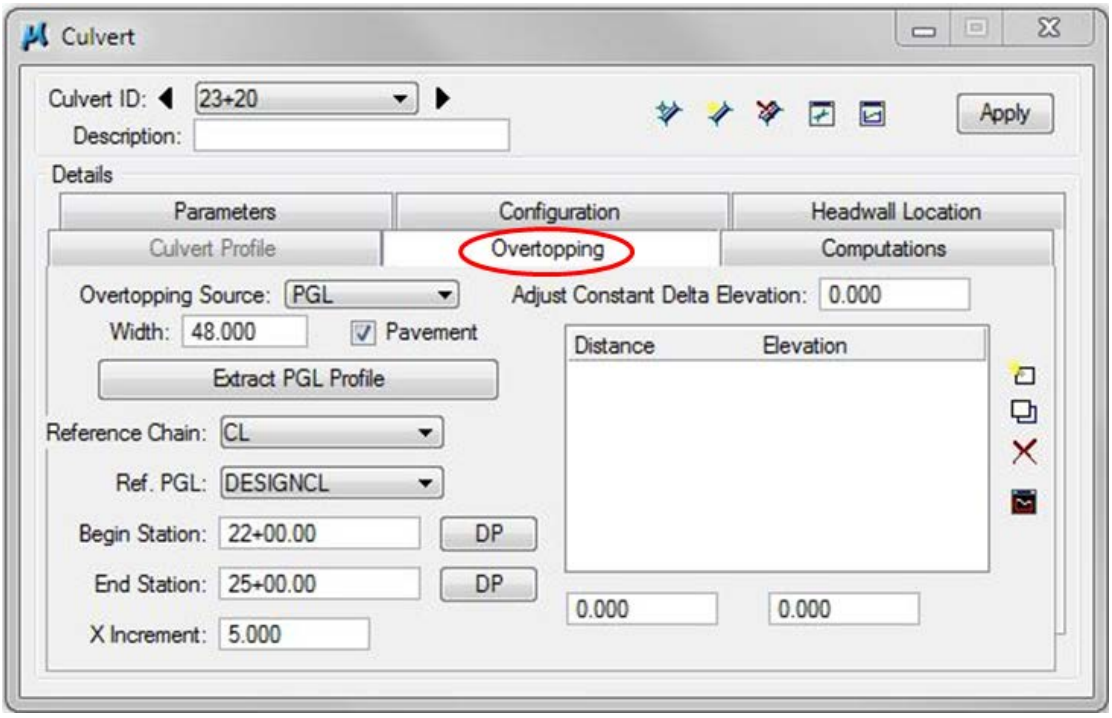
o) Locate the downstream headwall by clicking **Dynamic Place** under the **Downstream Headwall** group.





p) Select the **Overtopping** tab to define the limits of roadway overtopping. Make settings as listed below and click **Extract PGL Profile**.

NOTE: This step is only necessary if your culvert is in a **sag** condition. If you are not in a sag condition you may proceed to **Step 17.**



Overtopping Source: PGL

(This option sets the roadway profile as the controlling surface elevation for overtopping. Other options include ‘User Supplied’ or constant elevation and ‘DTM’)

Width: 48.00

(This is the width of your roadway)

Pavement: Toggle ON

(This should be checked unless your road is not paved)

Reference Chain: CL

(Roadway Centerline)

Ref. PGL: DESIGNCL

(Roadway Profile)

Begin Station: 22+00.00

(Use the **DP** button to select a point before the Culvert.)

End Station: 25+00.00

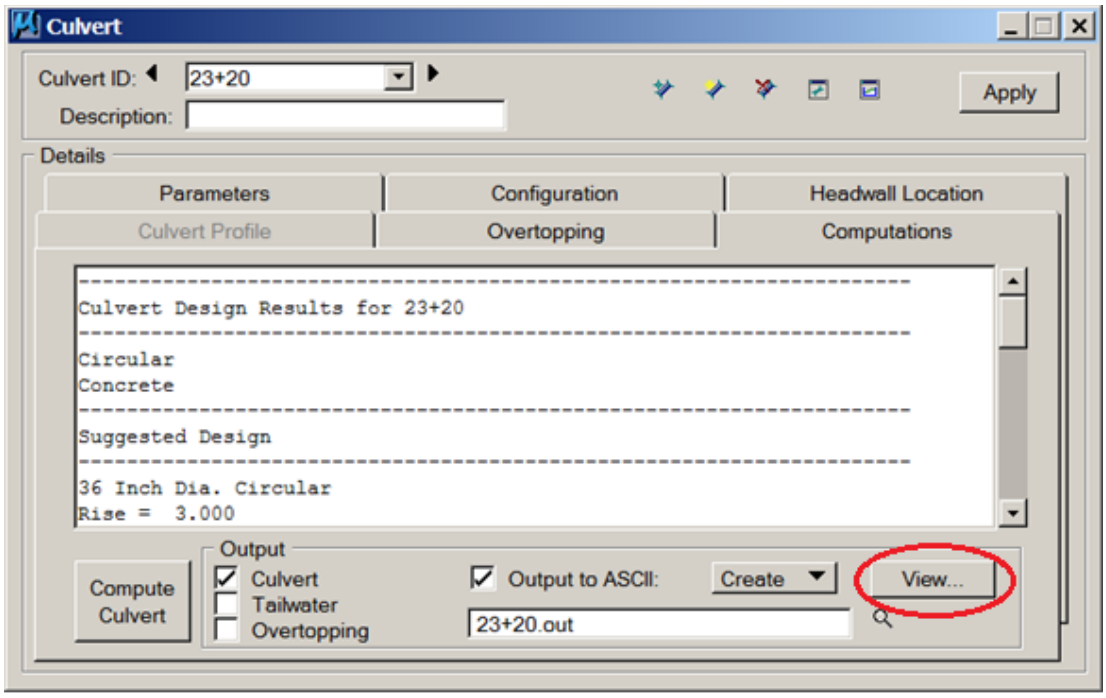
(Use the **DP** button to select a point after the Culvert.)

X Increment: 5.000

(This may be automatically adjusted depending on the distance between the begin station and end station.)

q) Once the Nodes have been located, and the elevations appropriately calculated, the Culvert can be added to the project. Click the **Apply** button and the culvert will be drawn and labeled according to the symbology in the Preferences.

r) The information to this point is enough to check the culvert computations. Select the **Computations** tab. Toggle on the option to view the **Culvert** calculations. Click the **Compute Culvert** button to perform the calculations.



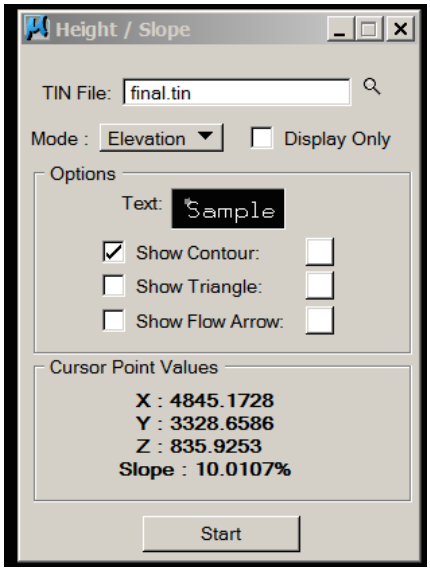
NOTE: You may include Tailwater and Overtopping calculations (if you need them) by toggling ON the option to view them.

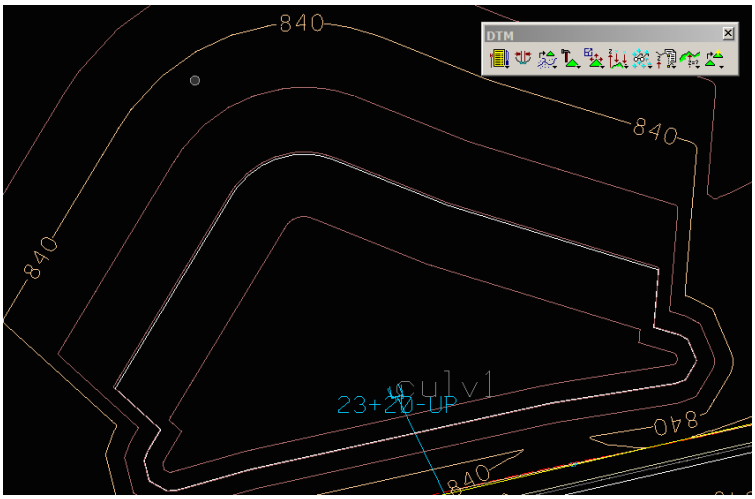
To view the Culvert Design Results, simply press the "View" button on the lower right of the "Culvert" menu to access the output file or you could open the file "23+20.out" from your Project Folder. View and/or print the Culvert Design Results that the Geopak Drainage software has calculated for you. Alternate design options have been found that may be considered.

The report also includes hydraulic computations such as Maximum Head Water Depth and Outlet Velocity for Q50 and Q100 which are helpful in analyzing the culvert design.

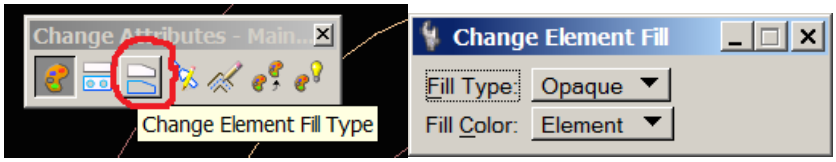
```
----
Culvert    Allow.     MAX      Inlet     Outlet    Tailwater
Discharge    HW        HW        HW        HW        Elev.
--------- -------- -------- -------- --------- ----------
39.200    836.500  835.926  835.926   835.926   829.770
44.429    836.500   836.240  836.240  836.240   829.800
-------------------------------------------------------------
```

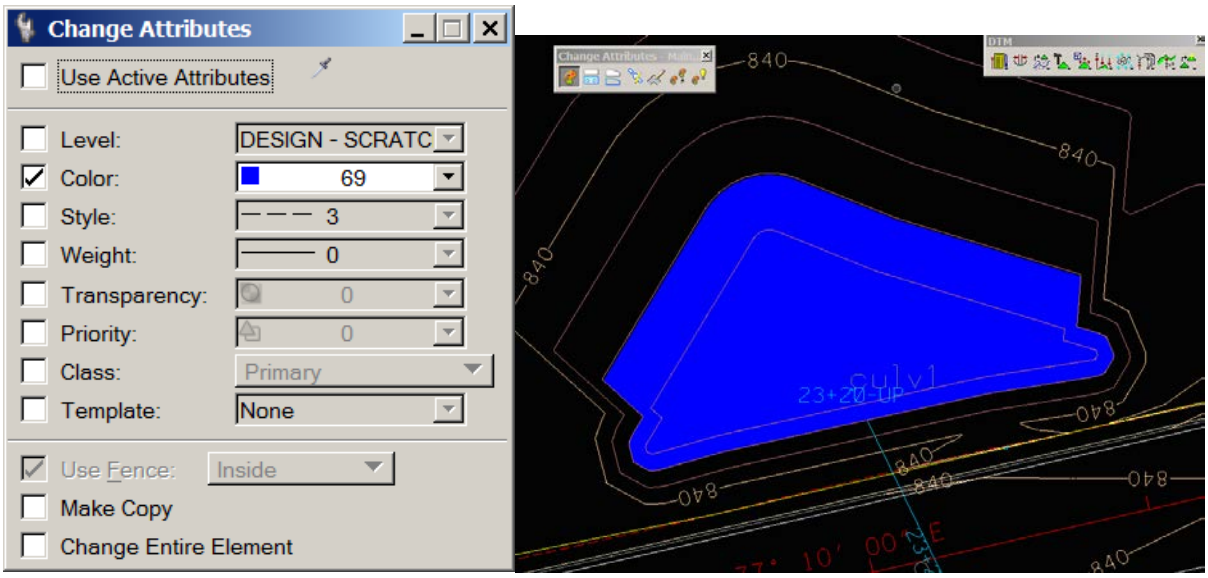
For the 50 year storm, the Head Water Depth is 835.926 ft. Using the DTM Height/Slope tool, a shape may be drawn at that elevation which represents the water surface for this storm event. This is the white shape in the picture below.



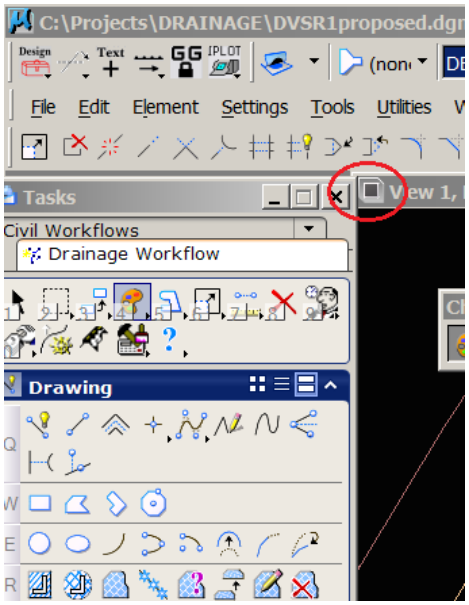


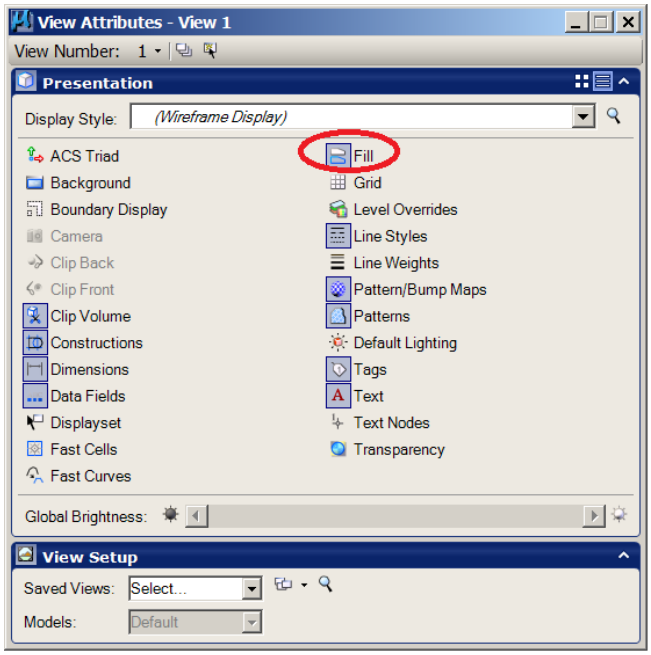
The Microstation Change Element Fill Type tool can be used to illustrate the ponded water for visual analysis. Use the Change Attributes tool to change the color to blue if desired.



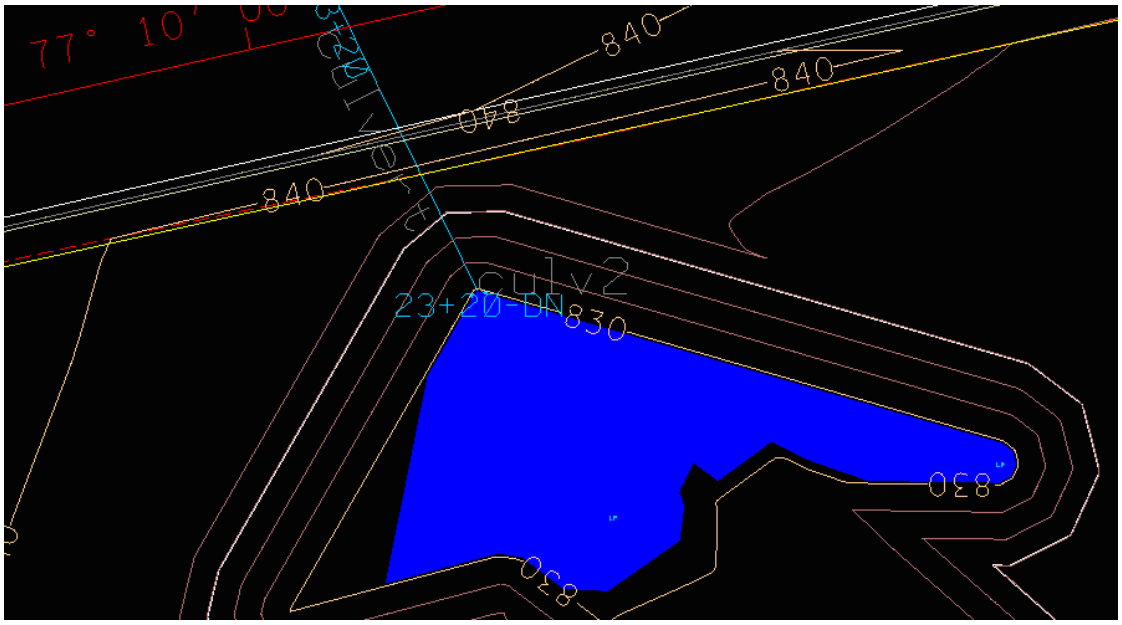


Be sure that your **Fill is toggled On** in the View Attributes menu.





Similarly, a visualization of the Tail Water pond may be created.

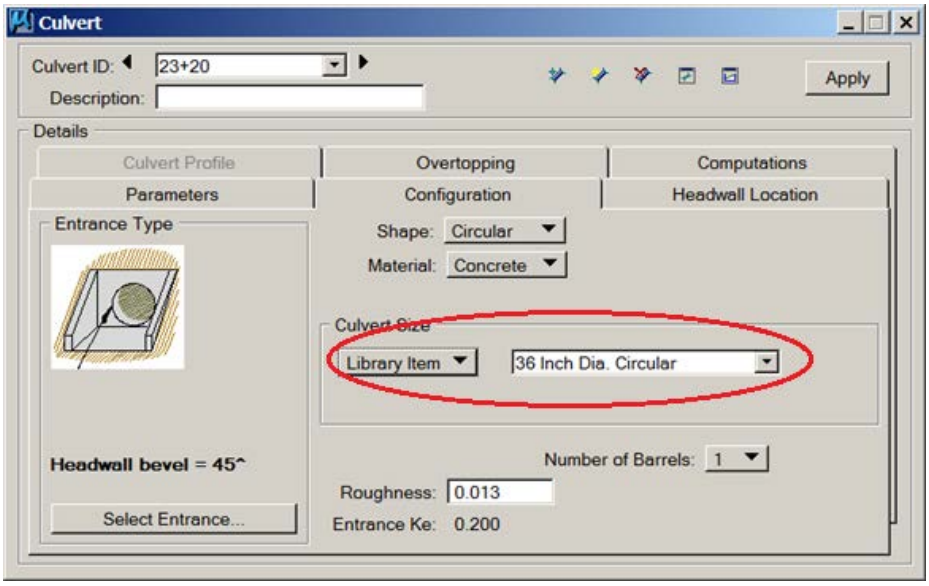


The Drainage Manual states that outlet velocities on Culverts should be based on the 50 year storm. In our file 23+20.out, we see that Geopak Drainage has calculated the Outlet Velocity for the 50 year storm at 13.567 fps.

Culvert Discharge	Outlet Velocity	Uniform Depth	Critical Depth	Critical Slope	Friction Slope
39.200	13.567	1.284	2.038	0.005	0.024
44.429	14.024	1.378	2.172	0.006	0.024

The use of riprap as scour protection at a culvert outlet is discussed in Section 6.04.3.3 of the Drainage Manual. It says that riprap can be used to provide protection at a culvert outfall for velocities between 5 fps and 12 fps. Since our velocity is greater than 12 fps, we would either need to lessen the slope of the culvert, thereby reducing the velocity at the outlet, or we would need to design a stilling basin or some other type of energy dissipator. See the Drainage Manual for guidance.

Before the next step, go back to “Configurations”, change Culvert Size to “Library Item” - 36 Inch Dia Circular. Then, select the Culvert Size drop down and switch it to Design Size and set the Maximum Rise to 3.



4.3 Culvert Profile

At this point, the designer has the pipe size that will be required and can use regular Geopak proposed cross section tools to set up a culvert section to finalize the length & inverts for the cross drain.

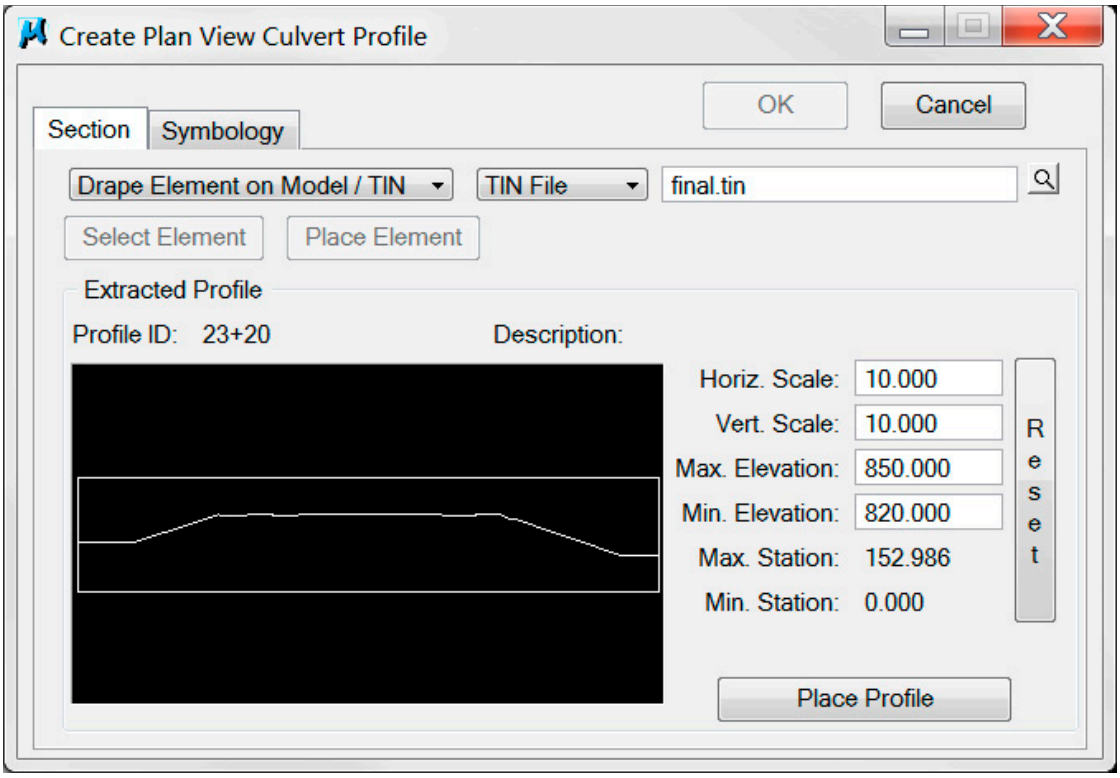
The next several steps illustrate the functionality available through Geopak Drainage to set up a culvert section in profile format along the cross drain.

a) On the **Headwall Location** tab click on **Create Profile** to set up a culvert section and finalize headwall locations. The **Create Plan View Culvert Profile** dialog will open up. Make settings as shown below.

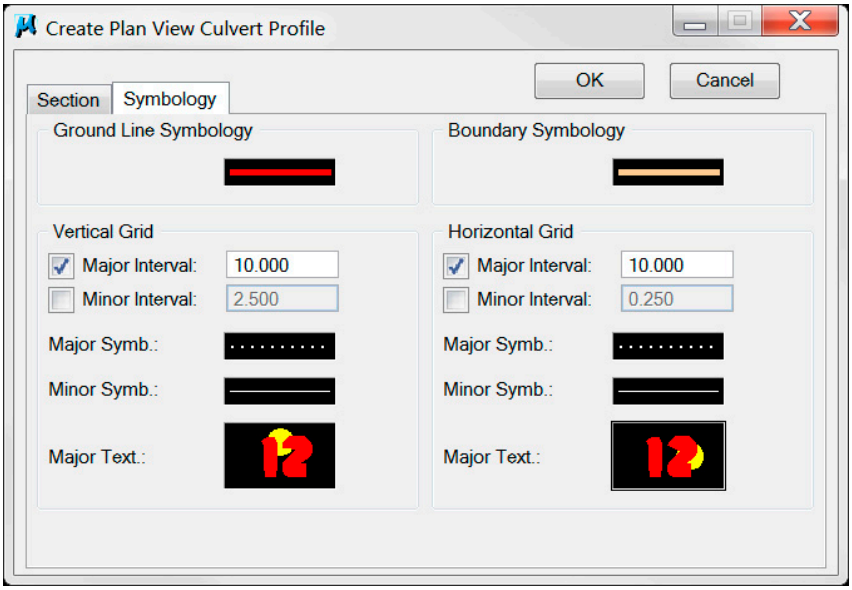
Set **Horiz scale 10** and **Vert scale 10**.

Change **max** and **min** elevations to be the next even 10' up or down.

Use default values for Max and Min station.



b) Click on the **Symbology** tab and make the following settings:

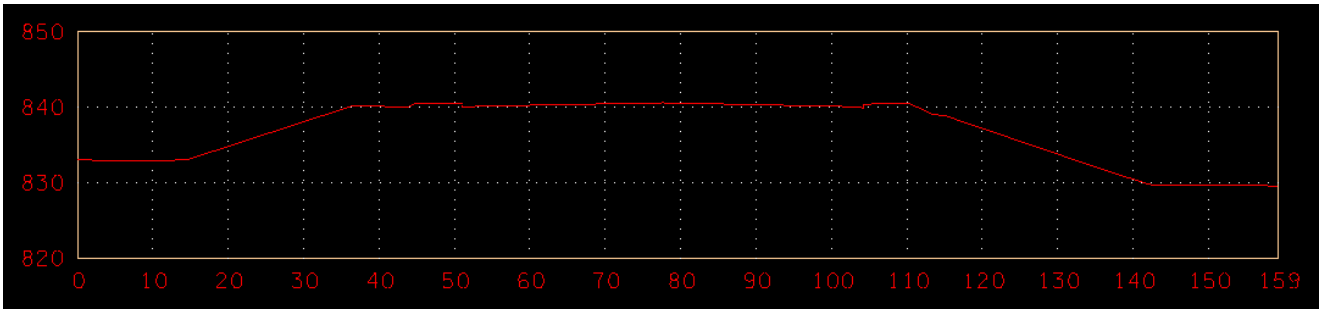


Ground Line Symbology (Proposed Roadway):
LV= DESIGN - TYPICAL - Finished Grade and Subgrade
CO= 6, Style=0, WT=4

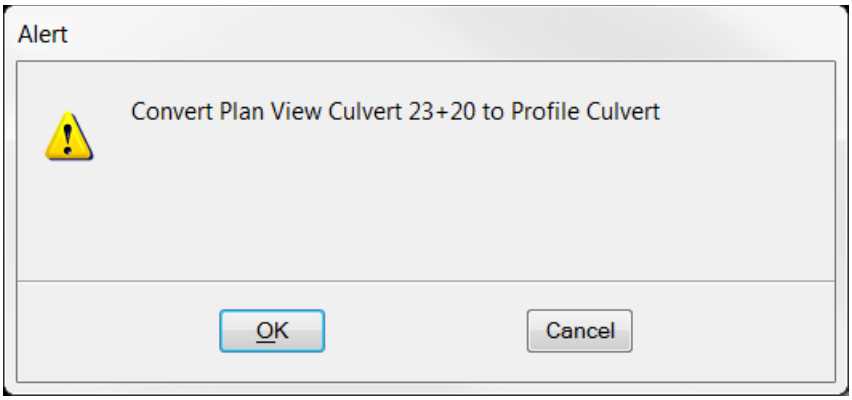
Boundary Symbology:
LV= DESIGN – SHEET – Light Grid
CO=2, Style=0, WT=4

Vertical Grid Major Interval:
ON, Value=10
Vertical Grid Minor Interval:
OFF
Vertical Grid Major Symbology:
LV= DESIGN – SHEET – Light Grid
CO=0, Style=1, WT=1
Vertical Major Text:
LV= DESIGN – SHEET – Corner Text
CO=6, WT=10, TH=2, TW=2, FT=LEROYMON(3)
Click the Top Center to set Justification
Horizontal Grid Major Interval:
ON, Value=10
Horizontal Grid Minor interval:
OFF
Horizontal Grid major symbology:
LV= DESIGN – SHEET – Light Grid
CO=0 Style=1 WT=1
Horizontal Major Text:
LV= DESIGN – SHEET – Corner Text
CO=6, WT=10, TH=2, TW=2, FT=LEROYMON(3)
Click the Middle Right to set Justification

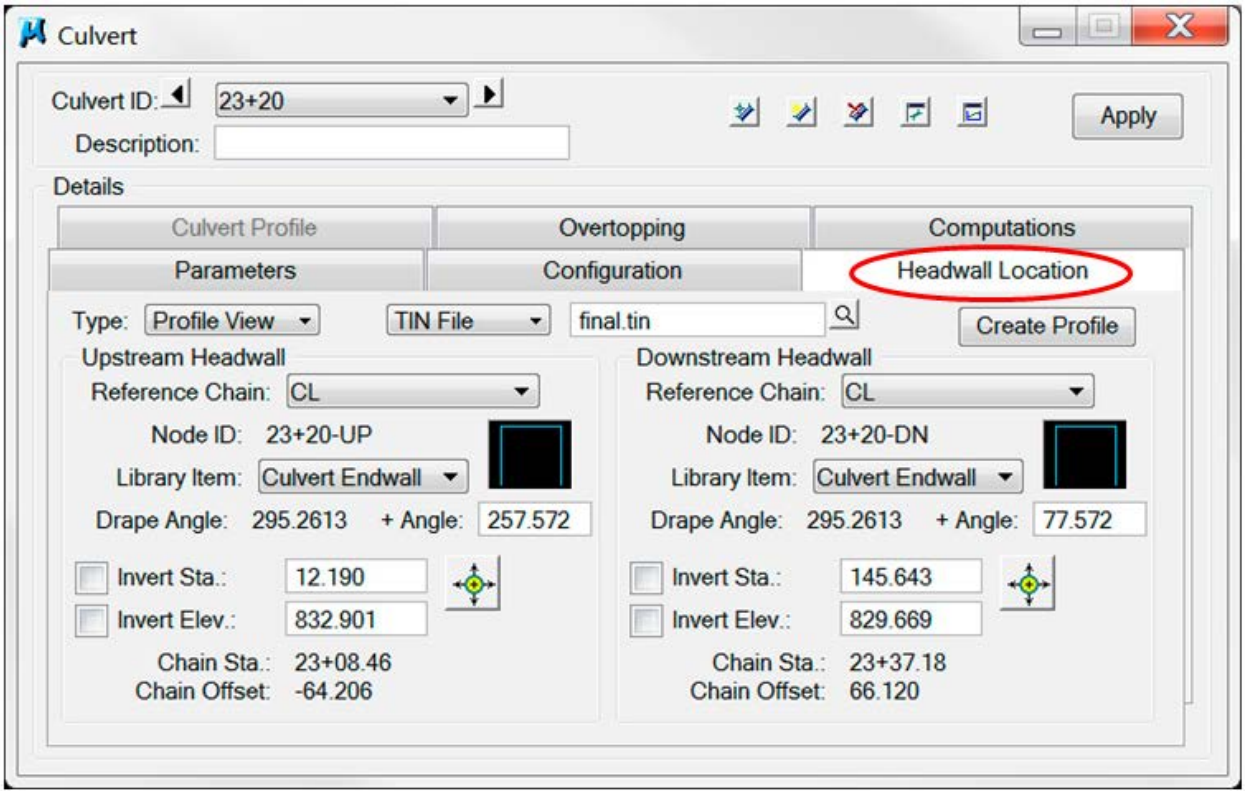
c) Once symbologies are set click on the **Section** tab and click on **Place Profile** in the lower right of the dialog. Culvert Section graphics will appear on the cursor, **Data Point out in the open somewhere to place the graphics**. Click **OK** on **Create Plan View Culvert Profile** dialog to dismiss and reopen the **Culvert Edit** dialog. Click **Apply** to store the culvert information.



d) Now that we have placed our culvert section we can finalize our inlet and outlet locations. On the **Headwall Location** tab change **Type** from Plan View setting to **Profile View**. **When prompted to "Convert Plan View Culvert to Profile Culvert" click OK:**



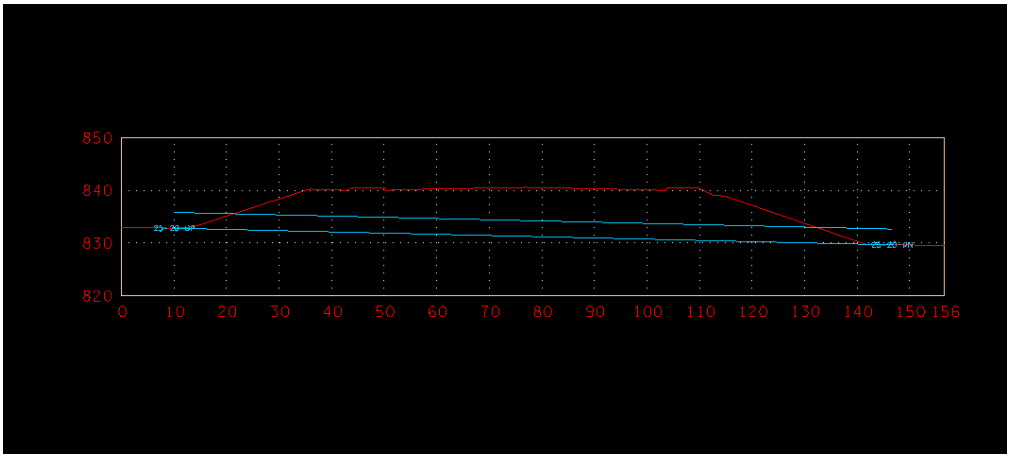
e) The **Headwall location** tab will change to show Profile view controls.



f) Under **Upstream Headwall** controls click **Station DP** button.  Move cursor over culvert section profile near the upstream end of pipe. That end will start dynamically tracking with cursor movement. Relocate inlet so that the upstream invert of the pipe coincides with roadway side slope.

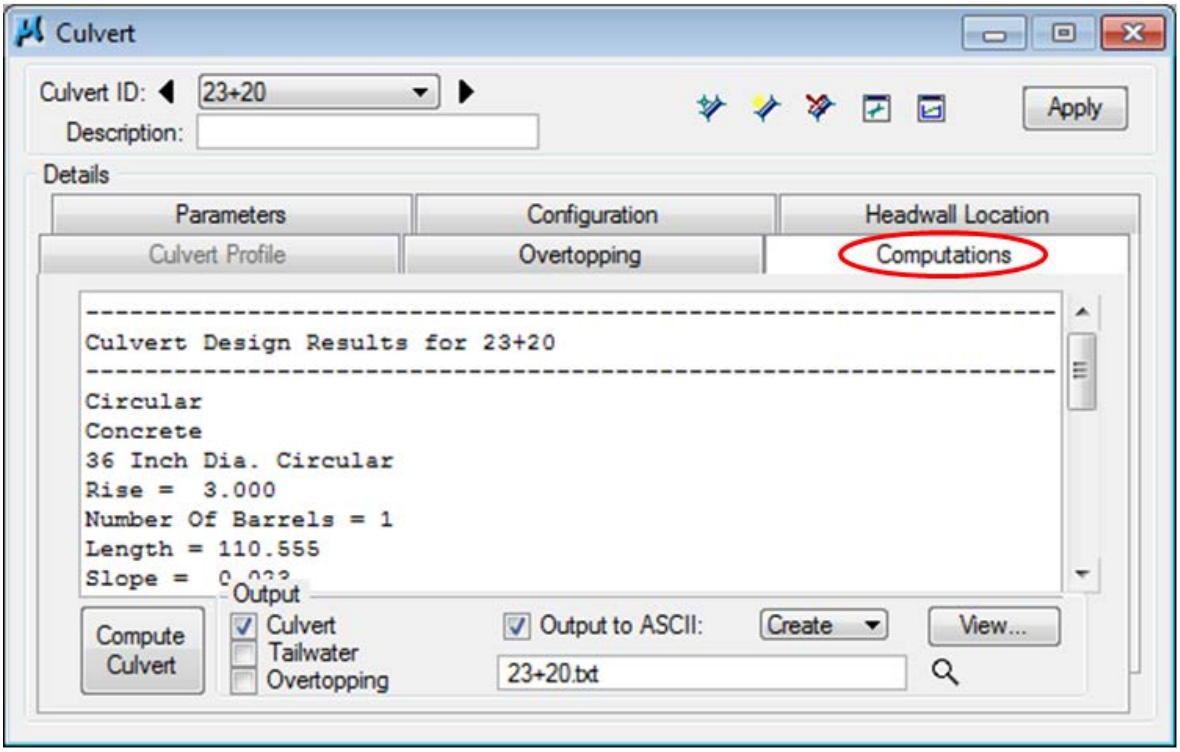
NOTE: This location could be located previously with Microstation commands or calculated and input as values in the Invert Sta. & Invert Elev. Keyin fields.

g) Repeat this procedure on the **Downstream Headwall** by clicking on **Station DP** and locating in culvert section profile.



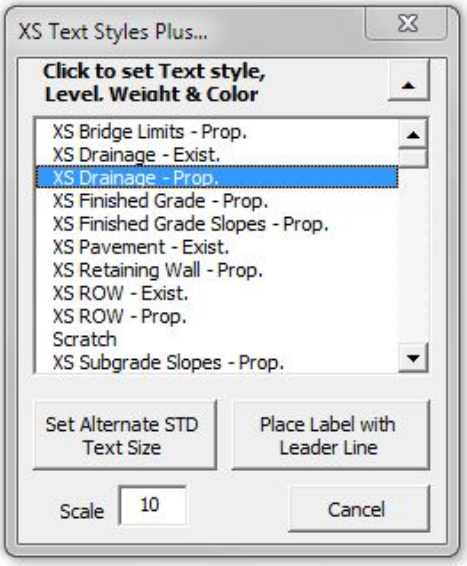
h) Once Headwall locations have been reset click on **Apply** in the upper right corner of the **Culvert Edit** dialog. Now go back to the **Computation** tab and this time before clicking on **Compute Culvert, toggle ON** option for **Output to ASCII**, keyin name **23+20.txt** and set file to **Create** option.

When **Compute Culvert** is clicked the output data in dialog is updated and text output file is created.

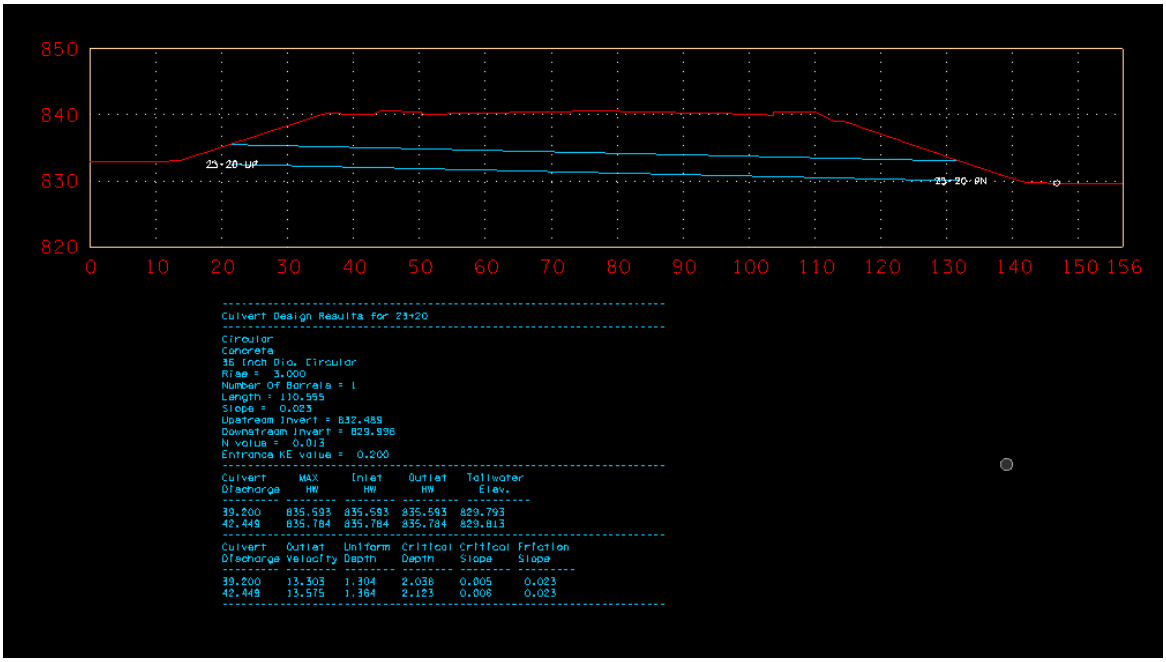


i) To place drainage info with culvert section profile :

Set active text settings by going to **TDOT>Cross Sections>XS Text Styles Plus,** set Scale to **10** and select **XS Drainage - Prop.**:



Go to Microstation's **File>Import>Text** and pick the file **23+20.txt** in your project directory. Data Point in the DGN file for placement near the culvert section profile. This data can now be used when filling out TDOT Standard Drainage Data cells or can be edited to show additional data needed with the culvert section.



5. Storm Drainage Nodes

This exercise shows the user how to create surface drainage components for storm drainage. The user will add drainage areas, inlets, and outlets as necessary for proper roadway drainage design. Unless designing for the interstate, TDOT typically uses a 10-yr storm to design (See Appendix J).

Typically, each segment of the roadway drainage system will have an outlet to a side ditch, natural river or stream, or an adjacent storm drainage system. Possibilities of these outlets should be considered when determining catch basin locations.

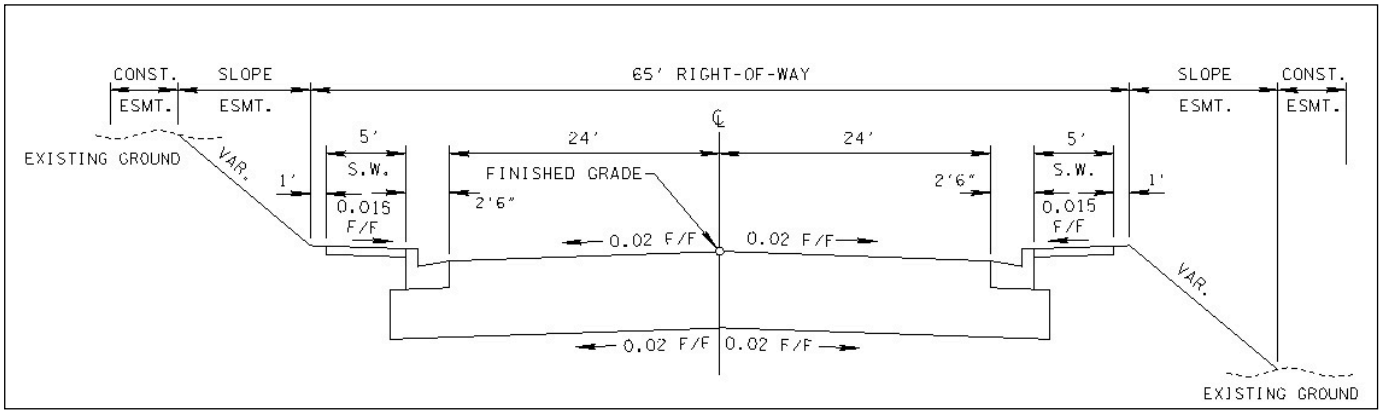
Initial locations for catch basins (inlets) should be based on the following criteria:

1.) At all low points (sag points) in the gutter grade or low points behind curbs, shoulders or sidewalks
2.) At the location down grade from the highpoint of a vertical curve where the spread is equal to the allowable spread
3.) At areas where off-site flow will flow across the top of curbs
4.) Upstream of median breaks, entrance/exit ramp gores, cross walks, street intersections, and bridges
5.) At side streets upgrade from the intersection
6.) At least every 400 feet (required for maintenance)

Once these primary locations are determined, adjustments or additions can be made to ensure that a safe travel way is maintained.

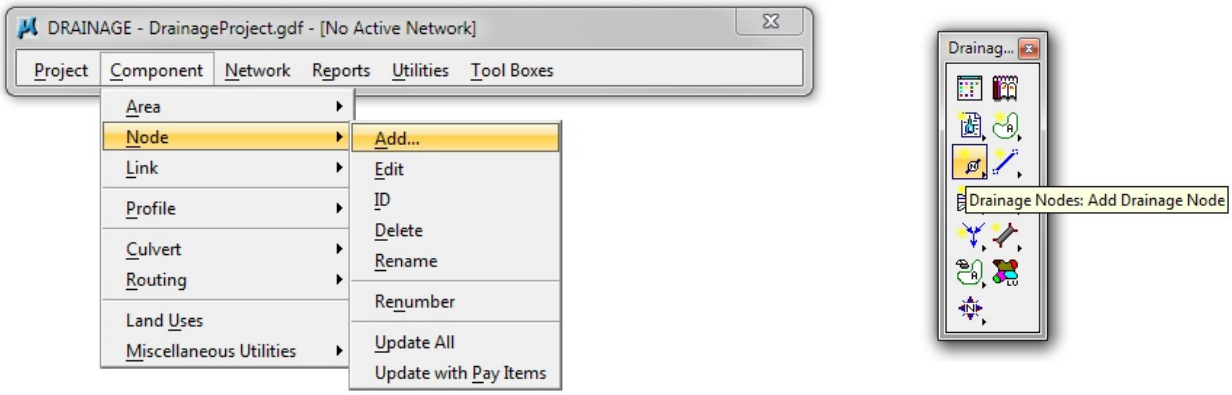
5.1 Design Drainage Node CB – 1

a) Determine the location of the Proposed Inlet. The proposed roadway is 4 lanes with no shoulders and a 6" non-mountable curb with curb and grate inlets.

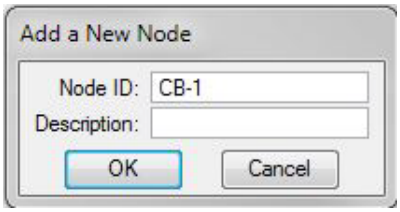


We will assume for this project that the curb and gutter begins at 0+00.00. We have also determined that our maximum allowable spread is 8.0 feet (See TDOT Drainage Manual Chapter 7 Section 7.03.3.7). Using sound engineering judgment we will assume our first inlet to be at Station **4+00.00** Offset –**26.00**.

b) From the Drainage Main Menu Bar, select **Component > Node > Add** *OR* from the Main Toolbar, select **Add Drainage Node.**



c) Type in **CB-1** for the node ID. Leave the Description blank. Click OK. Over the next several steps, we will progress through the Node Configuration until everything has been set successfully.



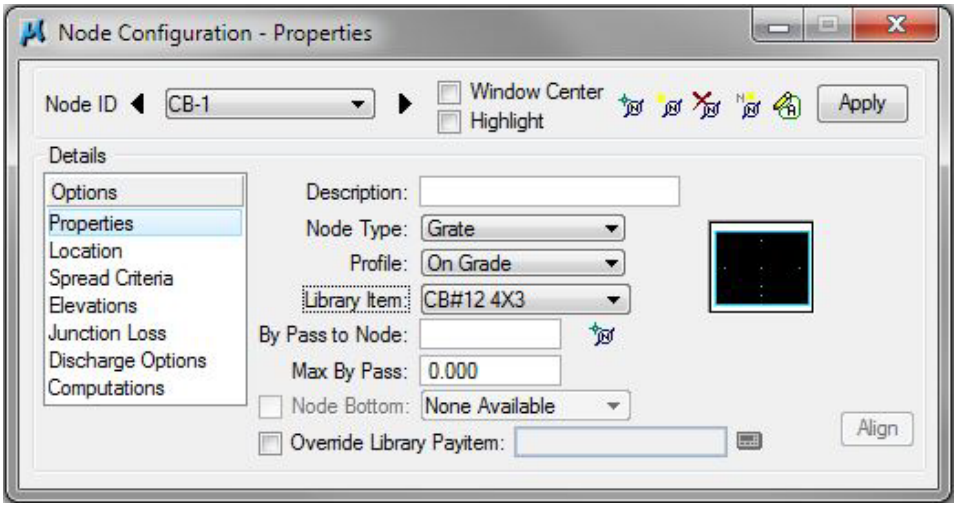
d) Properties > With the Node Id set to CB-1, set the properties as shown below*:*

Node Type: Grate

Profile: On Grade

Library Item: CB #12 4X3

(See Standard Drawing D-CB-12S for details.)



NOTE: This project calls for a 6" nonmountable curb and gutter inlet. A type 12 catch basin is used since it is the most common for this type of gutter. The 4X3 is chosen because it requires the least amount of depth for the type 12's. It is common practice to choose the smallest catch basin at the beginning of the system. Refer to the TDOT GEOPAK Drainage Nodes shown in Appendix A to see other sizes and types of nodes.

e) Location > Describe the inlet's location in the design file as shown below:

Reference Chain: CL

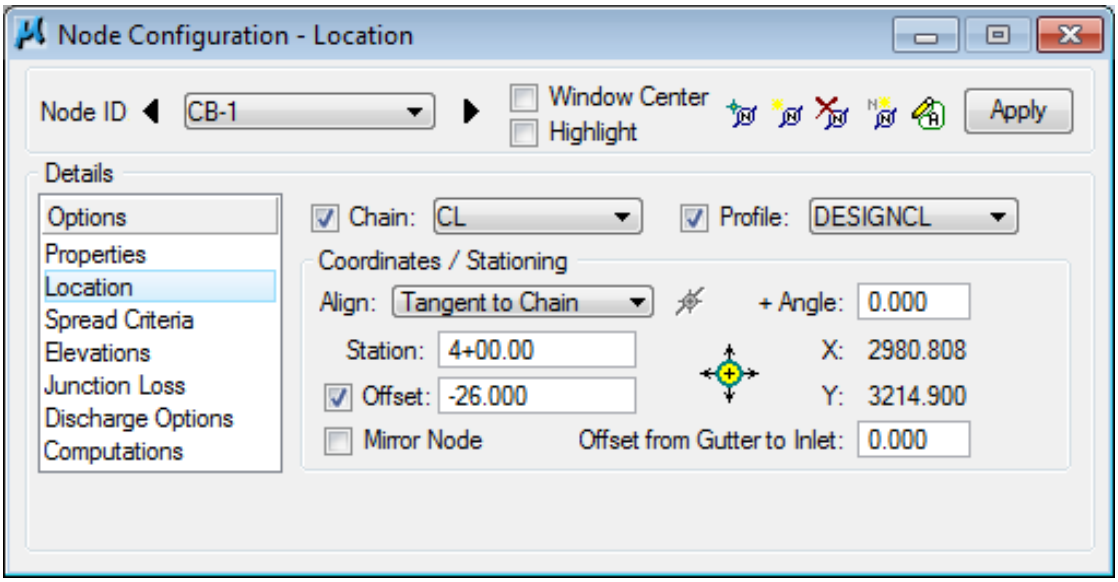
Profile: DESIGNCL

Align: Tangent to Chain

Angle: 0.00

Station: 4+00.00

Offset: -26.00



NOTES:
Once the location options are set, hit enter on your keyboard or data in one of the fields to add the catch basin. The angle of the catch basin is automatically set to match the centerline.

If a line or some other MicroStation element is located at the desired station and offset, the **Station DP** button can be used. If Station DP is active and the location is set, **DO NOT** move out of the dialog because the station range will change. Hit enter on your keyboard or data in one of the fields to add the catch basin.

Other Align Options:

Tangent to Chain: Allows independent station and offset while matching a specified chain's angle.

Tangent to Element: Allows independent station and offset while matching an elements angle.

Tangent on Element: Allows independent station (within limits of the element) while matching elements offset and angle**.** (Mirror Node is often required when using this option)

At Point: Allows independent station, offset and angle**.**

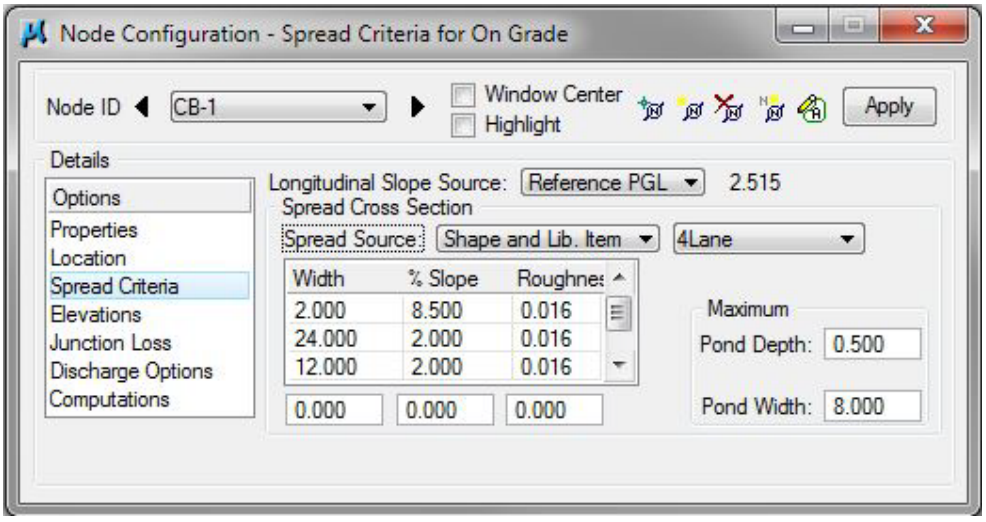
f) Spread Criteria > Describe the roadway cross sectional characteristics directly in front of the inlet. These values will be utilized to calculate inlet capacity and resulting by-pass flow. Turn ON the display for the reference file: **DVSR1SEshapes.dgn** and choose the following options:

Longitudinal Slope Source: Reference PGL

Spread Source: Shape & Lib. Item - 4Lane

Max Pond Depth: 0.50 feet

Max Pond Width: 8.00 feet



Change Spread Source back to User Supplied to remove extra links created by the combination of the Shape and Library Item. The 24' link is defined in the library item but is not required since we have superelevation shapes for the pavement area, one shape for each 12' lane. **Delete the item with 24 for the width, and change the last item width from 11.993 to 12 and slope percent from 2.001 to 2**.

g) Spread Criteria > In the previous step, we set the spread section using a combination of the project's superelevation shapes and a standard drainage library spread section to illustrate that if a final TIN file has not yet been made, other methods could be used. The recommended method is to use a final TIN file which should represent the roadway accurately at any given inlet location.

Change the **Spread Source** to Reference TIN.

h) Elevation > Assign the inlet vertical elevation and vertical pipe alignment options. The **Reference Surface: Tin File** should already be set.

Reference Surface: TIN File - final.tin

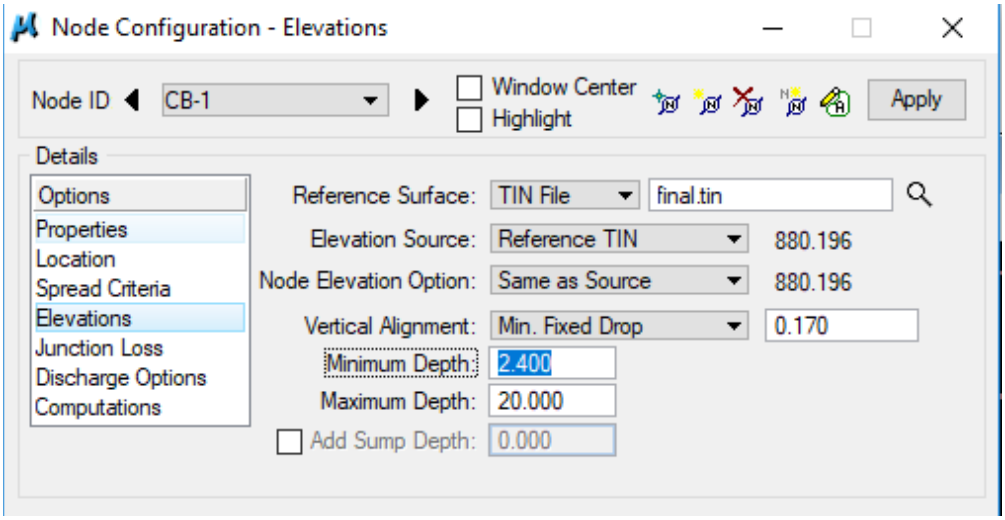
Elevation Source: Reference TIN

Node Elevation Option: Same as Source

Vertical Alignment: Min. Fixed Drop, 0.17

Minimum Depth: 2.40 feet (See first note at top of next page)

Maximum Depth: 20.00 feet



NOTES:

Refer to the **TDOT GEOPAK Drainage Nodes** listing in Appendix A of this manual or online for **Minimum Depth**, **Maximum Depth** and **Min. Fixed Drop** or **Drop Across Bottom of Structure** values for a given catch basin type and pipe size.

In Node Configuration, Minimum Depth refers to the Minimum Depth of Cover. It does not refer to the minimum depth of the catch basin. Both numbers are provided as shown below in a segment of the table taken from Appendix A.

Drainage Node Name Type: Grate	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes			
					15		18	
					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#10 32"X26"	Lowered 6-30 Curb & Grate Inlet	CB32X26S	0.12	5.08			3.77	2.15
CB#10 4X3	6" NonMount. Curb & Grate Inlet	CB4X3S	0.17	20.00			3.90	2.23
CB#10 4' DIA	6" NonMount Curb & Grate Inlet	CB4DIAS	0.17	20.00			3.89	2.22
CB#10 4X4	6" NonMount. Curb & Grate Inlet	CB4X4S	0.17	28.00			3.90	2.23
CB#12 32"X32"	6" NonMount. Curb & Grate Inlet	CB32X32	0.12	4.58			3.77	2.15
CB#12 4X3	6" NonMount. Curb & Grate Inlet	CB4X3	0.17	20.00			3.90	2.23

NOTES:
In the TDOT GEOPAK Drainage Nodes table in Appendix A **"Minimum Depth of Cover = Minimum Depth - Pipe Size - Drop Across Bottom of Structure"** for catch basins with both inlet and outlet pipes. To determine Minimum Depth of Cover for catch basins with an outlet only: add **Drop Across Bottom of Structure** to **Minimum Depth of Cover.** The first catch basin in the system is considered an outlet only because there are no other pipes (inlets) coming into it.

For the initial design, use the value given under the 18 in. pipe size. **If larger pipes are designed, reset the Minimum Depth of Cover to the value for the pipe designed on and re-design the network.** Steps for this procedure are given in chapter 9 on **Drainage Navigator /Querying.**

Catch Basins – Inlet and Outlet:

Min. Depth of Basin – Pipe Size – Drop Across Bottom of Structure = Minimum Depth

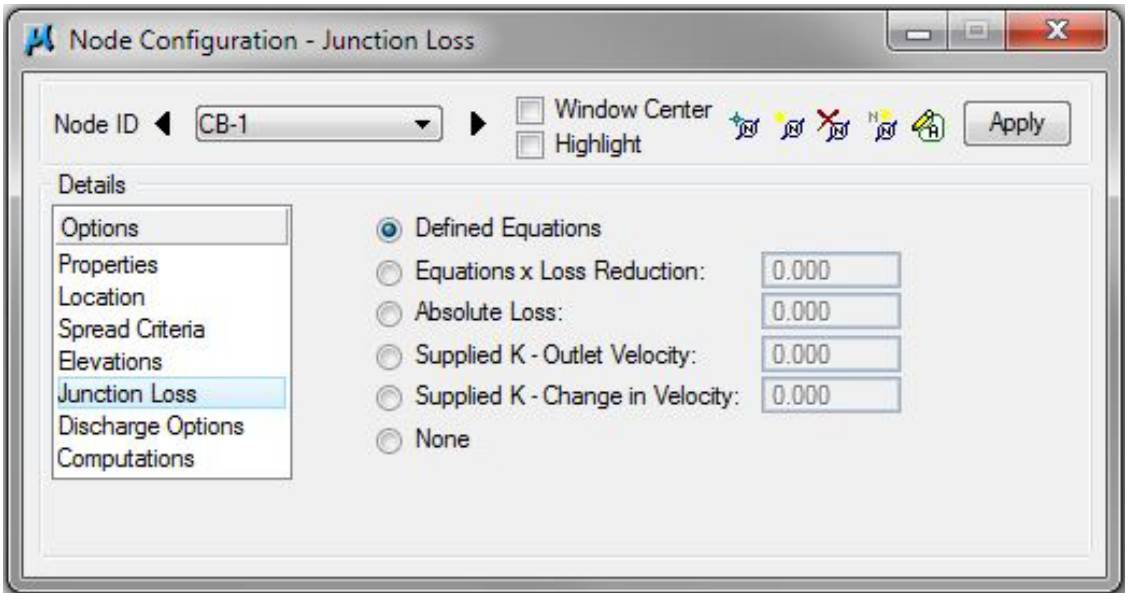
CB#12 4x3: 3.90' - 18"/12 - 0.17' = 2.23'

Catch Basins – Outlet Only:

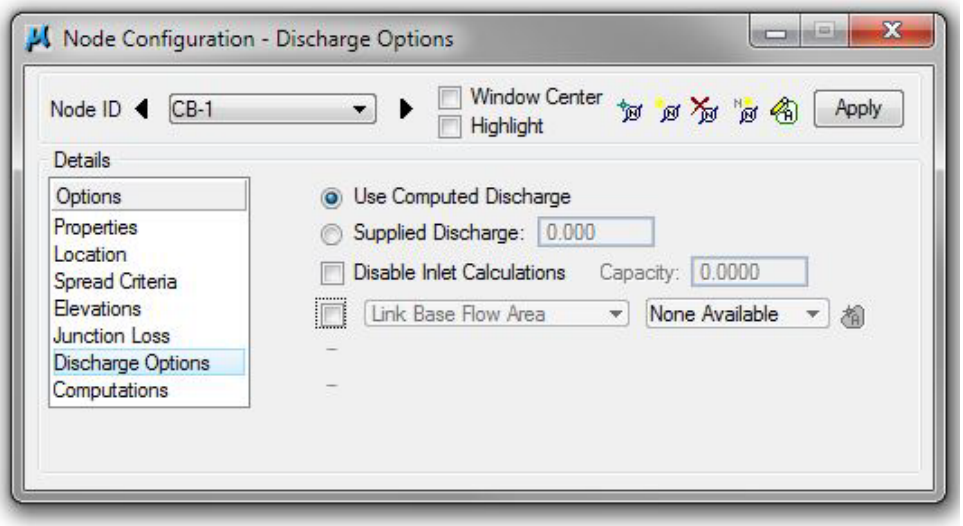
Drop Across Bottom of Structure + Min. Depth of Cover = Minimum Depth

CB#12 4x3: 0.17' + 2.23' = 2.40'

i) Junction Losses > Set to Use **Defined Equations** (This defaults to the project preference settings that were set in Exercise 1):

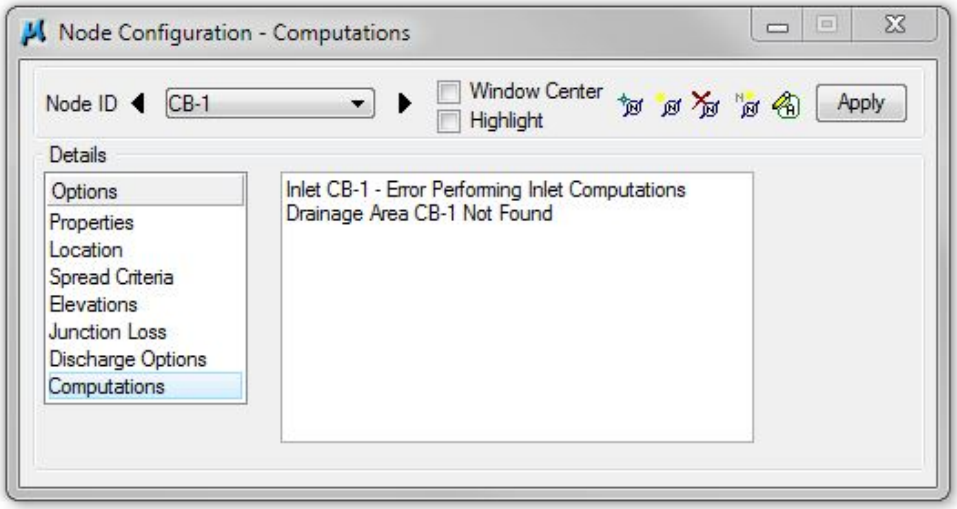


j) Discharge Options > Specify the source of the discharge contributing to this inlet. Toggle **Use Computed Discharge**:



k) Computations > Verify the inlet's hydraulic computations:

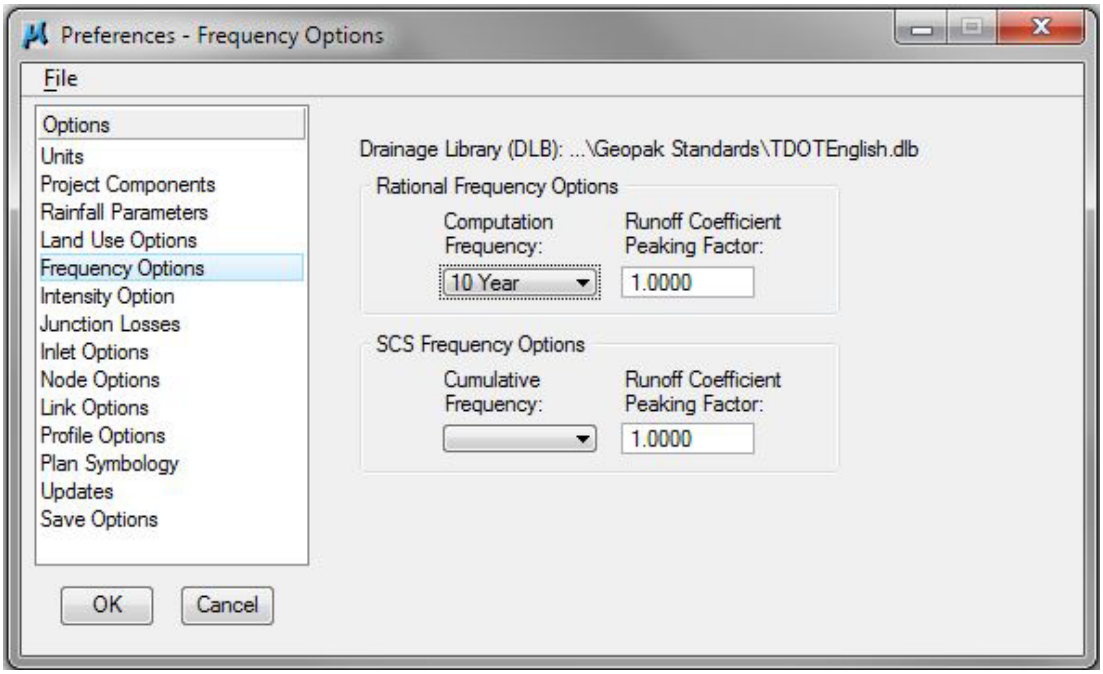
NOTE: The Drainage Area for this node hasn't been added; therefore, the computations for the node can't be completed until a discharge is known.



l) Add this Node to the project by pressing the **Apply** button.

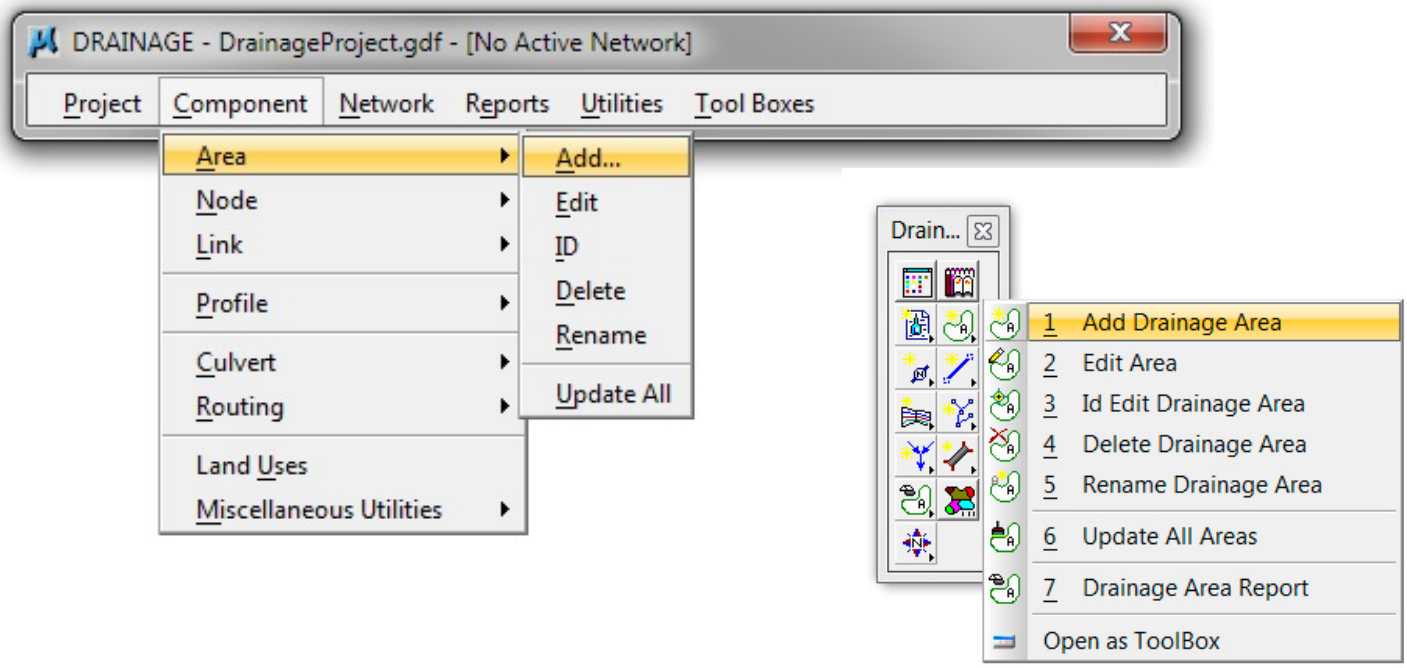
5.2 Delineate Drainage Area CB – 1

a) According to the TDOT Drainage Manual Chapter 4 Table 4-1 (see Appendix J) *Hydrologic Design Criteria,* the drainage area for CB-1 should be calculated for a 10 year frequency. Select **Project>Preferences** and **change the Frequency Options to the 10 Year Storm**. Click the **OK** button to accept the new preference settings.

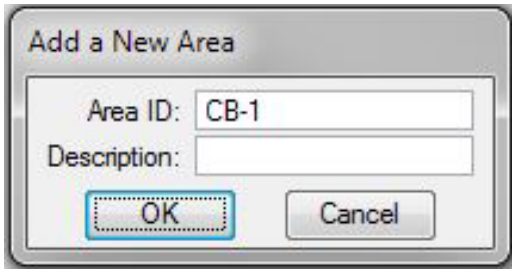


b) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.**

NOTE: If you have closed the Node Configuration Dialog you may create a new Drainage Area by going to the Drainage Main Menu Bar, and selecting **Component > Area > Add** *OR* from the Main Toolbar and selecting **Add Drainage Area.**

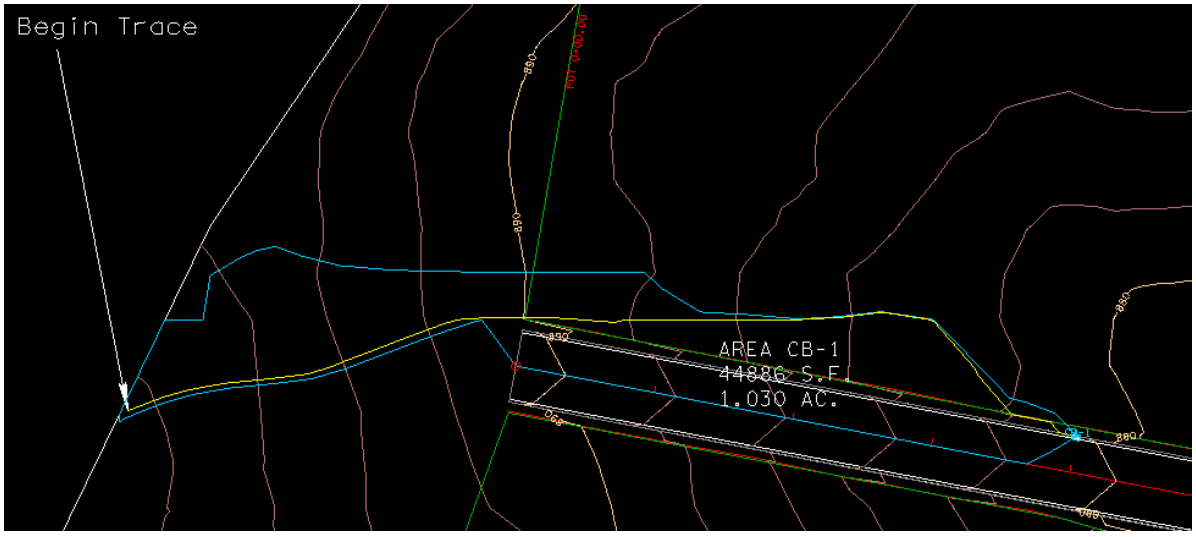


The following Add a New Area dialog box will pop up. Click **OK**.



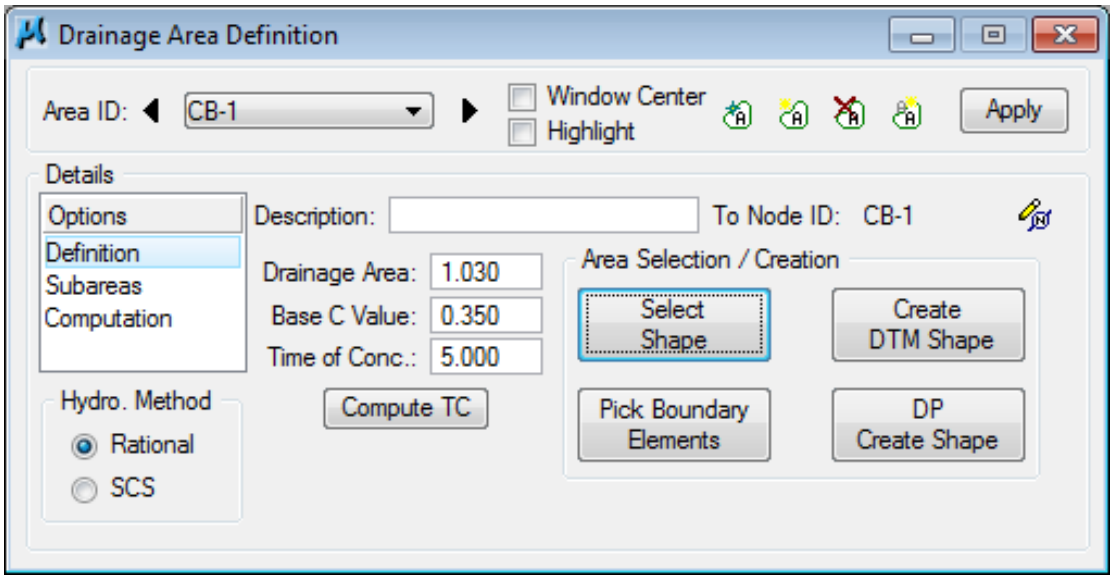
c) To delineate the area for CB-1, there are a couple of methods you can use. One method is to follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 1. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Another method is to use the areas that have already been drawn for all the catch basins. The files containing these areas are located in the folder "Drainage Areas" in the class directory. Attach reference file DA_CB-1. This is the file that contains the area for CB-1

Delineate Drainage Area:



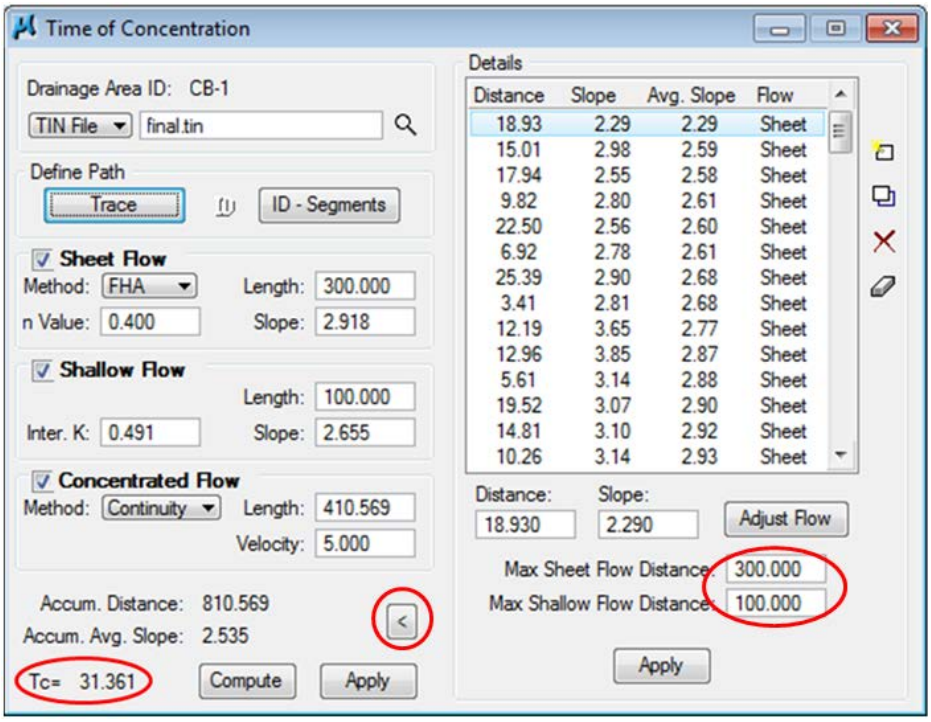
d) Define Drainage Area:

Use Select Shape to identify the drainage area. Our Base C Value was set previously in the culvert exercise.



This Base C Value should be set to the most common land use item within your project area then only the remaining areas would need land use shapes developed for them.

e) Calculate Time of Concentration:



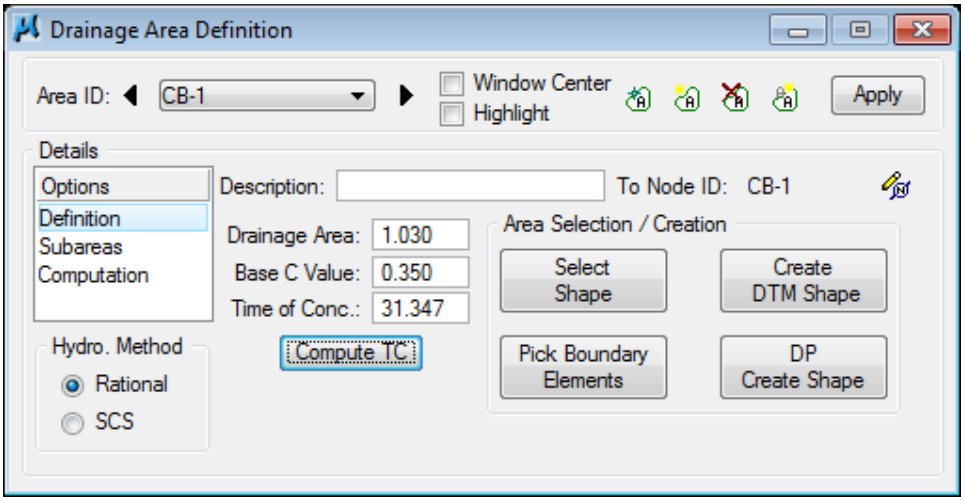
Note that the n value for the sheet flow and the Inter. K value for the shallow flow has changed and will remain the same throughout this exercise unless noted.

Sheet Flow – When water flows at a depth of 0.1 feet (1.2 inches) or less

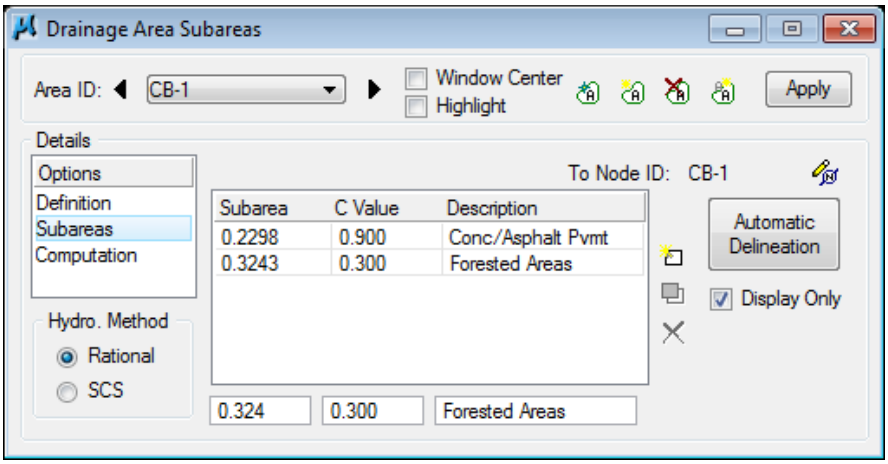
Shallow Flow – Sheet flow usually becomes shallow flow and flows at a depth above 0.1 feet (1.2 inches)

Concentrated Flow – Water flowing in a ditch, gutter, channel, or other drainage structure

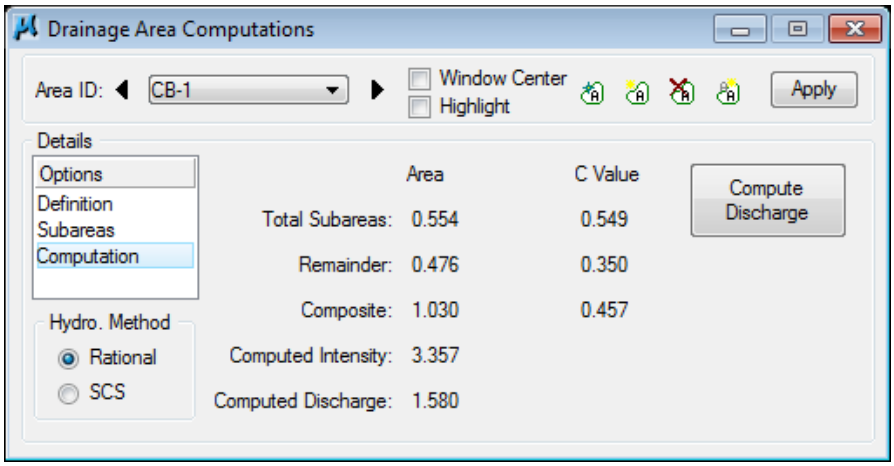
The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required.



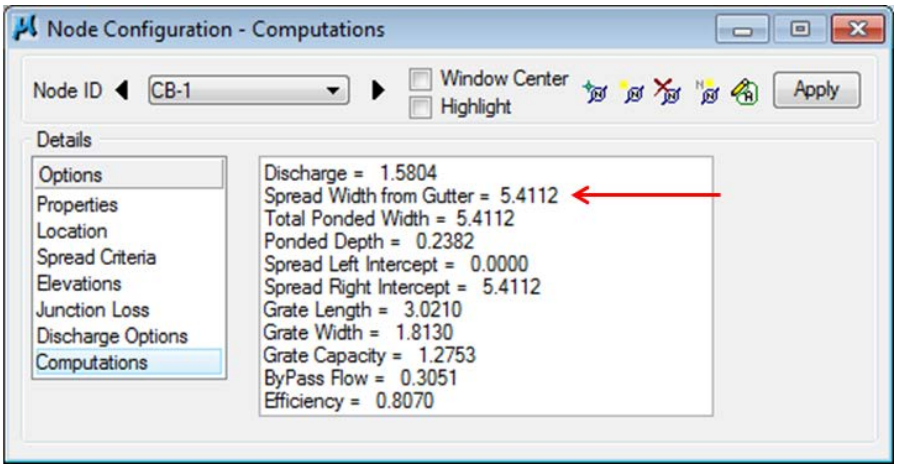
f) Delineate Subareas utilizing the Land Use DGN:



g) Compute Discharge and Apply:



h) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

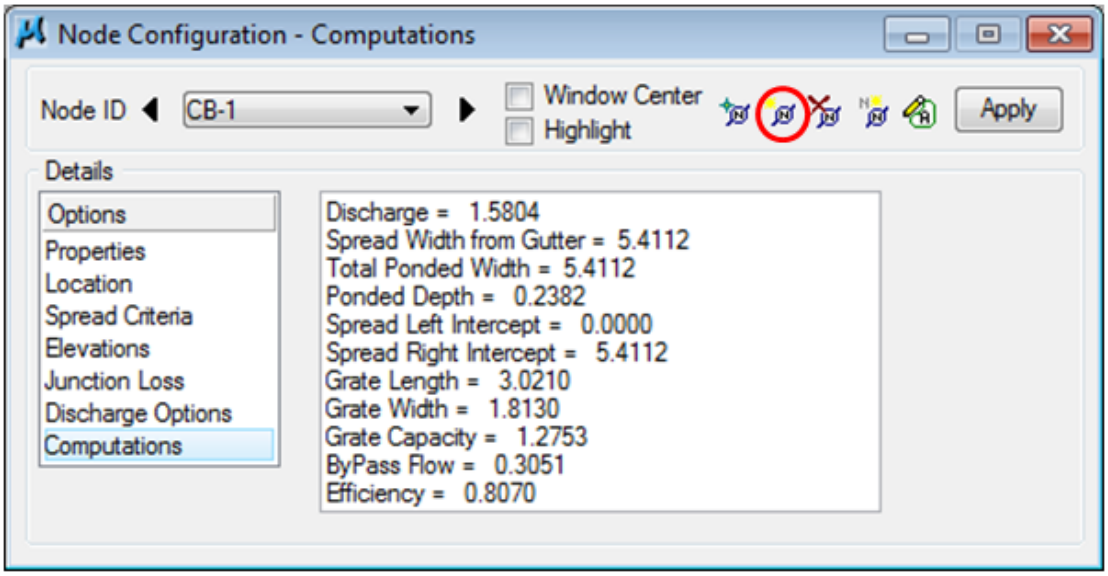
5.3 Design Inlet CB – 2

It has been determined that another standard **CB#12 4X3** will be used.

See Standard Drawing D-CB-12S for details.

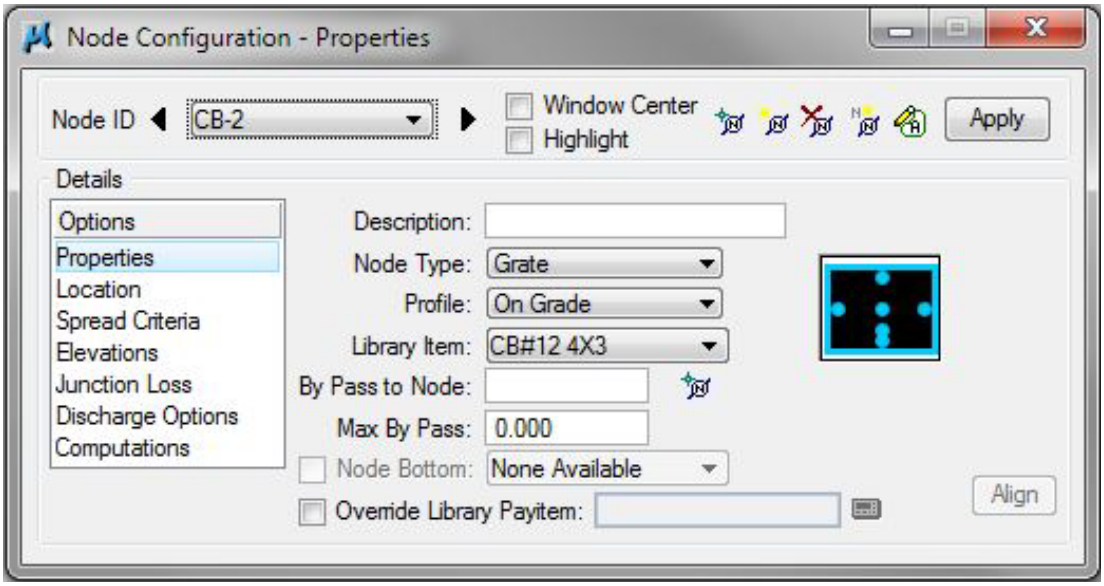
CB- 2 will be at nearly the same location as CB-1 but will be on the right side of the road. Many of the parameters will be defaulted to those used to place CB-1.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog.



b) Click **OK** to add CB-2. CB-2 will automatically take the place of CB-1 in the Node Configuration dialog which is already open.

c) **Properties >** Verify the Node Properties are defaulted from the previous Node (CB-1) such that no user-input is required for this similar curb inlet.



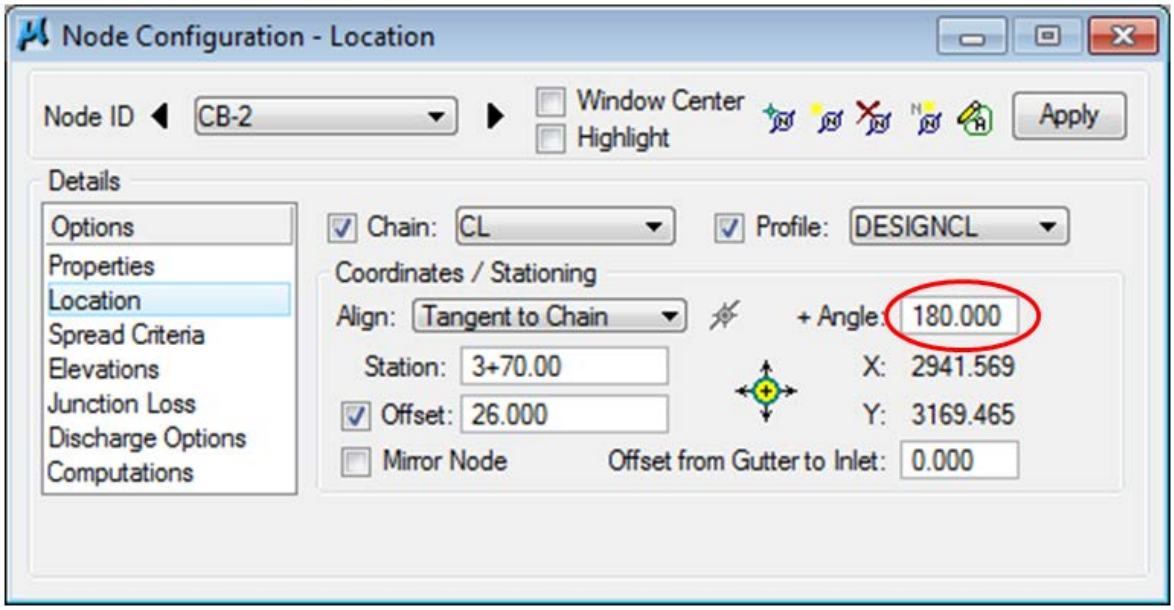
d) **Location >** All Reference information is defaulted from the previous Node (CB-1) such that only the **station**,**+ Angle (OR Mirror Node but NOT both)** and the **Offset** needs to be changed. Change the

Station: 3+70

Angle: *180 (or toggle on Mirror Node)

Offset: 26.00

*(180 for Right side, 0 for the Left), (Mirror Node ON for the Right, OFF for the Left)



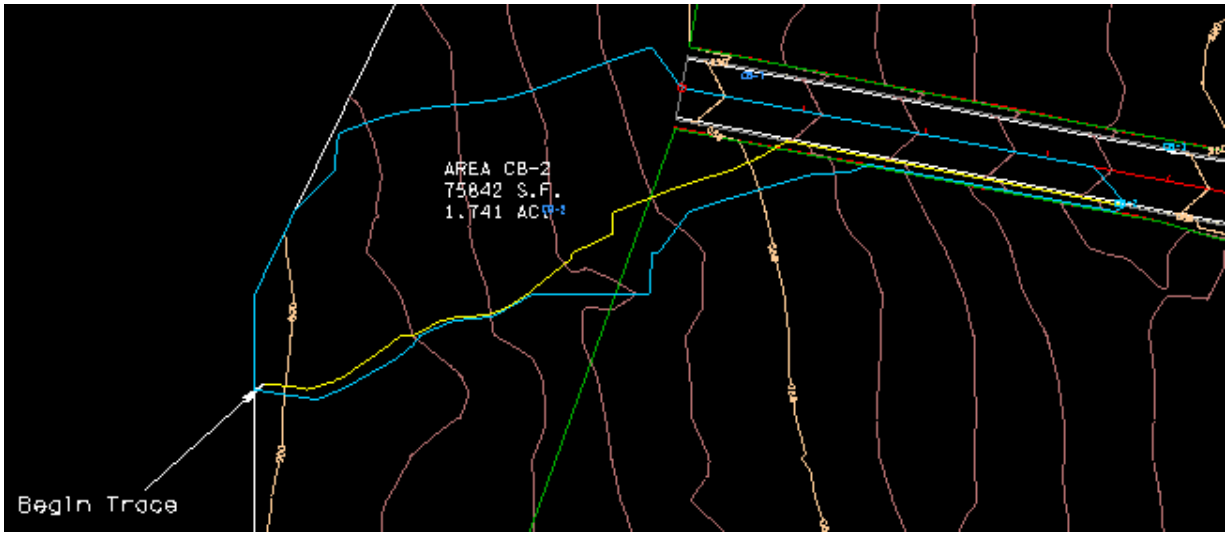
e) Click **Apply** to include this node in the Drainage Project.

5.4 Delineate Drainage Area CB – 2

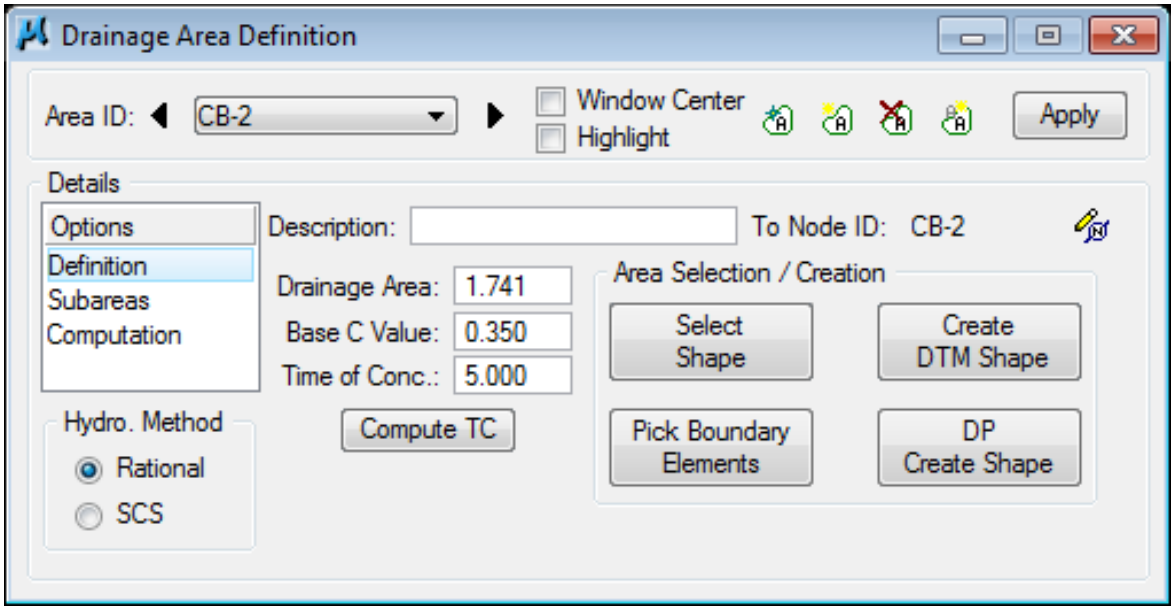
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-2** should automatically appear, click **OK**.

b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 2. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-2 and turn off DA_CB-1.

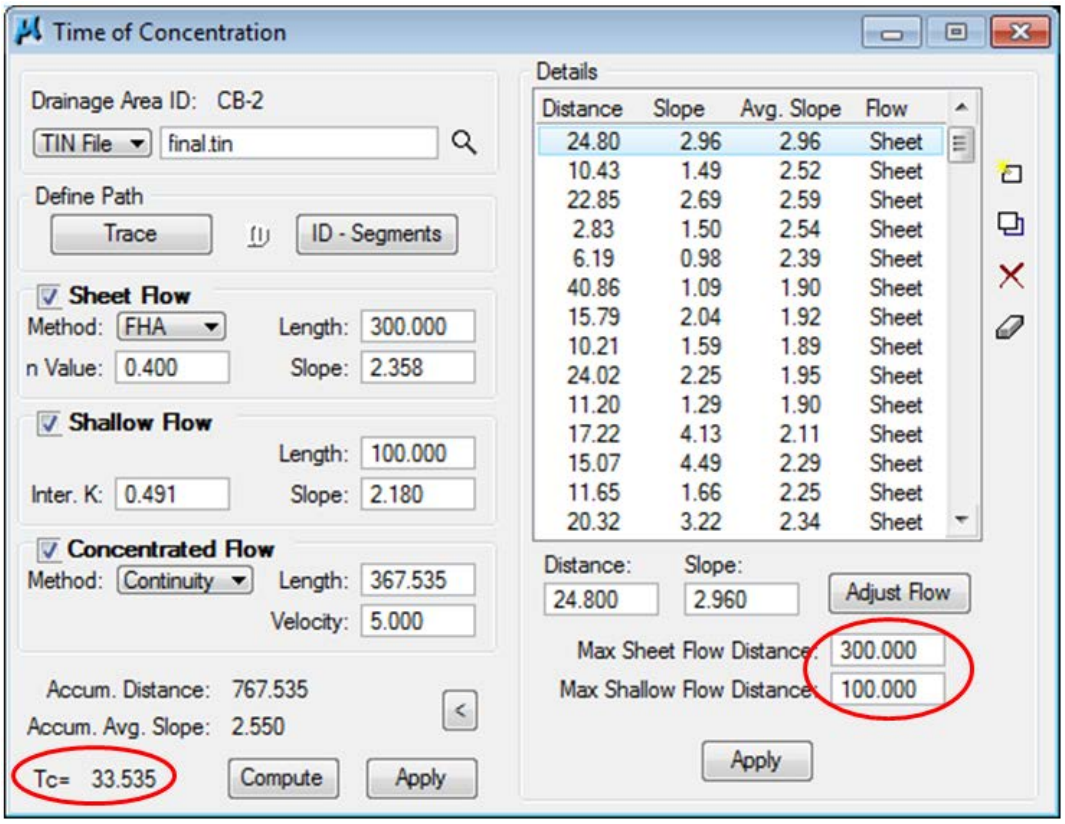
Delineate Drainage Area:



c) Define Drainage Area:



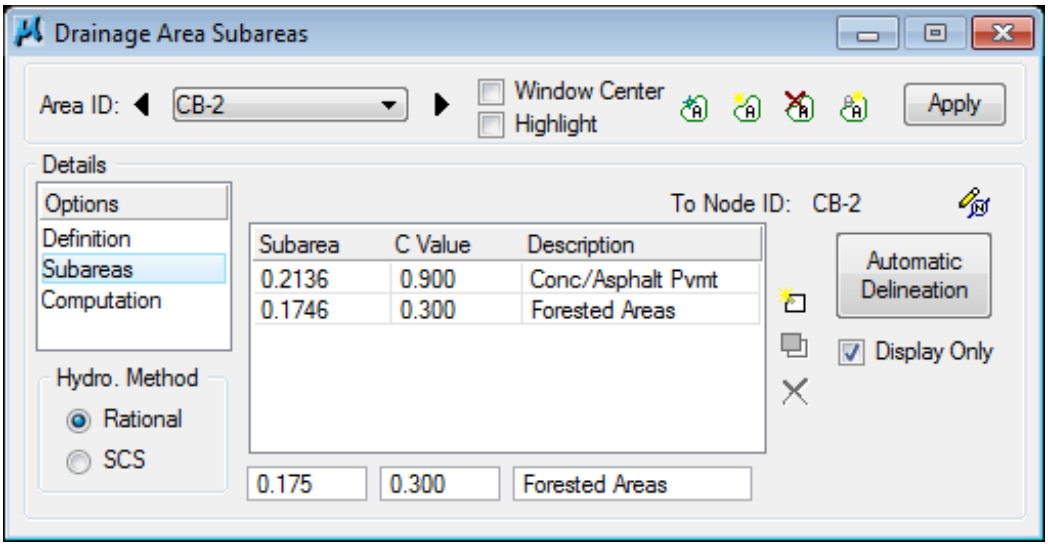
d) Calculate Time of Concentration:



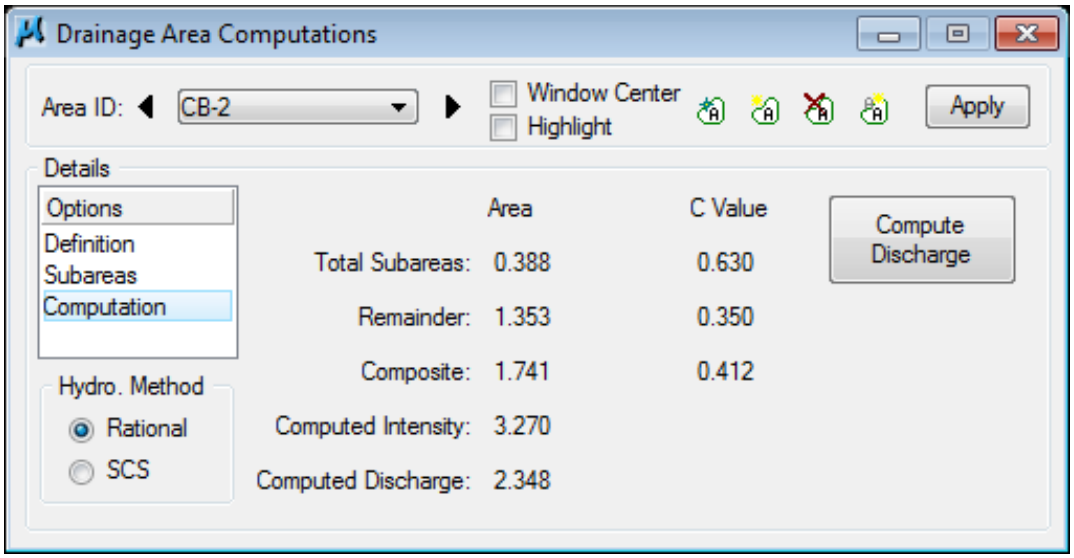
The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required.

