Roadway Design Manual

TDOT Department of Transportation **Roadway Design Division**

Website www.tn.gov/tdot/roadway-design/training.html

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Introduction

This purpose of this document is to serve as a general guide for the design of a roadway project. This manual will attempt to provide the basic background of how to start and design a project and where to find design information. Not every situation that you encounter in your work will be covered in this manual. Many steps will be referenced from the GEOPAK V8i ROAD manual.

The example project used in this guide is State Route 99 (New Salem Road) in Rutherford County, from Southwest Loop Road to Cason Lane. The actual project covers a distance along the alignment of approximately 2.5 miles, but in this manual we will only design a section of a mile or so in length. The original design calls for a 5-lane curb and gutter (urban) section. In addition, we will also design a rural section for the same portion of roadway.

Getting Started

At the start of every project, Survey will provide you with some files. For this project those files are:

1) job3M4.gpk GEOPAK file
2) RF099-03Survey.dgn design file containing existing topo
3) RF099-03Survey.tin existing surface elevations
4) 106982.00_acq.xlsm property owner and tracts table

Before beginning work in Microstation and GEOPAK, read the Transportation Planning Report (TPR). **Also, find a set of plans to use as a reference.** Begin a project activity status sheet for the job by going to C:/Users/Public/Office Standards/TDOT Letters and saving the word file "Project Activity Status Sheet.dotx" to the active job directory. Also, there are roadway design checklists for each stage of a project. From the same directory, copy the file "Roadway Design Checklist.dotx" to your active job directory. Use the list and plans as a guide.

Other documents you need to become familiar with:

Roadway Design Guidelines
CADDv8.pdf (CADD Manual)
TDOT Roadway Design Division Programs.pdf

Making Files

Use the Survey & Design Computer-Aided Drafting and Design Standards from the CADDV8.pdf file. Refer to "Standard Filename Section" pages 2-4 to make all necessary files names with the proper extension and seed files. **Make sure that the SeedXS.DGN file is used when making both the cross section file and cross section sheet file.** For this project, the county is Rutherford and the alphanumeric name is RF099. The survey file RF099-03Survey.dgn has been supplied for you. For this project, the following files with a *.DGN extension should be made on the C drive in a new folder named Projects\Rutherford\SR099:

1) RFSR099Alignments.dgn
2) RFSR099Proposed.dgn

3) RFSR099PropertyMap.dgn
4) RFSR099SEShapes.dgn
5) RFSR099RoadwayPattern.dgn
6) RFSR099CulvertPattern.dgn
7) RFSR099MainlineXSections.dgn
8) RFSR099CulvertXSections.dgn

For this project, the following files with a *.SHT extension should be needed:

1) SR099XSections.sht
2) SR099CulvertXSections.sht
3) 001.sht (Title Sheet)
4) 002.sht (Typical Section sheet)
5) 003.sht (Property Map)
6) 004.sht (Present Layout Sheet)
7) *****004A.sht (Proposed Layout Sheet)
8) 004B.sht (Profile Sheet)

Open up the file RF099-03Survey.dgn by selecting the Microstation icon on your desktop. Select tdot interface. Highlight the file and double click (or select "Open"). You should always use this method when opening a Microstation file for the first time. This allows the "T.D.O.T." option on the top menu bar. Then, to create a new file, select File –> New and type in the file name. Make sure the correct seed file is selected (seed2d.dgn for most files, seedXS.dgn for cross section files). Use this method to create above-named files. You can also create a new file by selecting "File -> Save As" and typing in new file name.

At this time, only create sheets through 002.sht. Since there will be several layout sheets in this project, use the Plan and Profile Sheets Icon found in Project Manager in GEOPAK to lay out and clip sheets. We will do this later when the length of the project is known, after we have set the vertical grade. If the project has so much present and proposed R.O.W. text that readability is affected, an additional sheet may be added for R.O.W. In this case, the R.O.W. sheet would become sheet 4A and the proposed and profile sheet 4B and 4C, respectively.

*****Do not create this sheet file. The sheet files 004A.sht and 004B.sht will be copied from sheet 004.sht. The sheet filters can be used to change the active levels for each sheet.

Checking the Survey

Use the computer guidelines to check the levels in the survey file. This will be very important in using File Filters in your sheet files. Refer to the Survey & Design Computer-Aided Drafting and Design Standards pages 88 - 96 when checking the levels of each Microstation element.

Referencing Files

Even though RFSR099Alignments.dgn and RFSR099Proposed.dgn do not contain any Microstation elements at this time, reference each file into the file RF099-03Survey.dgn file. Make sure that each file is referenced using the method Coincident World. Open the file RFSR099Alignments.dgn and reference the files RF099-03Survey.dgn and RFSR099Proposed.dgn using the method Coincident World. Use the Fit View -> Reference after referencing in the files and save settings. By doing this, each time the files are opened the project site is in view. Open the file RFSR099Proposed.dgn and reference the files RFSR099Alignments.dgn and RF099-03Survey.dgn using the method Coincident World.

GEOPAK

At this point it will be assumed that the designer is familiar enough with GEOPAK that the processes of starting a project and performing vertical and horizontal alignment, cross-section, and other operations need not be described in detail in this manual.

READ THE PROJECT TPR. The report may have specifics pertaining to the proposed vertical grade of the structure. The grade may need to remain as is across the structure or may need to be raised 2 feet. The report will also state the Roadway Design Standard that should be used for the proposed cross section. The Roadway Design Standard has vital information such as maximum grades, “K” values, roadway width and shoulder width.

Determine Length of Project

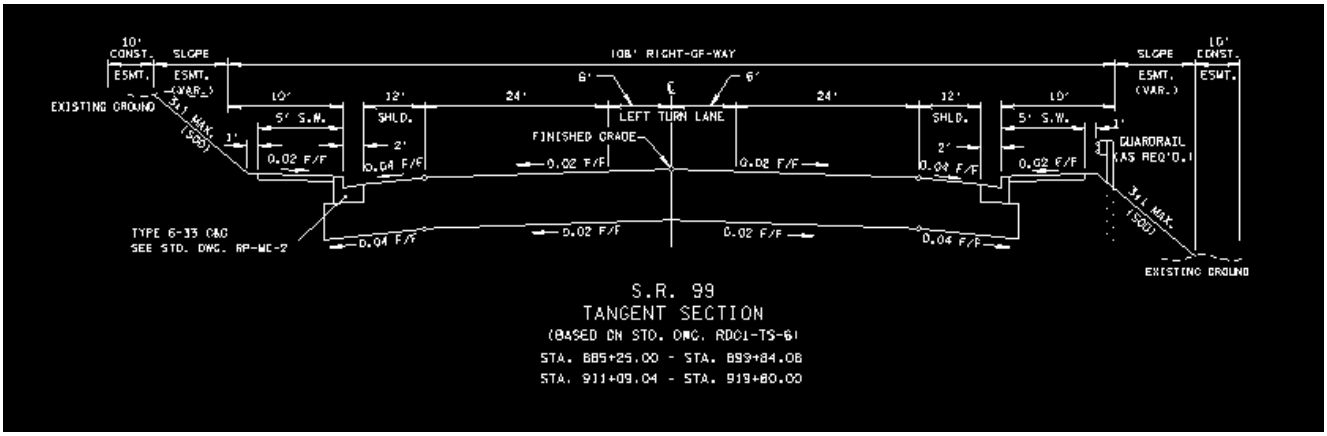
The TPR calls for the project to go from SW Loop Rd at Log Mile 14.39 to Cason Lane at Log Mile 16.12. However, for instructional purposes we will design a shorter section of a mile or less in length. We will avoid the section where the road is adjacent to Puckett Creek since the alignment would likely have to be shifted away from the creek. We will begin our design section at approximate station 885+00 to include the box bridge at Armstrong Branch, continue through the curve and end in the tangent section at approximate station 915+00.