Max. Sheet and Max. Shallow Flow Distance values should be the same.

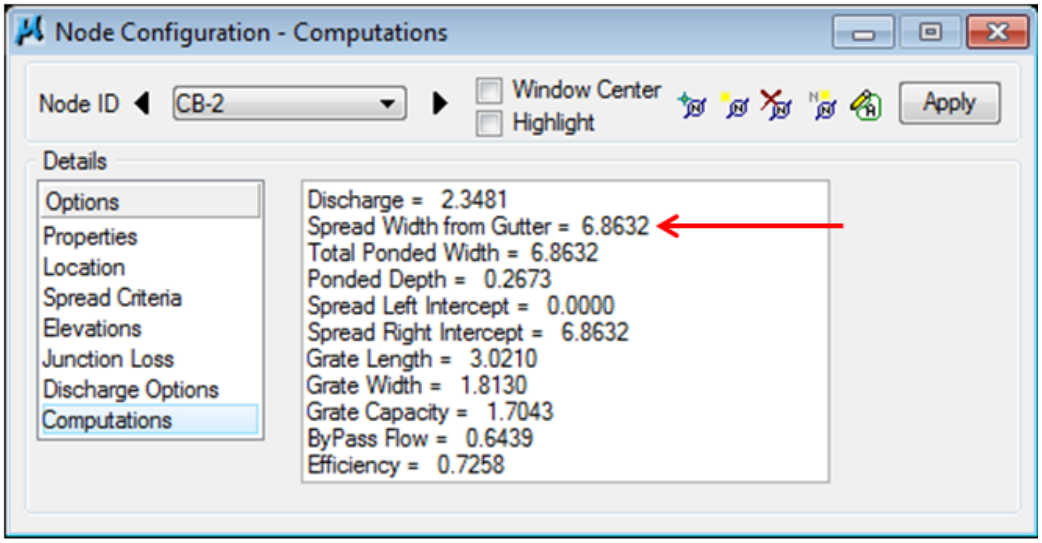
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if you results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

5.5 Design Inlet CB – 3

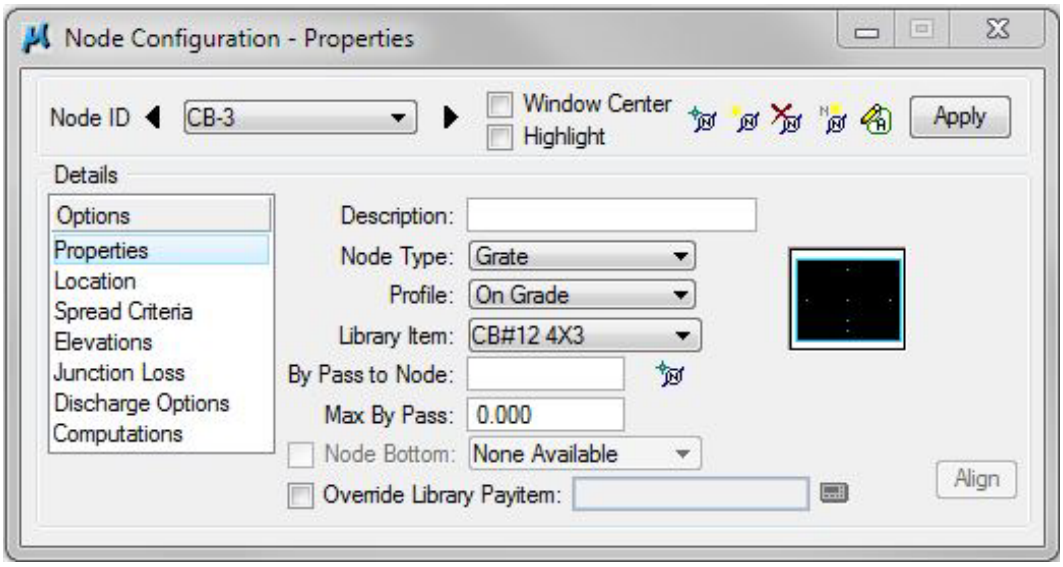
It has been determined that another standard **CB#12 4X3** will be used.

See Standard Drawing D-CB-12S for details.

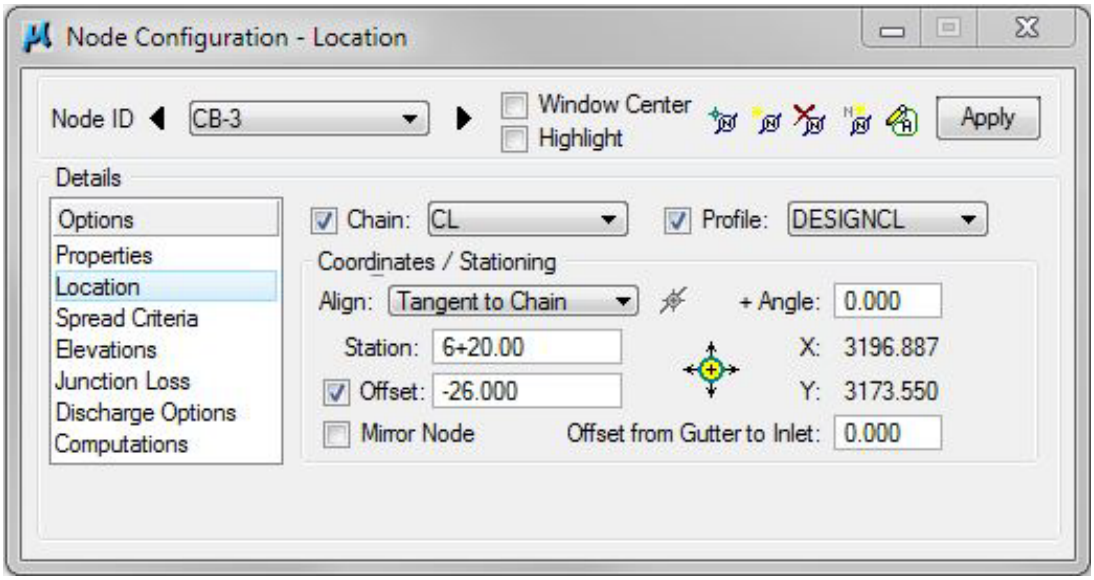
a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog.

Click **OK** to set the name CB-3

Properties > Verify the Node Properties are defaulted from the previous Node such that no user-input is required:



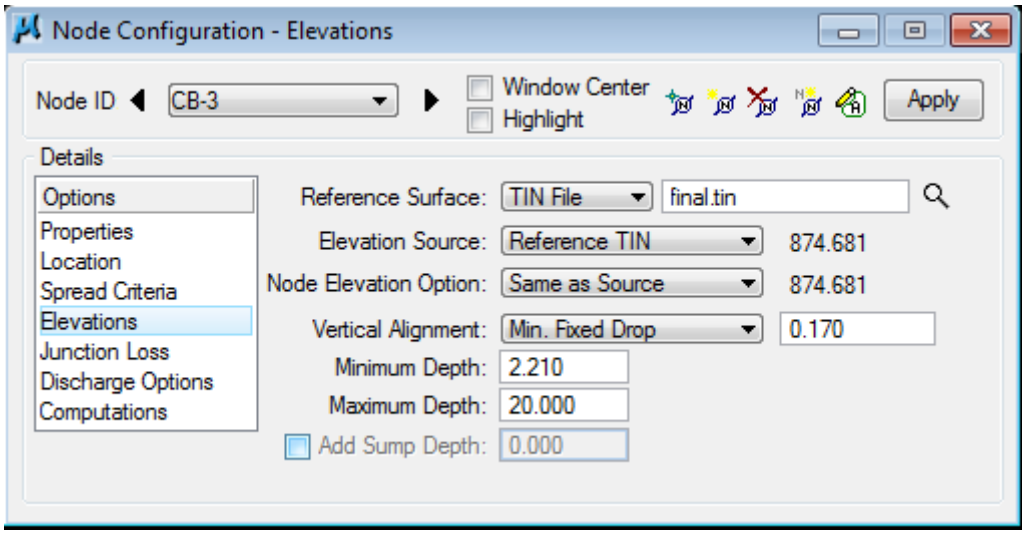
b) **Location >** All Reference information is defaulted from the previous Node (CB-2) such that only the **Angle**, **Station** and the **Offset** needs to be changed. After a few iterations it was determined that CB-3 should be placed at Station 6+20.00:



c) Elevation > Reset Minimum Depth for a node with both inlet and outlet pipes.

Minimum Depth: 2.23 FT

NOTE: SEE Appendix H – Storm sewer sketch, inlet and outlet on the right**.**



d) Click the **Apply** button to include this node in the Drainage Project.

Catch Basins – Inlet and Outlet:

Min. Depth of Basin – Pipe Size – Drop Across Bottom of Structure = Minimum Depth

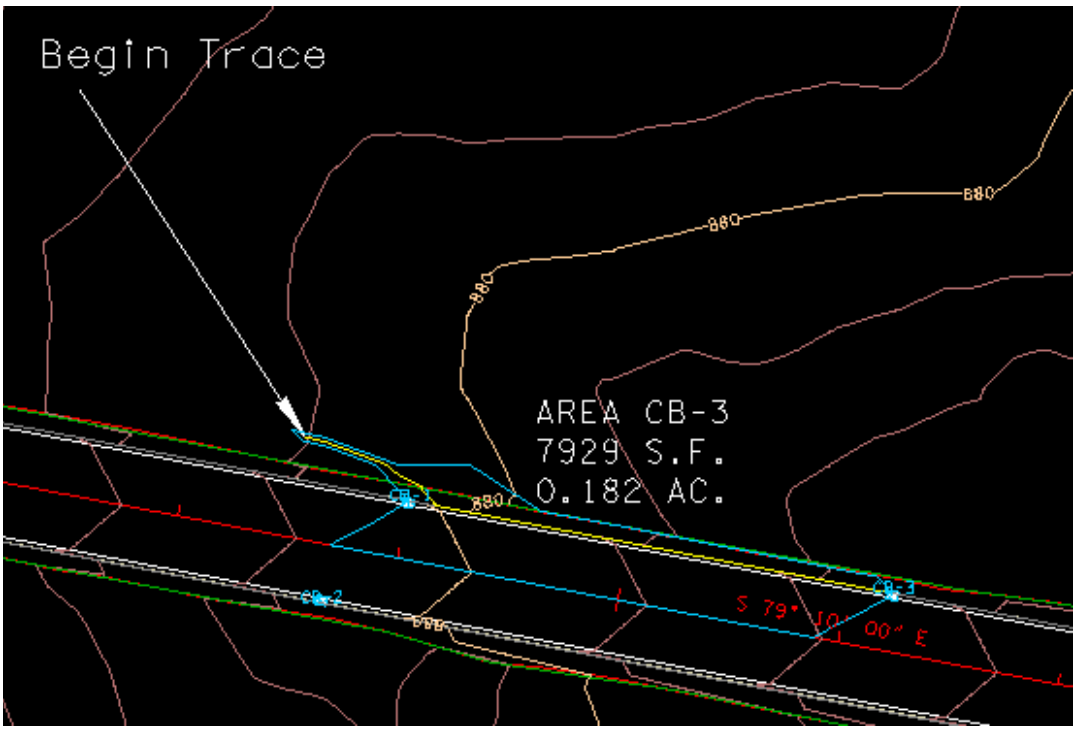
CB#12 4x3: 3.90’ - 18”/12 - .17’ = 2.23’

5.6 Delineate Drainage Area CB – 3

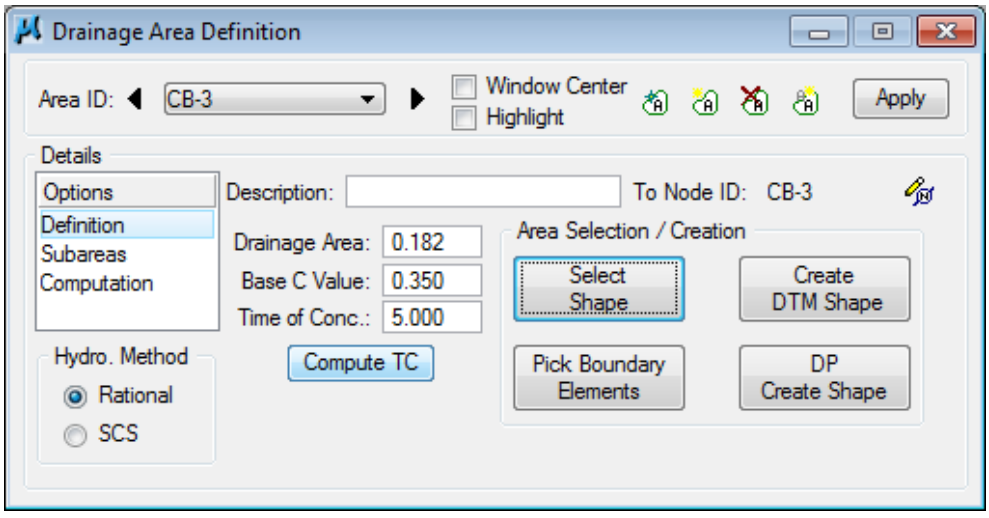
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-3** should automatically appear, click **OK**.

b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 3. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-3 and turn off DA_CB-2.

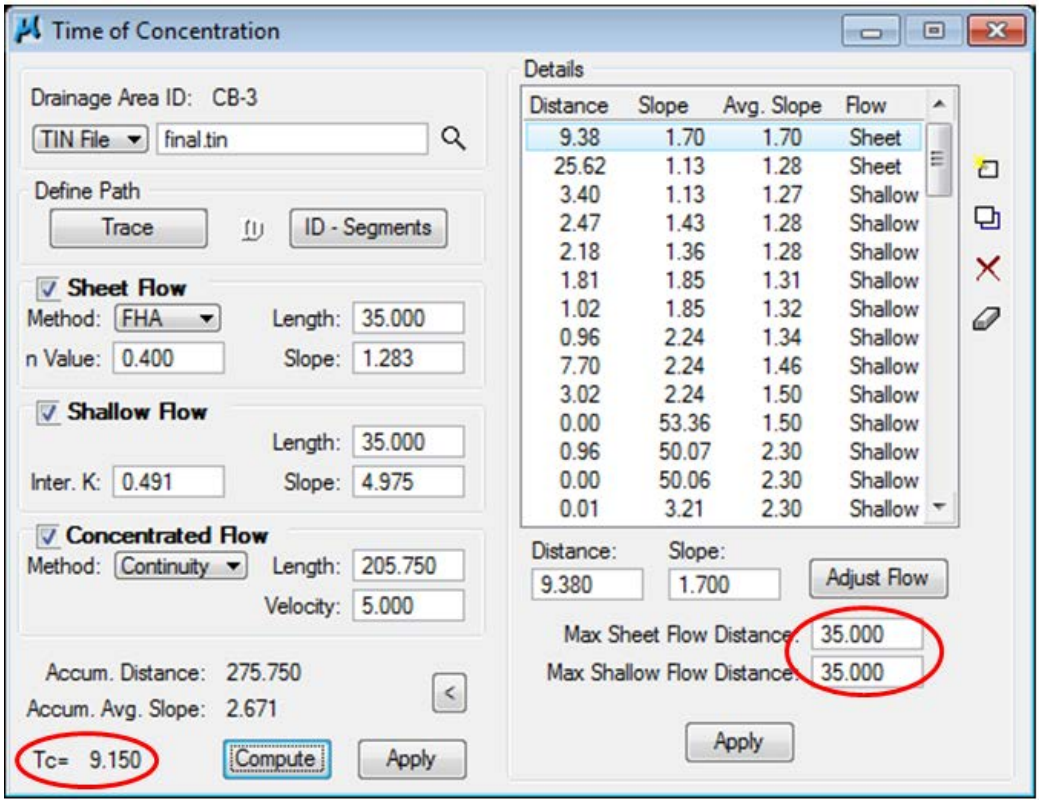
Delineate Drainage Area:



c) Define Drainage Area:



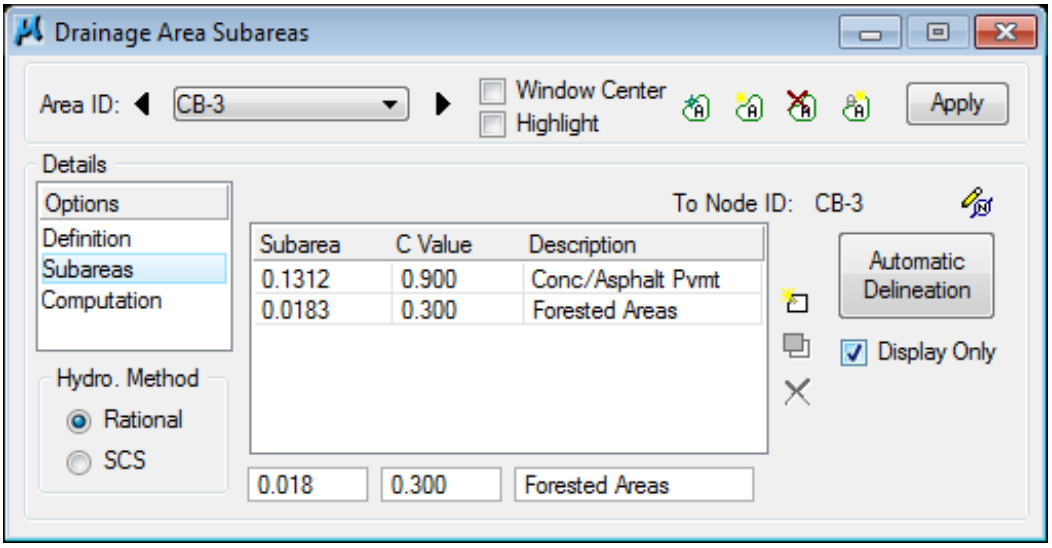
d) Calculate Time of Concentration:



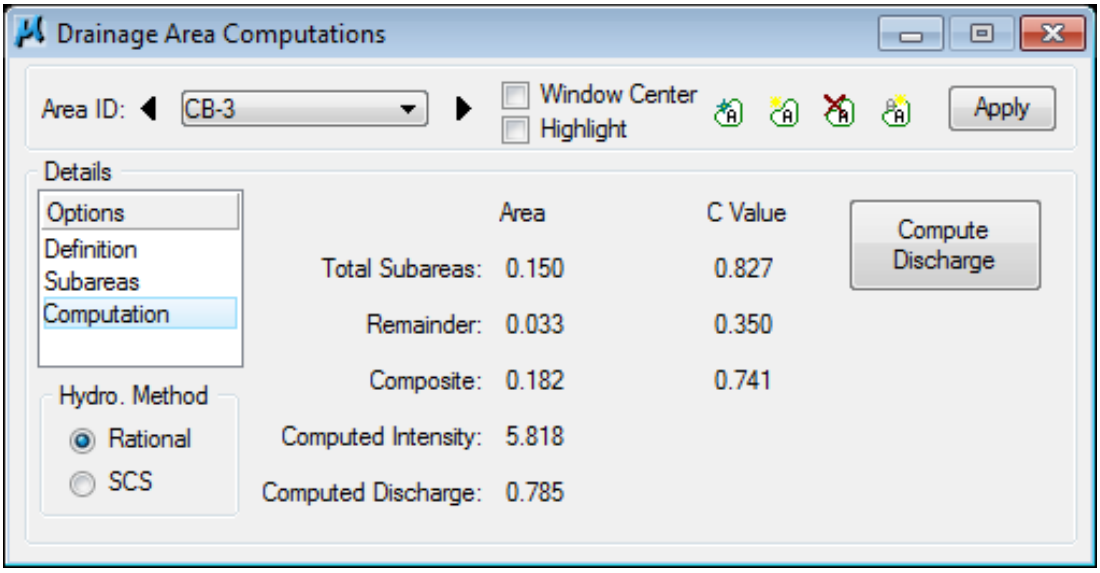
The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required.

The maximum length for sheet flow and shallow flow has changed and will vary depending upon the drainage area. For this area, set Max. Sheet Flow and Max. Shallow Flow to 35.

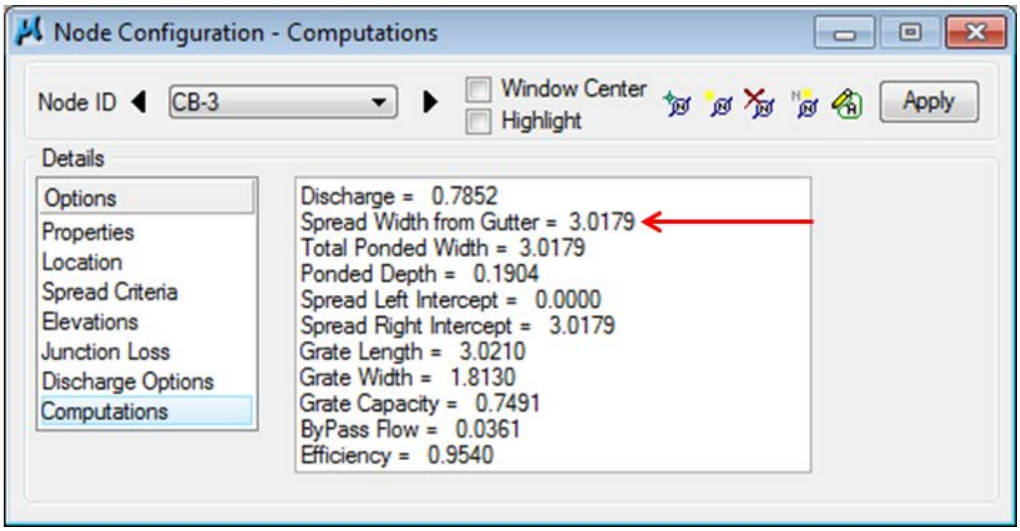
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

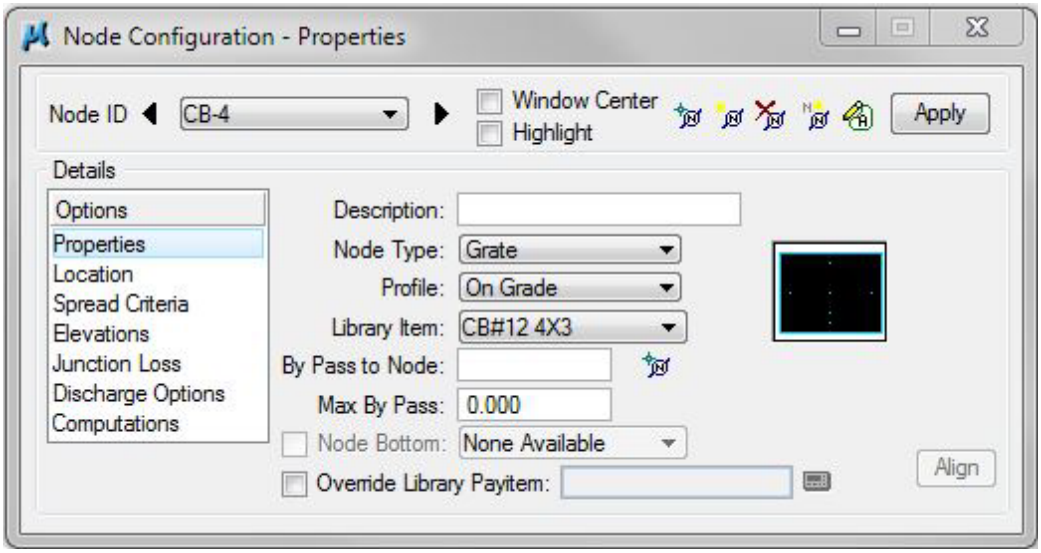
5.7 Design Inlet CB – 4

It has been determined that another standard **CB#12 4X3** will be used.

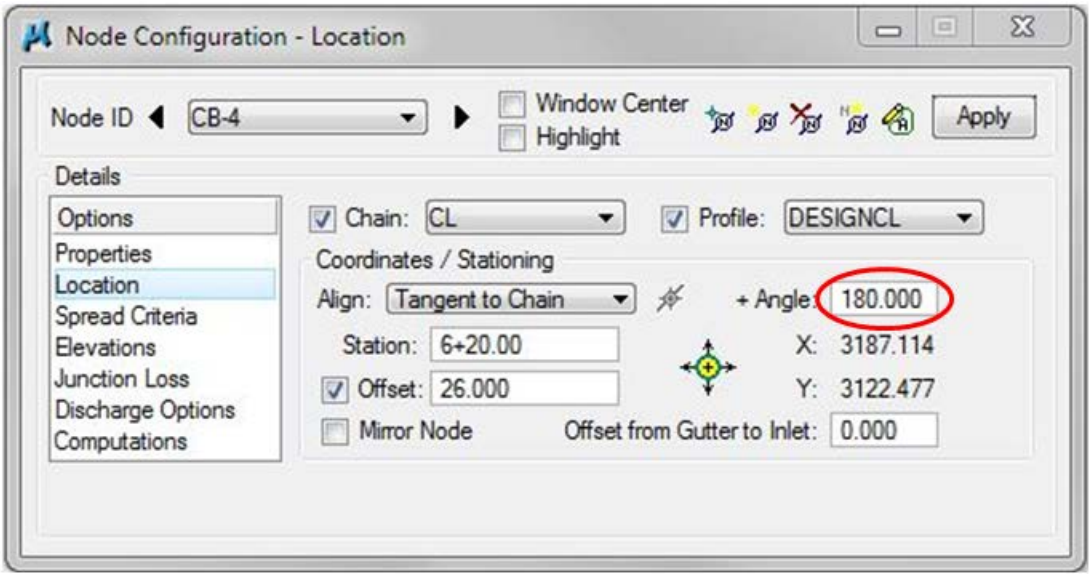
See Standard Drawing D-CB-12S for details.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-4.

Properties > Verify the Node Properties are defaulted from the previous Node such that no user-input is required:



b) **Location >** All Reference information is defaulted from the previous Node (CB-3) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. We will set this catch basin at the same Station as CB-3.:



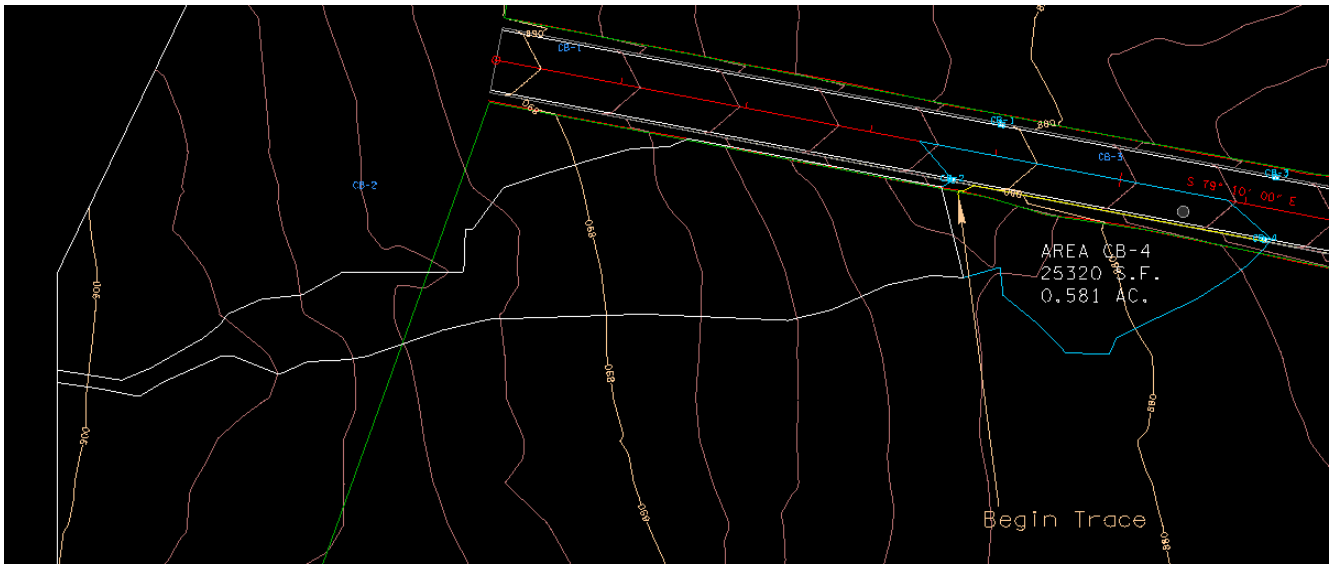
c) Click the **Apply** button to include this node in the Drainage Project.

5.8 Delineate Drainage Area CB – 4

a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-4** should automatically appear, click **OK**.

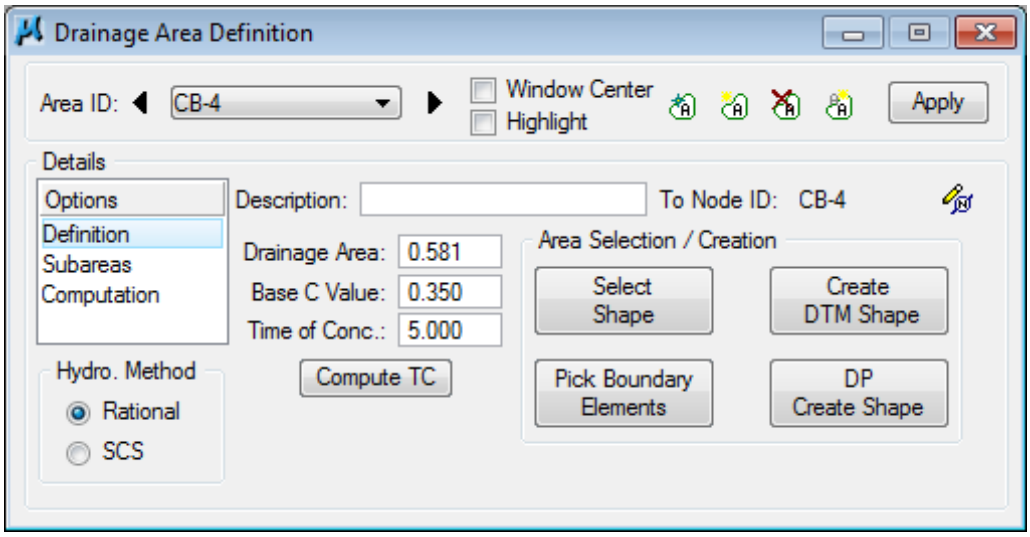
b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 4. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-4 and turn off DA_CB-3.

Delineate Drainage Area:

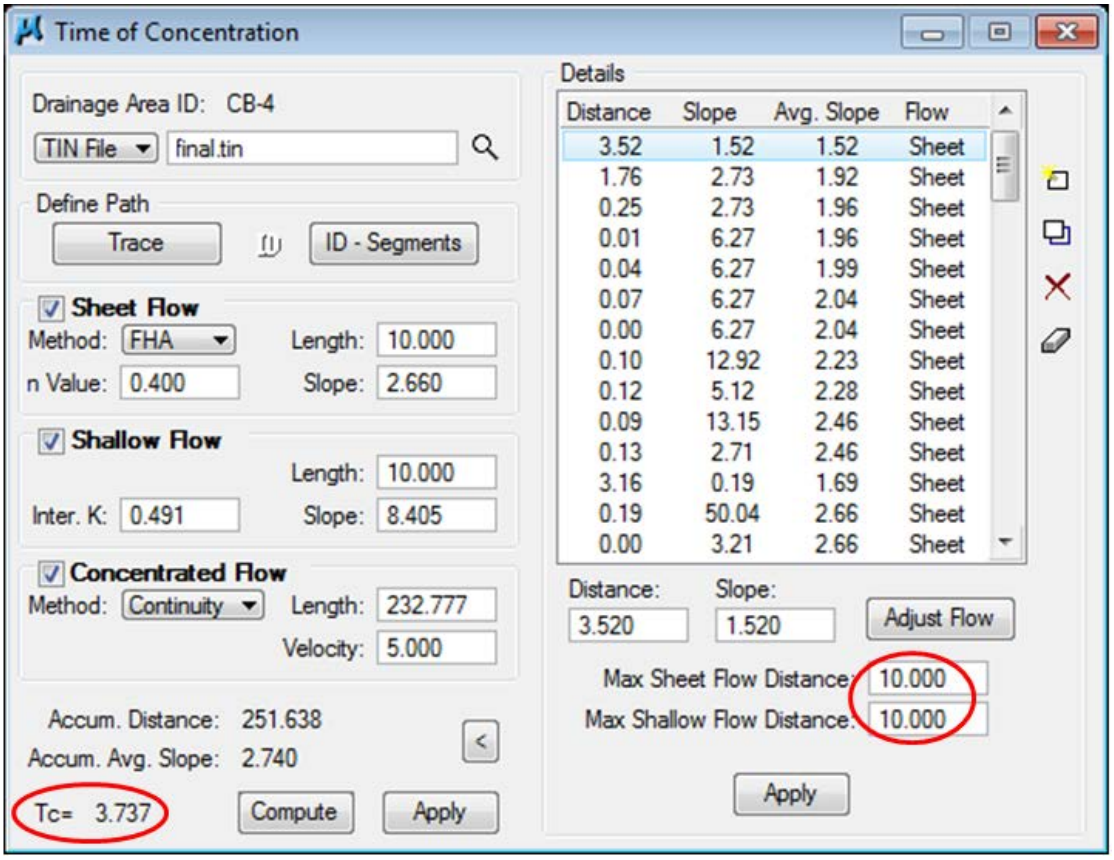


NOTE: After a first iteration the spread for the entire contributing drainage area was found to exceed the spread limit. After consideration it was determined an area drain could collect the water before it spills over the back of the curb. The white shape shows the drainage area to be captured by that area drain. (See next Exercise 5.9)

a) Define Drainage Area:



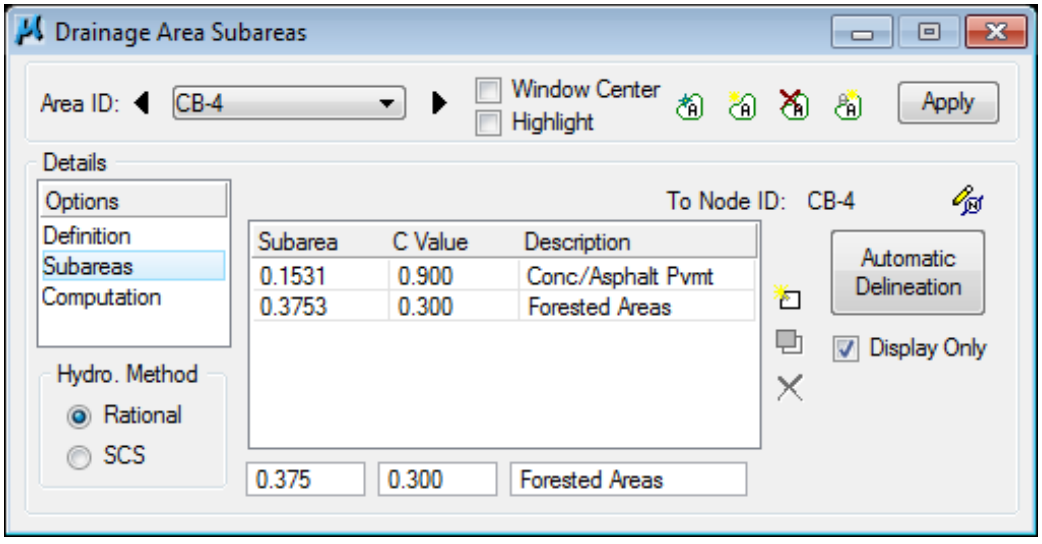
b) Calculate Time of Concentration:



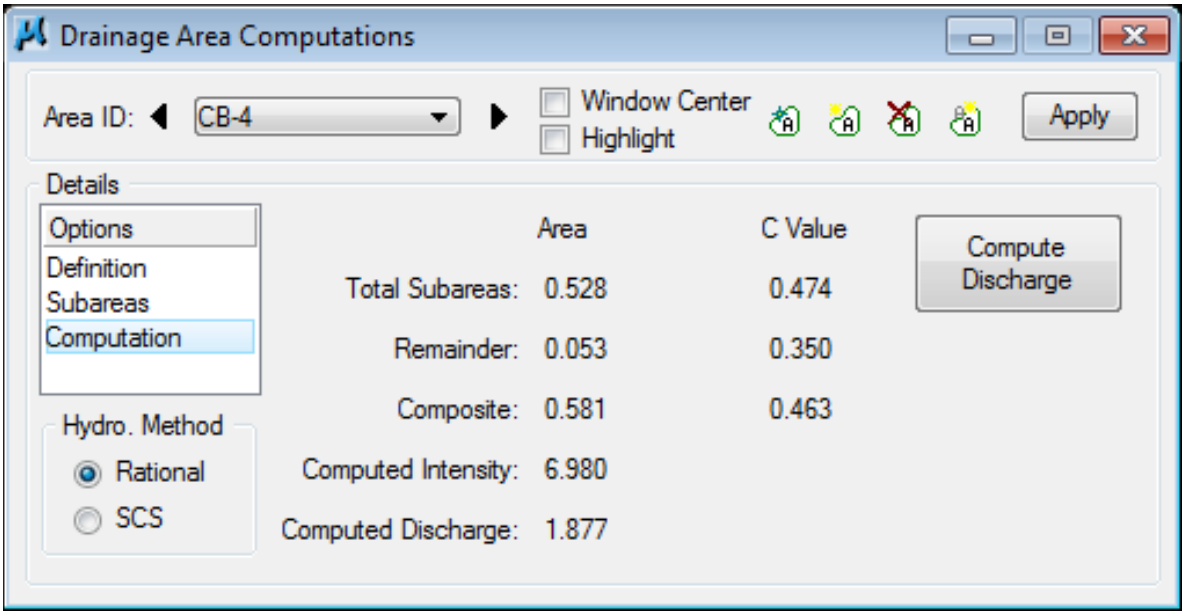
The calculated Time of Concentration is less than the minimum of 5 minutes, therefore 5 must be manually typed in the Drainage Area Definition dialog after hitting apply in the Time of Concentration Window.

The maximum length for sheet flow and shallow flow has changed and will vary depending upon the drainage area. For this area, set Max. Sheet Flow and Max. Shallow Flow to 10.

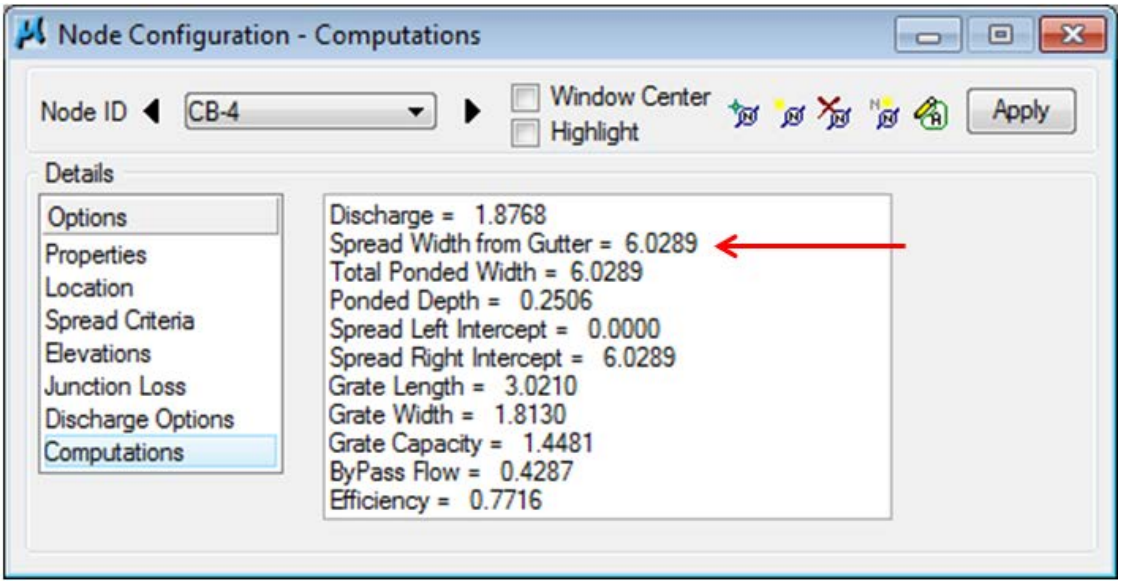
c) Delineate Subareas utilizing the Land Use DGN:



d) Compute Discharge and Apply:



e) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

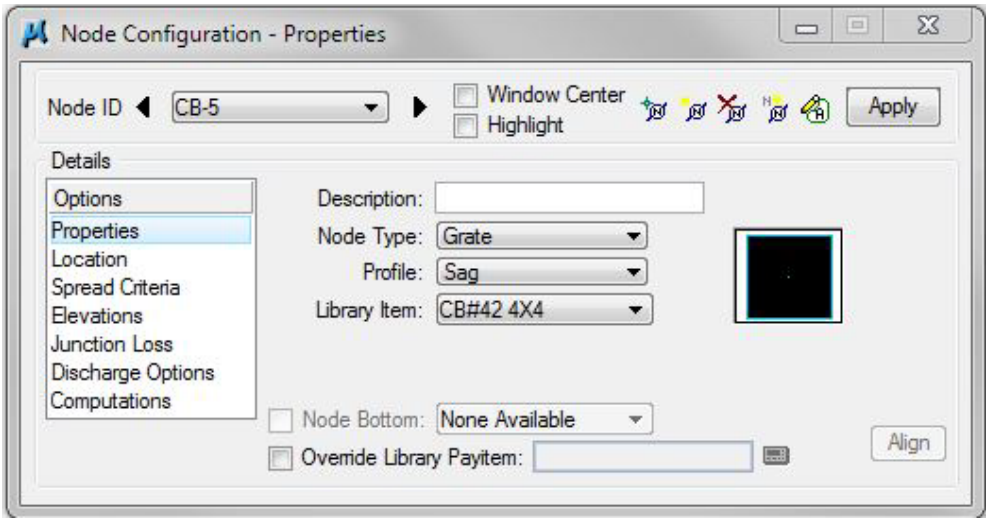
5.9 Design Inlet CB – 5

a) After a first iteration, it has been determined that an area drain needs to be installed behind the curb at **Station 3+70.00, Offset 35.00' RT** in order to catch flow that would otherwise enter the roadway and cause the roadway spread to exceed the allowable limit.

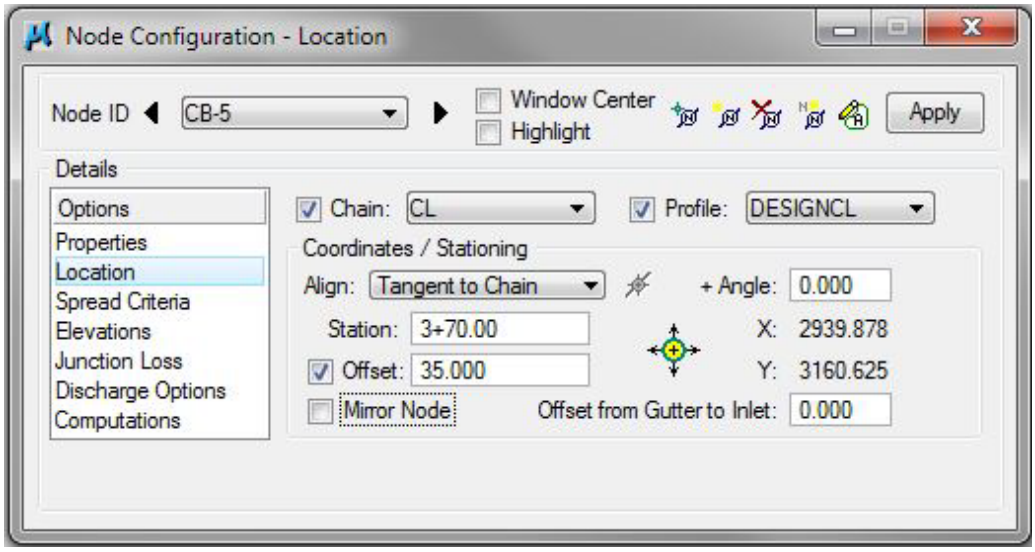
One way to determine the appropriate catch basin to be used is to review TDOT Drainage Manual Chapter 7 Table 7-3 *Standard Inlet Types and Applications.*

It has been determined that a **CB#42 4X4** will be used. See Standard Drawing D-CB-42SB for details.

b) **Properties >** Change **Profile** to **Sag** and change **Library Item** to **CB#42 4X4**:



c) **Location >** All Reference information is defaulted from the previous Node such that only the **+Angle**, **Station** and the **Offset** needs to be changed:



NOTE: Since CB-5 is an area drain, it does not matter if the angle is 0 or 180, even though it is on the right side of the roadway.

d) Spread Criteria > For an inlet in a sag, we must specify certain spread criteria for each side of an inlet.

% Slope Left: 1.00 % (From DTM Tools>Analysis>Height/Slope)

% Slope Right: 1.50 % (From DTM Tools>Analysis>Height/Slope)

% Discharge Left: 98.00% (Estimated based on placement within drainage area)

% Discharge Right: 2.00% (Leftover area)

NOTE: Left and Right should be defined based on an inlet at angle = 0.

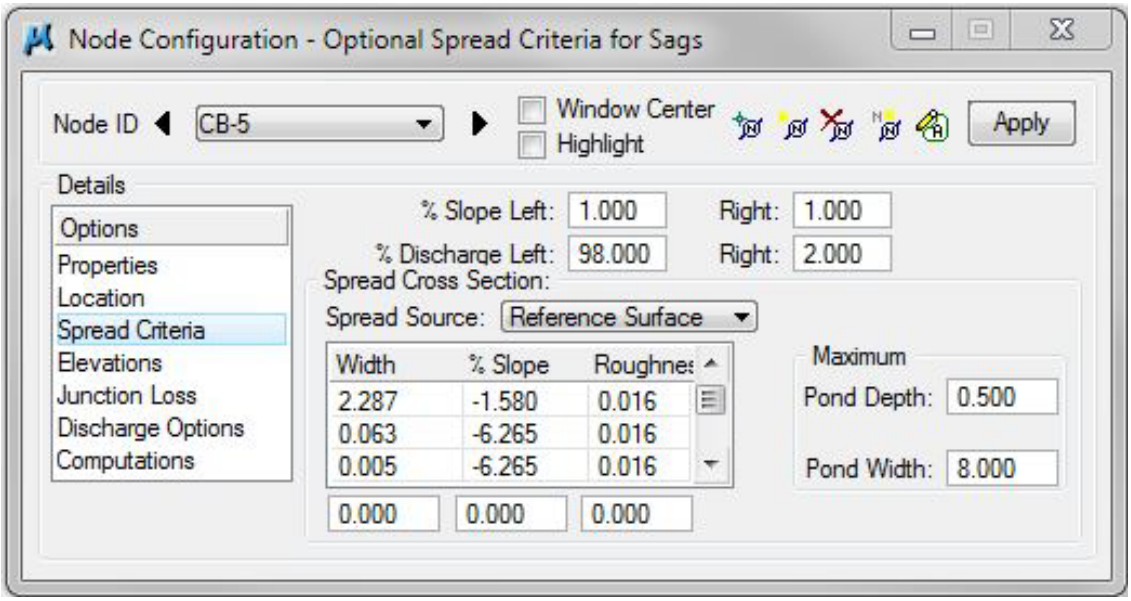
In other words:

Left of inlet is Viewed Left for all inlets at angles <90 and >270.

Right of inlet is Viewed Right for all inlets at angles <90 and >270.

Left of inlet is Viewed Right for all inlets at angles >90 and <270.

Right of inlet is Viewed Left for all inlets at angels >90 and <270.

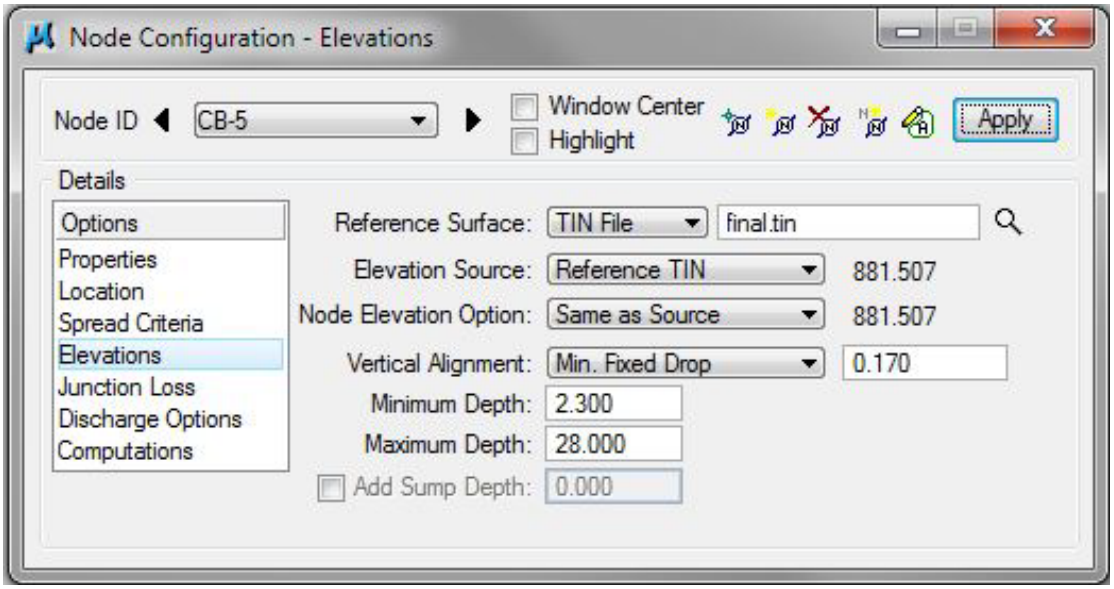


e) Elevations > Elevation Data must be changed to match a CB#42. From the TDOT GEOPAK Drainage Nodes Document set the following:

Vertical Alignment: Min. Fixed Drop, 0.17

Minimum Depth: 2.32 feet (See note at top of page 5-6)

Maximum Depth: 28.00 feet



f) Click the **Apply** button to include this node in the Drainage Project.

Catch Basins – Outlet Only:

Drop Across Bottom of Structure + Min. Depth of Cover = Minimum Depth

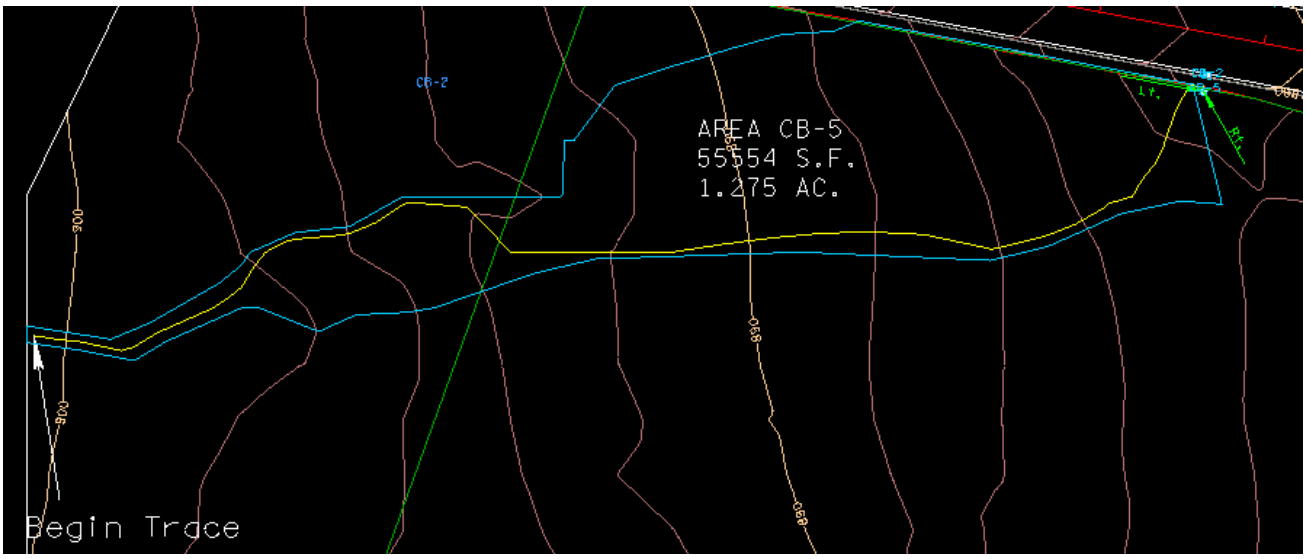
CB#42 4x4: 0.17’ + 2.15’ = 2.32’

5.10 Delineate Drainage Area CB – 5

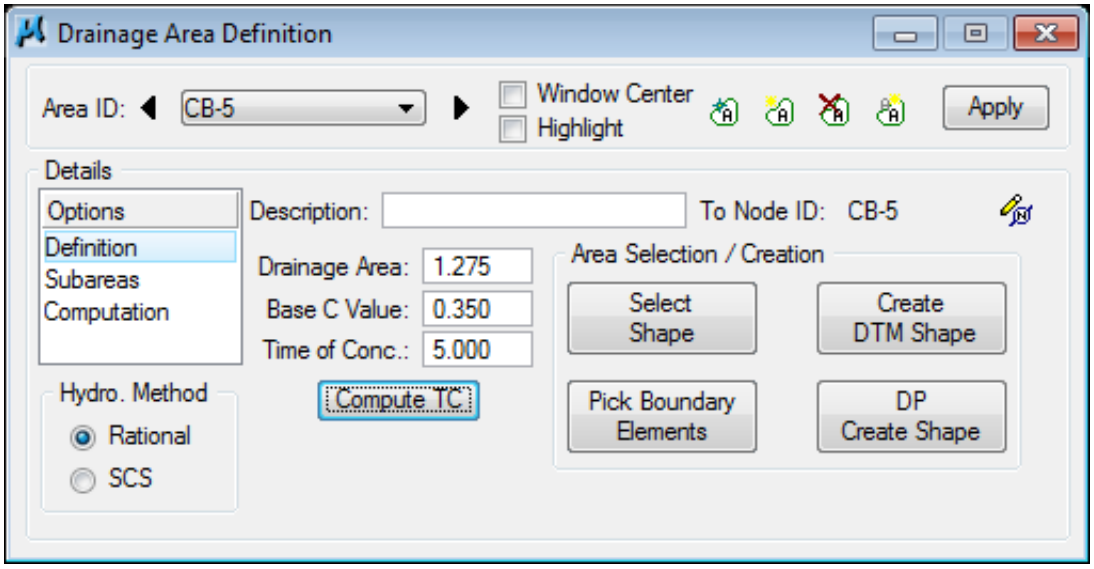
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-5** should automatically appear, click **OK**.

b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 5. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-5 and turn off DA_CB-4.

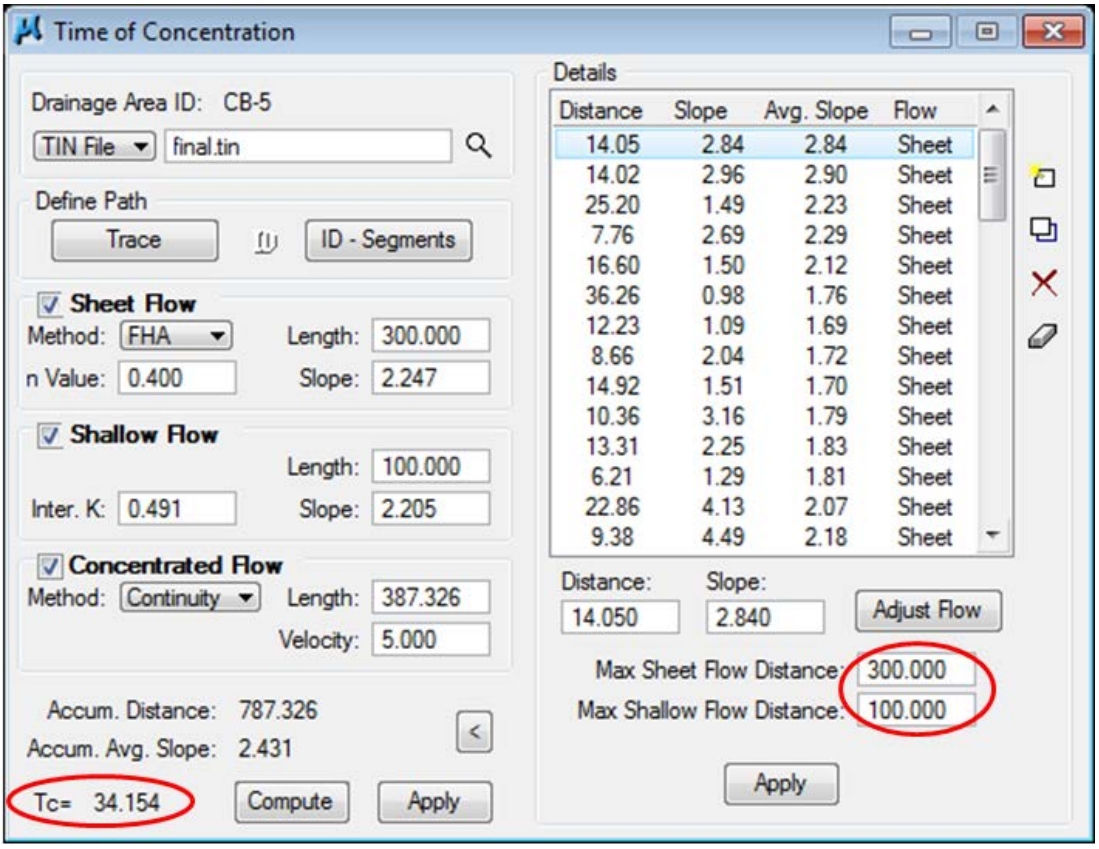
Delineate Drainage Area:



c) Define Drainage Area:



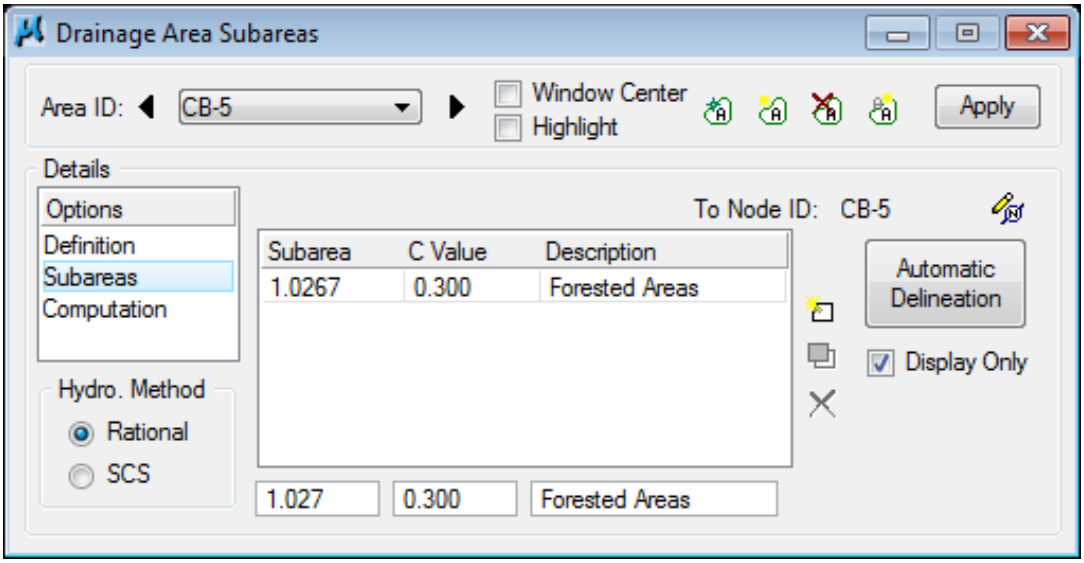
d) Calculate Time of Concentration:



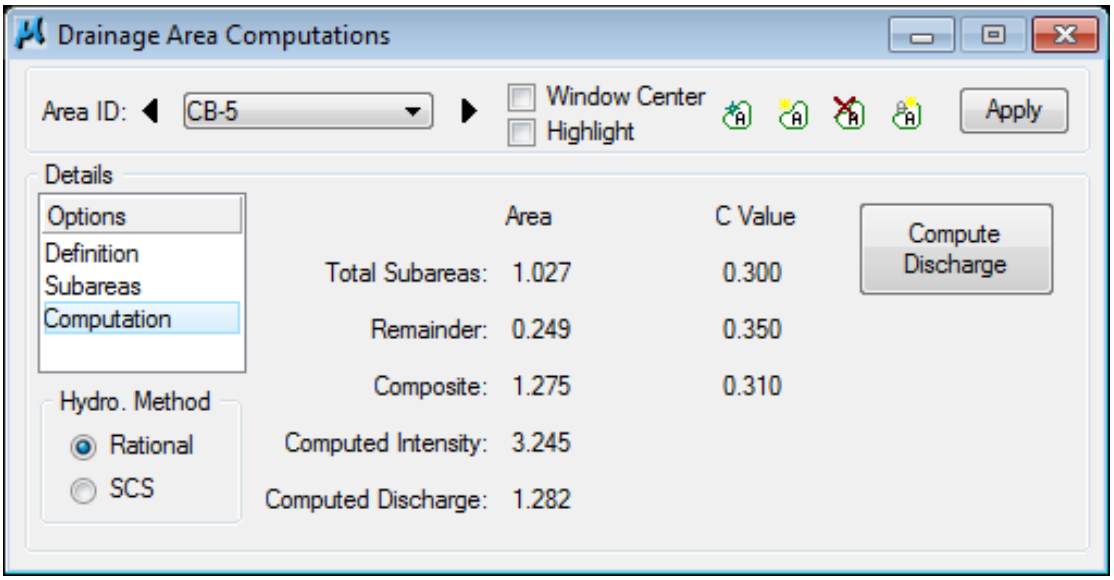
The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required.

The maximum length for sheet flow and shallow flow has changed and will vary depending upon the drainage area. For this area, set Max. Sheet Flow to 300 and Max. Shallow Flow to 100.

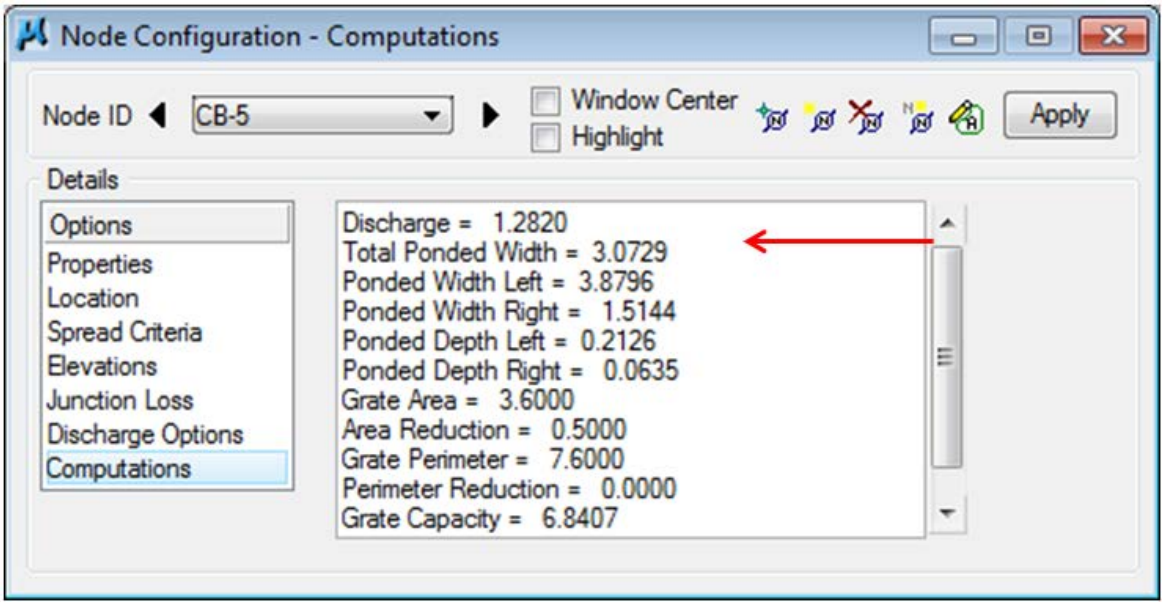
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



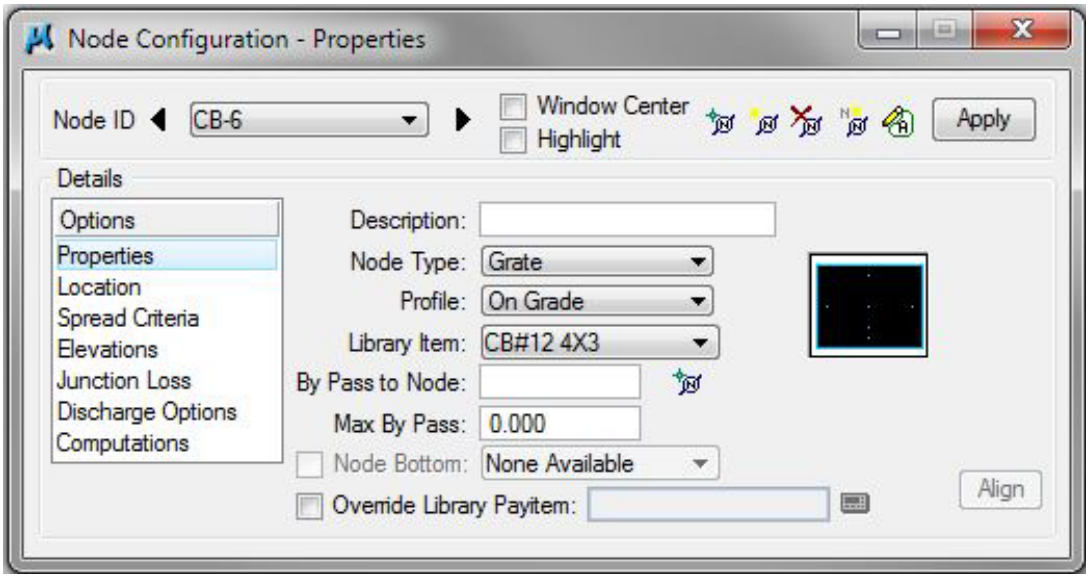
Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

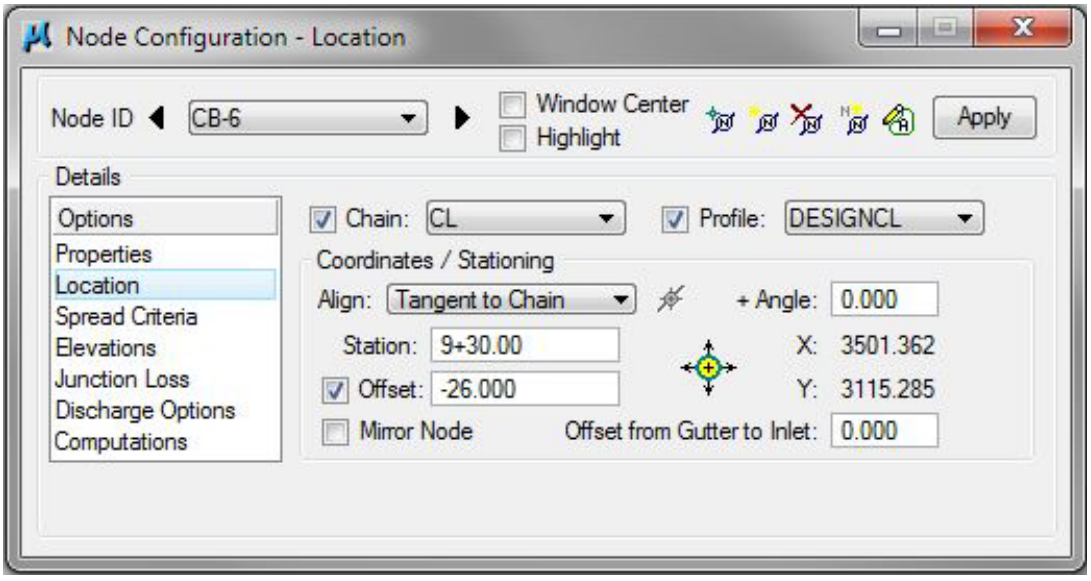
5.11 Design Inlet CB – 6

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-6

Properties > Change the Node **Properties** back to **On Grade** and to a **CB#12 4X3:**

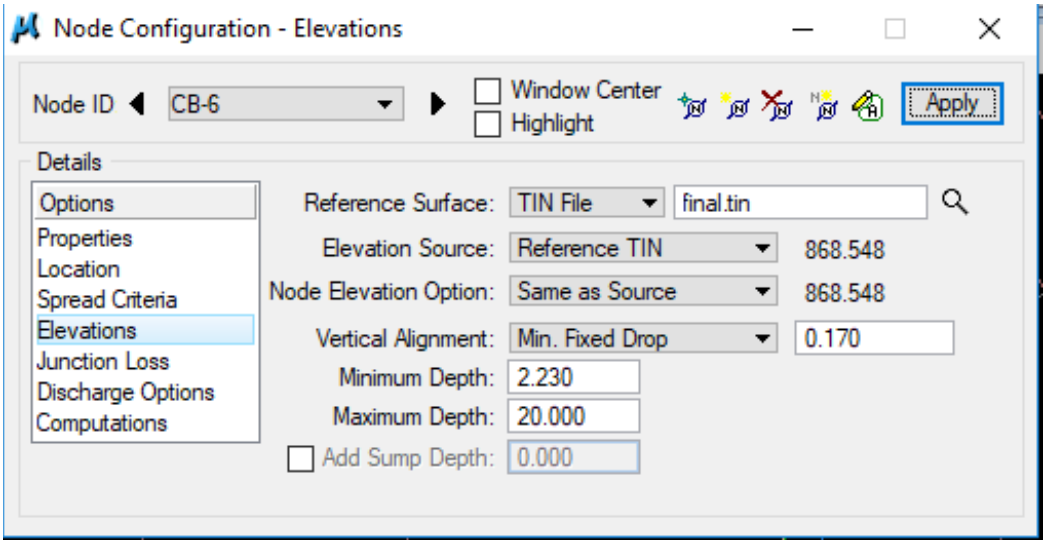


b) **Location >** All Reference information is defaulted from the previous Node (CB-5) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. Discussion for the reason this station was chosen is presented in Step 2 of 5.11.:



NOTE: The **Spread Criteria** defaults back automatically when the node is changed back to **ON GRADE**, therefore no changes are necessary.

c) Elevations > Be sure to change the elevation data back to that which is required for a Type 12 catch basin.



d) Click the **Apply** button to include this node in the Drainage Project.

Catch Basins – Inlet and Outlet:

Min. Depth of Basin – Pipe Size – Drop Across Bottom of Structure = Minimum Depth

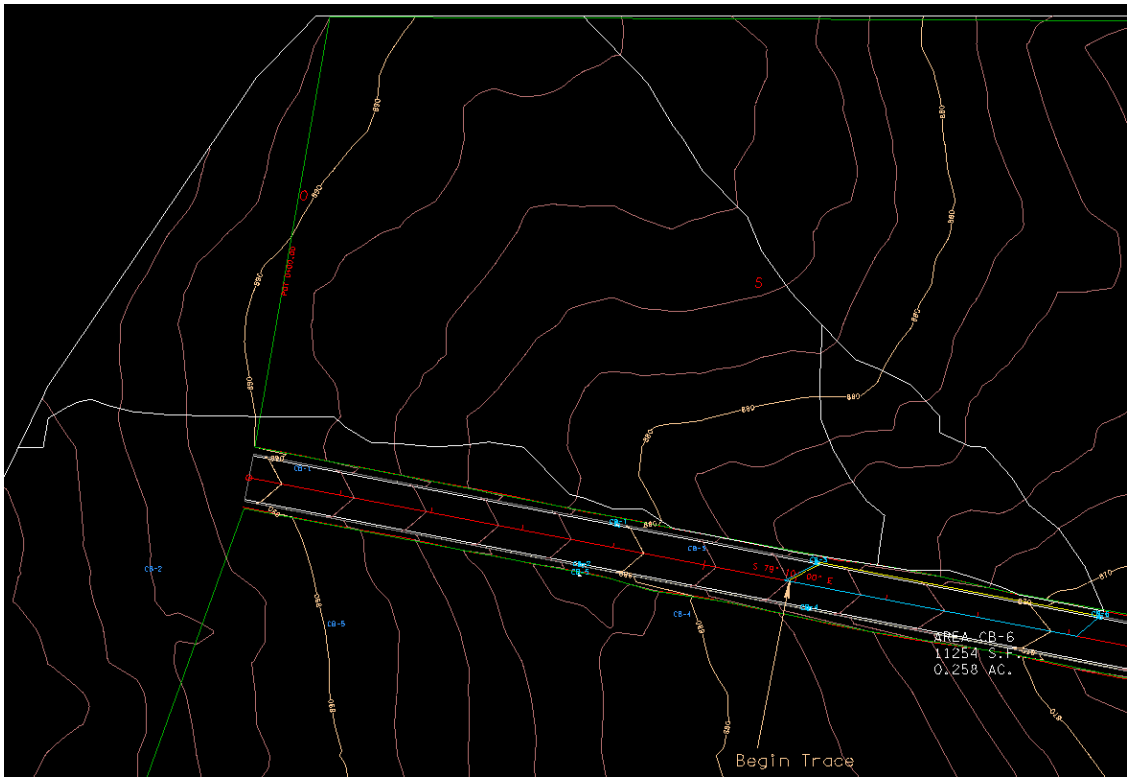
CB#12 4x3: 3.90’ - 18”/12 - .17’ = 2.23’

5.12 Delineate Drainage Area CB – 6

a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-6** should automatically appear, click **OK**.

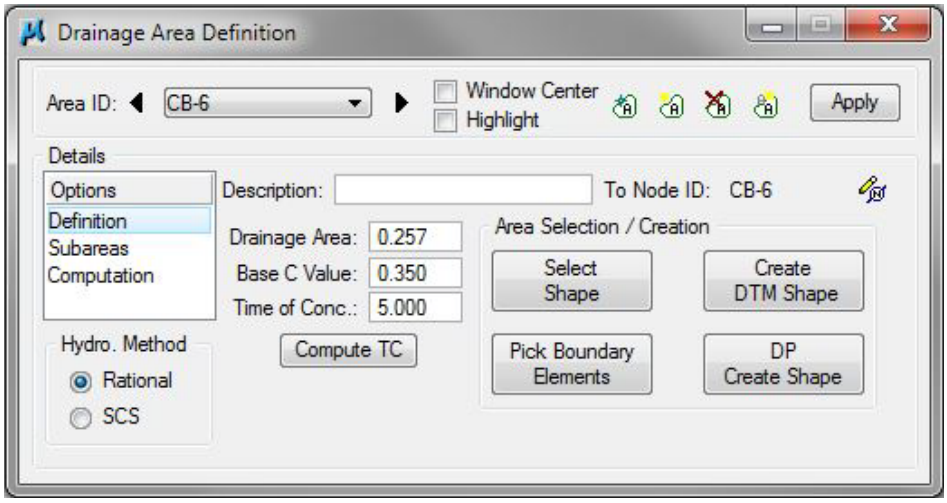
b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 6. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-6 and turn off DA_CB-5.

Delineate Drainage Area:

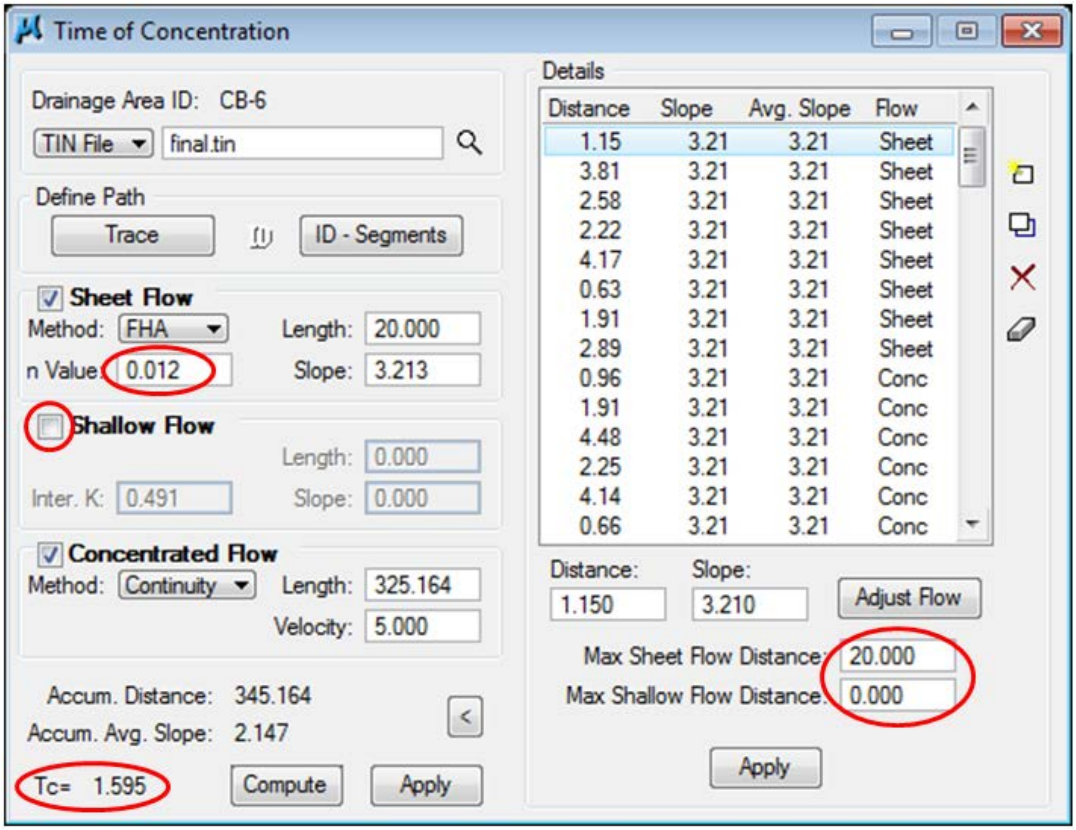


NOTE: Upon inspection of the entire drainage area, it has been determined that area drains need to be installed to collect runoff before it enters the roadway. The white area shapes show the area to be collected by these drains which will be input in subsequent exercises.

c) Define Drainage Area:



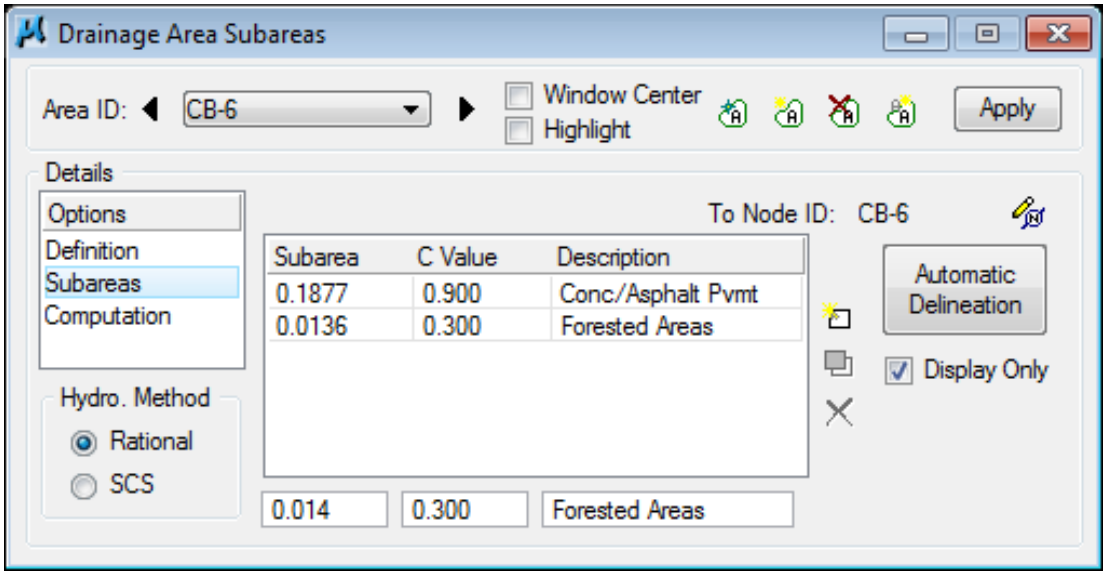
d) Calculate Time of Concentration:



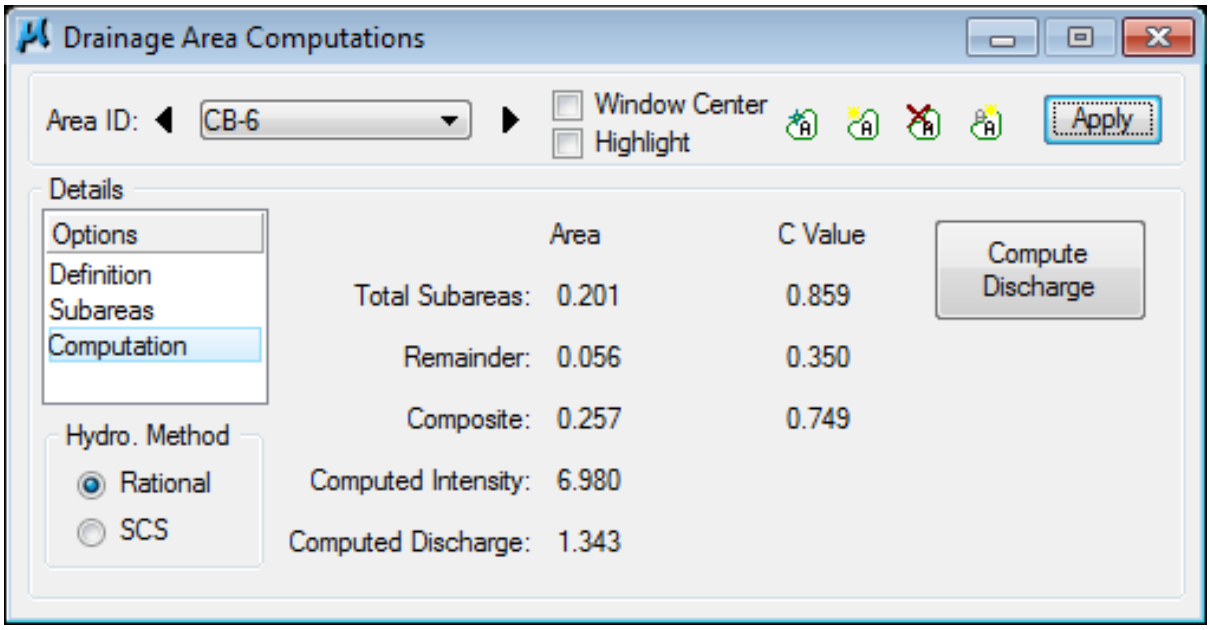
The calculated Time of Concentration is less than the minimum of 5 minutes, therefore **5 must be manually typed** in the Drainage Area Definition dialog after hitting apply in the Time of Concentration Window.

Since the flow appears to go directly from sheet to concentrated flow we unchecked shallow flow. For this area, set Max Sheet Flow to 20. Also note that the n Value changes to 0.012 (Asphalt).

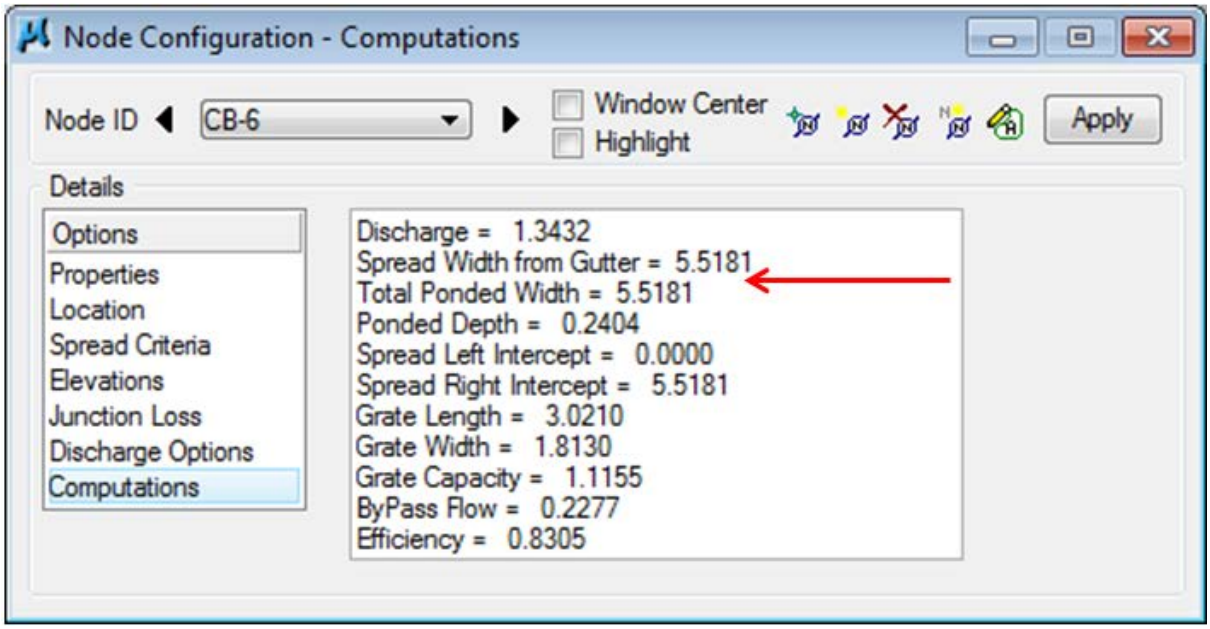
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

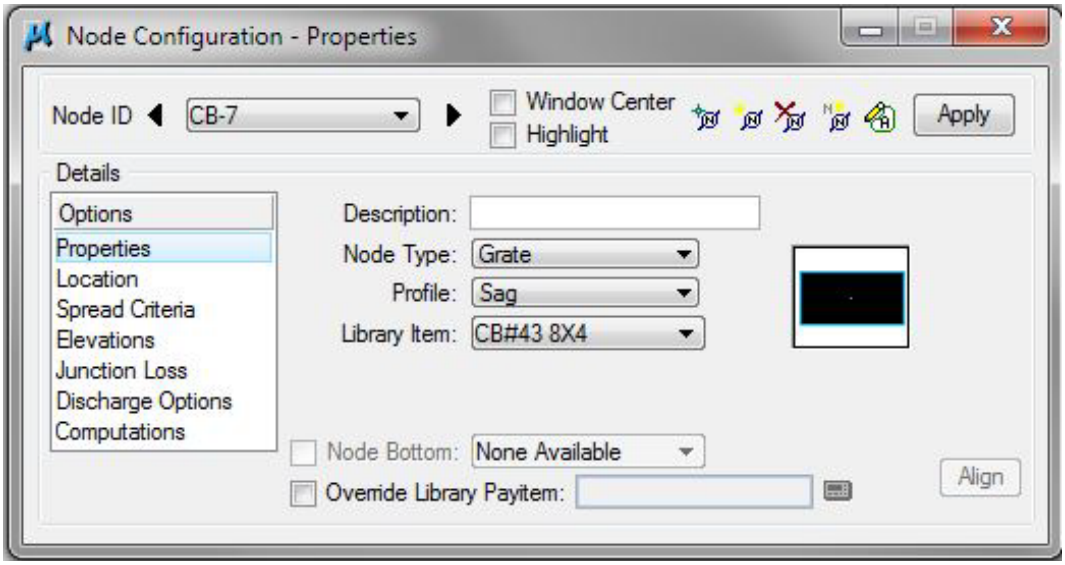
5.13 Design Inlet CB – 7

It has been determined that a **CB#43 8X4** will be used.

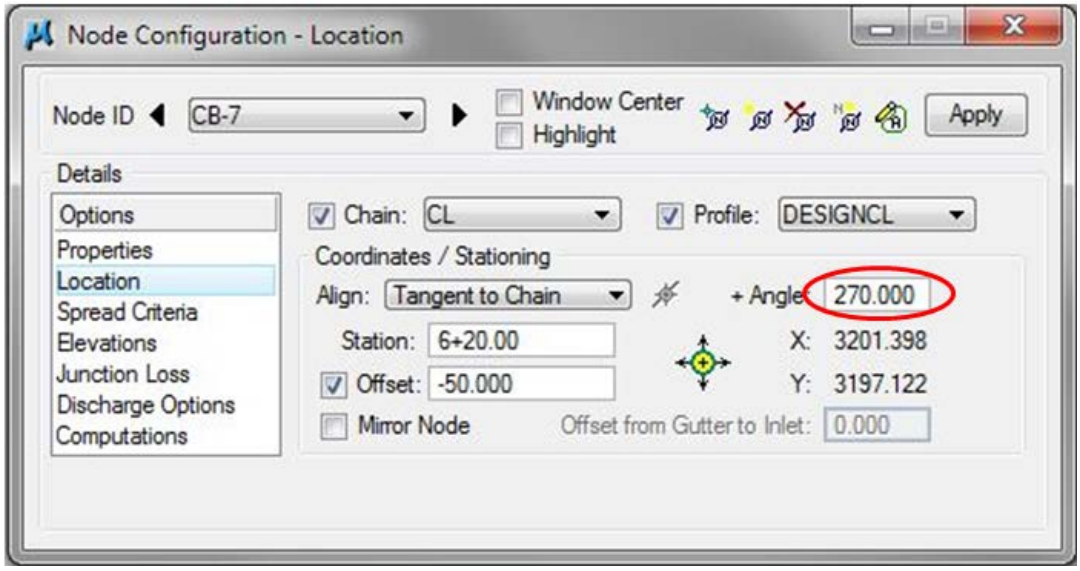
See Standard Drawing D-CB-43SB for details.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-7

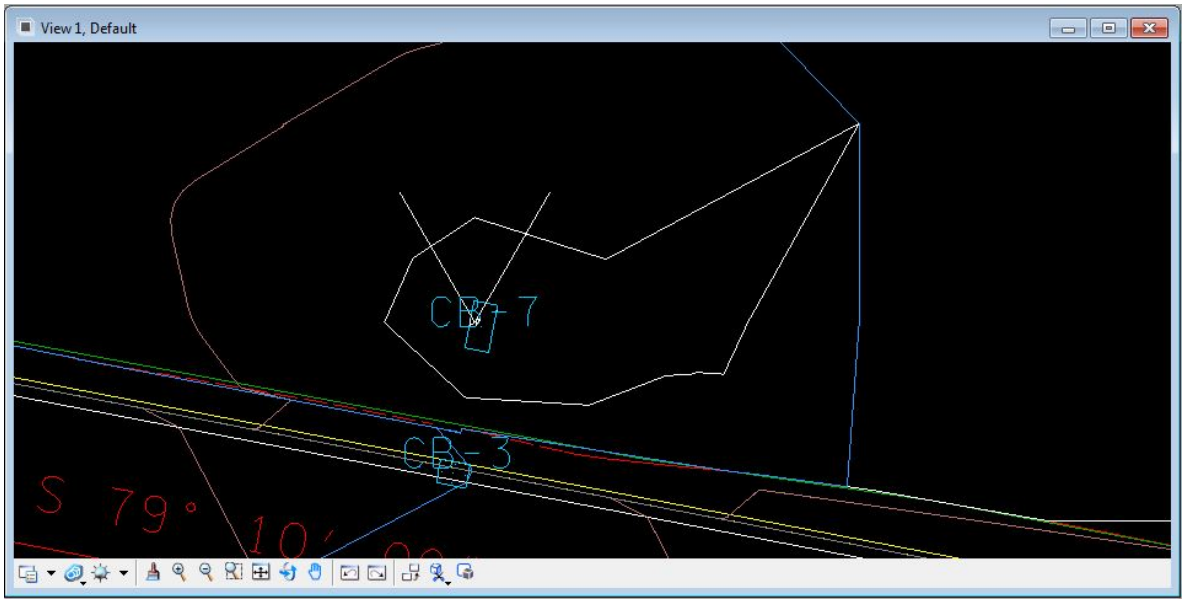
Properties > Change the Node **Properties** to **Sag** and to a **CB#43 8X4** (a type #43 catch basin was chosen due to the fact that this will collect a significant amount of water not on the roadway):



b) **Location >** All Reference information is defaulted from the previous Node (CB-6) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. Pay special attention to the placement and rotation of this catch basin. It has been rotated to intercept as much runoff as possible:



NOTE: The following image shows why this location was chosen for CB-7. Upon inspection of the TIN File, utilizing the DTM Drainage Tools discussed in Chapter 3, a ponded area was discovered at this location. CB-7 was set at the low point of the ponded area. To simplify the design and minimize land disturbance, CB-3 and CB-4 were set at the same station. **The iterative steps required for this determination were not shown in this manual, but would be required in an actual design project.**



c) Spread Criteria > Enter the Spread Criteria as shown below.

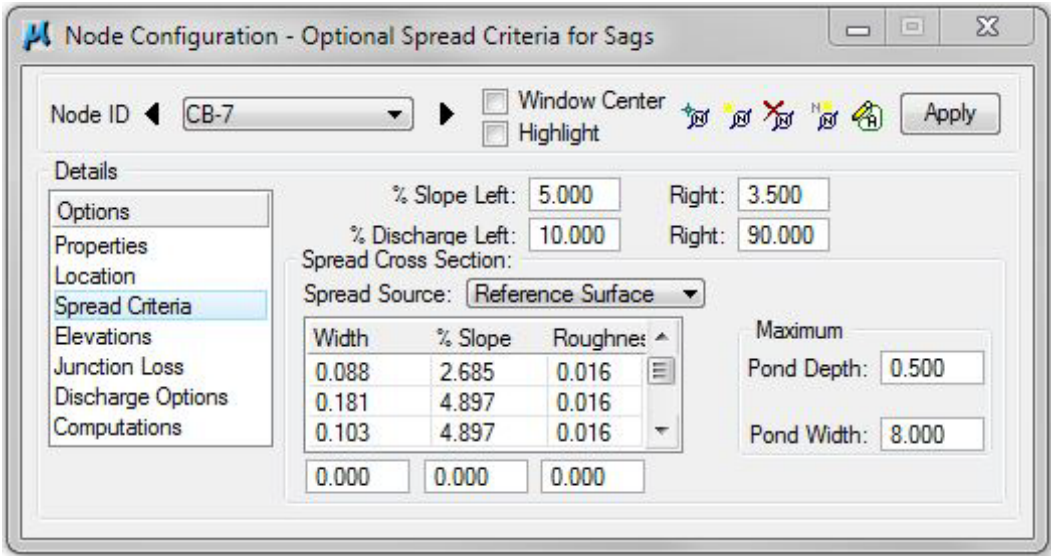
% Slope Left: 5.00 % (From DTM Tools>Analysis>Height/Slope)

% Slope Right: 5.00 % (From DTM Tools>Analysis>Height/Slope)

% Discharge Left: 10.00% (Estimated based on placement within drainage area)

% Discharge Right: 90.00% (Leftover area)

NOTE: Left and Right are defined by a node at angle 0. To gain your bearing, remember this node has been rotated 270 degrees or 90 degrees clockwise.

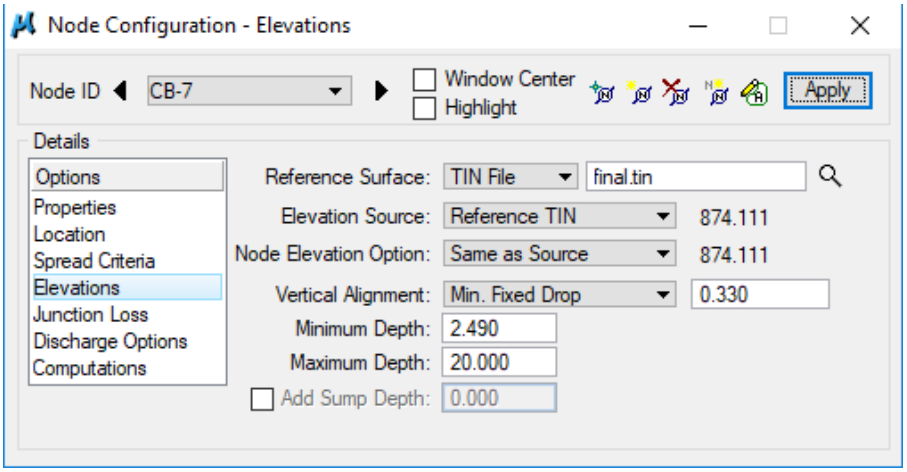


d) Elevations > Elevation Data must be changed to match a CB#43 8x4. From the TDOT GEOPAK Drainage Nodes Document set the following:

Vertical Alignment: Min. Fixed Drop, 0.33

Minimum Depth: 2.49 feet (See note at top of page 5-7)

Maximum Depth: 20.00 feet



e) Click the **Apply** button to include this node in the Drainage Project.

Catch Basins – Outlet Only:

Drop Across Bottom of Structure + Min. Depth of Cover = Minimum Depth

CB#43 8x4: .33’ + 2.16’ = 2.49’

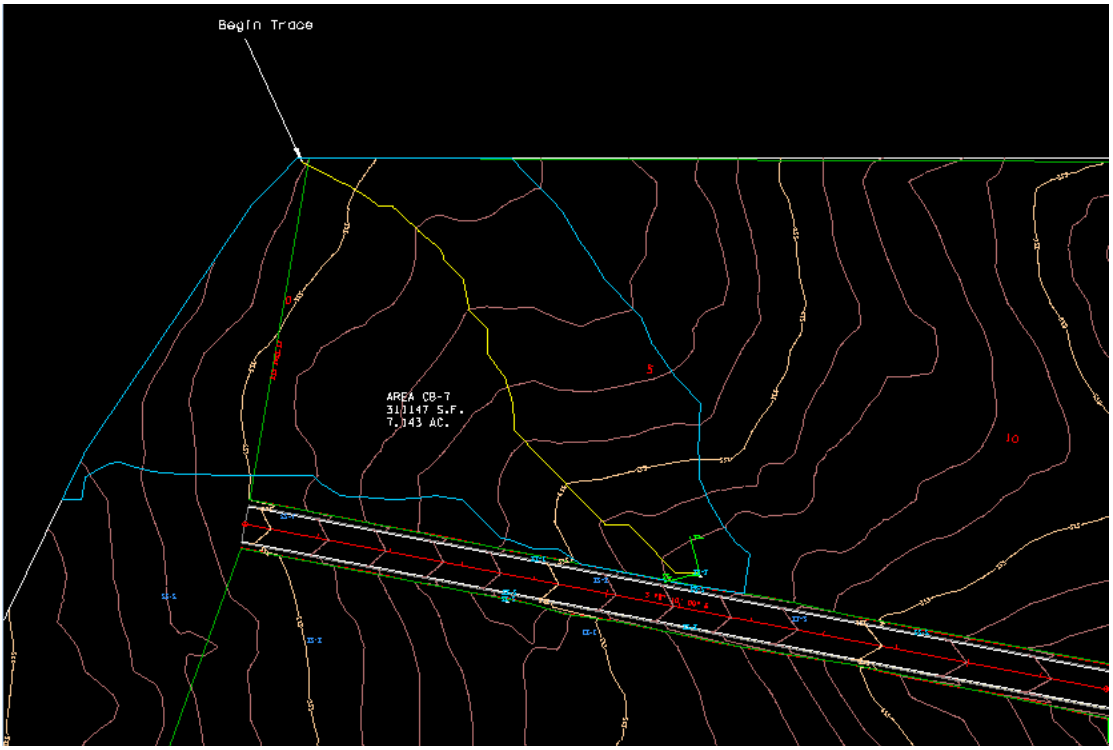
NOTE: See Appendix A, pg. A-4

5.14 Delineate Drainage Area CB – 7

a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-7** should automatically appear, click **OK**.

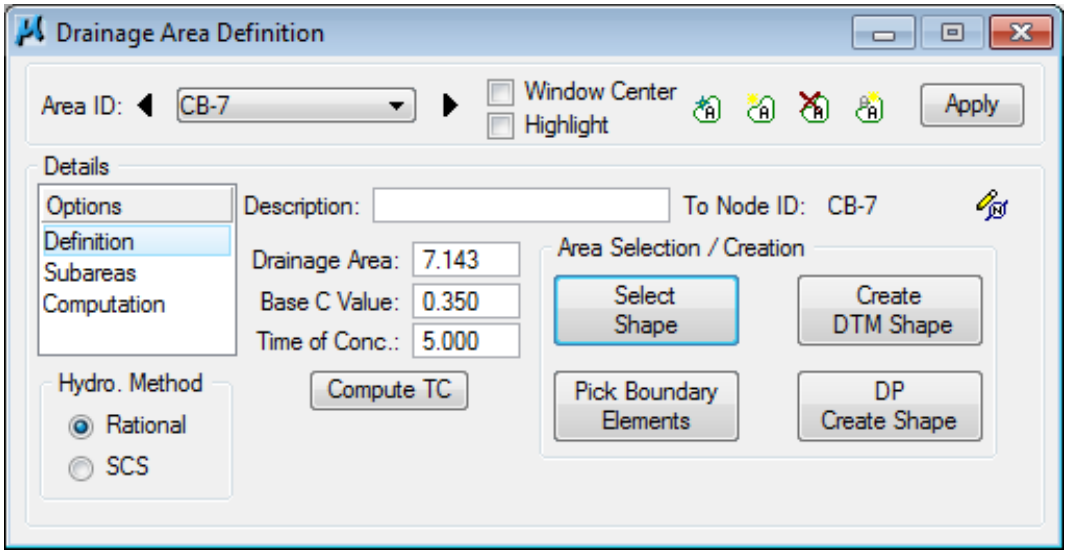
b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 7. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-7 and turn off DA_CB-6.

Delineate Drainage Area:

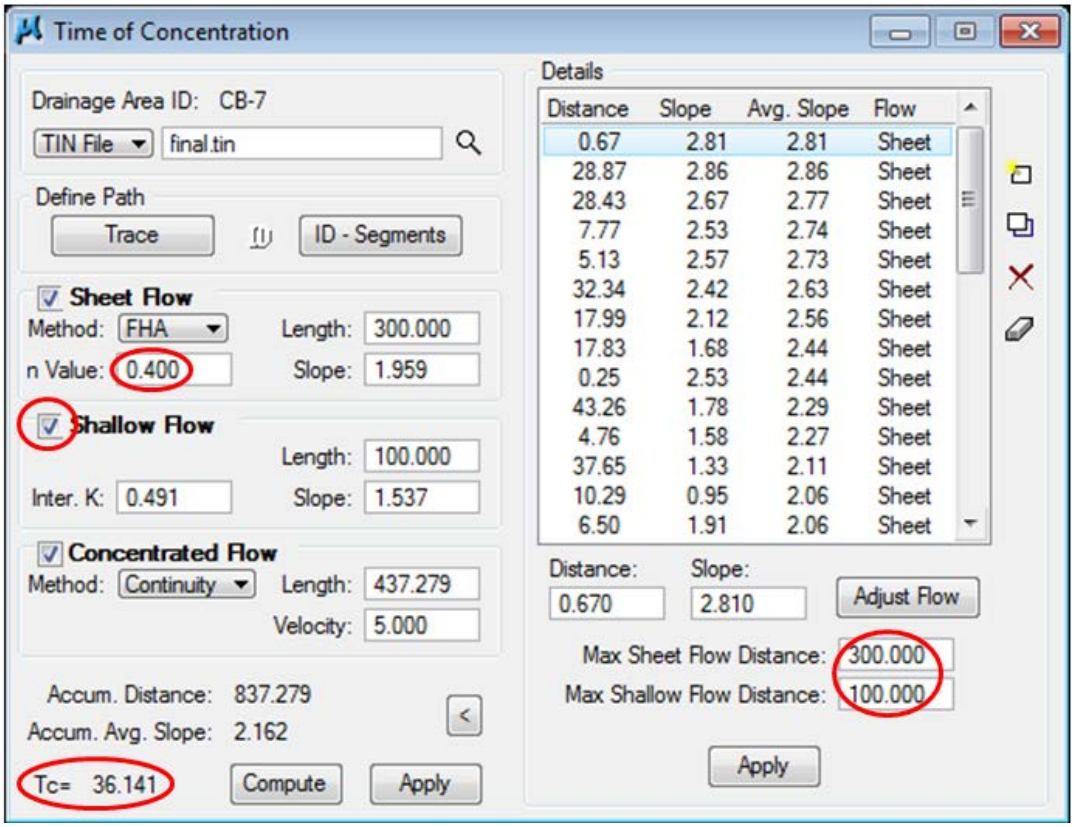


NOTE: As discussed in Exercise 5.12 *Delineate Drainage Area CB-6* this area will catch a large amount of runoff prior to it entering the roadway.

c) Define Drainage Area:



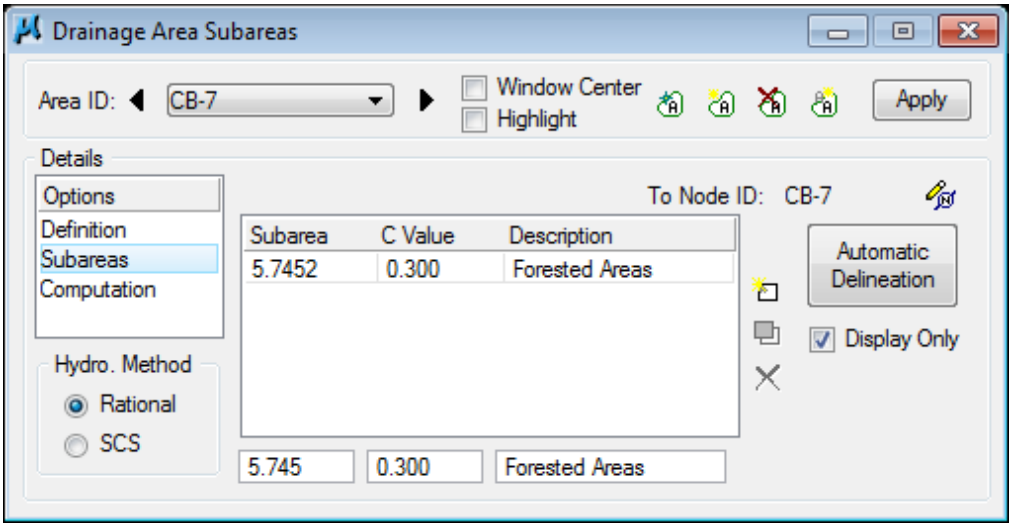
d) Calculate Time of Concentration:



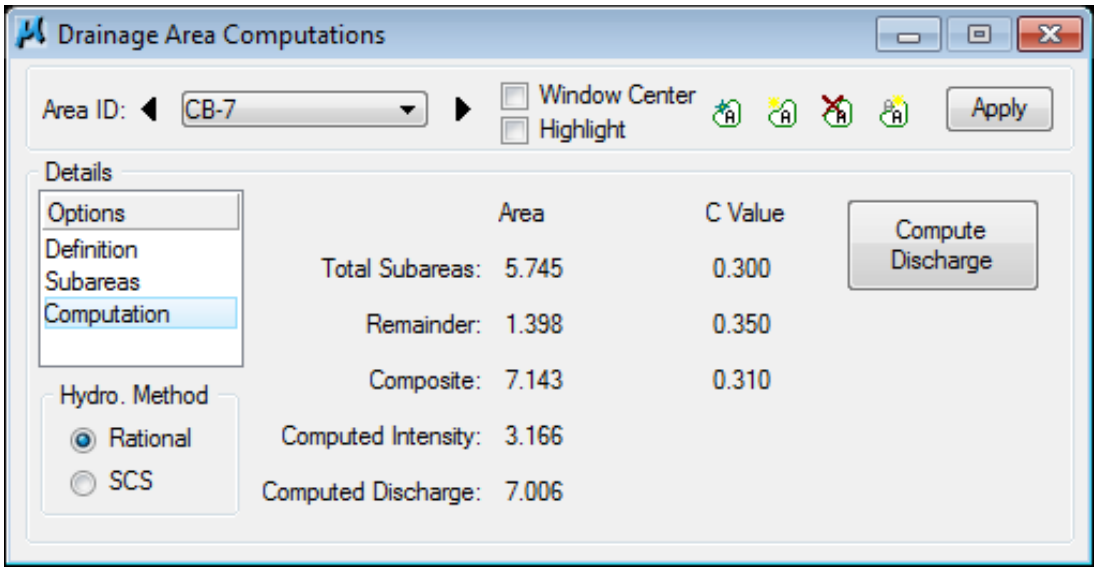
The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required.

NOTE: The maximum length for sheet flow has changed and will vary depending upon the drainage area. For this area, the Max Sheet Flow changes to 300 and the Max Shallow Flow changes to 100. The n Value for Sheet Flow changes back to 0.400

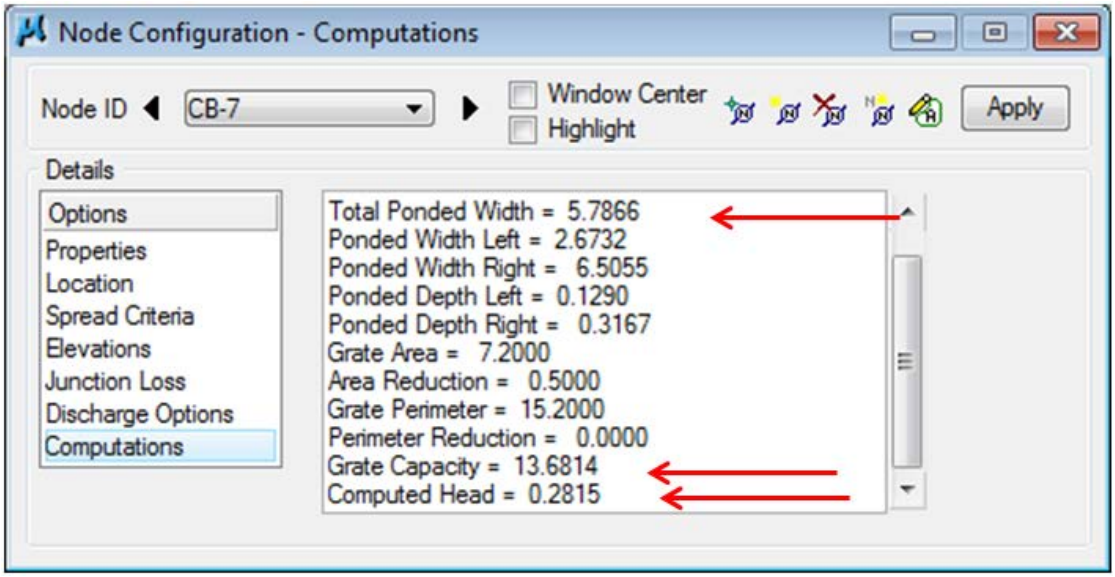
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Review the Computed Data. Items to review specifically are:

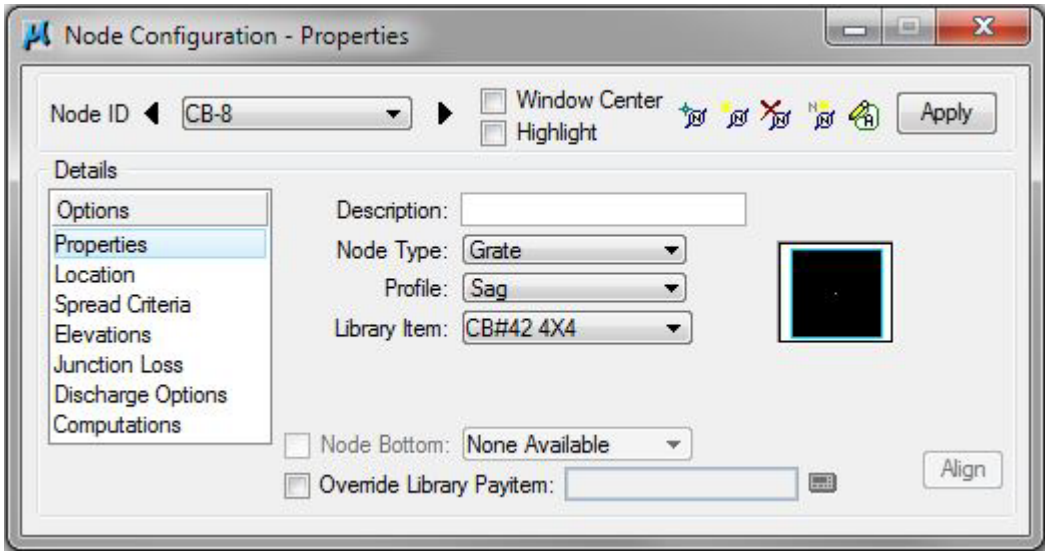
Total Ponded Width, Grate Capacity compared with **Computed Discharge** and **Computed Head**

5.15 Design Inlet CB – 8

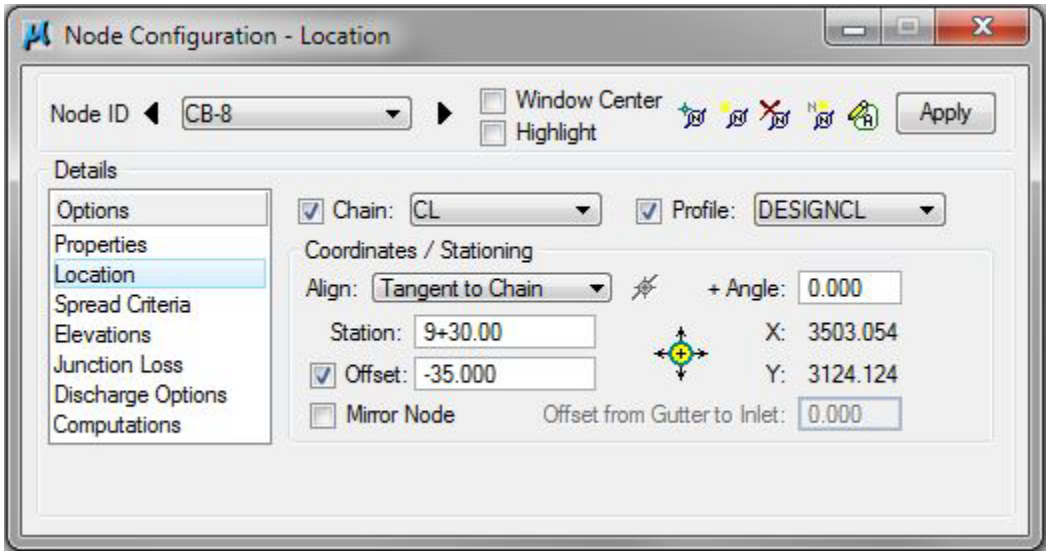
It has been determined that a **CB#42 4X4** will be used. See Standard Drawing D-CB-42SB for details.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-8

Properties > Change the Node **Properties** to **Sag** and to a **CB#42 4X4**:



b) **Location >** All Reference information is defaulted from the previous Node (CB-7) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed:



c) Spread Criteria > Enter the Spread Criteria as shown below.

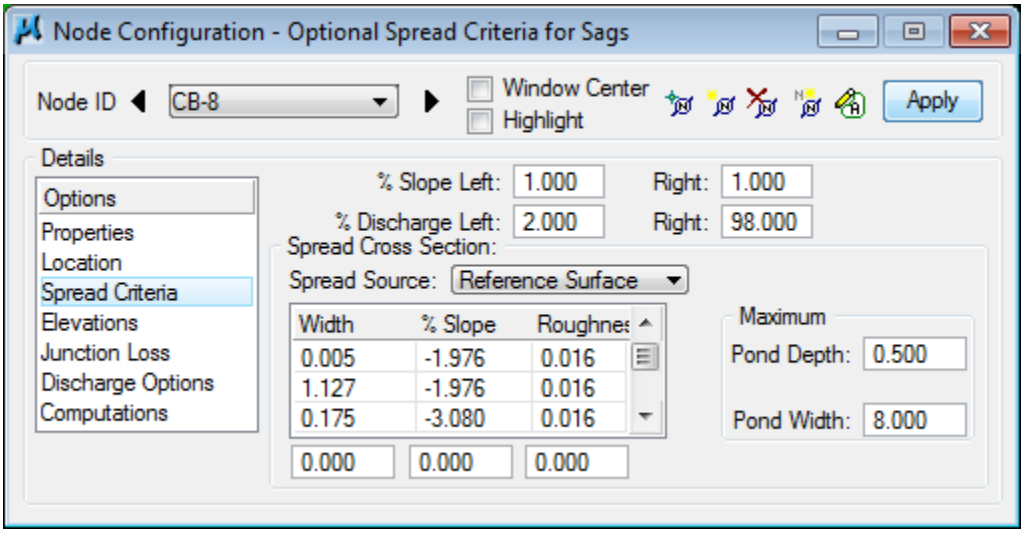
% Slope Left: 3.50 % (From DTM Tools>Analysis>Height/Slope)

% Slope Right: 2.50 % (From DTM Tools>Analysis>Height/Slope)

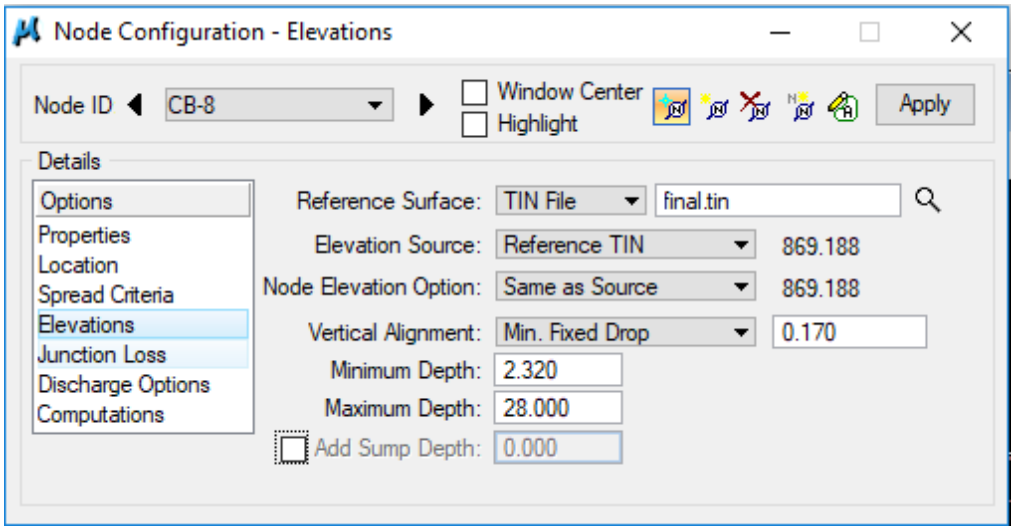
% Discharge Left: 98.00% (Estimated based on placement within drainage area)

% Discharge Right: 2.00% (Leftover area)

NOTE: Left and Right are defined by a node at angle 0.



d) Elevations > Elevation Data must be changed to match a CB#42 4X4. From the TDOT GEOPAK Drainage Nodes Document set the following:



e) Click the **Apply** button to include this node in the Drainage Project.

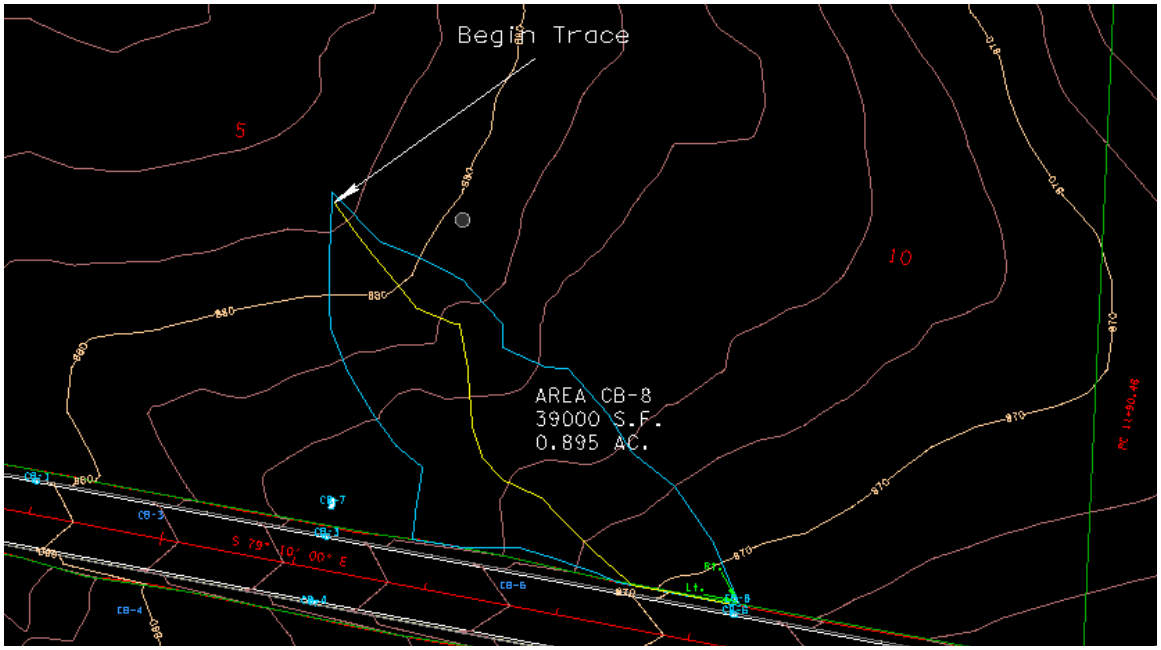
CB#42 4x4: 0.17’ + 2.15’ = 2.32’

5.16 Delineate Drainage Area CB – 8

a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-8** should automatically appear, click **OK**.

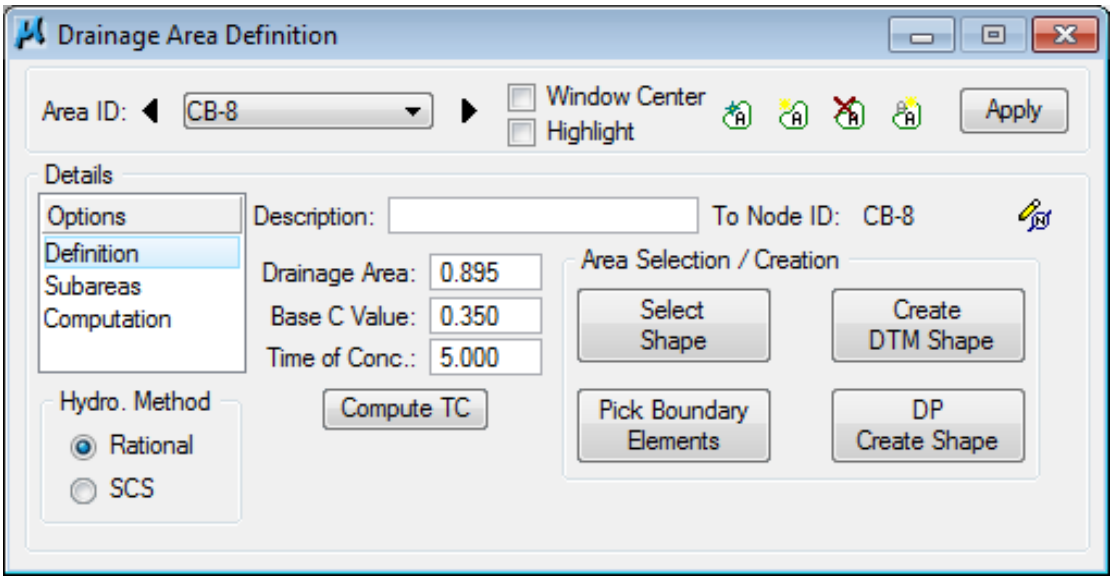
b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 8. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-8 and turn off DA_CB-7.

Delineate Drainage Area:

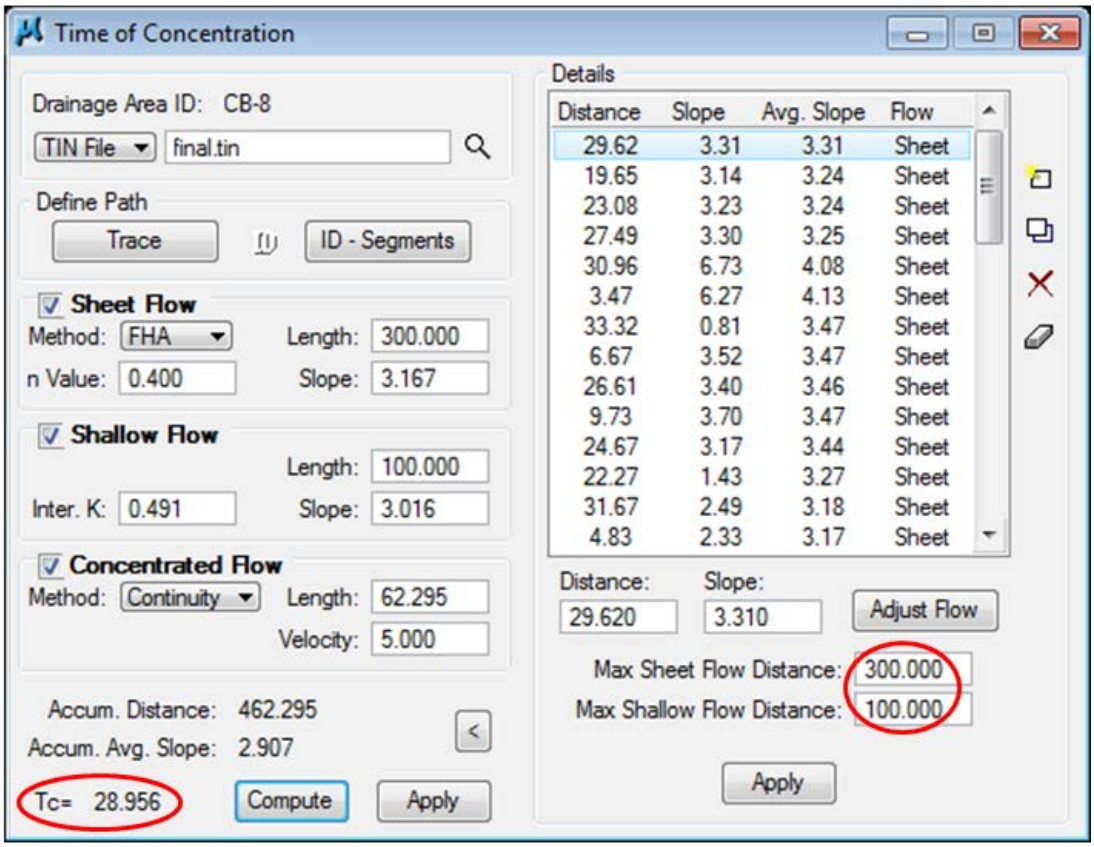


NOTE: As discussed in Exercise 5.11 *Create Drainage Area CB-6* this area will catch runoff prior to it entering the roadway.

c) Define Drainage Area:



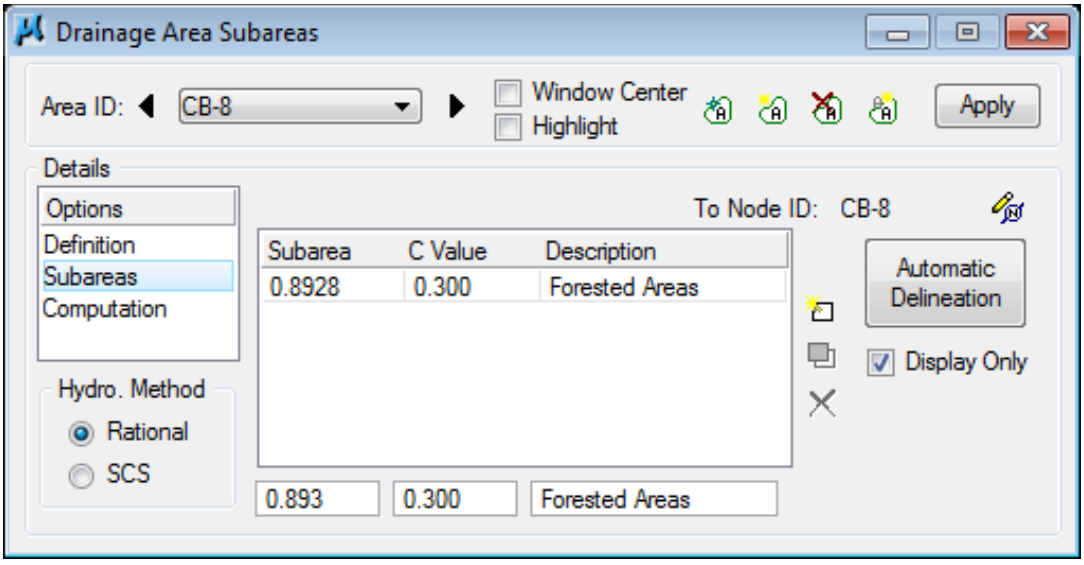
d) Calculate Time of Concentration:



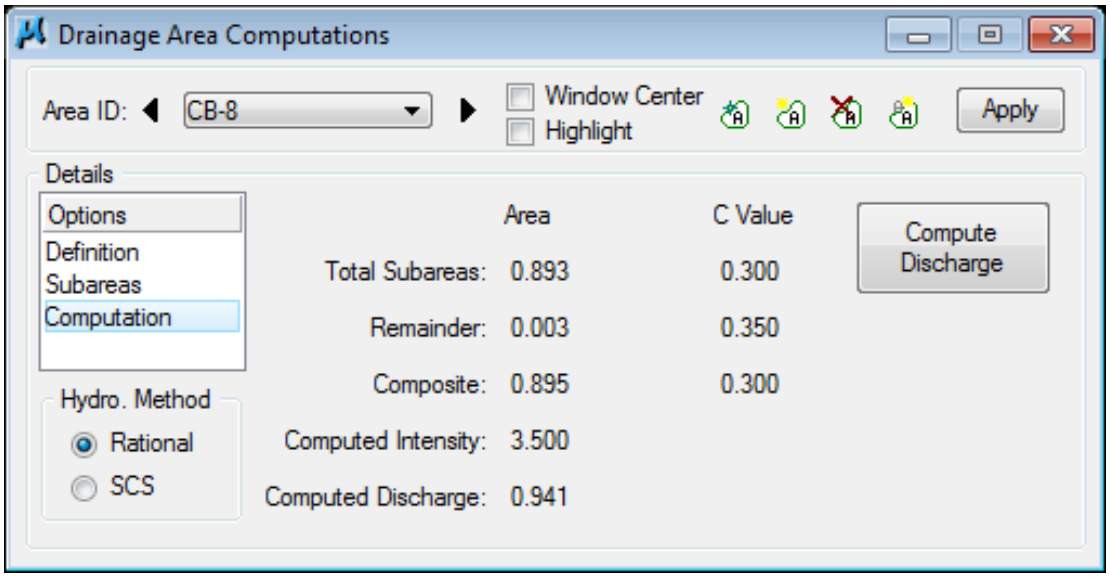
The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required.

The maximum length for sheet flow has changed and will vary depending upon the drainage area. Keep Max Sheet Flow at 300 and Max Shallow Flow at 100.

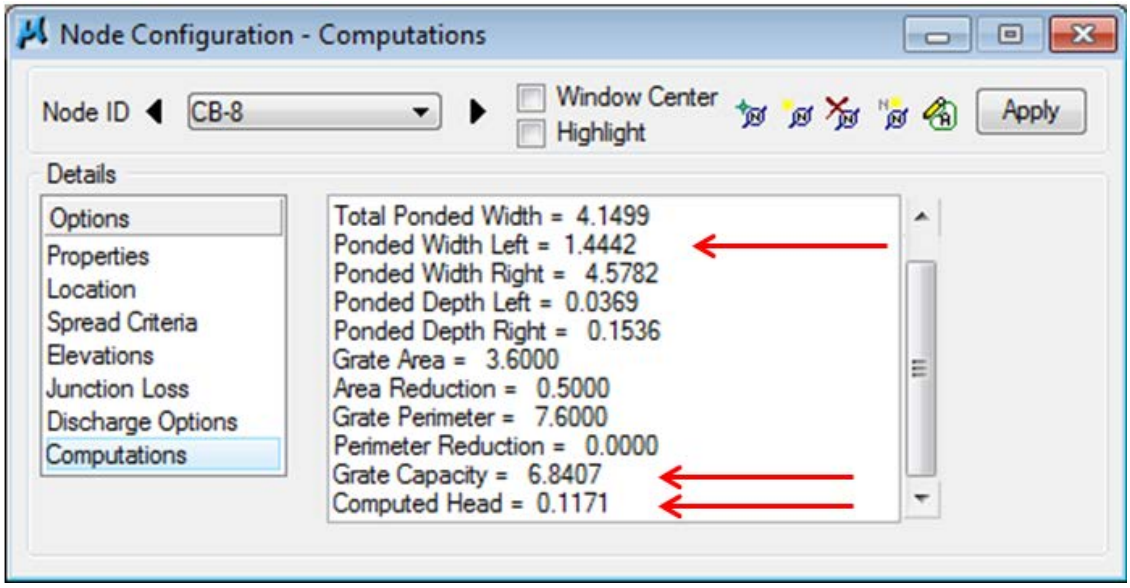
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Review the Computed Data. Items to review specifically are:

Total Ponded Width, Grate Capacity compared with **Computed Discharge** and **Computed Head**

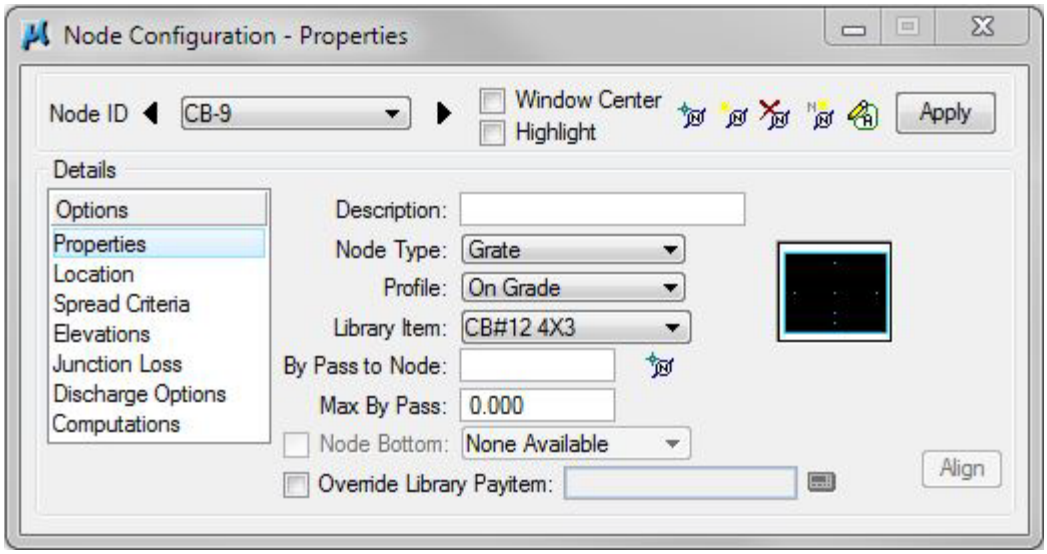
5.17 Design Inlet CB – 9

It has been determined that another standard **CB#12 4X3** will be used.

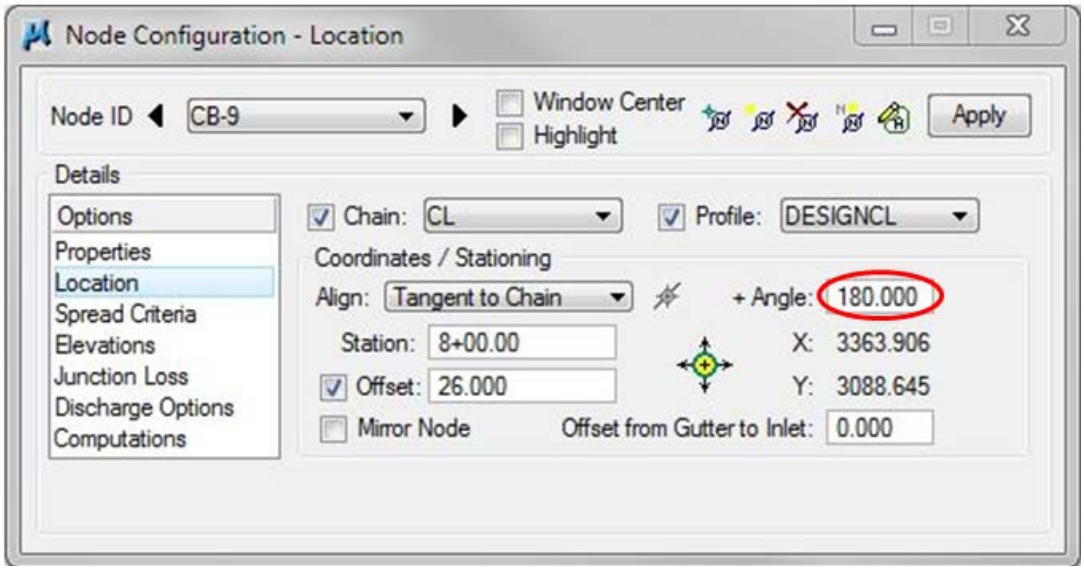
See Standard Drawing D-CB-12S for details.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-9

Properties > Change the Node **Properties** to **On Grade** and to a **CB#12 4X3**:

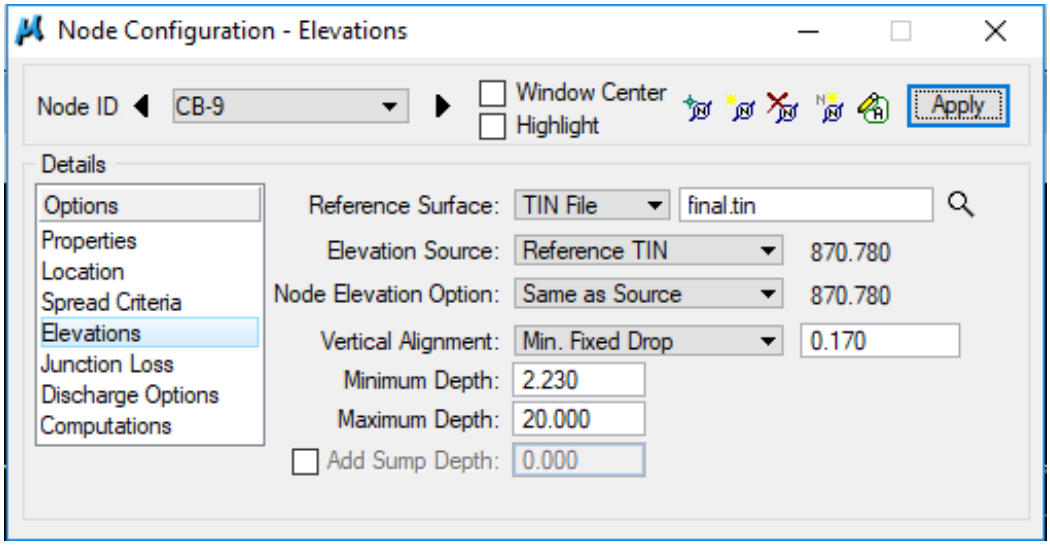


b) **Location >** All Reference information is defaulted from the previous Node (CB-8) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. The reasoning for the location of CB-9 will be given in the drainage area discussion:



NOTE: The **Spread Criteria** defaults back automatically when the node is changed back to **ON GRADE**, therefore no changes are necessary.

c) Elevations > Elevation Data must be changed to match a CB#12 4X3. From the TDOT GEOPAK Drainage Nodes Document set the following:



d) Click the **Apply** button to include this node in the Drainage Project.

Catch Basins – Inlet and Outlet:

Min. Depth of Basin – Pipe Size – Drop Across Bottom of Structure = Minimum Depth

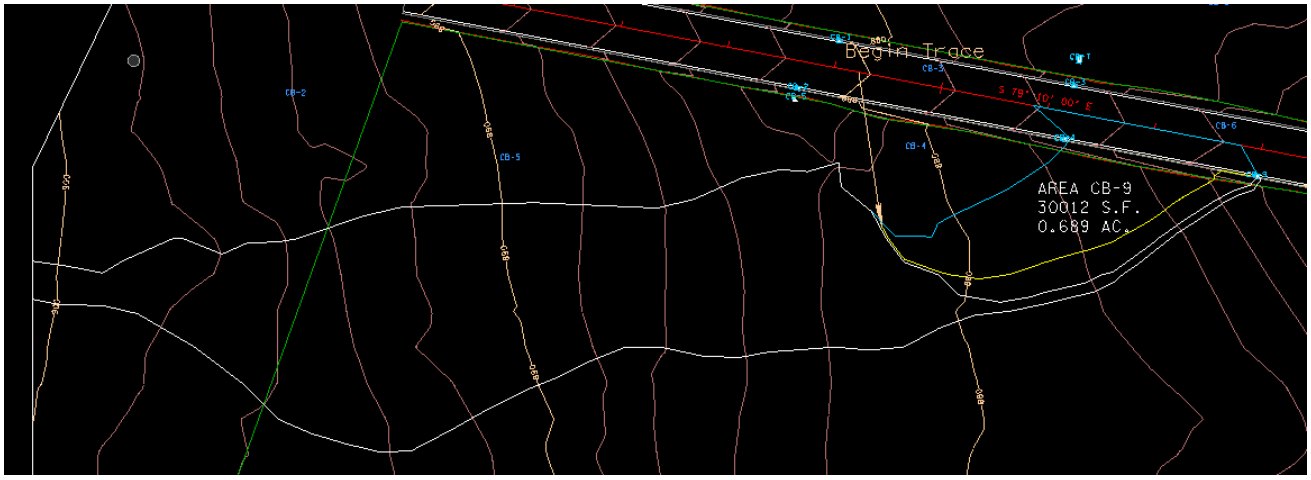
CB#12 4x3: 3.90’ - 18”/12 - 0.17’ = 2.23’

5.18 Delineate Drainage Area CB – 9

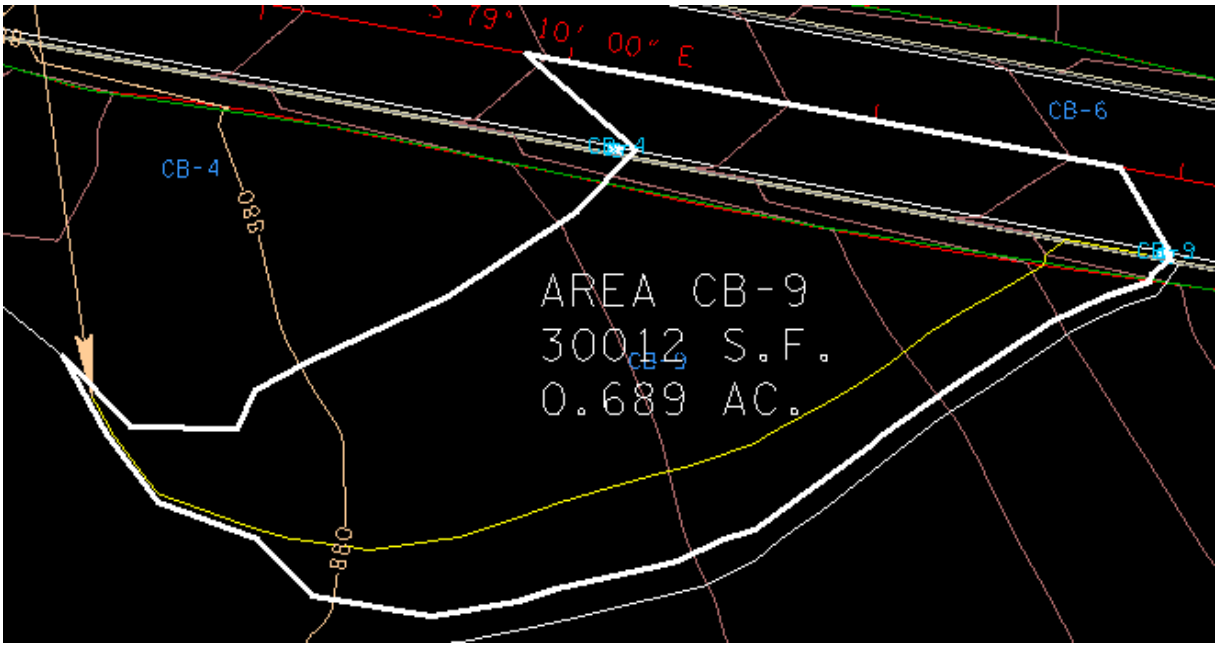
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-9** should automatically appear, click **OK**.

b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 9. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-9 and turn off DA_CB-8.

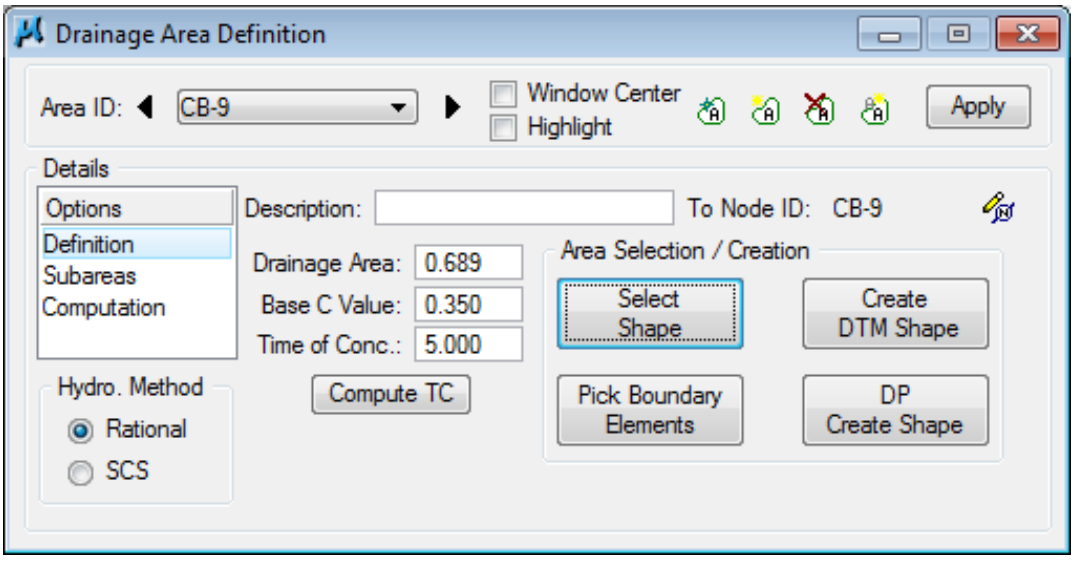
Delineate Drainage Area:



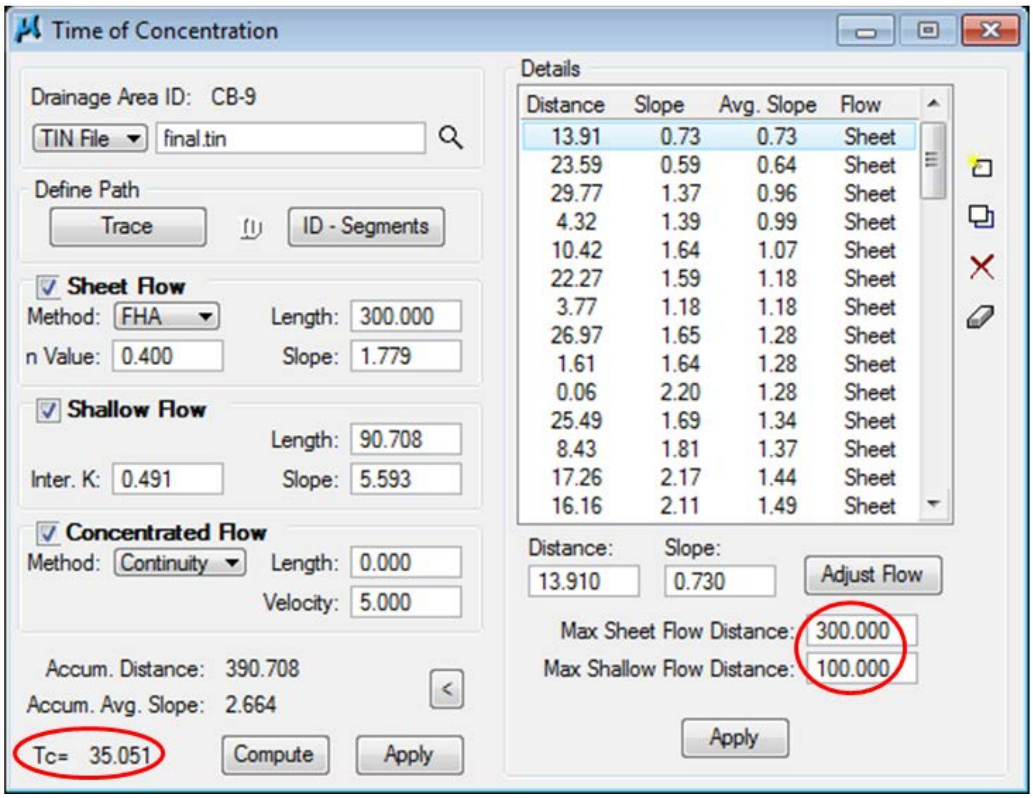
NOTE: Many iterations and much investigation went into developing the placement of the next few catch basins. The whole of the drainage area if one were to set CB-9 at the same station as CB-6 & CB-8 is delineated by CB-9 Area and the white drainage area. These were divided to keep the roadway spread within the required limits. The large portion of the drainage area and the odd shape will be discussed in Exercise 5.19.



c) Define Drainage Area:



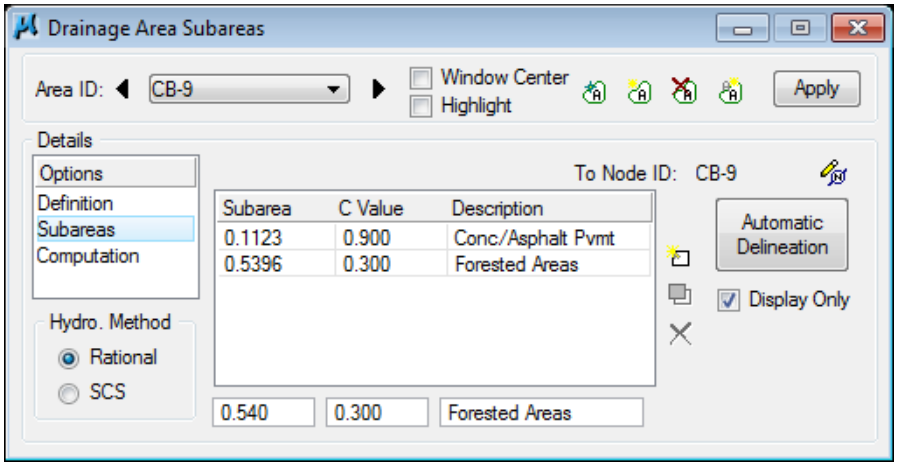
d) Calculate Time of Concentration:



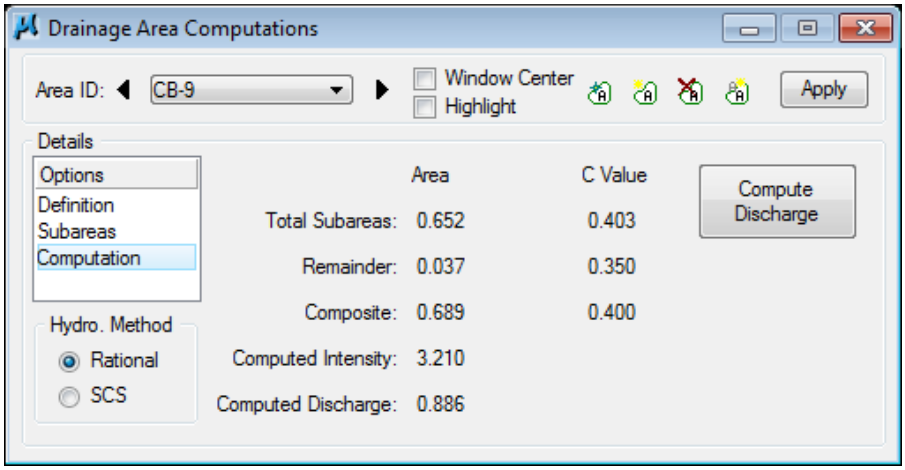
The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required.

NOTE: The maximum length for sheet flow has changed and will vary depending upon the drainage area. Keep Max Sheet Flow at 300 and Max Shallow Flow at 100.

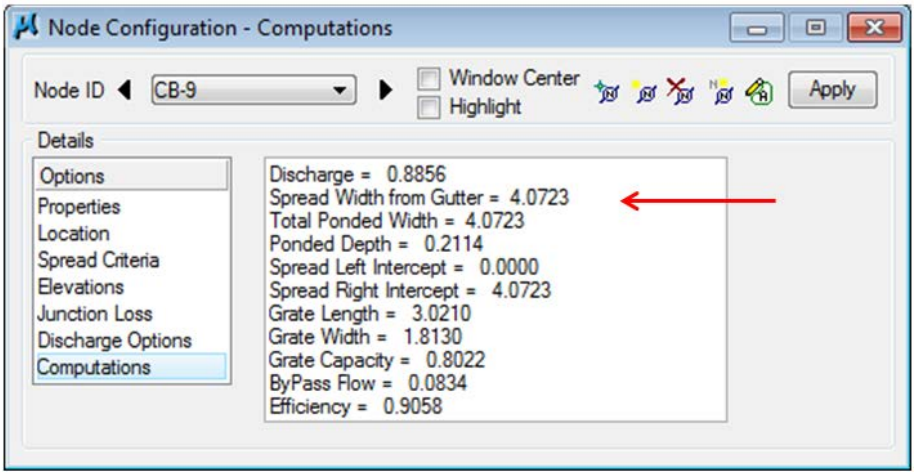
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

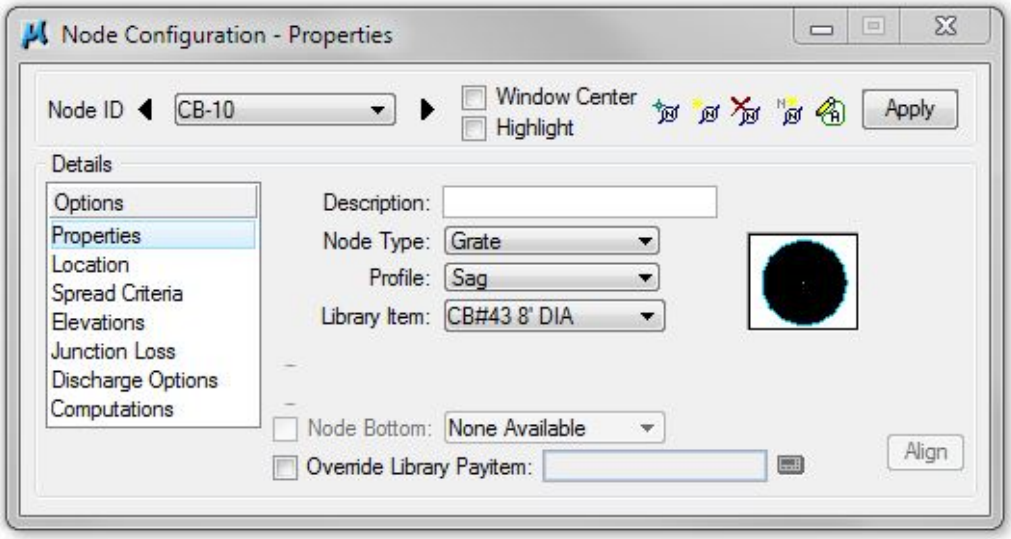
5.19 Design Inlet CB – 10

It has been determined that a **CB#43 8’ DIA.** will be used.

See Standard Drawing D-CB-43R for details.

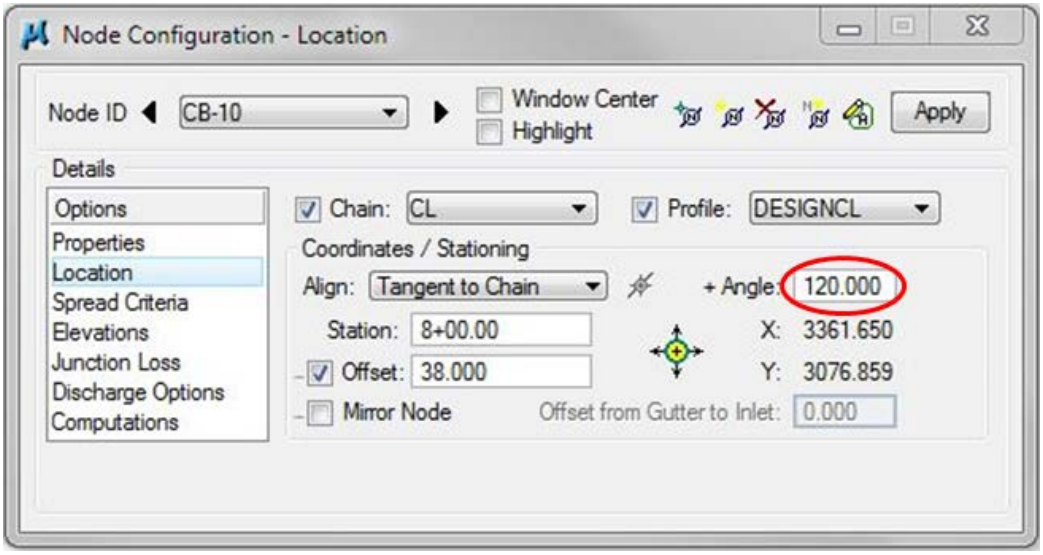
a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-10

Properties > Change the Node **Properties** to **Sag** and to a **CB#43 8’ DIA**:



NOTE: 8’ Diameter is a round catch basin. The reasoning behind this selection is the need for the grates to be at such an angle that a pipe cannot be attached at a skew within the required limits. See TDOT Drainage Manual Chapter 7 Section 7.03.5.5 *Pipe Connections to Structures*.

b) **Location >** All Reference information is defaulted from the previous Node (CB-9) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. The reasoning for the location of CB-10 will be given in the drainage area discussion. Especially note the Angle and Offset:



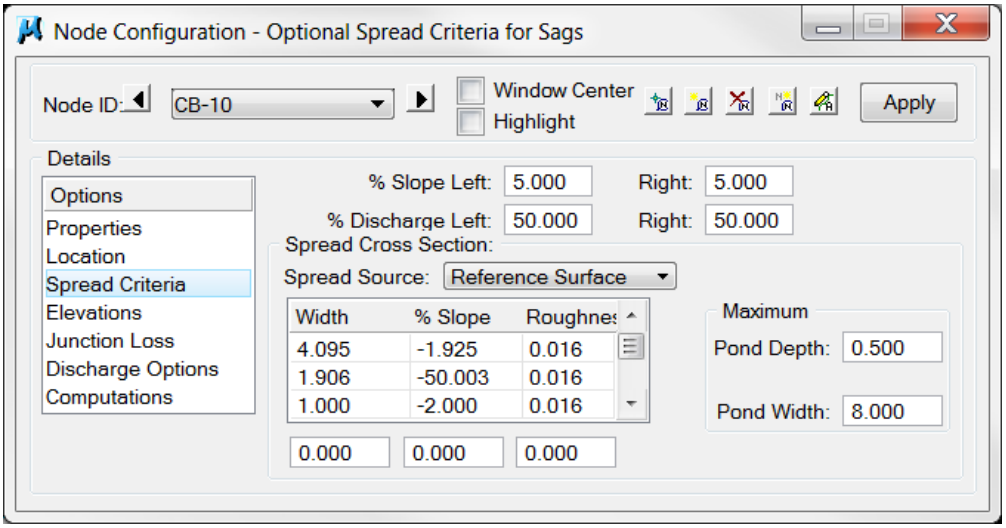
c) Spread Criteria > Enter the Spread Criteria as shown below.

% Slope Left: 5.00 % (From DTM Tools>Analysis>Height/Slope)

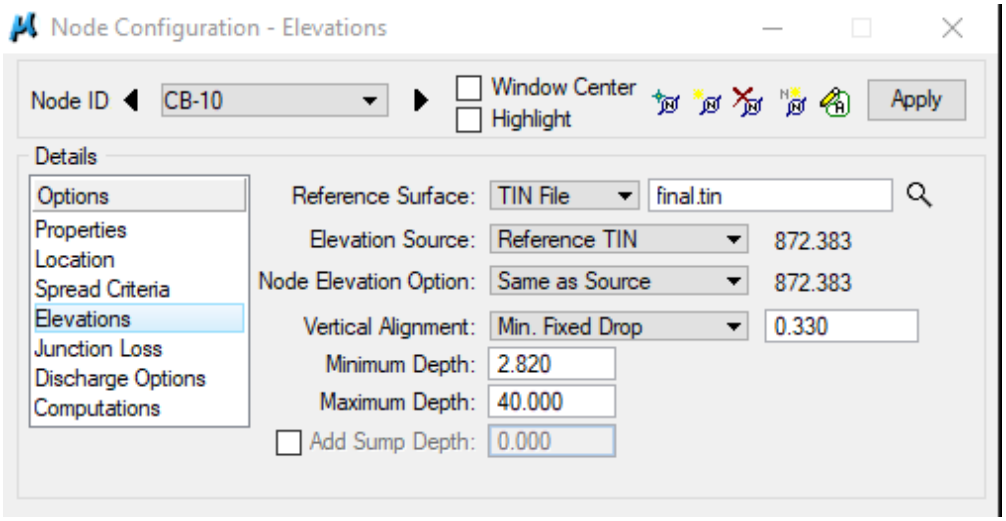
% Slope Right: 5.00 % (From DTM Tools>Analysis>Height/Slope)

% Discharge Left: 50.00% (Estimated based on placement within drainage area)
% Discharge Right: 50.00% (Leftover area)

NOTE: Left and Right are set equal since the flow will come to each equally.



d) Elevations > Elevation Data must be changed to match a CB#43 8' DIA. From the TDOT GEOPAK Drainage Nodes Document set the following:



e) Click the **Apply** button to include this node in the Drainage Project.

Catch Basins – Outlet Only:

Drop Across Bottom of Structure + Min. Depth of Cover = Minimum Depth

CB#43 8'DIA: 0.33' + 2.49' = 2.82'

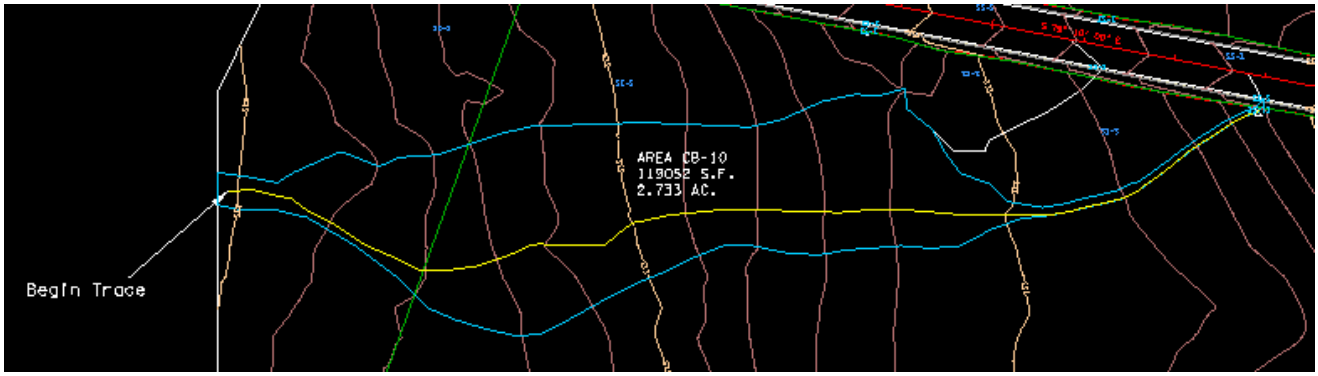
NOTE: See Appendix A, pg. A-4

5.20 Delineate Drainage Area CB – 10

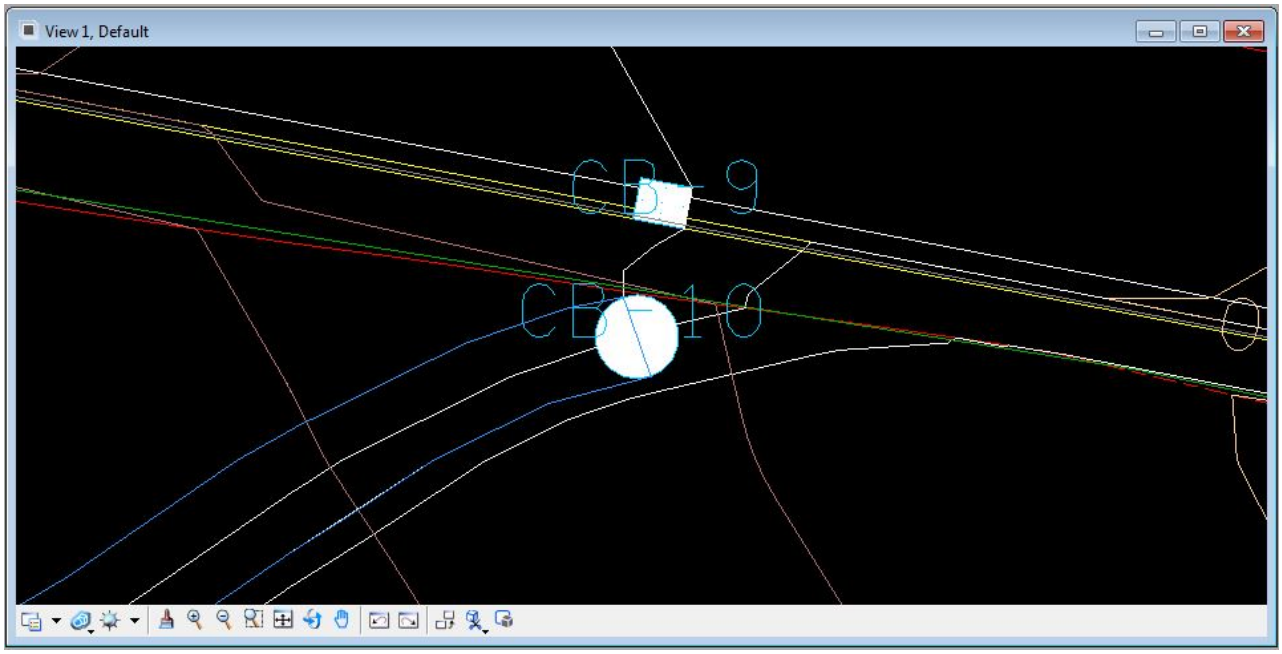
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-10** should automatically appear, click **OK**.

b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 10. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-10 and turn off DA_CB-9.

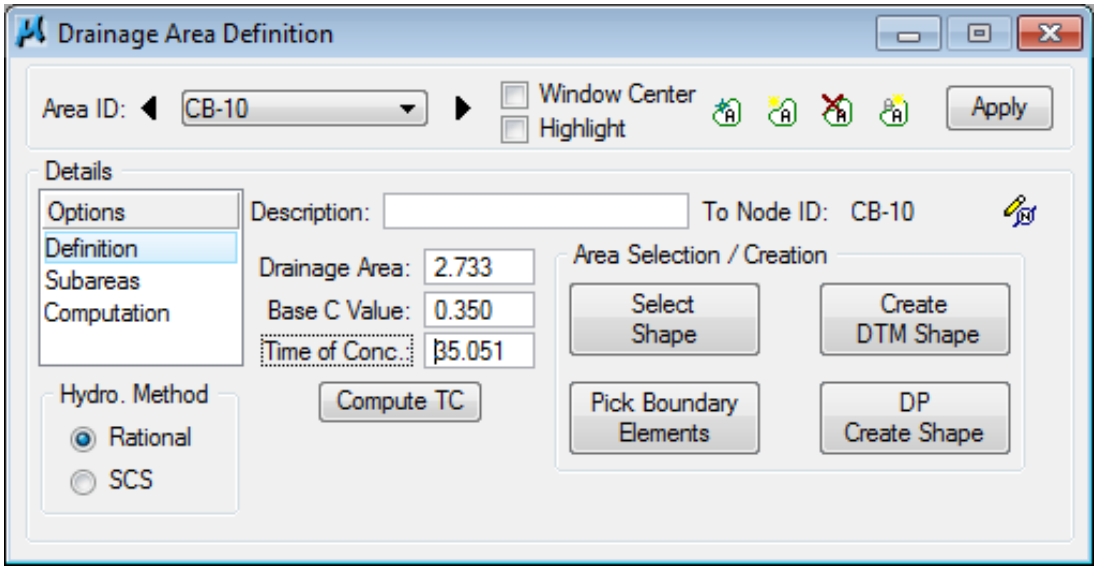
Delineate Drainage Area:



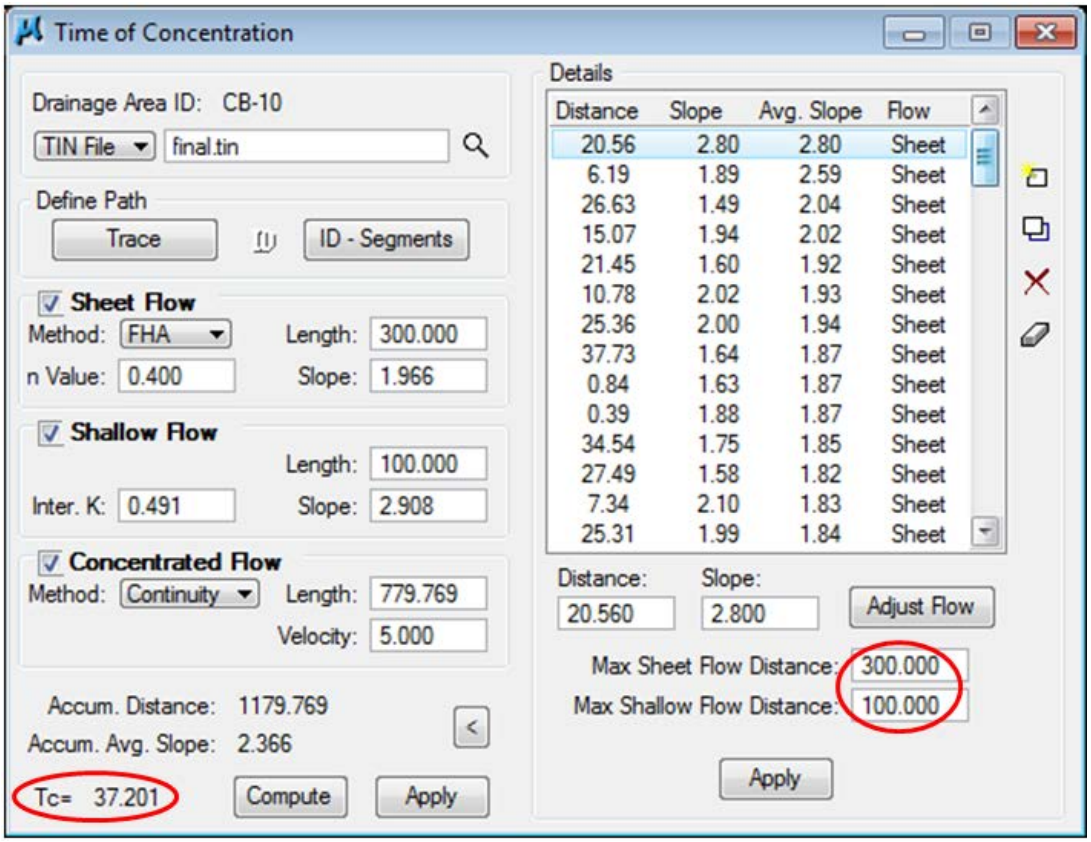
NOTE: Drainage area CB-10 was created by first using downstream trace and discovering that it converges into a relatively small area. Therefore when CB-10 was placed, upstream trace was used from either side of the catch basin to determine the drainage area. CB-10 was rotated to match the contours in order to catch as much flow as possible.



c) Define Drainage Area:



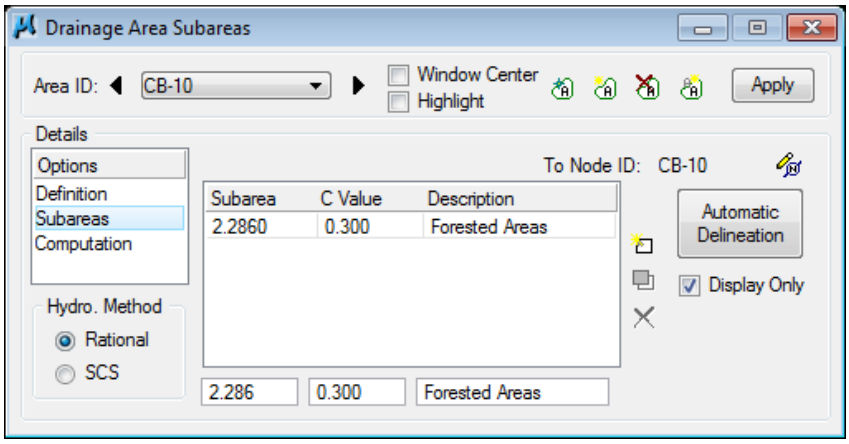
d) Calculate Time of Concentration:



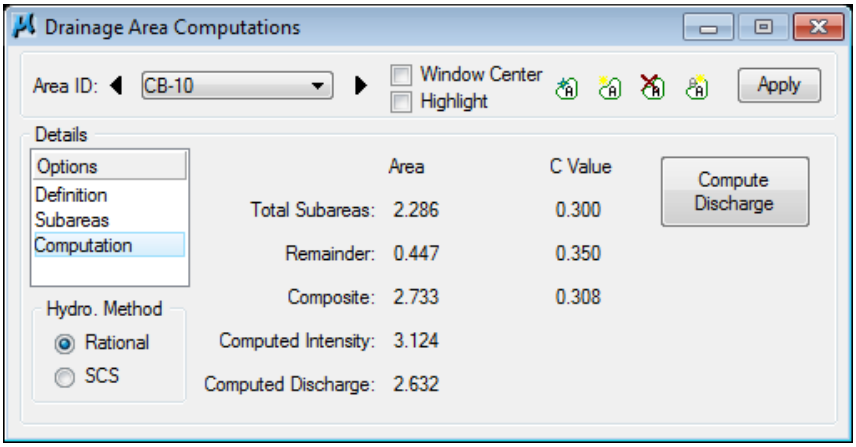
The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required.

NOTE: The maximum length for sheet flow has changed and will vary depending upon the drainage area. Keep Max Sheet Flow at 300 and Max Shallow Flow at 100.

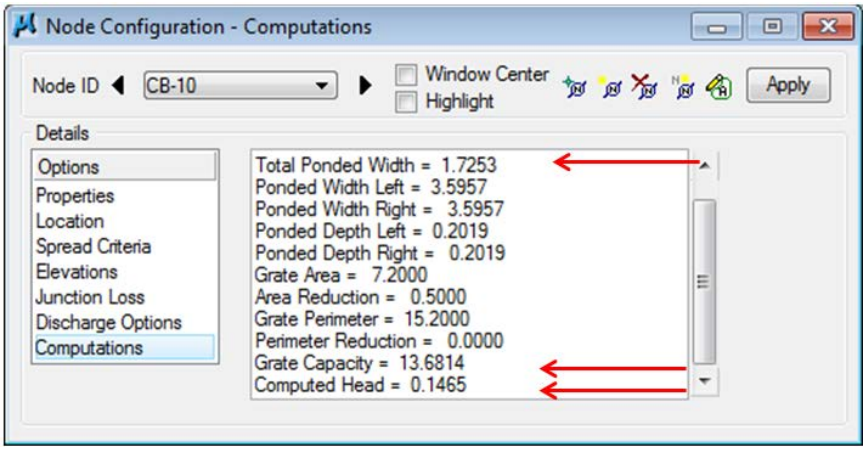
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Review the Computed Data. Items to review specifically are:

Total Ponded Width, Grate Capacity compared with **Computed Discharge** and **Computed Head**

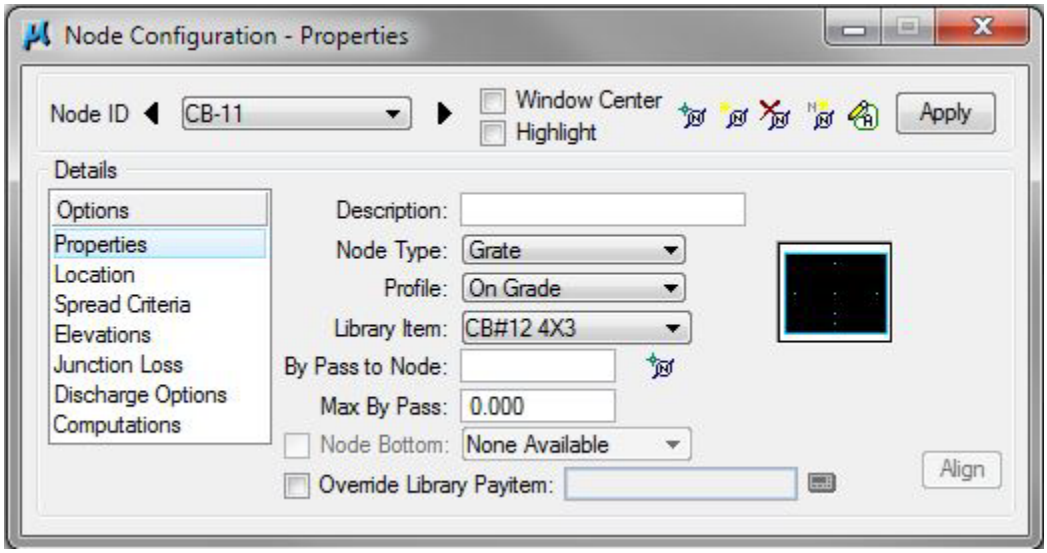
5.21 Design Inlet CB – 11

It has been determined that another standard **CB#12 4X3** will be used.

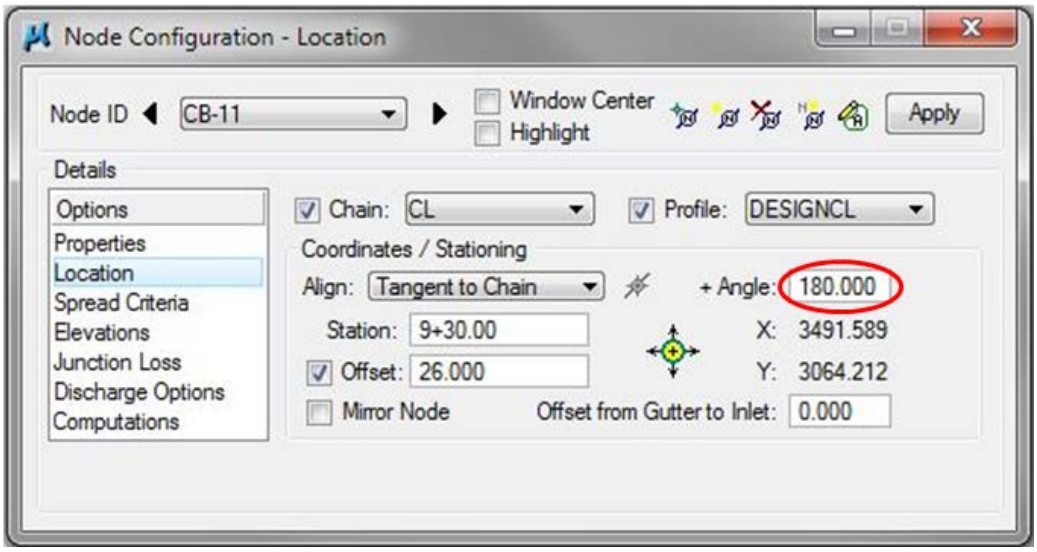
See Standard Drawing D-CB-12S for details.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-11

Properties > Change the Node **Properties** to **On Grade** and to a **CB#12 4x3**:

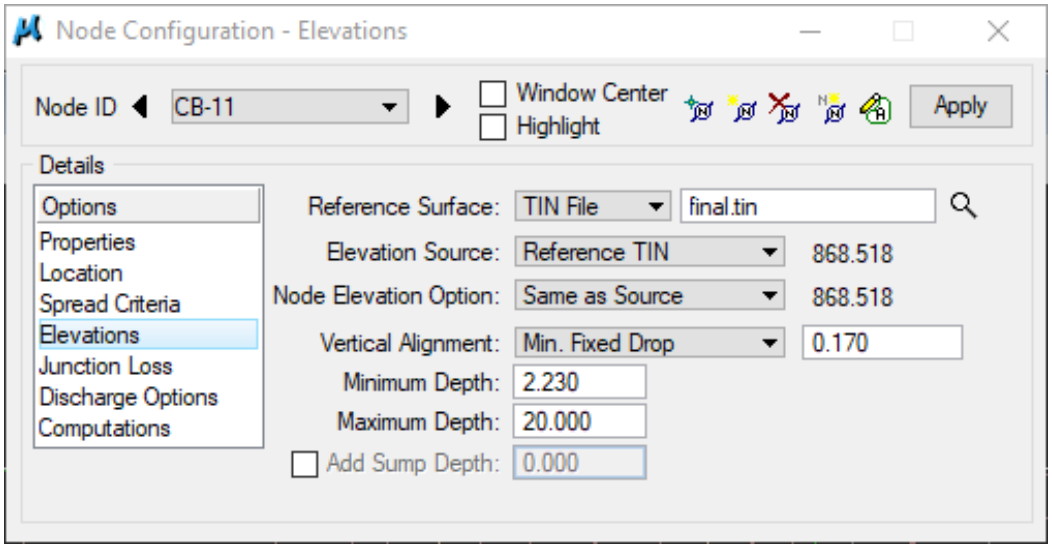


b) **Location >** All Reference information is defaulted from the previous Node (CB-10) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed:



NOTE: The **Spread Criteria** defaults back automatically when the node is changed back to **ON GRADE**, therefore no changes are necessary.

c) Elevations > Elevation Data must be changed to match a CB#12 4X3. From the TDOT GEOPAK Drainage Nodes Document set the following:



d) Click the **Apply** button to include this node in the Drainage Project.

Catch Basins – Inlet and Outlet:

Min. Depth of Basin – Pipe Size – Drop Across Bottom of Structure = Minimum Depth

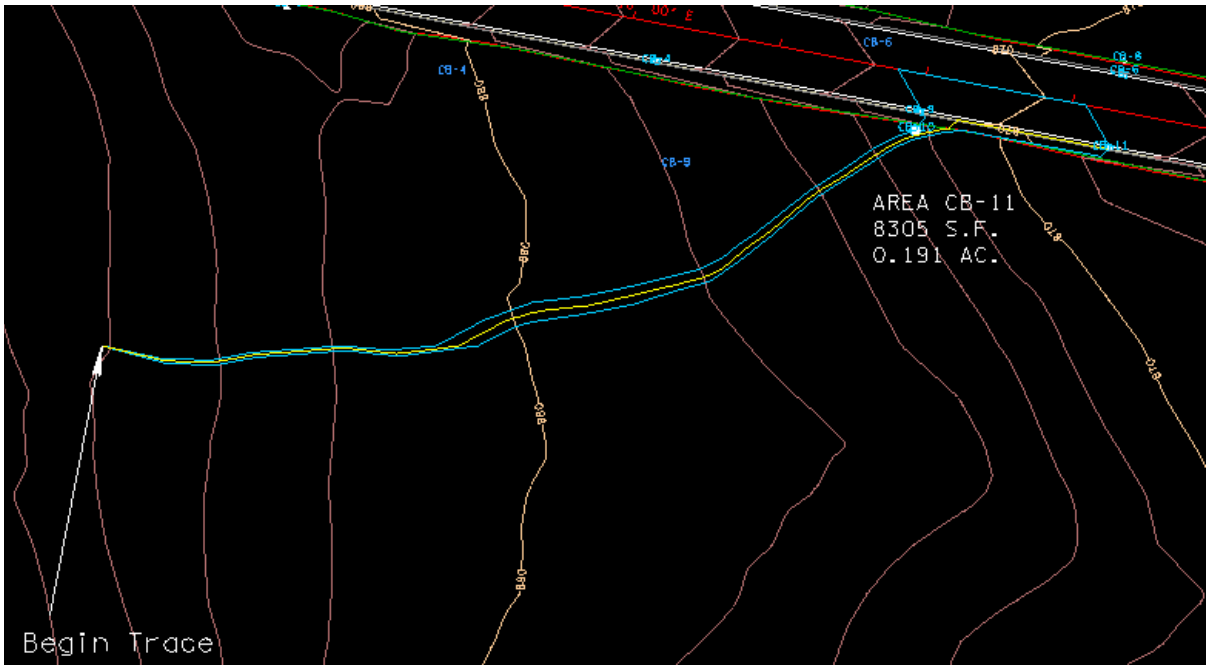
CB#12 4x3: 3.90’ - 18”/12 - 0.17’ = 2.23’

5.22 Delineate Drainage Area CB – 11

a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-11** should automatically appear, click **OK**.

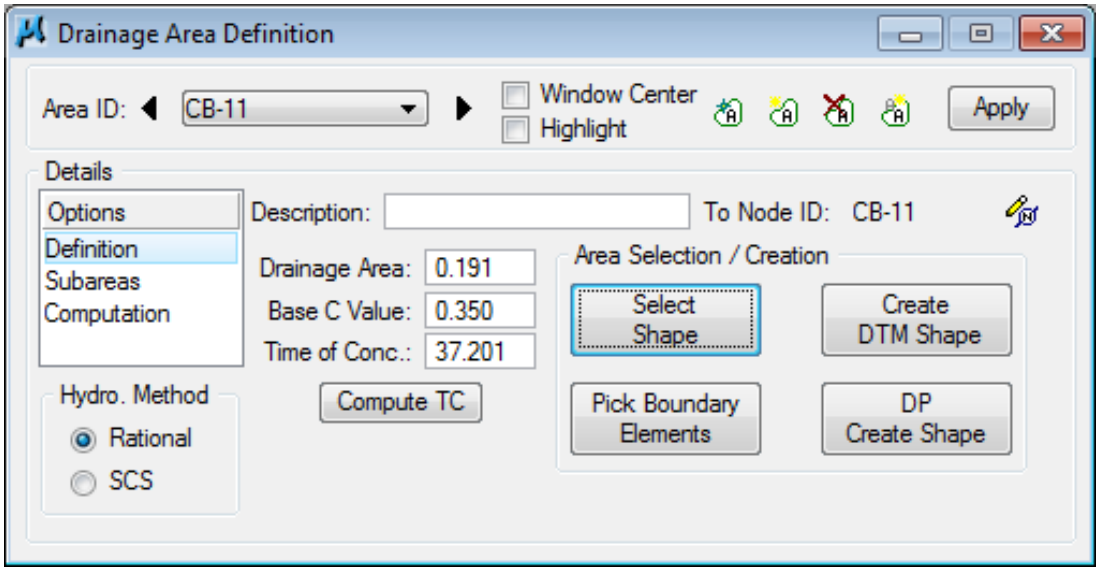
b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 11. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-11 and turn off DA_CB-10.

Delineate Drainage Area:

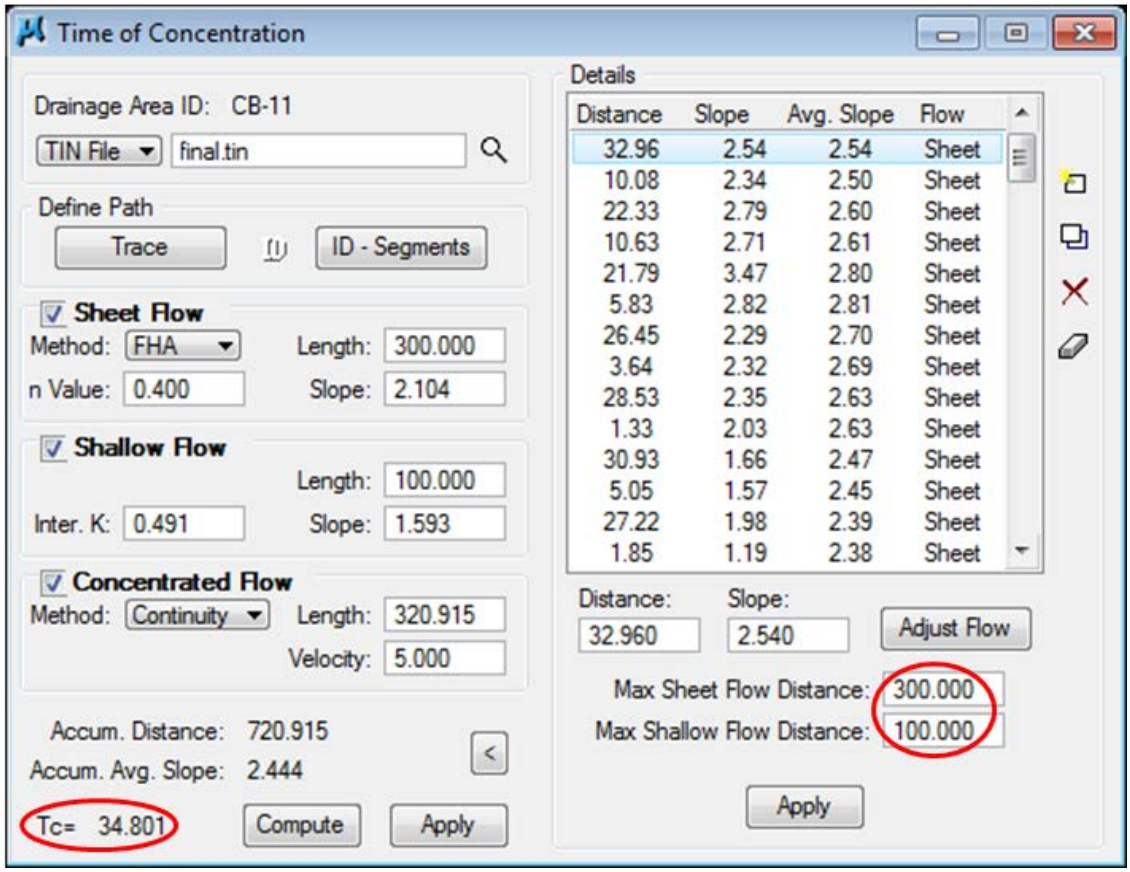


NOTE: There is a small sliver of CB-11 Drainage Area that lies alongside CB-10. This is included to make sure all drainage area is captured. In reality, this sliver would likely be captured by CB-10

c) Define Drainage Area:

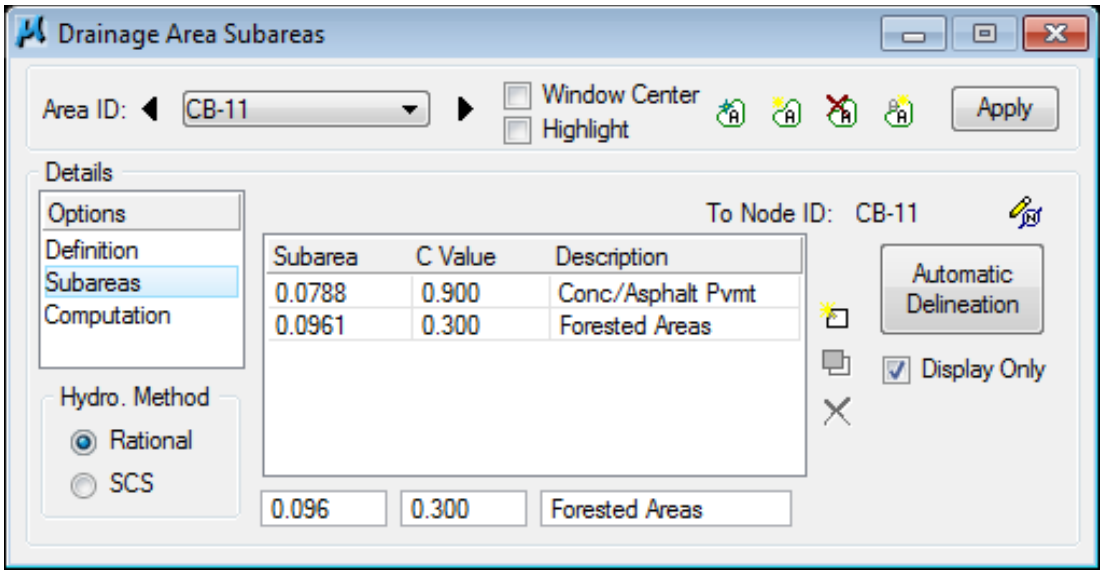


d) Calculate Time of Concentration:

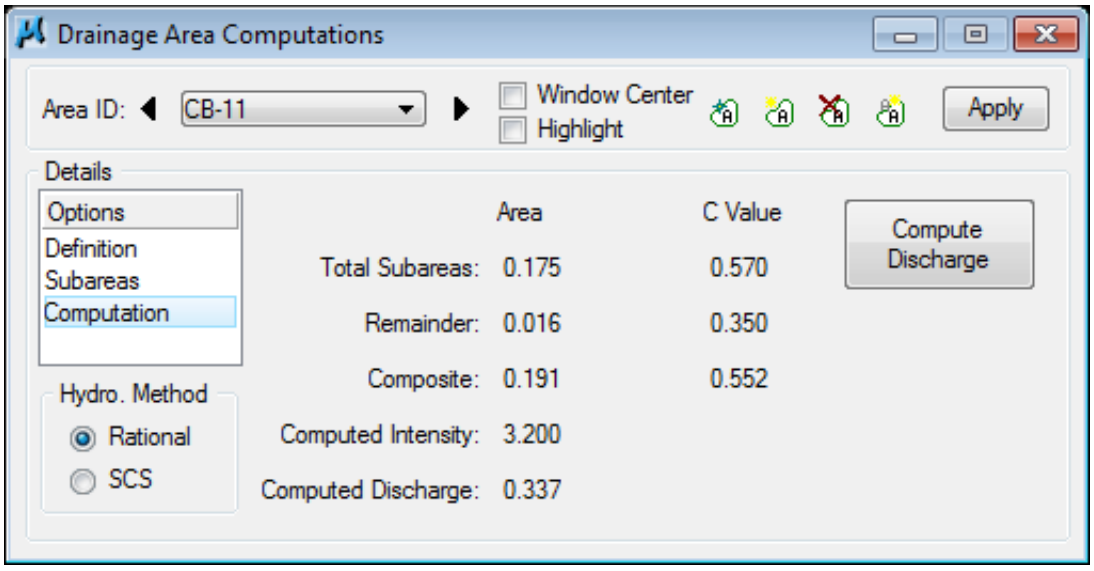


The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required. Keep Max Sheet Flow at 300 and Max Shallow Flow at 100.