The proposed design section is 5 @ 12 foot lane with curb and gutter and 12 foot shoulders. (TPR says 14 feet but it considers the curb part of the shoulder). We will be widening from the existing so a transition length will need to be calculated. This will determine the total length of the project. The proposed width of the roadway is 5 x 12 = 60 feet.
The existing road width at the beginning (sta. 885+00) is 23.48 measured from the survey dgn file. We will consider it to be 24 feet. The equation for length of transition is found in the Design Guidelines on p.2-37. The design speed for the project is 50 mph from the TPR, so the length of the transition is L=WxS. Width (W) is (60-24)/2=18, so L=18 x 50 =900. We will begin the project at sta. 876+00 (88500-900). At the other end, sta. 915+00, the existing roadway width is 35.36 feet, but we will say 36 feet. This is three lanes but a short distance further narrows down to two lanes, so we will consider this when figuring the transition. As at the beginning the transition length at the end will be 900 feet which would extend the project to sta. 924+00. However, the road widens back out to three lanes a little further down so we will extend the end to that point which appears to be at sta. 926+37.75.

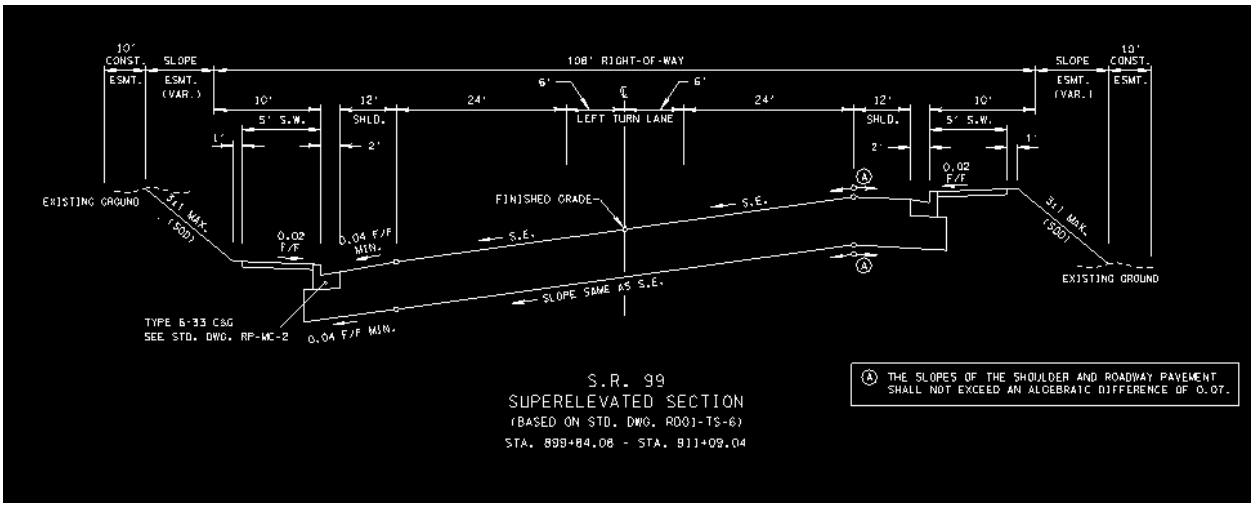
Still in RFSR099Alignments.dgn, window area to the SR99 profile. We now need to set a vertical alignment. If the existing profile is not showing, Go to File -> Reference, select RF099-03Survey.dgn reference file, make sure display is checked on, go to Settings -> Level Display, select Filters then Sheets –> Profiles to turn the necessary levels on. On a scratch level, place a vertical line at 876+00 and 926+37.75 to mark the beginning and end of the proposed vertical alignment.

TYPICAL SECTIONS

Typical Section for Mainline, Tangent Section, Curb And Gutter:

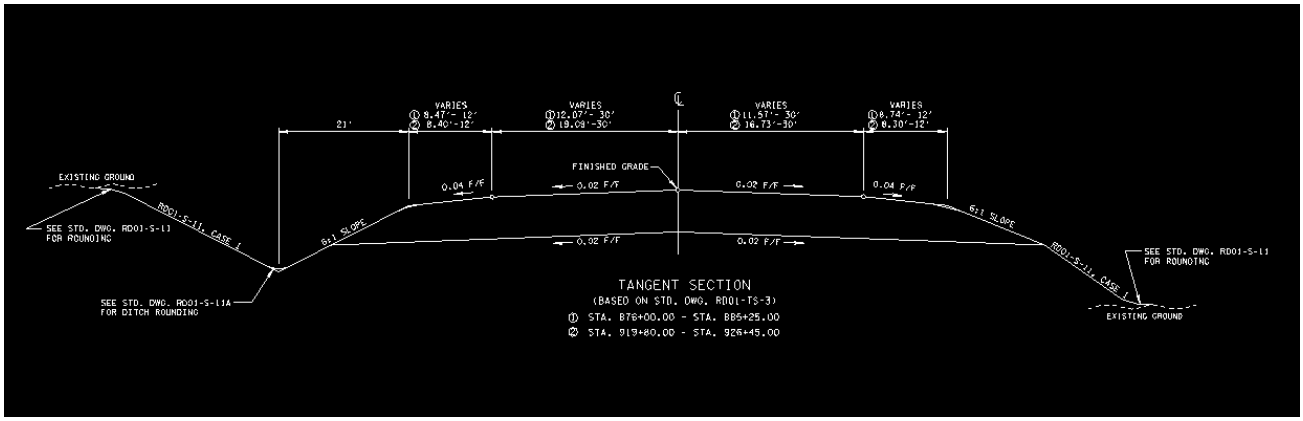


Typical Section for Mainline, Superelevated Section, Curb and Gutter:



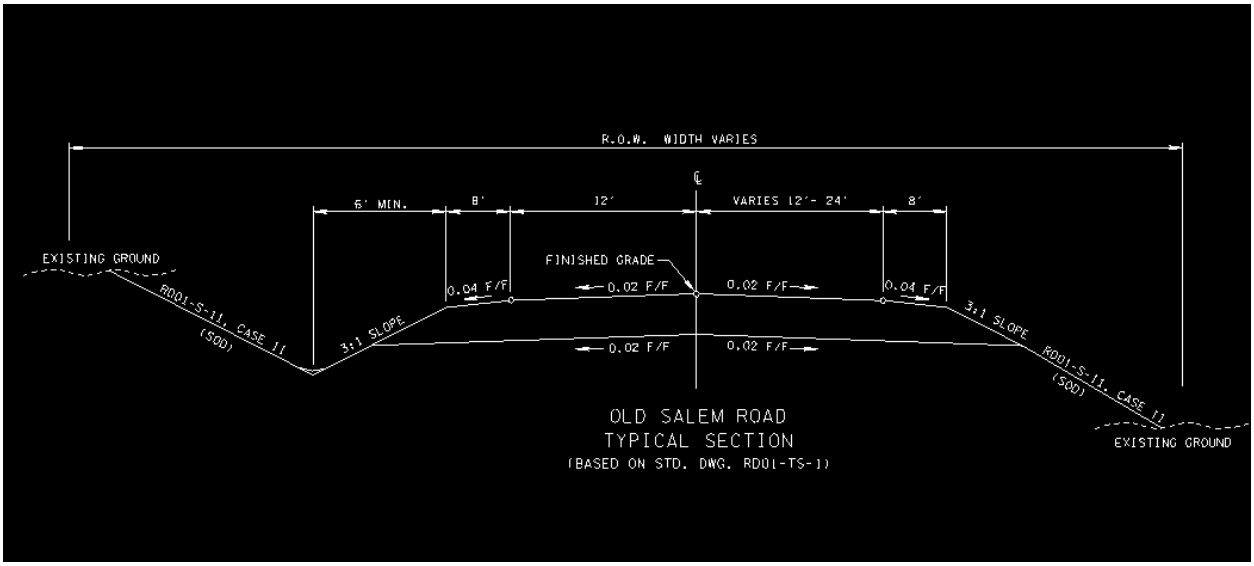
Lane and Shoulder widths are based on information given in Transportation Planning Report (TPR) – Appendix A

Typical Section for Mainline, Tangent Section, Transition:



Per the Transportation Planning Report (TPR) , SR 99 is classified as Arterial, therefore RD01-TS-3 is the standard used for the transition sections without curb and gutter.

Typical Section for Old Salem Road:



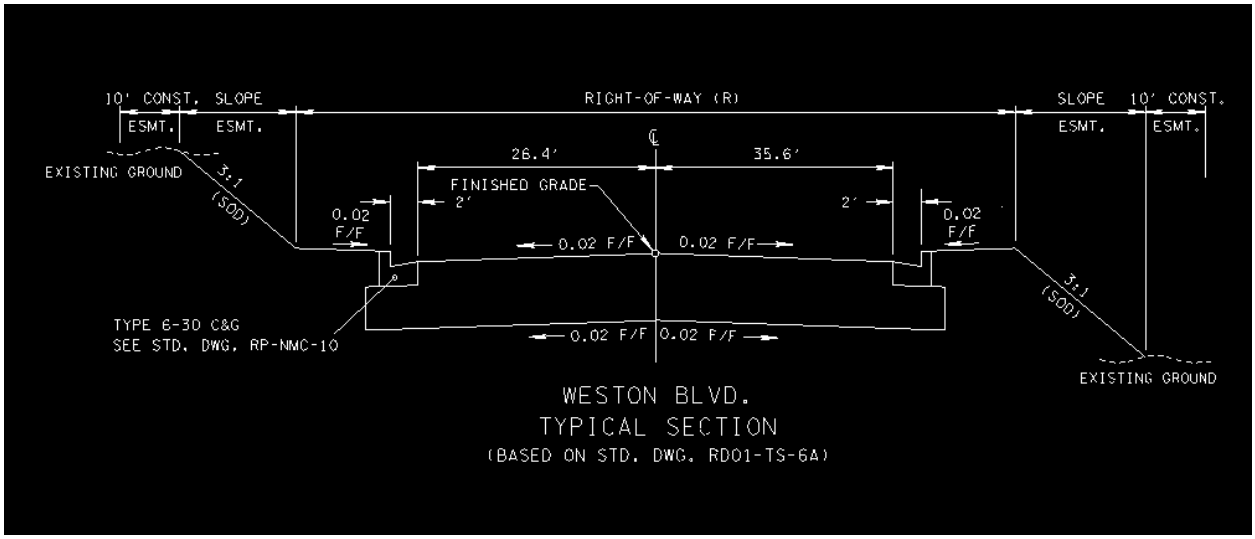
Lane widths and shoulder widths for Old Salem from RD01-TS-1, Table IV

Design Speed, ADT over 2,000:

TABLE IV. LOCAL ROADS AND STREETS - DESIGN STANDARDS ⑧

DESIGN STANDARDS (FOR GIVEN DESIGN SPEED)		DESIGN SPEEDS (MPH)										MINIMUM WIDTH OF SHOULDERS FOR ALL SPEEDS (FEET) (SEE PAGE 388)
		15	20	25	30	35	40	45	50	55	60	
MINIMUM WIDTH OF TRAVELED WAY IN RURAL AREAS (FEET) (SEE PAGE 388)	DESIGN ADT UNDER 400	18	18	18	18	18	18	20	20	22	22	4 ⑦
	DESIGN ADT 400 - 1,500	20⑦	20⑦	20⑦	20⑦	20⑦	20⑦	22	22	22	22	5 ⑦⑨
	DESIGN ADT 1,500 - 2,000	20	22	22	22	22	22	22	22	24⑩	24⑩	6
	DESIGN ADT OVER 2,000	22	24⑩	24⑩	24⑩	24⑩	24⑩	24⑩	24⑩	24⑩	24⑩	8
MINIMUM RADIUS (FEET) 0.04 MAX. S.E.		70	125	205	300	420	565	730	930	1190	1505	SEE PAGE 145
MINIMUM RADIUS (FEET) 0.06 MAX. S.E.		65	115	185	275	380	510	660	835	1065	1340	
MINIMUM RADIUS (FEET) 0.08 MAX. S.E.		60	105	170	250	350	465	600	760	965	1205	
MAXIMUM RURAL GRADES %	LEVEL TERRAIN	9	8	7	7	7	7	7	6	6	5	SEE PAGE 386
	ROLLING TERRAIN	12	11	11	10	10	10	9	8	7	6	
	MOUNTAINOUS TERRAIN	17	16	15	14	14	13	12	10	10	X	
MINIMUM STOPPING SIGHT DISTANCE (FEET)		80	115	155	200	250	305	360	425	495	570	SEE PAGE 385
MINIMUM "K" VALUE	CREST VERTICAL CURVE	3	7	12	19	29	44	61	84	114	151	
	SAG VERTICAL CURVE	10	17	26	37	49	64	79	96	115	136	
MINIMUM PASSING SIGHT DISTANCE (FEET)		X	710	900	1090	1280	1470	1625	1835	1985	2135	SEE PAGE 386
MINIMUM "K" VALUE FOR CREST VERTICAL CURVE		X	180	289	424	585	772	943	1203	1407	1628	
SUPERELEVATION		SEE STANDARD DRAWINGS RD01-SE-2 AND RD01-SE-3										

Typical Section for Weston Blvd.:



Lane widths are based on existing conditions for Weston Blvd.

VERTICAL ALIGNMENT

According to the TPR, the classification for this road is Urban Minor Arterial. Refer to Standard Drawing RD01-TS-3C for maximum grades and k-values. Information on Vertical curves is found in “Green Book” p. 265-280. The Design Speed is 50 mph. This is the current signed speed on the roadway. Also refer to Exercise 7 in the GEOPAK Road Manual.