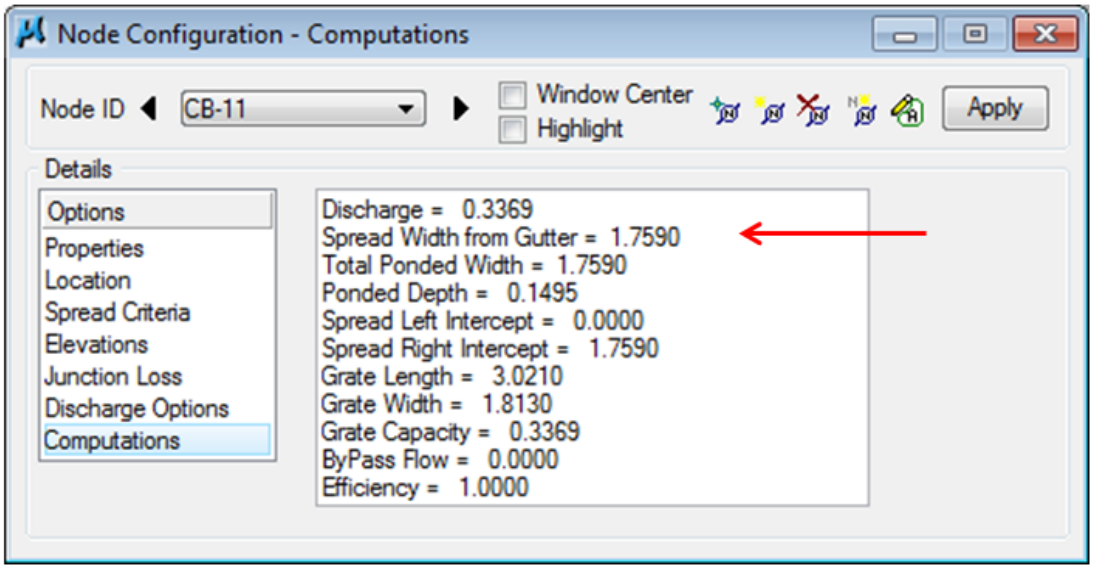
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

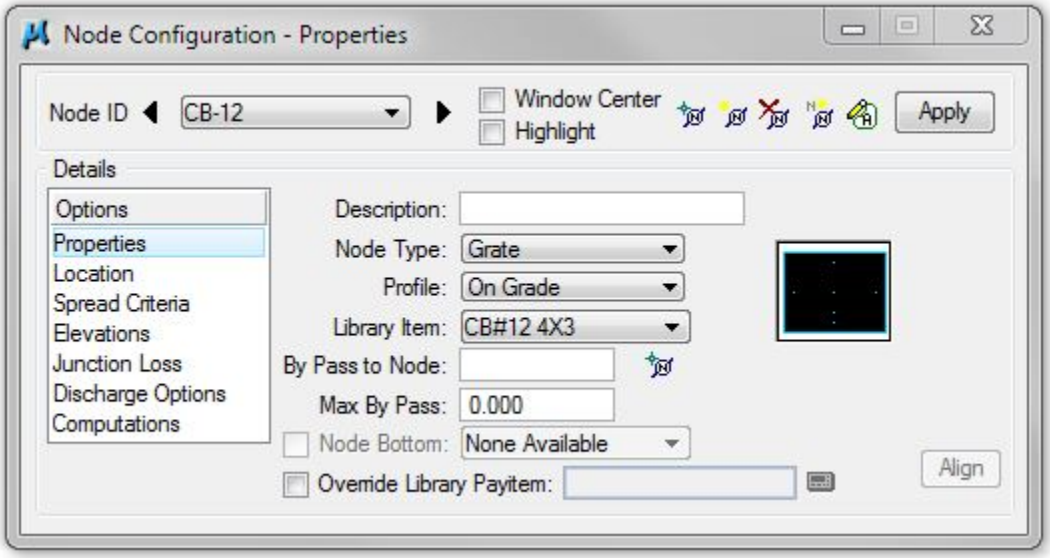
5.23 Design Inlet CB – 12

It has been determined that another standard **CB#12 4X3** will be used.

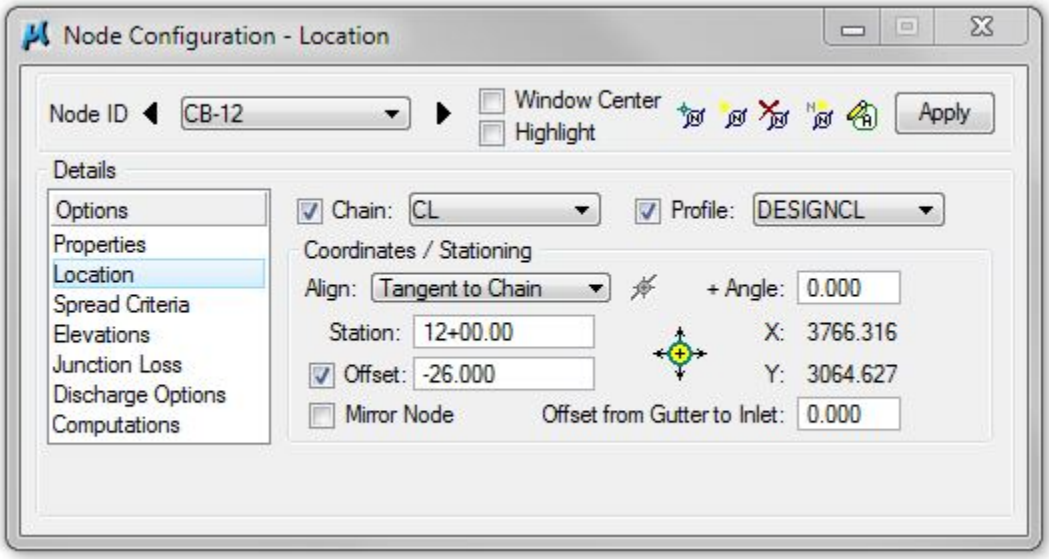
See Standard Drawing D-CB-12S for details.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-12

Properties > Verify the Node Properties are defaulted from the previous Node (CB-11) such that no user-input is required for this similar curb inlet.



b) **Location >** All Reference information is defaulted from the previous Node (CB-11) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed:



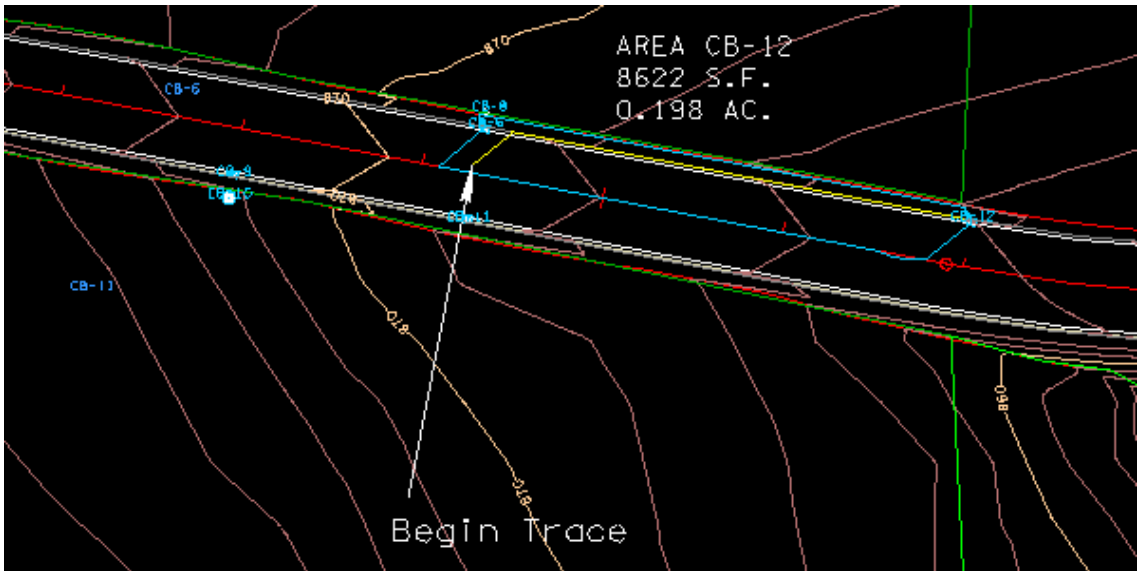
c) Click the **Apply** button to include this node in the Drainage Project.

5.24 Delineate Drainage Area CB – 12

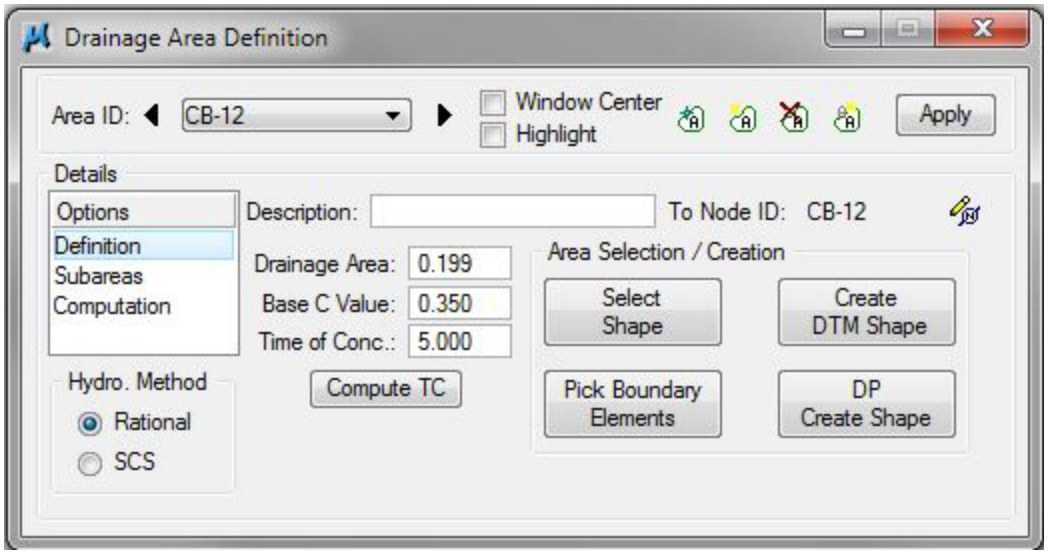
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-12** should automatically appear, click **OK**.

b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 12. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-12 and turn off DA_CB-11.

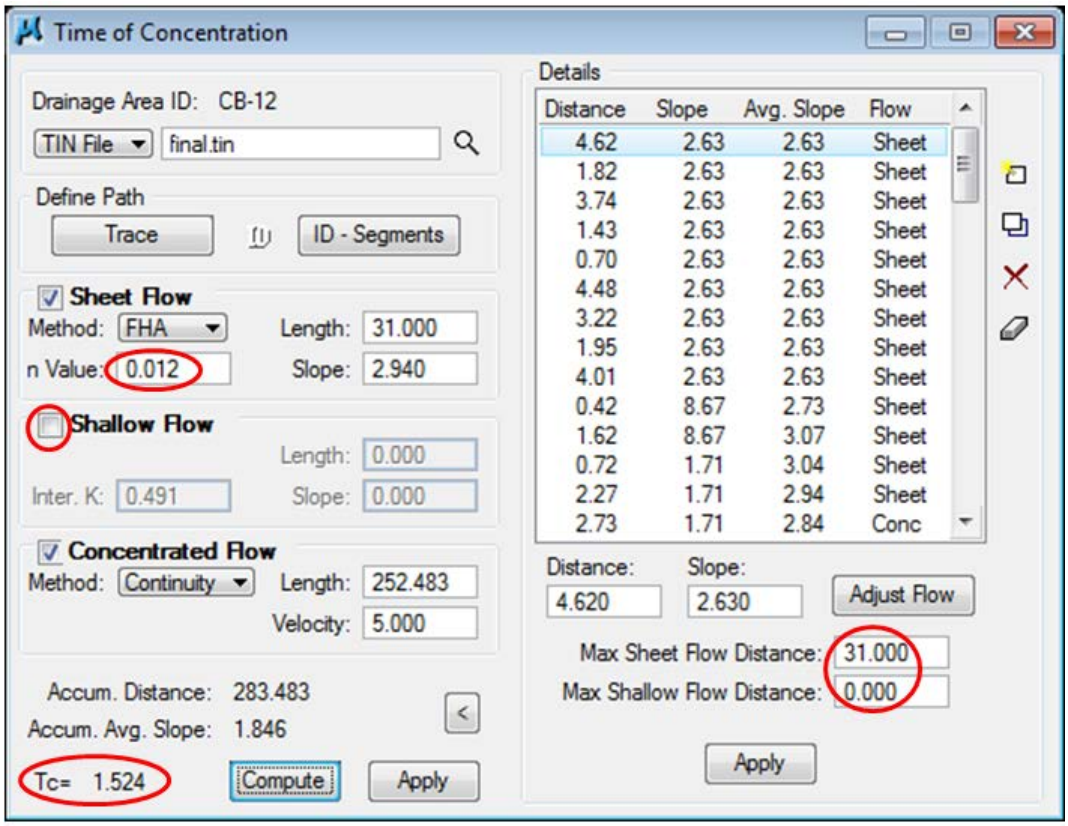
Delineate Drainage Area:



c) Define Drainage Area:



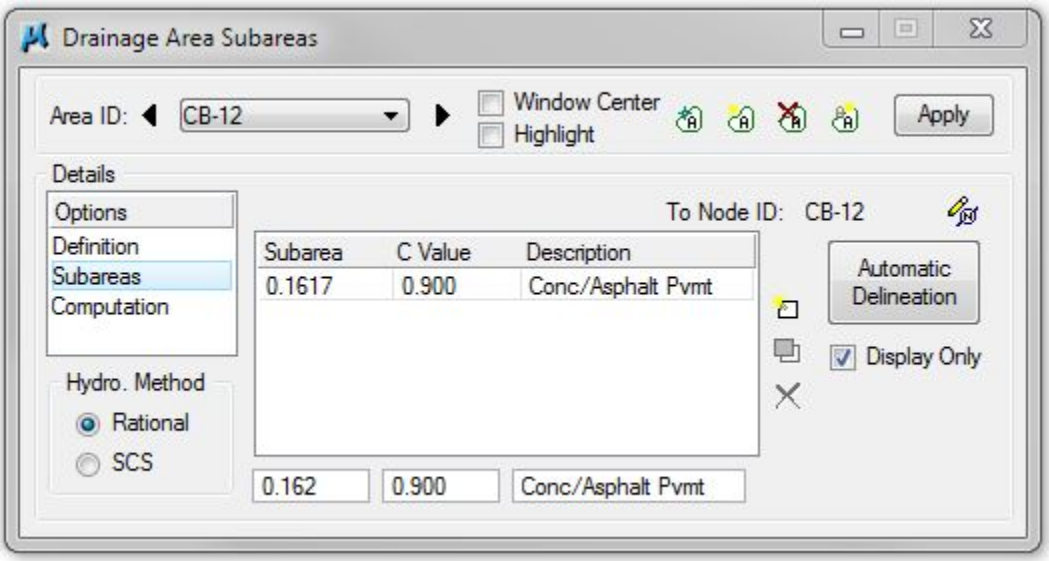
d) Calculate Time of Concentration:



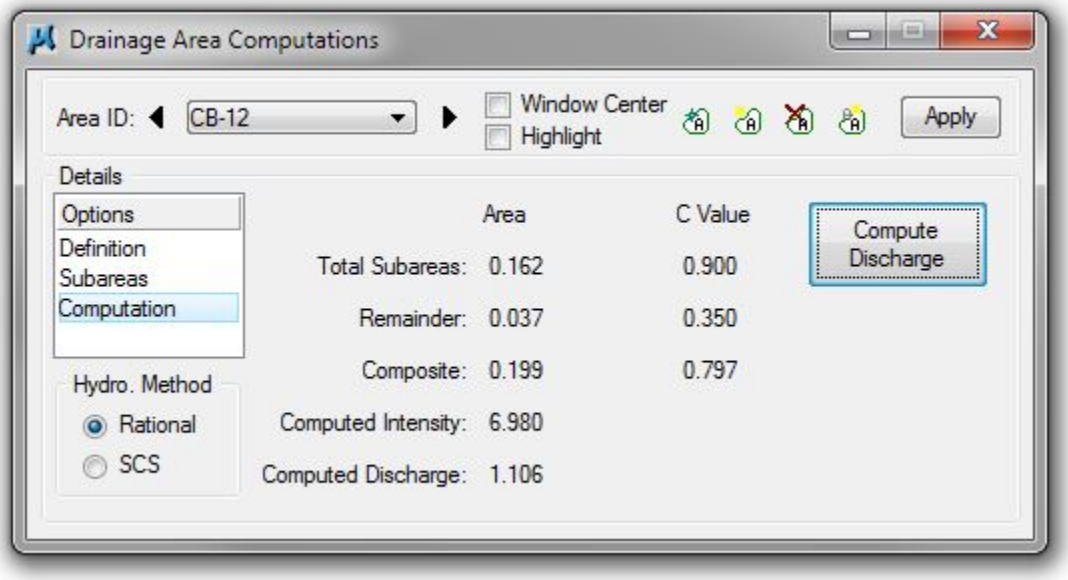
The calculated Time of Concentration is less than the minimum of 5 minutes, therefore **5 must be manually typed** in the Drainage Area Definition dialog after hitting apply in the Time of Concentration Window.

The maximum length for sheet flow has changed and will vary depending upon the drainage area. Max. Sheet Flow is 31 and Shallow Flow should be toggled off. The n value should be set to .012.

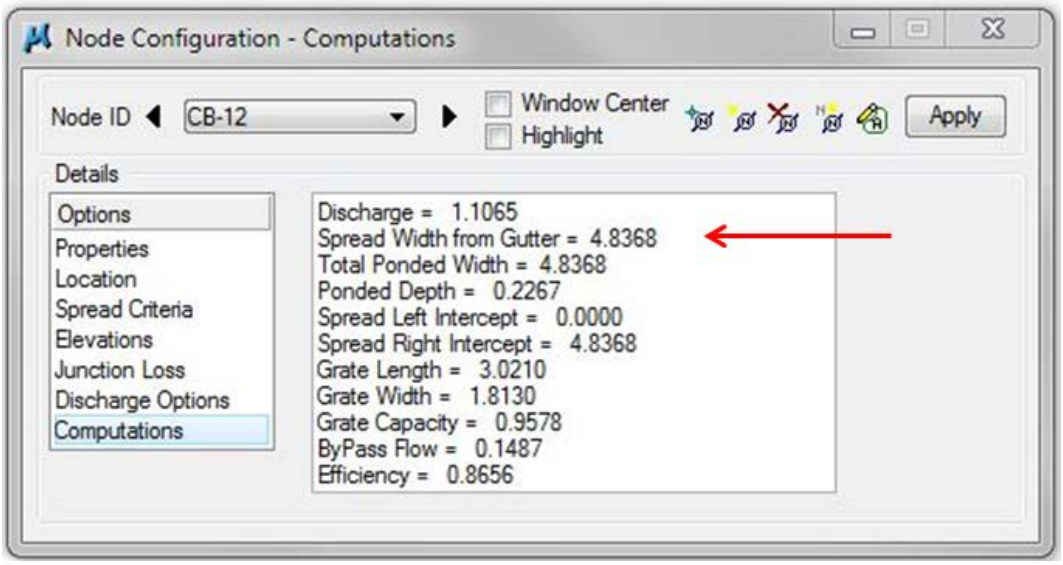
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

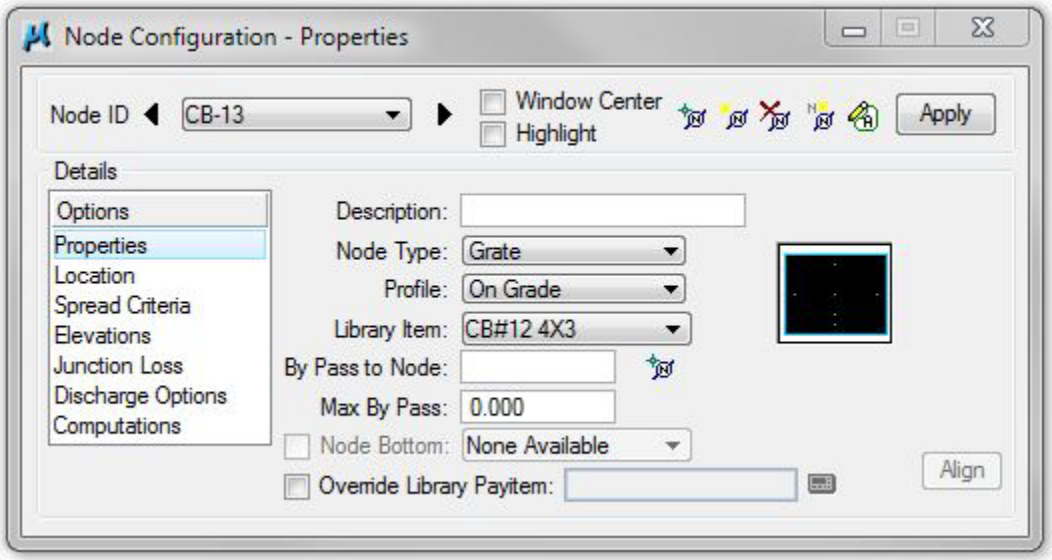
5.25 Design Inlet CB – 13

It has been determined that another standard **CB#12 4X3** will be used.

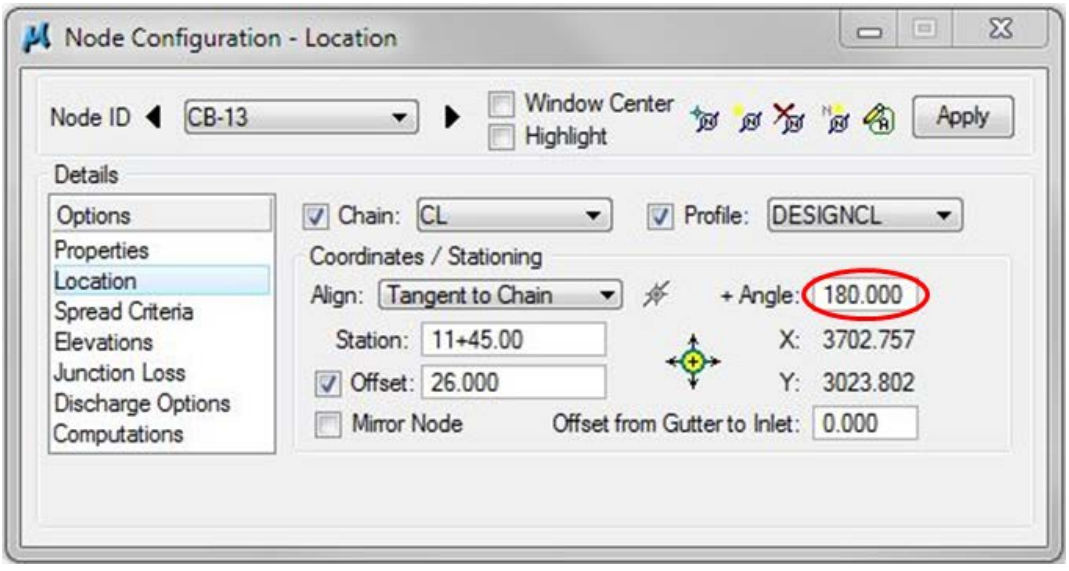
See Standard Drawing D-CB-12S for details.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-13

Properties > Verify the Node Properties are defaulted from the previous Node (CB-12) such that no user-input is required for this similar curb inlet.



b) **Location >** All Reference information is defaulted from the previous Node (CB-12) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. This station is not set equal to CB-12 due to changing super elevation shapes. After a few iterations this station was chosen in order to keep the spread within the limits. :



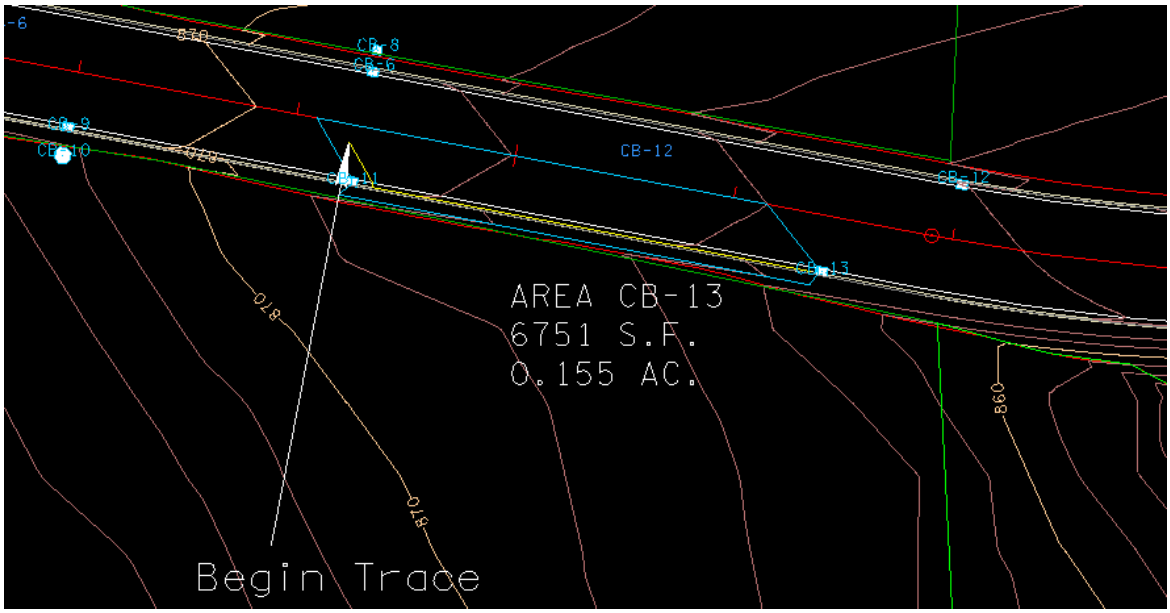
c) Click the **Apply** button to include this node in the Drainage Project.

5.26 Delineate Drainage Area CB – 13

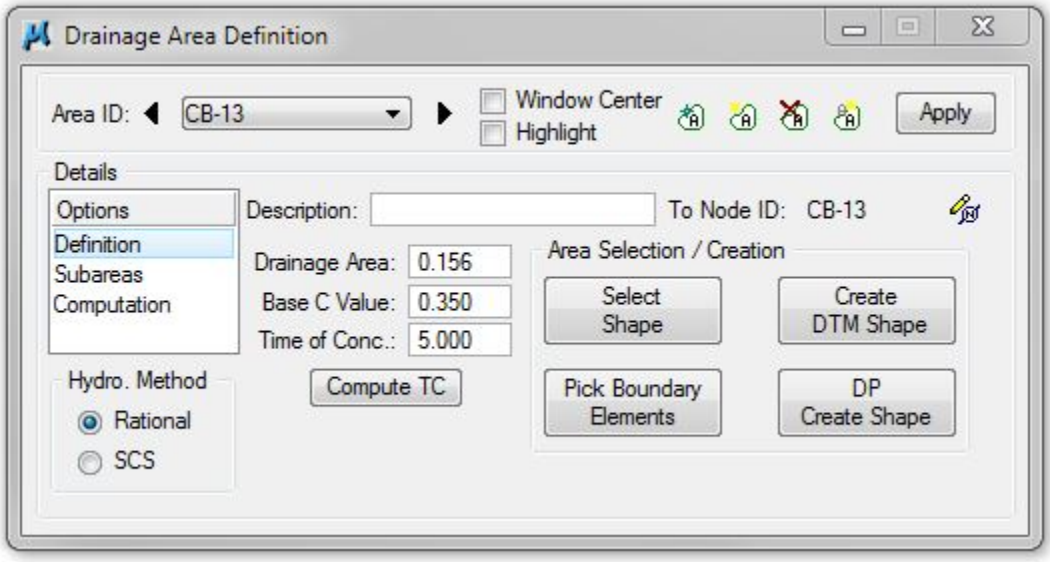
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-13** should automatically appear, click **OK**.

b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 13. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-13 and turn off DA_CB-12.

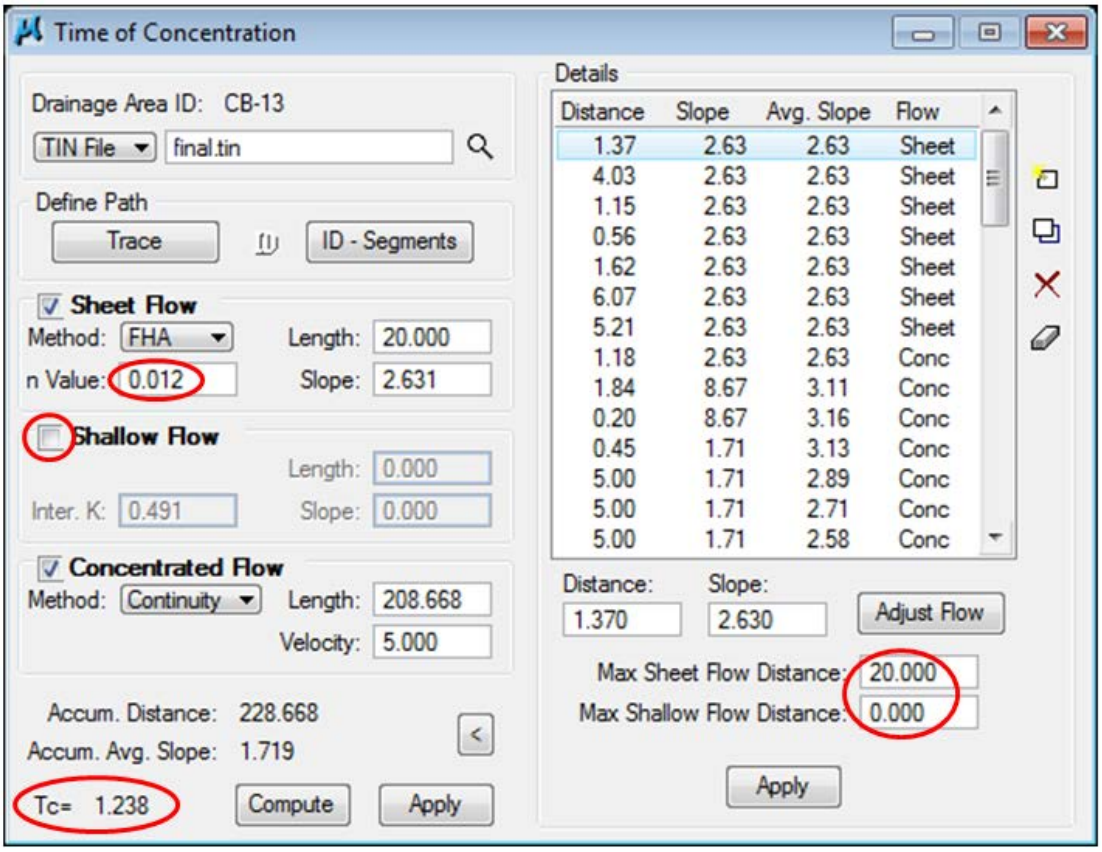
Delineate Drainage Area:



c) Define Drainage Area:



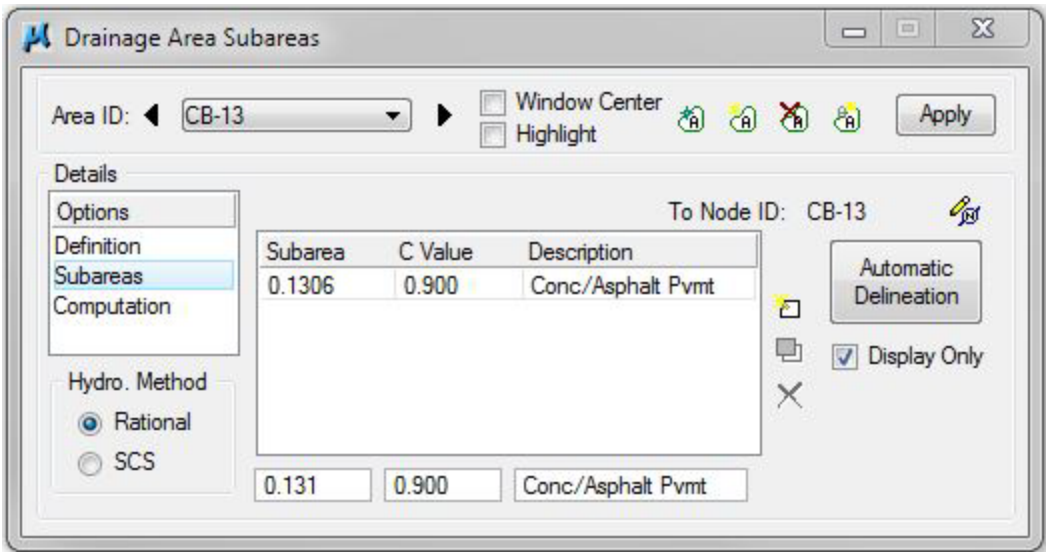
d) Calculate Time of Concentration:



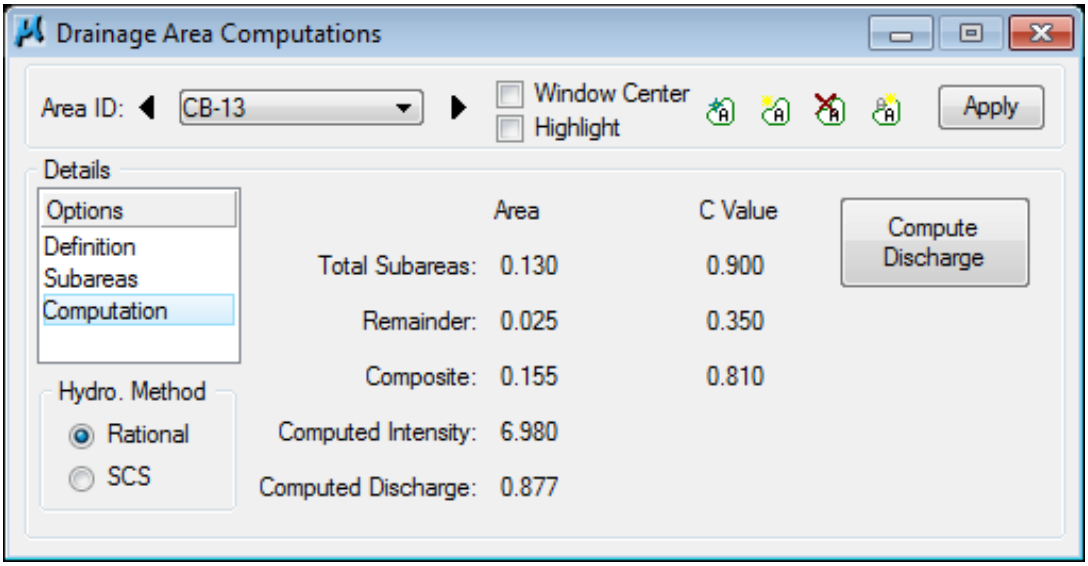
The calculated Time of Concentration is less than the minimum of 5 minutes, therefore **5 must be manually typed** in the Drainage Area Definition dialog after hitting apply in the Time of Concentration Window.

NOTE: Since the majority of flow is in the gutter (Concentrated Flow), we toggle off Shallow Flow and change Max Sheet Flow to 20. The n Value for Sheet flow changes to 0.012.

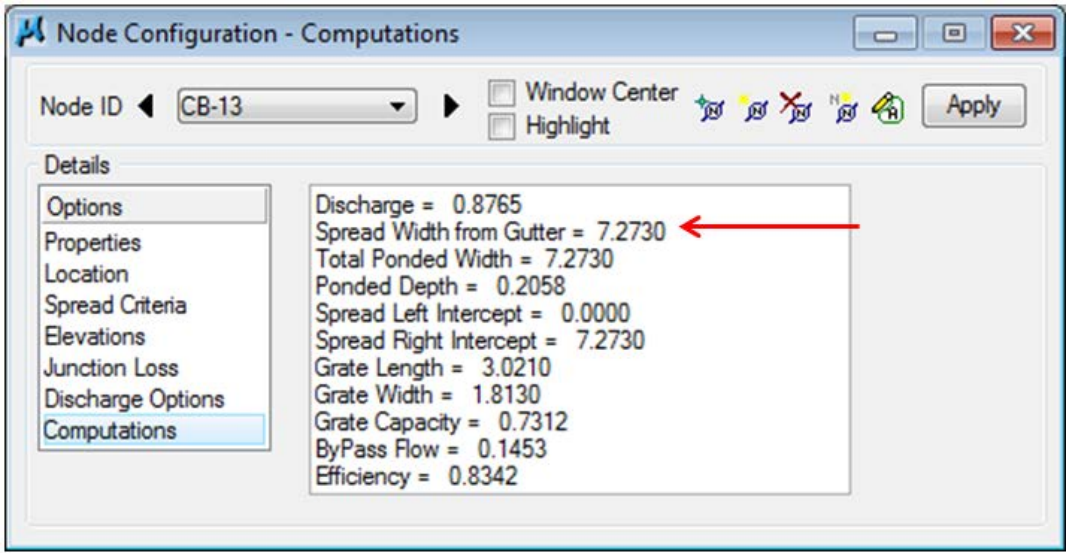
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

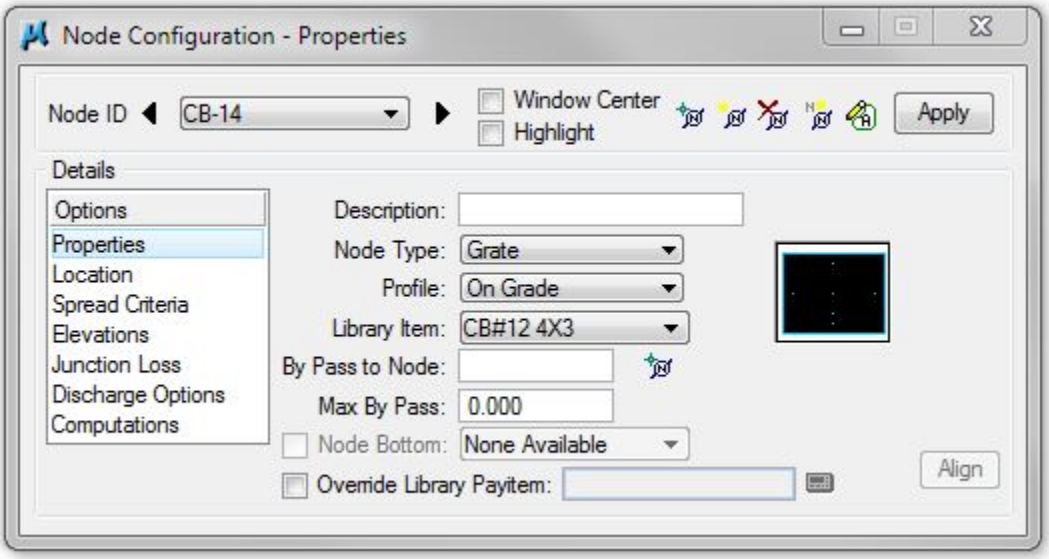
5.27 Design Inlet CB – 14

It has been determined that another standard **CB#12 4X3** will be used.

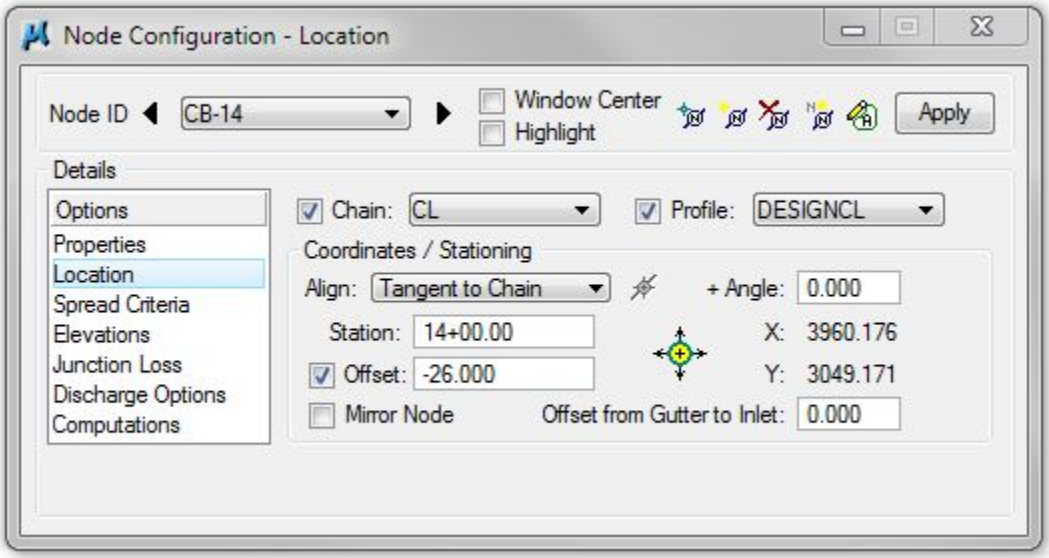
See Standard Drawing D-CB-12S for details.

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name CB-14

Properties > Verify the Node Properties are defaulted from the previous Node (CB-13) such that no user-input is required for this similar curb inlet.



b) **Location >** All Reference information is defaulted from the previous Node (CB-13) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. This station is chosen since it is on an even station and near where we want our outlet:



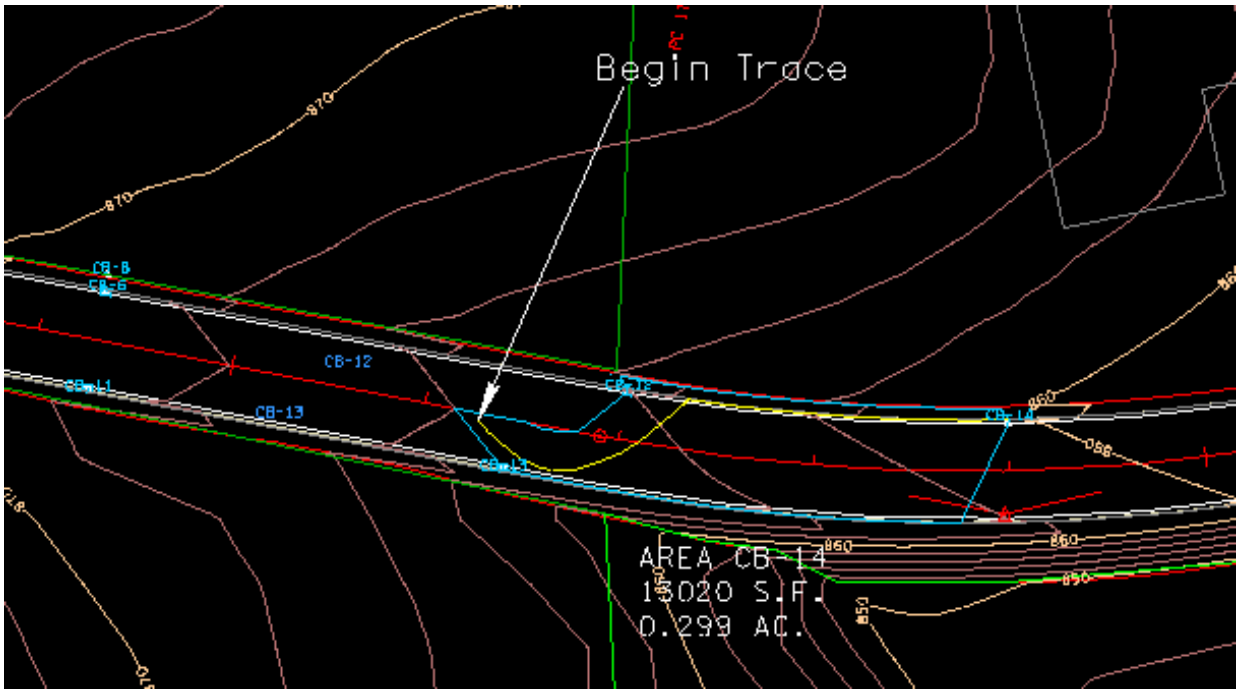
c) Click the **Apply** button to include this node in the Drainage Project.

5.28 Delineate Drainage Area CB – 14

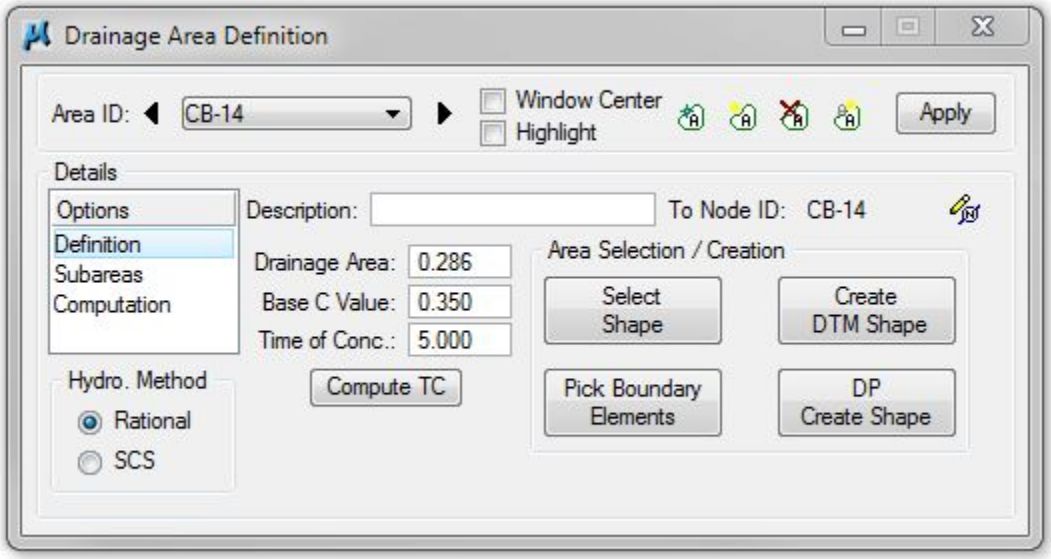
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **CB-14** should automatically appear, click **OK**.

b) Follow the steps in Exercise 3.2 to delineate and define the drainage area for Catch Basin 14. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_CB-14 and turn off DA_CB-13.

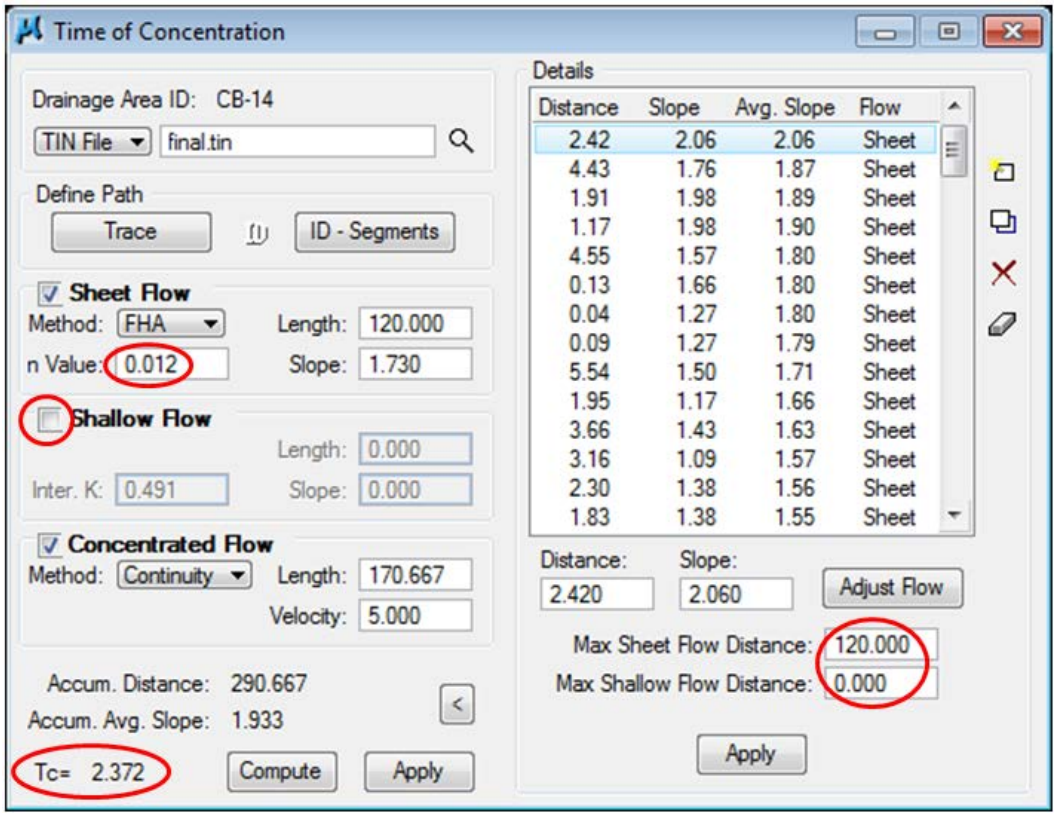
Delineate Drainage Area:



c) Define Drainage Area:



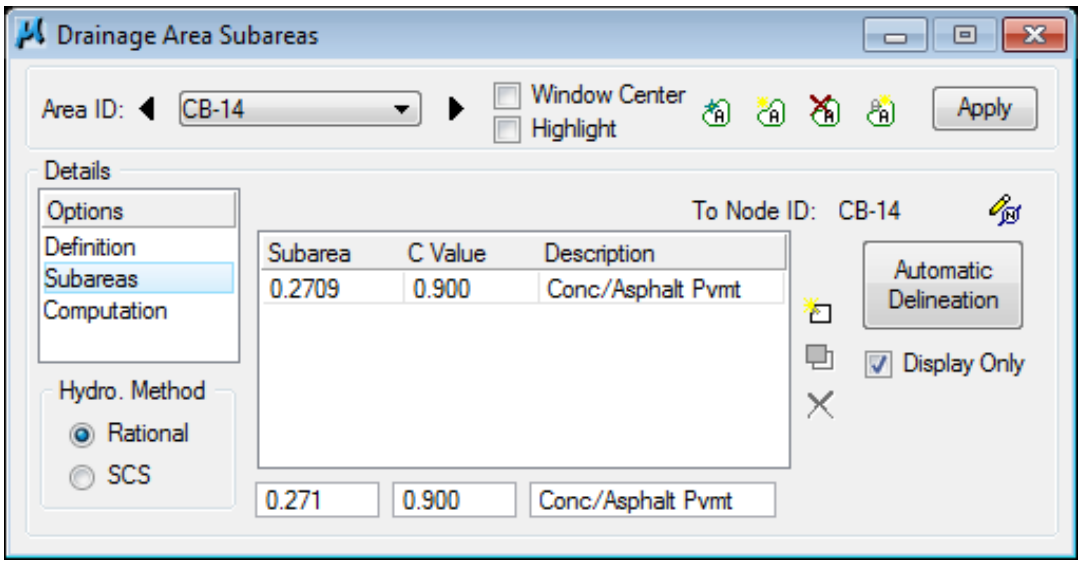
d) Calculate Time of Concentration:



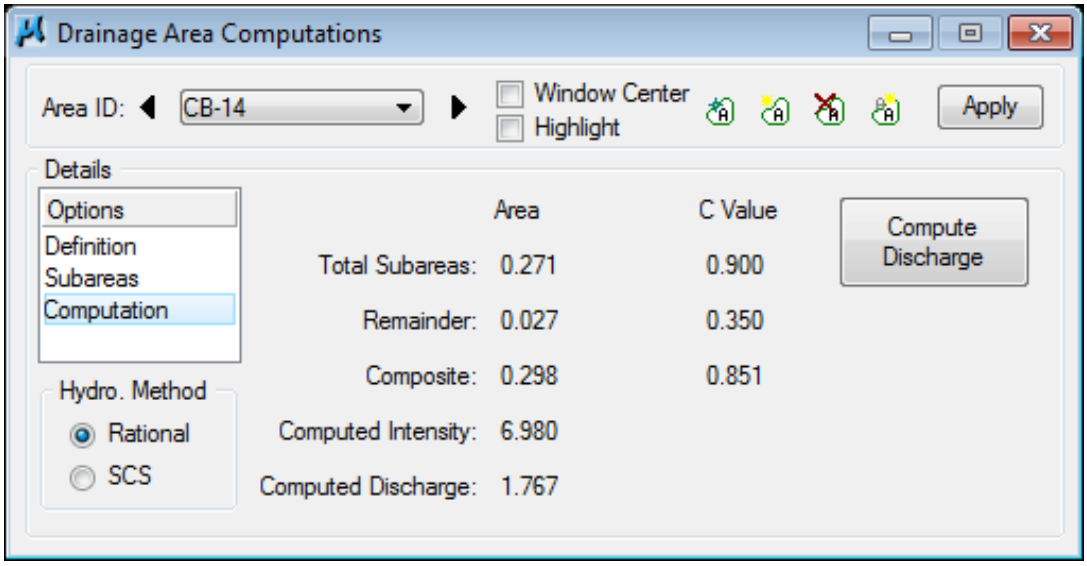
The calculated Time of Concentration is less than the minimum of 5 minutes, therefore **5 must be manually typed** in the Drainage Area Definition dialog after hitting apply in the Time of Concentration Window

NOTE: The maximum length for sheet flow has changed and will vary depending upon the drainage area. Change Max. Sheet Flow to 120 and leave Shallow Flow toggled off.

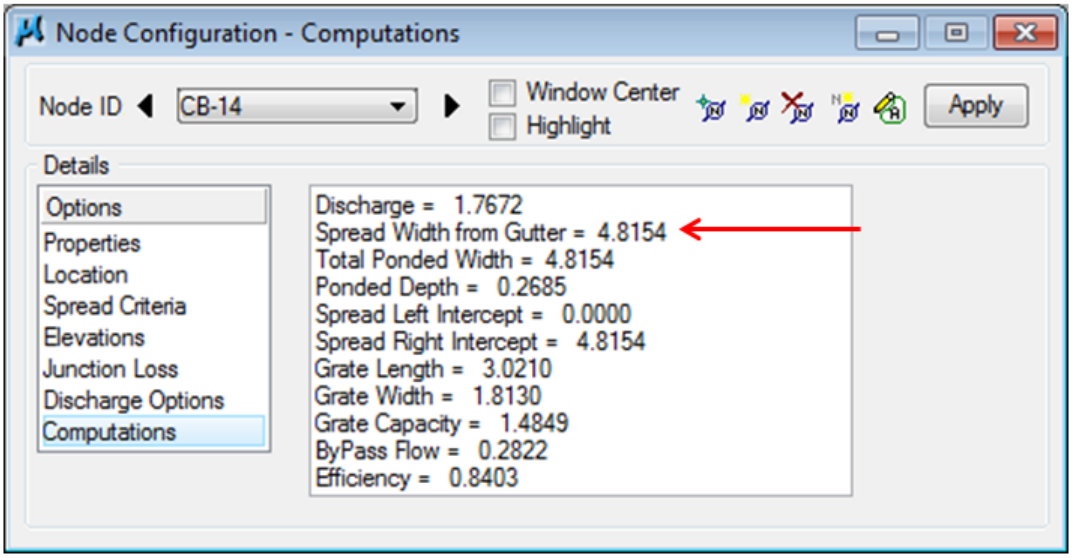
e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



g) Back in the **Node Configuration** dialog box click on **Properties**, then click again on **Computations**. This allows the program to update and run calculations. Review the Computations.



Don't be alarmed if your results are off by a few 100th's. It could just be a tolerance issue.

NOTE: Upon review of the computations the **Spread Width from Gutter** is within our limit of 8.0 feet, therefore the inlet is in good position.

This is the last catch basin in this network. The curb and gutter section continues and any ByPass will be caught by the next network. If this were not the case, we would need to take steps to capture or mitigate the ByPass Flow.

5.29 Design Junction MH-1

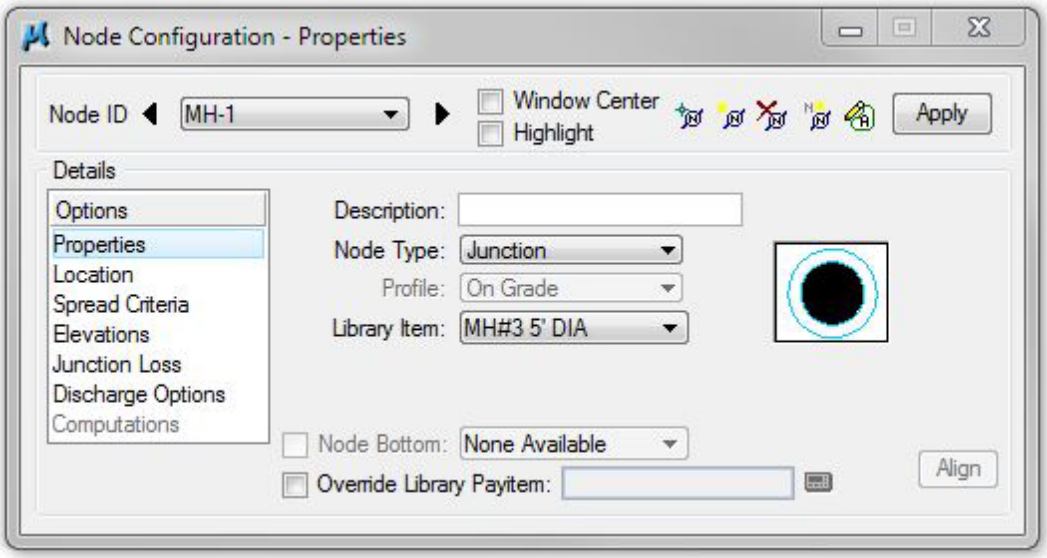
a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name MH-1

Properties > Make the following changes:

Node Type: Junction

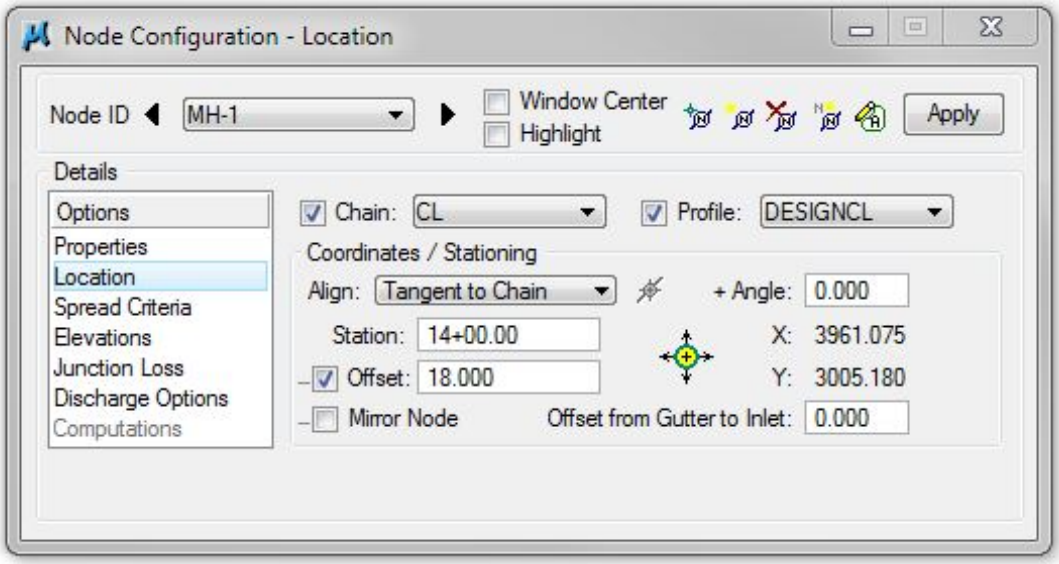
Library Item: MH#3 5' DIA

(See Standard Drawing D-MH-3 for details.)

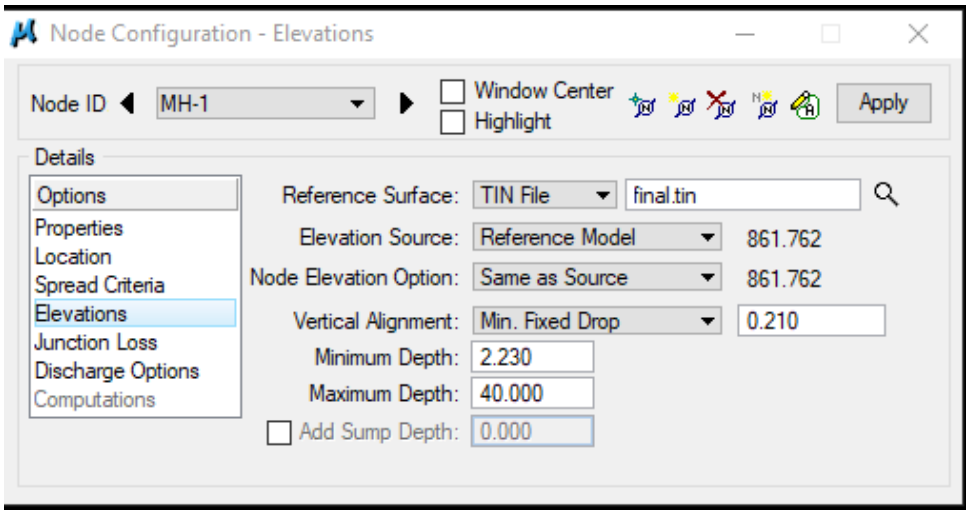


NOTE: A manhole is used at this location since; a junction is required, the superelevation of the roadway is such that there is little to no flow, and Junction Boxes are not allowed to be used under roadways.

b) **Location >** All Reference information is defaulted from the previous Node (CB-14) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. Be sure manholes are located out of wheel paths:



c) **Elevations >** Elevation Data must be changed to match a **MH#3 5' DIA**. From the TDOT GEOPAK Drainage Nodes Document set the following:



d) Click the **Apply** button to include this node in the Drainage Project.

Manhole:

Min. Depth of Basin – Pipe Size – Drop Across Bottom of Structure = Minimum Depth

MH#3 5'DIA: 3.94' - 18"/12 - 0.21' = 2.23'

NOTE: See Appendix A, pg. A-5

5.30 Design Outlet EW-1

a) Select from the Main Menu Bar: **Component > Node > Add**; or from the Main Toolbar: **Add Drainage Node**; or click the **Add Node** button within the Node Configuration Dialog. Click **OK** to set the name EW-1

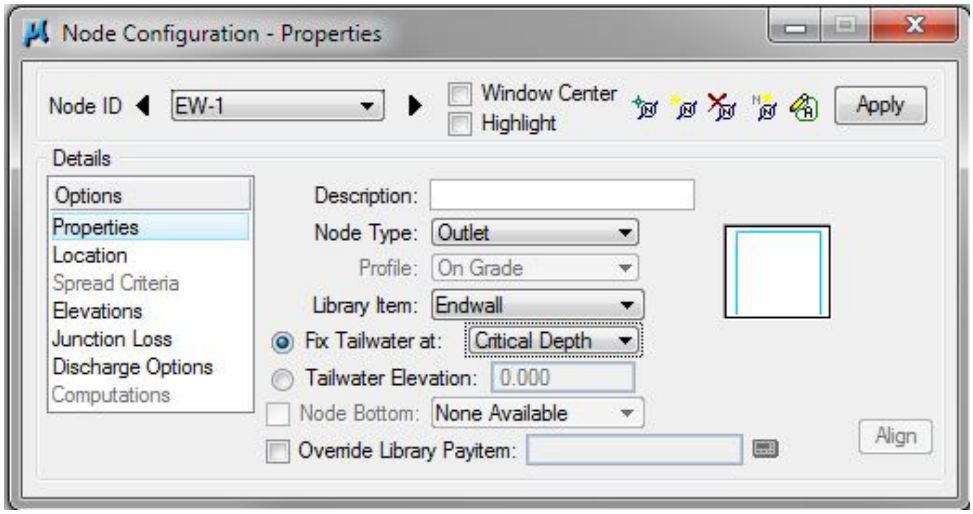
Properties > Make the following changes:

Node Type: Outlet

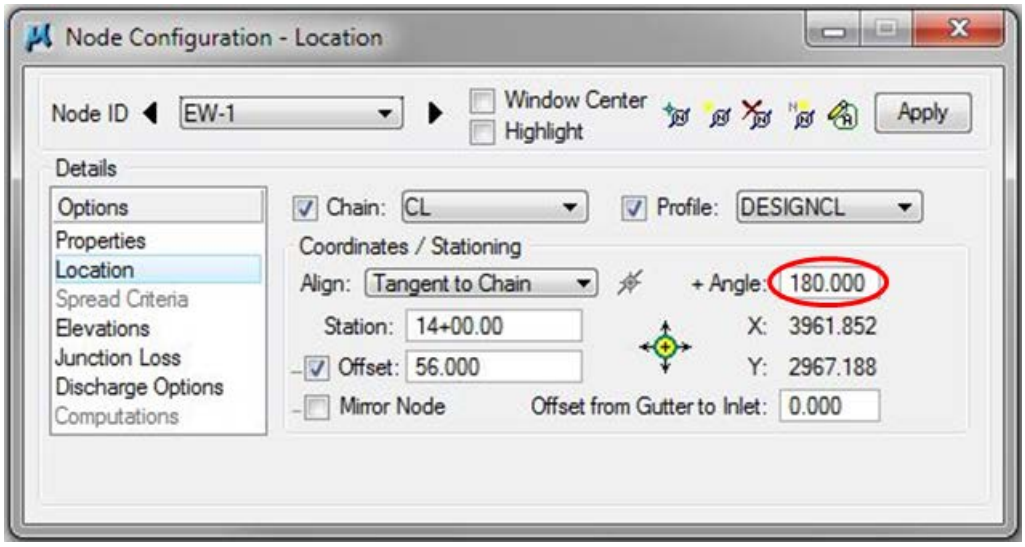
Library Item: Endwall

Fix Tailwater at: Critical Depth

Other Tailwater options are: Uniform Depth, Soffit (Top of pipe), or Elevation: User input (known elevation)



b) Location > All Reference information is defaulted from the previous Node (CB-14) such that only the **+ Angle**, **Station** and the **Offset** needs to be changed. Angle is critical as to direction node will be displayed.

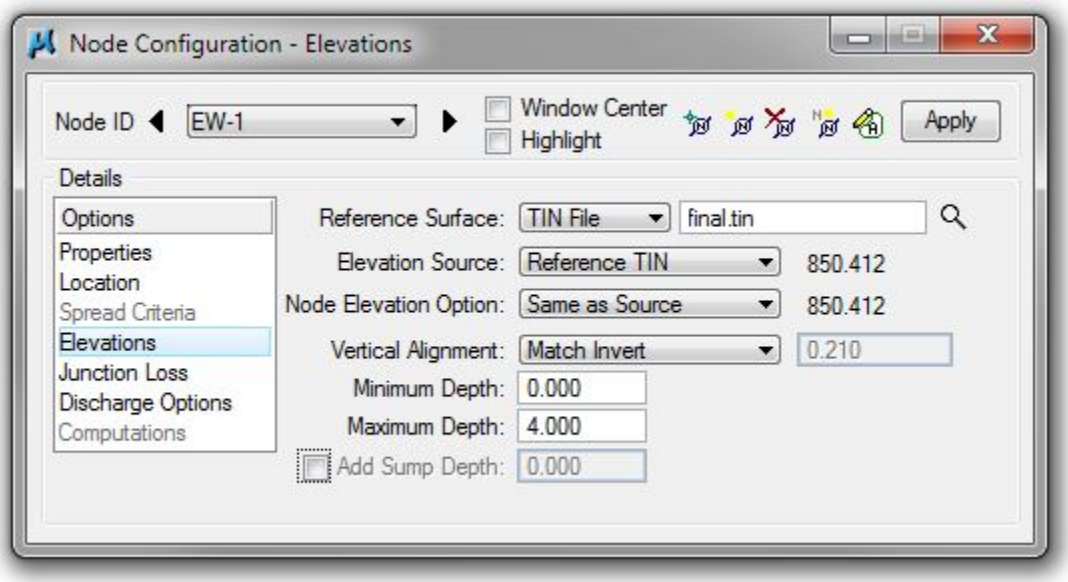


c) Elevations > Change the Elevation data to the following:

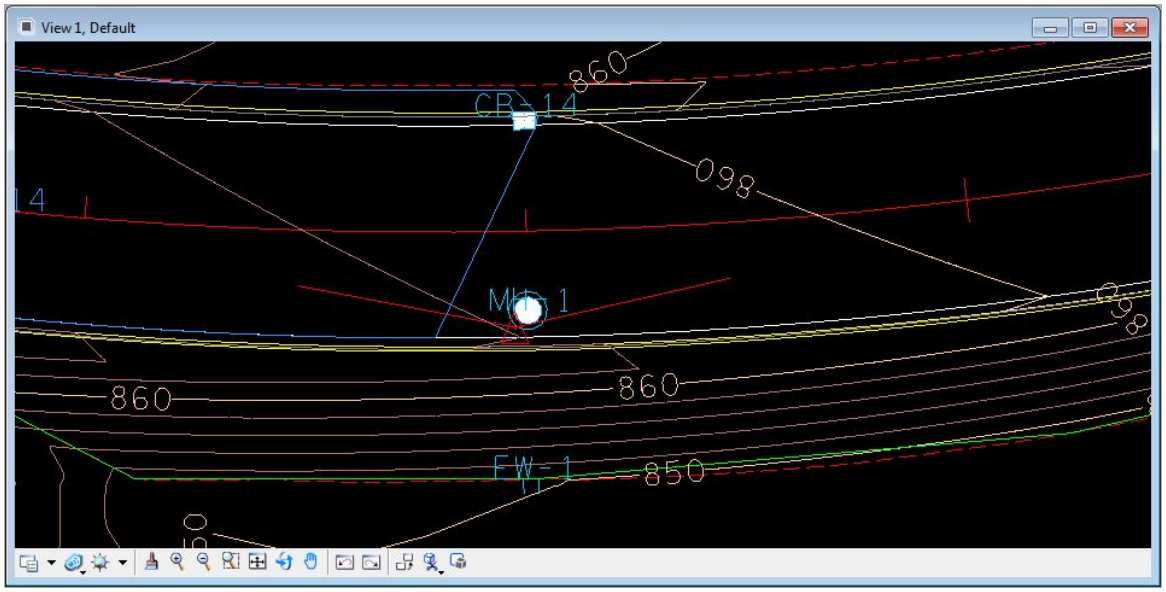
Vertical Alignment: Match Invert

Minimum Depth: 0.000

Maximum Depth: 4.000



NOTE: This is a preliminary location used to determine outlet elevation, etc. This node will need to be adjusted to account for the side slope, endwall, velocity, and the final pipe size which is designed.

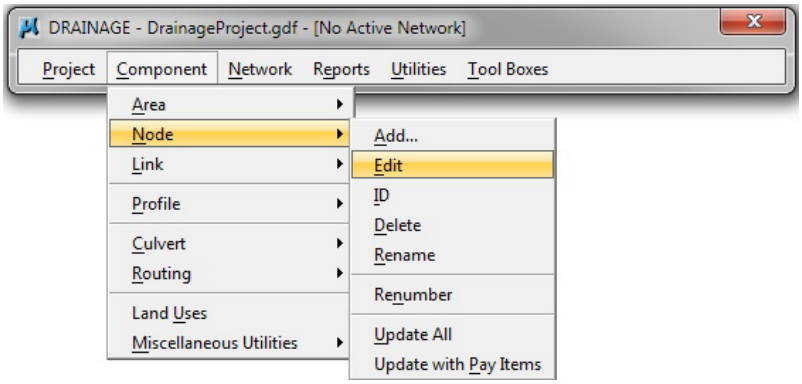


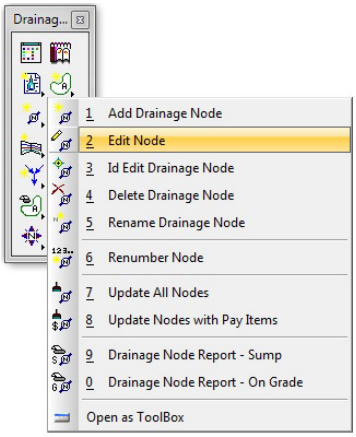
d) Click the **Apply** button to include this node in the Drainage Project.

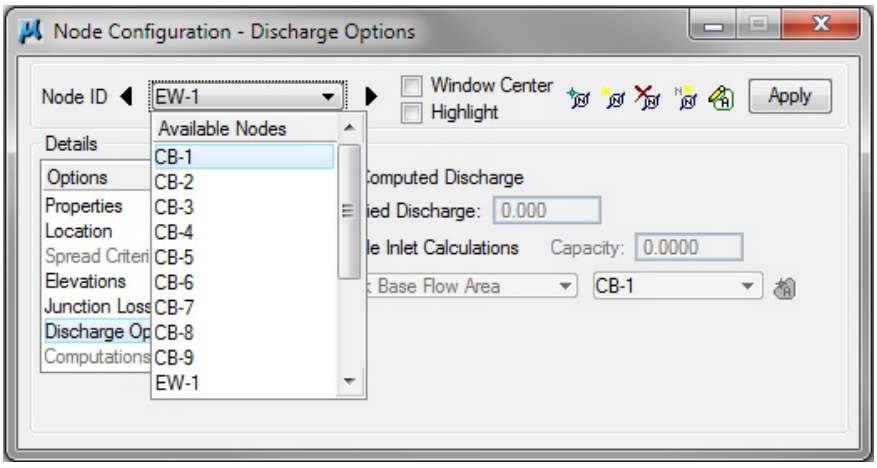
5.31 Inlet Bypass

Set the Inlet bypass as required to bypass flow to the downstream inlets.

a) Select **Component > Node > Edit** or choose from the Tool Box and use the drop-down menu to select CB-1.

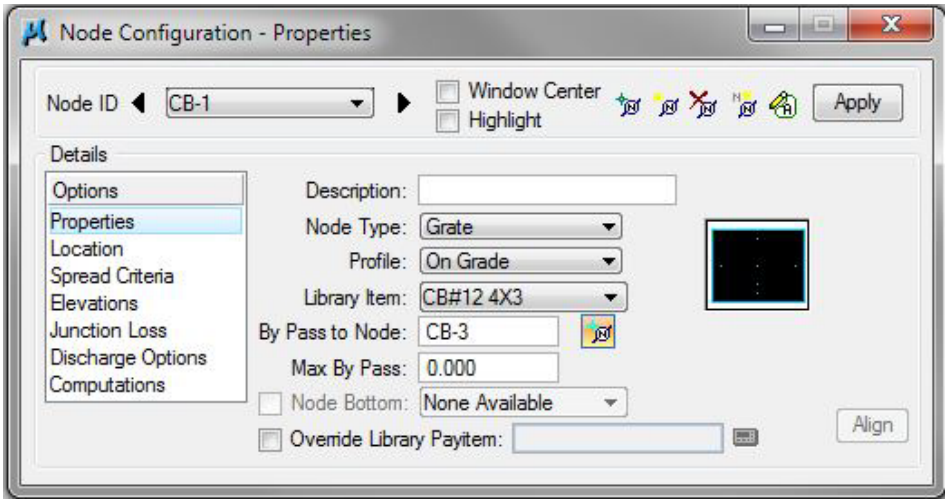




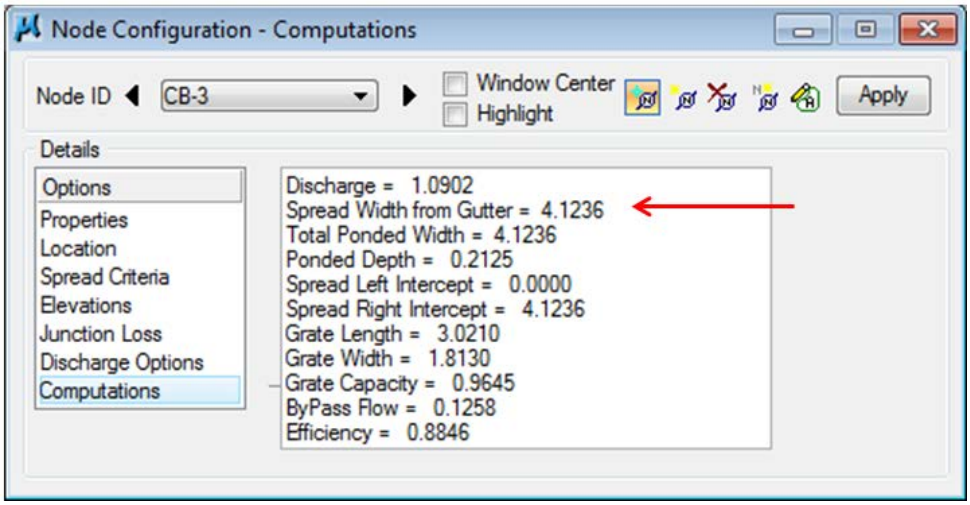


b) **Properties >** Keyin the **By Pass to Node** as CB-3 or click the **ID** button and data point on the node in the plan view.

The Bypass flow from this inlet will then contribute its resulting bypass flow to CB-3. Click the **Apply** button to accept the changes.



c) Select **CB-3**, **Computations >** Review the computations to make sure the spread is still within the design limits.



d) Follow the same procedures to bypass the remaining flow to the inlets as described in the table below:

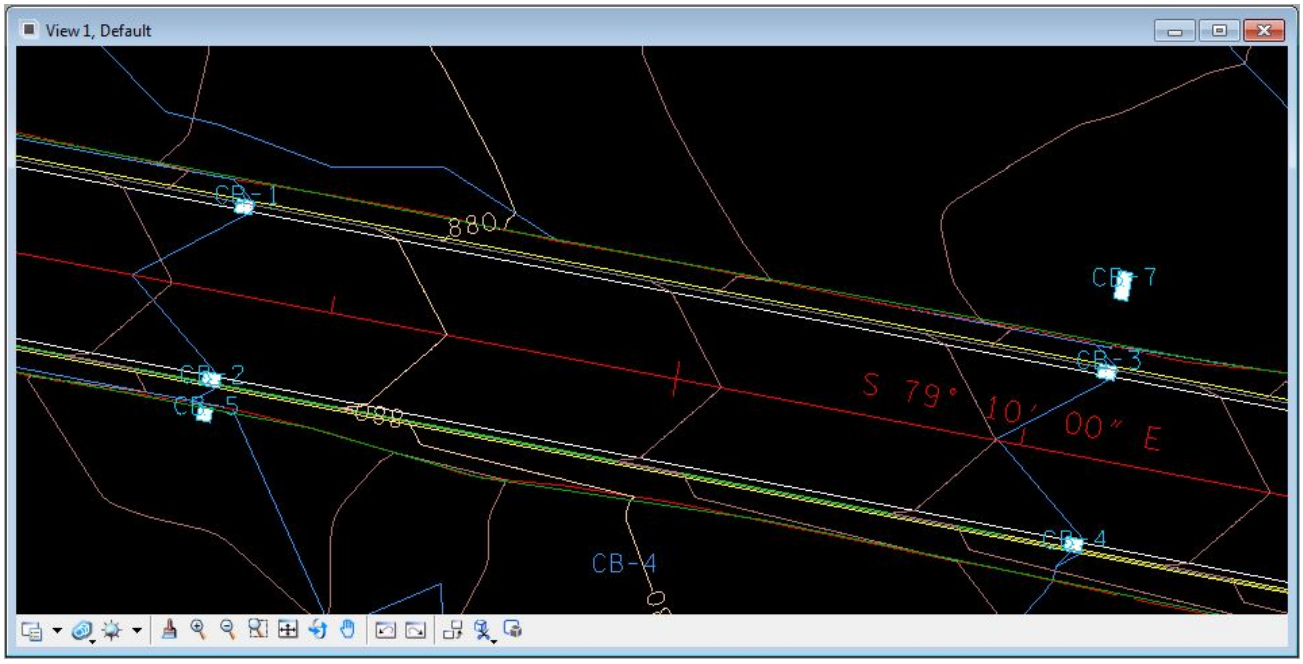
Node ID	By Pass to Node	Spread Width	
		Before Bypass	After Bypass
CB-2	CB-4	6.0289	7.1331
CB-3	CB-6	5.5181	5.8409
CB-4	CB-9	4.0723	6.1784
CB-6	CB-12	4.8368	5.6188
CB-9	CB-11	1.7590	3.1144
CB-11	CB-13	7.2730	7.5241
CB-12	CB-14	4.8154	5.1393
CB-13	CB-14	5.1393	5.3333

6. Storm Drainage Links

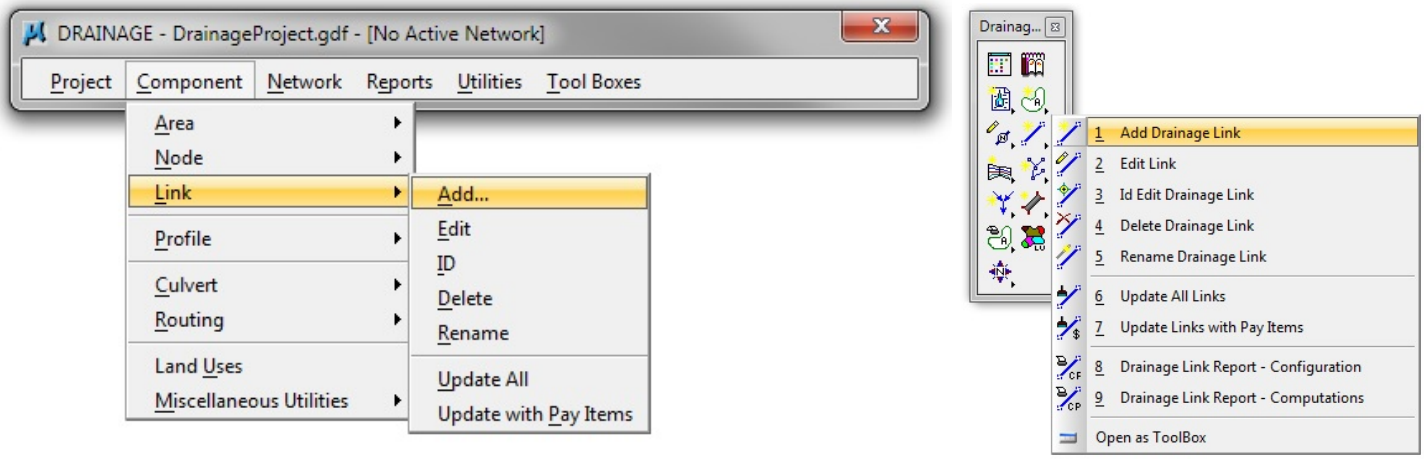
This exercise shows the user how to utilize the tools necessary for connecting the surface drainage (inlets) to the collection system (pipes). The user will design the storm drainage pipes for this project.

6.1 Link Design

a) Visually determine the tentative location of the first storm drainage pipe. This link will connect Nodes CB-1 and CB-3.



b) Select from the Drainage Menu Bar: **Component > Link > Add** or from the main toolbar: **Add Drainage Link***:*

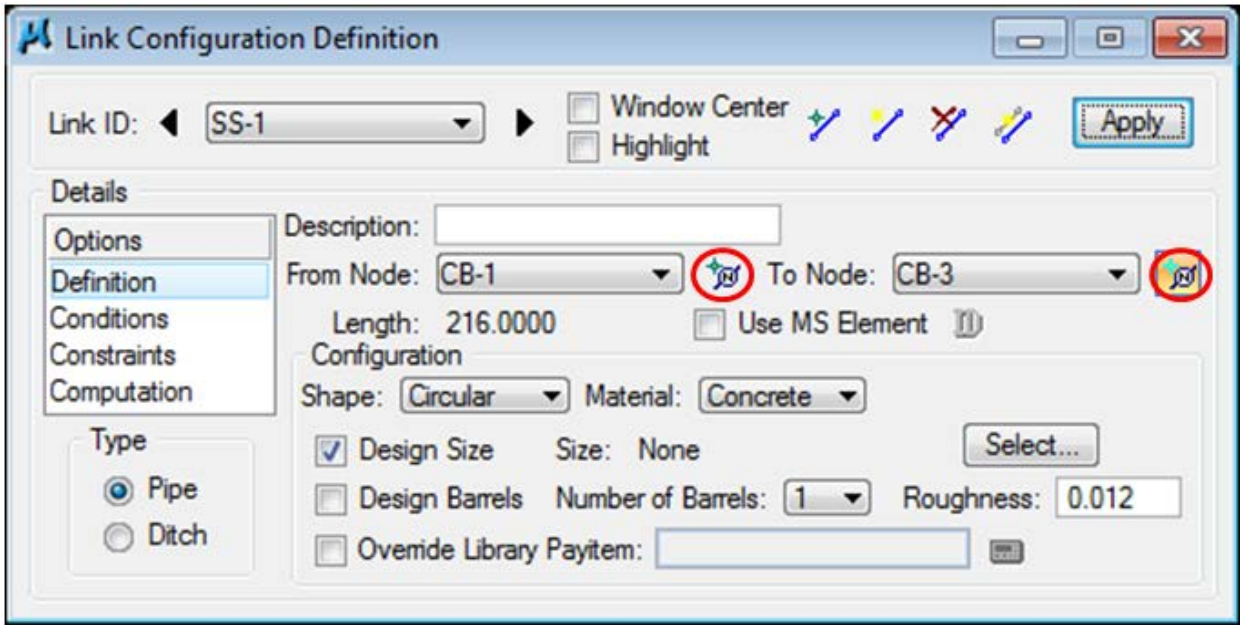


c) In the **New Link** window that appears, click OK to set the name **SS-1**

d) **Definition >** This dialog sets the pipe configuration including: From Node, To Node, Shape, Material, Library Item, etc.

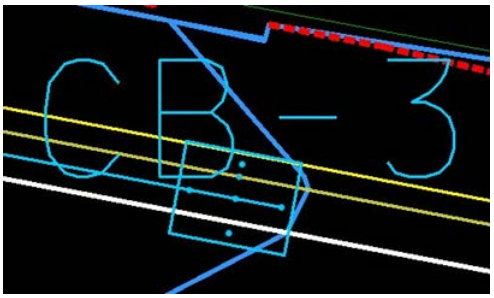
There are two ways to set the Nodes: from the dropdown list or graphically selecting the Nodes. Graphically is recommended to ensure the correct pipe connection points are utilized. See note concerning these on the next page.

To select graphically click the ID button for each and identify the correct Node. SS-1 traverses **From Node** CB-1 **to Node** CB-3:

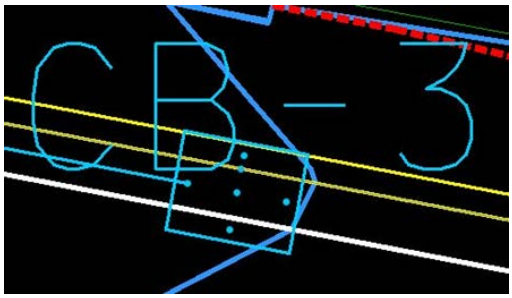


NOTE: All drainage nodes include pipe connection points on the structures (for circular structures there are NOT single points but an entire circle for connection). When a drainage node is identified for connection it will use the nearest face to the identification Data Point. **Therefore it is important to Zoom in close enough to drainage nodes and identify them at the correct connection point of the structure.** Correct and Incorrect examples are shown below.

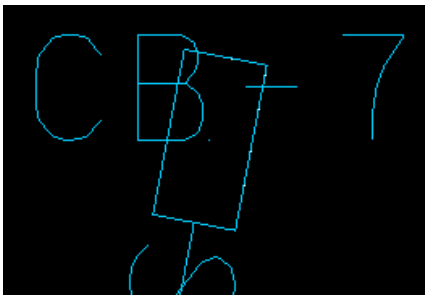
INCORRECT

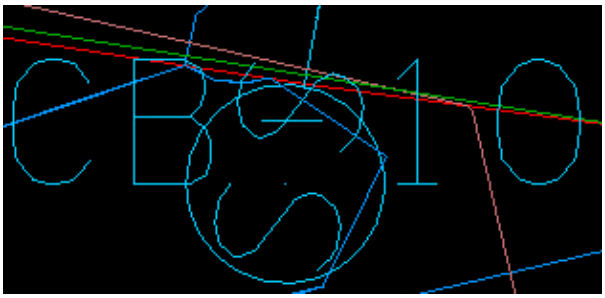


CORRECT



The symbolization for drop inlets display the full extent of the sub-structure as opposed to the normal smaller symbol used for curb and gutter inlets. This is done so that the designer can ensure adequate R.O.W. or easement is provided. For this reason you will **not** see the pipe connection points for these structures since they coincide with the structure wall as shown below.





e) Set the remaining Link Configurations as follows:

Shape: Circular

Material: Concrete

Design Size: Toggle ON

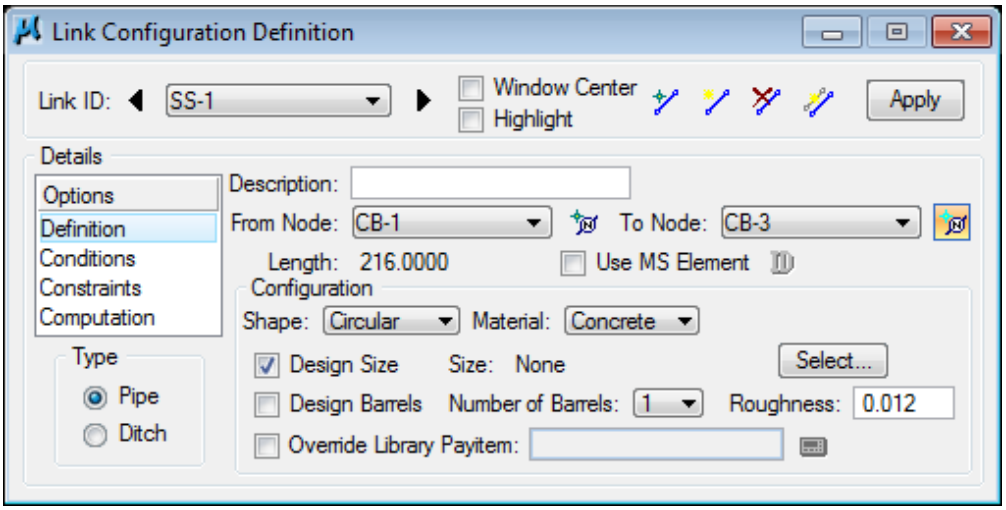
Design Barrels: Toggle OFF

Number of Barrels: 1

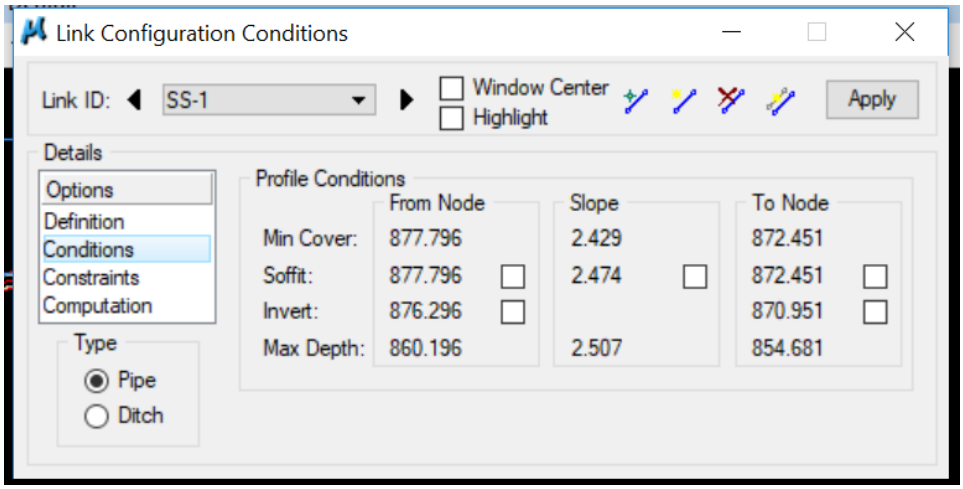
Roughness: Automatically set based on the selected Material

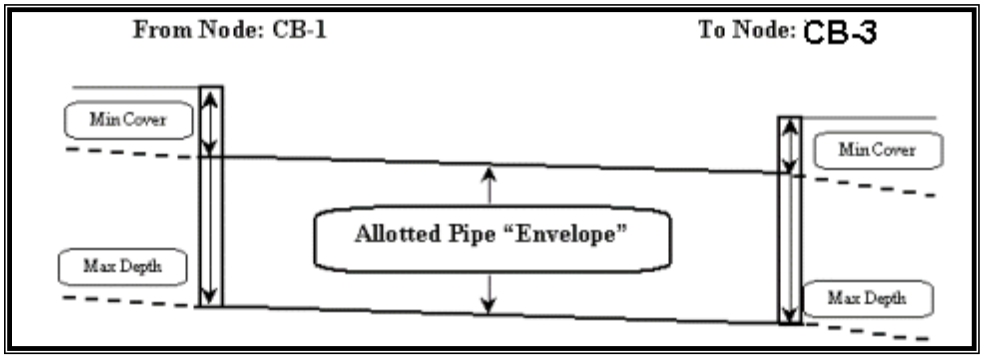
NOTES:
Multiple barrels could be designed, if required, by toggling **Design Barrels** ON or setting **Number of Barrels** to the determined number.

If the link size is known, it may be input by toggling **Design Size** OFF and clicking on the **Select…** button.



f) Conditions > The elevations shown are based on the Node Elevation minus the min/max depth. These depths were specified in the **Node Definition** (See Exercise 5) Dialog Box for Nodes CB-1 (From Node) and CB-3 (To Node) respectively. In this case, no entries are necessary and GEOPAK Drainage will design all the profiles for this project.





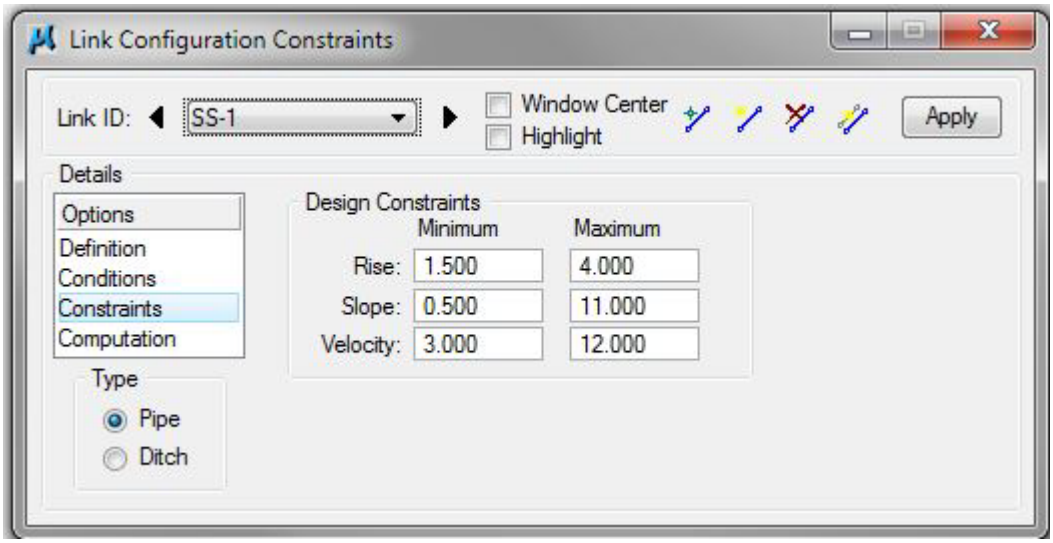
NOTE: When **manually** defining Invert elevations for links, make sure the drop across a structure is accounted for. In other words, if you were to define the Invert elevations for Links SS-1 and SS-3 at CB-3, then make sure the **From Node Invert e**levation for Link SS-3 is at least the minimum drop lower than the **To Node Invert** elevation for Link SS-1.

g) Constraints > Establish the min/max design criteria for Links as follows:

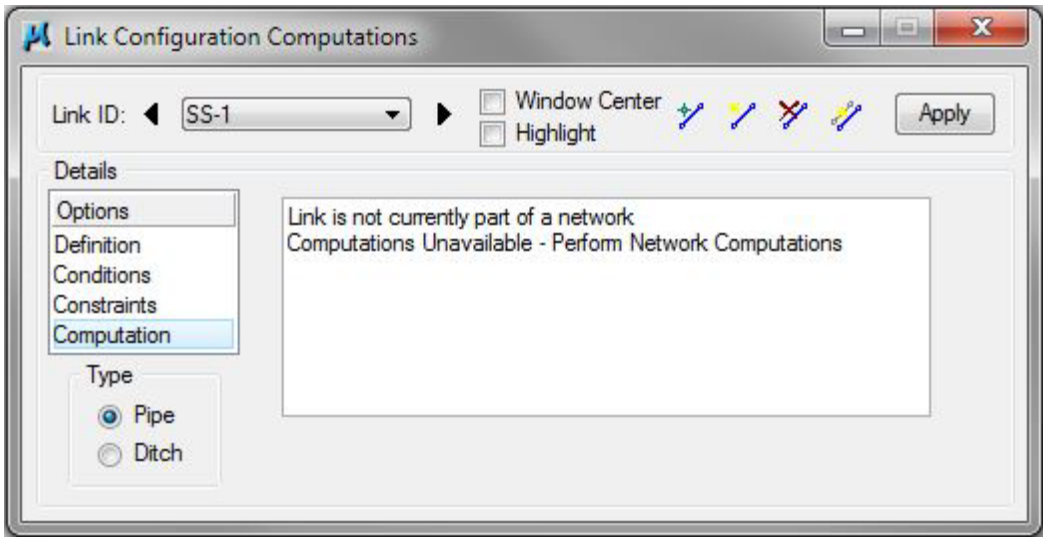
Rise Min/Max: 1.5 / 4.0 (feet)

Slope Min/Max: 0.50 / 11.00 (%)

Velocity Min/Max: 3.00 / 12.00 (fps)



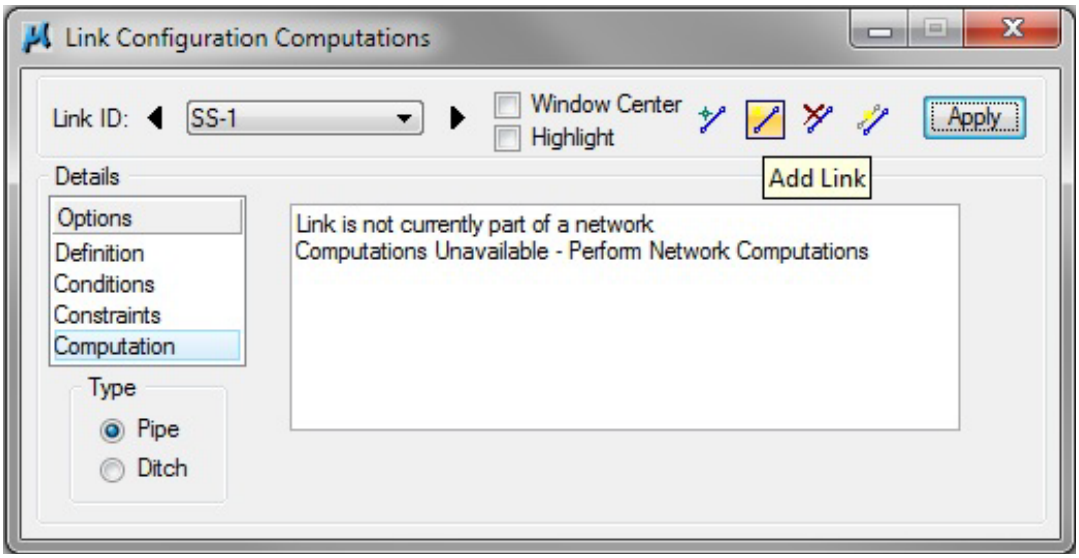
h) Computations > Displays the computed hydraulic properties of the Link.



NOTE: Link hydraulics are not available for review until a Network has been established and designed or analyzed successfully (See Exercise 8). Check back here for computations after the Network has been added and designed or analyzed.

i) Click the **Apply** button to include this Link in the drainage project.

j) **Add** the remainder of the link conveyance system using **Component > Link > Add** from the Drainage Menu Bar or by clicking the **Add Link** button as shown below.



As Links are added, most dialog values default from the previous Link with the exception of **From Node** and **To Node**. Add Links between all of the following Nodes:

Link SS-2 Traverses From Node CB-2 To Node CB-4
Link SS-3 Traverses From Node CB-3 To Node CB-6
Link SS-4 Traverses From Node CB-4 To Node CB-9
Link SS-5 Traverses From Node CB-5 To Node CB-2
Link SS-6 Traverses From Node CB-6 To Node CB-12
Link SS-7 Traverses From Node CB-7 To Node CB-3
Link SS-8 Traverses From Node CB-8 To Node CB-6
Link SS-9 Traverses From Node CB-9 To Node CB-11
Link SS-10 Traverses From Node CB-10 To Node CB-9
Link SS-11 Traverses From Node CB-11 To Node CB-13
Link SS-12 Traverses From Node CB-12 To Node CB-14
Link SS-13 Traverses From Node CB-13 To Node MH-1
Link SS-14 Traverses From Node CB-14 To Node MH-1
Link SS-MH1 Traverses From Node MH-1 To Node EW-1

**** See notes on next page ****

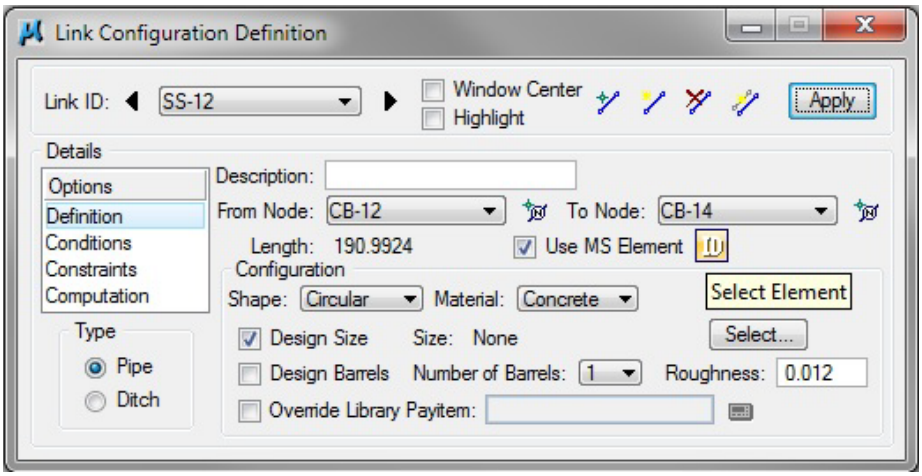
6.2 Curved Links

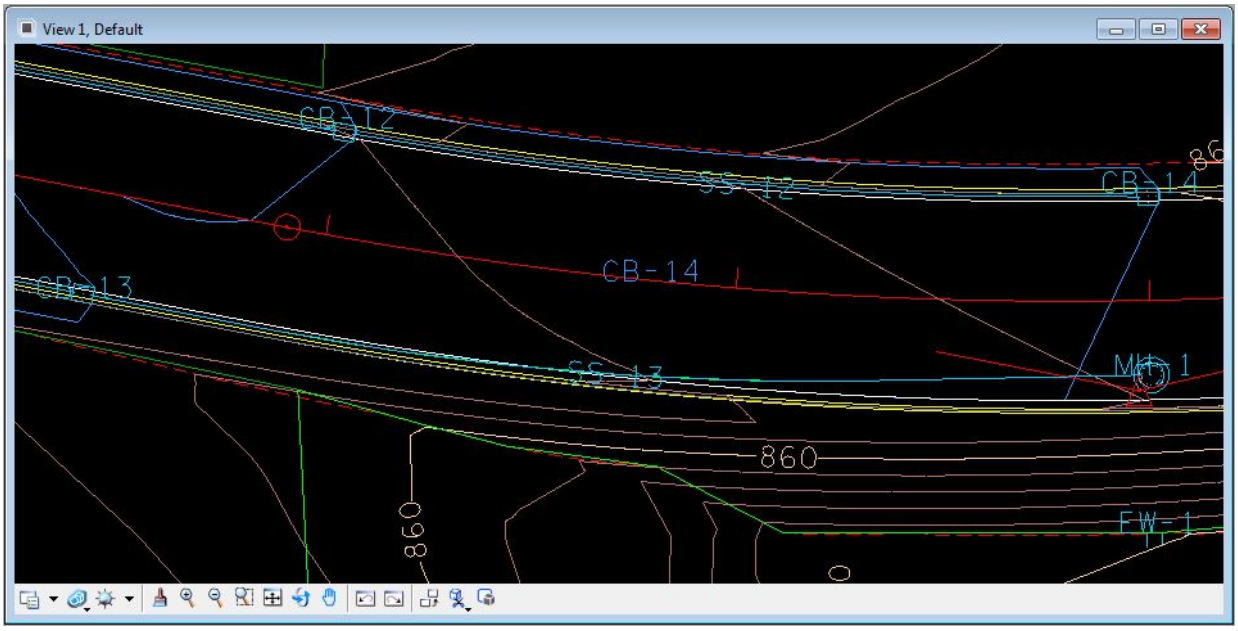
a) Use MicroStation's Place Arc Tool and use the settings 'Method: Start, Mid, End' to draw a curved element (must be a continuous line string) between the nodes and following the middle of the gutter to the extent possible.

NOTE: Make sure the ends of the MicroStation Element terminate at the correct attachment point on the catch basin.

b) In the **Link Configuration Definition** dialog **toggle ON Use MS Element.**

c) Click the Select Element button then Data Point on the element created in **Step a).** Then click **Apply**.



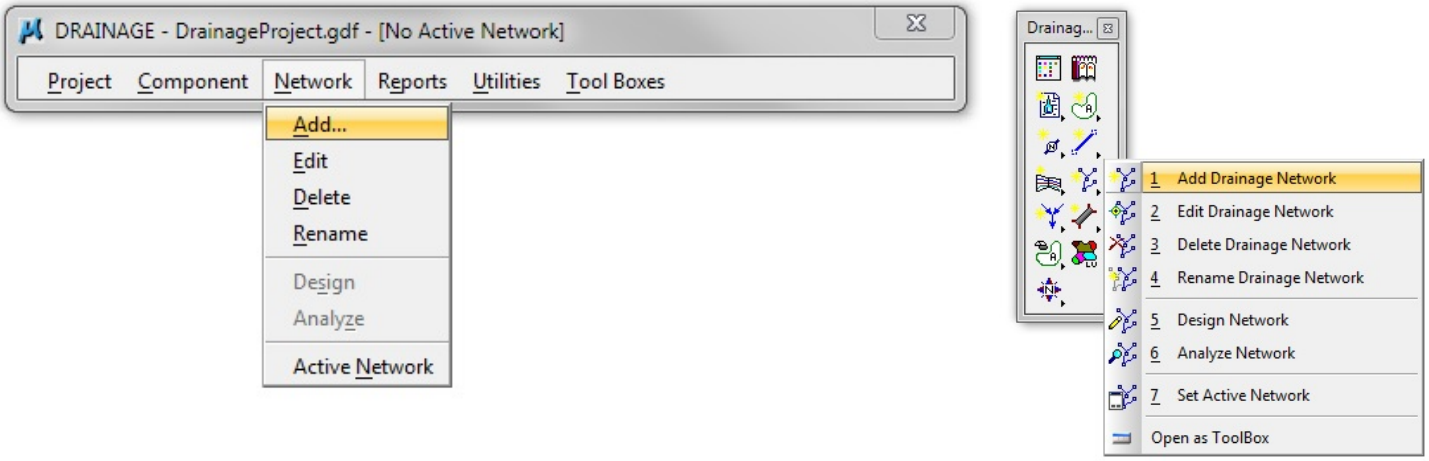


Link SS-13 is created in the same manner, from CB-13 to MH1

NOTE: Be sure to toggle **Use MS Element** OFF for subsequent Links that are not curved. When used, the Link position and length are defined by the MS Element. **Caution must be used** in order to properly define the Link.

6.3 Storm Drainage Network Design

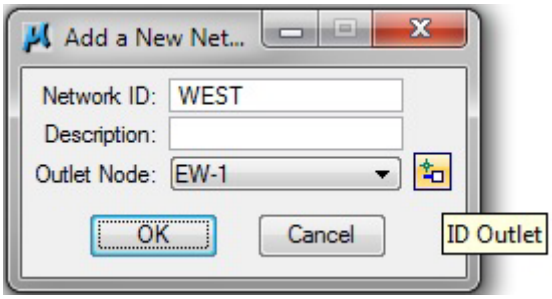
a) Select the **Add Drainage Network** tool or select **Network > Add** from the main drainage menu bar.



b) In the **Add a New Network** dialog, enter the following information:

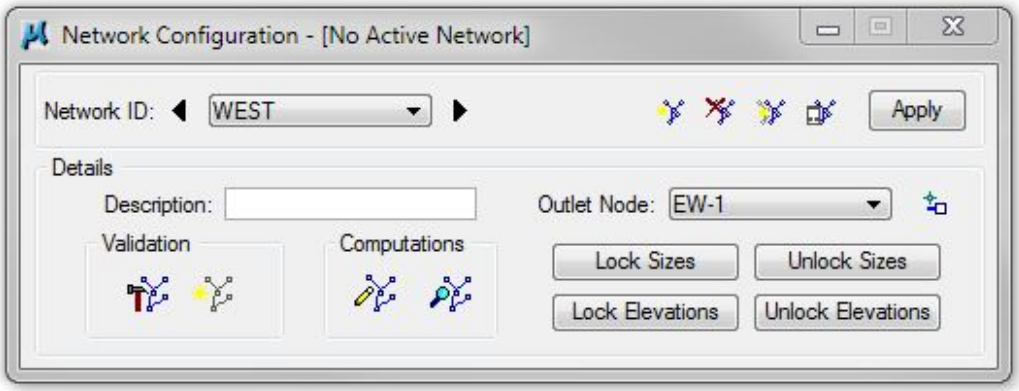
Network ID: WEST

Outlet Node: EW-1

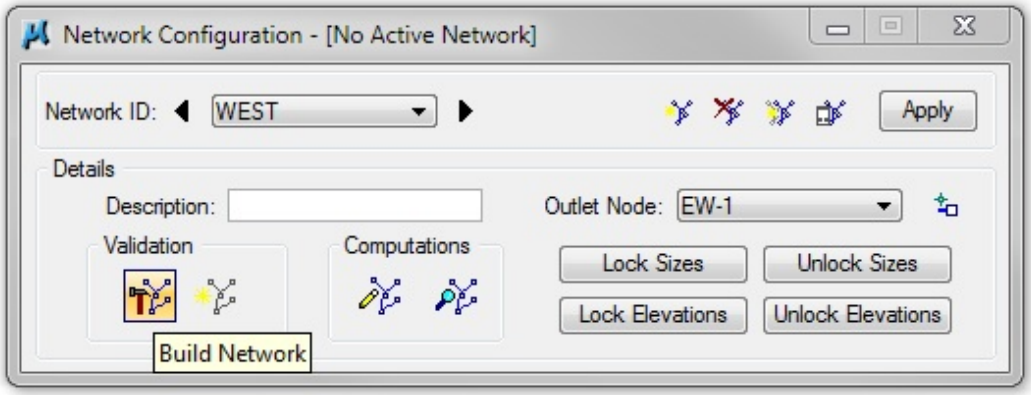


NOTE: The **Outlet Node** may be selected via the dropdown or by clicking **ID Outlet** and selecting the Node in the plan view.

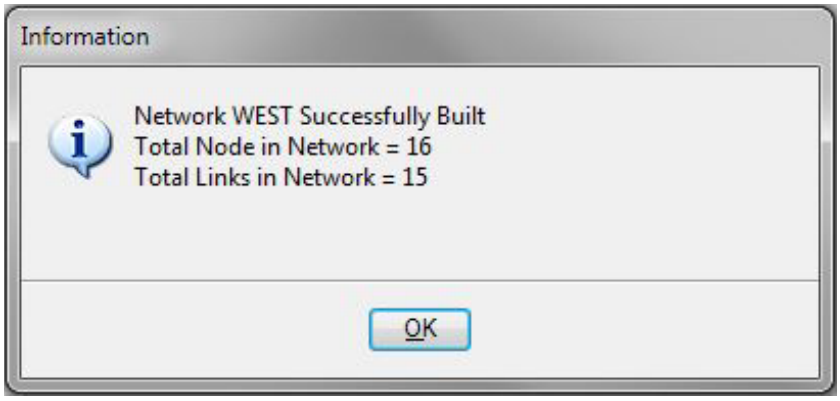
c) Click **OK** in the Add a New Network dialog box.



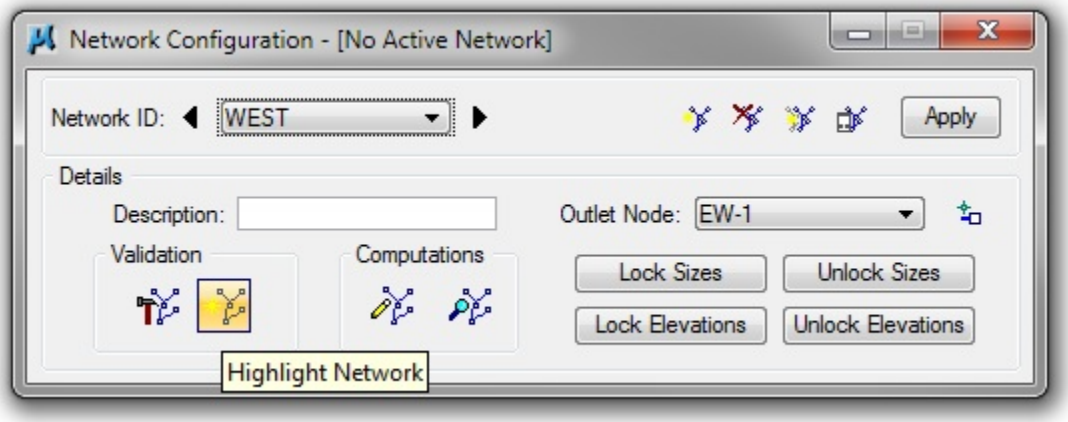
d) Click the **Build Network** button. This feature verifies the nodes and link connectivity.



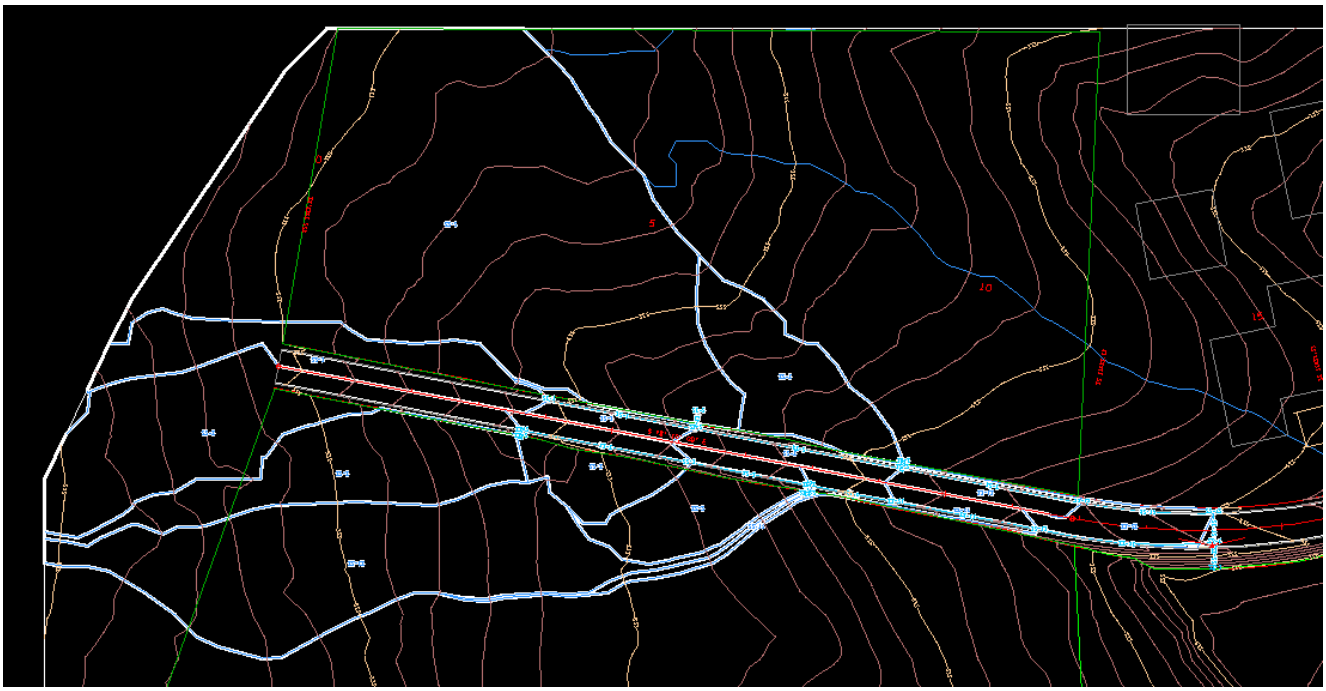
Click **OK.**



e) Click the **Highlight Network** feature. This Feature highlights all components (areas, inlets, pipes, etc.) connected to the active Network.

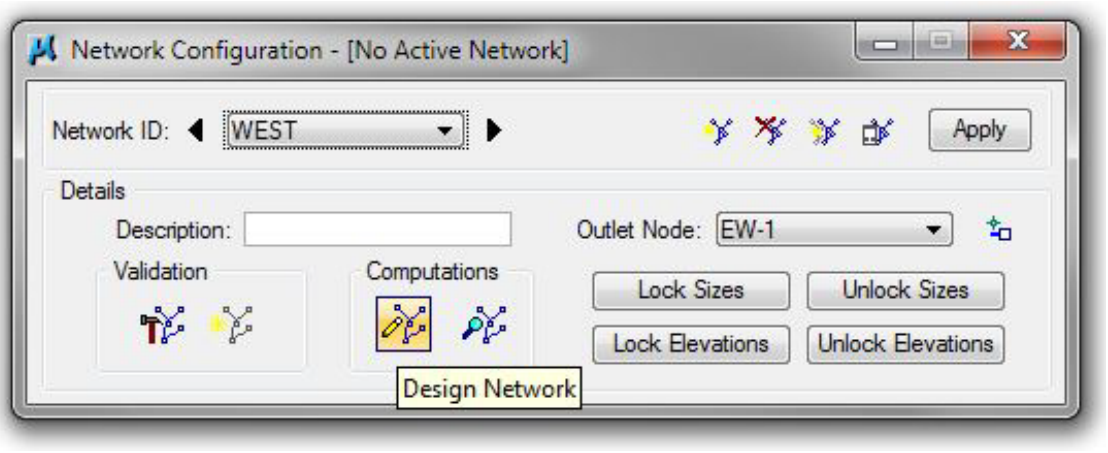


f) Verify that all network components are highlighted.

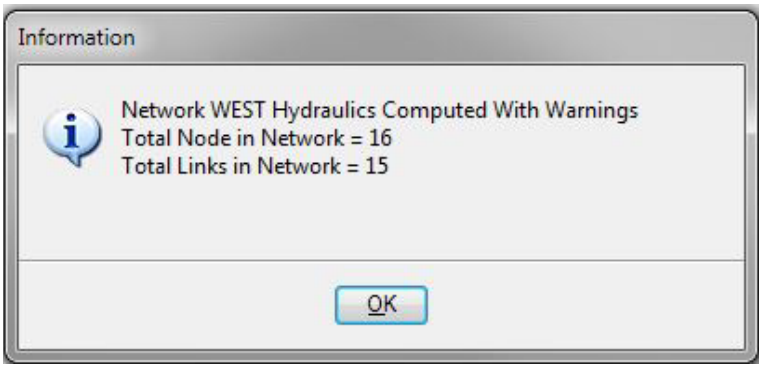


g) Click the **Apply** button. Network "WEST" has been added to the project.

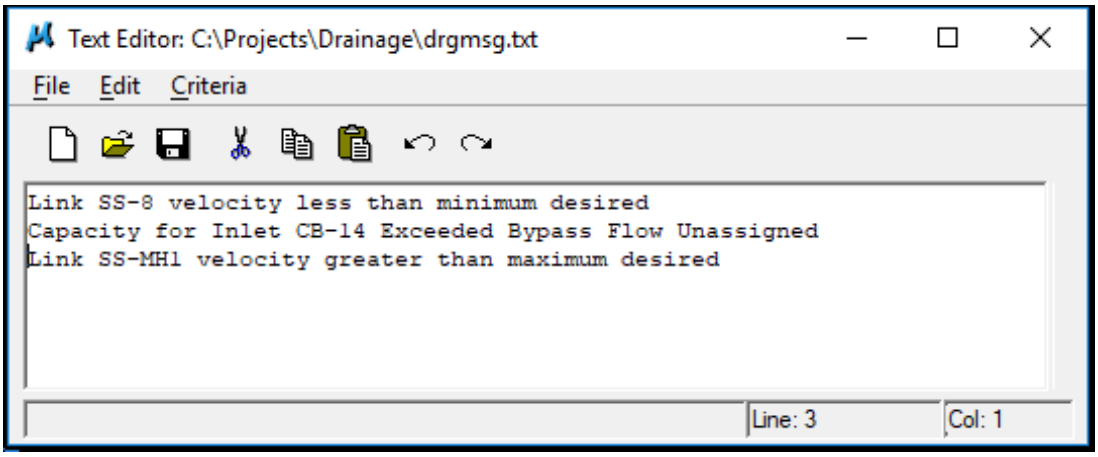
h) Click the **Design** button. This command initiates the hydraulic design of the components contained in the Network.

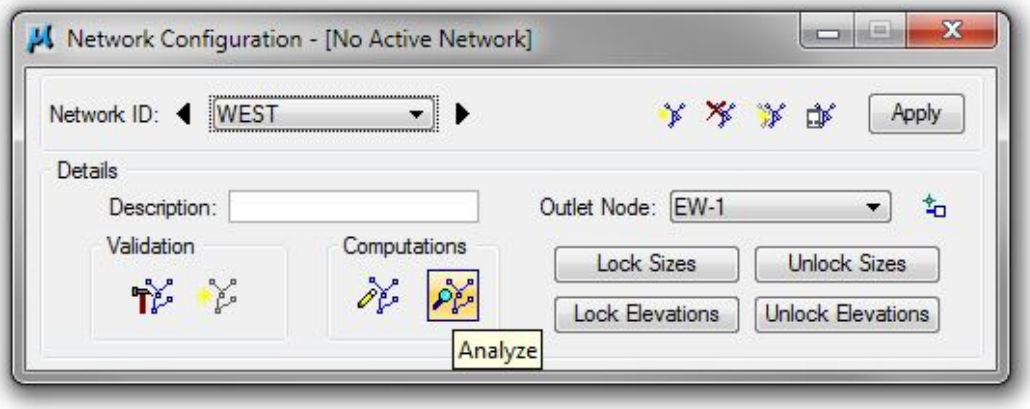


Click **OK**.



i) Review errors to determine steps needed to correct and close the text editor. (See **Appendix C** for common errors and fixes)



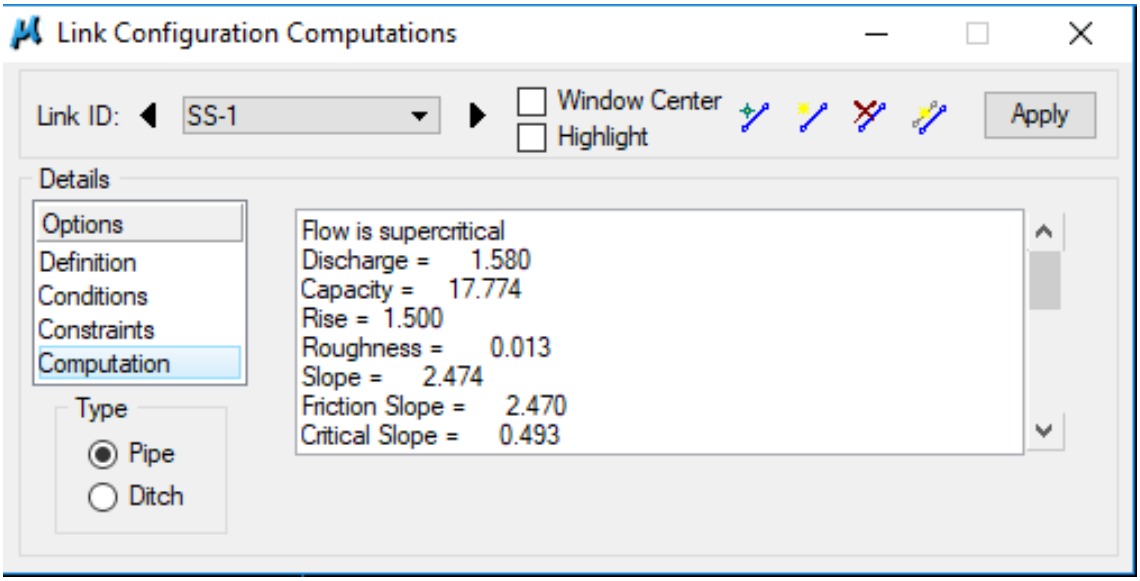


NOTES:
Pressing Design or Analyze should be the last step in Designing or Analyzing the Network.

Design performs hydraulic design of the network and designs components of the network as indicated by the 'design toggles'. **Analyze** performs hydraulic analysis of the network as is and ignores all 'design toggles'.

Lock and **Unlock buttons** allow the user to lock or unlock all components in a network at the given **Size** or **Elevation. Caution** must be used when selecting **Unlock** as this action will unlock ALL **Sizes or Elevations,** including ones that should not have been unlocked.

After **Design** or **Analyze** has been utilized, computation values are shown in each link configuration of the network which can be reviewed in the Link Configuration edit dialog. Other methods of reviewing this data will be discussed in Exercise 10, Drainage Navigator.



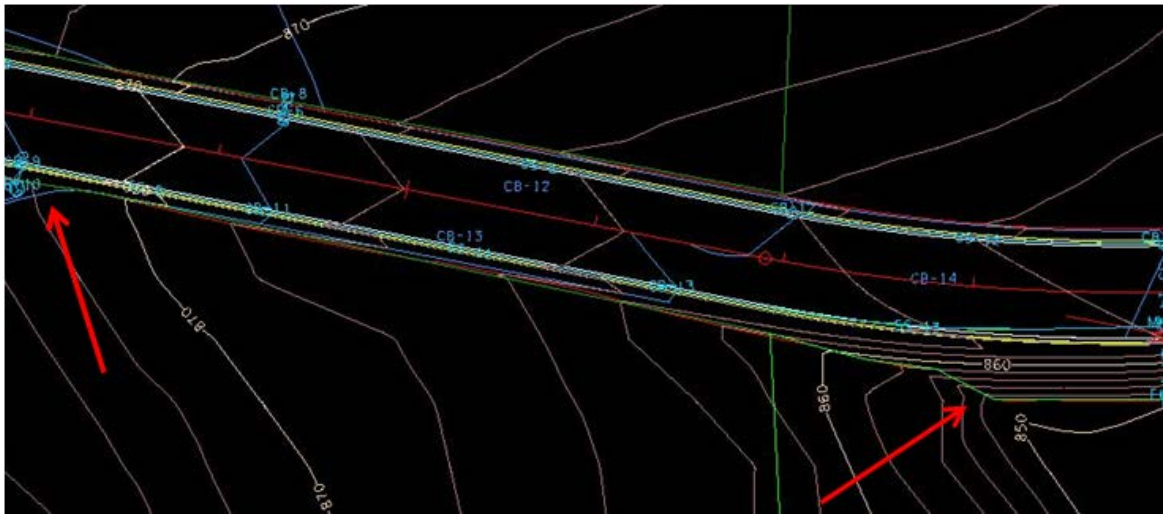
7. Ditch Nodes and Links

This exercise shows the user how to utilize the tools for nodes and links for ditch analysis. We will investigate the drainage flow along a fill slope with these settings and in a later chapter define a special ditch to manage it.

7.1 Ditch Node Design DIT-1

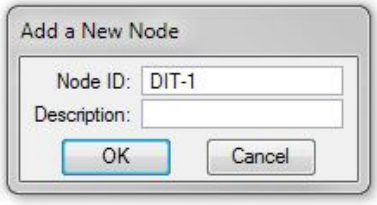
Begin Ditch

a) Visually determine the tentative location of the beginning of the ditch. In this case a ditch is created along the south side of the roadway by the new fill slopes.

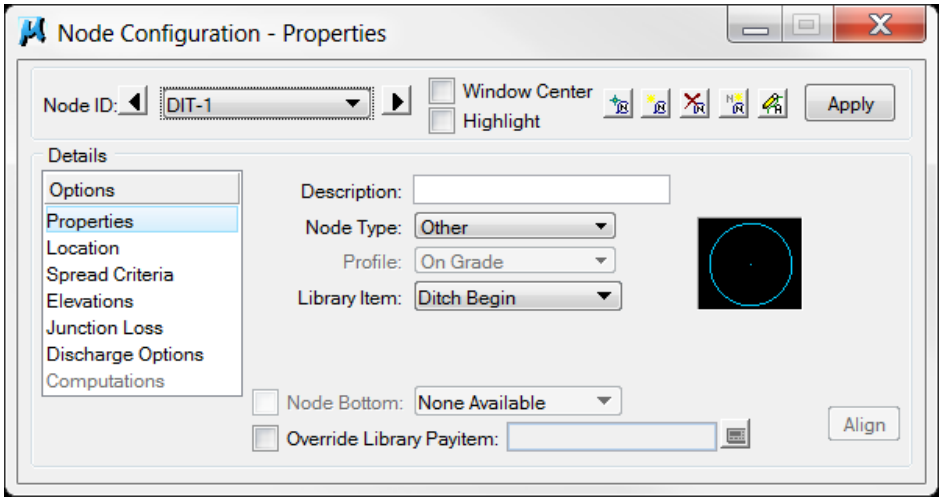


b) Select from the Drainage Menu Bar: **Component > Node > Add** or from the main toolbar: **Add Drainage Node**.

c) In the **New Node** window that appears, set the name **DIT-1** and click **OK.**



d) Properties > Set **Node Type** to Other and **Library Item** to Ditch Begin.

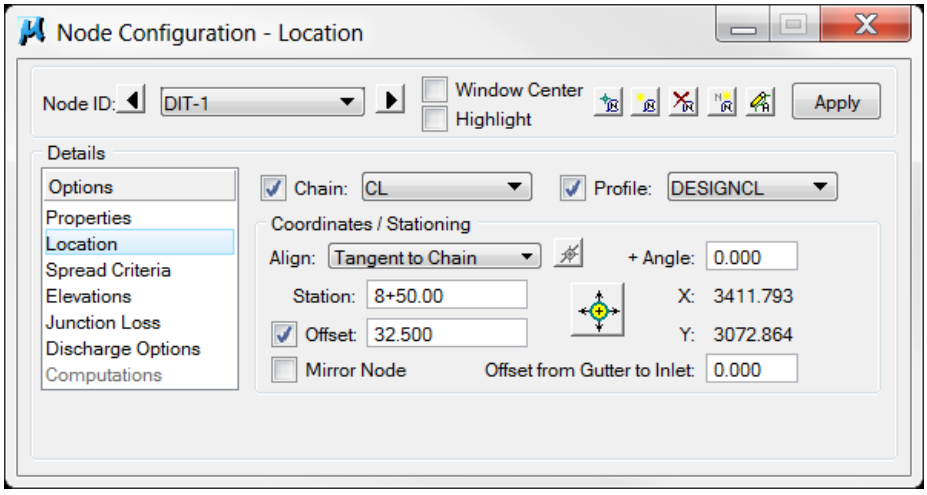


e) Location > All settings should have carried over from the last Node input. Review and make the following changes:

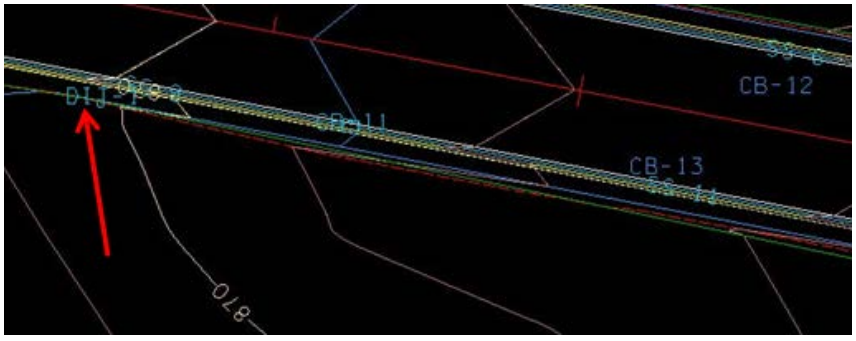
Station: 8+50.00

Offset: 32.50

+Angle: 0.00



This will approximate the beginning of the ditch as shown below:



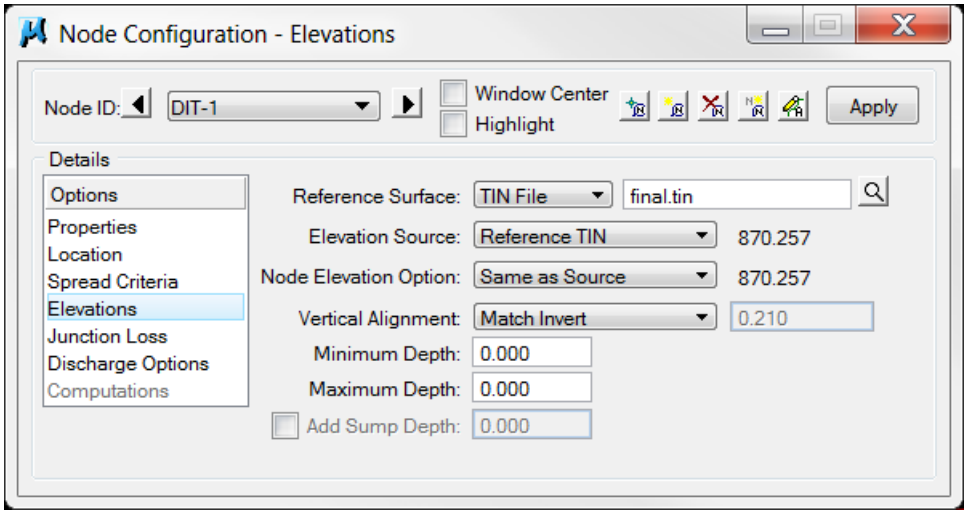
NOTE: The **Spread Criteria** configuration is not required for **Other** node types such as are used by ditches.

f) Elevations > All settings should have carried over from the last Node input. Review and make the following changes:

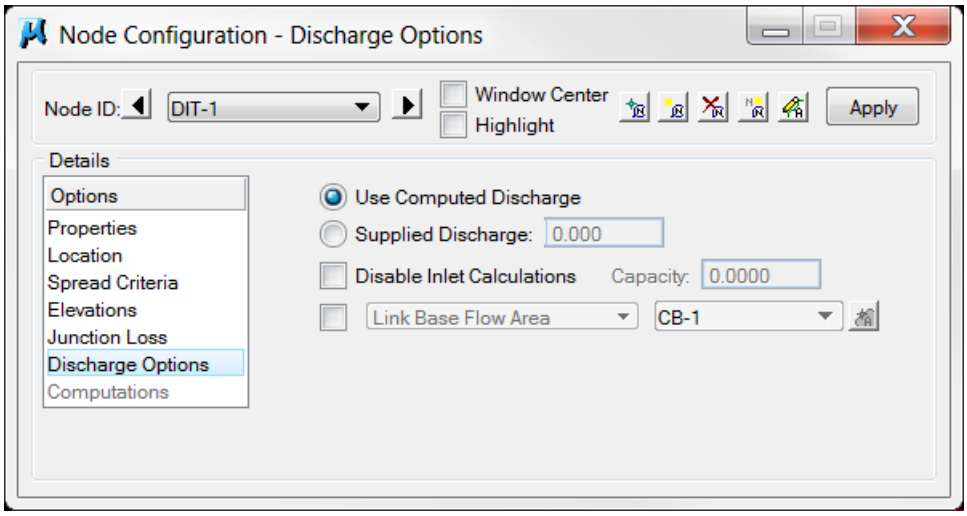
Vertical Alignment: Match Invert

Minimum Depth: 0.00

Maximum Depth: 0.00



g) Discharge Options > Leave **Use Computed Discharge** selected and click **Apply** to save all settings.



NOTE: For short ditches where only a single drainage area is utilized, the **Link Base Flow Area** option should be toggled ON and set to add the discharge for that area. It is then toggled off at the ditch outlet. If this is not toggled OFF at other nodes beyond the beginning, the discharge will accumulate at each node and not accurately represent the area's discharge.

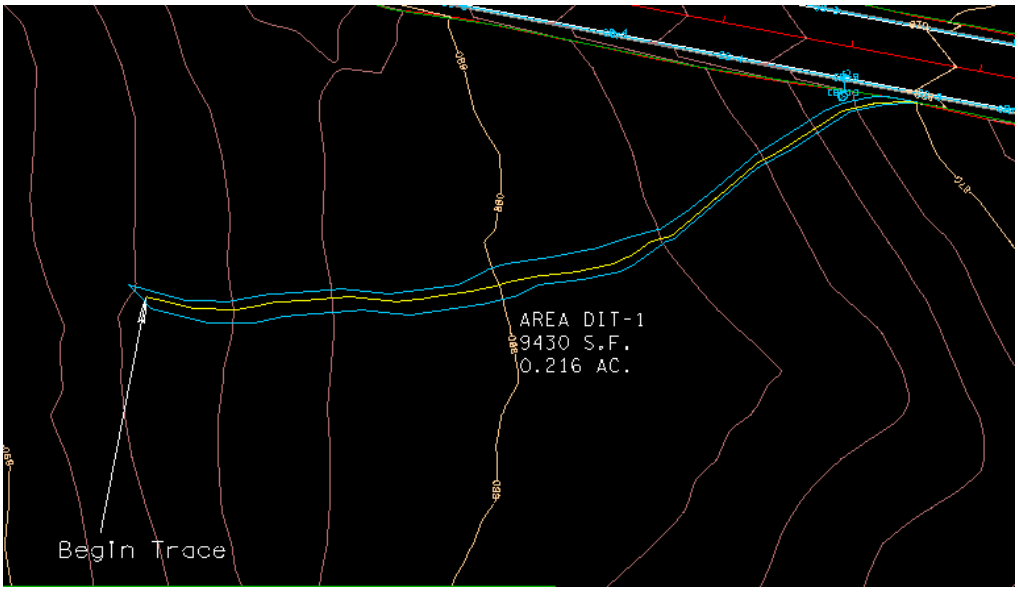
7.2 Delineate Drainage Area DIT-1

Begin Ditch Drainage Area

a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **DIT-1** should automatically appear, click **OK**.

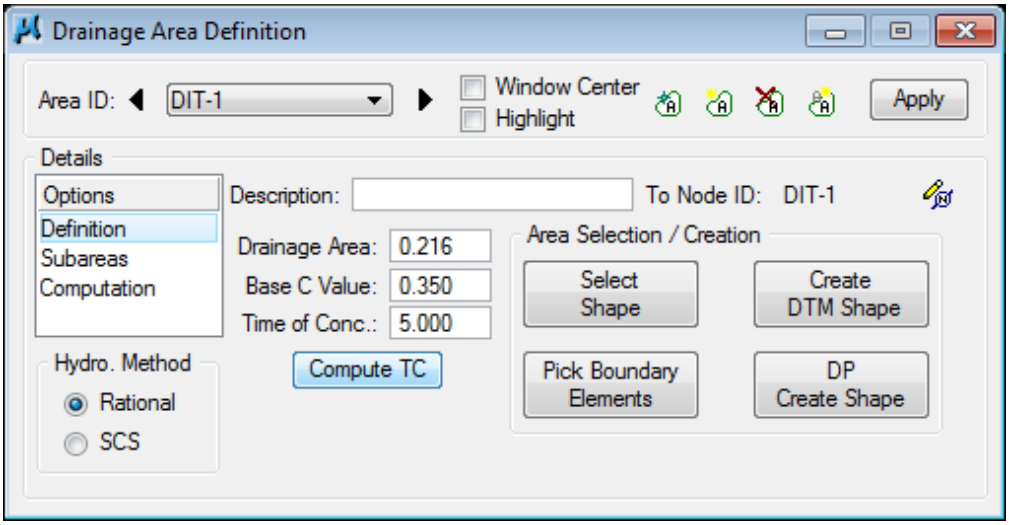
b) Follow the steps in Exercise 4.1 to delineate and define the drainage area for the begin ditch location. (You may use the following images as reference points. It is ok if your numbers do not match exactly.) Attach reference file DA_DIT-1. **You may want to turn off the level SURVEY – DRAINAGE – Area Shapes** to see the ditch easier.

Delineate Drainage Area:

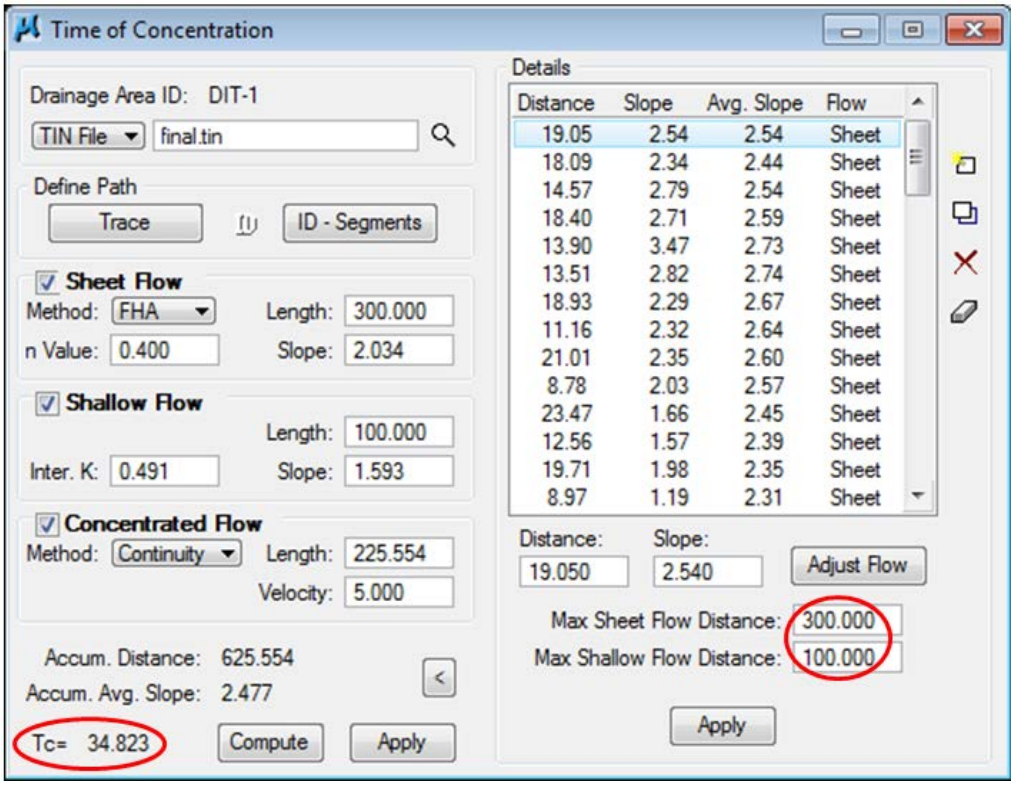


NOTE: The drainage area should be broken into sections for long ditches, however, for short ditches; determine the area from the most downstream point (i.e. the stream outlet).

c) Define Drainage Area:



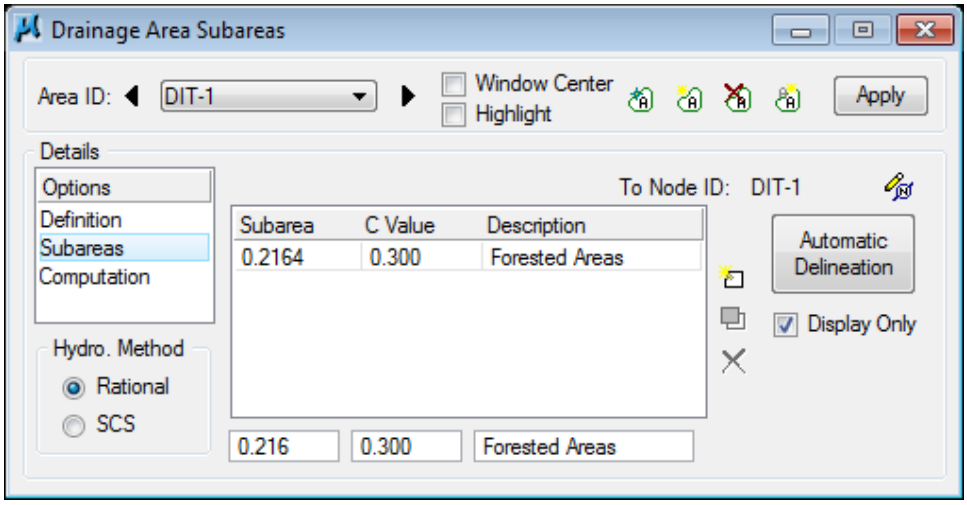
d) Calculate Time of Concentration:



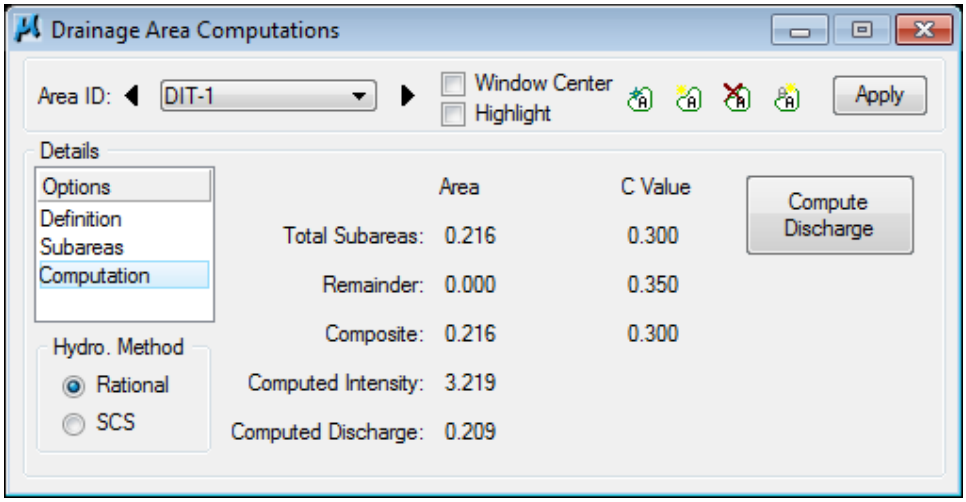
Make settings as shown for Max Sheet Flow and Max Shallow Flow. We will use these settings for all the ditch areas.

The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required

e) Delineate Subareas utilizing the Land Use DGN:



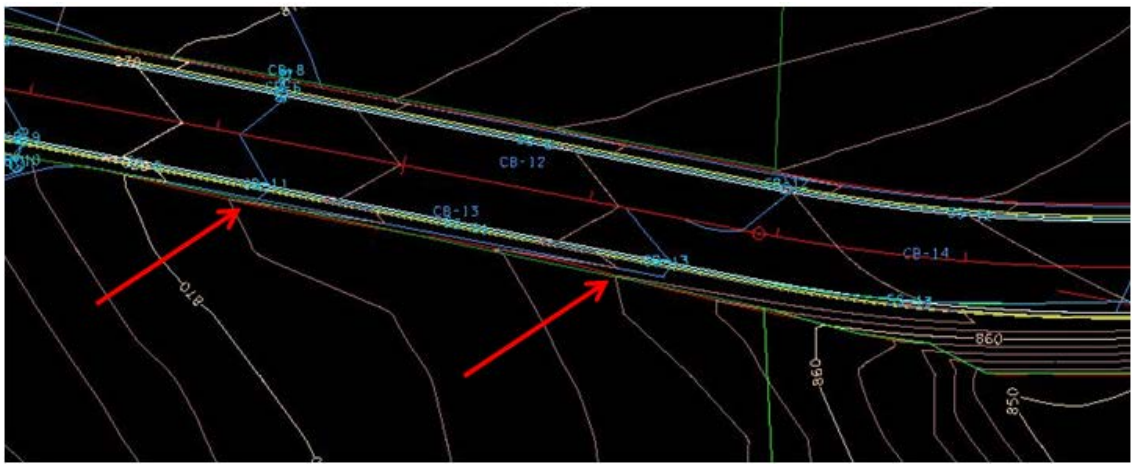
f) Compute Discharge and Apply:



7.3 Ditch Node Design DIT-2

a) Visually determine the location of any major ditch change; such as a change in horizontal or vertical alignment or a change in cross section.

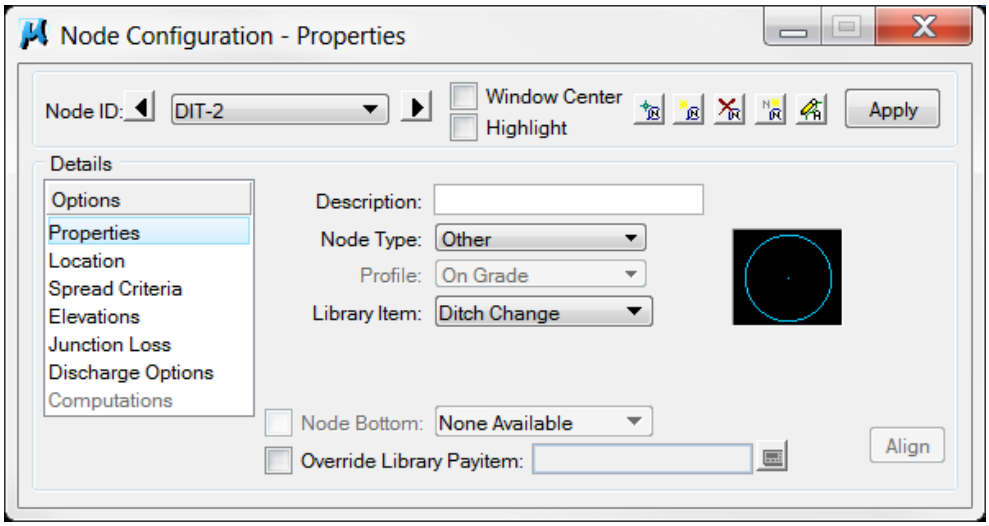
In this initial set up we are analyzing the flow along the fill slope and will set them as shown.



b) Select from the Drainage Menu Bar: **Component > Node > Add** or from the main toolbar: **Add Drainage Node**.

c) In the **New Node** window that appears, set the name **DIT-2** and click **OK.**

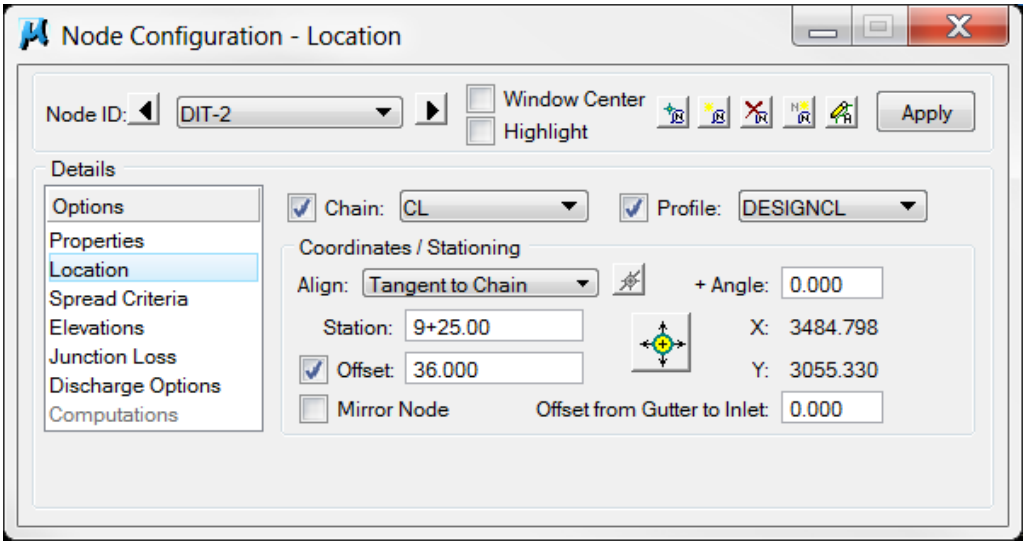
d) Properties > Set **Node Type** to Other and **Library Item** to Ditch Change.



e) Location > All settings should have carried over from DIT-1. Review and make the following changes (estimated change locations):

Station: 9+25.00

Offset: 36.00



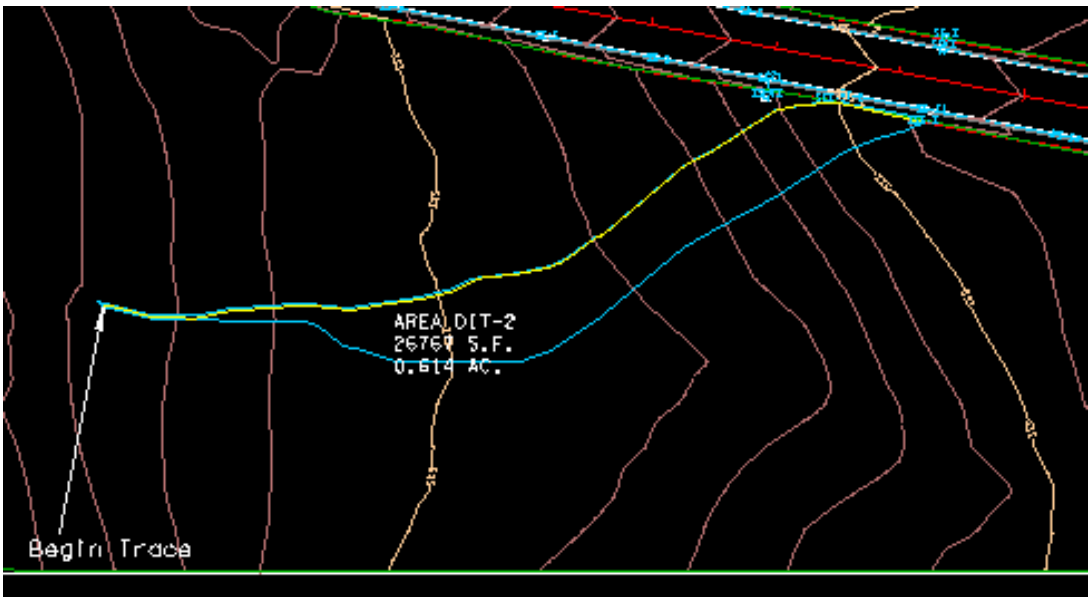
f) Click **Apply**.

7.4 Delineate Drainage Area DIT-2

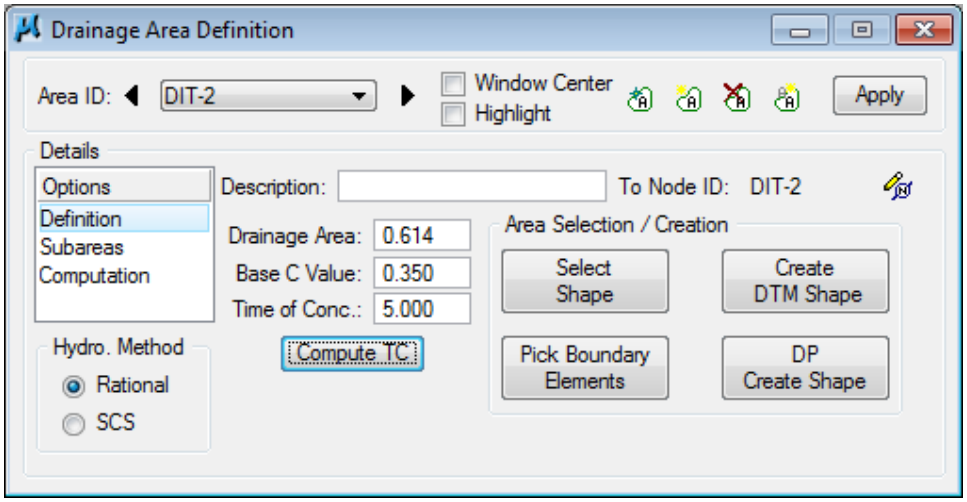
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **DIT-2** should automatically appear, click **OK**.

b) Follow the steps in Exercise 4.1 to delineate and define the drainage area for this ditch change location. Attach reference file DA_DIT-2 and turn off DA_DIT-1.

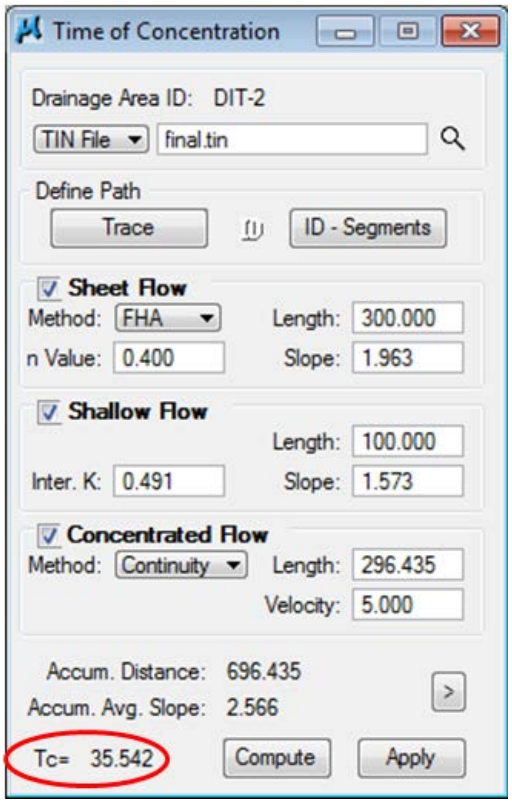
Delineate Drainage Area:



c) Define Drainage Area:

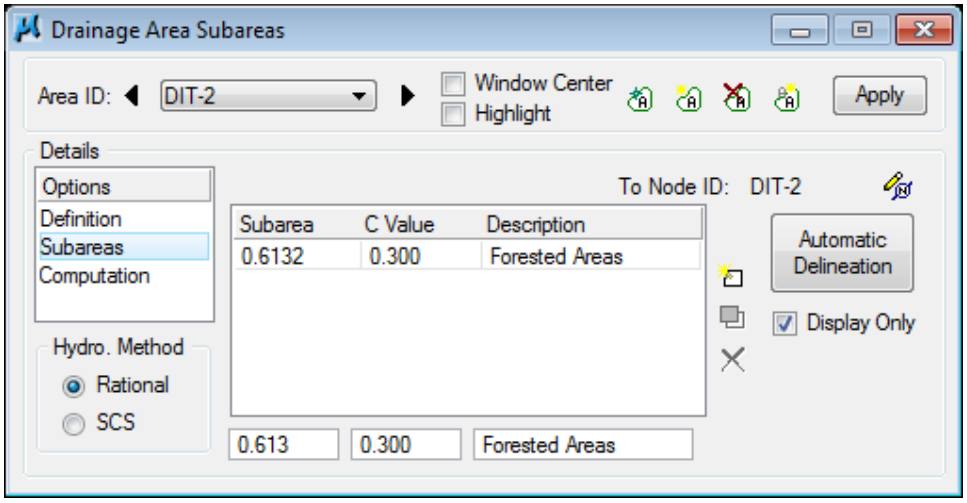


d) Calculate Time of Concentration:

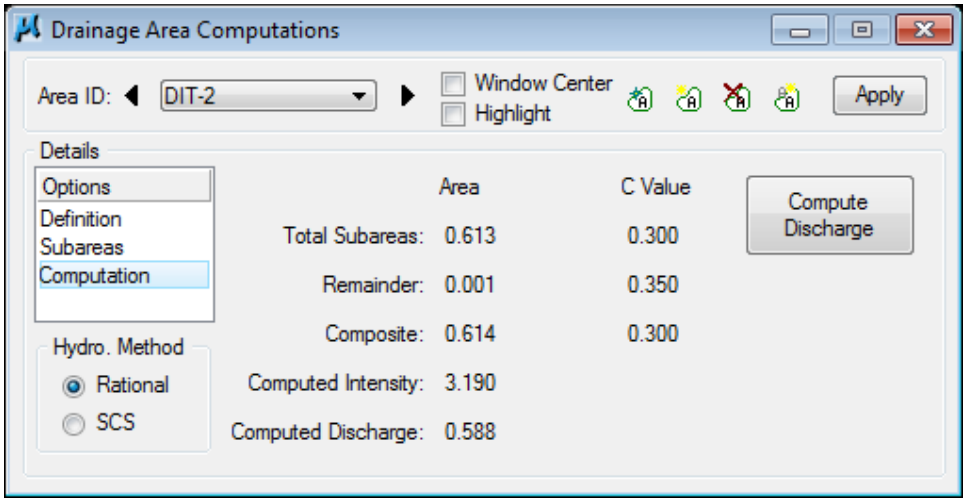


The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required

e) Delineate Subareas utilizing the Land Use DGN:



f) Compute Discharge and Apply:



7.5 Ditch Node Design DIT-3

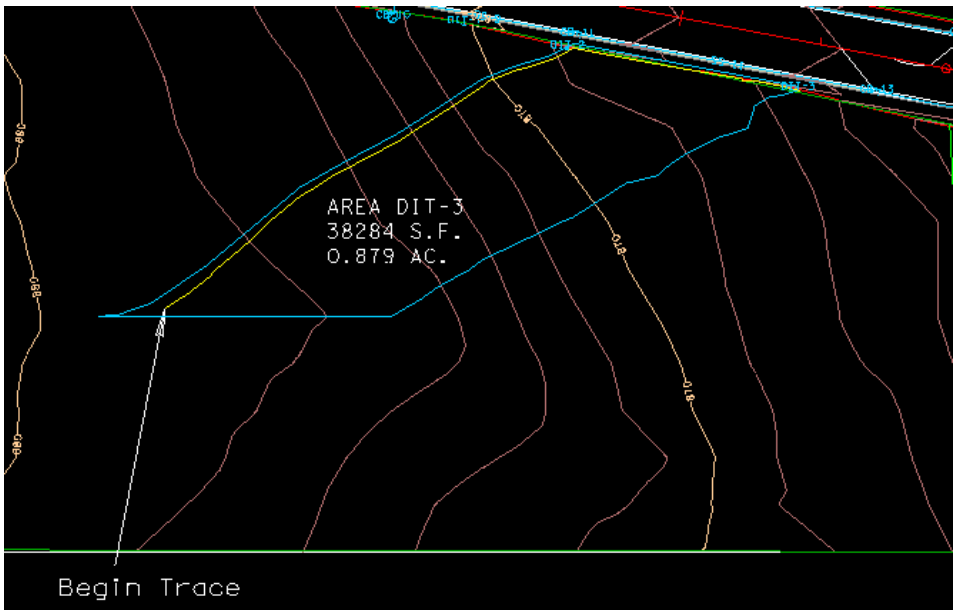
Repeat previous steps on pages 7-7 & 7-8 creating ditch change Node **DIT-3** at **Station: 10+90.00** and **Offset: 34.00**. All other information should remain unchanged.

7.6 Delineate Drainage Area DIT-3

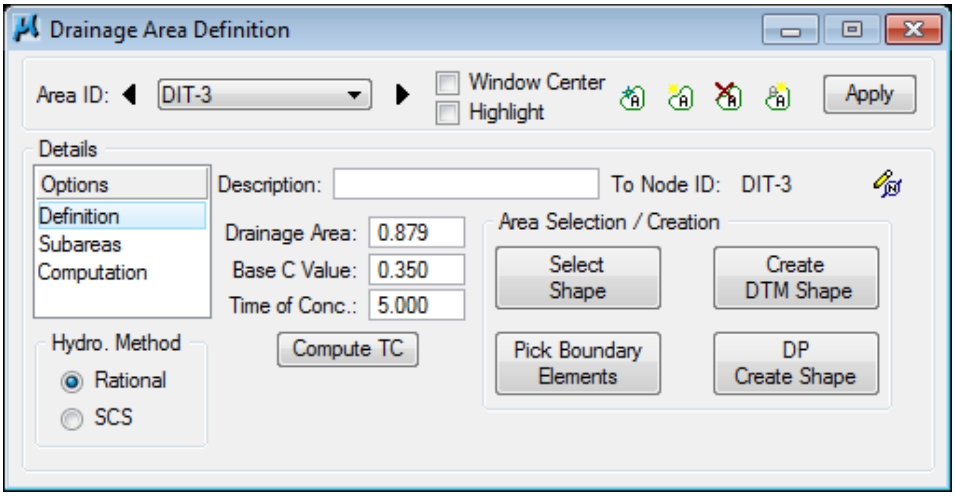
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **DIT-3** should automatically appear, click **OK**.

b) Follow the steps in Exercise 4.1 to delineate and define the drainage area for this ditch change location.

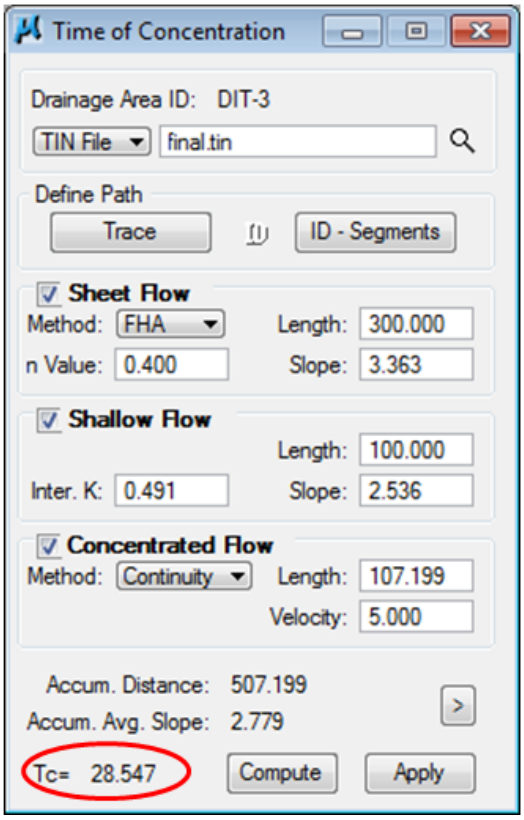
Delineate Drainage Area:



c) Define Drainage Area:

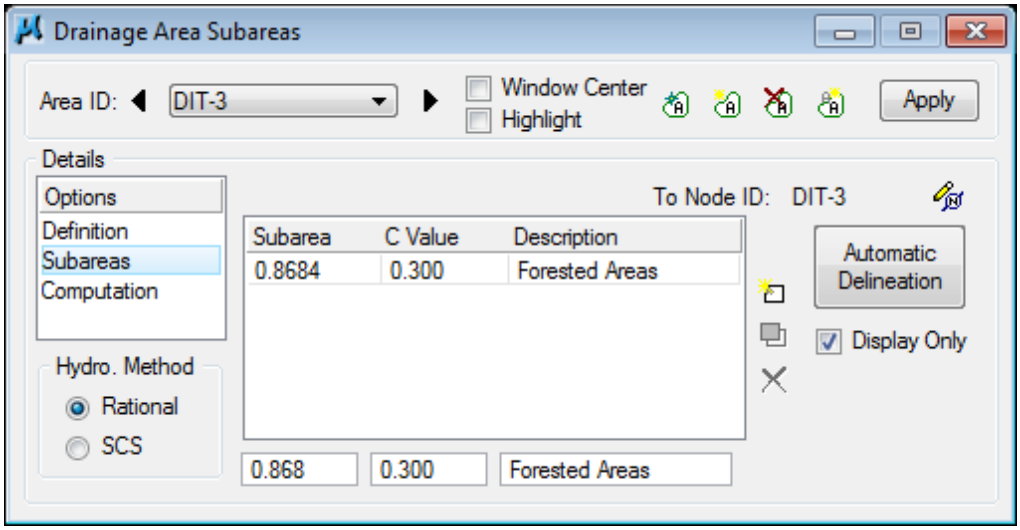


d) Calculate Time of Concentration:

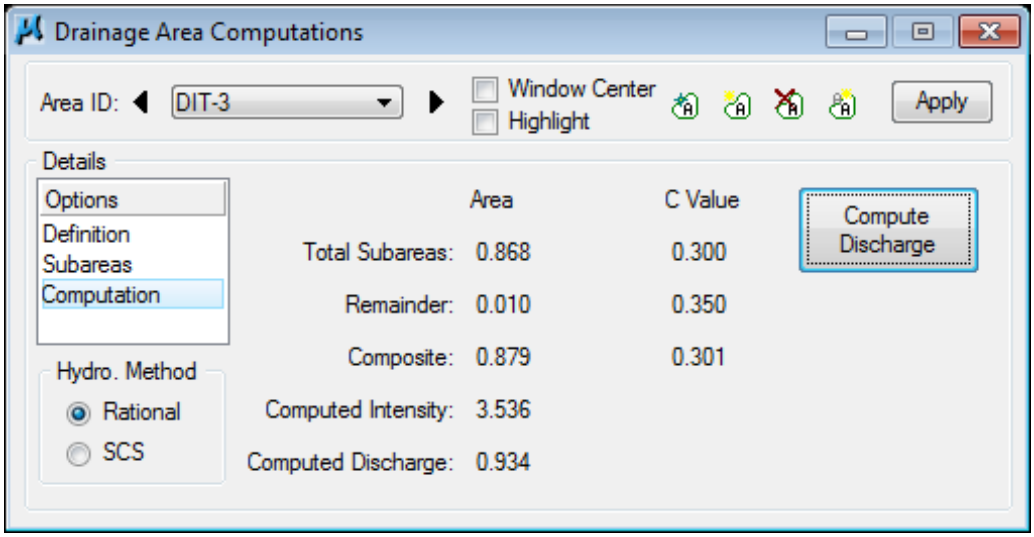


The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required

e) Delineate Subareas utilizing the Land Use DGN:

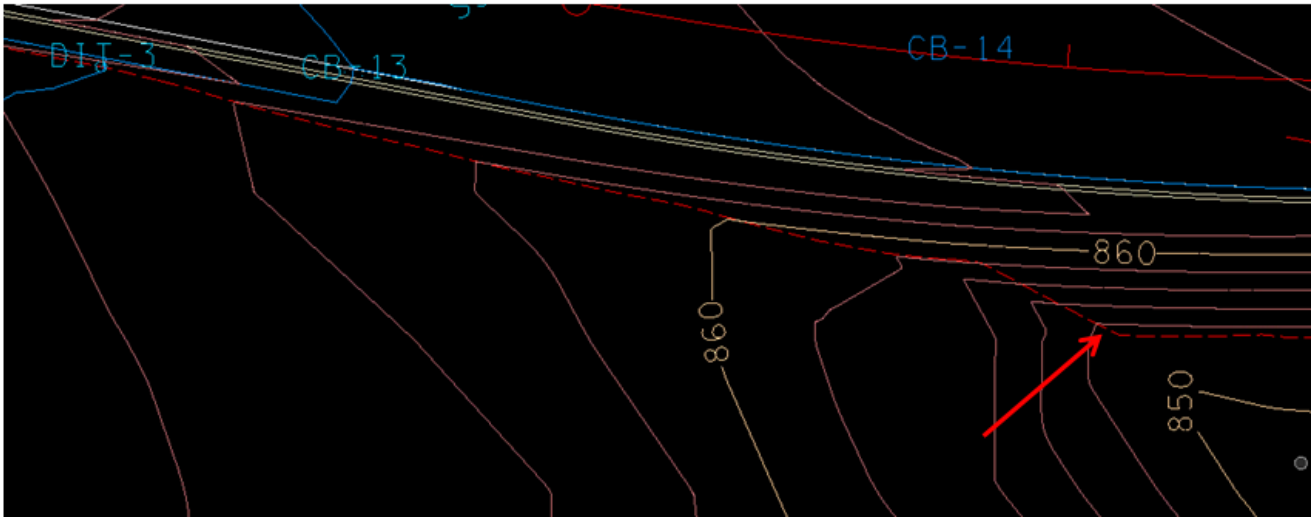


f) Compute Discharge and Apply:



7.7 Ditch Node Design DIT-4

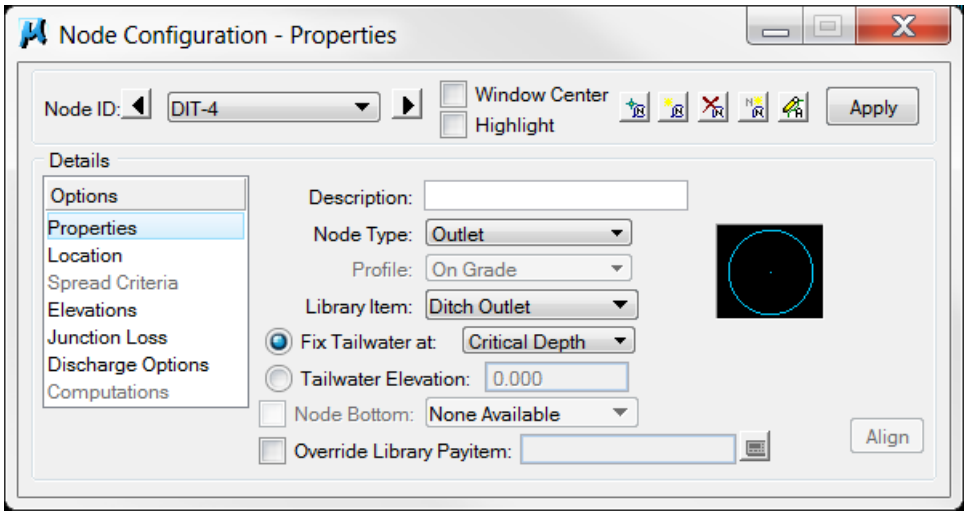
a) Visually determine the location of the ditch outlet.



b) Select from the Drainage Menu Bar: **Component > Node > Add** or from the main toolbar: **Add Drainage Node**.

c) In the **New Node** window that appears, set the name **DIT-4** and click **OK.**

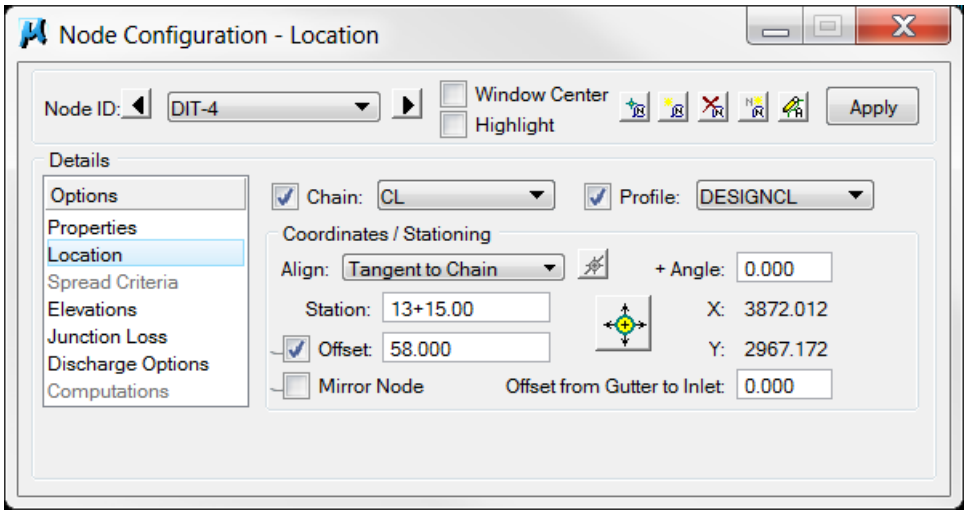
d) **Properties >** Set **Node Type** to Outlet, **Library Item** to Ditch Outlet and **Fix Tailwater at** Critical Depth



e) **Location >** All settings should have carried over from DIT-3. Review and make the following changes:

Station: 13+15.00

Offset: 58.00



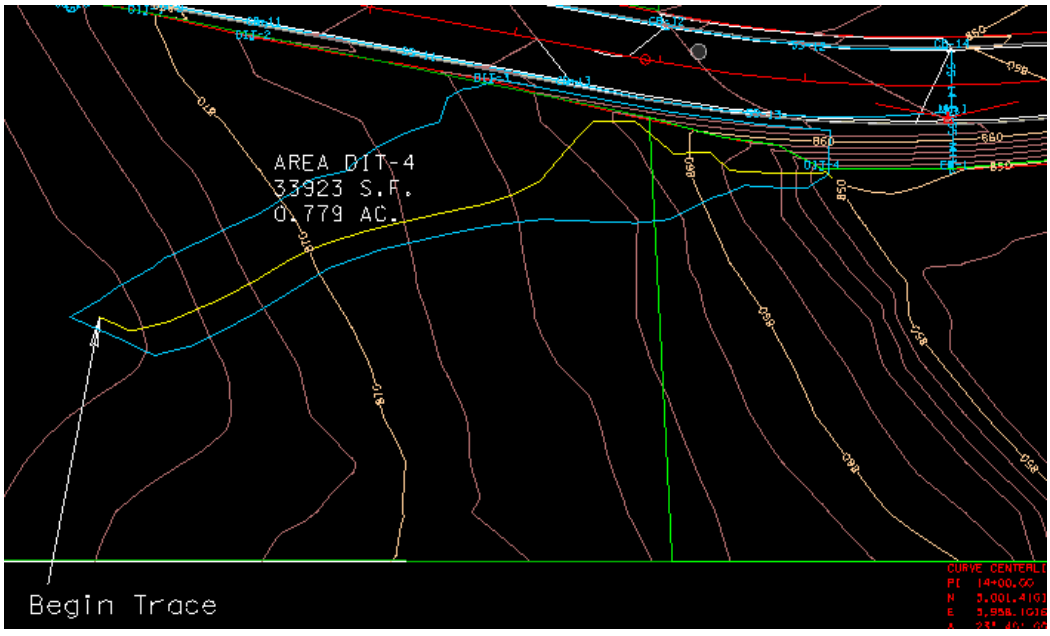
f) All other options should be set from previous nodes, click **Apply**.

7.8 Delineate Drainage Area DIT-4

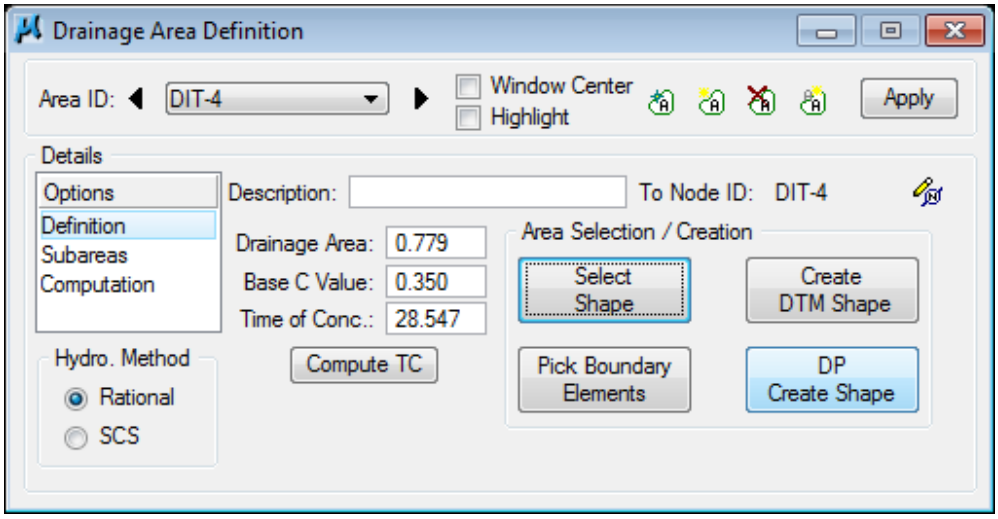
a) From the Node Configuration dialog select **Edit Area**. When asked if you want to create a new drainage area click **Yes.** The name **DIT-4** should automatically appear, click **OK**.

b) Follow the steps in Exercise 4.1 to delineate and define the drainage area for this ditch outlet location.

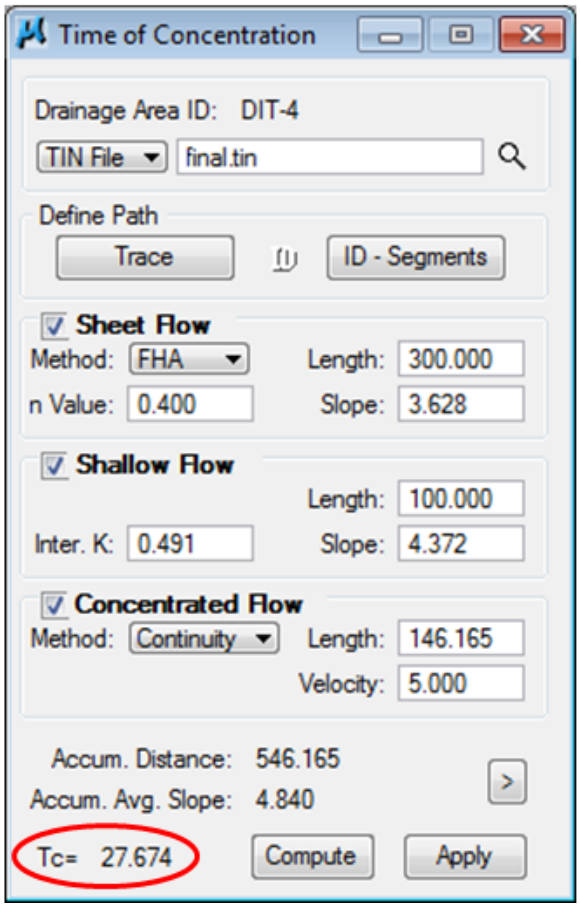
Delineate Drainage Area:



c) Define Drainage Area:

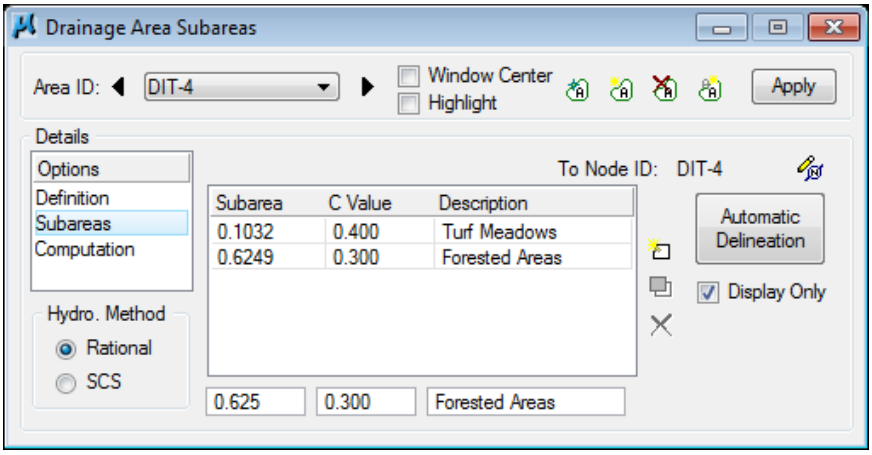


d) Calculate Time of Concentration:

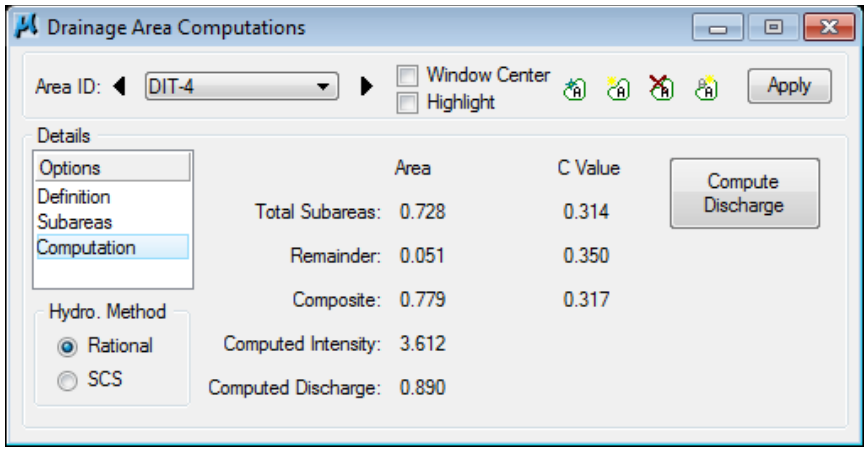


The calculated Time of Concentration is **GREATER** than the minimum of 5 minutes; therefore the Time of Concentration will automatically be filled in after hitting Apply with NO further steps required

e) Delineate Subareas utilizing the Land Use DGN:

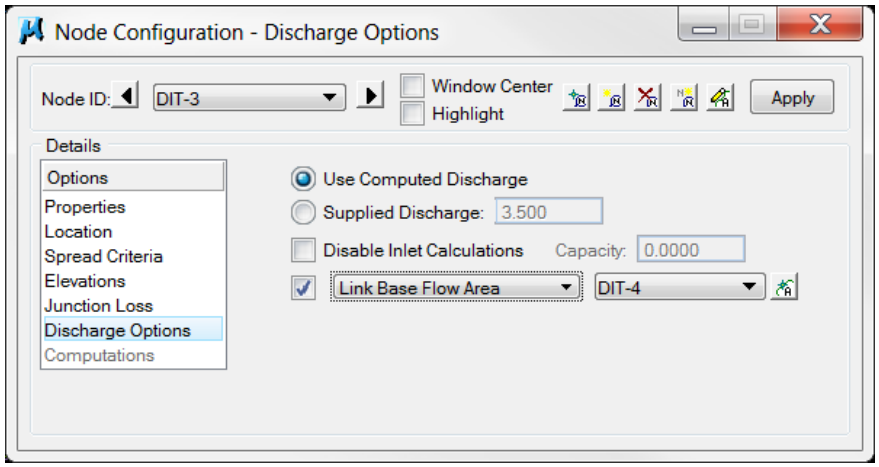


f) Compute Discharge and Apply:



g) Since Node DIT-4 is an outlet type, it will **not** consider the drainage area developed for it. In order to ensure the final ditch link, will be adequate for the capacity at the end we will need to link the DIT-4 drainage area to Node DIT-3.

Go to **Component> Node> Edit** and select node DIT-3. Under Discharge Options click on the option to **Link Base Flow Area** and set to include the DIT-4 drainage area.



7.9 Ditch Link DIT-1

We are checking the drainage flow along a fill slope so all links are set up as cross section based. The surface is read for the ditch shape and capacity is calculated at each cross section that is cut along the links.

Cross Section Based Link DIT-1

a) Select from the Drainage Menu Bar: **Component > Link > Add** or from the main toolbar: **Add Drainage Link**

b) Set the Name to **DIT-1** and click **OK**.

c) Set the **From Node** as **DIT-1** and the **To Node** as **DIT-2** via the dropdown list or by clicking the **Node ID** button and selecting the appropriate node.

d) In the *Details* portion of the dialog change **Type** to **Ditch**.

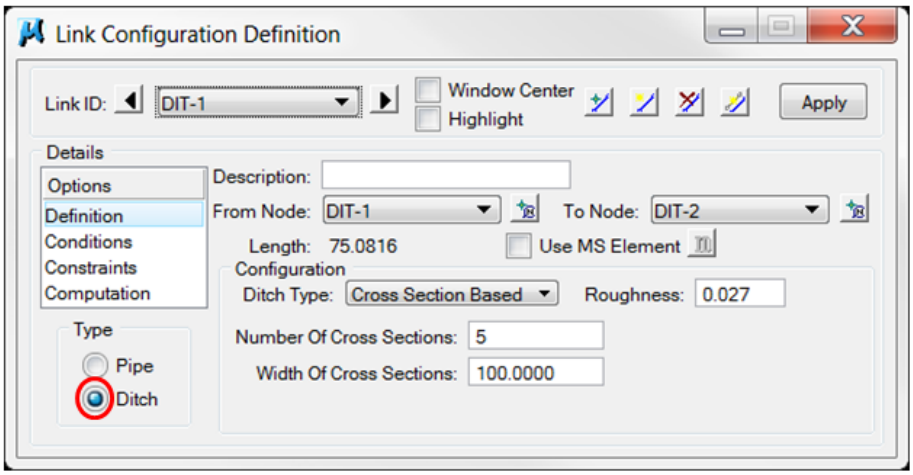
e) In the *Configuration* portion of the dialog set the following:

Ditch Type: Cross Section Based

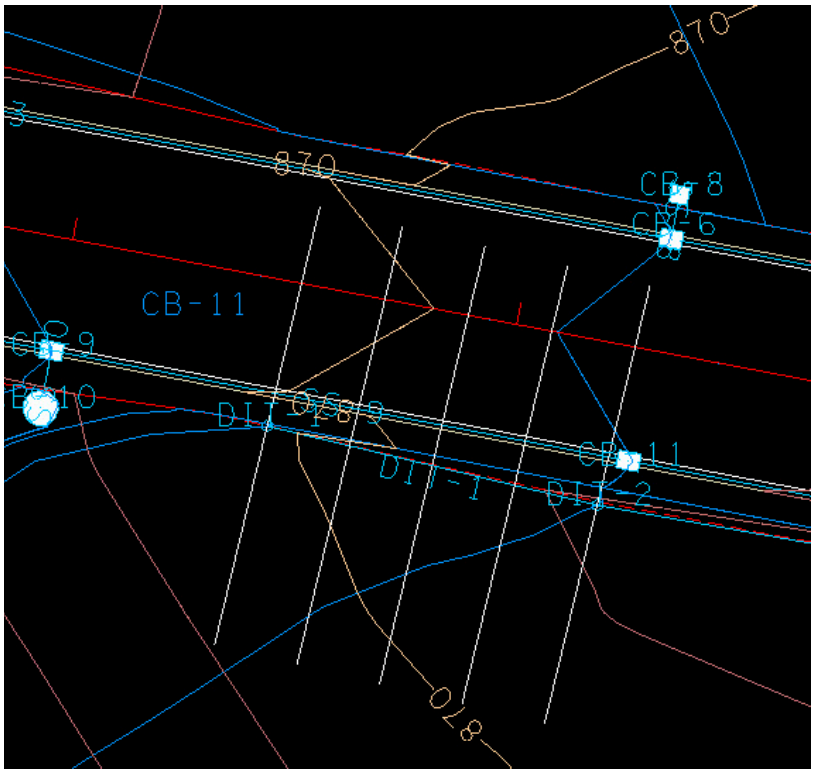
Roughness: 0.027 (See TDOT Drainage Manual Chapter 5 Table 5A-1 for typical values)

Number of Cross Sections: 5 (Typically one cross section every 5 feet to a maximum of every 50 feet for long ditches)

Width of Cross Sections: 100 (Ensure top of bank on both sides is captured)



f) Click **Apply** and review the cross section lines displayed in the plan view (shown on next page) to determine if adjustments should be made.



NOTES:
Since we are using the Cross Section Based ditch type to analyze existing conditions, the **Conditions** and **Constraints** require no special settings. In the system modification chapter, we will use those to control the proposed ditch that is to be designed.

Computation will not show any information until a drainage network is built from the nodes and links in this ditch system.

This same set up using the **Cross Section Based** ditch type can be used to analyze long proposed roadway ditches for capacity and function.

7.10 Ditch Link DIT-2

Cross Section Based Link DIT-2

a) Select from the Drainage Menu Bar: **Component > Link > Add** or from the main toolbar: **Add Drainage Link**

b) Set the Name to **DIT-2** and click **OK**.

c) Set the **From Node** as **DIT-2** and the **To Node** as **DIT-3** via the dropdown list or by clicking the **Node ID** button and selecting the appropriate node.

d) In the *Details* portion of the dialog change **Type** to **Ditch**.

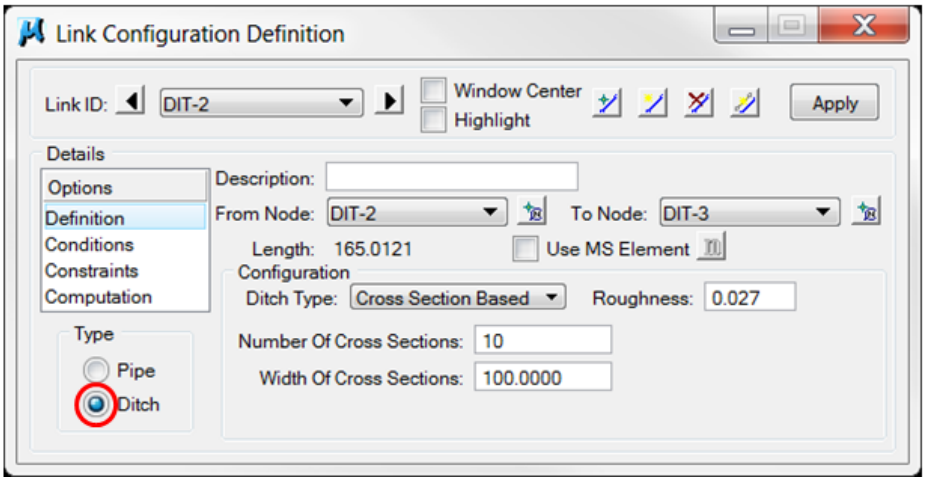
e) In the *Configuration* portion of the dialog set the following:

Ditch Type: Cross Section Based

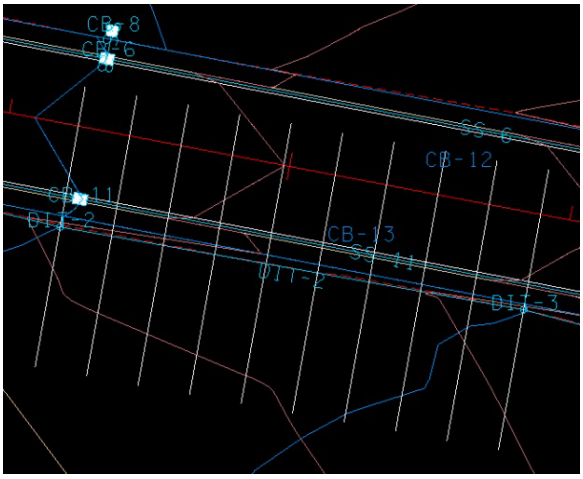
Roughness: 0.027 (See TDOT Drainage Manual Chapter 5 Table 5A-1 for typical values)

Number of Cross Sections: 10 (Typically one cross section every 5 feet to a maximum of every 50 feet for long ditches)

Width of Cross Sections: 100 (Ensure top of bank on both sides is captured)



f) Click **Apply.**



7.11 Ditch Link DIT-3

Cross Section Based Link DIT-3

a) Select from the Drainage Menu Bar: **Component > Link > Add** or from the main toolbar: **Add Drainage Link**

b) Set the Name to **DIT-3** and click **OK**.

c) Set the **From Node** as **DIT-3** and the **To Node** as **DIT-4** via the dropdown list or by clicking the **Node ID** button and selecting the appropriate node.

d) In the *Details* portion of the dialog change **Type** to **Ditch**.

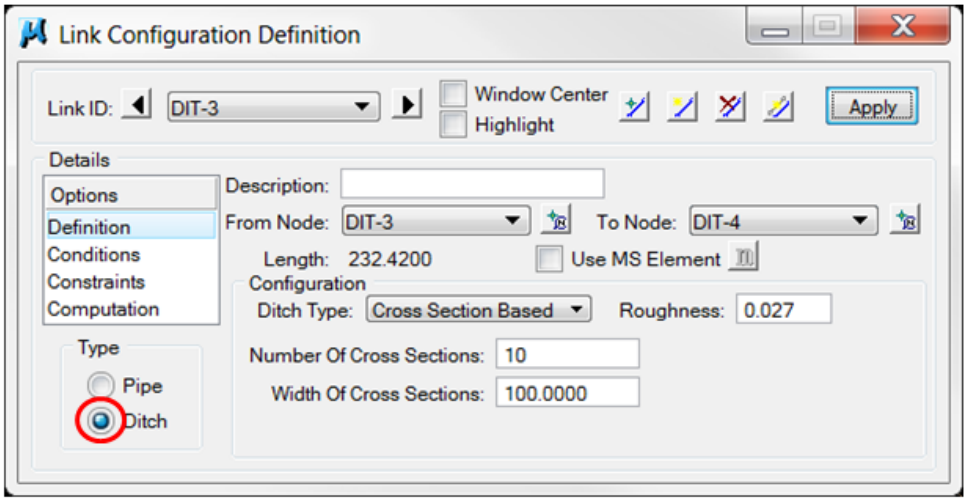
e) In the *Configuration* portion of the dialog set the following:

Ditch Type: Cross Section Based

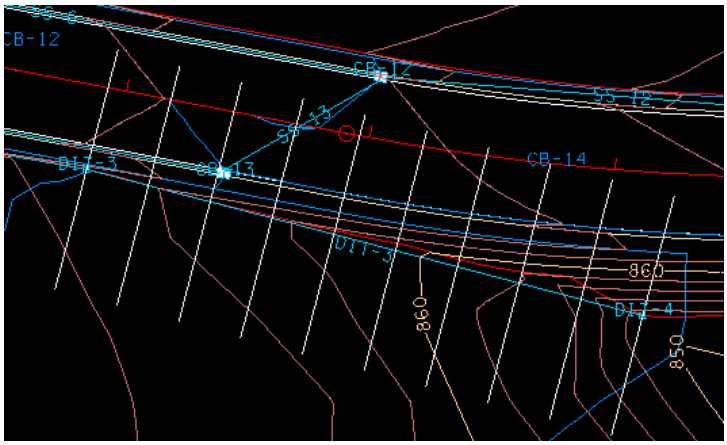
Roughness: 0.027 (See TDOT Drainage Manual Chapter 5 Table 5A-1 for typical values)

Number of Cross Sections: 10 (Typically one cross section every 5 feet to a maximum of every 50 feet for long ditches)

Width of Cross Sections: 100 (Ensure top of bank on both sides is captured)



f) Click **Apply.**



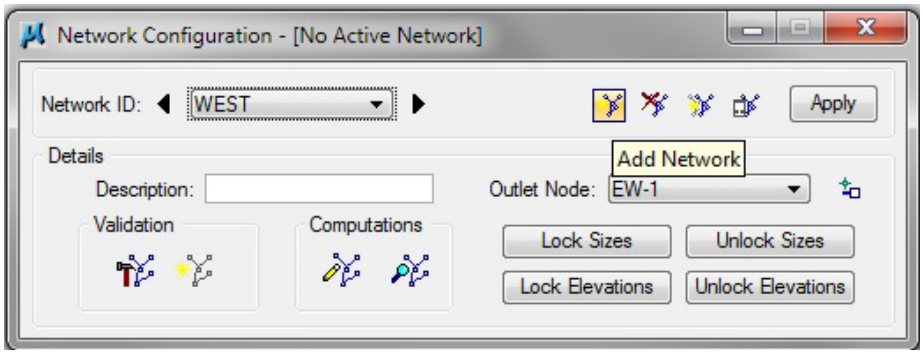
8. Ditch Networks

This exercise shows the user how to setup a network and perform network computations.