Designing a Vertical Alignment seems to be the most challenging thing to learn for most new designers. The following are some tips that might help:

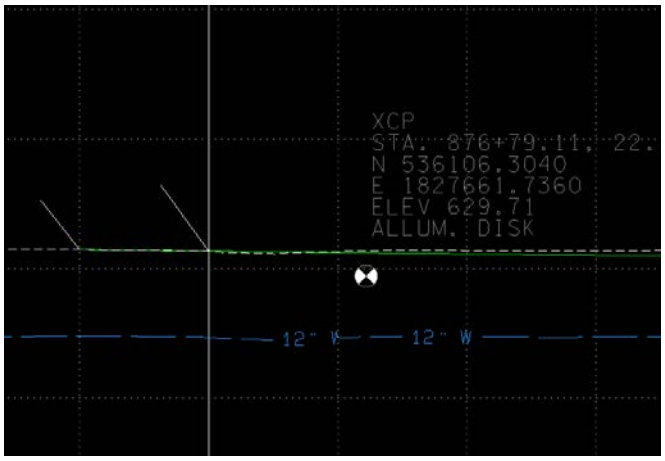
Determine the necessary length of the project. Where will the proposed horizontal alignment tie in after the pavement transitions are drawn? There may be 1 mile of horizontal alignment sent with the survey but work may be required only on 0.4 miles of the project. A vertical alignment is only necessary for the project length that has been determined.

Designing Preliminary Vertical Alignment

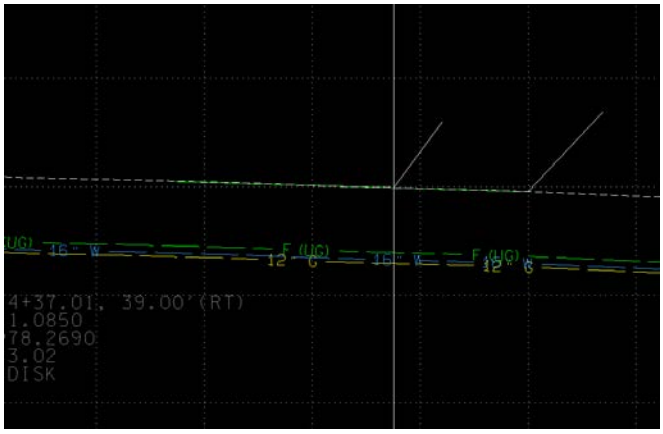
From Standard Drawing RD01-TS-3C, the maximum grade for our design is 7%. This is for urban design with rolling terrain. The minimum grade to assure proper drainage is 0.5%.

In file RFSR099Alignments.dgn, make sure Survey reference file is displayed. Go to File -> References. Select survey reference file, then Settings -> Level Display. Set “Levels” to “Filters”, select Sheets -> Profiles to display correct levels. Window area to the profile.

At the beginning (sta. 876+00), with intersection snap on, draw a line where the vertical line intersects the ground line (Line 1). Go back about 50 feet, draw another line to intersect the ground line. Connect these two lines and use the Extend Line command to extend about 50 to 100 feet past the beginning station. This determines the tie-in grade at the beginning of the project. Then go to the ending (sta. 926+37.75) and determine the ending tie-in grade using the same procedure (Line 2).



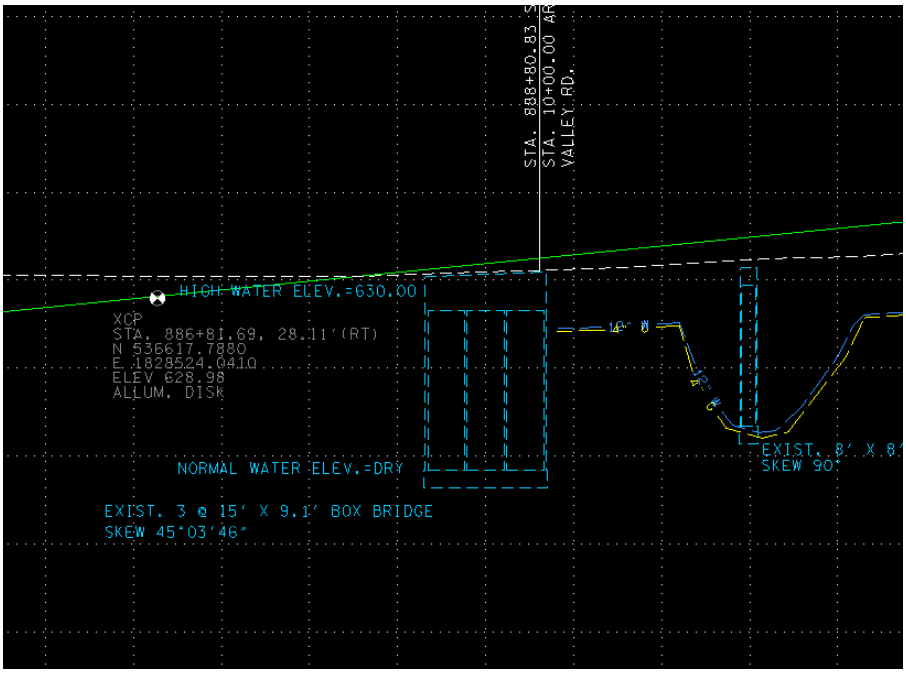
Line 1



Line2

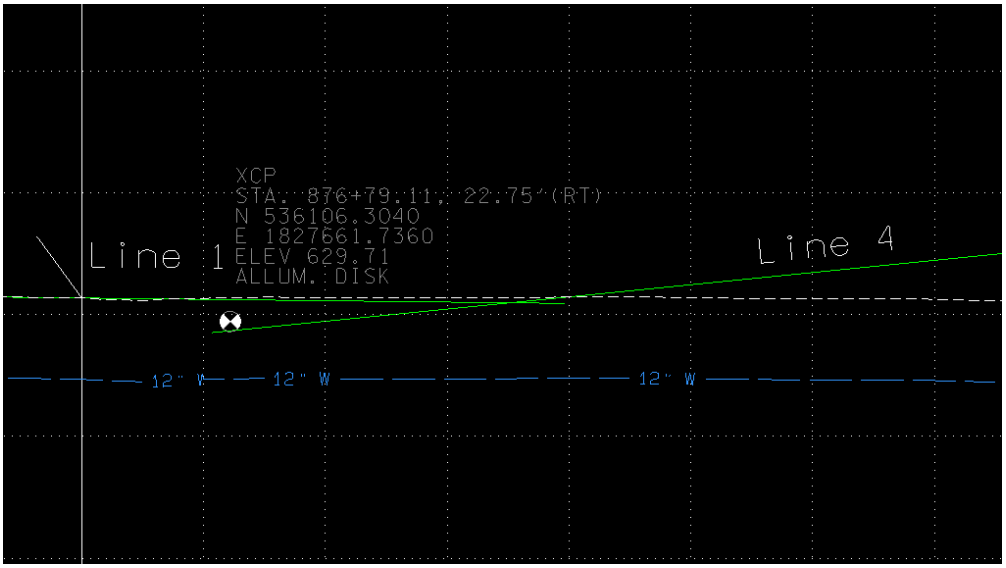
Take note of the Side Road crossing locations (sta. 888+80.83, sta. +/- 899+00, sta. 912+46.59). The proposed grade needs to be close to the existing for traffic maintenance purposes. However, for drainage purposes in a curb and gutter design, the profile needs to “roll”. That is, the profile needs to have a series of alternating up and down grades. Also keep in mind that since this is a widening project the proposed grades should not deviate greatly from existing.

At the box bridge at sta. 888+50, draw Line 3 at a 1% grade. Using the MicroStation Place Line command, place data point and keyin dx=1000, 100. Grab the line near the middle and move so that the line intersects the ground line near the top of box on left side.



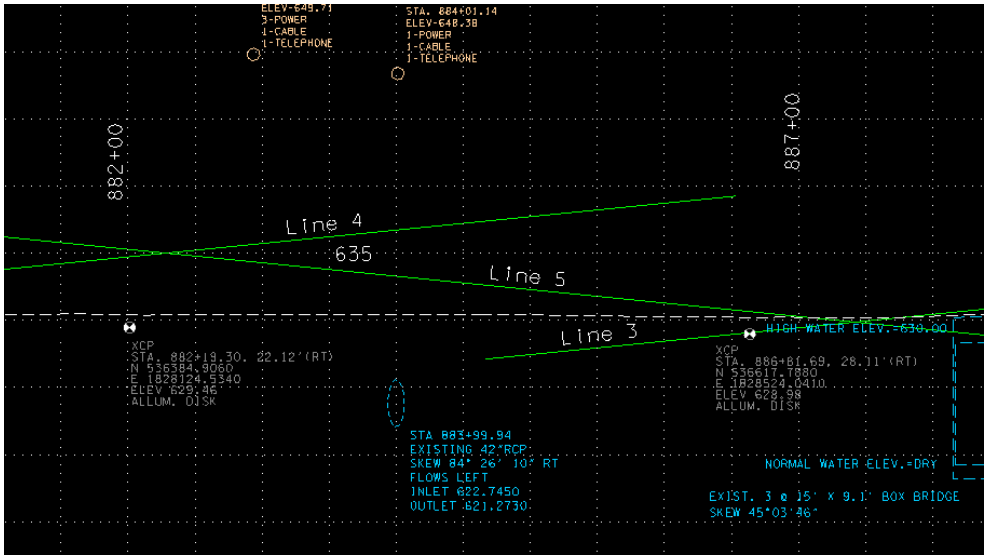
Line 3

Near the beginning, draw a 1% grade line (Line 4) by placing a data point and keying in dx=1000, 100. Grab the line near the left end and move the line so that it intersects the ground line about 200 feet from the beginning end. Extend Line 1 so that it intersects with Line 4.



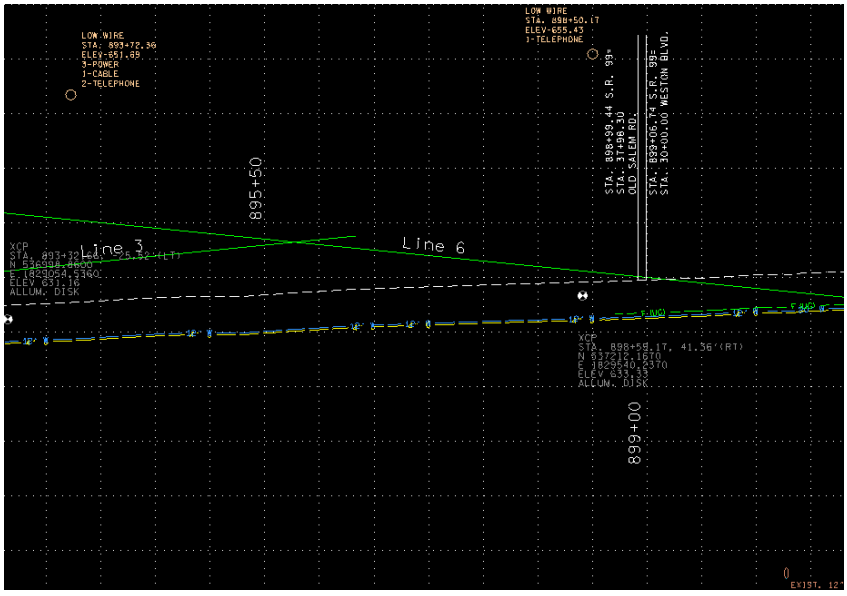
Line 4

Now place another 1% grade line (Line 5). This time key in dx=1000,-100. Move the line so that it intersects Line 4 near the 635 elevation. This should be near sta. 882+00. This line should also intersect Line 3 near sta. 887+00.



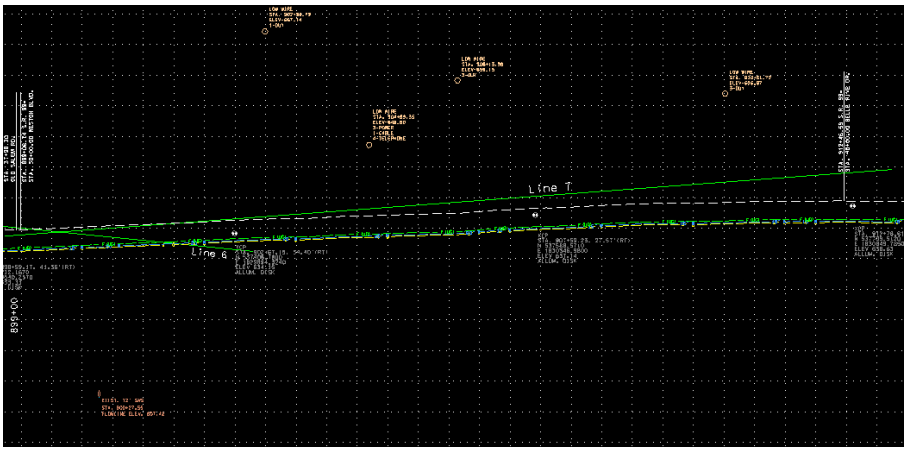
Line 5

Next, draw Line 6 by placing a data point and keying in dx=1000,-100. Grab the line near the middle and move it so that it intersects the ground line near the side road intersection at sta. 899+00. It should also intersect Line 3 near sta.895+50. You may have to extend it some.



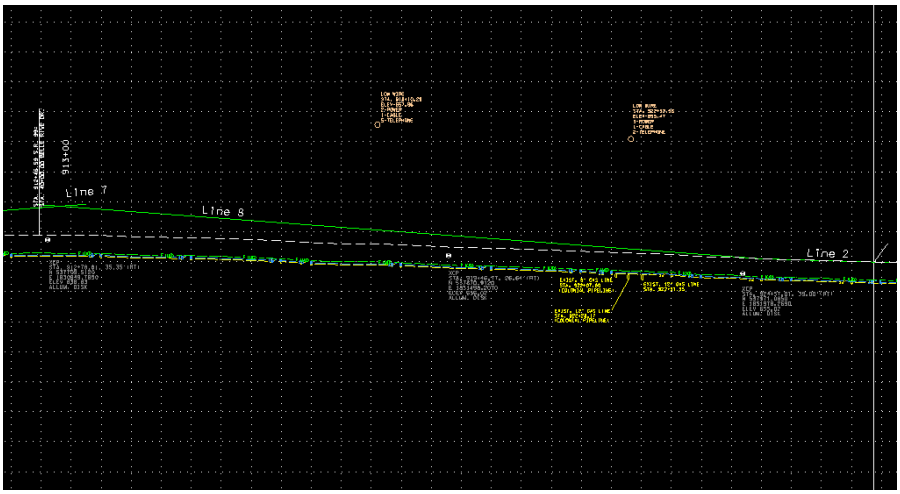
Line 6

Now, draw Line 7 as before (dx=1000, 100). Move the line so that near the left end it intersects Line 6 near the 899+50 grid line. You can see that it will raise the grade considerably at the next side road intersection (912+46). Change the grade to 0.75% by selecting the Modify Element command. Snap to the right end, then snap the left end and key in dx=1000, 75. Then extend the line past the side road intersection.