The Network computations serve as the final calculation process in the design or analysis of a storm drainage system. A GEOPAK drainage network is defined as a series of interconnected nodes, links and areas which drain to a single outlet. GEOPAK drainage accommodates multiple networks in a single drainage project.

8.1 Ditch Network Design

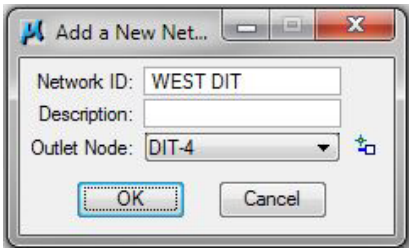
a) Select the **Add Drainage Network** tool, select **Network > Add** from the main drainage menu bar or click the **Add Network** button in the Network Configuration Dialog.



b) In the **Add a New Network** dialog, enter the following information:

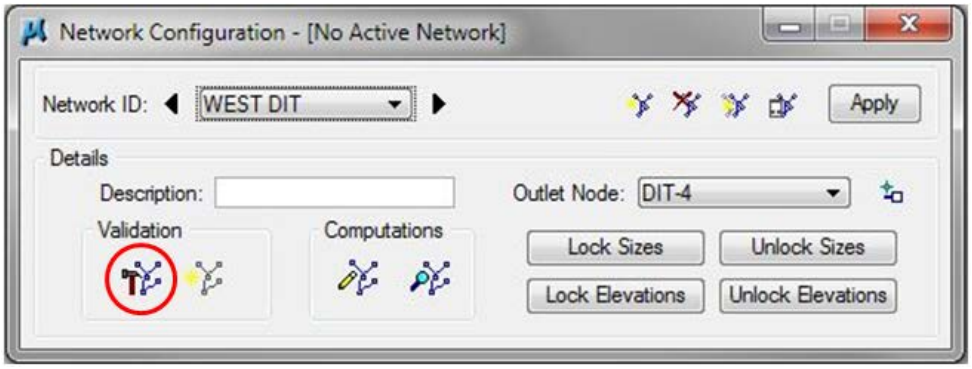
Network ID: WEST DIT

Outlet Node: DIT-4



NOTE: The **Outlet Node** may be selected via the dropdown or by clicking **ID Outlet** and selecting the Node in the plan view.

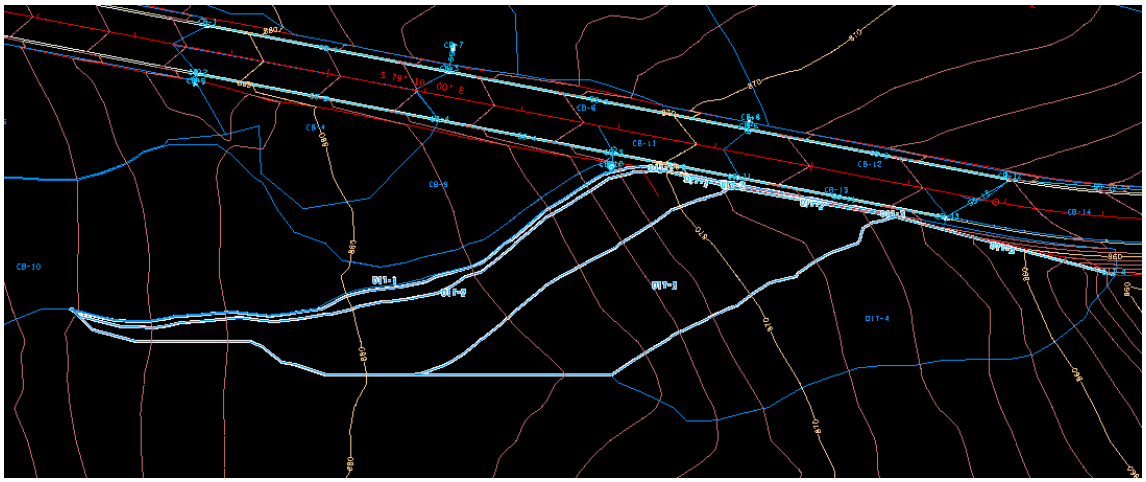
c) Click **OK** in the Add a New Network dialog box.



d) Click the **Build Network** button. Click **OK.**

e) Click the **Highlight Network** feature.

f) Verify that all network components are highlighted.

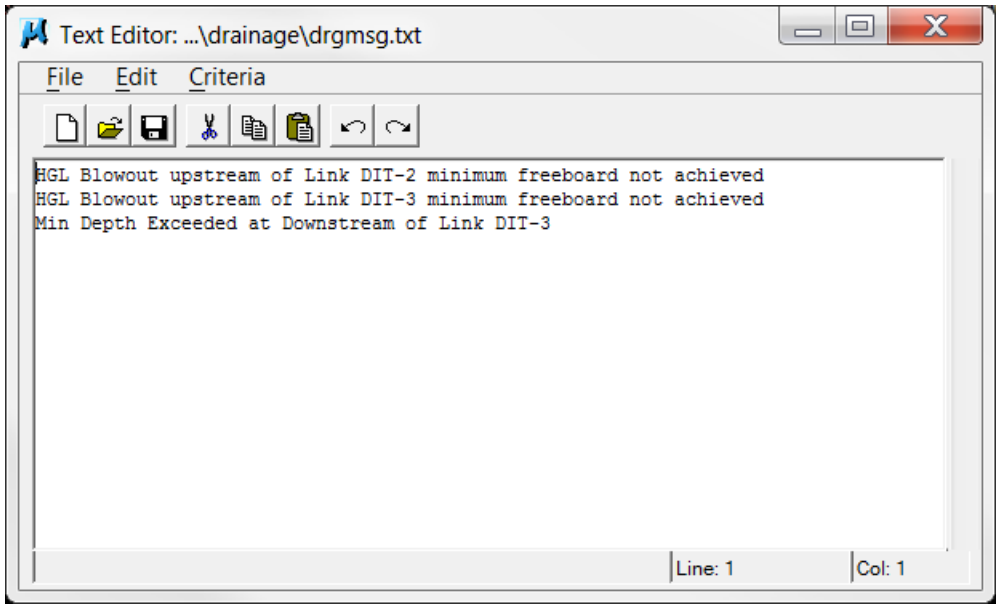


NOTE: The drainage area DIT-4 will not be highlighted since it is built for an outlet node type which does not consider drainage areas. In the previous chapter, we linked that area to node DIT-3 so that it is covered in this ditch drainage analysis.

g) Click the **Apply** button. Network "WEST DIT" has been added to the project.

h) Click the **Design** button, then click **OK.**

i) Review errors to determine steps needed to correct and close the text editor. (See **Appendix C** for common errors and fixes)

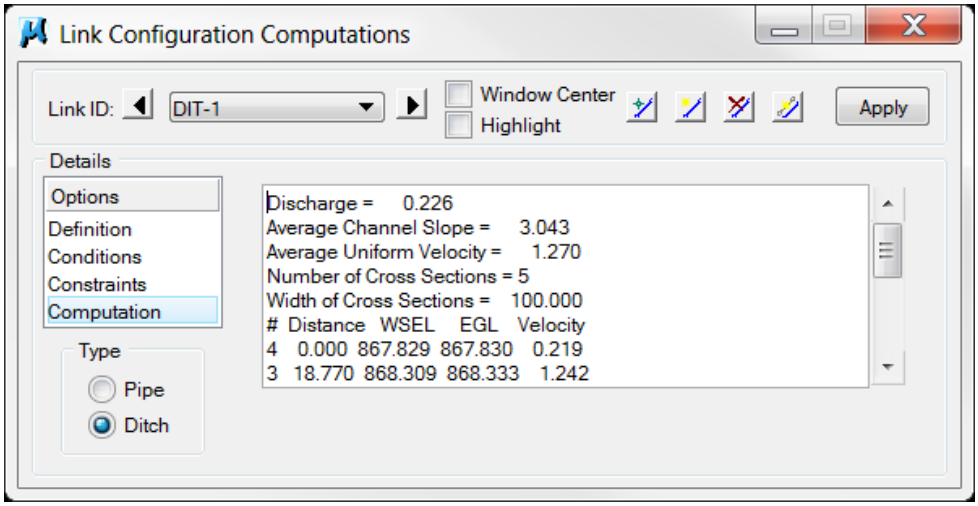


8.2 Ditch Link Review

Now that the ditch network has been built and designed, we can review the computation results for the existing ditch links in the network.

a) Select the **Edit Link** tool, select **Component> Link> Edit** from the main drainage menu bar or click the **Edit Link** button in the Network Configuration Dialog.

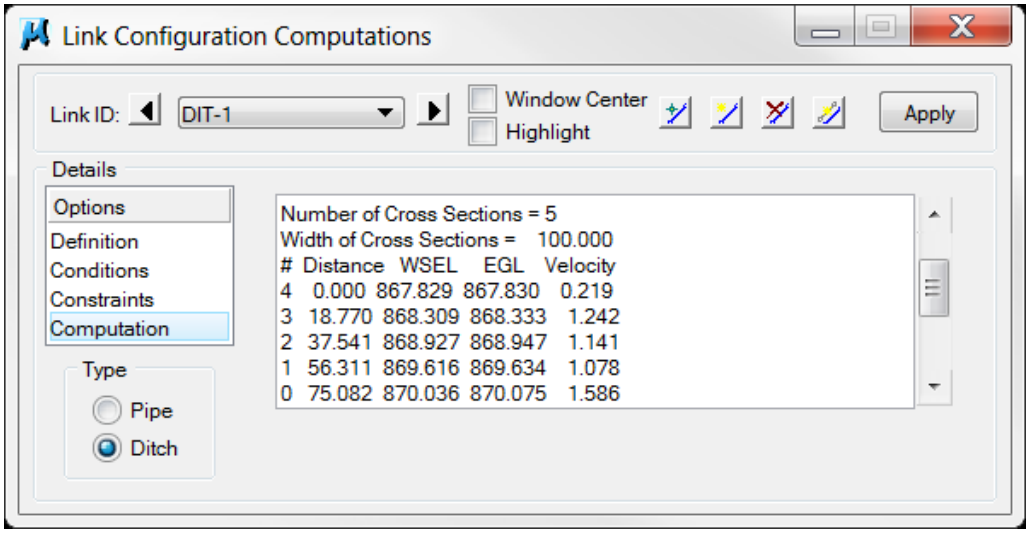
Set to link **DIT-1** and select **Computation**.



b) Scroll down through the computation results to the data following the **Width of Cross Sections**.

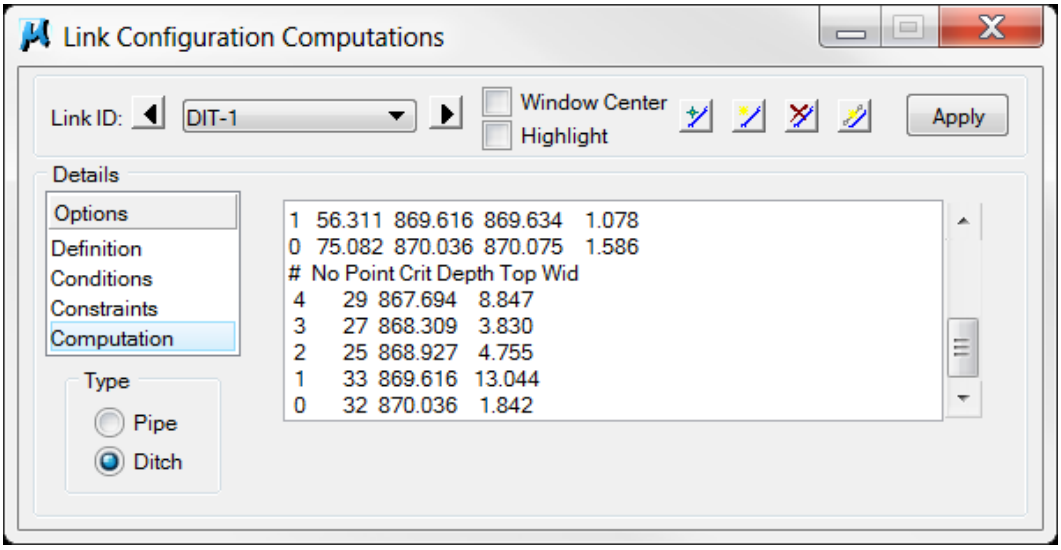
This data represents conditions at each cross section drop along the link. Note that these points start at the end of the link and come back up the link to the beginning.

The first data group provides the cross section number (0-4 in this case with 5 cross sections), distance from end, water surface elevation, energy grade line elevation and velocity.

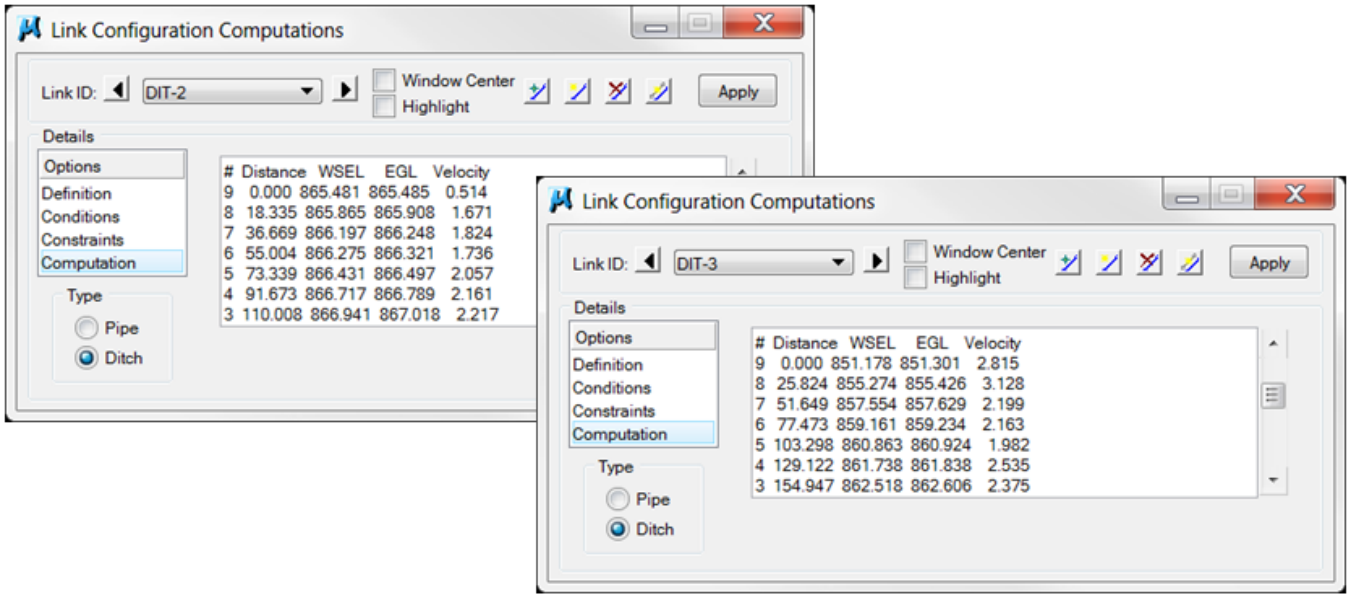


c) Scroll down further to review the second data group.

The second data group provides the cross section number, number of slope break points in cross section, critical depth elevation, and top of water surface width.



d) Switch to our other ditch links, DIT-2 & DIT-3, and review the computed data.



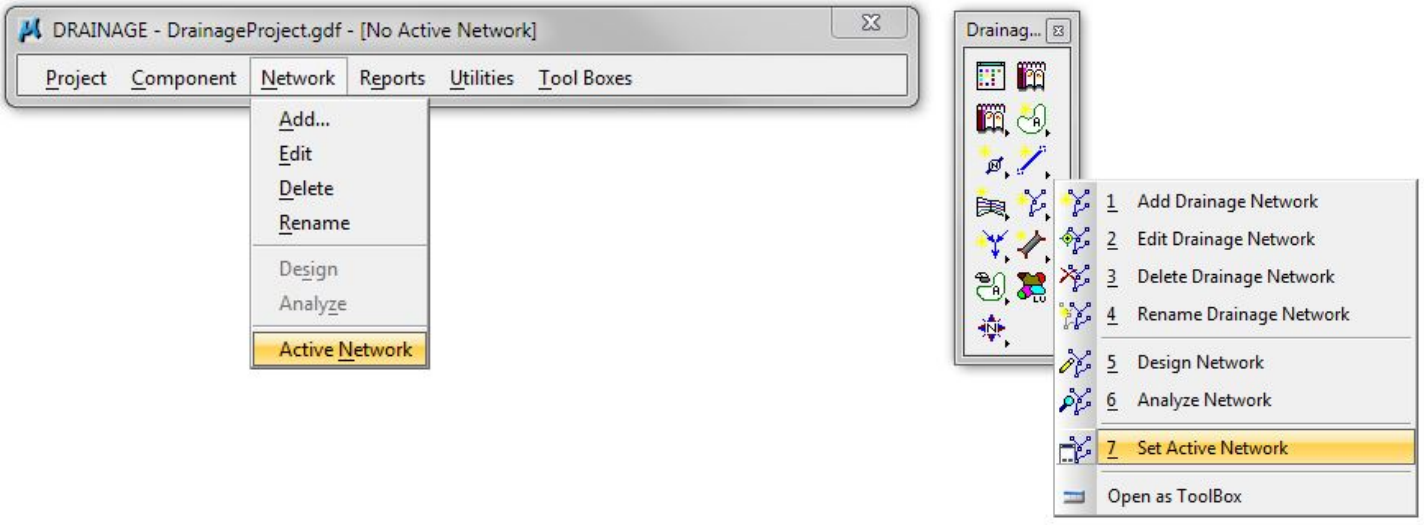
Using this information, we can determine if the existing conditions are adequate to convey the water along the fill line and critical points where more capacity may be required.

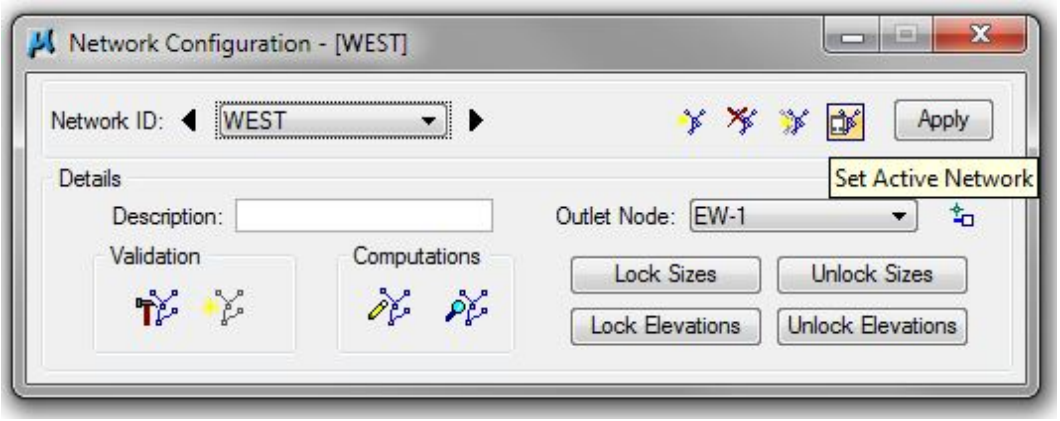
If using this methodology to analyze long proposed roadway ditches, you can determine locations where special ditches may be required as the depth\volume becomes too great for the regular ditch to handle.

8.3 Select Active Network

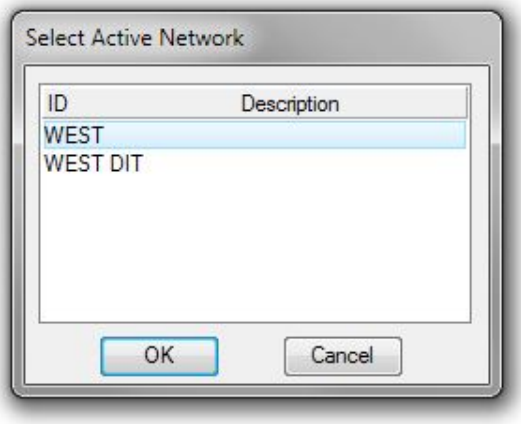
With the possibility of multiple networks in a single drainage project it may be necessary to choose an Active Network to utilize certain GEOPAK Drainage Features.

a) Select the **Set Active Network** tool, select **Network > Active Network** from the main drainage menu bar or click the **Add Network** button in the Network Configuration Dialog.





b) Select the network **West** and click **OK.**



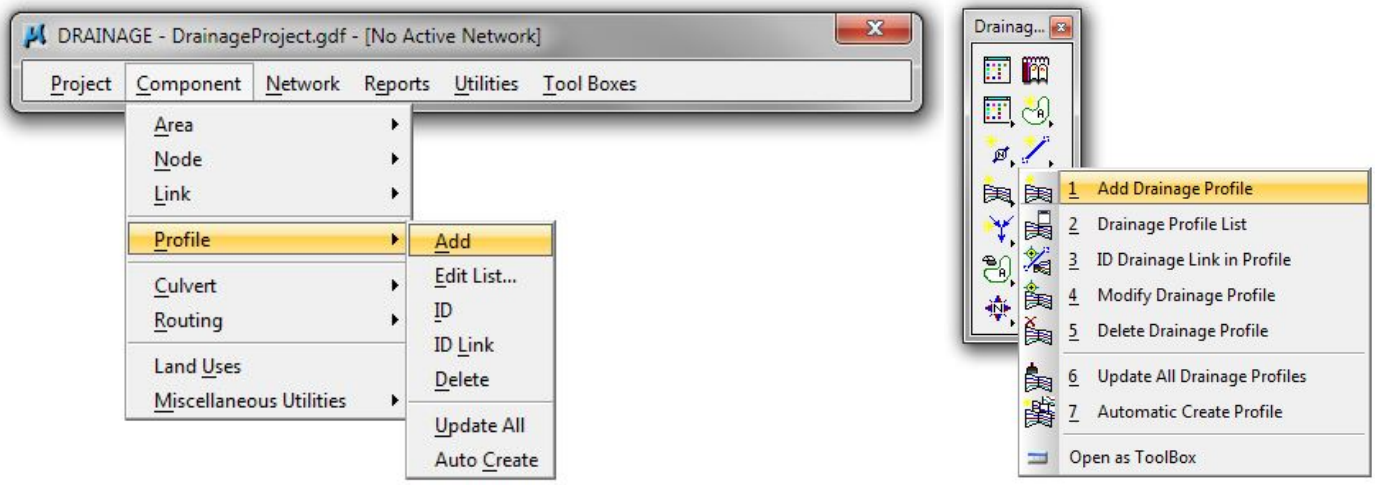
9. Profiles

This exercise shows the user how to perform profile computations and properly display the drainage profile.

Profiles can be constructed in a path running in either direction, upstream or downstream, in a drainage network. The Profiles dialog is used to display customized profiles including groundline, nodes, links, depth of cover, hydraulic grade line, etc.

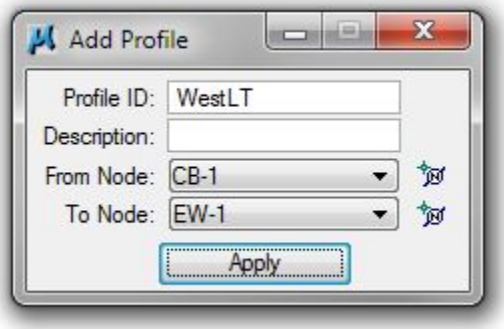
9.1 Storm Drainage Profile Design

a) Select from the Menu Bar: **Component > Profile > Add** or from the main toolbar: **Add Drainage Profile**



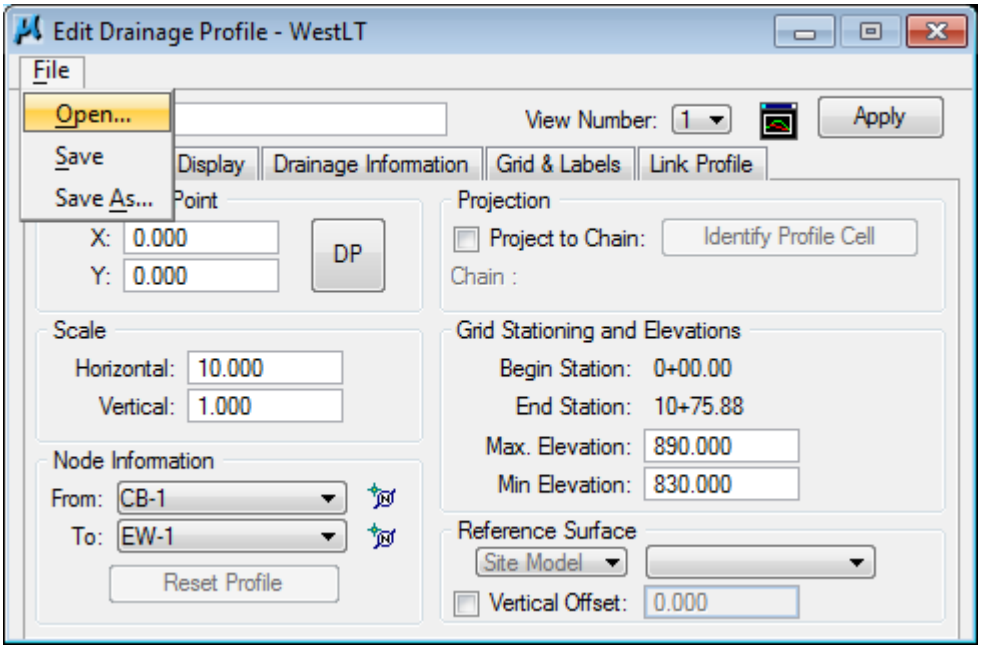
b) Complete the **Profile Configuration** dialog box information as follows for the left side of the roadway in the WEST drainage network. Click **Apply** when finished.

Profile ID: WestLT **From Node:** CB-1 **To Node:** EW-1

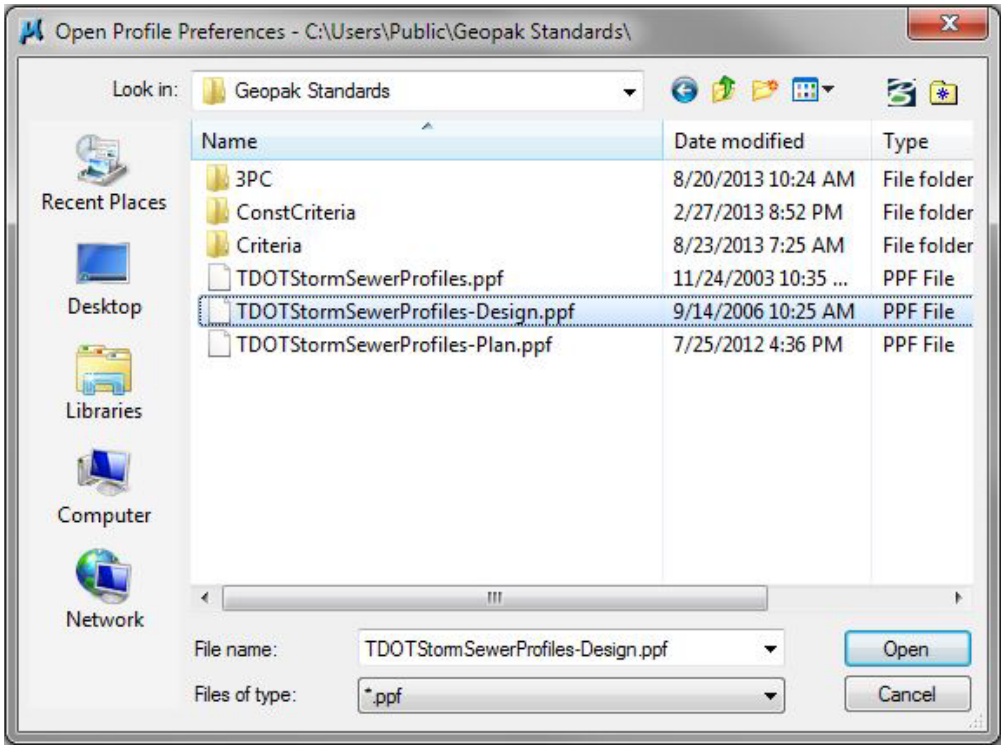


NOTE: To select the appropriate node; use the dropdown menu or use the **ID** node button and select the node from the plan view. **From Node and To Node *must* be in the same network.**

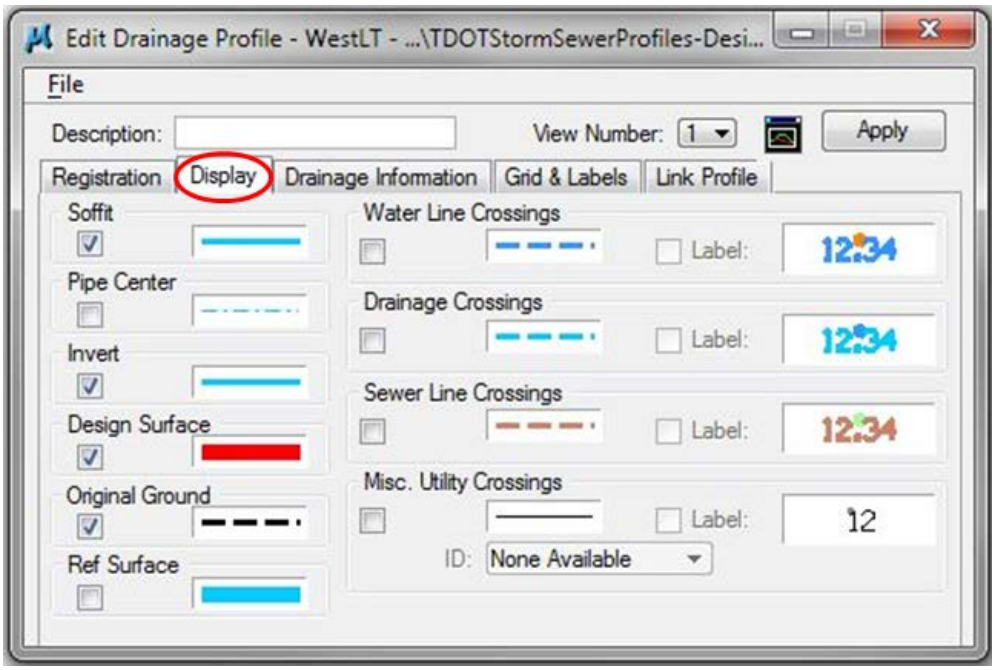
c) Load the **Profile Preferences** file. Inside the Edit Drainage Profile dialog, click **File > Open**.

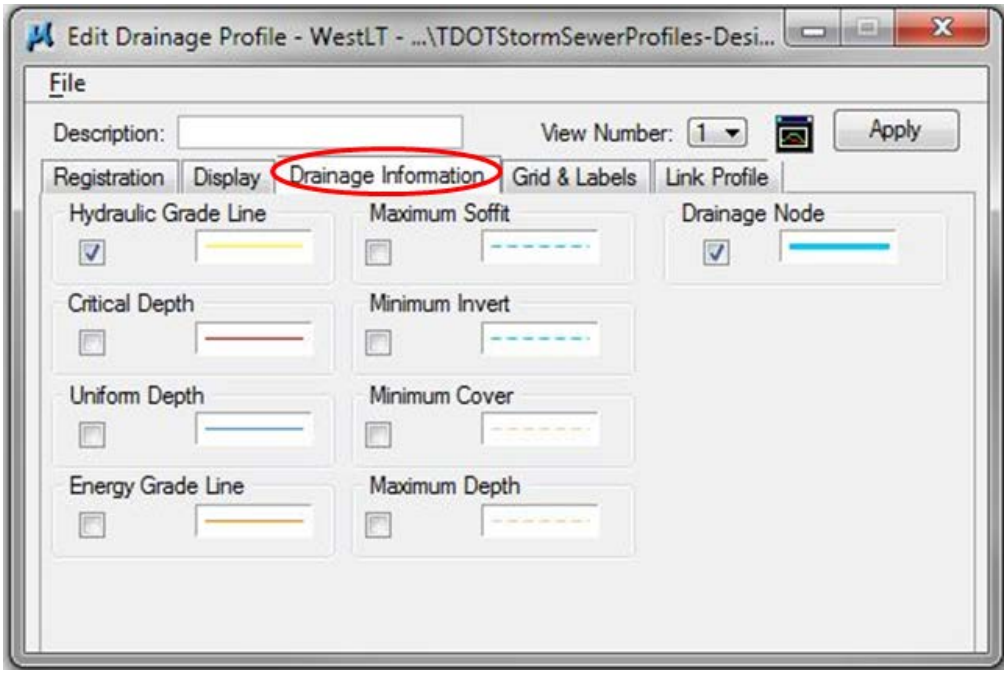


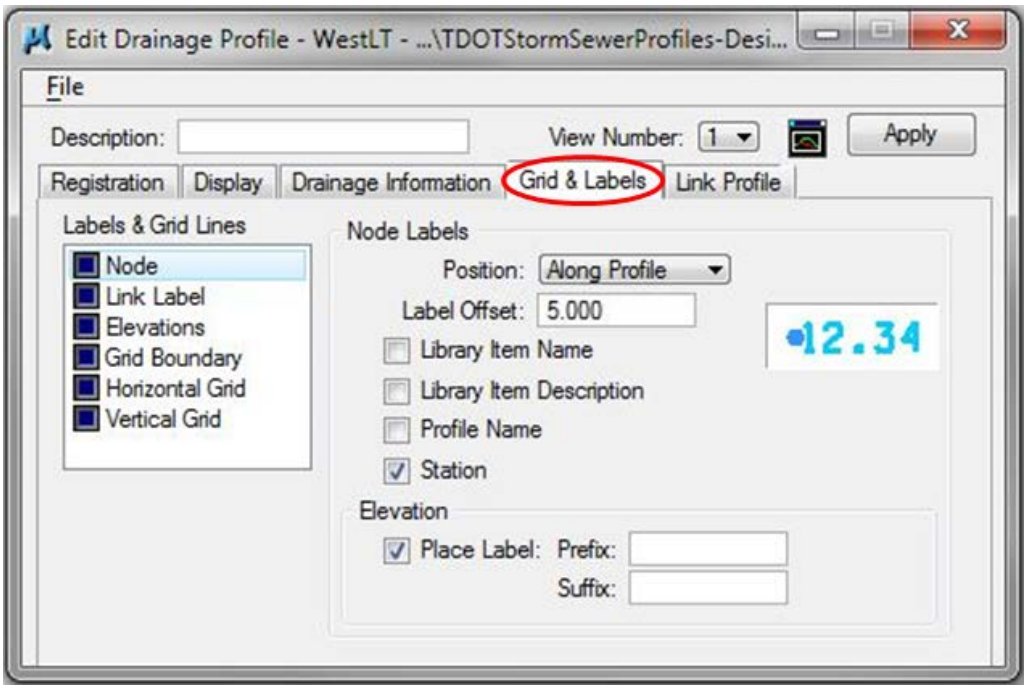
Navigate to **C:Users\Public\Geopak Standards** and select **TDOTStormSewerProfiles-Design.ppf**. Click **Open.**



All settings have been set for the profile. To view the settings, click on the **Display**, **Drainage Information** and **Grid & Labels** tabs. They should look as shown below.

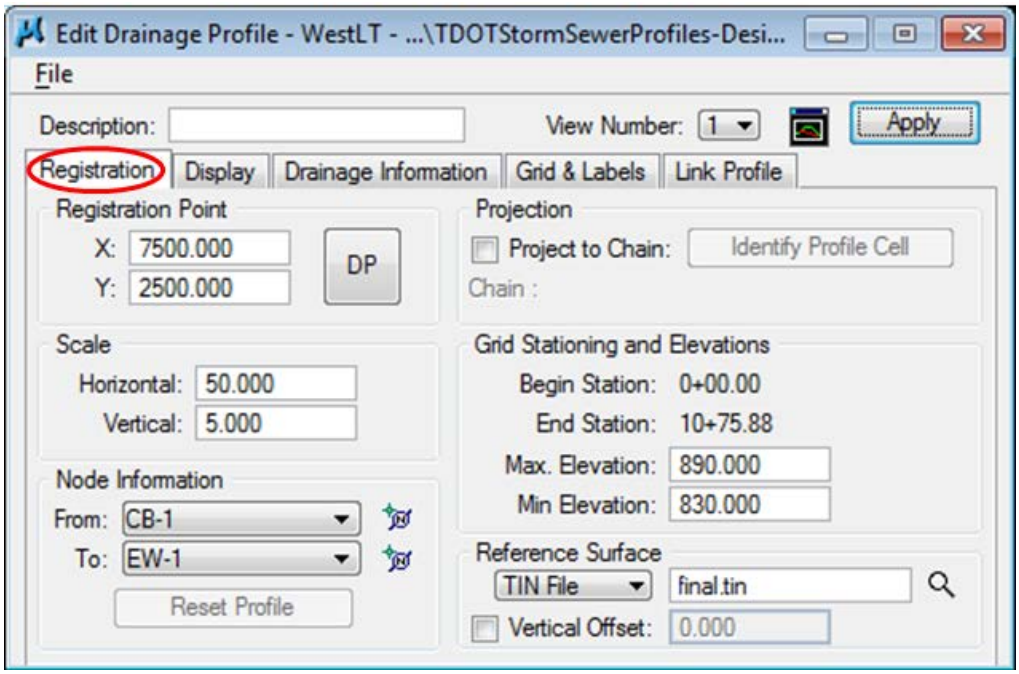

Edit Drainage Profile - WestLT - ...\TDOTStormSewerProfiles-Desi...
File
Description:
View Number: 1
Apply
Registration
Display
Drainage Information
Grid & Labels
Link Profile
Soffit
Pipe Center
Invert
Design Surface
Original Ground
Ref Surface
Water Line Crossings
Label:
Drainage Crossings
Label:
Sewer Line Crossings
Label:
Misc. Utility Crossings
Label:
12
ID: None Available

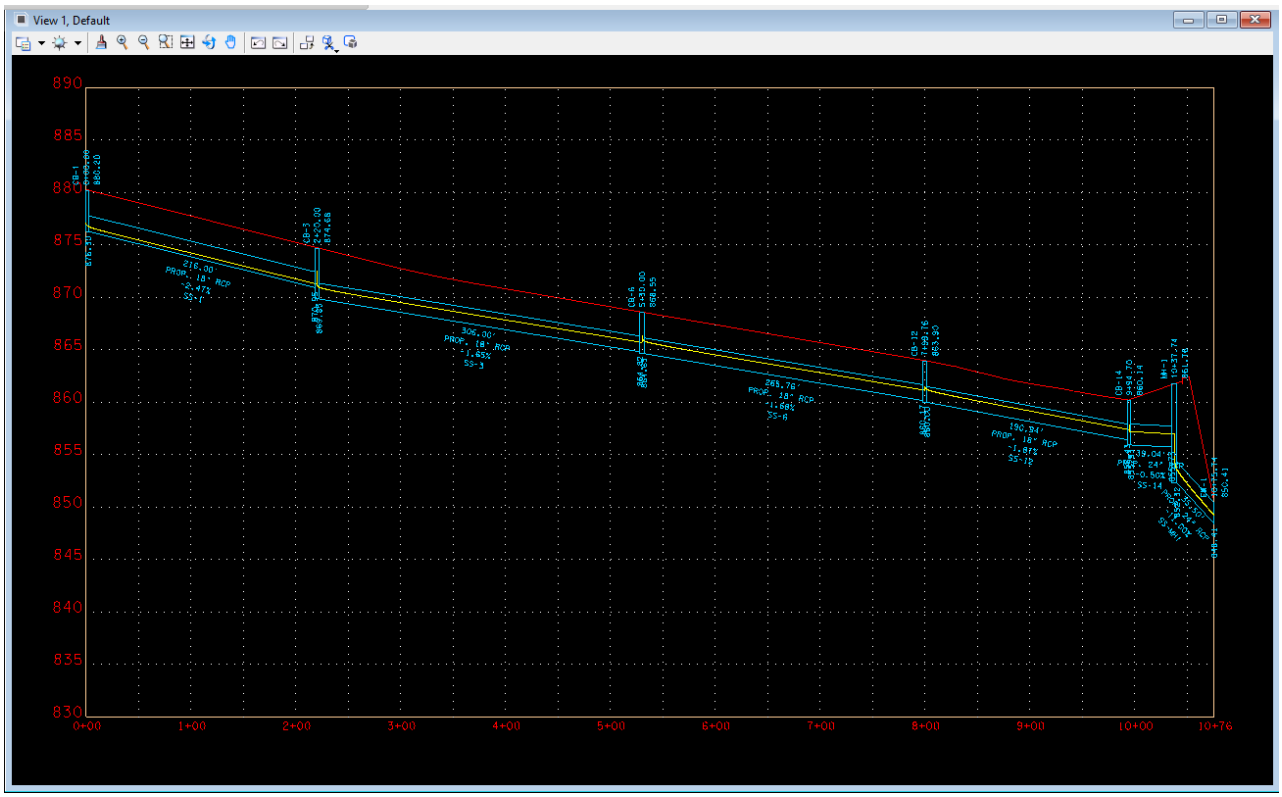

Edit Drainage Profile - WestLT - ...\TDOTStormSewerProfiles-Desi...
File
Description:
View Number: 1
Apply
Registration
Display
Drainage Information
Grid & Labels
Link Profile
Hydraulic Grade Line
Critical Depth
Uniform Depth
Energy Grade Line
Maximum Soffit
Minimum Invert
Minimum Cover
Maximum Depth
Drainage Node



NOTE: During the design process these preferences can be modified to display needed information. However, when projecting to a profile (see Exercise 9.2) the settings should match those defined in profile preference file **TDOTStormSewerProfiles-Plan.ppf**.

d) Click the **Registration** tab and make the settings as below in the *Registration Point*, *Scale* and *Reference Surface* portions (ignore the *Projection* portion for now). The Registration Point will correspond to the lower left corner of the profile and can be wherever an open space is available. Click **Apply**.





e) Review the profile for anything that needs to be corrected.

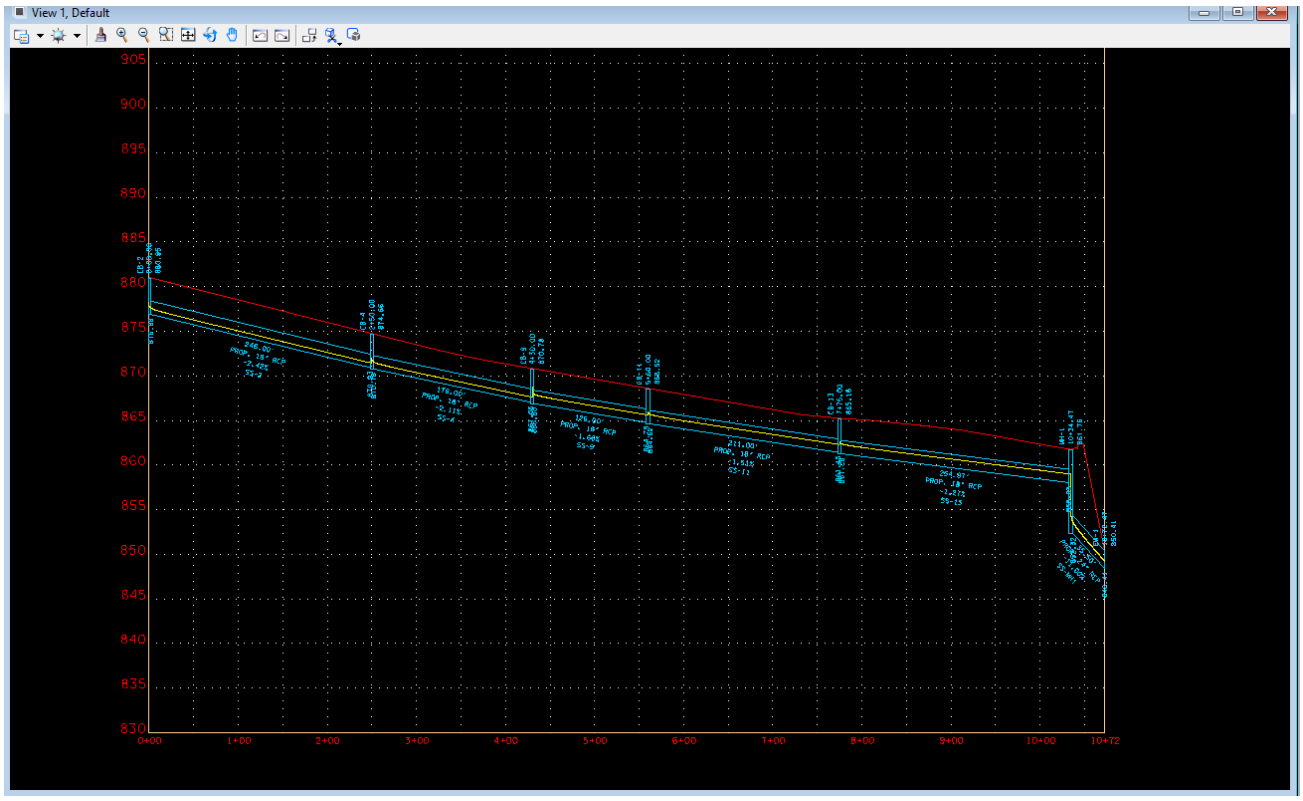
f) Repeat steps a-d to create the following profiles:

Profile ID	From Node - To Node	Registration Point	
WestRT	CB-2 - EW-1	X = 7500	Y = 1000
CB5	CB-5 - CB-2	X = 9000	Y = 1000
CB7	CB-7 - CB-3	X = 9000	Y = 2500
CB8	CB-8 - CB-6	X = 9500	Y = 2500
CB10	CB-10 - CB-9	X = 9500	Y = 1000

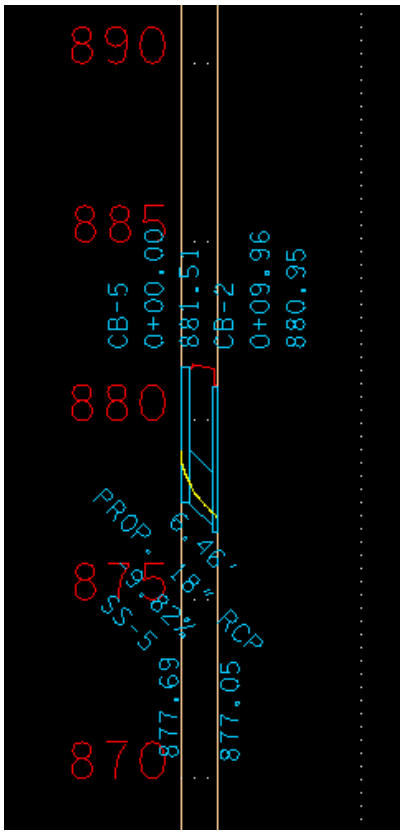
NOTE: All Profiles should go forward with the alignment so they can be projected to the roadway alignment profile at a later time.

See the following pages for images of the profiles.

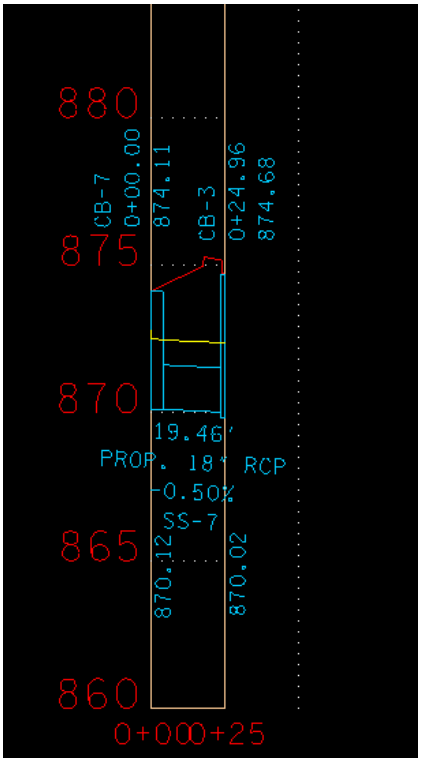
WestRT



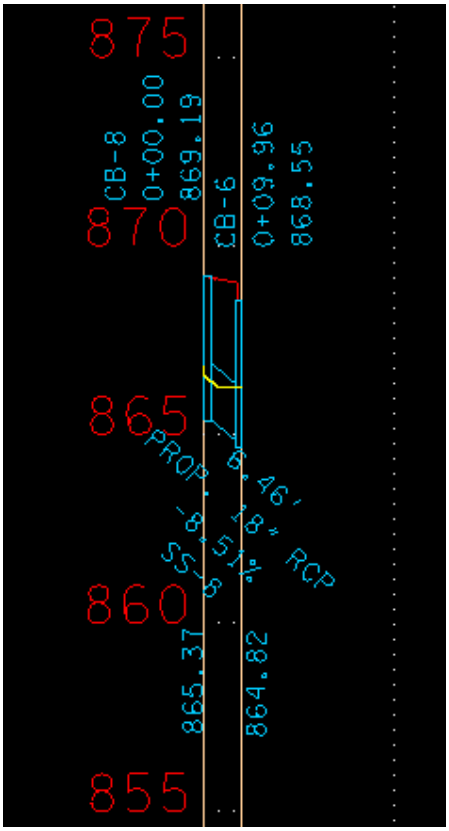
CB5



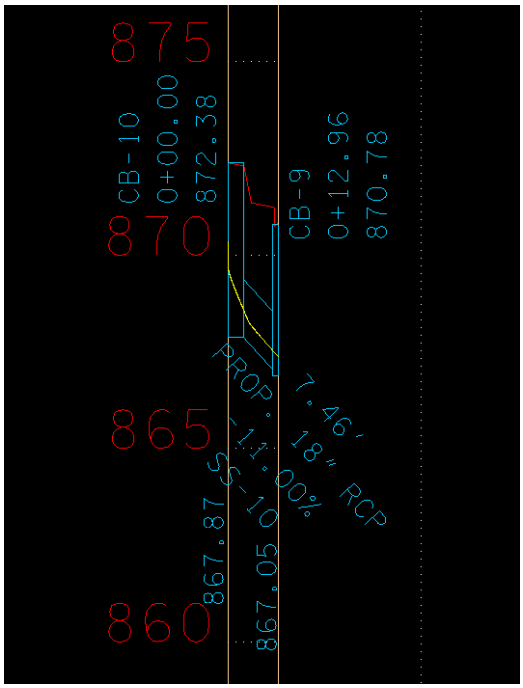
CB7



CB8

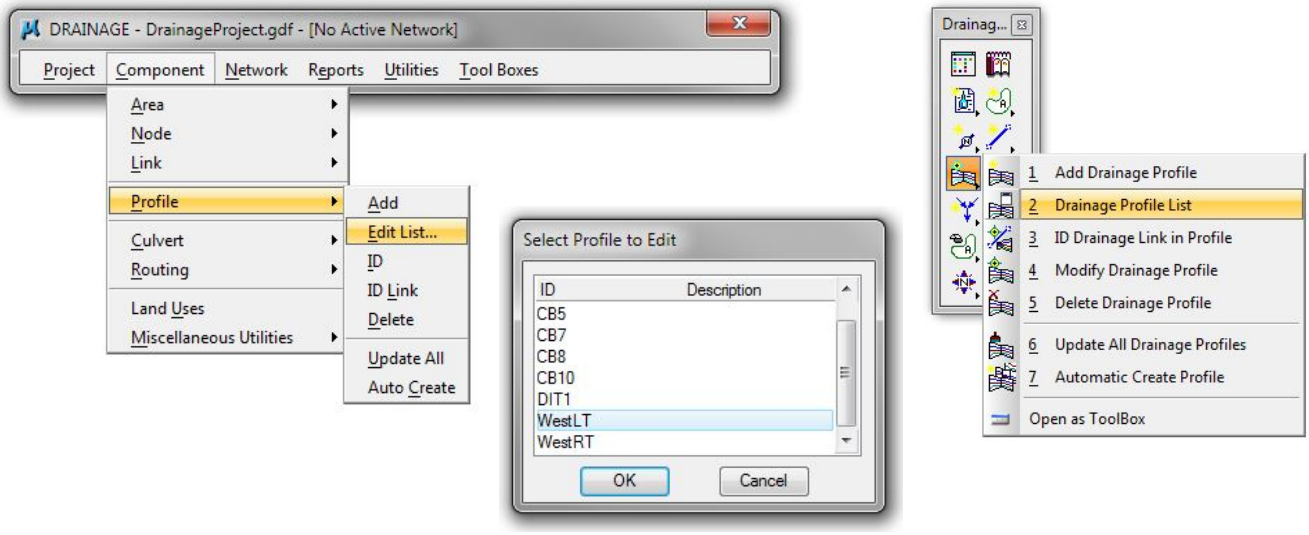

875
870
865
860
855
CB-8
0+00.00
869.19
CB-6
0+09.96
868.55
865.37
864.82
6" RCP
46'
8.51%
55.6

CB10


875
870
865
860
CB-10
0+00.00
872.38
CB-9
0+12.96
870.78
867.87
867.98
18" RCP
46'
13.00%
55.10

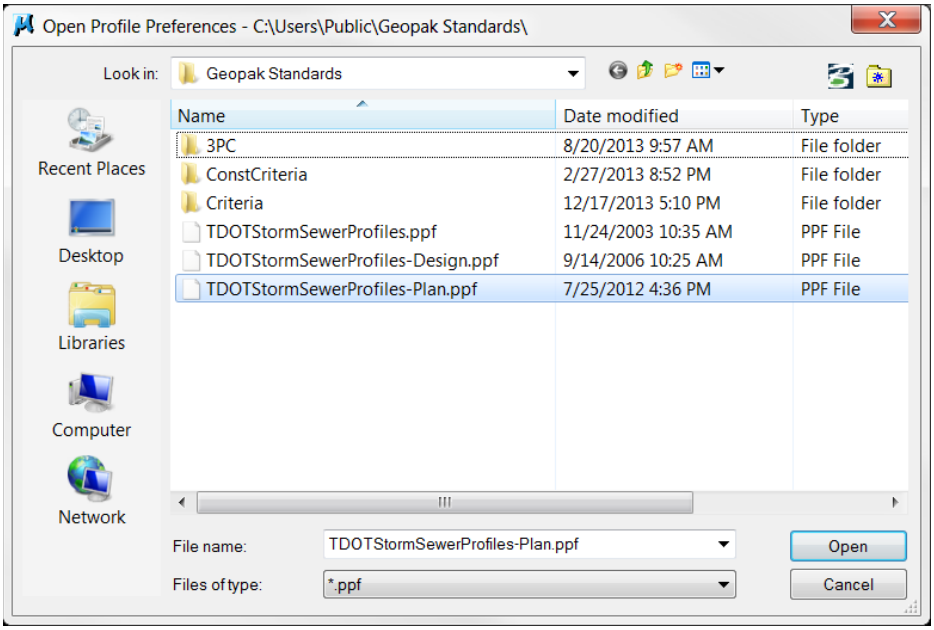
9.2 Projecting Profiles to a Chain

a) Click **Component > Profile > Edit List** from the GEOPAK Drainage Menu or by **Drainage Profile List** from the Drainage Toolbar and select the Profile **WestLT**. Click **OK**.

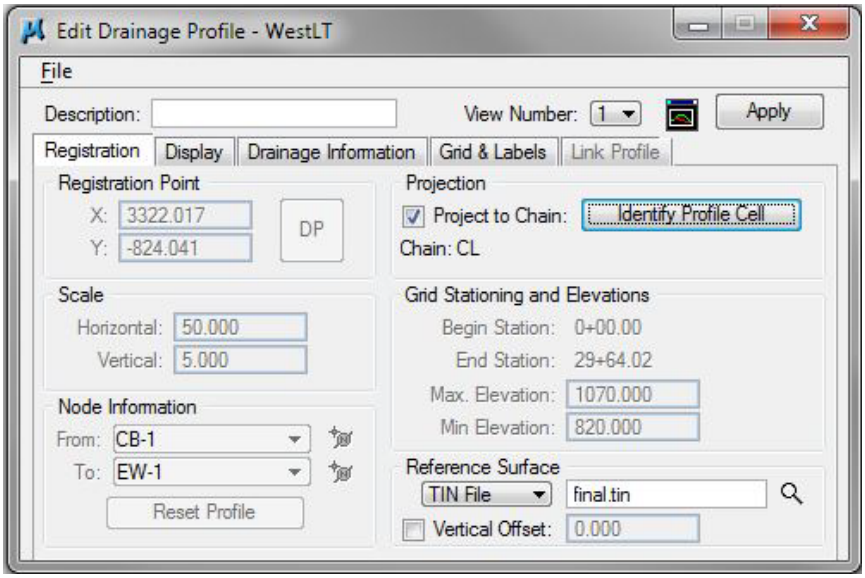


b) Load the **Profile Preferences** file. Inside the Edit Drainage Profile dialog, click **File > Open**.

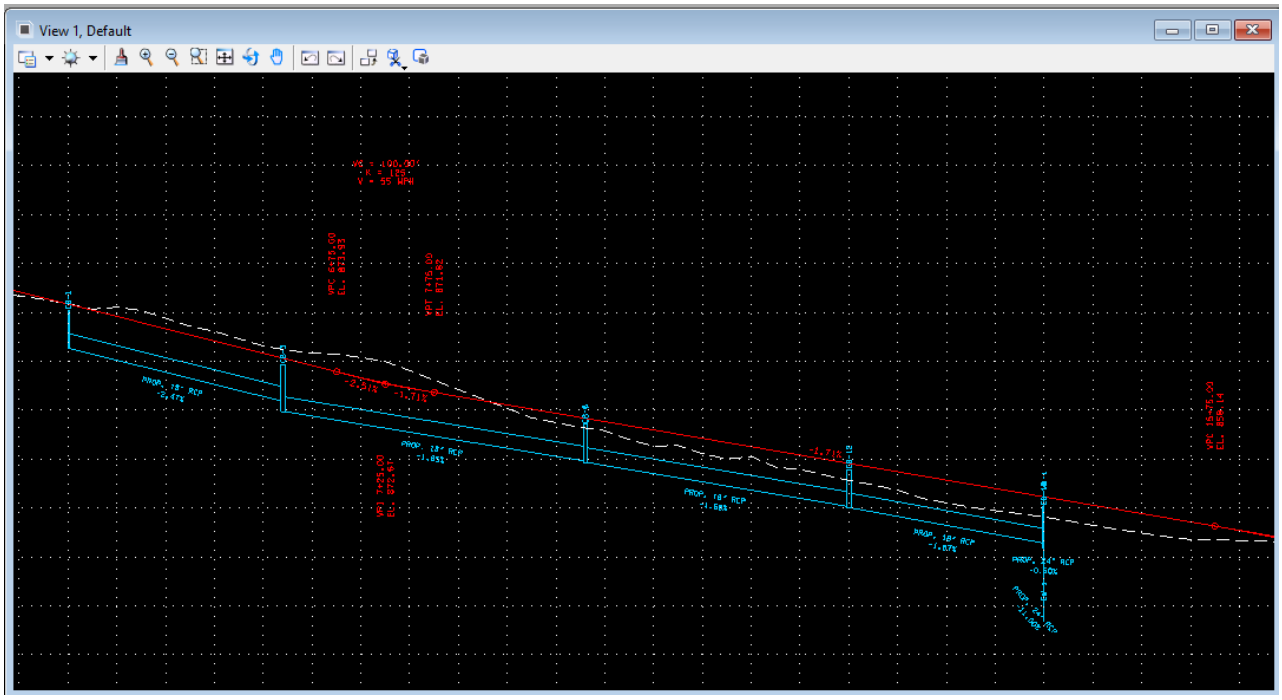
Navigate to **C:Users\Public\Geopak Standards** and select **TDOTStormSewerProfiles-Plan.ppf**. Click **Open.**



c) Toggle ON **Project to Chain** in the *Projection* portion of the dialog. Click **Identify Profile Cell** and select the Profile Cell for the *Roadway* Profile and Data Point to accept. Click **Apply**.



d) View the Projected Drainage Profile along the Roadway Profile.



NOTE: Caution must be used when Projecting Drainage Profiles since the profile will be skewed to fit the station and elevation data of the roadway profile.

9.3 Ditch Profile

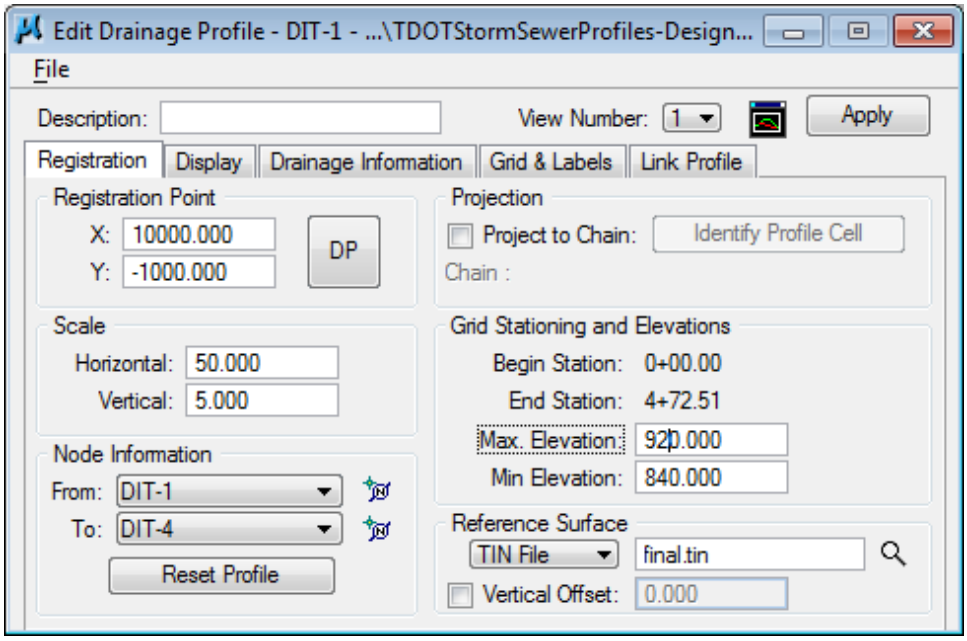
a) Select from the Menu Bar: **Component > Profile > Add** or from the main toolbar: **Add Drainage Profile**

b) Complete the **Profile Configuration** dialog box information as follows for the special ditch drainage network. Click **Apply** when finished.

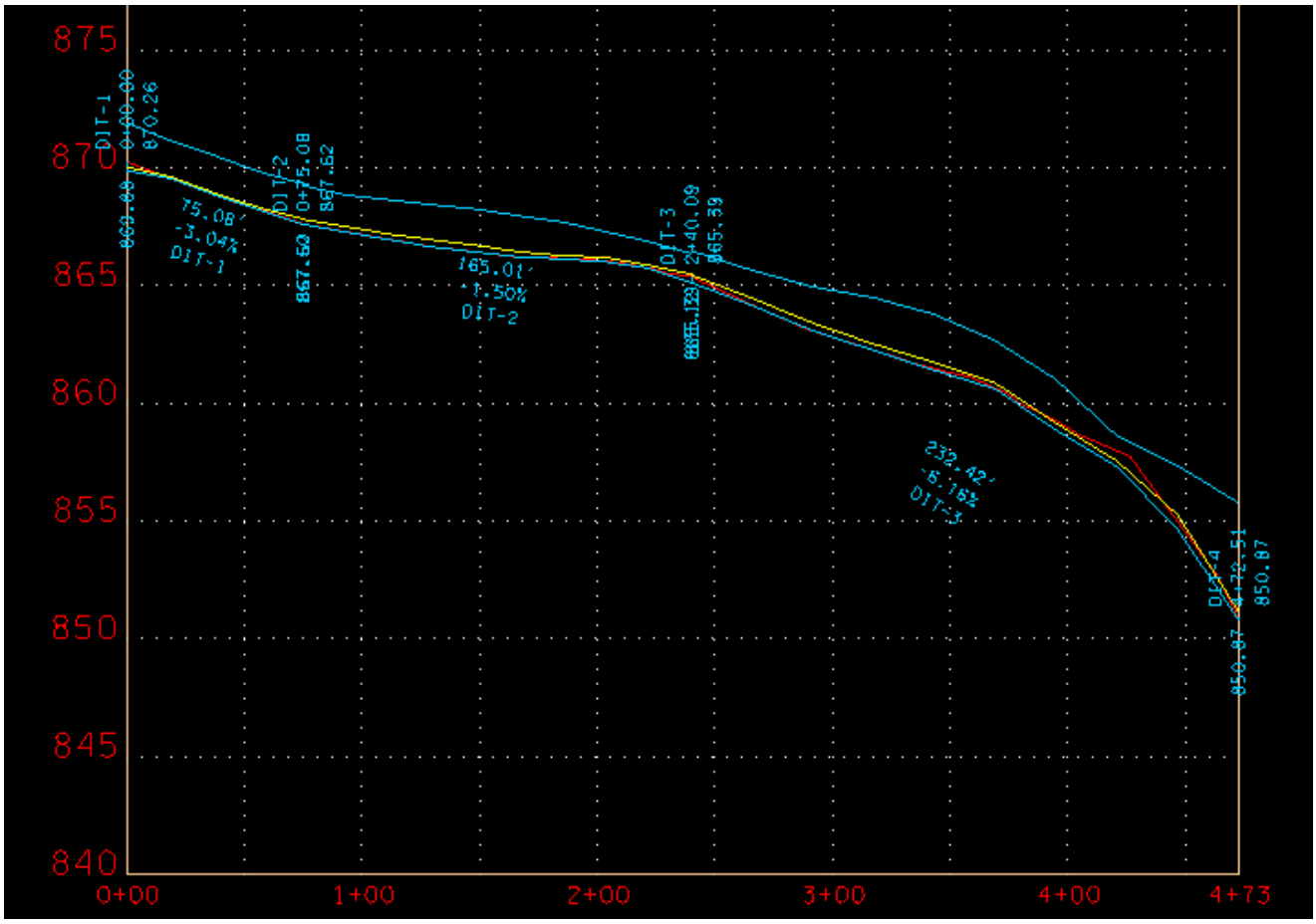
Profile ID: DIT1 **From Node:** DIT-1 **To Node:** DIT-4

c) Load the **Profile Preferences** file. Inside the Edit Drainage Profile dialog, click **File > Open**. Navigate to **C:Users\Public\Geopak Standards** and select **TDOTStormSewerProfiles-Design.ppf**. Click **Open.**

d) Click the **Registration** tab and make the settings as below in the *Registration Point*, *Scale* and *Reference Surface* portions (make sure **Project to Chain** is toggled OFF). Click **Apply**.



NOTE: For ditch profiles defined with Fixed Geometry, this dialog can be used to help identify and correct errors produced in the drainage calculations and ensure the drainage flows as it should. Our current ditch network set up is Cross Section Based on the existing terrain so that functionality is not applicable.



NOTES:
For Cross Section Based links the invert generally follows the existing surface terrain.

The yellow hydraulic grade line indicates locations where the existing ditch cross section geometry and water volume cause a rise or fall in the water surface elevation. Rises indicate points where greater capacity may be required. This information along with computation information provided with the links can be used to determine any possible special ditch needs.

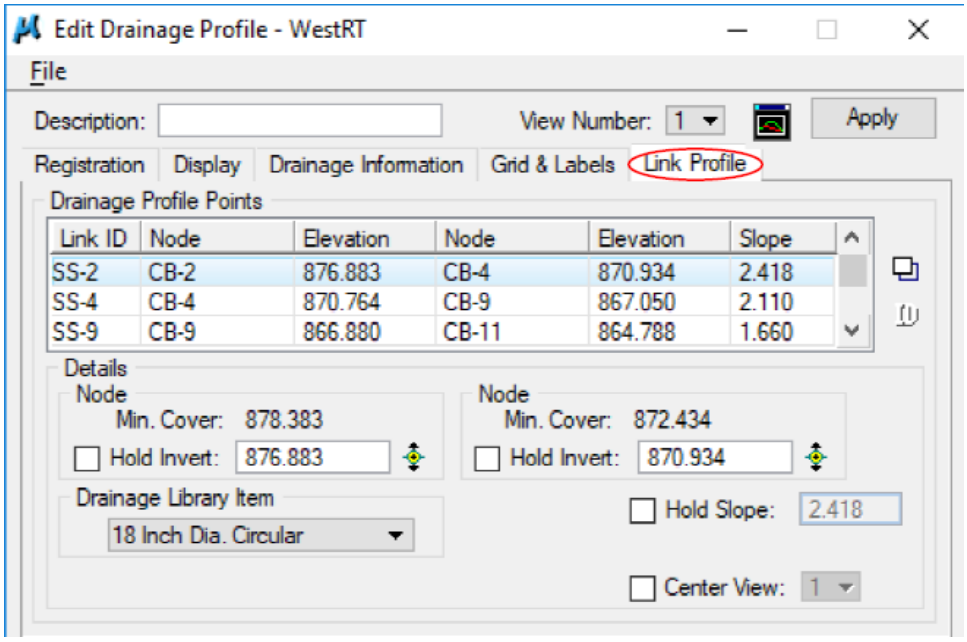
In Exercise 11, the system modification chapter, we will relocate these nodes and set the links as fixed geometry to define a special ditch set up to handle the drainage in this area.

9.4 Editing Links via Profiles

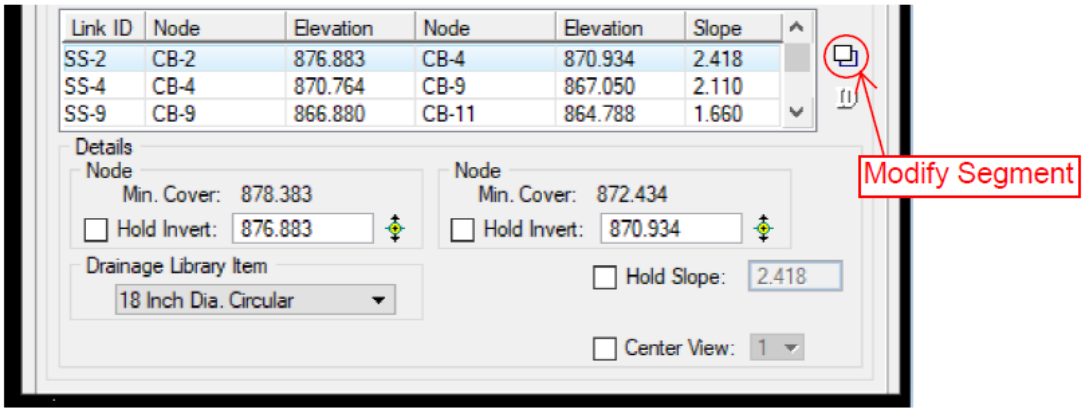
The Edit Profiles dialog allows you to edit a Link's design. This being the case the **Link Configuration** dialog must be closed in order to open the **Edit Drainage Profile** dialog.

a) Open profile **WestRT** by selecting **Component > Profile > Edit List** or by selecting **Drainage Profile List** from the GEOPAK Drainage Main Toolbar**.**

b) Click the **Link Profile** tab. Highlight the **SS-2** Link ID.



The SS-2 link's control data is populated in the **Details** section at the bottom.



From here you can set and hold the invert elevations, set the slope to hold or change the pipe size.

Once any desired changes are made, click the **Modify Segment** icon on the right. An alert will appear. Click **Yes**, review and dismiss the warnings.

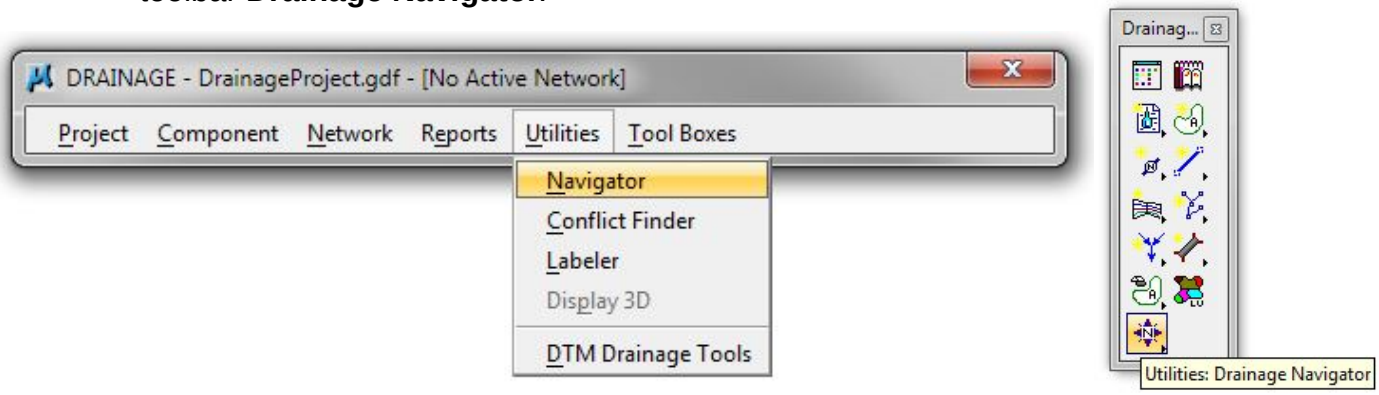
c) Do not make any changes at this time. Click the red X to dismiss the dialog.

10. Drainage Navigator

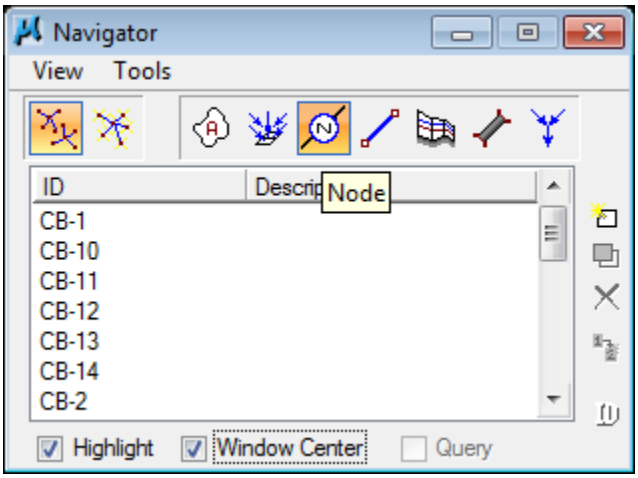
This exercise shows the user how to navigate a network and perform queries.

10.1 Navigating/Query

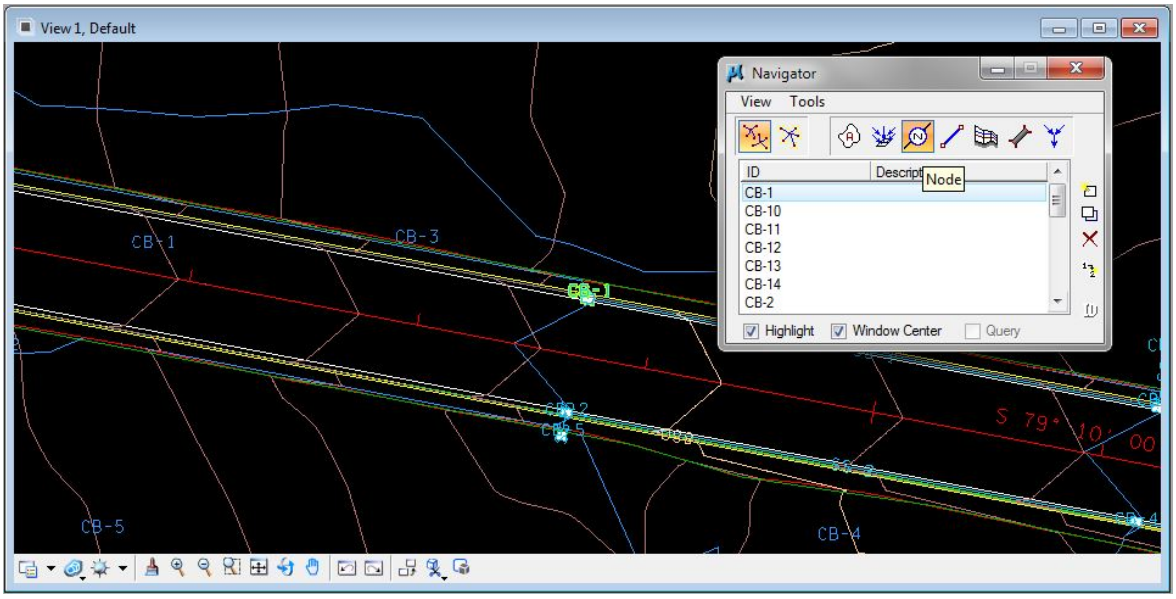
a) Select from the Drainage Menu Bar **Utilities > Navigator** or from the drainage main toolbar **Drainage Navigator**.



b) Select the Drainage **Nodes** button on the *Navigator*:



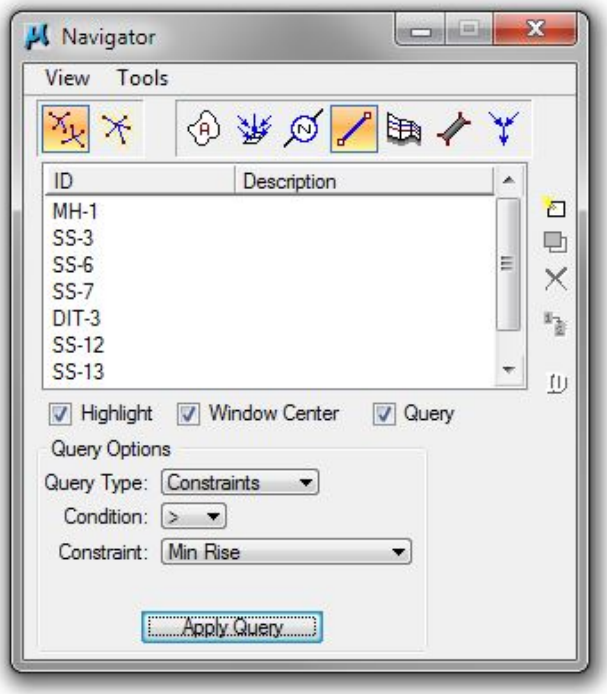
c) Toggle ON the Highlight and Window Center tools and click **once** on various nodes in the network.



As you can see the **Drainage Navigator** makes it easy to go to specific components in the network. A **double click** automatically opens the component's configuration dialog for easy editing of any Drainage component.

d) Set the Active Component Type to **Link** and toggle the **Query** option:

e) Use the Query tool to determine which Links have exceeded the Min Rise. Make the settings as shown and then click on **Apply Query**.



Note the results of your query here:

_____

f) Follow the same procedures to determine the following:

Using Query type **Values;**
Which pipes have a velocity less than 3 fps?

_____
(This will show you which links need to be modified to increase the velocity.)

Using Query type **Values;**
Which pipes have a velocity greater than 12 fps?

_____
(This will show you which links need to be modified to decrease the velocity.)

Using Query type **Constraints;**
Which links have slopes less than Min Slope?

_____
(This will show you which links need to have their slopes increased.)

Set the active component type to Inlet.
Using Query type **Constraints;**
Which inlets have exceeded their max ponded width?

_____
(This will show you which inlets need to be relocated to decrease the ponded width.)

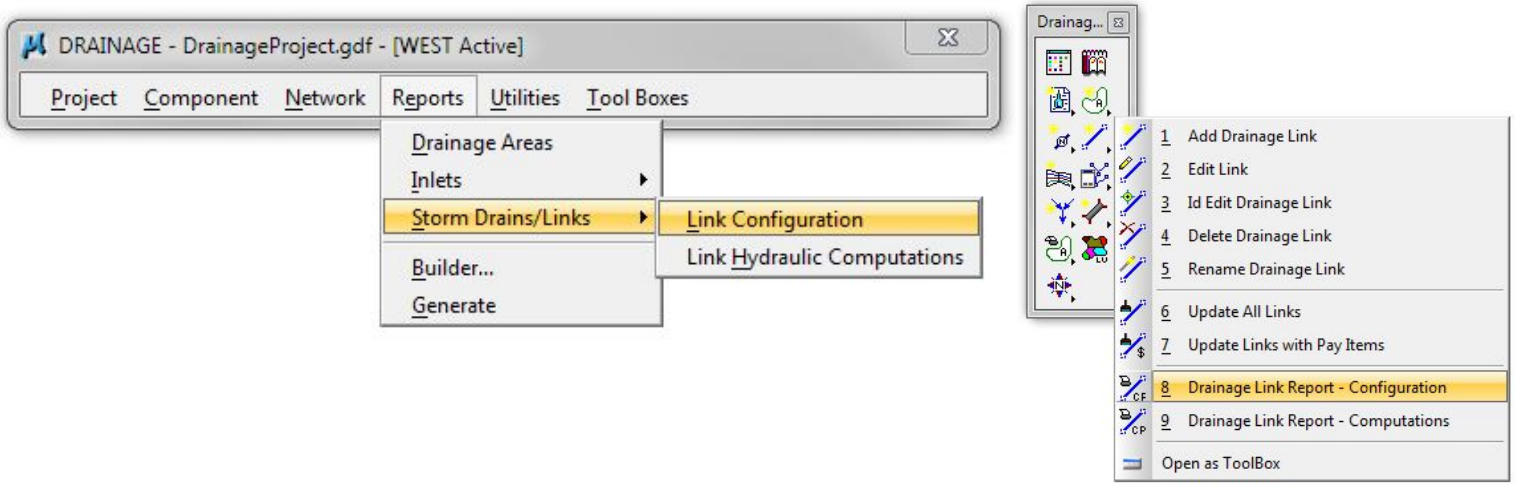
10.2 Navigating/Global Editor

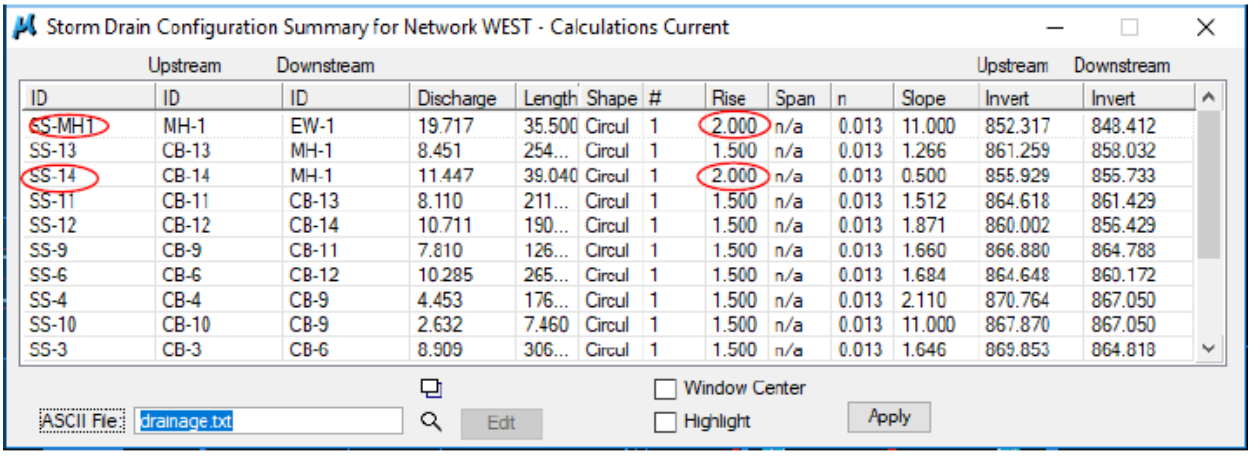
From the query in **Step 5** of Exercise 10.1 you should have found that 2 pipes were designed at a value greater than the minimum rise 1.5' (18"). These should have been SS-14 and SS-MH1.

Since for the initial design we set our minimum depth of cover based on the minimum pipe size it will be necessary to check our catch basin depths to be sure they have not violated minimum depth requirements and to make sure that the larger pipe size is valid for the node which was used. To do this take the following steps:

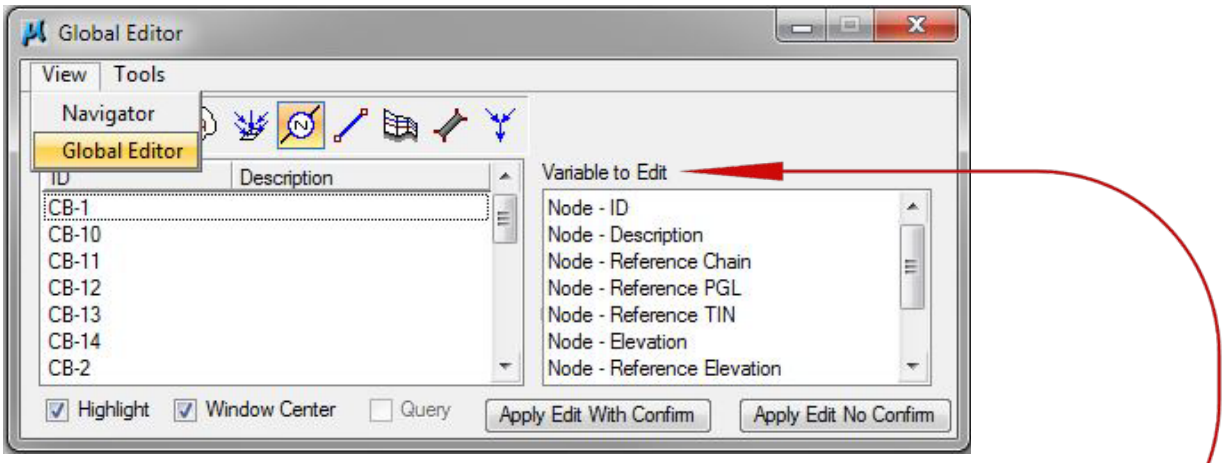
Checking Minimum Depth Requirements vs. Designed Node Depths & Pipe Sizes:

a) Identify which drainage nodes are involved by going to **Reports > Storm Drains/Links > Link Configuration** in the GEOPAK Drainage menu bar. This report describes each link including From Node (Upstream), To Node (Downstream) and Size/Diameter (Rise).

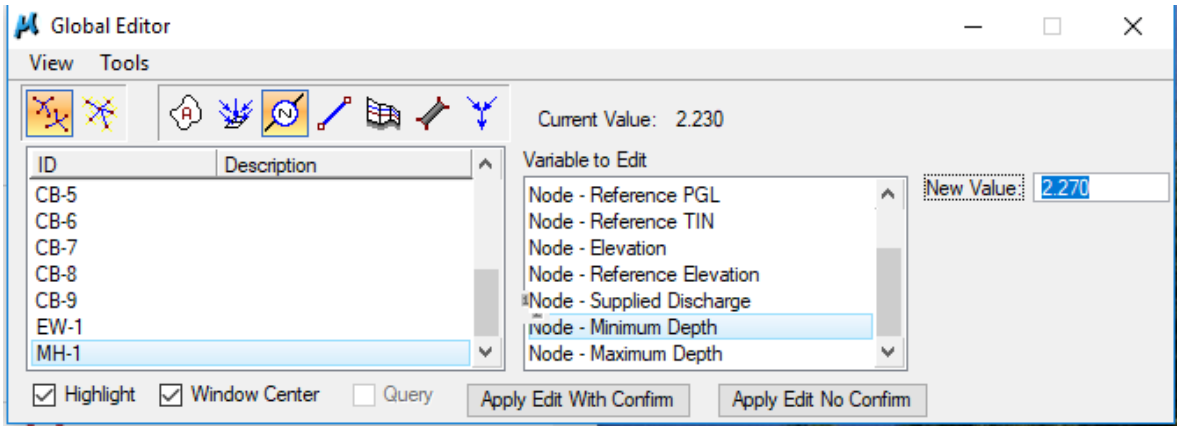




b) Open the **Navigator** tool under **Utilities** and expand it to the Global Editor by choosing from the pull-down menu **View > Global Editor**. Once the Global Editor is open, click on the **Node** button.



c) SS-MH1 is the first link shown in the Storm Drain Configuration Summary (**Step 1**). This link was designed by GEOPAK drainage to have a rise of 2.0 feet (24 inches). Find and select the Upstream Node (From Node) MH-1 for this Link in the Global Editor Dialog, then find and select **Node – Minimum Depth** in the *Variable to Edit* portion of the editor. Set the **New Value** to the correct minimum depth for a 2.0' (24") diameter pipe found in the TDOT GEOPAK Drainage Nodes document (Appendix A, pg. A-5).



NOTE: If the type of structure for a given node is unknown or needs to be changed (would happen if pipe size is too large for a given catch basin), simply double click the **Node ID** in the Global Editor and the Node Configuration Dialog will be invoked.

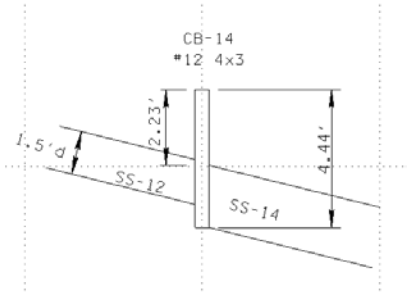
Min. Depth of Basin – Pipe Size – Drop Across Bottom of Structure = Minimum Depth

MH#3 5'DIA: 4.48' - 24"/12 - 0.21' = 2.27'

d) Click **Apply Edit With Confirm** to apply the New Value and Click Yes in the Alert box.

NOTE: Global Editor may be used to edit multiple Nodes/Links at once.

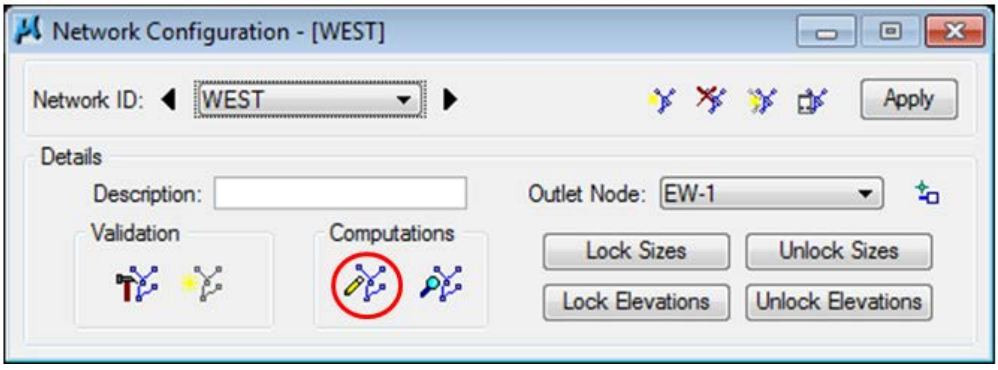
e) Repeat the previous steps to correct the minimum depth settings for the other storm drainage nodes for pipe link SS-14. (node CB-14)



Min Depth of Basin – Pipe Size – Drop Across Bottom of Structure = Minimum Depth

CB#12 4x3, 24'DIA Pipe: 4.44 - 24"/12 - 0.17' = 2.27'

f) Re-design the network **WEST** and review your profile. The Nodes should now meet minimum depth requirements.



10.3 Re-Run the Network

It is recommended that once a drainage network is set up all component constraints should be reviewed to insure that all criteria for design has been met.

After re running the network **WEST** in Step 6 there are three errors:

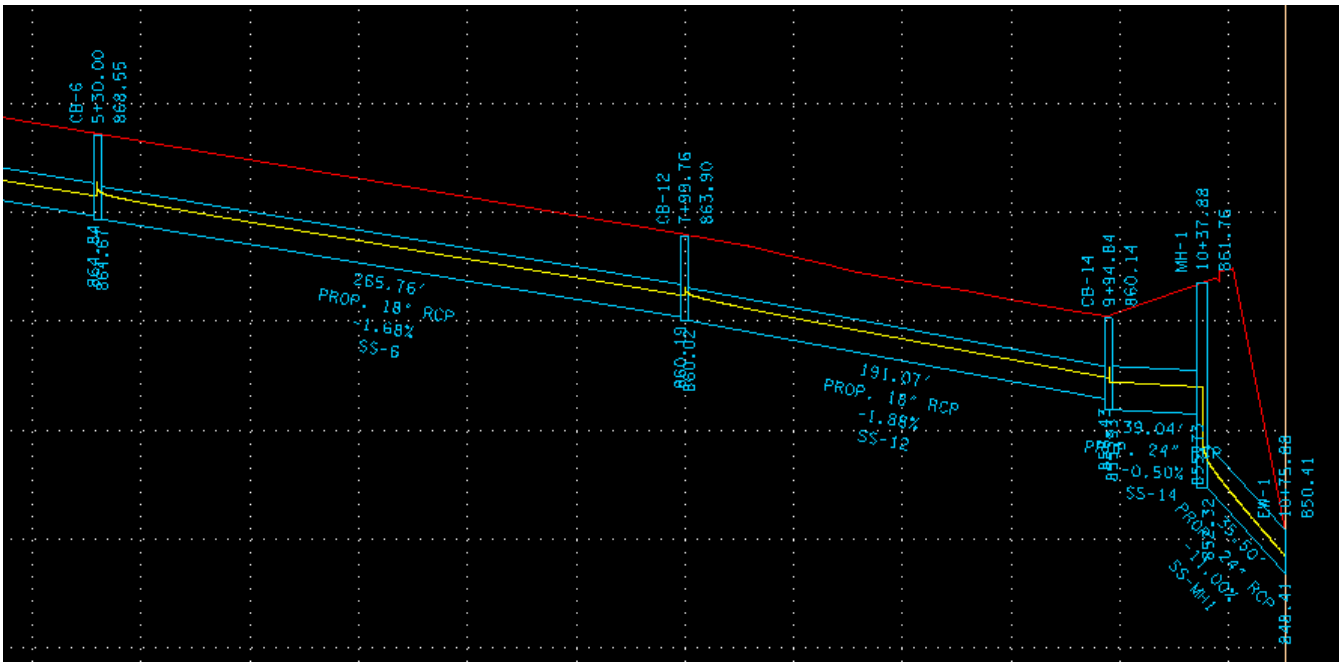
SS-8 Velocity less than minimum desired

SS-MH-1 Velocity greater than maximum desired

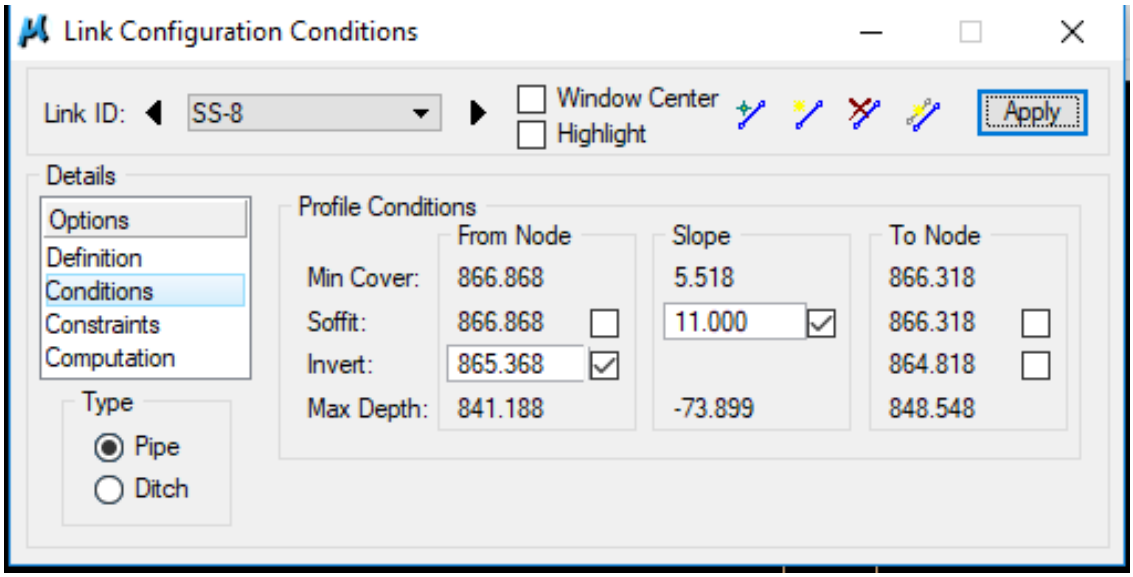
Capacity for Inlet CB-14 Exceeded Bypass Flow Unassigned

a) Navigate to Reports > Storm Drains/Links > Link Hydraulic Computations.

For link SS-8, the slope is 8.512 and the actual velocity is 0.539. To correct this error we can increase the slope of SS-8. The maximum slope is 11 percent. The upper end of SS-8 at CB-8 is at minimum depth, so we will have to lower the outlet end which is connected to CB-6. For link SS-MH-1, the slope is the maximum 11% and the actual velocity is 16.561. Looking at the profile, we definitely have some room to both lower the CB-6 outlet and to decrease the slope of SS-MH-1.

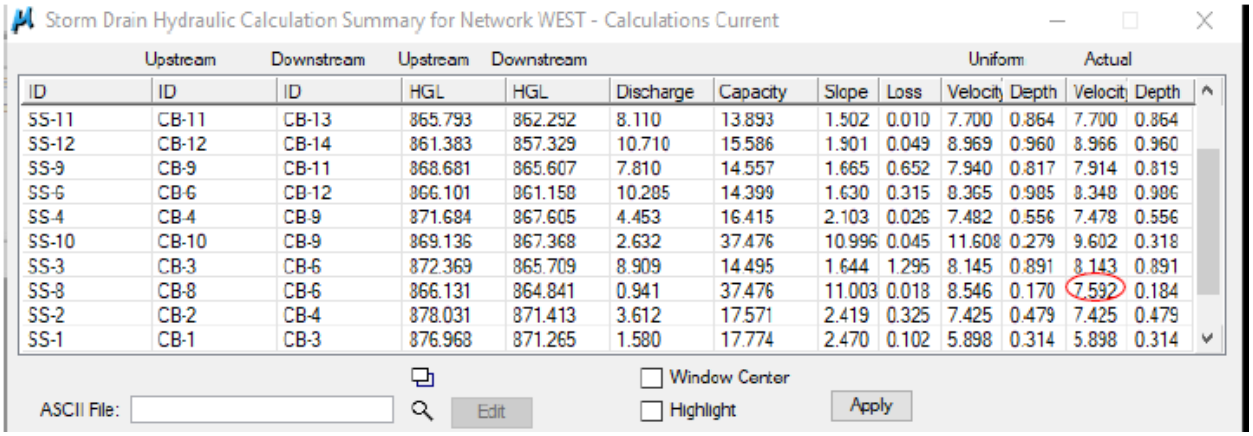


b) Go to **Component – Link- Edit – SS-8 – Conditions**. Fix the upper invert elevation at 865.368 and the slope at 11.000 by checking the boxes next to the elevations. Click Apply after making changes.