Line 7

Now, go the ending of the project and extend Line 2 so that it intersects the grid at station 924+50. From that point, draw Line 8, 0.75 % line (dx=-1000,75). Now extend Line 8 to intersect the Line 7 at approx. sta.913+00.



Line 8

Now you can go to GEOPAK and enter the vertical alignment. Locate VPI 1 at the intersection of Line 1 and the existing ground line at station 876+00. Tentatively locate the next 7 VPIs where the lines intersect. Then locate the last VPI (VPI 8) at the intersection of Line 2 and the existing ground line at station 926+37.50.

Relocate VPIs to even stations close to their original locations. You might end up with something like this:

VPI	Station	elev.
1	876+00	630.68
2	878+00	630.46
3	882+25	635.06
4	887+50	629.80
5	895+75	638.28
6	899+75	634.34
7	913+00	644.30
8	924+50	635.49
9	926+37.75	634.95

Next, add vertical curves at each VPI. At VPI 2, select speed of 50. This gives a curve length of 114.31 and a k-value of 96. We like to use even lengths, so round up to 200. This gives a speed of 65. Use a similar procedure for VPIs 3-8. It is permissible to use a longer curve length than the design speed warrants. This will make for a smoother design, as long as there is no overlap with adjacent curves. A good selection of curve lengths is as follows:

VPI	L
2	200
3	500
4	500
5	400
6	400
7	2000
8	200

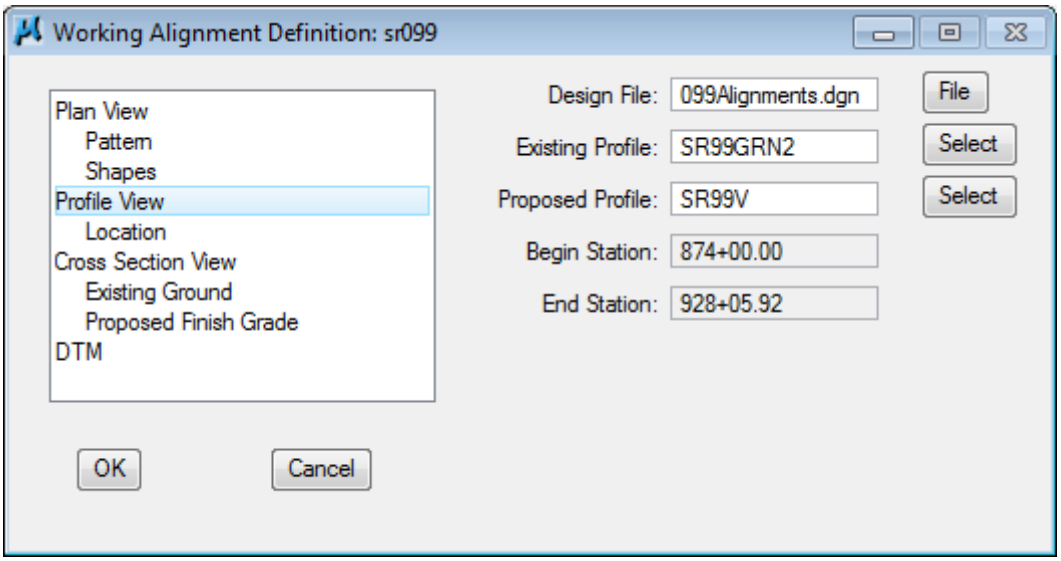
Note that the k-values will exceed those shown in the Standard Drawing for the design speed.

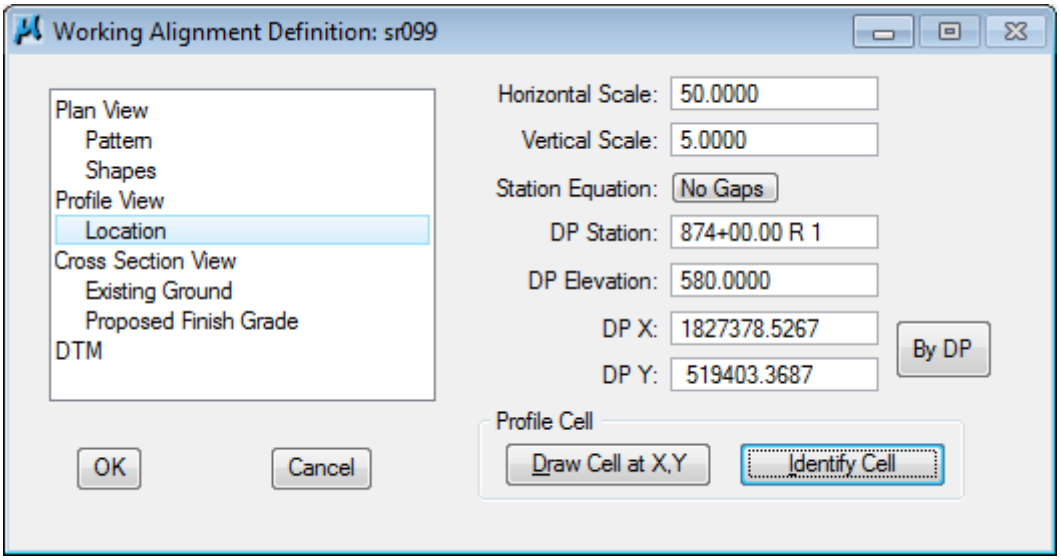
At VPI 7, the finished grade elevation is still about a foot higher than existing ground at the Belle Rive side road. Using station lock, lower VPI elevation to about 643.09; the finished grade is now about 2 or 3 inches above existing. Now make some further adjustments so that the finished grade is closer to the other side road intersections:

VPI 4 – change elevation to 629.04
VPI 6 – change station to 898+75, elevation to 634.50, curve length to 200.

Now use D&C Manager to display the proposed vertical alignment.

Set Profile definition in Working Alignment:



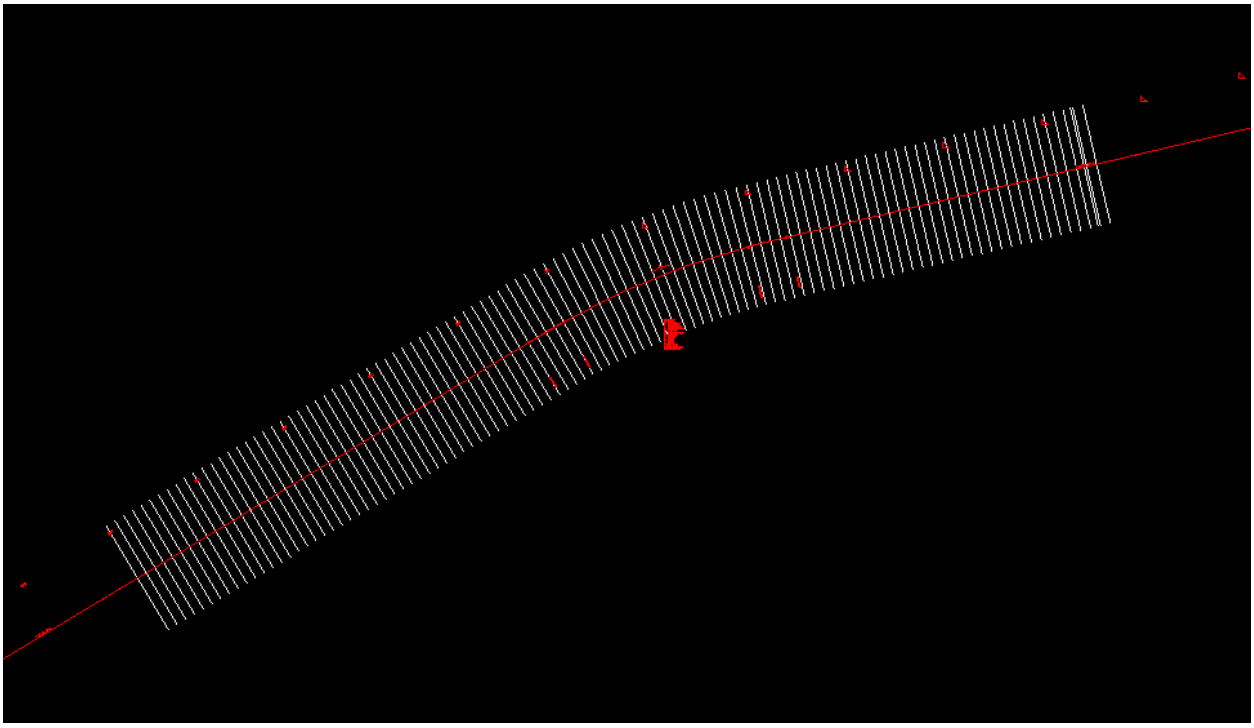


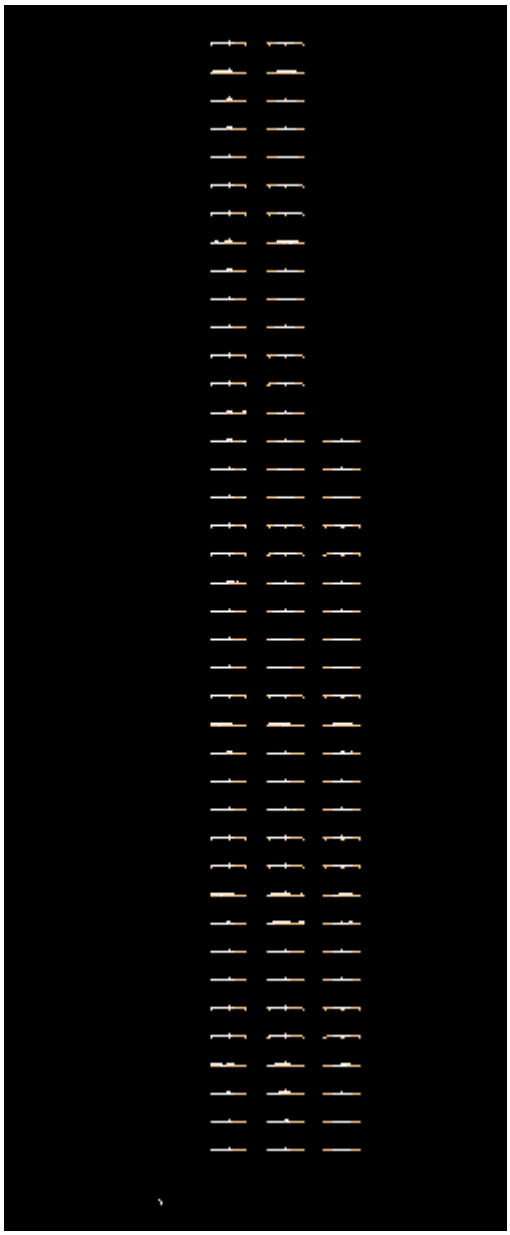
CROSS SECTIONS

The next step is to cut some preliminary cross sections along the project to see if there are any encroachments that could determine whether the alignment needs to be shifted.

Existing Sections

Refer to the GEOPAK v8i Road Manual, Exercise 8 to draw pattern lines in RFSR099RoadwayPattern.dgn, and then draw existing ground cross sections in RFSR099MainlineXSections.dgn. Place patterns at a 50 foot interval and at the beginning and end stations (876+00 and 926+37.75). Remember to include at least one station before the beginning and after the end station. To insure plenty of room to work, go from 874+00 to 928+00.