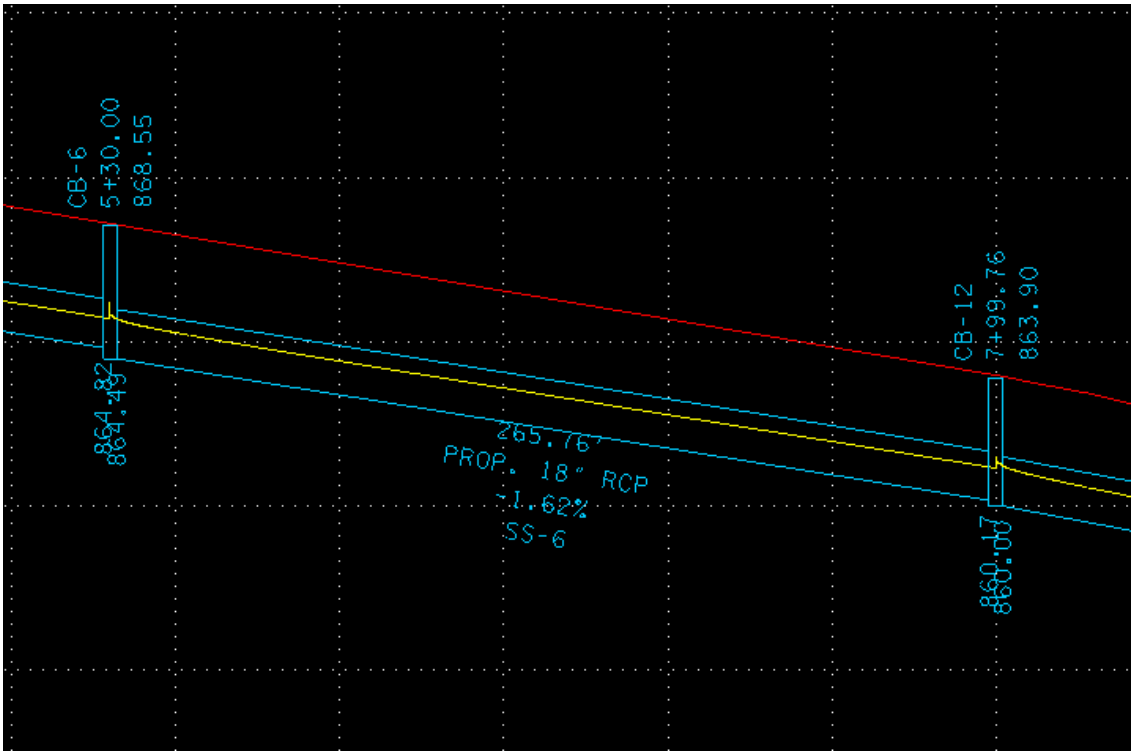


c) Re- run Network **WEST**

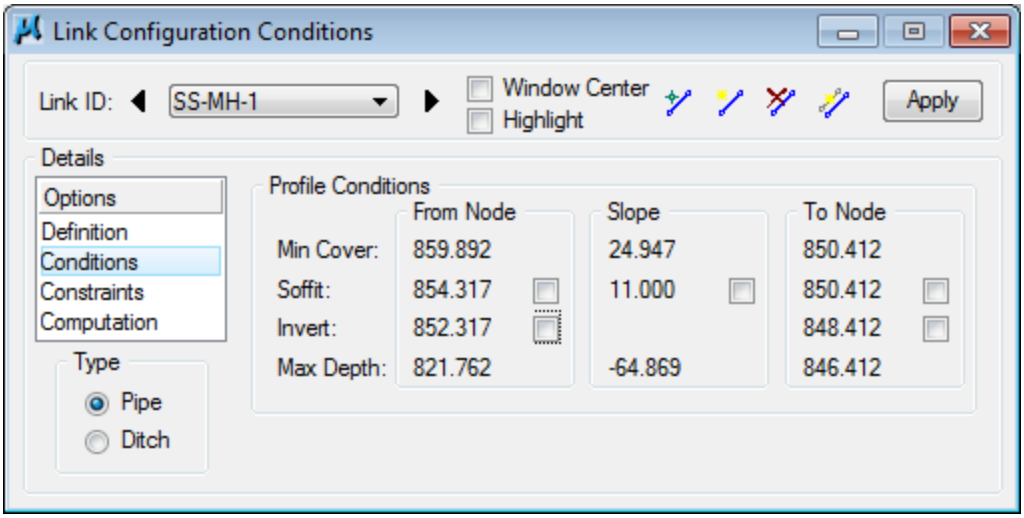
Upon checking the hydraulic computations, the new velocity is 7.592, which is in our acceptable range:



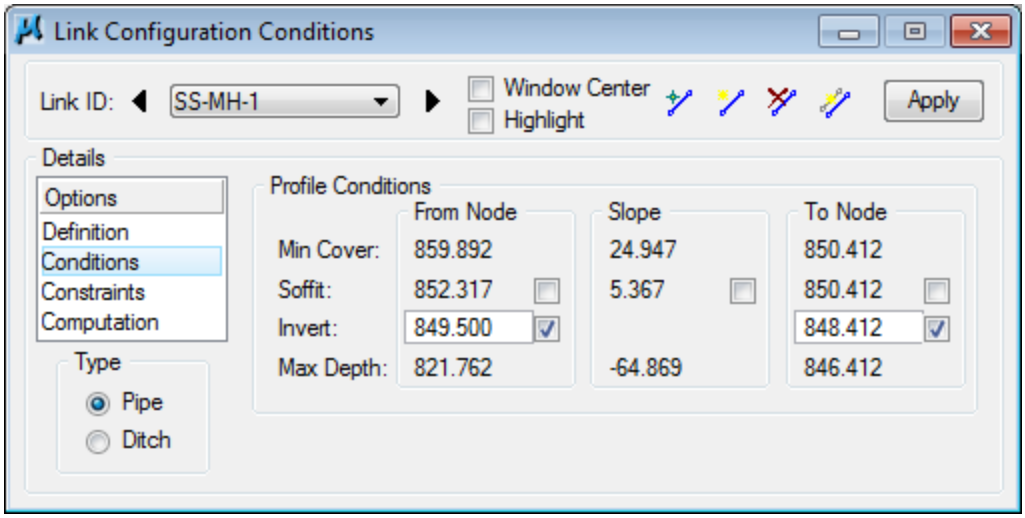
Upon rerunning the network, you can see the profile automatically updated, the upper invert of SS-6 changing to 864.49 from 864.67 and the slope to 1.62% from 1.68%. :



d) Now to correct the high velocity in SS-MH-1, we need to reduce the slope. In Link Configuration Conditions for SS-MH-1, the upper invert is 852.317 so let's lower it to 849.5 and fix the lower at its current value of 848.412 which is the outlet endwall.

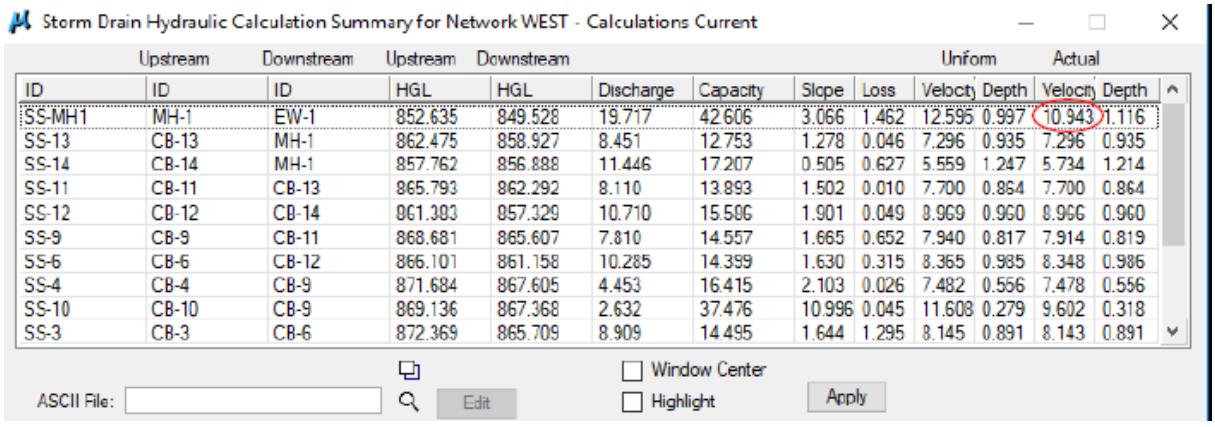


Change to:

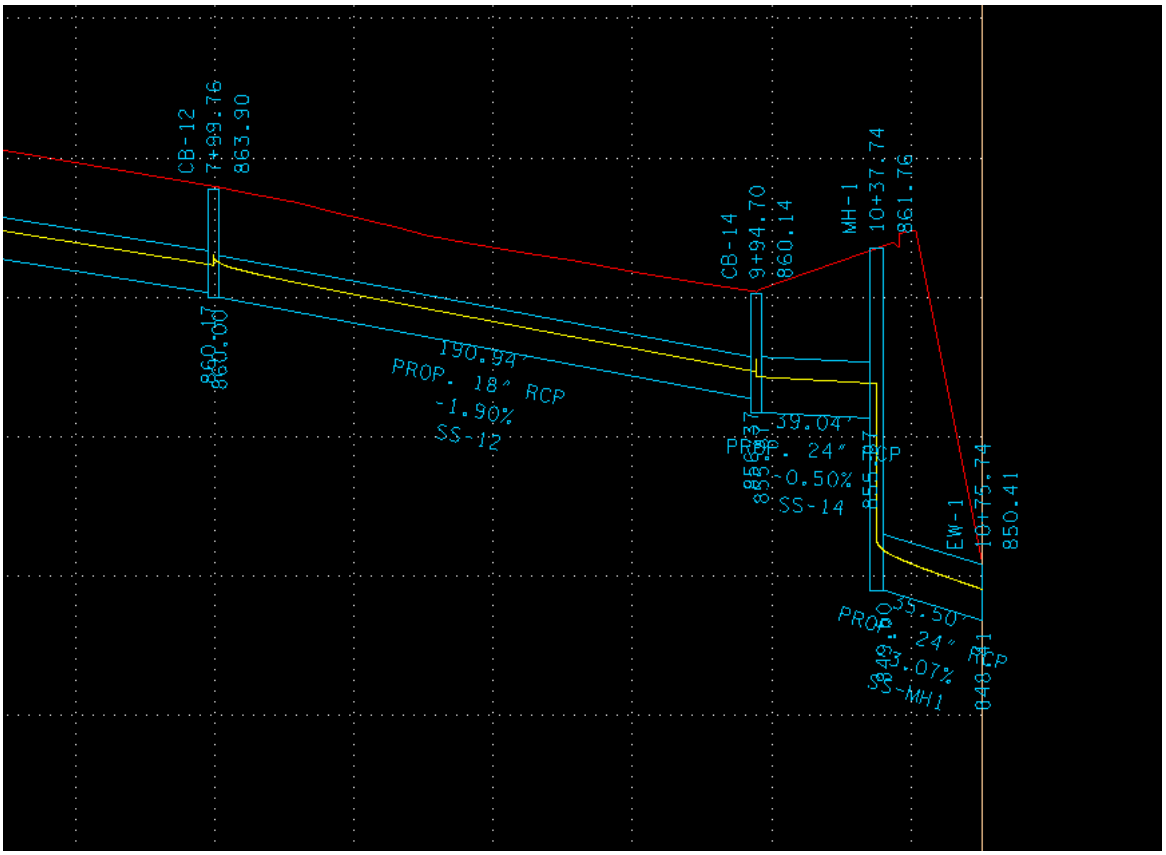


e) Re-run Network **WEST**.

Check Hydraulic Computations, 10.943 is within our acceptable range



Also note that the profile at SS-MH-1 is automatically updated:

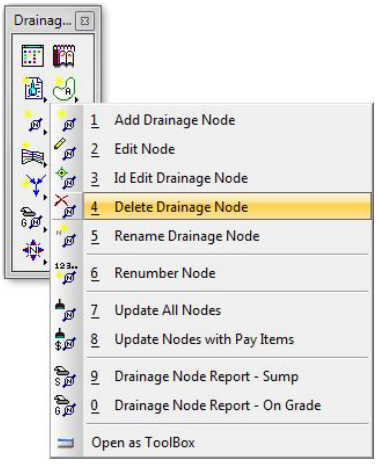


11. System Modification

This exercise shows the user how to modify the storm drainage system design. Specifically we will combine links SS-14 & SS-MH1 by eliminating MH-1, change SS-13 to end at CB-12 instead of at MH-1, reengineering the network connectivity. We will also change our ditch network set up to define a special ditch to handle the drainage along the base of the fill slope in that area.

11.1 Storm Drainage Network Modification

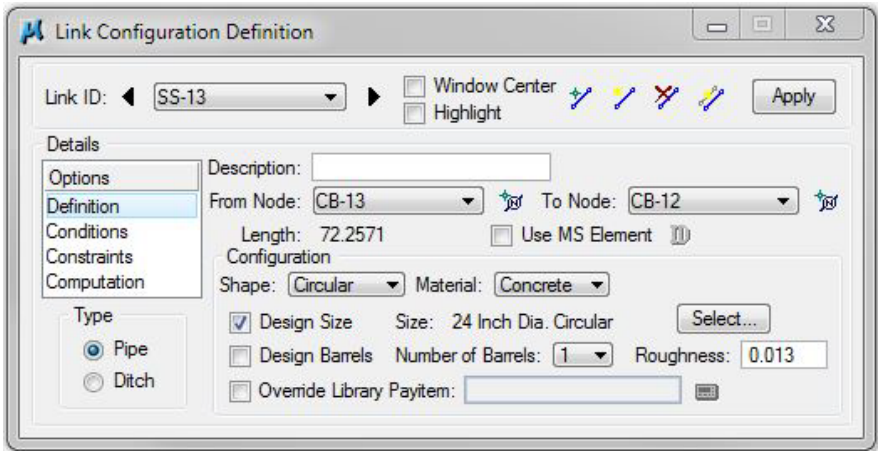
a) Delete **Node MH-1** by using **Drainage Navigator**, selecting **Component > Node > Delete** from the Drainage Menu Bar, or by selecting **Delete Drainage Node** from the Drainage Toolbar.



NOTE: Click **Yes** that you would like to delete the Node, **OK** to delete the Network WEST and NO to *Do you want to delete all the components of the network as well?*

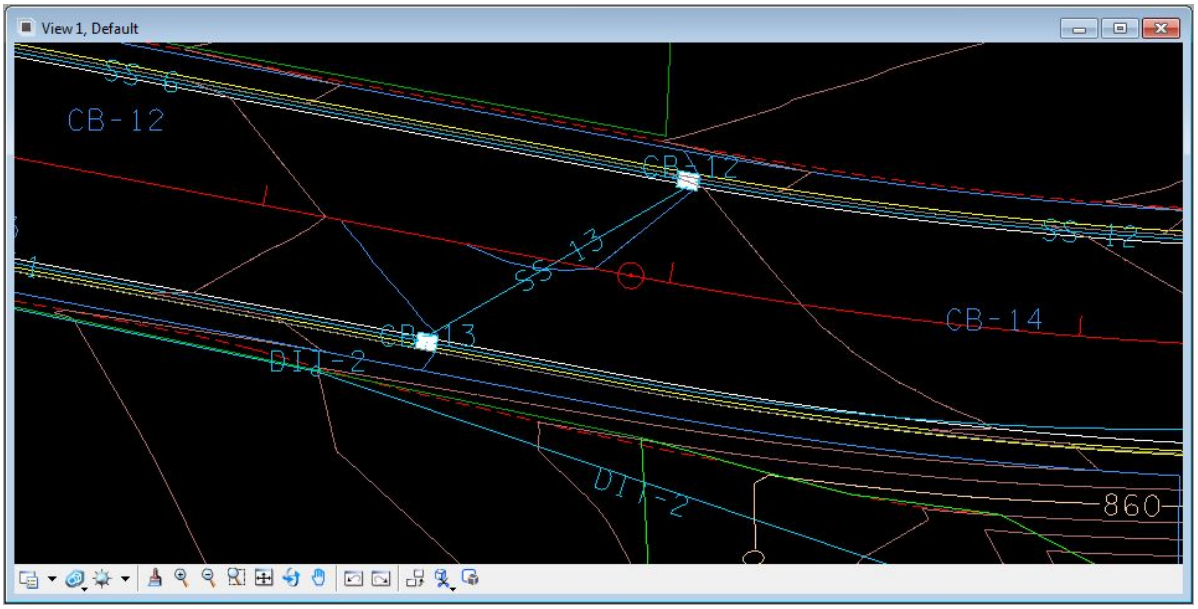
b) Follow the same basic procedures to delete **Link** SS-**MH1**.

c) Edit Link SS-13, to start at the front face of CB-13 towards centerline and end at the front face of Node CB-12 across the road.



d) Go to **edit CB-12 and CB-13** to change the **Library Item to CB#12 4'DIA**.

REMINDER: Use the **ID** button to the right of the node list to identify the front wall connection points at nodes CB-13 and CB-12.

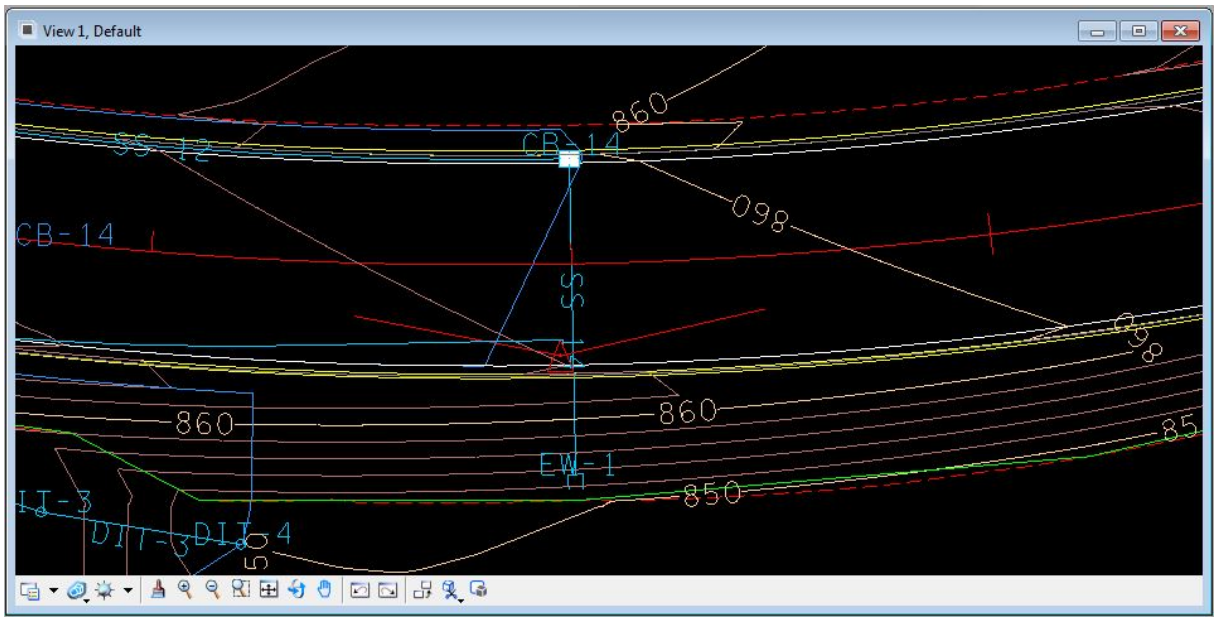


NOTE: In an actual design, the skew angles would now need to be checked to ensure the pipe would fit in the catch basin wall.

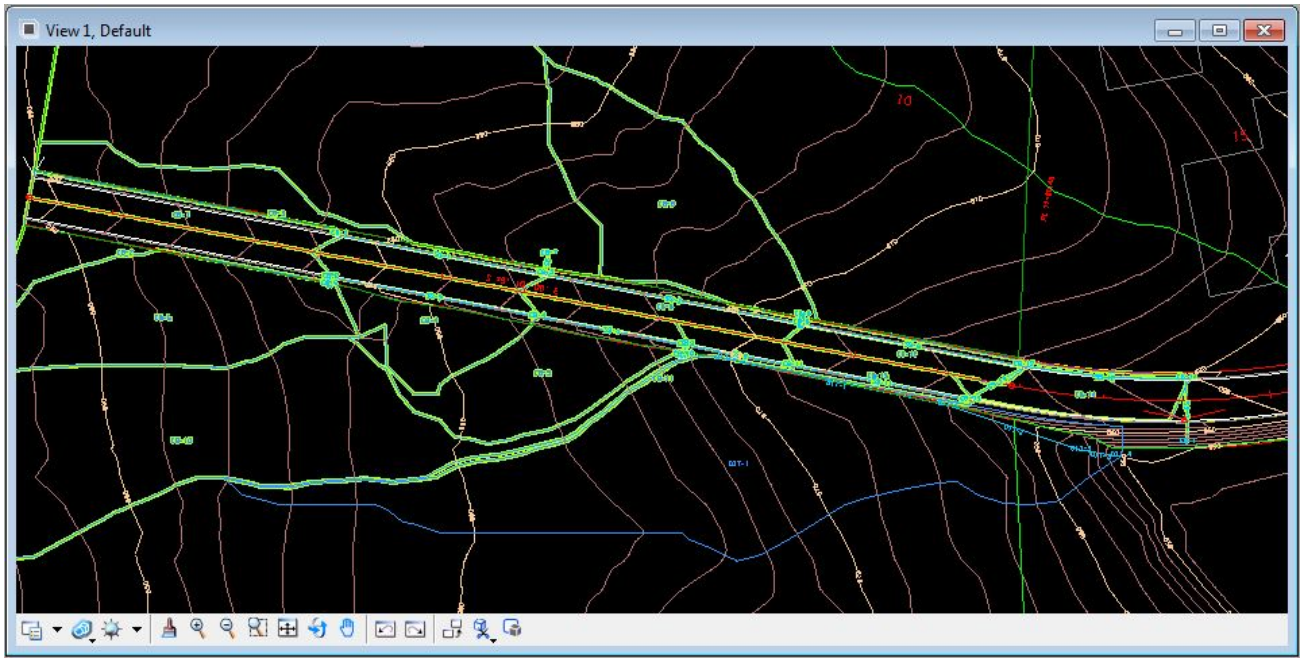
e) Edit Link SS-14, to go to Node **EW-1**.

f) Since pipe at EW-1(link SS-14) is now a 24" pipe (from previous exercise) and the side slope at that location is 2:1, **move the location of the outlet from an offset of 56' to 52'** to account for the length of the end wall and properly locate the outlet.

g) Reset EW-1's Max Depth to 2.0 (designed pipe size at outlet).



h) **Add a New Network** named **WEST** with the Outlet Node set to **EW-1** (this is necessary since the network WEST was deleted in **Step 1**). Highlight the Network to ensure all components are connected, and then Design the Network.



i) Update Profile **WestRT** to End at CB-12 and redraw other profiles as required based on these modifications.

Optional:

Depending on the drainage areas developed in the previous exercises you may still have errors in your network. If your hydraulic gradeline exceeds the minimum freeboard, try increasing pipe sizes to lower the water surface. If the velocity in Link

SS-14 is over the maximum limit try hard coding SS-14's invert elevation at Node CB-14 to lower the slope of that Link.

11.2 Ditch Network Modification

Initially, we set up a ditch network along a fill line using the Cross Section Based ditch type to analyze the drainage there. Now we will relocate our ditch nodes and set up our links as fixed geometry to design a special ditch along that slope to handle the drainage.

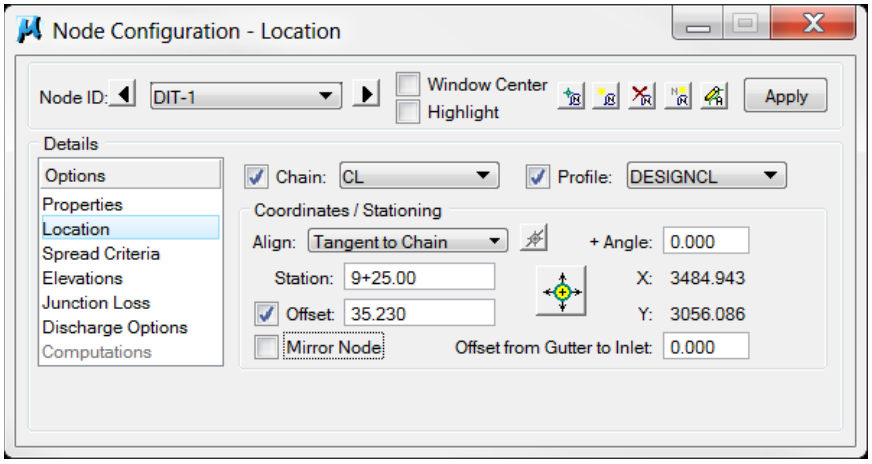
Relocate Ditch Nodes and their Drainage Areas

a) Delete previous drainage areas for ditch nodes.

b) Go to **Component > Node > Edit** and select Node DIT-1.

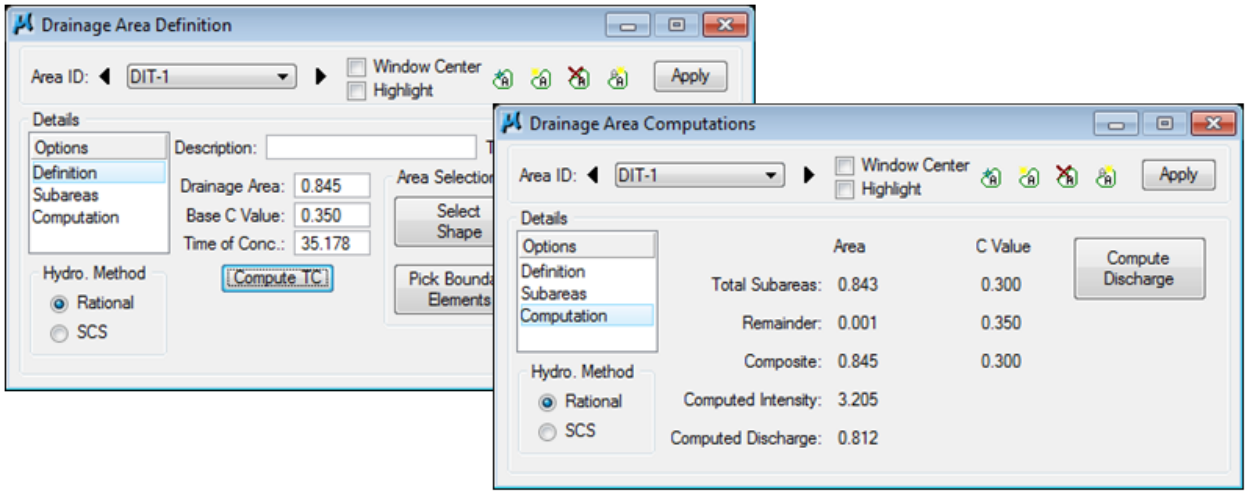
Under **Location**, change the station to **9+25** and the offset to **35.23**.

This is the beginning of the desired special ditch at the base of the fill slope. We will define the ditch link later as a “V” ditch with 2:1 side slopes although it will be at the existing ground elevation here at the beginning.



Click **Apply**.

c) Reference in the new DIT-1 file and use methods described previously to **rebuild the DIT-1 drainage area** for the new location, establish a time of concentration, apply land use areas and compute discharge.

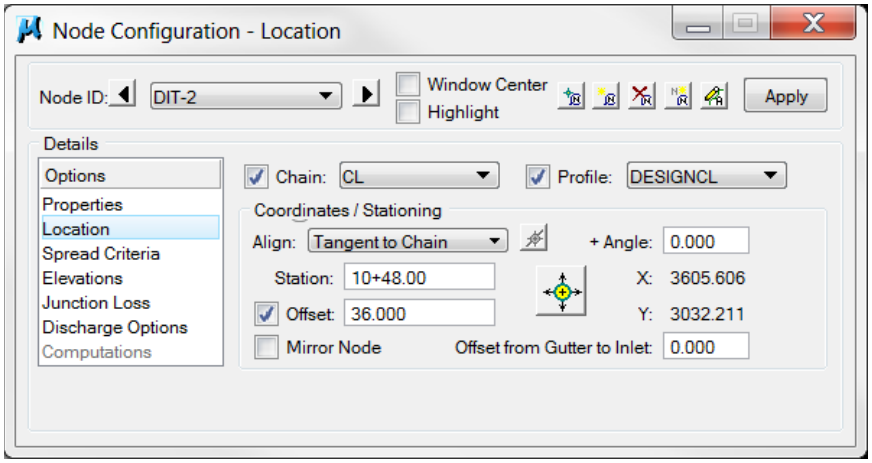


Click **Apply** to save the changes.

d) Go to **Component > Node > Edit** and select Node DIT-2.

Under **Location**, change the station to **10+48** and the offset to **36.00**.

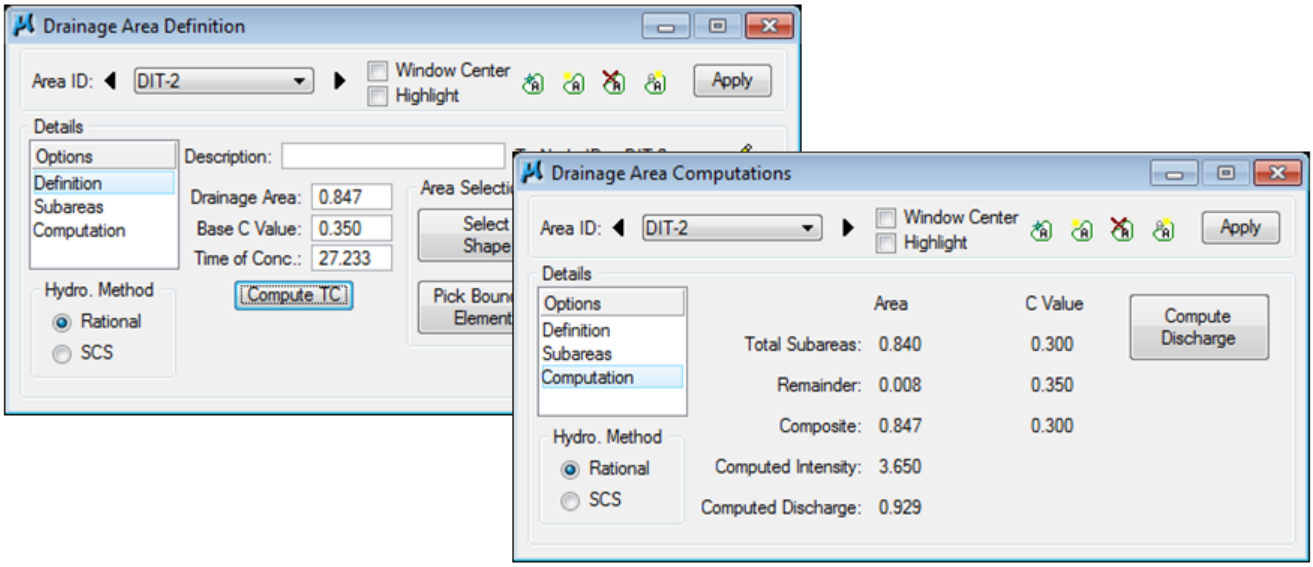
This is the point where we will achieve the 1 foot depth in our special ditch. By modifying the links at this location the ditch link will be a “V” ditch with 2:1 side slopes and is offset from the fill slope tie by 2 feet.



Click **Apply**.

e) Use methods described previously to rebuild the **DIT-2** drainage area for the new location, establish a time of concentration, apply land use areas and compute discharge.

Remember …ditch node drainage areas should include the area for the current node as well as any others previously defined that contribute to the ditch drainage network.

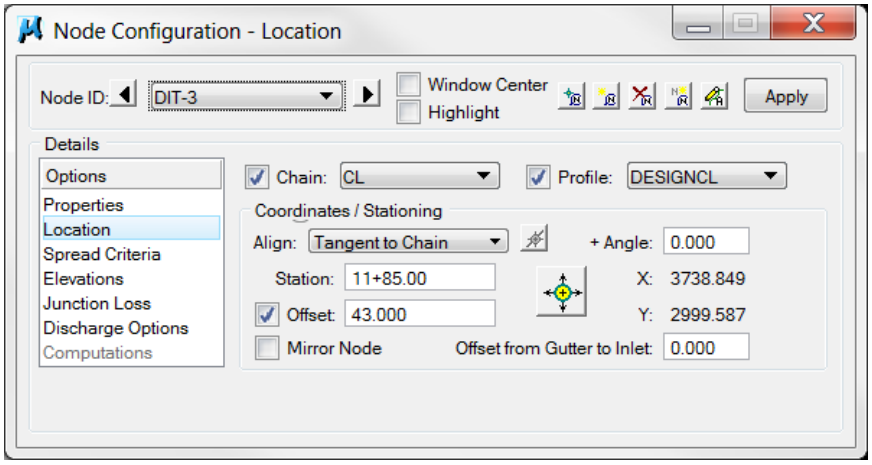


Click **Apply** to save the changes.

f) Go to **Component > Node > Edit** and select Node DIT-3.

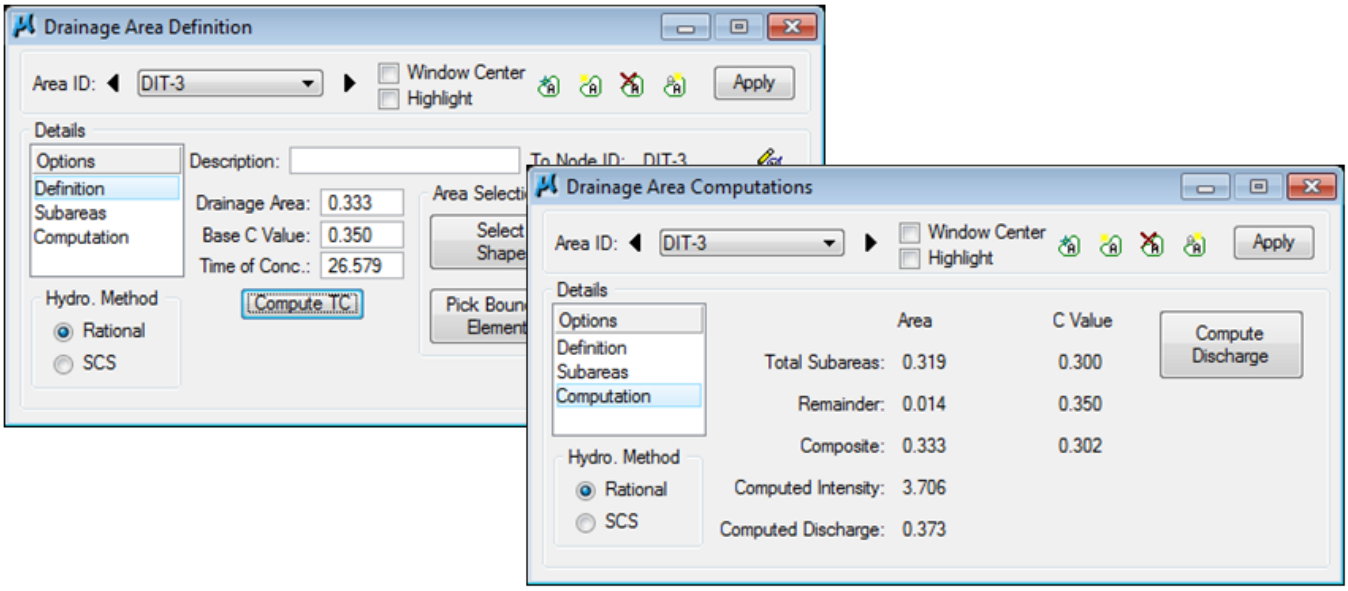
Under **Location**, change the station to **11+85** and the offset to **43.00**.

This is the beginning of the final ditch slope and to mitigate the steeper slope and resulting increase in velocity we will change the ditch link section to a 2 foot wide trapezoidal shape, 1 foot deep with 2:1 side slopes and is offset from the fill slope tie by 3 feet.



Click **Apply**.

g) Use methods described previously to rebuild the **DIT-3** drainage area for the new location, establish a time of concentration, apply land use areas and compute discharge.

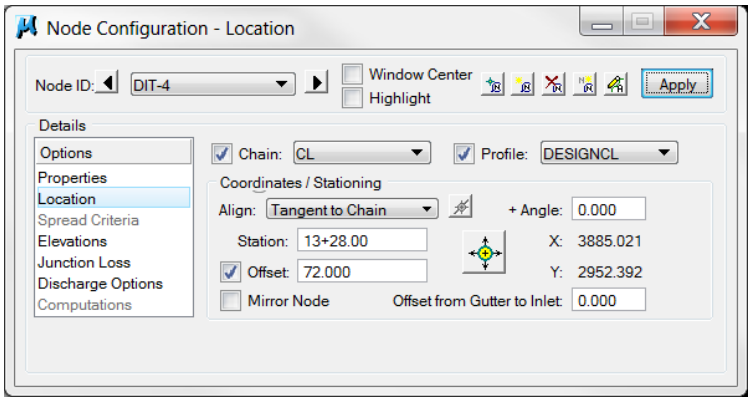


Click **Apply** to save the changes.

h) Go to **Component > Node > Edit** and select Node DIT-4.

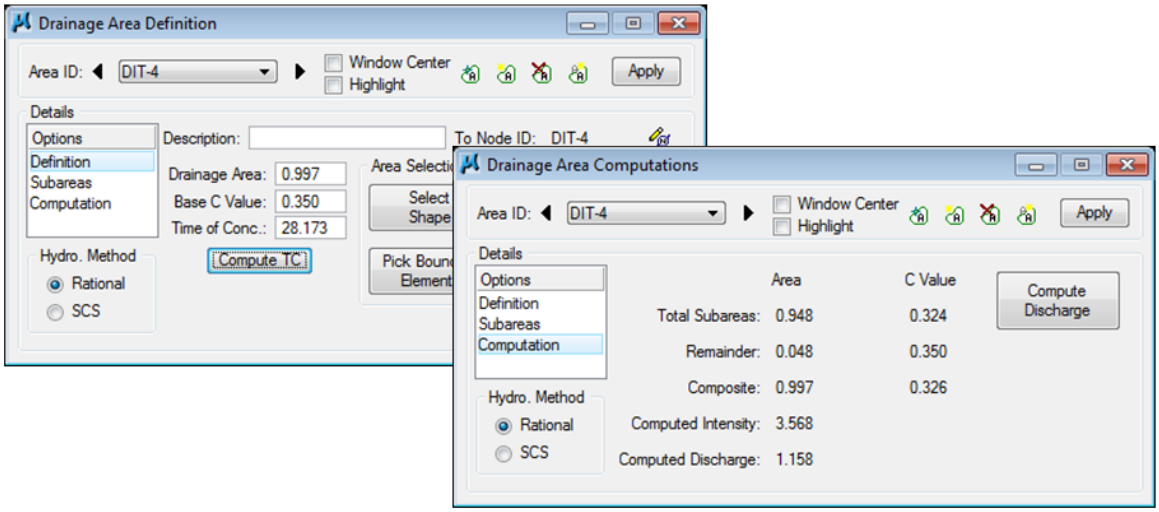
Under **Location**, change the station to **13+28** and the offset to **72.00**.

This is the outlet for the special ditch and is shifted away from the fill slope tie to lead into the current existing drainage path.



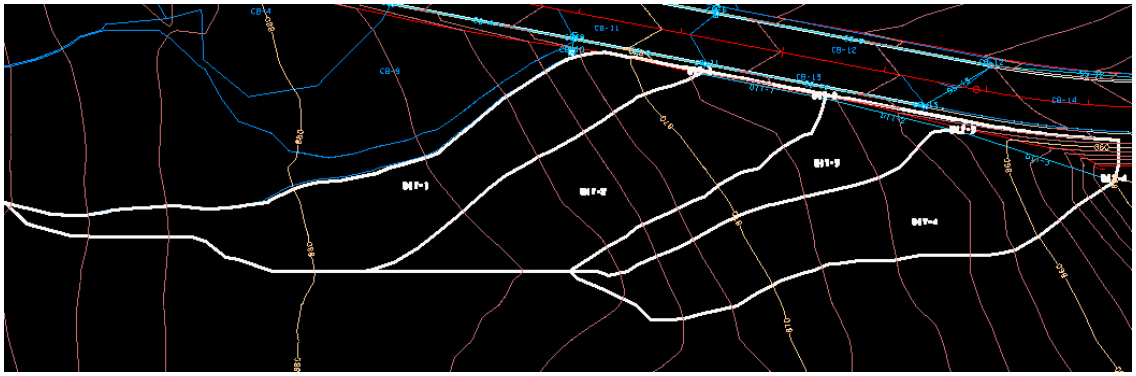
Click **Apply**.

i) Use methods described previously to rebuild the **DIT-4** drainage area for the new location, establish a time of concentration, apply land use areas and compute discharge.



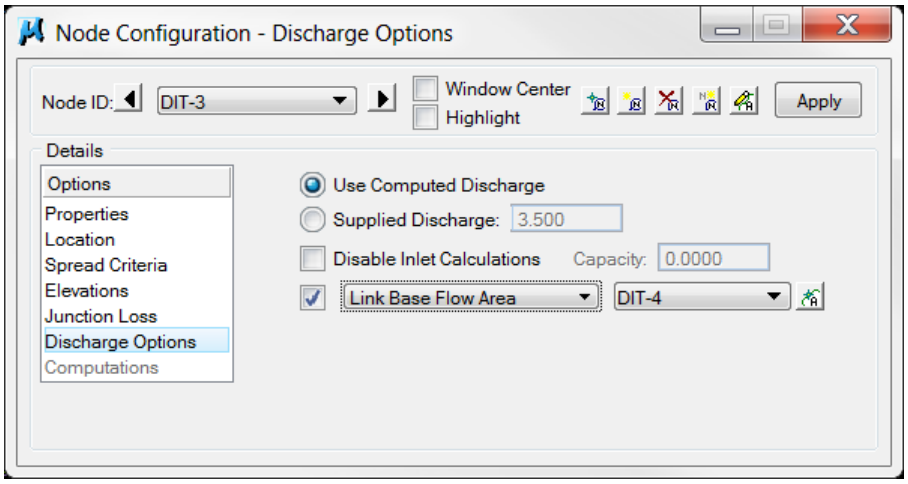
Click **Apply** to save the changes.

Final layout of revised ditch nodes and drainage areas.



j) Since Node DIT-4 is an outlet type, it will not consider the drainage area developed for it. In order to ensure the final ditch link, DIT-3, will be adequate for the capacity at the end we will need to link the DIT-4 drainage area to it.

Go to **Component> Node> Edit** and select node DIT-3. Under Discharge Options click on the option to **Link Base Flow Area** and set to include the DIT-4 drainage area.



11.3 Ditch Link Modification

Redefine Ditch Links with Fixed Geometry & Invert Elevations

a) Go to **Component > Link > Edit** and select Link DIT-1.

Under **Definition**, make the following changes:

Ditch Type: Fixed Geometry

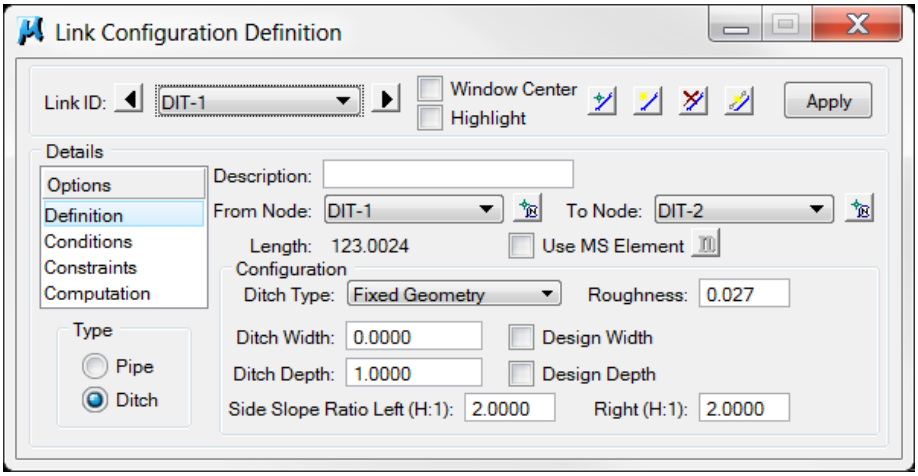
Ditch Width: 0 (Toggle OFF Design Width) - for V-ditch

Ditch Depth: 1 (Toggle OFF Design Depth)

Side Slope Ratio Left (H:1): 2.00

Side Slope Ratio Right (H:1): 2.00

These settings define a “V” ditch at a 1’ depth with 2:1 side slopes.

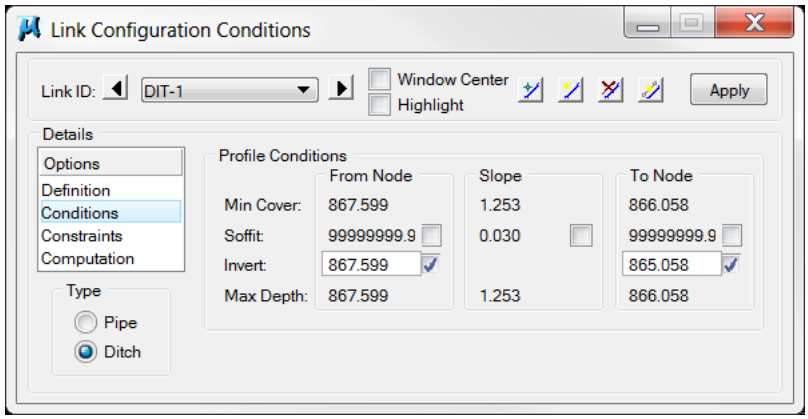


NOTE: You can use the **Design Width** or **Design Depth** options individually but it is **not** recommended to use both at the same time. The software will always use the Minimum Rise value under **Constraints** for the depth and only adjusts the width if needed from that point.

b) Under **Conditions**, make the following changes:

From Node Invert: 867.599 (existing ground elevation)

To Node Invert: 865.058 (1 foot below existing ground elevation)

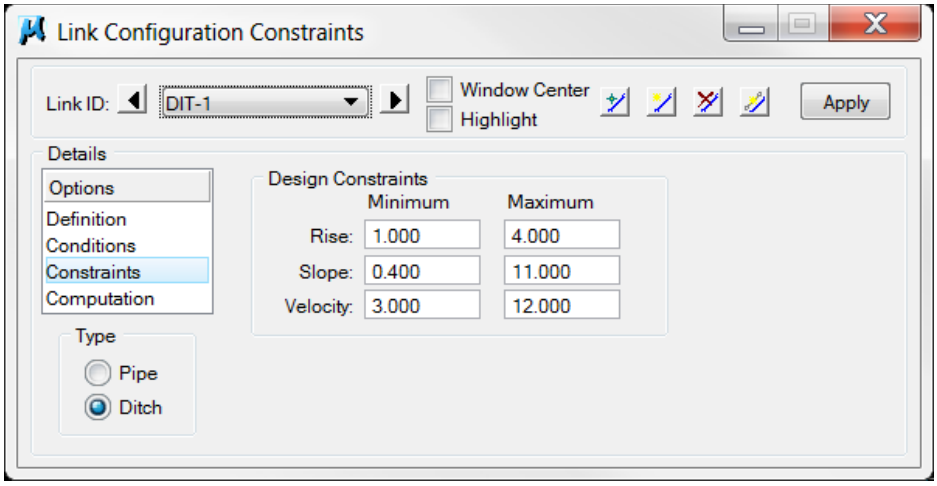


These settings provide the transition from existing ground to the 1' depth.

NOTE: The large numbers you may see specified for **Soffit** elevations can be ignored. These values are a result of the previous application of the Cross Section Based ditch type where these values are not applicable. When the ditch network is redesigned, the Soffit elevations will be recalculated.

c) Under **Constraints**, make the following change:

Minimum Rise: 1.000 (to allow for defined 1 foot depth)



d) Click **Apply** to save the changes to link DIT-1.

e) In the **Link Configuration Definition** dialog go to Link DIT-2.

Under **Definition**, make the following changes:

Ditch Type: Fixed Geometry

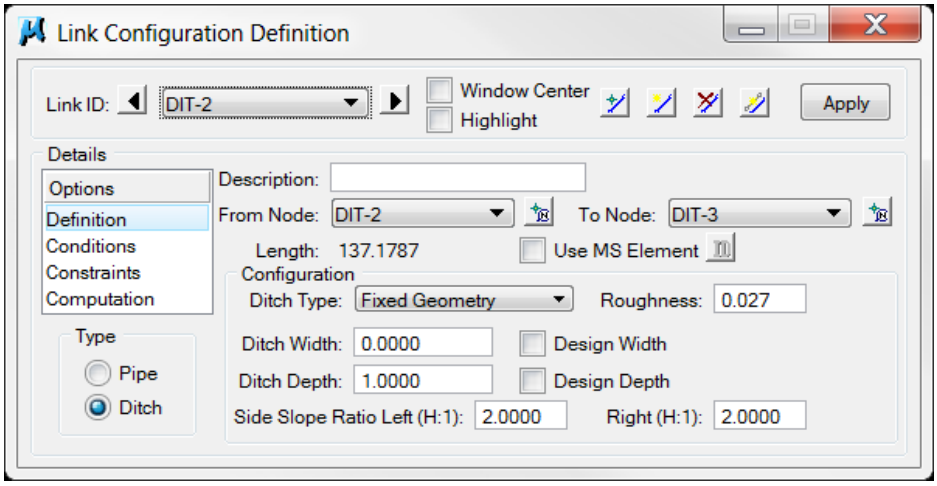
Ditch Width: 0 (Toggle OFF Design Width) – for V-ditch

Ditch Depth: 1 (Toggle OFF Design Depth)

Side Slope Ratio Left (H:1): 2.00

Side Slope Ratio Right (H:1): 2.00

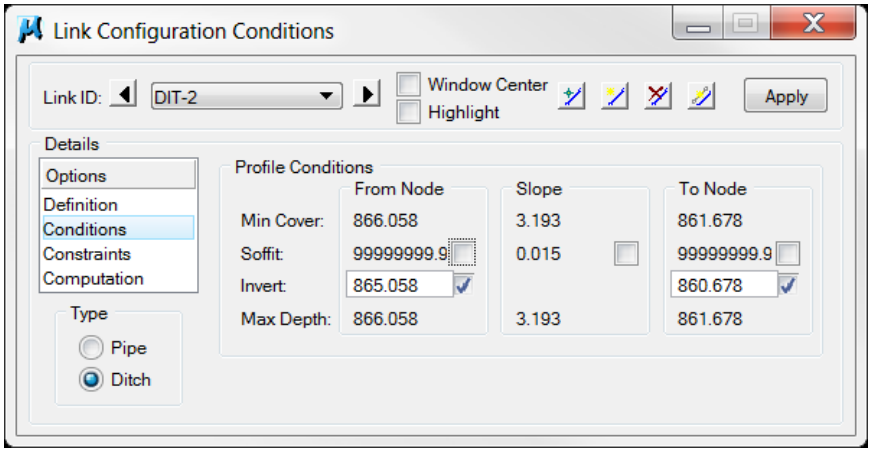
These settings define a "V" ditch at a 1' depth with 2:1 side slopes.



f) Under **Conditions**, make the following changes:

From Node Invert: 865.058 (1 foot below existing ground elevation)

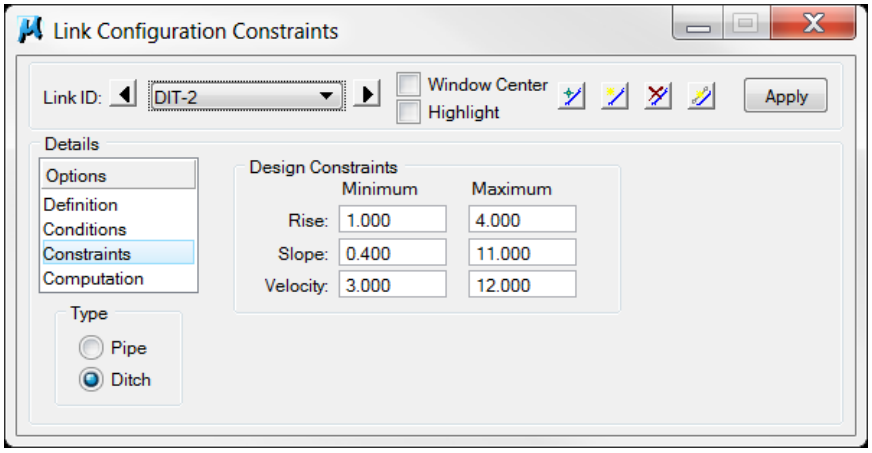
To Node Invert: 860.678 (1 foot below existing ground elevation)



These settings maintain the 1' depth below the existing ground.

g) Under **Constraints**, make the following change:

Minimum Rise: 1.000 (to allow for defined 1 foot depth)



Click **Apply** to save the changes to link DIT-2.

h) In the **Link Configuration Definition** dialog go to Link DIT-3.

Under **Definition**, make the following changes:

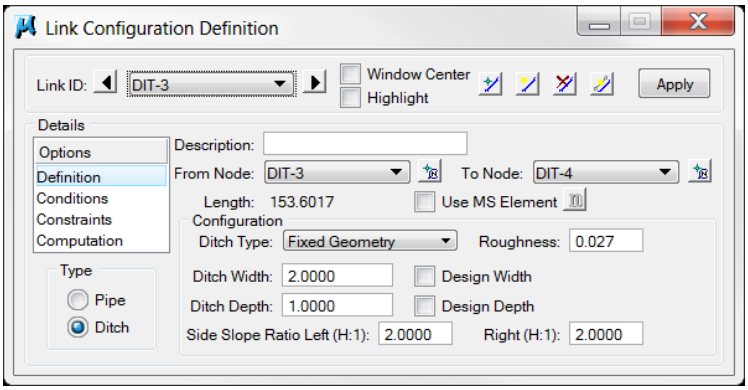
Ditch Type: Fixed Geometry

Ditch Width: 2 (Toggle OFF Design Width)

Ditch Depth: 1 (Toggle OFF Design Depth)

Side Slope Ratio Left (H:1): 2.00

Side Slope Ratio Right (H:1): 2.00



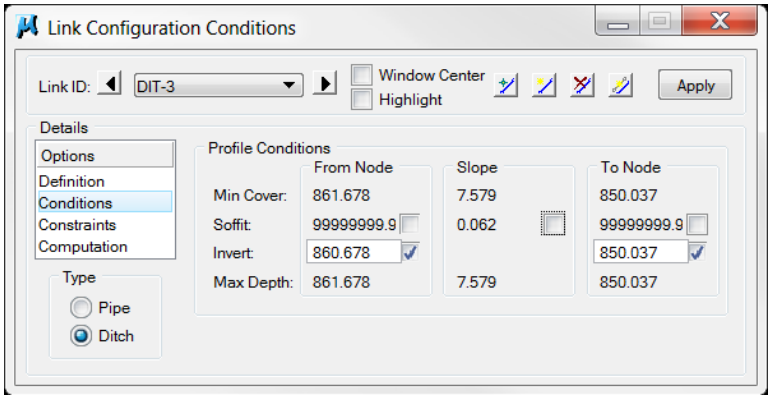
These settings define a 2' wide trapezoidal (flat bottom) ditch at a 1' depth with 2:1 side slopes.

Note: See Appendix E for Roughness Values for Open Channel Hydraulics.

i) Under **Conditions**, make the following changes:

From Node Invert: 860.678 (1 foot below existing ground elevation)

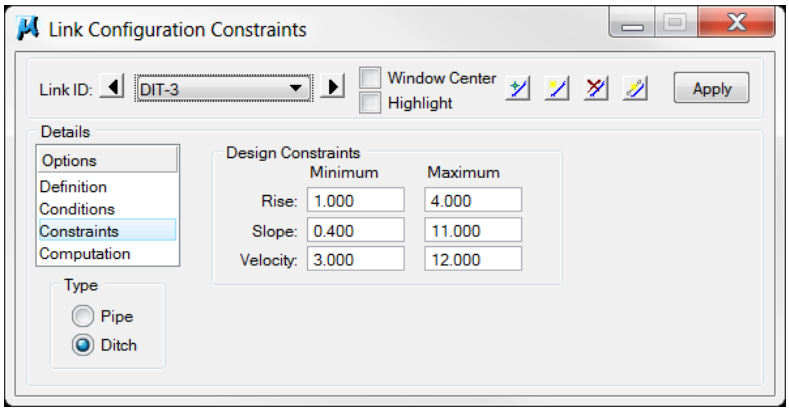
To Node Invert: 850.037 (existing ground elevation)



These settings provide the transition from the 1' depth back to the existing ground elevation at the end of the ditch.

j) Under **Constraints**, make the following change:

Minimum Rise: 1.000 (to allow for defined 1 foot depth)



k) Click **Apply** to save the changes to link DIT-3.

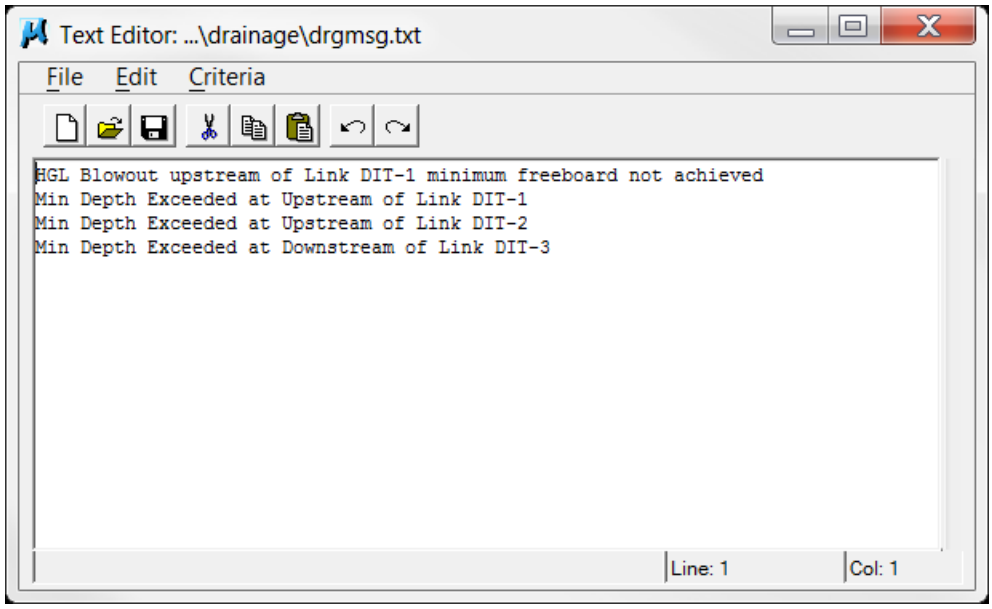
NOTE: You can select the entire ditch of one profile, copy beside itself, select all and Edit > Group so that you will still have the ditch profile from before modifications and you can compare.

11.4 Redesign Ditch Network & Review

a) Go to **Network > Active Network** and select WEST DIT.

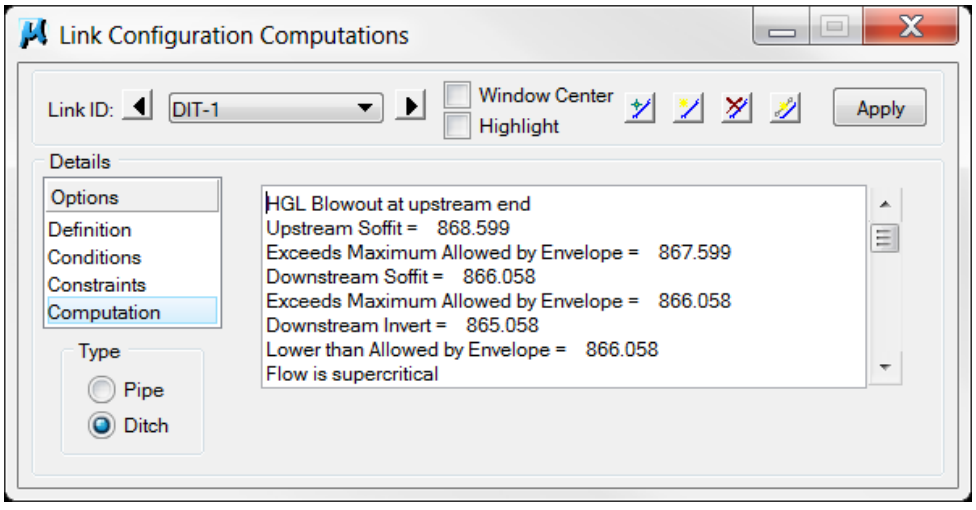
b) Go to **Network > Design** to run the network.

c) Review any errors that are generated by the redesign of the network and close the text editor. (See **Appendix C** for common errors and fixes)

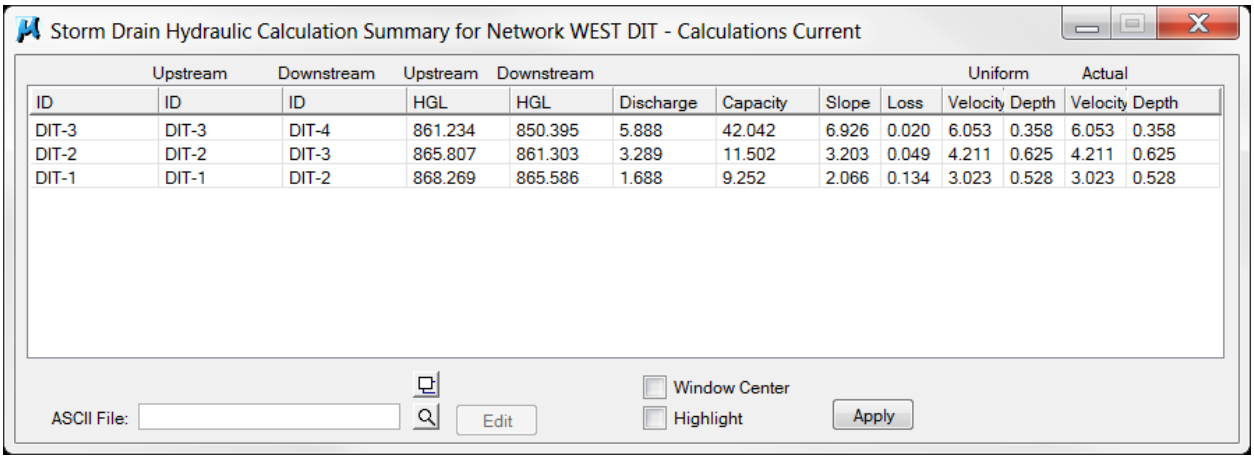


d) Review computation results.

Go to **Component > Link > Edit** and review the link computations for links DIT-1, DIT-2 & DIT-3.

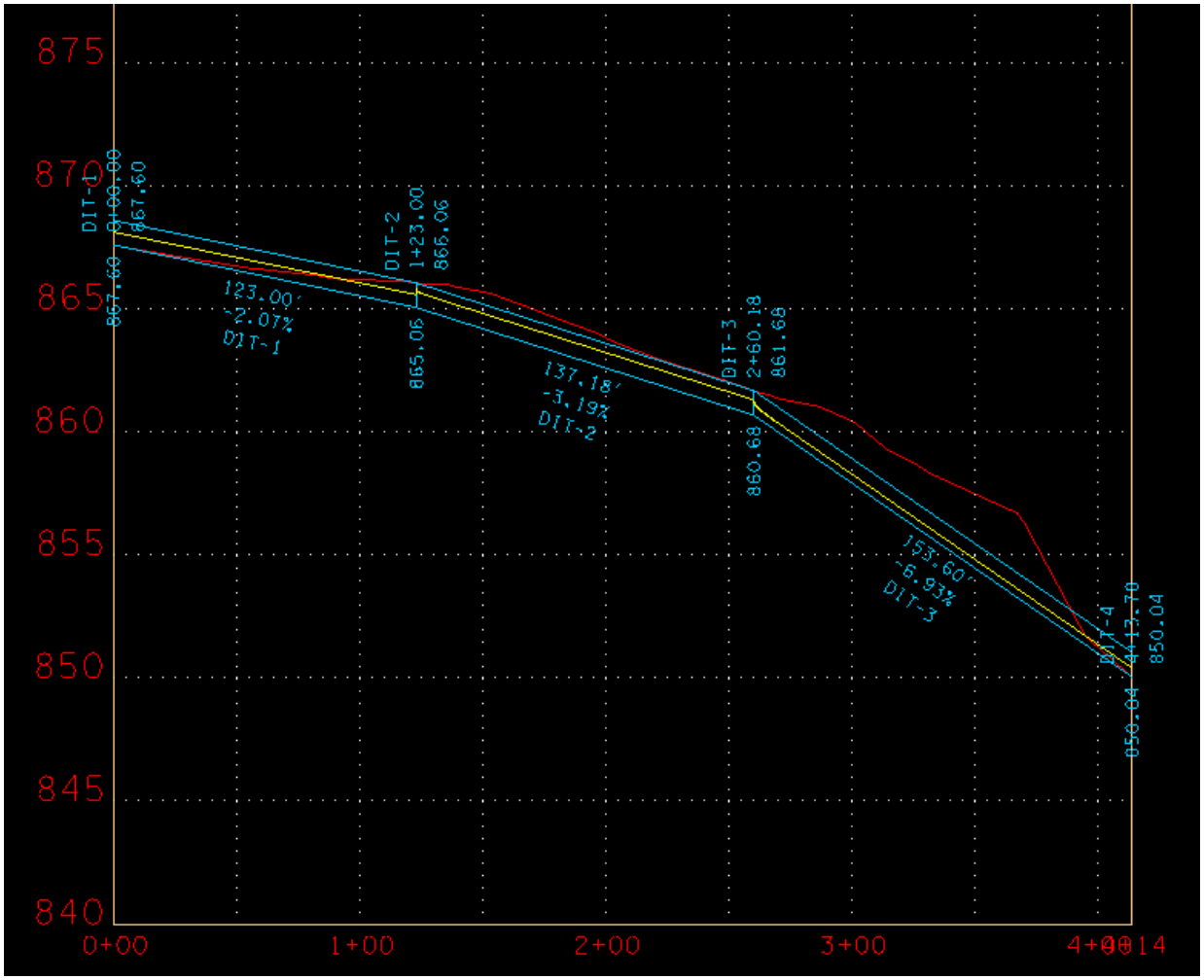


Go to **Reports> Storm Drains\Links> Link Hydraulic Computations**.



e) Zoom in on the ditch profile graphics.

The profile has been automatically updated and reflects our new proposed ditch definitions.

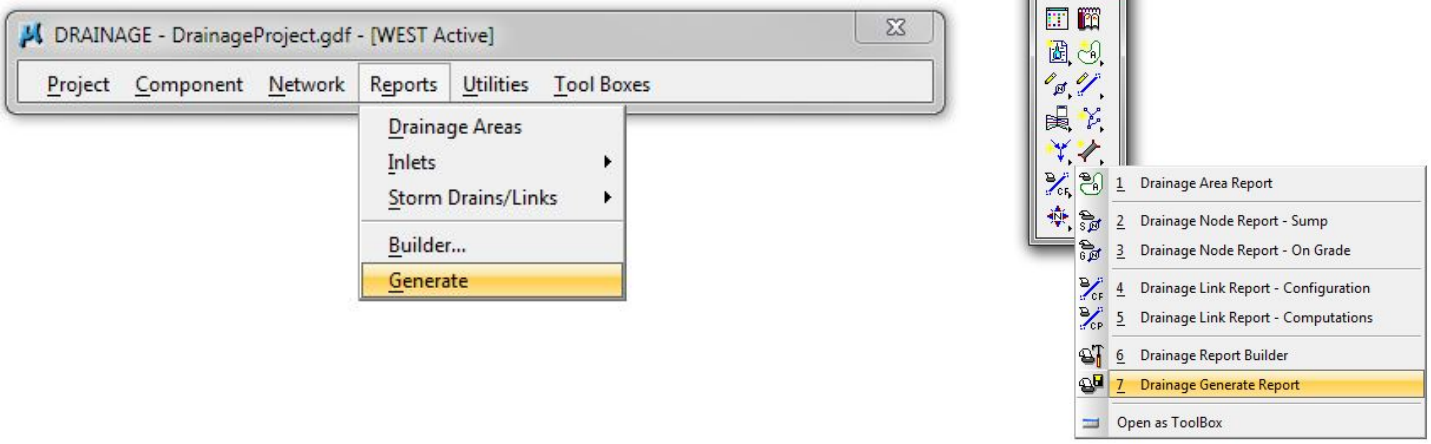


12. Reports

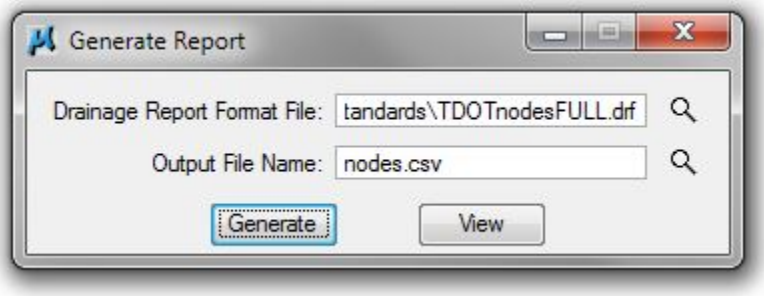
This exercise shows the user the report options by creating standard and customized reports.

12.1 Customized Reports

a) Select **Reports > Generate** from the Drainage Menu Bar or **Drainage Generate Report** from the Drainage Toolbar*:*



b) Use the browse button to select report format file **TDOTnodesFULL.drf** (from C:\Users\Public\Geopak Standards\). Click in the Output File Name area and type in **nodes.csv** as the file name. Click **Generate** to create the report file.



c) Use Excel to open and review **nodes.csv** report file.

d) Access report format **TDOTlinksFULL.drf** and generate **links.csv** report file.

e) Use Excel to open and review **links.csv** report file.

12.2 Excel Tab Builder

a) Open Excel and click **File > New**

b) Click **My templates > TDOT English Tab Quantities > Storm Drainage Structure Tab Builder**

If the “My templates” button does not provide you with the Storm Drainage Structure Tab Builder excel file, then navigate to **C:\Users\Public\Office Standards\TDOT English Tab Quantities** and open the file there. Do a “Save As” and save it into your Project folder before making any changes.

c) Click **Build Catch Basins and Manholes Block**.

d) Navigate to the project folder, select the file **nodes.csv** created in Exercise 12.1 and click open. The tab block is created.

CATCH BASINS														
SHEET NO.	LOCATION	STATION	OFFSET (FT.)	DRAINAGE CODE	GRATE/TOP ELEV.	STRUCTURE TYPE	INSIDE DIMENSION	DEPTH (FT.)	STANDARD DRAWINGS	TYPE 12 C.B. 611-12.01 0' - 4'	TYPE 12 C.B. 611-12.02 4' - 8'	TYPE 42 C.B. 611-42.01 0' - 4'	TYPE 43 C.B. 611-43.02 4' - 8'	REMARKS
	CL	11+45.00	26	CB-13	865.16	#12	4X3	4.59			1			
	CL	12+00.00	-26	CB-12	863.9	#12	4X3	5.9			1			
	CL	14+00.00	-26	CB-14	860.14	#12	4X3	6.64			1			
	CL	3+70.00	-26	CB-1	880.97	#12	4X3	3.88		1				
	CL	3+70.00	26	CB-2	880.95	#12	4X3	4.05			1			
	CL	3+70.00	35	CB-5	881.51	#42	4X4	3.8				1		
	CL	6+20.00	-26	CB-3	874.68	#12	4X3	5.24			1			
	CL	6+20.00	26	CB-4	874.66	#12	4X3	3.88		1				
	CL	6+20.00	-50	CB-7	874.11	#43	8X4	4.42					1	
	CL	8+00.00	26	CB-9	870.78	#12	4X3	4.21			1			
	CL	8+00.00	38	CB-10	872.38	#43	8' DIA	4.49					1	
	CL	9+30.00	-26	CB-6	868.55	#12	4X3	4.42			1			
	CL	9+30.00	-35	CB-8	869.19	#42	4X4	3.8				1		
	CL	9+30.00	26	CB-11	868.52	#12	4X3	4.38			1			
TOTALS										2	8	2	2	

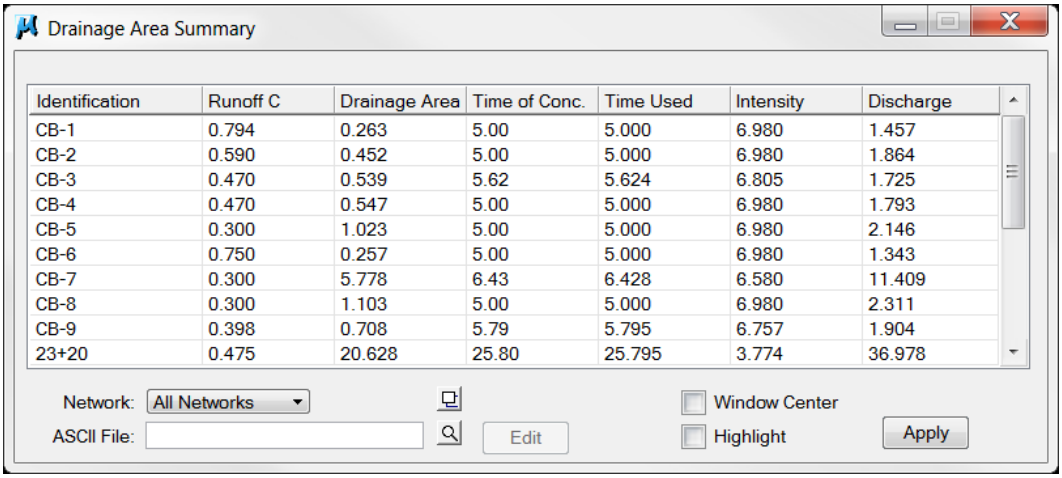
e) Repeat Step 1 through Step 4 using the **links.csv** file and the **Storm Drainage Pipe Tab Builder**

STORM DRAINAGE PIPES									
SHEET NO.	FROM		TO		% GRADE	RCP CLASS III			
	CODE	OUTLET ELEV.	CODE	INLET ELEV.		607-03.02 18" (L.F.)	607-05.02 24" (L.F.)	607-06.02 30" (L.F.)	607-07.02 36" (L.F.)
	CB-1	877.09	CB-3	870.93	2.50	246			
	CB-2	876.90	CB-4	870.95	2.42	246			
	CB-3	869.44	CB-6	864.30	1.68		306		
	CB-4	870.78	CB-9	867.07	2.11	176			
	CB-5	877.71	CB-2	877.07	9.82	6			
	CB-6	864.13	CB-12	859.65	1.68		266		
	CB-7	869.69	CB-3	869.61	0.40		19		
	CB-8	865.39	CB-6	864.80	9.13	6			
	CB-9	866.57	CB-11	864.31	1.79		126		
	CB-10	867.89	CB-9	867.07	11.00	7			
	CB-11	864.14	CB-13	860.74	1.61		211		
	CB-12	858.00	CB-14	854.00	2.10			191	
	CB-13	860.57	CB-12	859.65	1.27		72		
	CB-14	853.50	EW-1	850.42	4.18				74
TOTALS						688	1000	191	74

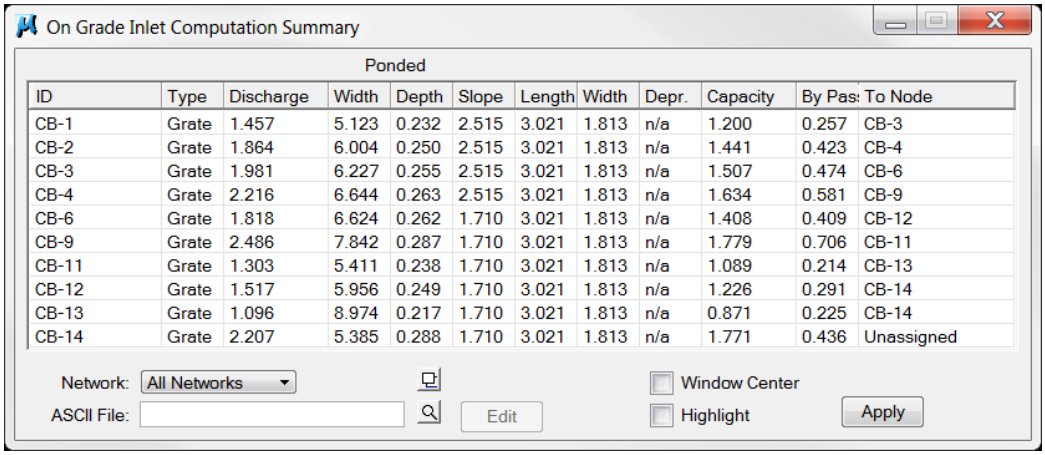
12.3 Standard Reports

Geopak Drainage also provides several standard reports which are useful during storm drainage network design. The current Active Network will determine which drainage features are listed.

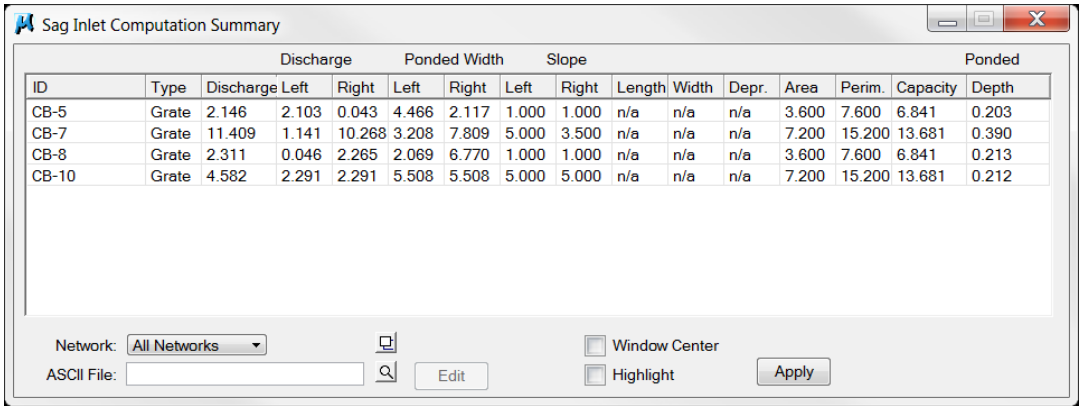
a) Select **Reports > Drainage Areas** from the Drainage Menu Bar.



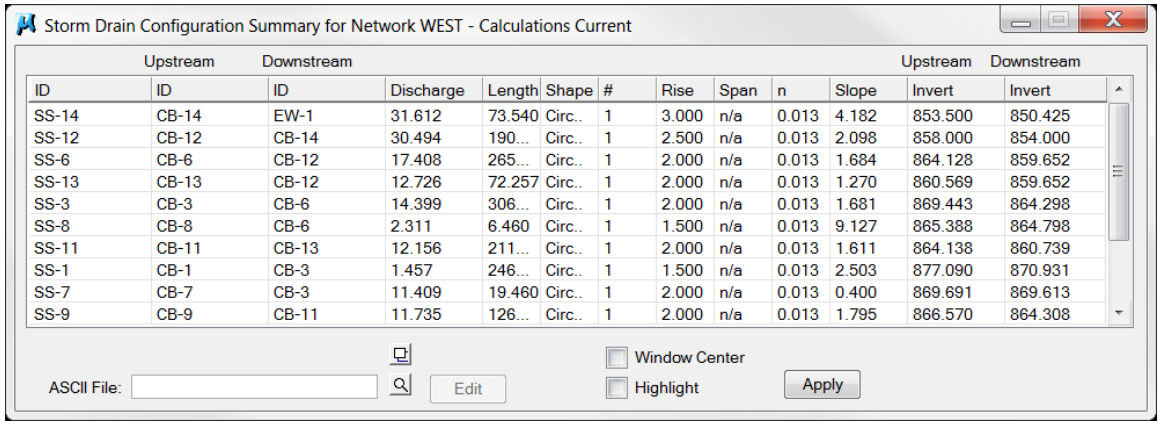
b) Select **Reports > Inlets> On Grade Inlets** from the Drainage Menu Bar.



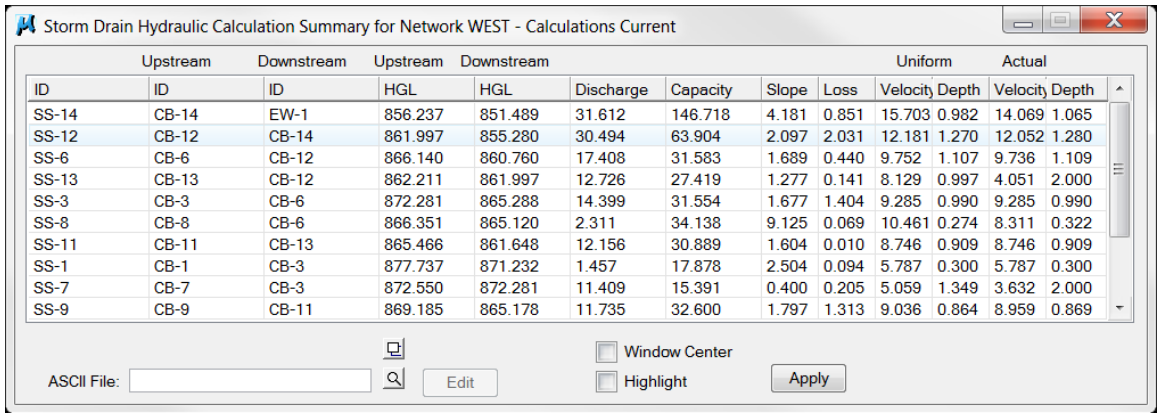
Sag Inlets



c) Select **Reports > Storm Drains/Links> Link Configuration** from the Drainage Menu Bar.



Link Hydraulic Calculations



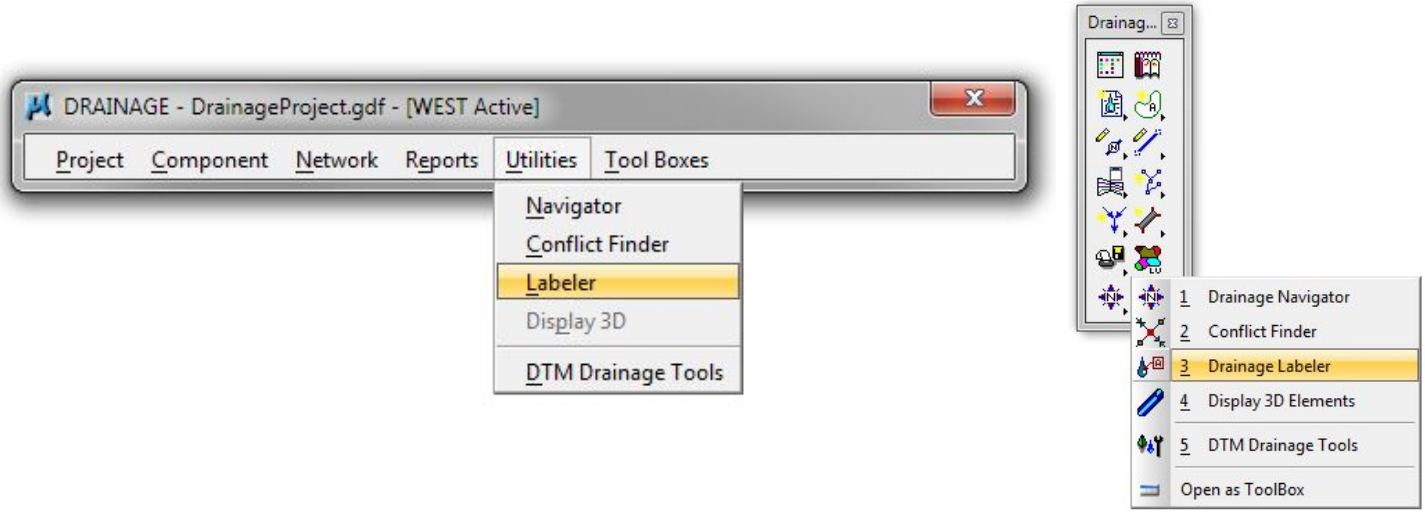
13. Storm Drainage Labeling

This exercise shows the user how to use standard labels by labeling the plan and profile views.

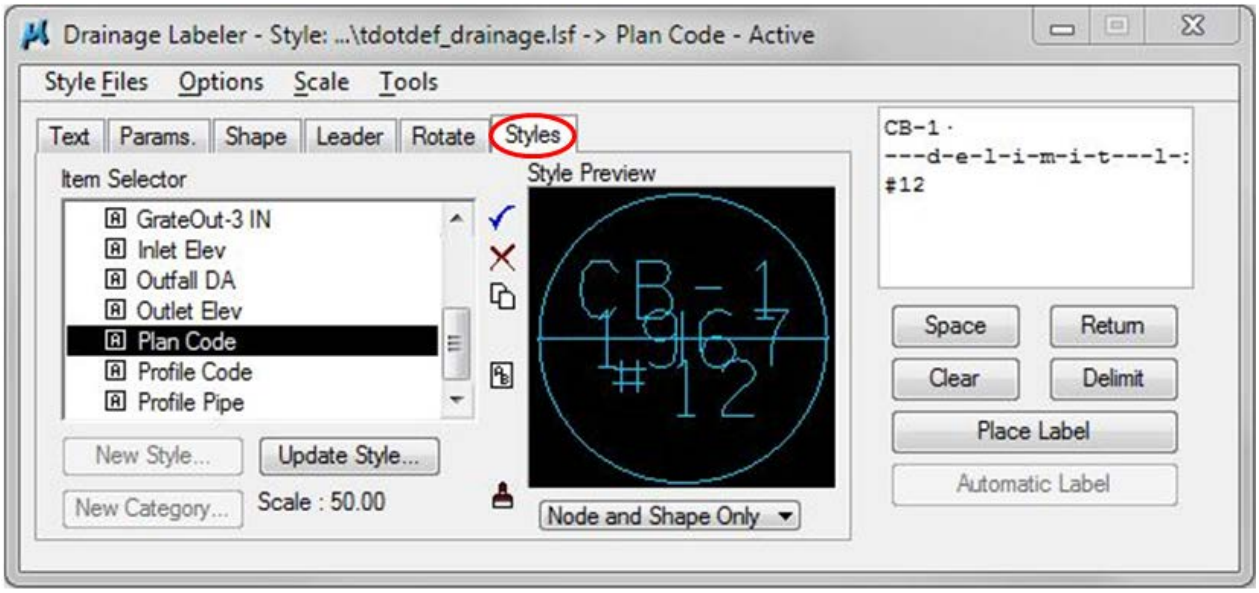
The Labeler automates the composition and placement of many types of labels into the dgn file. This interactive tool permits the creation of very simple to very complex labels.

13.1 Plan View Labeling

a) Open the Drainage Labeler by selecting **Utilities > Labeler** from the pull down menu or **Drainage Labeler** from the Drainage Toolbar.



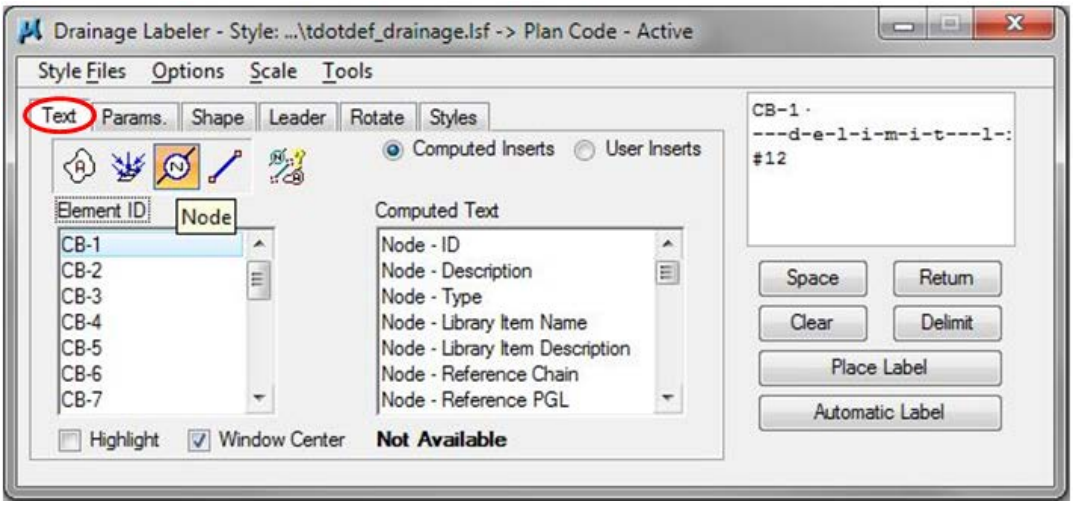
b) Click on the **Style** tab, double click **Plan Code** under the Storm Drainage category and double click it to make it the active style.



c) Zoom in to CB-1 in plan view.

d) Click on the **Text** tab, then click the **Nodes** icon and toggle ON **Window Center**.

e) Click on **CB-1** from the node list. Label data is automatically set for that node and view centers at node location.

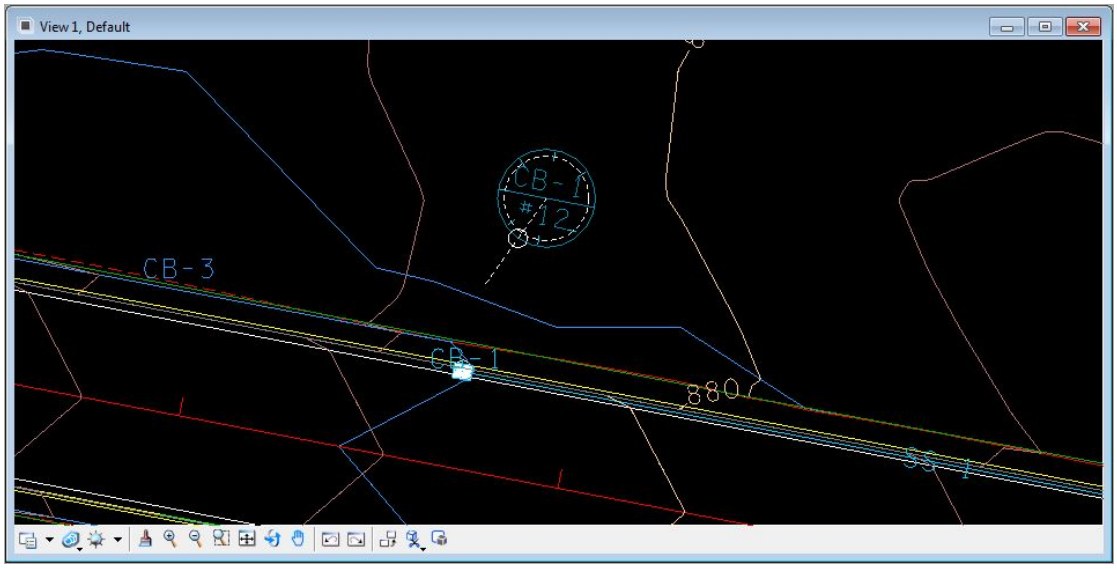


f) Select from the pulldown menu: **Scale > Change Scale** and change to **50**.

g) Click the **Place Label** button on the right of dialog to initiate placement of the label.

h) Move the cursor to position the label and **data point** to place the label in the vicinity of CB-1. If the label text is not horizontal to the view or alignment, you may need to go to the **Rotate** tab to set the angle prior to placement.

i) Move the cursor around and **data point** once again to locate the leader line point of beginning (i.e. where you want the leader to connect to the label).



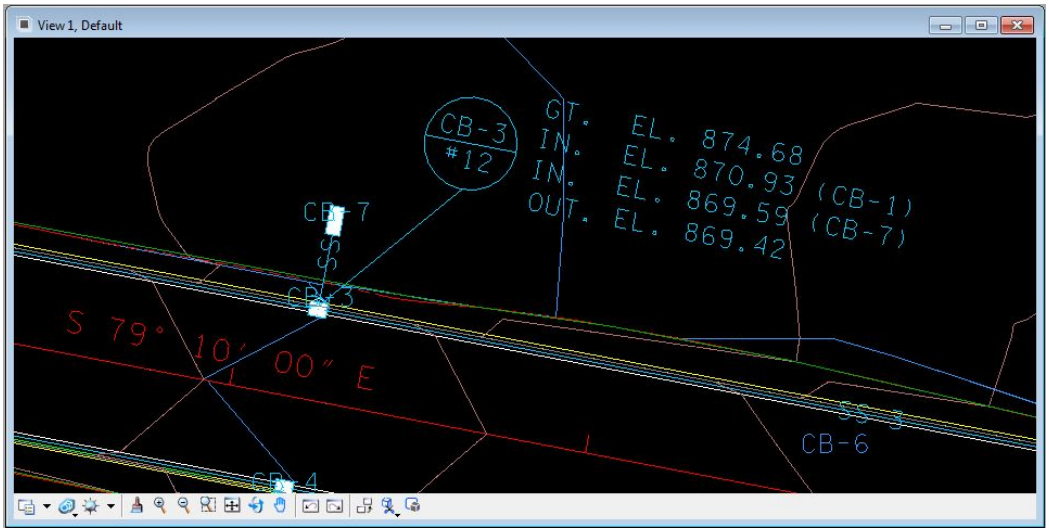
j) Click the **Style** tab and set the active style to **GrateOut-0IN** with a double click.

k) Click the **Text** tab and select **CB-1**. Click **Place Label** and data point next to the Code Label to position the text.

NOTE: For catch basins with one or more inlets, elevation labels will require an extra step to insert the inlet elevation(s).

l) Place labels for CB-3 which includes 2 inlet pipes.

1. Click the **Style** tab and set the active style to **GrateOut-2IN** with a double click.
2. Click the **Text** tab and select **CB-3**. Click **Place Label** and data point next to the Code Label to position the text.
3. Click the **Style** tab and set the active style to **Inlet Elev** with a double click.
4. Click the **Text** tab and select **SS-1**. Click **Place Label** and data point below the **GT. EL.** Text placed in step **b**.
5. Select **SS-7**. Click **Place Label** and data point below the **IN. EL.** Text placed in step **d**.



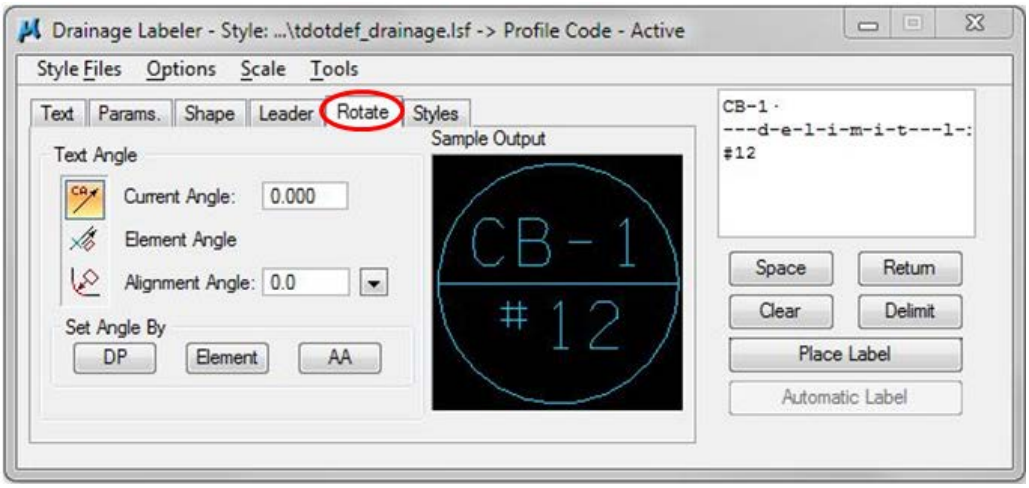
m) Place the remaining plan view Node labels.

13.2 Profile View Labeling

Normally the plan view displays most of the data for a catch basin, however, in some circumstance labels on the profile may be required.

a) Click on the **Styles** tab and double click on the style **Profile Code** to activate it.

b) Click on the **Rotate** tab and click on **Current Angle** (If needed set to 0)



c) Click on the **Text** tab and toggle OFF the **Window Center Box**. This option works with plan view only.

d) Zoom in on the alignment profile view in the vicinity of CB-1.

e) Click on CB-1 in the node list and then click **Place Label**.

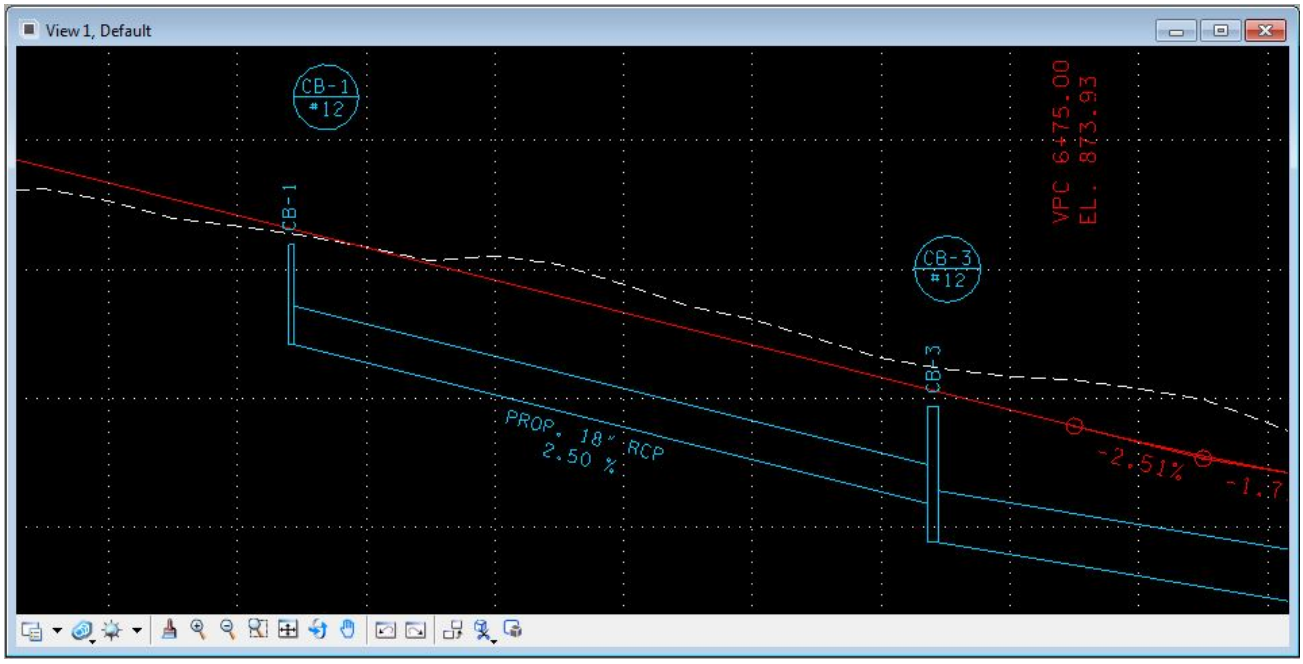
f) Locate in profile view and place the label.

g) Repeat until all codes are placed for all nodes in the profile view.

Leader Line Optional Steps:

Step 8. Use MicroStation's **Match Element Attributes** and click on any code placement.

Step 9. Use MicroStation's **Place Line** to place leader lines from code placement to node.



NOTE:
Pipes are automatically annotated correctly for the plans when the preference file **TDOTStormSewerProfiles-Plan.ppf** is used for profile display control. When using label style **Profile pipe** to label proposed pipes on the profile …

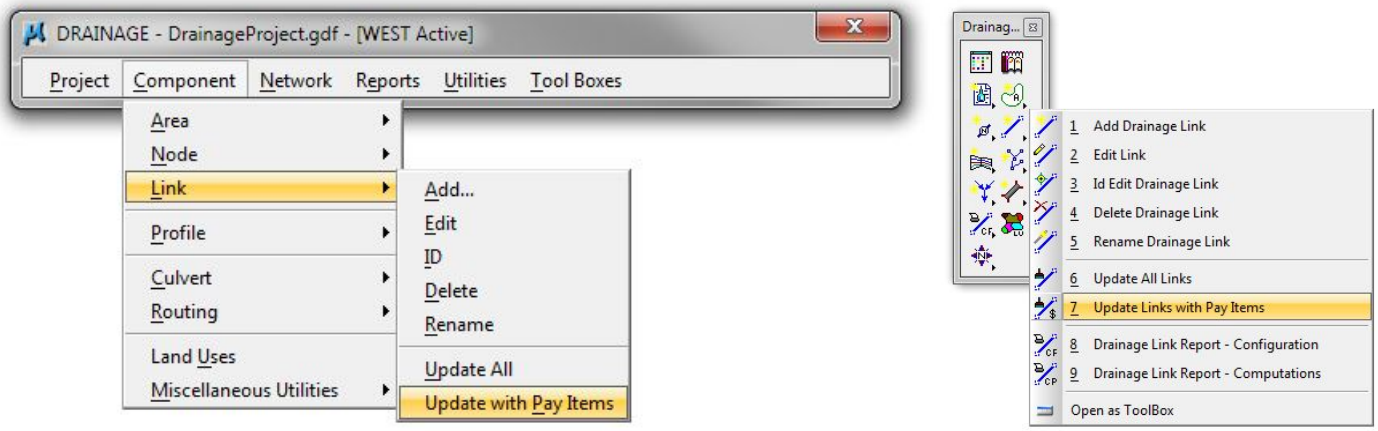
1) Select the link under the **Text** tab
2) Go to the **Rotate** tab and set to **Element Angle**
3) Click **Element** button in the *Set Angle* By portion of the dialog and identify the bottom of pipe on the profile to set label angle.
4) Data point to place label.

14. Design & Computation Manager with Drainage Links

This exercise shows the user how to use the D&C Manager to control symbology, compute quantities, which can be used in preliminary estimates, and set pay items for drainage links by setting the symbology of all pipes and generating pipe quantities for this project.

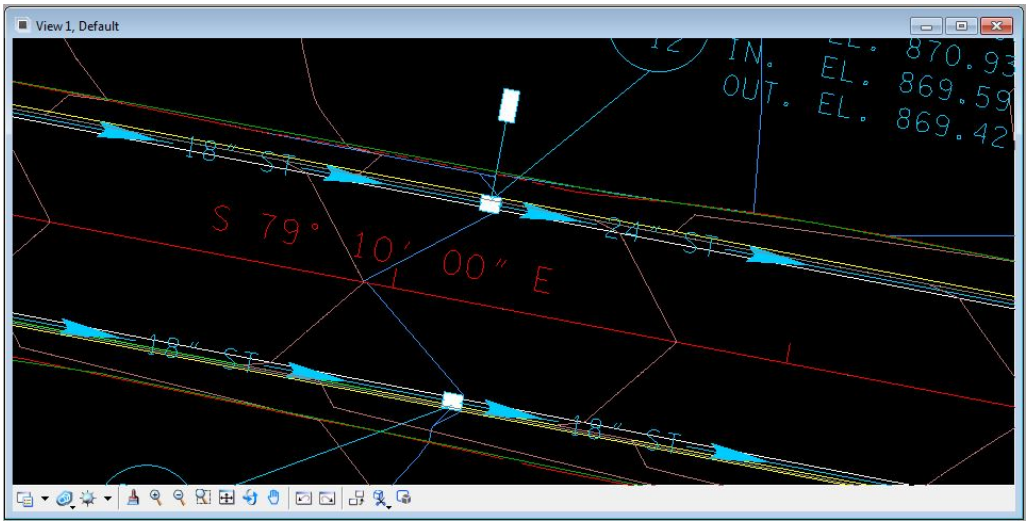
14.1 Set Link Symbology

a) Select **Components > Links > Update With Pay Items** from the main menu bar or **Update Links with Pay Items** from the Drainage Toolbox.



b) Utilize the MicroStation command **Fit View** to view the entire Drainage Network.

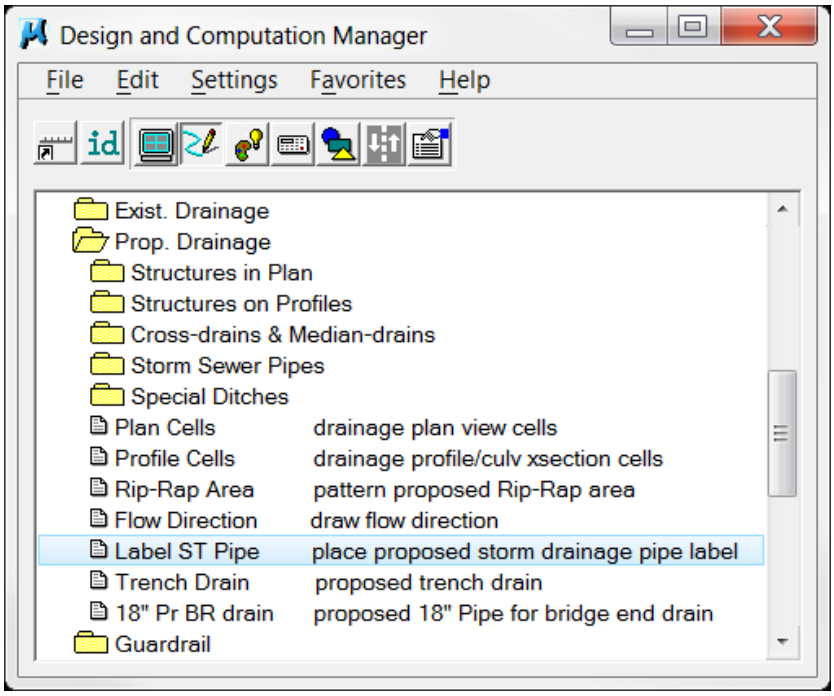
c) Note that the Link symbology has changed to reflect that of the D&C Manager. All links use appropriate custom line styles and are labeled with ST's and pipe size.



14.2 Label Short Pipe Links

Often we have cases where the pipes are too short for their symbology to show as is the case with the pipes from various drop inlets just off the roadway in this project. We have a tool available to handle these with a separate label which is available through D&C Manager.

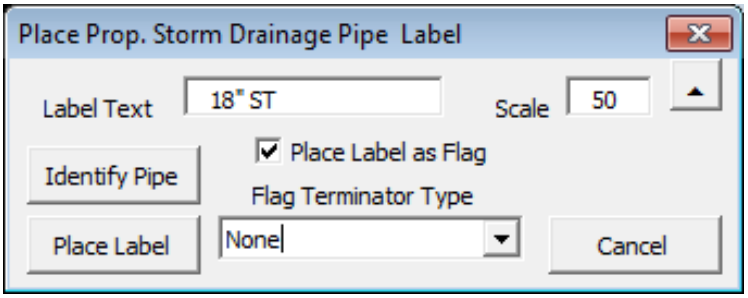
a) Open the Design and Computation Manager and select item **Drafting Standards> Prop. Drainage> Label ST Pipe**.



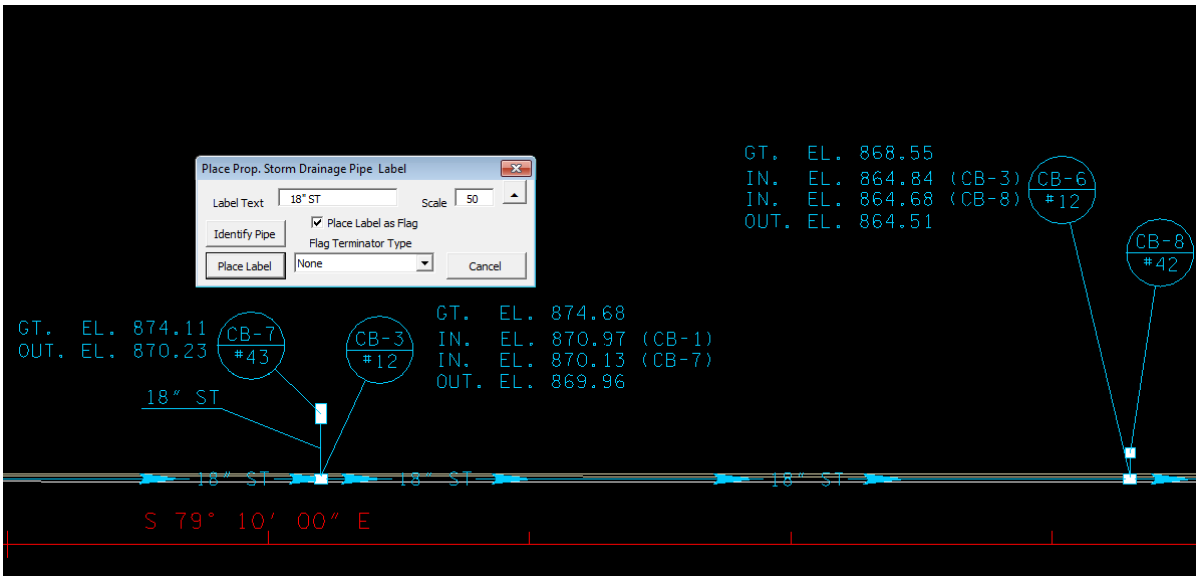
b) The **Place Prop. Storm Drainage Pipe Label** dialog opens and you are prompted to identify the pipe. Data point on link SS-7, the pipe between CB-7 and CB-3, and the appropriate text is filled in on the dialog.

By default the label will come up as text only at the angle of the pipe. If there is room, you can place the label as such along the pipe.

For pipes too short for that, click on the option to **Place Label as Flag** and click the **Place Label** button.

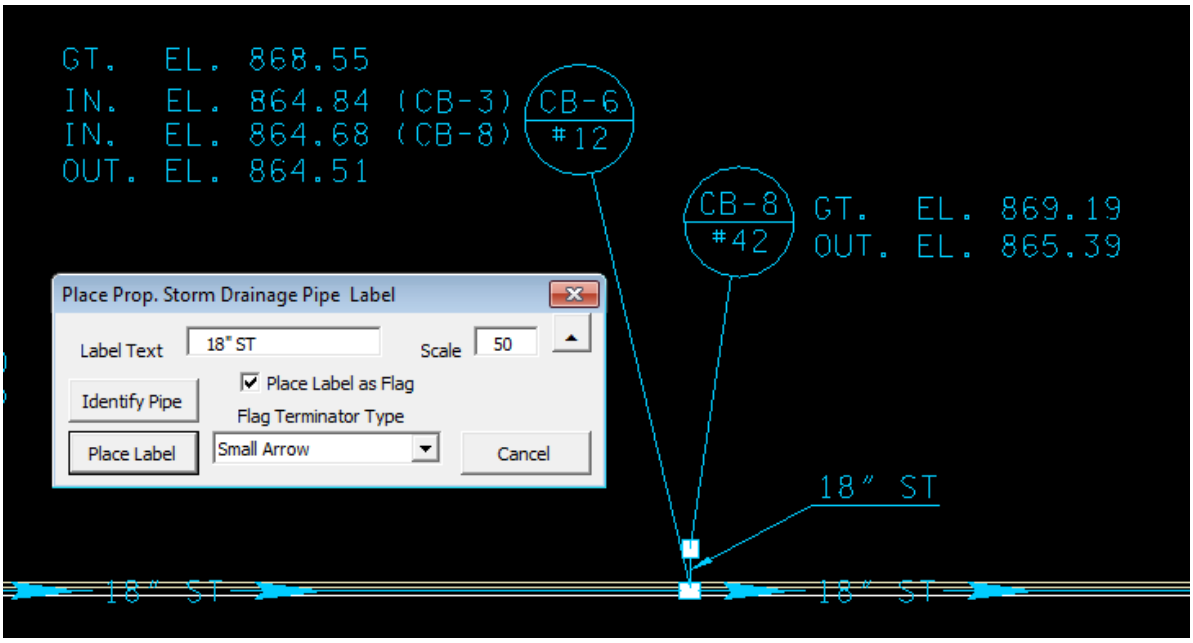


c) Data point on or near the pipe for the beginning of the leader and once again to position the label which is shown dynamically.



d) Use the **Identify Pipe** button to read and **label** the other short pipe links on the project.

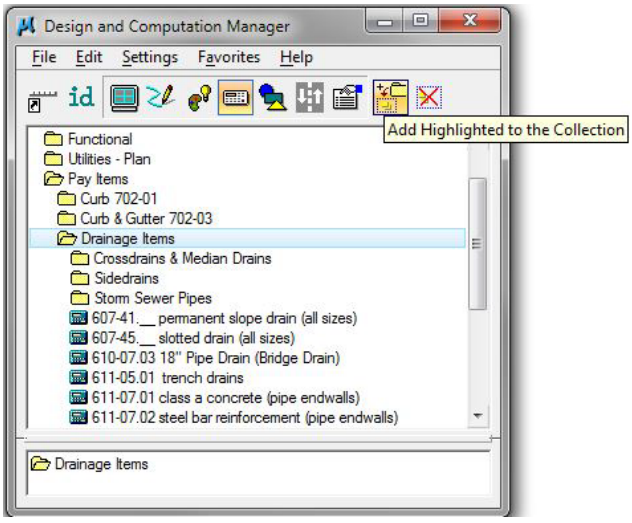
You may wish to use one of the terminator options for pipes in tight places with other text and line work.



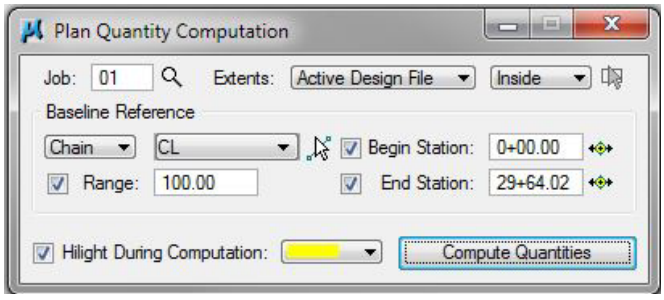
14.3 Compute Link Quantities

a) Open the Design and Computation Manager and set the Mode to Compute by clicking the **'calculator'** icon button.

b) Under **Pay Items**, highlight the **Prop. Drainage** category, then click the **Add to Collection** button on the Design & Computation Manager toolbar.

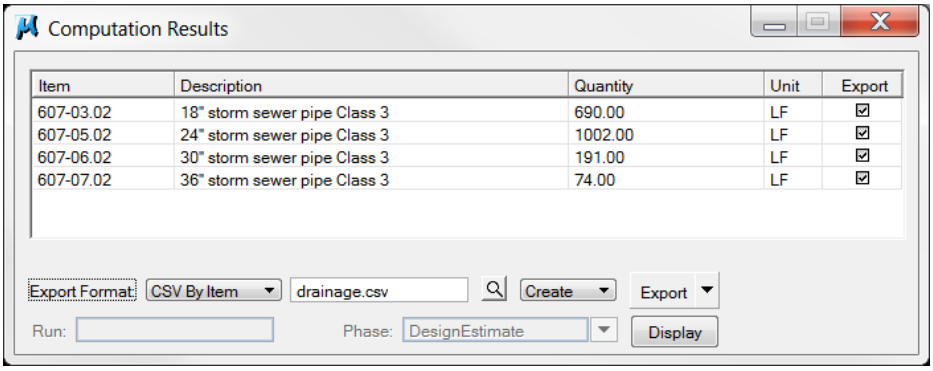


c) Within the Plan Quantity Computation box ensure Extents: is set to **Active Design File**. Click the Compute Quantities button for initiation of the report. Your results may vary.



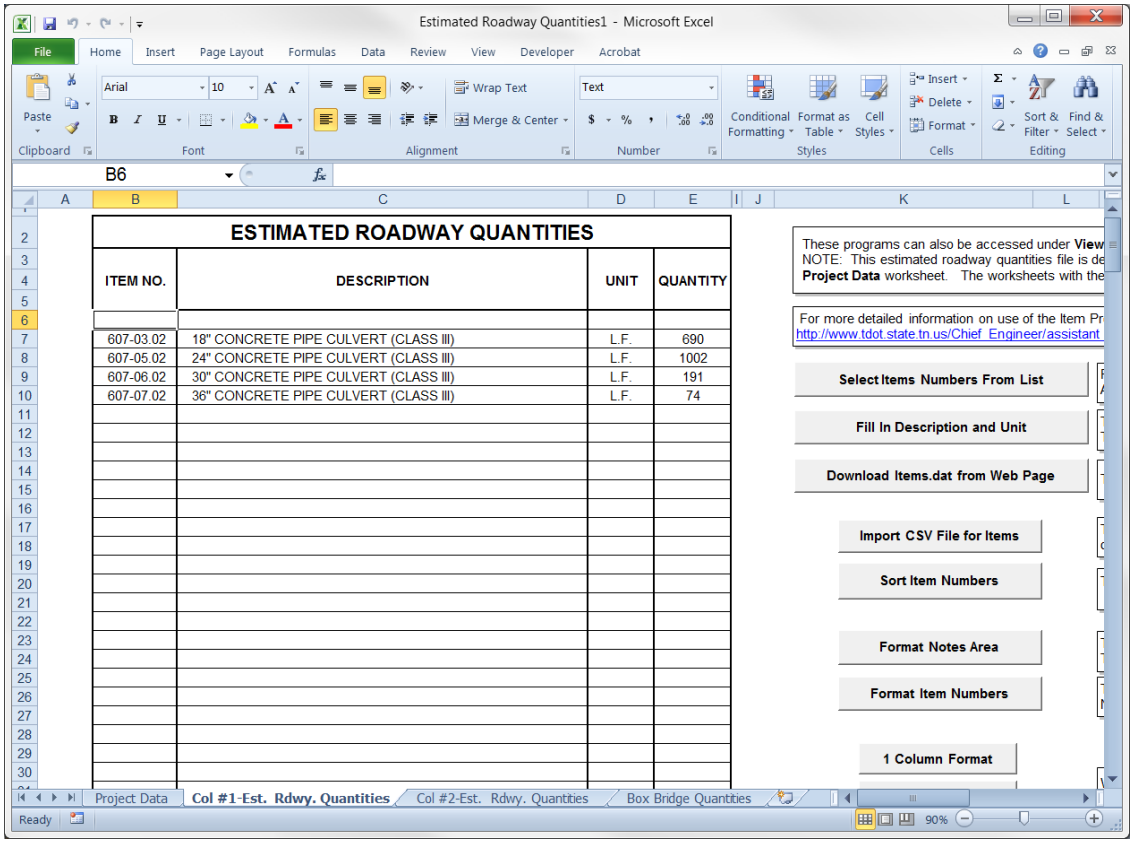
NOTE: To limit the extent of calculation set Extents: to Station Range, and set the limits desired in the *Baseline Reference* portion of the dialog.

d) Select your Export Format. Select **CSV By Item** for use with standard estimate files. Type in drainage.csv for the filename and click on **Export**.



In the Estimated Roadway Quantities Excel file use the **Import CSV File for Items** command button to import the data compiled with D&C Manager.

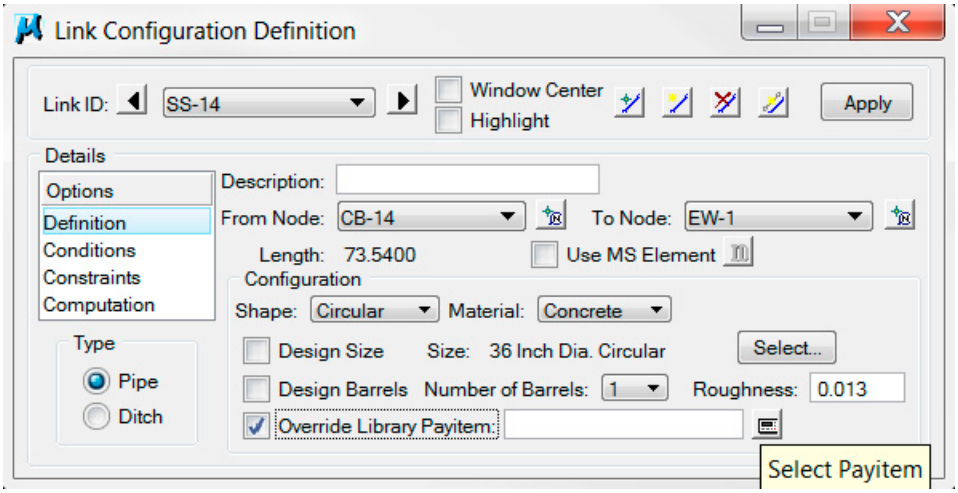
NOTE: This function reads only the item number and quantity from the csv file. Item description and unit are pulled from the official item number listing.



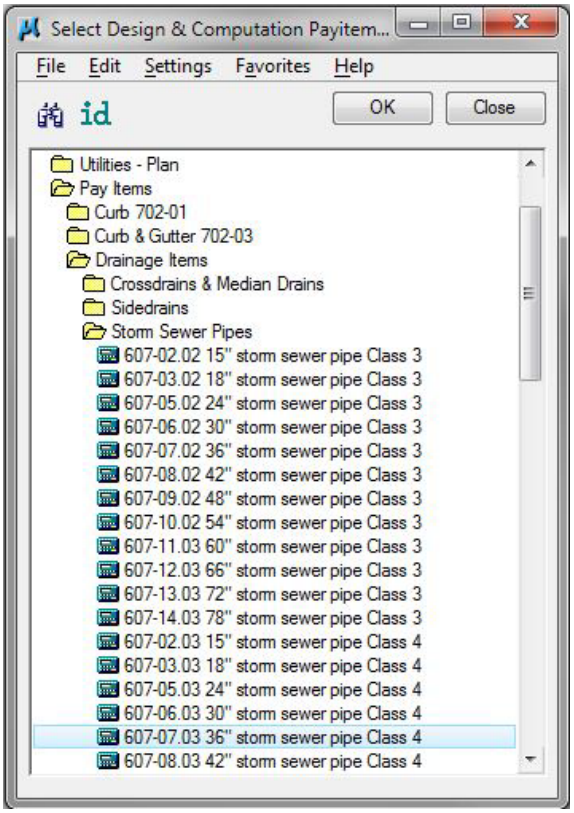
14.4 Alternate Pay Items for Links

a) Open Edit Link and select **Link SS-14**.

b) In **Definition**, under the *Configuration* portion, toggle ON **Override Library Payitem**.



c) Click on the calculator button to select an alternate pay item. Go to **Pay Items > Storm Sewer Pipes > 607-07.03 36” storm sewer pipe Class 4**.
Double click on the 36” Class 4 Concrete pipe item to switch it from the defaulted Class 3 item number.

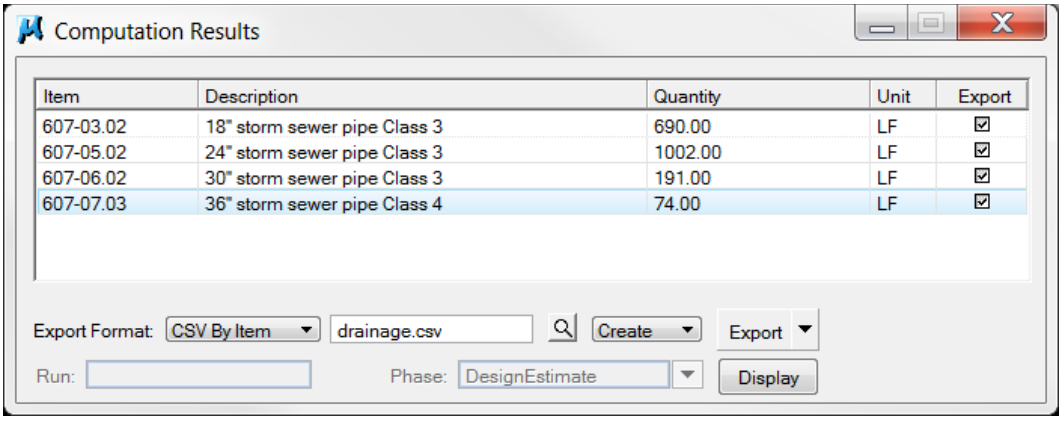


NOTE: All circular concrete pipes are set up with Class 3 concrete pipe item numbers. When setting up a system of median drains for depressed grass medians then all pipes will need to be set to use alternate pipe item numbers as listed under D & C manager category **Pay Items > Drainage Items > Crossdrains & Median Drains**.

d) Click **Apply** in the Link Configuration Definition dialog to accept the change.

Follow Exercise 14.1 to update the link graphics.

Follow Exercise 14.3 to re-compute the quantities and see the difference.



NOTE: See Appendix G for Pipe Selection Criteria based on system and fill height.

T.D.O.T. Geopak Drainage Nodes

1) Names for nodes indicate inside length & width dimensions of square structures or inside diameter of circular structures.
2) All values are from T.D.O.T. Standard Roadway Drawings based on concrete pipe.
3) For use with "Min Fixed Drop" option… Minimum Depth of Cover = Minimum Depth of Node - (Pipe Size + Drop Across Bottom of Structure) with both inlet & outlet pipes of the same size. When node has outlet pipe only or the outlet pipe is larger than the inlet pipe, increase the minimum depth of cover by the drop across bottom of structure value.
4) If no values are entered under a pipe size this indicates that pipe size is not valid with that node.
5) Any pipe size which includes a "W" with the minimum depth of cover value indicates the pipe size can only be used in the wide side of the structure.

Table A Pipe Sizes 15" - 42"

Drainage Node Name	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					15		18		24		30		36		42	
Type: Grate					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#10 32"X26"	Lowered 6-30 Curb & Grate Inlet	CB32X26S	0.12	5.08			3.77	2.15	4.31	W 2.19						
CB#10 4X3	6" NonMount. Curb & Grate Inlet	CB4X3S	0.17	20.00			3.90	2.23	4.45	2.28	4.99	W 2.32	5.50	W 2.33		
CB#10 4' DIA	6" NonMount. Curb & Grate Inlet	CB4DIAS	0.17	20.00			3.89	2.22	4.43	2.26						
CB#10 4X4	6" NonMount. Curb & Grate Inlet	CB4X4S	0.17	28.00			3.90	2.23	4.45	2.28	4.99	2.32	5.53	2.36		
CB#12 32"X32"	6" NonMount. Curb & Grate Inlet	CB32X32	0.12	4.58			3.77	2.15	4.31	2.19						
CB#12 4X3	6" NonMount. Curb & Grate Inlet	CB4X3	0.17	20.00			3.90	2.23	4.44	2.27	4.98	W 2.31	5.52	W 2.35		
CB#12 4' DIA	6" NonMount. Curb & Grate Inlet	CB4DIA	0.17	20.00			3.89	2.22	4.43	2.26						
CB#12 4X4	6" NonMount. Curb & Grate Inlet	CB4X4	0.17	28.00			3.90	2.23	4.45	2.28	4.99	2.32	5.53	2.36		
CB#12 5' DIA	6" NonMount. Curb & Grate Inlet	CB5DIA	0.21	40.00			3.94	2.23	4.48	2.27	5.02	2.31	5.56	2.35	6.11	2.40
CB#12 5'2"X5'2"	6" NonMount. Curb & Grate Inlet	CB62X62	0.22	28.00			4.12	2.40	4.66	2.44	5.20	2.48	5.74	2.52	6.29	2.57
CB#12 6' DIA	6" NonMount. Curb & Grate Inlet	CB6DIA	0.25	40.00			3.98	2.23	4.53	2.28	5.07	2.32	5.61	2.36	6.15	2.40
CB#12 7' DIA	6" NonMount. Curb & Grate Inlet	CB7DIA	0.29	40.00			4.36	2.57	4.90	2.61	5.45	2.66	5.99	2.70	6.53	2.74
CB#12 7X7	6" NonMount. Curb & Grate Inlet	CB7X7	0.29	28.00			4.20	2.41	4.74	2.45	5.28	2.49	5.82	2.53	6.37	2.58
CB#12 8' DIA	6" NonMount. Curb & Grate Inlet	CB8DIA	0.33	40.00			4.41	2.58	4.95	2.62	5.49	2.66	6.03	2.70	6.57	2.74
CB#12 9' DIA	6" NonMount. Curb & Grate Inlet	CB9DIA	0.38	40.00			4.45	2.57	4.99	2.61	5.54	2.66	6.08	2.70	6.62	2.74
CB#12 9X9	6" NonMount. Curb & Grate Inlet	CB9X9	0.38	28.00			4.29	2.41	4.83	2.45	5.37	2.49	5.91	2.53	6.45	2.57
CB#12 10' DIA	6" NonMount. Curb & Grate Inlet	CB10DIA	0.42	40.00			4.50	2.58	5.04	2.62	5.58	2.66	6.12	2.70	6.66	2.74
CB#13 4X3	6" NonMount. Curb & Grate Inlet	CB4X3	0.17	12.00			3.90	2.23	4.44	2.27	4.98	W 2.31	5.52	W 2.35		
CB#13 4' DIA	6" NonMount. Curb & Grate Inlet	CB4DIA	0.17	20.00			3.89	2.22	4.43	2.26						
CB#13 5' DIA	6" NonMount. Curb & Grate Inlet	CB5DIA	0.21	40.00			3.94	2.23	4.48	2.27	5.02	2.31	5.56	2.35	6.11	2.40

Table A Pipe Sizes 15" - 42"

Drainage Node Name Type: Grate	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					15		18		24		30		36		42	
					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#13 6' DIA	6" NonMount. Curb & Grate Inlet	CB6DIA	0.25	40.00			3.98	2.23	4.53	2.28	5.07	2.32	5.61	2.36	6.15	2.40
CB#13 7' DIA	6" NonMount. Curb & Grate Inlet	CB7DIA	0.29	40.00			4.36	2.57	4.90	2.61	5.45	2.66	5.99	2.70	6.53	2.74
CB#13 8' DIA	6" NonMount. Curb & Grate Inlet	CB8DIA	0.33	40.00			4.41	2.58	4.59	2.62	5.49	2.66	6.03	2.70	6.57	2.74
CB#13 9' DIA	6" NonMount. Curb & Grate Inlet	CB9DIA	0.38	40.00			4.45	2.57	4.99	2.61	5.54	2.66	6.08	2.70	6.62	2.74
CB#13 10' DIA	6" NonMount. Curb & Grate Inlet	CB10DIA	0.42	40.00			4.50	2.58	5.04	2.62	5.58	2.66	6.12	2.70	6.66	2.74
CB#14 8X3	6" NonMount. Curb & Grate Inlet	CB8X3	0.33	10.00			4.06	2.23	4.61	2.28	5.15	W 2.32	5.69	W 2.36	6.23	W 2.40
CB#14 8' DIA	6" NonMount. Curb & Grate Inlet	CB8DIA	0.33	40.00			4.41	2.58	4.95	2.62	5.49	2.66	6.03	2.70	6.57	2.74
CB#14 9X9	6" NonMount. Curb & Grate Inlet	CB9X9	0.38	28.00			4.45	2.57	4.99	2.61	5.54	2.66	6.08	2.70	6.62	2.74
CB#16 8X4	6" NonMount. Curb & Grate Inlet	CB8X4	0.33	20.00			4.07	2.24	4.61	2.28	5.15	2.32	5.70	2.37	6.24	W 2.41
CB#17 8X5'2"	6" NonMount. Curb & Grate Inlet	CB8X62	0.33	20.00			4.24	2.41	4.78	2.45	5.32	2.49	5.86	2.53	6.40	2.57
CB#25 32"X32"	6" Mountable Curb & Grate Inlet	CB32X32	0.12	4.58			3.77	2.15	4.31	2.19						
CB#25 4X3	6" Mountable Curb & Grate Inlet	CB4X3	0.17	12.00			3.90	2.23	4.44	2.27	4.98	W 2.31	5.52	W 2.35		
CB#25 4' DIA	6" Mountable Curb & Grate Inlet	CB4DIA	0.17	20.00			3.89	2.22	4.43	2.26						
CB#25 4X4	6" Mountable Curb & Grate Inlet	CB4X4	0.17	28.00			3.90	2.23	4.45	2.28	4.99	2.32	5.53	2.36		
CB#25 5' DIA	6" Mountable Curb & Grate Inlet	CB5DIA	0.21	40.00			3.94	2.23	4.48	2.27	5.02	2.31	5.56	2.35	6.11	2.40
CB#25 5'2"X5'2"	6" Mountable Curb & Grate Inlet	CB62X62	0.22	28.00			4.12	2.40	4.66	2.44	5.20	2.48	5.74	2.52	6.29	2.57
CB#25 6' DIA	6" Mountable Curb & Grate Inlet	CB6DIA	0.25	40.00			3.98	2.23	4.53	2.28	5.07	2.32	5.61	2.36	6.15	2.40
CB#25 7' DIA	6" Mountable Curb & Grate Inlet	CB7DIA	0.29	40.00			4.36	2.57	5.90	3.61	5.45	2.66	5.99	2.70	6.53	2.74
CB#25 7X7	6" Mountable Curb & Grate Inlet	CB7X7	0.29	28.00			4.28	2.49	4.82	2.53	5.37	2.58	5.91	2.62	6.45	2.66
CB#25 8' DIA	6" Mountable Curb & Grate Inlet	CB8DIA	0.33	40.00			4.41	2.58	4.98	2.62	5.49	2.66	6.03	2.70	6.57	2.74
CB#25 9X9	6" Mountable Curb & Grate Inlet	CB9X9	0.38	28.00			4.29	2.41	4.83	2.45	5.37	2.49	5.91	2.53	6.45	2.57
CB#26 8X3	6" Mountable Curb & Grate Inlet	CB8X3	0.33	10.00			4.06	2.23	4.61	2.28	5.15	W 2.32	5.69	W 2.36	6.23	W 2.40
CB#27 8X4	6" Mountable Curb & Grate Inlet	CB8X4	0.33	20.00			4.07	2.24	4.61	2.28	5.15	2.32	5.70	2.37	6.24	W 2.41
CB#28 32"X32"	4" Mountable Curb & Grate Inlet	CB32X32	0.12	4.58			3.77	2.15	4.31	2.19						
CB#28 4X3	4" Mountable Curb & Grate Inlet	CB4X3	0.17	12.00			3.90	2.23	4.44	2.27	4.98	W 2.31	5.52	W 2.35		
CB#28 4' DIA	4" Mountable Curb & Grate Inlet	CB4DIA	0.17	20.00			3.89	2.22	4.43	2.26						

Table A Pipe Sizes 15" - 42"

Drainage Node Name Type: Grate	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes 15		18		24		30		36		42	
					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#28 5' DIA	4" Mountable Curb & Grate Inlet	CB5DIA	0.21	40.00			3.94	2.23	4.48	2.27	5.02	2.31	5.56	2.35	6.11	2.40
CB#28 6' DIA	4" Mountable Curb & Grate Inlet	CB6DIA	0.25	40.00			3.98	2.23	4.53	2.28	5.07	2.32	5.61	2.36	6.15	2.40
CB#28 7' DIA	4" Mountable Curb & Grate Inlet	CB7DIA	0.29	40.00			4.36	2.57	4.90	2.61	5.45	2.66	5.99	2.70	6.53	2.74
CB#28 8' DIA	4" Mountable Curb & Grate Inlet	CB8DIA	0.33	40.00			4.41	2.58	4.95	2.62	5.49	2.66	6.03	2.70	6.57	2.74
CB#29 8X3	4" Mountable Curb & Grate Inlet	CB8X3	0.33	10.00			4.06	2.23	4.61	2.28	5.15	W 2.32	5.69	W 2.36	6.23	W 2.40
CB#31 7' DIA	Med. Barrier Curb & Grate Inlet	CB7DIAC	0.29	40.00			4.36	2.57	4.90	2.61	5.45	2.66	5.99	2.70	6.53	2.74
CB#31 7X7	Med. Barrier Curb & Grate Inlet	CB7X7C	0.29	28.00			4.37	2.58	4.91	2.62	5.45	2.66	5.99	2.70	6.53	2.74
CB#31 9X9	Med. Barrier Curb & Grate Inlet	CB9X9C	0.38	28.00			4.45	2.57	4.99	2.61	5.54	2.66	6.08	2.70	6.62	2.74
CB#32 32"X80"	Med. Barrier Curb & Grate Inlet	CB32X80C	0.12	6.00			3.77	2.15	4.31	2.19						
CB#38 32"X32"	Median Ditch Grate	CB32X32M	0.12	4.58			2.94	1.32	3.48	1.36						
CB#38 4X4	Median Ditch Grate	CB4X4M	0.17	28.00			3.82	2.15	4.36	2.19	4.90	2.23	5.45	2.28		
CB#38 5' DIA	Median Ditch Grate	CB5DIAM	0.21	40.00			3.94	2.23	4.48	2.27	5.02	2.31	5.56	2.35	6.11	2.40
CB#38 5'2"X5'2"	Median Ditch Grate	CB62X62M	0.22	28.00			4.04	2.32	4.58	2.36	5.12	2.40	5.66	2.44	6.20	2.48
CB#38 6' DIA	Median Ditch Grate	CB6DIAM	0.25	40.00			3.98	2.23	4.53	2.28	5.07	2.32	5.61	2.36	6.15	2.40
CB#38 7' DIA	Median Ditch Grate	CB7DIAM	0.29	40.00			4.36	2.57	4.90	2.61	5.45	2.66	5.99	2.70	6.53	2.74
CB#38 8' DIA	Median Ditch Grate	CB8DIAM	0.33	40.00			4.41	2.58	4.95	2.62	5.49	2.66	6.03	2.70	6.57	2.74
CB#39 4X4	Median Ditch Grate	CB4X4M	0.17	28.00			2.99	1.32	3.53	1.36	4.07	1.40	4.61	1.44		
CB#39 5'2"X5'2"	Median Ditch Grate	CB62X62M	0.22	28.00			4.08	2.36	4.62	2.40	5.16	2.44	5.70	2.48	6.24	2.52
CB#39 7' DIA	Median Ditch Grate	CB7DIAM	0.29	40.00			4.32	2.53	4.86	2.57	5.40	2.61	5.95	2.66	6.49	2.70
CB#39 7X7	Median Ditch Grate	CB7X7M	0.29	28.00			4.16	2.37	4.70	2.41	5.24	2.45	5.78	2.49	6.32	2.53
CB#39 8' DIA	Median Ditch Grate	CB8DIAM	0.33	40.00			4.45	2.62	4.99	2.66	5.53	2.70	6.07	2.74	6.62	2.79
CB#39 9X9	Median Ditch Grate	CB9X9M	0.38	28.00			4.24	2.36	4.79	2.41	5.33	2.45	5.87	2.49	6.41	2.53
CB#40 8X4	Median Ditch Grate	CB8X4M	0.33	20.00			3.15	1.32	3.70	1.37	4.24	1.41	4.78	1.45	5.32	W 1.49
CB#40 9X9	Median Ditch Grate	CB9X9M	0.38	28.00			4.41	2.53	4.95	2.57	5.49	2.61	6.04	2.66	6.58	2.70
CB#41 32"X32"	Med. Barrier Curb & Grate Inlet	CB32X32B	0.12	4.58			3.77	2.15	4.31	2.19						
CB#41 4X3	Med. Barrier Curb & Grate Inlet	CB4X3B	0.17	20.00			3.90	2.23	4.44	2.27	4.98	W 2.31	5.52	W 2.35		

Table A Pipe Sizes 15" - 42"

Drainage Node Name	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					15		18		24		30		36		42	
Type: Grate					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#41 4X4	Med. Barrier Curb & Grate Inlet	CB4X4B	0.17	28.00			3.90	2.23	4.45	2.28	4.99	2.32	5.53	2.36		
CB#41 5' DIA	Med. Barrier Curb & Grate Inlet	CB5DIAB	0.21	40.00			3.94	2.23	4.48	2.27	5.02	2.31	5.56	2.35	6.11	2.40
CB#41 5'2"X5'2"	Med. Barrier Curb & Grate Inlet	CB62X62B	0.22	28.00			4.12	2.40	4.66	2.44	5.20	2.48	5.74	2.52	6.29	2.57
CB#41 6' DIA	Med. Barrier Curb & Grate Inlet	CB6DIAB	0.25	40.00			3.98	2.23	4.53	2.28	5.07	2.32	5.61	2.36	6.15	2.40
CB#41 7' DIA	Med. Barrier Curb & Grate Inlet	CB7DIAB	0.29	40.00			4.36	2.57	4.90	2.61	5.45	2.66	5.99	2.70	6.53	2.74
CB#41 7X7	Med. Barrier Curb & Grate Inlet	CB7X7B	0.29	28.00			4.20	2.41	4.74	2.45	5.28	2.49	5.82	2.53	6.37	2.58
CB#41 8' DIA	Med. Barrier Curb & Grate Inlet	CB8DIAB	0.33	40.00			4.41	2.58	4.95	2.62	5.49	2.66	6.03	2.70	6.57	2.74
CB#41 9X9	Med. Barrier Curb & Grate Inlet	CB9X9B	0.38	28.00			4.29	2.41	4.83	2.45	5.37	2.49	5.91	2.53	6.45	2.57
CB#42 32"X32"	Drop Inlet Grate	DI32X32	0.12	5.08			2.94	1.32	3.48	1.36						
CB#42 4X4	Drop Inlet Grate	DI4X4	0.17	28.00			3.82	2.15	4.36	2.19	4.90	2.23	5.45	2.28		
CB#42 5' DIA	Drop Inlet Grate	DI5DIA	0.21	40.00			3.94	2.23	4.48	2.27	5.02	2.31	5.56	2.35	6.11	2.40
CB#42 5'2"X5'2"	Drop Inlet Grate	DI62X62	0.22	28.00			4.04	2.32	4.58	2.36	5.12	2.40	5.66	2.44	6.20	2.48
CB#42 6' DIA	Drop Inlet Grate	DI6DIA	0.25	40.00			3.98	2.23	4.53	2.28	5.07	2.32	5.61	2.36	6.15	2.40
CB#42 7' DIA	Drop Inlet Grate	DI7DIA	0.29	40.00			4.36	2.57	4.90	2.61	5.45	2.66	5.99	2.70	6.53	2.74
CB#42 7X7	Drop Inlet Grate	DI7X7	0.29	28.00			4.28	2.49	4.82	2.53	5.37	2.58	5.91	2.62	6.45	2.66
CB#42 8' DIA	Drop Inlet Grate	DI8DIA	0.33	40.00			4.41	2.58	4.95	2.62	5.49	2.66	6.03	2.70	6.57	2.74
CB#43 8X4	Drop Inlet Grate	DI8X4	0.33	20.00			3.99	2.16	4.53	2.20	5.07	2.24	5.61	2.28	6.15	W 2.32
CB#43 8X5'2"	Drop Inlet Grate	DI8X62	0.33	20.00			4.15	2.32	4.70	2.37	5.24	2.41	5.78	2.45	6.32	2.49
CB#43 8' DIA	Drop Inlet Grate	DI8DIA	0.33	40.00			4.32	2.49	4.87	2.54	5.41	2.58	5.95	2.62	6.49	2.66
CB#44 9X9	Drop Inlet Grate	DI9X9	0.38	28.00			4.37	2.49	4.91	2.53	5.45	2.57	5.99	2.61	6.54	2.66
CB#45 8X4	Med. Barrier Curb & Grate Inlet	CB8X4B	0.33	20.00			4.07	2.24	4.61	2.28	5.15	2.32	5.70	2.27	6.24	W 2.41
CB#46 9X9	Med. Barrier Curb & Grate Inlet	CB9X9C	0.38	28.00			4.45	2.57	4.99	2.61	5.54	2.66	6.08	2.70	6.62	2.74
CB#51 5'2"X5'2"	Retaining Wall Curb & Grate Inlet	CB62X62R	0.22	28.00			4.12	2.40	4.66	2.44	5.20	2.48	5.74	2.52	6.24	2.52
CB#51 7X7	Retaining Wall Curb & Grate Inlet	CB7X7R	0.29	28.00			4.37	2.58	4.91	2.62	5.45	2.66	5.99	2.70	6.53	2.74
CB#51 9X9	Retaining Wall Curb & Grate Inlet	CB9X9R	0.38	28.00			4.62	2.74	5.16	2.78	5.70	2.82	6.24	2.86	6.79	2.91
CB#52 9X9	Retaining Wall Curb & Grate Inlet	CB9X9R	0.38	28.00			4.62	2.74	5.16	2.78	5.70	2.82	6.24	2.86	6.79	2.91

Table A Pipe Sizes 15" - 42"

Drainage Node Name	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					15		18		24		30		36		42	
Type: Junction					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
MH#3 4' DIA	Manhole	MH4DIA	0.17	40.00			3.89	2.22	4.43	2.26						
MH#3 5'DIA	Manhole	MH5DIA	0.21	40.00			3.94	2.23	4.48	2.27	5.02	2.31	5.56	2.35	6.11	2.40
MH#3 5'2"X5'2"	Manhole	MH62X62	0.22	28.00			4.18	2.46	4.72	2.50	5.26	2.54	5.81	2.59	6.35	2.63
MH#3 6' DIA	Manhole	MH6DIA	0.25	40.00			3.98	2.23	4.53	2.28	5.07	2.32	5.61	2.36	6.15	2.40
MH#3 7' DIA	Manhole	MH7DIA	0.29	40.00			4.36	2.57	4.90	2.61	5.45	2.66	5.99	2.70	6.53	2.74
MH#3 7X7	Manhole	MH7X7	0.29	28.00			4.43	2.64	4.97	2.68	5.51	2.72	6.05	2.76	6.60	2.81
MH#3 8' DIA	Manhole	MH8DIA	0.33	40.00			4.41	2.58	4.95	2.62	5.49	2.66	6.03	2.70	6.57	2.74
MH#3 9' DIA	Manhole	MH9DIA	0.38	40.00			4.45	2.57	4.99	2.61	5.54	2.66	6.08	2.70	6.62	2.74
MH#3 9X9	Manhole	MH9X9	0.38	28.00			4.43	2.55	4.97	2.59	5.51	2.63	6.06	2.68	6.60	2.72
MH#3 10' DIA	Manhole	MH10DIA	0.42	40.00			4.50	2.58	5.04	2.62	5.58	2.66	6.12	2.70	6.66	2.74
JB#1 32"X32"	Junction Box*	JB32X32	0.12	50.00			3.29	1.67	3.83	1.71						
JB#2 4X4	Junction Box*	JB4X4	0.17	50.00			3.29	1.62	3.83	1.66	4.38	1.71	4.92	1.75		
JB#3 5'2"X5'2"	Junction Box*	JB62X62	0.22	50.00			3.63	1.91	4.17	1.95	4.71	1.99	5.25	2.03	5.79	2.07
JB#4 7X7	Junction Box*	JB7X7	0.29	30.00			3.83	2.04	4.38	2.09	4.92	2.13	5.46	2.17	6.00	2.21
JB#5 9X9	Junction Box*	JB9X9	0.38	30.00			4.17	2.29	4.71	2.33	5.25	2.37	5.79	2.41	6.33	2.45
JB#6 4' DIA	Junction Box*	JB4DIA	0.17	20.00			3.88	2.21	4.42	2.25						
JB#6 5' DIA	Junction Box*	JB5DIA	0.21	40.00			3.92	2.21	4.46	2.25	5.00	2.29	5.55	2.34	6.09	2.38
JB#6 6' DIA	Junction Box*	JB6DIA	0.25	40.00			3.97	2.22	4.51	2.26	5.05	2.30	5.59	2.34	6.13	2.38
JB#6 7' DIA	Junction Box*	JB7DIA	0.29	40.00			4.34	2.55	4.88	2.59	5.42	2.63	5.97	2.68	6.51	2.72
JB#6 8' DIA	Junction Box*	JB8DIA	0.33	40.00			4.38	2.55	4.92	2.59	5.46	2.63	6.00	2.67	6.54	2.71
JB#6 9' DIA	Junction Box*	JB9DIA	0.38	40.00			4.42	2.54	4.96	2.58	5.50	2.62	6.04	2.66	6.58	2.70
JB#6 10' DIA	Junction Box*	JB10DIA	0.42	40.00			4.46	2.54	5.00	2.58	5.54	2.62	6.08	2.66	6.63	2.71
Stub	Stub into Culvert	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Maximum Depth for use in Geopak equals tabulated depth (to top of structure) + Minimum Depth based on pipe size.
Add an additional 2 feet for mimimum cover over structure to Minimum Depth of Cover if junction box is within the clear zone.

Type: Outlet																
Endwall	Endwall for outlet pipe(generic)	EW	0.00	Pipe Size*	1.25	0.00	1.50	0.00	2.00	0.00	2.50	0.00	3.00	0.00	3.50	0.00
Outlet Stub	Stub into existing structure	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Outlet	Special ditch end	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* During initial design, set the Maximum Depth to a value greater than the expected pipe size and the Minimum Depth of Cover to 0.00. Once pipe size is determined, reset the Maximum Depth to the designed pipe size + the distance to the top lip of the endwall to be used with the pipe and reset the Minimum Depth of Cover to the distance to the top lip of the endwall.

Table A Pipe Sizes 15" - 42"

Drainage Node Name	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					15		18		24		30		36		42	
Type: Other					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
EW Inlet	Endwall inlet into drainage system	EW	0.00	Pipe Size*	1.25	0.00	1.50	0.00	2.00	0.00	2.50	0.00	3.00	0.00	3.50	0.00
Ditch Begin	Begin special ditch	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Change	Special ditch shape change	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type: Headwall																
Culvert Endwall	Pipe Culvert Endwall(generic)	EW	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type: Grate - Bridge Drains																
BD 2'X8'7"	Bridge End Drain	BD2X8	0.00	3.50			3.50	2.00								
BD 4'X8'7"	Bridge End Drain	BD4X8	0.00	3.50			3.50	2.00								
					6		9									
BD 2'X9"	Bridge Deck Drain	BD9X2	0.00	1.50	1.25	0.75	1.50	0.75								
Type: Curb - Bridge Drains																
BD-PRPT	Bridge Deck Drain - Parapet	BDPRPT	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Type: Slotted Drain					12" CMP		15" CMP		18" CMP		24" CMP		30" CMP		36" CMP	
SD 12"	Slotted Drain	SLOT12	0.00	1.50	1.50	0.50										
SD 15"	Slotted Drain	SLOT15	0.00	1.75			1.75	0.50								
SD 18"	Slotted Drain	SLOT18	0.00	2.00					2.00	0.50						
SD 24"	Slotted Drain	SLOT24	0.00	2.50							2.50	0.50				
SD 30"	Slotted Drain	SLOT30	0.00	3.00									3.00	0.50		
SD 36"	Slotted Drain	SLOT36	0.00	3.50											3.50	0.50

* During initial design, set the Maximum Depth to a value greater than the expected pipe size and the Minimum Depth of Cover to 0.00. Once pipe size is determined, reset the Maximum Depth to the designed pipe size + the distance to the top lip of the endwall to be used with the pipe and reset the Minimum Depth of Cover to the distance to the top lip of the endwall.

Table B Pipe Sizes 48" - 78"

Drainage Node Name / Type: Grate	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					48		54		60		66		72		78	
					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#10 32"X26"	Lowered 6-30 Curb & Grate Inlet	CB32X26S	0.12	5.08												
CB#10 4X3	6" NonMount. Curb & Grate Inlet	CB4X3S	0.17	20.00												
CB#10 4' DIA	6" NonMount. Curb & Grate Inlet	CB4DIAS	0.17	20.00												
CB#10 4X4	6" NonMount. Curb & Grate Inlet	CB4X4S	0.17	20.00												
CB#12 32"X32"	6" NonMount. Curb & Grate Inlet	CB32X32	0.12	4.58												
CB#12 4X3	6" NonMount. Curb & Grate Inlet	CB4X3	0.17	20.00												
CB#12 4' DIA	6" NonMount. Curb & Grate Inlet	CB4DIA	0.17	20.00												
CB#12 4X4	6" NonMount. Curb & Grate Inlet	CB4X4	0.17	28.00												
CB#12 5' DIA	6" NonMount. Curb & Grate Inlet	CB5DIA	0.21	40.00	6.65	2.44										
CB#12 5'2"X5'2"	6" NonMount. Curb & Grate Inlet	CB62X62	0.22	28.00	6.83	2.61										
CB#12 6' DIA	6" NonMount. Curb & Grate Inlet	CB6DIA	0.25	40.00	6.69	2.44										
CB#12 7' DIA	6" NonMount. Curb & Grate Inlet	CB7DIA	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86	8.70	2.91	9.24	2.95	9.78	2.99
CB#12 7X7	6" NonMount. Curb & Grate Inlet	CB7X7	0.29	28.00	6.91	2.62	7.45	2.66	7.99	2.70	8.83	3.04				
CB#12 8' DIA	6" NonMount. Curb & Grate Inlet	CB8DIA	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91	9.28	2.95	9.83	3.00
CB#12 9' DIA	6" NonMount. Curb & Grate Inlet	CB9DIA	0.38	40.00	7.16	2.78	7.70	2.82	8.25	2.87	8.79	2.91	9.33	2.95	9.87	2.99
CB#12 9X9	6" NonMount. Curb & Grate Inlet	CB9X9	0.38	28.00	6.99	2.61	7.54	2.66	8.08	2.70	8.62	2.74	9.16	2.78	9.70	2.82
CB#12 10' DIA	6" NonMount. Curb & Grate Inlet	CB10DIA	0.42	40.00	7.21	2.79	7.75	2.83	8.29	2.87	8.83	2.91	9.37	2.95	9.92	3.00
CB#13 4X3	6" NonMount. Curb & Grate Inlet	CB4X3	0.17	12.00												
CB#13 4' DIA	6" NonMount. Curb & Grate Inlet	CB4DIA	0.17	20.00												
CB#13 5' DIA	6" NonMount. Curb & Grate Inlet	CB5DIA	0.21	40.00	6.65	2.44										
CB#13 6' DIA	6" NonMount. Curb & Grate Inlet	CB6DIA	0.25	40.00	6.69	2.44										
CB#13 7' DIA	6" NonMount. Curb & Grate Inlet	CB7DIA	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86	8.70	2.91	9.24	2.95	9.78	2.99
CB#13 8' DIA	6" NonMount. Curb & Grate Inlet	CB8DIA	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91	9.58	3.25	9.83	3.00
CB#13 9' DIA	6" NonMount. Curb & Grate Inlet	CB9DIA	0.38	40.00	7.16	2.78	7.70	2.82	8.25	2.87	8.79	2.91	9.33	2.95	9.87	2.99
CB#13 10' DIA	6" NonMount. Curb & Grate Inlet	CB10DIA	0.42	40.00	7.21	2.79	7.75	2.83	8.29	2.87	8.83	2.91	9.37	2.95	9.92	3.00
CB#14 8X3	6" NonMount. Curb & Grate Inlet	CB8X3	0.33	10.00	6.77	W 2.44	7.31	W 2.48	7.86	W 2.53						

Table B Pipe Sizes 48" - 78"

Drainage Node Name / Type: Grate	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					48		54		60		66		72		78	
					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#14 8' DIA	6" NonMount. Curb & Grate Inlet	CB8DIA	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91				
CB#14 9X9	6" NonMount. Curb & Grate Inlet	CB9X9	0.38	28.00	7.16	2.78	7.70	2.82	8.25	2.87	8.79	2.91	9.33	2.95	9.87	2.99
CB#16 8X4	6" NonMount. Curb & Grate Inlet	CB8X4	0.33	20.00	6.78	W 2.45	7.32	W 2.49	7.86	W 2.53						
CB#17 8X5'2"	6" NonMount. Curb & Grate Inlet	CB8X62	0.33	20.00	6.95	2.62	7.49	W 2.66	8.03	W 2.70						
CB#25 32"X32"	6" Mountable Curb & Grate Inlet	CB32X32	0.12	4.58												
CB#25 4X3	6" Mountable Curb & Grate Inlet	CB4X3	0.17	12.00												
CB#25 4' DIA	6" Mountable Curb & Grate Inlet	CB4DIA	0.17	20.00												
CB#25 4X4	6" Mountable Curb & Grate Inlet	CB4X4	0.17	28.00												
CB#25 5' DIA	6" Mountable Curb & Grate Inlet	CB5DIA	0.21	40.00	6.65	2.44	7.19	2.48	7.73	2.52	8.27	2.56				
CB#25 5'2"X5'2"	6" Mountable Curb & Grate Inlet	CB62X62	0.22	28.00	6.83	2.61										
CB#25 6' DIA	6" Mountable Curb & Grate Inlet	CB6DIA	0.25	40.00	6.69	2.44	7.23	2.48	7.78	2.53	8.32	2.57				
CB#25 7' DIA	6" Mountable Curb & Grate Inlet	CB7DIA	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86	8.70	2.91				
CB#25 7X7	6" Mountable Curb & Grate Inlet	CB7X7	0.29	28.00	6.99	2.70	7.53	2.74	8.08	2.79	8.62	2.83				
CB#25 8' DIA	6" Mountable Curb & Grate Inlet	CB8DIA	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91				
CB#25 9X9	6" Mountable Curb & Grate Inlet	CB9X9	0.38	28.00	6.99	2.61	7.54	2.66	8.08	2.70	8.62	2.74	9.16	2.78	9.70	2.82
CB#26 8X3	6" Mountable Curb & Grate Inlet	CB8X3	0.33	10.00	6.77	W 2.44	7.31	W 2.48	7.86	W 2.53						
CB#27 8X4	6" Mountable Curb & Grate Inlet	CB8X4	0.33	20.00	6.78	W 2.45	7.32	W 2.49	7.86	W 2.53						
CB#28 32"X32"	4" Mountable Curb & Grate Inlet	CB32X32	0.12	4.58												
CB#28 4X3	4" Mountable Curb & Grate Inlet	CB4X3	0.17	12.00												
CB#28 4' DIA	4" Mountable Curb & Grate Inlet	CB4DIA	0.17	20.00												
CB#28 5' DIA	4" Mountable Curb & Grate Inlet	CB5DIA	0.21	40.00	6.65	2.44	7.19	2.48	7.73	2.52	8.27	2.56				
CB#28 6' DIA	4" Mountable Curb & Grate Inlet	CB6DIA	0.25	40.00	6.69	2.44	7.23	2.48	7.78	2.53	8.32	2.57				
CB#28 7' DIA	4" Mountable Curb & Grate Inlet	CB7DIA	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86	8.70	2.91				
CB#28 8' DIA	4" Mountable Curb & Grate Inlet	CB8DIA	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91				
CB#29 8X3	4" Mountable Curb & Grate Inlet	CB8X3	0.33	10.00	6.77	W 2.44	7.31	W 2.48	7.86	W 2.53						
CB#31 7' DIA	Med. Barrier Curb & Grate Inlet	CB7DIAC	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86						

Table B Pipe Sizes 48" - 78"

Drainage Node Name	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					48		54		60		66		72		78	
Type: Grate					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#31 7X7	Med. Barrier Curb & Grate Inlet	CB7X7C	0.29	28.00	7.07	2.78	7.62	2.83	8.16	2.87	8.70	2.91				
CB#31 9X9	Med. Barrier Curb & Grate Inlet	CB9X9C	0.38	28.00	7.16	2.78	7.70	2.82	8.25	2.87	8.79	2.91	9.33	2.95	9.87	2.99
CB#32 32"X80"	Med. Barrier Curb & Grate Inlet	CB32X80C	0.12	6.00												
CB#38 32"X32"	Median Ditch Grate	CB32X32M	0.12	4.58												
CB#38 4X4	Median Ditch Grate	CB4X4M	0.17	28.00												
CB#38 5' DIA	Median Ditch Grate	CB5DIAM	0.21	40.00	6.65	2.44	7.19	2.48	7.73	2.52	8.27	2.56				
CB#38 5'2"X5'2"	Median Ditch Grate	CB62X62M	0.22	28.00	6.74	2.52										
CB#38 6' DIA	Median Ditch Grate	CB6DIAM	0.25	40.00	6.69	2.44	7.23	2.48	7.78	2.53	8.32	2.57				
CB#38 7' DIA	Median Ditch Grate	CB7DIAM	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86	8.70	2.91				
CB#38 8' DIA	Median Ditch Grate	CB8DIAM	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91				
CB#39 4X4	Median Ditch Grate	CB4X4M	0.17	28.00												
CB#39 5'2"X5'2"	Median Ditch Grate	CB62X62M	0.22	28.00	6.79	2.57										
CB#39 7' DIA	Median Ditch Grate	CB7DIAM	0.29	40.00	7.03	2.74	7.57	2.78	8.11	2.82	8.66	2.87				
CB#39 7X7	Median Ditch Grate	CB7X7M	0.29	28.00	6.87	2.58	7.41	2.62	7.95	2.66	8.49	2.70				
CB#39 8' DIA	Median Ditch Grate	CB8DIAM	0.33	40.00	7.16	2.83	7.70	2.87	8.24	2.91	8.78	2.95				
CB#39 9X9	Median Ditch Grate	CB9X9M	0.38	28.00	6.95	2.57	7.50	2.62	8.04	2.66	8.58	2.70	9.12	2.74	9.66	2.78
CB#40 8X4	Median Ditch Grate	CB8X4M	0.33	20.00	5.86	W 1.53	6.40	W 1.57	6.95	W 1.62						
CB#40 9X9	Median Ditch Grate	CB9X9M	0.38	28.00	7.12	2.74	7.66	2.78	8.20	2.82	8.75	2.87	9.59	3.21	9.83	2.95
CB#41 32"X32"	Med. Barrier Curb & Grate Inlet	CB32X32B	0.12	4.58												
CB#41 4X3	Med. Barrier Curb & Grate Inlet	CB4X3B	0.17	12.00												
CB#41 4X4	Med. Barrier Curb & Grate Inlet	CB4X4B	0.17	28.00												
CB#41 5' DIA	Med. Barrier Curb & Grate Inlet	CB5DIAB	0.21	40.00	6.65	2.44	7.19	2.48	7.73	2.52	8.27	2.56				
CB#41 5'2"X5'2"	Med. Barrier Curb & Grate Inlet	CB62X62B	0.22	28.00	6.83	2.61										
CB#41 6' DIA	Med. Barrier Curb & Grate Inlet	CB6DIAB	0.25	40.00	6.69	2.44	7.23	2.48	7.78	2.53	8.23	2.48				
CB#41 7' DIA	Med. Barrier Curb & Grate Inlet	CB7DIAB	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86	8.70	2.91				
CB#41 7X7	Med. Barrier Curb & Grate Inlet	CB7X7B	0.29	28.00	6.91	2.62	7.45	2.66	7.99	2.70	8.53	2.74				

Table B Pipe Sizes 48" - 78"

Drainage Node Name Type: Grate	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					48		54		60		66		72		78	
					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
CB#41 8' DIA	Med. Barrier Curb & Grate Inlet	CB8DIAB	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91				
CB#41 9X9	Med. Barrier Curb & Grate Inlet	CB9X9B	0.38	28.00	6.99	2.61	7.54	2.66	8.08	2.70	8.62	2.74	9.16	2.78	9.70	2.82
CB#42 32"X32"	Drop Inlet Grate	DI32X32	0.12	5.08												
CB#42 4X4	Drop Inlet Grate	DI4X4	0.17	28.00												
CB#42 5' DIA	Drop Inlet Grate	DI5DIA	0.21	40.00	6.65	2.44	7.19	2.48	7.73	2.52	8.27	2.56				
CB#42 5'2"X5'2"	Drop Inlet Grate	DI62X62	0.22	28.00	6.74	2.52										
CB#42 6' DIA	Drop Inlet Grate	DI6DIA	0.25	40.00	6.69	2.44	7.23	2.48	7.78	2.53	8.23	2.48				
CB#42 7' DIA	Drop Inlet Grate	DI7DIA	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86	8.70	2.91				
CB#42 7X7	Drop Inlet Grate	DI7X7	0.29	28.00	6.99	2.70	7.53	2.74	8.08	2.79	8.62	2.83				
CB#42 8' DIA	Drop Inlet Grate	DI8DIA	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91				
CB#43 8X4	Drop Inlet Grate	DI8X4	0.33	20.00	6.70	W 2.37	7.24	W 2.41	7.78	W 2.45						
CB#43 8X5'2"	Drop Inlet Grate	DI8X62	0.33	20.00	6.86	2.53	7.40	W 2.57	7.95	W 2.62						
CB#43 8' DIA	Drop Inlet Grate	DI8DIA	0.33	40.00	7.03	2.70	7.57	2.74	8.12	2.79	8.66	2.83				
CB#44 9X9	Drop Inlet Grate	DI9X9	0.38	28.00	7.08	2.70	7.62	2.74	8.16	2.78	8.70	2.82	9.25	2.87	9.79	2.91
CB#45 8X4	Med. Barrier Curb & Grate Inlet	CB8X4B	0.33	20.00	6.78	W 2.45	7.32	W 2.49	7.86	W 2.53						
CB#46 9X9	Med. Barrier Curb & Grate Inlet	CB9X9C	0.38	28.00	7.16	2.78	7.70	2.82	8.25	2.87	8.79	2.91	9.33	2.95	9.87	2.99
CB#51 5'2"X5'2"	Retaining Wall Curb & Grate Inlet	CB62X62R	0.22	28.00	6.83	2.61										
CB#51 7X7	Retaining Wall Curb & Grate Inlet	CB7X7R	0.29	28.00	7.07	2.78	7.62	2.83	8.16	2.87	8.70	2.91				
CB#51 9X9	Retaining Wall Curb & Grate Inlet	CB9X9R	0.38	28.00	7.33	2.95	7.87	2.99	8.41	3.03	8.95	3.07	9.50	3.12	10.04	3.16
CB#52 9X9	Retaining Wall Curb & Grate Inlet	CB9X9R	0.38	28.00	7.33	2.95	7.87	2.99	8.41	3.03	8.95	3.07	9.50	3.12	10.04	3.16

Table B Pipe Sizes 48" - 78"

Drainage Node Name	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					48		54		60		66		72		78	
Type: Junction					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
MH#3 4' DIA	Manhole	MH4DIA	0.17	40.00												
MH#3 5'DIA	Manhole	MH5DIA	0.21	40.00												
MH#3 5'2"X5'2"	Manhole	MH62X62	0.22	28.00	6.89	2.67										
MH#3 6' DIA	Manhole	MH6DIA	0.25	40.00	6.33	2.08										
MH#3 7' DIA	Manhole	MH7DIA	0.29	40.00	6.33	2.04	6.88	2.09	7.42	2.13						
MH#3 7X7	Manhole	MH7X7	0.29	28.00	7.14	2.85	7.68	2.89	8.22	2.93	8.76	2.97				
MH#3 8' DIA	Manhole	MH8DIA	0.33	40.00	6.42	2.09	6.96	2.13	7.50	2.17	8.04	2.21				
MH#3 9' DIA	Manhole	MH9DIA	0.38	40.00	6.42	2.04	6.96	2.08	7.50	2.12	8.04	2.16	8.58	2.20		
MH#3 9X9	Manhole	MH9X9	0.38	28.00	7.14	2.76	7.68	2.80	8.22	2.84	8.77	2.89	9.31	2.93	9.85	2.97
MH#3 10' DIA	Manhole	MH10DIA	0.42	40.00	6.42	2.00	6.96	2.04	7.50	2.08	8.04	2.12	8.58	2.16	9.13	2.21
JB#1 32"X32"	Junction Box*	JB32X32	0.12	50.00												
JB#2 4X4	Junction Box*	JB4X4	0.17	50.00												
JB#3 5'2"X5'2"	Junction Box*	JB62X62	0.22	50.00	6.34	2.12										
JB#4 7X7	Junction Box*	JB7X7	0.29	30.00	6.58	2.29	7.12	2.33	7.66	2.37	8.20	2.41				
JB#5 9X9	Junction Box*	JB9X9	0.38	30.00	6.92	2.54	7.46	2.58	8.00	2.62	8.54	2.66	9.09	2.71	9.63	2.75
JB#6 4' DIA	Junction Box*	JB4DIA	0.17	20.00												
JB#6 5' DIA	Junction Box*	JB5DIA	0.21	40.00	6.65	2.44										
JB#6 6' DIA	Junction Box*	JB6DIA	0.25	40.00	6.69	2.44										
JB#6 7' DIA	Junction Box*	JB7DIA	0.29	40.00	7.07	2.78	7.61	2.82	8.15	2.86	8.70	2.91	9.24	2.95	9.78	2.99
JB#6 8' DIA	Junction Box*	JB8DIA	0.33	40.00	7.12	2.79	7.66	2.83	8.20	2.87	8.74	2.91	9.28	2.95	9.83	3.00
JB#6 9' DIA	Junction Box*	JB9DIA	0.38	40.00	7.16	2.78	7.70	2.82	8.25	2.87	8.79	2.91	9.33	2.95	9.87	2.99
JB#6 10' DIA	Junction Box*	JB10DIA	0.42	40.00	7.21	2.79	7.75	2.83	8.29	2.87	8.83	2.91	9.37	2.95	9.92	3.00
Stub	Stub into Culvert	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Maximum Depth for use in Geopak equals tabulated depth (to top of structure) + Minimum Depth based on pipe size.
Add an additional 2 feet for mimimum cover over structure to Minimum Depth of Cover if junction box is within the clear zone.

Type: Outlet																
Endwall	Endwall for outlet pipe(generic)	EW	0.00	Pipe Size*	4.00	0.00	4.50	0.00	5.00	0.00	5.50	0.00	6.00	0.00	6.50	0.00
Outlet Stub	Stub into existing structure	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Outlet	Special ditch end	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* During initial design, set the Maximum Depth to a value greater than the expected pipe size and the Minimum Depth of Cover to 0.00. Once pipe size is determined, reset the Maximum Depth to the designed pipe size + the distance to the top lip of the endwall to be used with the pipe and reset the Minimum Depth of Cover to the distance to the top lip of the endwall.

Table B Pipe Sizes 48" - 78"

Drainage Node Name	Node Description	Cell Name	Drop Across Bottom of Structure	Max. Depth	Pipe Sizes											
					48		54		60		66		72		78	
Type: Other					Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover	Min. Depth	Min. Depth of Cover
EW Inlet	Endwall inlet into drainage system	EW	0.00	Pipe Size*	4.00	0.00	4.50	0.00	5.00	0.00	5.50	0.00	6.00	0.00	6.50	0.00
Ditch Begin	Begin special ditch	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Change	Special ditch shape change	STUB	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* During initial design, set the Maximum Depth to a value greater than the expected pipe size and the Minimum Depth of Cover to 0.00. Once pipe size is determined, reset the Maximum Depth to the designed pipe size + the distance to the top lip of the endwall to be used with the pipe and reset the Minimum Depth of Cover to the distance to the top lip of the endwall.

Type: Headwall																
Culvert Endwall	Pipe Culvert Endwall(generic)	EW	0.00	none	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Type: Grate - Bridge Drains																
BD 2'X8'7"	Bridge End Drain	BD2X8	0.00	3.50												
BD 4'X8'7"	Bridge End Drain	BD4X8	0.00	3.50												
BD 2'X9"	Bridge Deck Drain	BD9X2	0.00	1.50												

Type: Curb - Bridge Drains																
BD-PRPT	Bridge Deck Drain - Parapet	BDPRPT	0.00	none												

Completing Drainage Areas

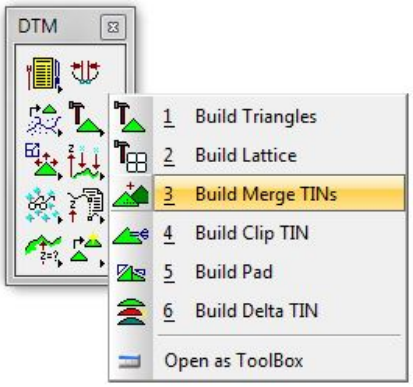
This exercise shows options for the user to calculate drainage areas not included in the survey TIN file.

Step 1. Create a TIN Surface for areas outside the Survey TIN. Follow the processes outlined in the TIN Surfaces from DEM document available from the Roadway Design Division – CADD Standards and Downloads website.

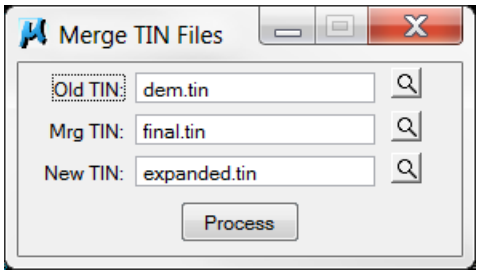
Step 2. Merge the project Final TIN with the TIN surface created in Step 1.

a. Open DTM Tools by clicking **Applications> GEOPAK> Road> DTM Tools**.

b. Within the DTM Tools dialog select **Build Merge TINs**.



c. Set **Old TIN:** to the TIN File created in Step 1. Set **Mrg TIN:** to the Final Project TIN file. Create a unique name for the **New TIN:** file.



d. Click **Process**.

Step 3. Visualize contours for the New Merged TIN utilizing steps from the TDOT GEOPAK Road Course Guide, Exercise 22b.

Step 4. Use this process with DTM tools presented in this document in conjunction with MrSID images or other aerial photography to determine approximate flow paths and drainage areas.

NOTE: MrSID images can be attached by following the process in the Using MrSID Image Files in MicroStation document.

Example image with expanded surface information:


View 1, Default

Common Network Errors and Fixes

This information shows common network errors experienced and possible solutions to correct them.

Error:

Link SS- # velocity less than minimum desired.

Solutions:

Increase the slope of the pipe/ditch.

Decrease the size of the pipe/ditch (if possible) (Smaller flow area means higher velocity).

Change the type of pipe/ditch (if possible) (Smoother pipes typically have higher velocities).

Error:

Link SS - # velocity greater than maximum desired.

Solutions:

Decrease the slope of the pipe/ditch.

Increase the size of the pipe/ditch (if possible) (Larger flow areas means lower velocity).

Change the type of pipe/ditch (if possible) (Rougher pipes typically have lower velocities).

Error:

Capacity for Inlet CB - # Exceeded Bypass Flow Unassigned.

Solutions:

Assign a downstream node to accept the bypass.

Use double or other multi-grate catch basin or drop inlet.

Add additional upstream catch basin(s) to ensure all runoff is captured within the system.

If none of the above are feasible/practical, ensure the bypass flow has a place to flow into another storm drain system or roadside ditch and the error can be ignored.

Error:

Computed Ponded Width for Inlet CB - # Exceeds Maximum.

Solutions:

Move closer to upstream catch basin.

Add additional catch basin upstream.

Error:

HGL Blowout upstream of Link SS - # minimum freeboard not achieved

Solutions:

For Storm Sewers:	Increase pipe size.
	Increase pipe slope.
For Ditches:	The top of node should be above the Hydraulic Grade Line (HGL). Confirm the HGL is below the soffit and ignore error.

Error:

Min/Max Depth Exceeded at Upstream/Downstream of Link SS- #.

Solutions:

For Storm Sewers:	Check held elevations and slopes in the *Link Configurations Conditions* dialog.
For Ditches:	Confirm node/link elevations are correct and ignore error.

Error:

Profile Warning for Link SS - #:
–>Minimum Slope used for Positive Drainage
–>Check Held Elevations and Slopes

Solutions:

Check held elevations and slopes in the *Link Configurations Conditions* dialog. Make changes as necessary.

Error:

Soffit elevation adjusted for ditches:

Solutions:

No correction required, normal adjustment required when ditch inverts are held at specific elevations.

Error:

Catch Basin Minimum Depth exceeded on most catch basins,
depth gets progressively deeper from beginning of network to end.

Solutions:

Check Link preferences, turn off rounding of link slopes if on.

From Hydraulic Engineering Circular No. 22, Third Edition
URBAN DRAINAGE DESIGN MANUAL
USDOT & FHWA Pub No FHWA-NHI-10-009 September 2009

Table 3-2. Manning's Roughness Coefficient (n) for Overland Sheet Flow.[6]

Surface Description	n
Smooth asphalt	0.011
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Brick with cement mortar	0.014
Vitrified clay	0.015
Cast iron	0.015
Corrugated metal pipe	0.024
Cement rubble surface	0.024
Fallow (no residue)	0.05
Cultivated soils	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Range (natural)	0.13
Grass	
Short grass prairie	0.15
Dense grasses	0.24
Bermuda grass	0.41
Woods*	
Light underbrush	0.40
Dense underbrush	0.80
*When selecting n, consider cover to a height of about 30 mm. This is only part of the plant cover that will obstruct sheet flow.	

Shallow Concentrated Flow Velocity. After short distances of at most 130 m (400 ft), sheet flow tends to concentrate in rills and then gullies of increasing proportions. Such flow is usually referred to as shallow concentrated flow. The velocity of such flow can be estimated using a relationship between velocity and slope as follows [6]:

$$V = K_u \, k \, S_p^{0.5} \qquad (3\text{-}4)$$

where:

K_u = 1.0 (3.28 in English units)
V = Velocity, m/s (ft/s)
k = Intercept coefficient (Table 3-3)
S_p = Slope, percent

From Hydraulic Engineering Circular No. 22, Third Edition
URBAN DRAINAGE DESIGN MANUAL
USDOT & FHWA Pub No FHWA-NHI-10-009 September 2009

Table 3-3. Intercept Coefficients for Velocity vs. Slope Relationship of Equation 3-4.[6]	
Land Cover/Flow Regime	k
Forest with heavy ground litter; hay meadow (overland flow)	0.076
Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overland flow)	0.152
Short grass pasture (overland flow)	0.213
Cultivated straight row (overland flow)	0.274
Nearly bare and untilled (overland flow); alluvial fans in western mountain regions	0.305
Grassed waterway (shallow concentrated flow)	0.457
Unpaved (shallow concentrated flow)	0.491
Paved area (shallow concentrated flow); small upland gullies	0.619

Open Channel and Pipe Flow Velocity. Flow in gullies empties into channels or pipes. Open channels are assumed to begin where either the blue stream line shows on USGS quadrangle sheets or the channel is visible on aerial photographs. Cross-section geometry and roughness should be obtained for all channel reaches in the watershed. Manning's equation can be used to estimate average flow velocities in pipes and open channels as follows:

$$V = (K_u/n)\, R^{2/3}\, S^{1/2} \qquad (3\text{-}5)$$

where:

n = Roughness coefficient (see Table 3-4)
V = Velocity, m/s (ft/s)
R = Hydraulic radius (defined as the flow area divided by the wetted perimeter), m (ft)
S = Slope, m/m (ft/ft)
K_u = Units conversion factor equal to 1 (1.49 in English units)

For a circular pipe flowing full, the hydraulic radius is one-fourth of the diameter. For a wide rectangular channel (W > 10 d), the hydraulic radius is approximately equal to the depth. The travel time is then calculated as follows:

$$T_{ti} = L / (60\, V) \qquad (3\text{-}6)$$

where:

T_{ti} = Travel time for Segment I, min
L = Flow length for Segment I, m (ft)
V = Velocity for Segment I, m/s (ft/s)

Type of Channel and Description	Minimum	Normal	Maximum
LINED CHANNELS (Selected Linings)			
a. Concrete			
Trowel Finish	0.011	0.013	0.015
Float Finish	0.013	0.015	0.016
Gunite, good section	0.016	0.019	0.023
b. Asphalt			
Smooth	0.013	0.013	-
Rough	0.016	0.016	-
EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.025	0.030	0.035
Stony bottom and weedy sides	0.025	0.035	0.045
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline excavated or dredged			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, uncut weeds and brush			
Dense weeds as high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.800	0.100	0.140
NATURAL STREAMS			
1. Minor streams (top width at flood stage<100 ft)			
a. Streams on Plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055

Table 5A-1
Values of Roughness
Coefficient 'n' (Uniform Flow)
Reference: Chow, Ven T., *Open Channel Hydraulics* (1959)
Continue on following page

$$h_1 + \left(\frac{V_1^2}{2g}\right) = h_2 + \left(\frac{V_2^2}{2g}\right) + h_L \qquad (5\text{-}7)$$

Where:
h_1 = upstream water surface elevation, (ft)
h_2 = downstream water surface elevation, (ft)
V_1 = mean velocity upstream, (ft/s)
V_2 = mean velocity downstream, (ft/s)
h_L = head loss due to local cross sectional changes and friction loss, (ft)
g = acceleration due to gravity, (32.2 ft/sec^2)

Figure 5-3 illustrates the terms in the Energy equation. The equation states that the total energy head at the upstream location of a channel is equal to the sum of the energy head at the next downstream location plus the energy head losses between the two consecutive sections. To apply the energy equation, streamlines must be approximately straight and parallel so that vertical acceleration can be neglected.

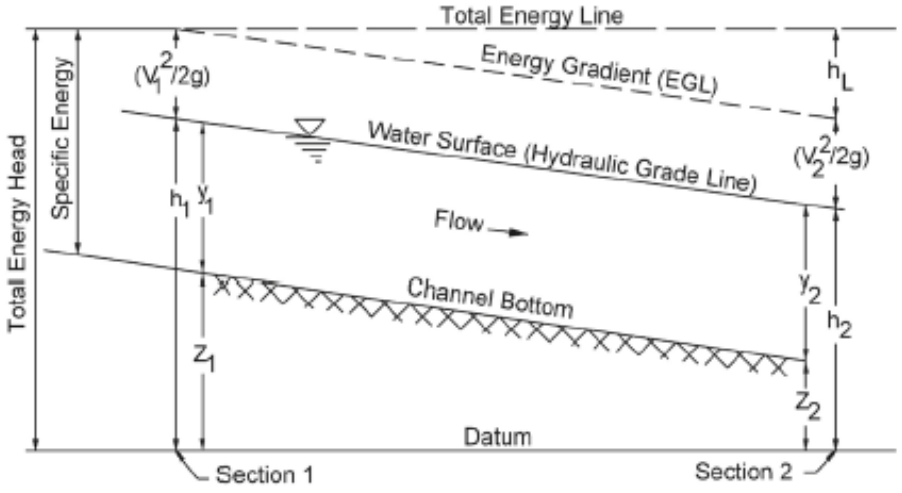


Figure 5-3
Total Energy in Open Channel Flow

5.03.3 MANNING'S CHANNEL ROUGHNESS COEFFICIENTS

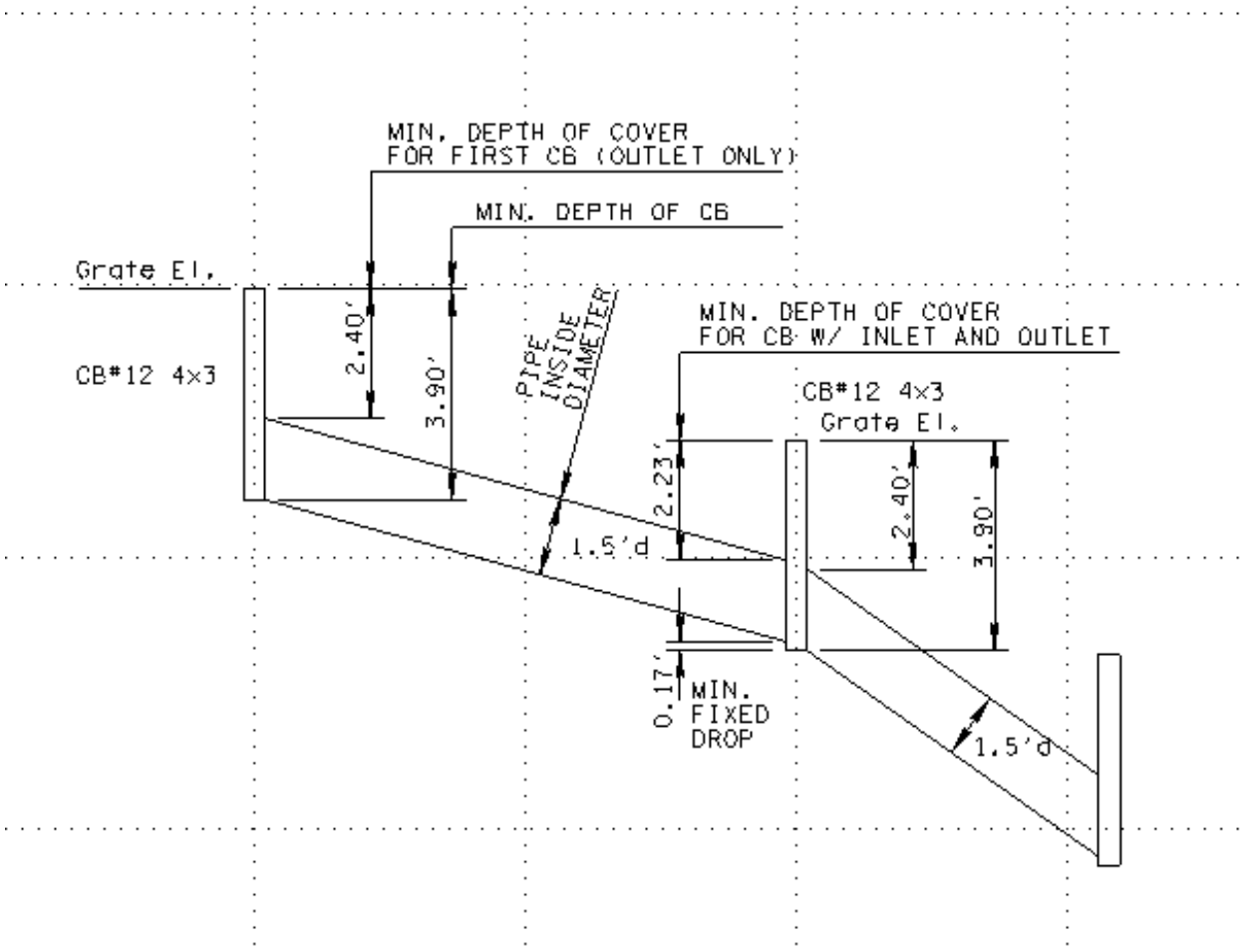
Manning's equation is an empirical relationship in which the roughness coefficient, n, is used to quantitatively express the degree of retardation of flow. The selection of a Manning's channel roughness coefficient is usually based on consideration of many factors, including the depth of flow, the season, the height of any obstructions, and the types of vegetation. Further, the selection of a coefficient for a natural stream channel is more dependent on engineering

TDOT DESIGN DIVISION DRAINAGE MANUAL

June 15, 2016

	Fill Height (feet)				
	≤ 10 ft	> 10 ft and ≤ 16 ft	> 16 ft and ≤ 24 ft	> 24 ft and ≤ 38 ft	> 38 ft
Interstate system and any arterial with full access control *(Freeways)*					
Cross drains, Transverse median drains & Longitudinal storm drains	RCP CL III	RCP CL III	RCP CL IV	RCP CL V	note 1
Arterials					
Cross drains & Transverse median drains	RCP CL III CMP 10 g PVC HDPE/PP	RCP CL III CMP 10 g PVC HDPE/PP	RCP CL IV PVC	RCP CL V	note 1
Longitudinal storm drains	RCP CL III PVC HDPE/PP	RCP CL III PVC HDPE/PP	RCP CL IV PVC	RCP CL V	note 1
Collectors					
Cross drains & Transverse median drains	RCP CL III CMP 12 g PVC *SRTRP* HDPE/PP	RCP CL III CMP 12 g PVC *SRTRP* HDPE/PP	RCP CL IV CMP 12 g PVC	RCP CL V CMP 12 g	note 1
Longitudinal storm drains	RCP CL III PVC HDPE/PP	RCP CL III PVC HDPE/PP	RCP CL IV PVC	RCP CL V	note 1
Local Roads					
Cross drains	RCP CL III CMP 14 g PVC *SRTRP* HDPE/PP	RCP CL III CMP 14 g PVC *SRTRP* HDPE/PP	RCP CL IV CMP 14 g PVC	RCP CL V CMP 14 g	note 1
Longitudinal Storm Drains	RCP CL III PVC *SRTRP* HDPE/PP	RCP CL III PVC SRTRP HDPE/PP	RCP CL IV PVC	RCP CL V	note 1
For All Road Systems					
Side Drains (Pipes under private drives, business or field entrances)	RCP CL III CMP 16 g PVC *SRTRP* HDPE/PP	RCP CL III CMP 14 g PVC *SRTRP* HDPE/PP	RCP CL IV CMP 14 g PVC	RCP CL V CMP 14 g	note 1
Longitudinal Median Drains	RCP CL III CMP 16 g PVC *SRTRP* HDPE/PP	RCP CL III PVC *SRTRP* HDPE/PP	RCP CL IV PVC	RCP CL V	note 1

Table 6A-1
Pipe Selection Criteria Based on System and Fill Height
(*see notes on next page*)


MIN. DEPTH OF COVER
FOR FIRST CB (OUTLET ONLY)
MIN. DEPTH OF CB
Grate El.
CB*12 4x3
2.40'
3.90'
PIPE INSIDE DIAMETER
1.5'd
MIN. DEPTH OF COVER
FOR CB W/ INLET AND OUTLET
CB*12 4x3
Grate El.
2.23'
2.40'
3.90'
0.17'
MIN.
FIXED
DROP
1.5'd

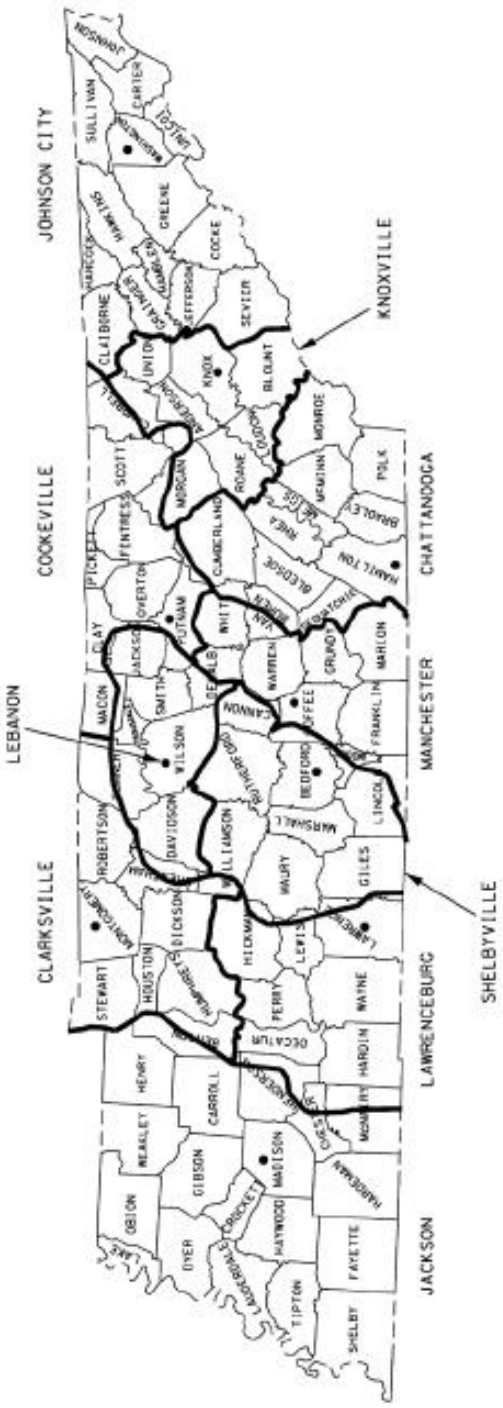


Figure 4A-1
IDF Zone Location Map

	Interstate System and Arterial With Full Access Control	Arterial Without Full Access Control	Collector	Local Road
Inlet Design Frequency	50-yr	10-yr [1]	10-yr [1]	10-yr
Sewer Design Frequency	50-yr	10-yr [1]	10-yr [1]	10-yr
Culvert Design Frequency	50-yr Check for 100-yr	50-yr Check for 100-yr	50-yr Check for 100-yr	50-yr Check for 100-yr
Roadway Freeboard [2]	50-yr	50-yr	50-yr	50-yr
Ditch Design Frequency	50-yr	10-yr [1]	10-yr [1]	10-yr

[1] 50-year in Roadway Sag Sections

[2] The design high water elevation should be at or below the bottom of the roadway subgrade.

Table 4-1
Hydrologic Design Criteria

Exercise 5 Catch Basin Values

CB	Drainage Area	Tc	Discharge	Spread Width
1	1.03	31.361	1.58	5.411
2	1.741	33.65	2.429	6.99
3	0.182	9.15	0.785	3.0179
4	0.581	3.724	1.877	6.029
5	1.275	34.154	1.282	3.073
6	0.257	1.595	1.343	5.5181
7	7.143	36.141	7	5.786
8	0.895	28.956	0.941	1.444
9	0.689	35.051	0.886	4.0723
10	2.733	37.2	2.63	1.725
11	0.191	34.8	0.337	1.759
12	0.199	1.421	1.106	4.836
13	0.156	1.238	0.877	7.273
14	0.286	2.372	1.767	4.81

January 1, 2010

Surface Type and Condition[1,2]	Runoff Coefficient (C)
Rural Areas	
Concrete or sheet asphalt pavement	0.8 - 0.9
Asphalt macadam pavement	0.6 - 0.8
Gravel roadways or shoulders	0.4 - 0.6
Bare earth	0.2 - 0.9
Steep grassed areas (2H:1V)	0.5 - 0.7
Turf meadows	0.1 - 0.4
Forested areas	0.1 - 0.3
Cultivated fields	0.2 - 0.4
Urban Areas	
Flat residential, with about 30 percent of area impervious	0.40
Flat residential, with about 60 percent of area impervious	0.55
Moderately steep residential, with about 50 percent of area impervious	0.65
Moderately steep developed area, with about 70 percent of area impervious	0.80
Flat commercial/industrial, with about 90 percent of area impervious	0.80

[1]For flat slopes and/or permeable soil, use the lower values. For steep slopes and/or impermeable soil, use the higher values.
[2]For areas where there is a shallow bedrock surface, use the higher values.

Table 4-2
Runoff Coefficients (C) for Use in the Rational Method
Reference: USDOT, FHWA, HDS-4 (2001)

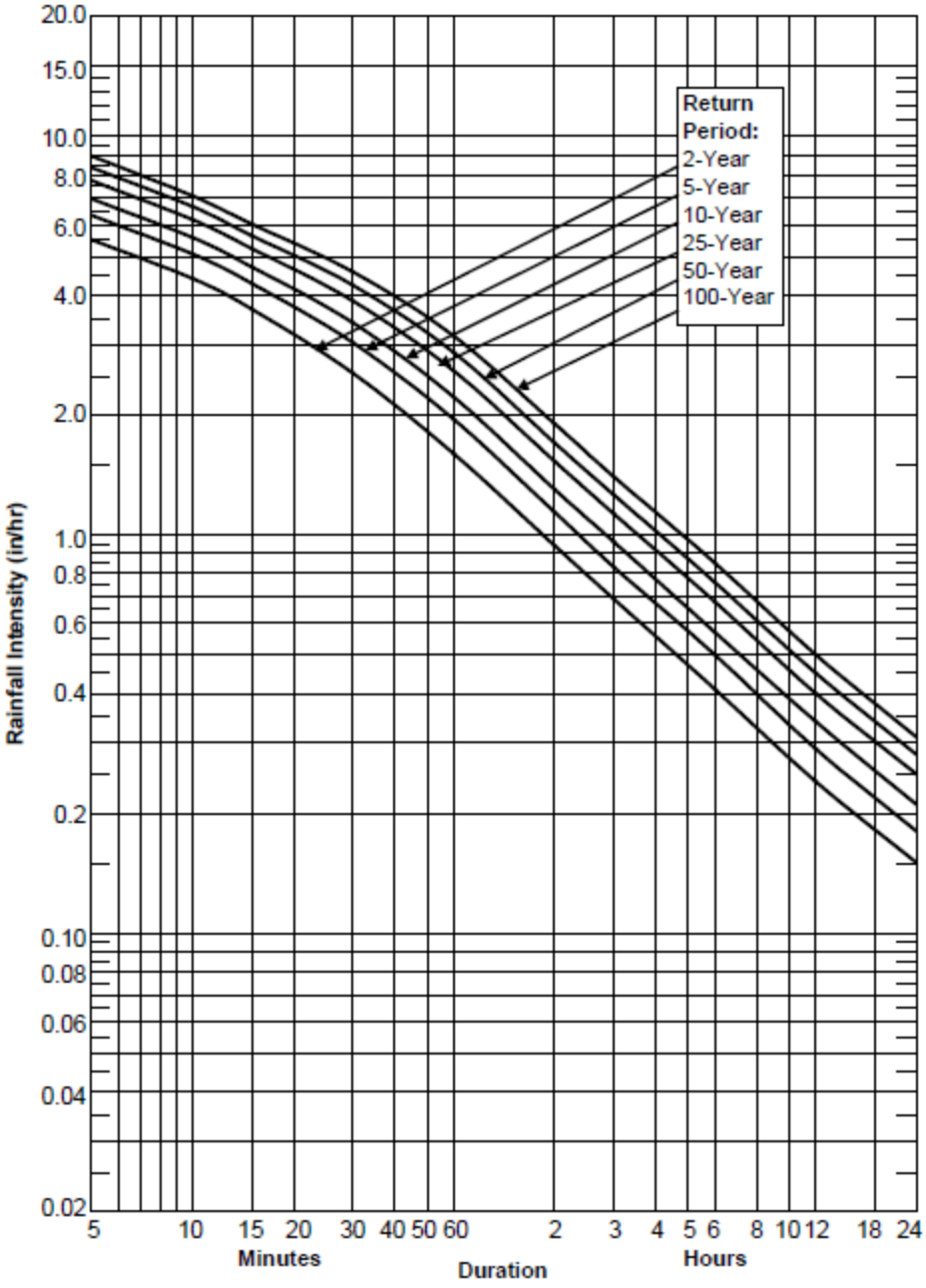


Figure 4A-9
Lebanon IDF Curve
NOTE: T_c = 5 minutes is a minimum value to use in all cases
Reference: National Weather Service, NOAA Atlas 14, Volume 2 (2004)