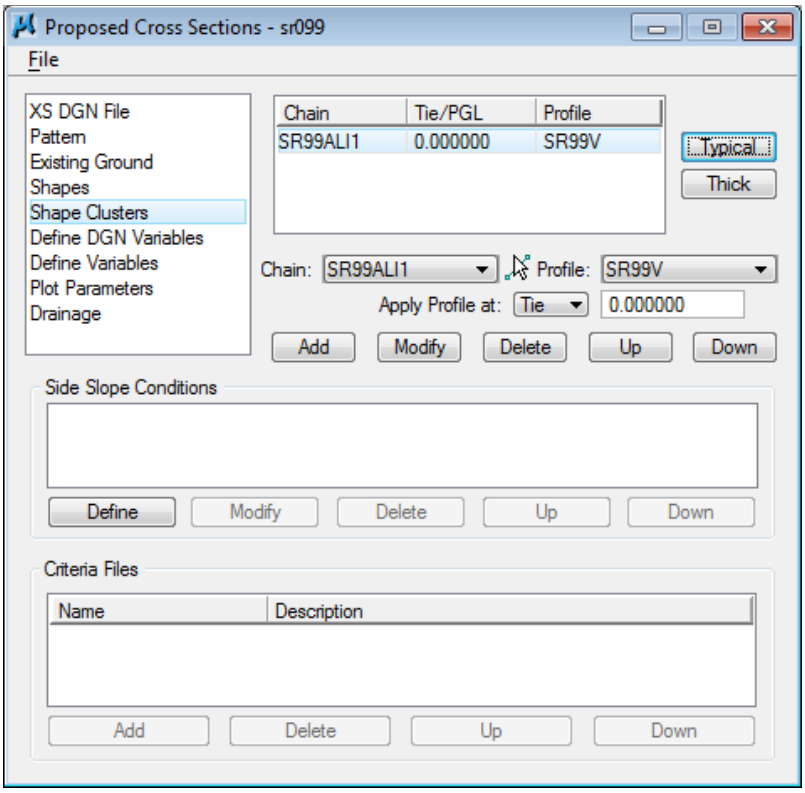


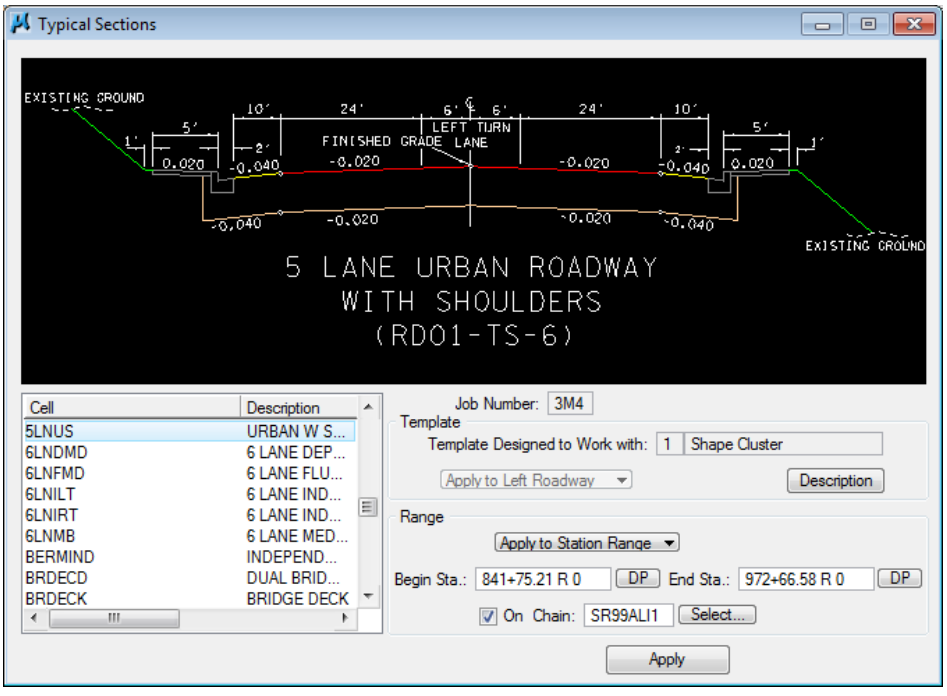


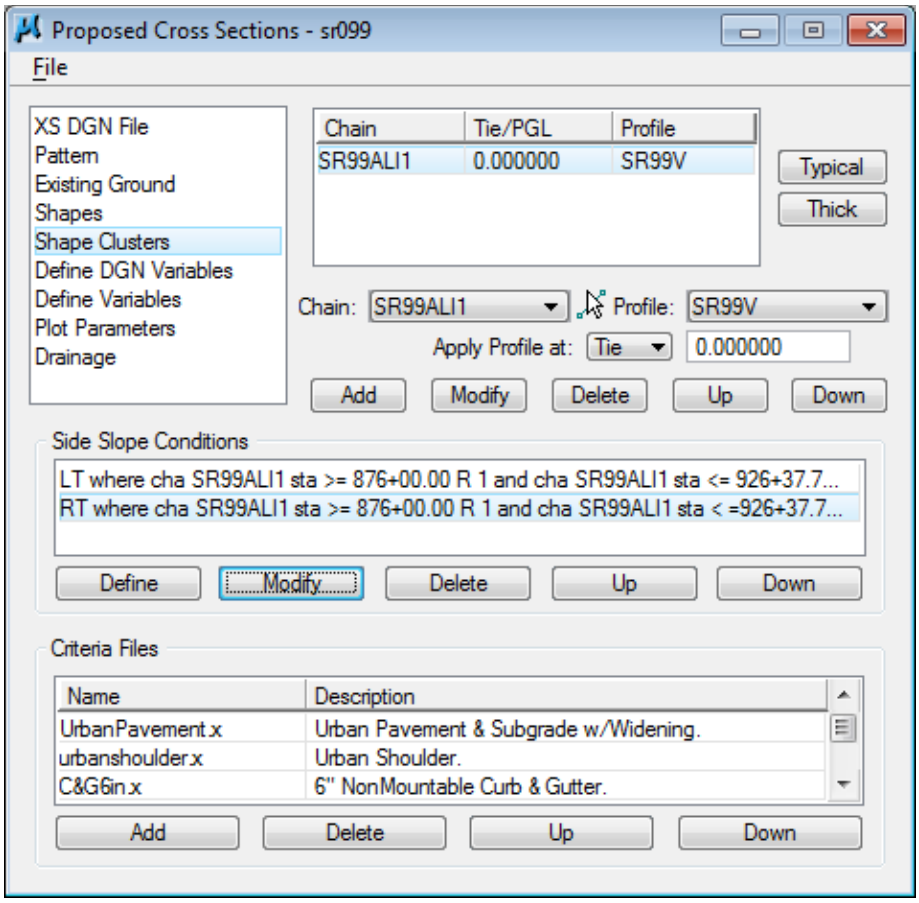
Proposed Sections

In the file RFSR099MainlineXSections.dgn now draw proposed cross sections. Use Exercise 9 of the GEOPAK Road Manual as a guide:

XS DGN File	RFSR099MainlineXSections.dgn
Pattern	Working Alignment definition
Existing Ground	Working Alignment definition
Shapes	Shapeless
Shape Clusters	See below


Proposed Cross Sections - sr099
File
XS DGN File
Pattern
Existing Ground
Shapes
Shape Clusters
Define DGN Variables
Define Variables
Plot Parameters
Drainage
Chain
Tie/PGL
Profile
SR99ALI1
0.000000
SR99V
Typical...
Thick
Chain: SR99ALI1
Profile: SR99V
Apply Profile at: Tie 0.000000
Add
Modify
Delete
Up
Down
Side Slope Conditions
Define
Modify
Delete
Up
Down
Criteria Files
Name
Description
Add
Delete
Up
Down


Typical Sections
EXISTING GROUND
10'
24'
6'
6'
24'
10'
5'
1'
2'
0.020
-0.040
FINISHED GRADE
-0.020
LEFT TURN LANE
EXISTING GROUND
5 LANE URBAN ROADWAY
WITH SHOULDERS
(RD01-TS-6)
Cell
Description
5LNUS
URBAN W S...
6LNDMD
6 LANE DEP...
6LNFMD
6 LANE FLU...
6LNILT
6 LANE IND...
6LNIRT
6 LANE IND...
6LNMB
6 LANE MED...
BERMIND
INDEPEND...
BRDECD
DUAL BRID...
BRDECK
BRIDGE DECK
Job Number: 3M4
Template
Template Designed to Work with: 1 Shape Cluster
Apply to Left Roadway
Description
Range
Apply to Station Range
Begin Sta.: 841+75.21 R 0
DP
End Sta.: 972+66.58 R 0
DP
On Chain: SR99ALI1
Select...
Apply



Define Variables:

Centerline	SR99ALI1
Plan DGN	RFSR099Proposed.dgn
XS DGN	RFSR099MainlineXSections.dgn
urban shoulder width	12
LT Sidewalk width	3.5
RT Sidewalk width	3.5
Fixed Cut Slope LT	3:1
Fixed Fill Slope LT	3:1
Fixed Cut Slope RT	3:1
Fixed Fill Slope RT	3:1
Plot Parameters	Refer p. 9-14 in GEOPAK Road Manual

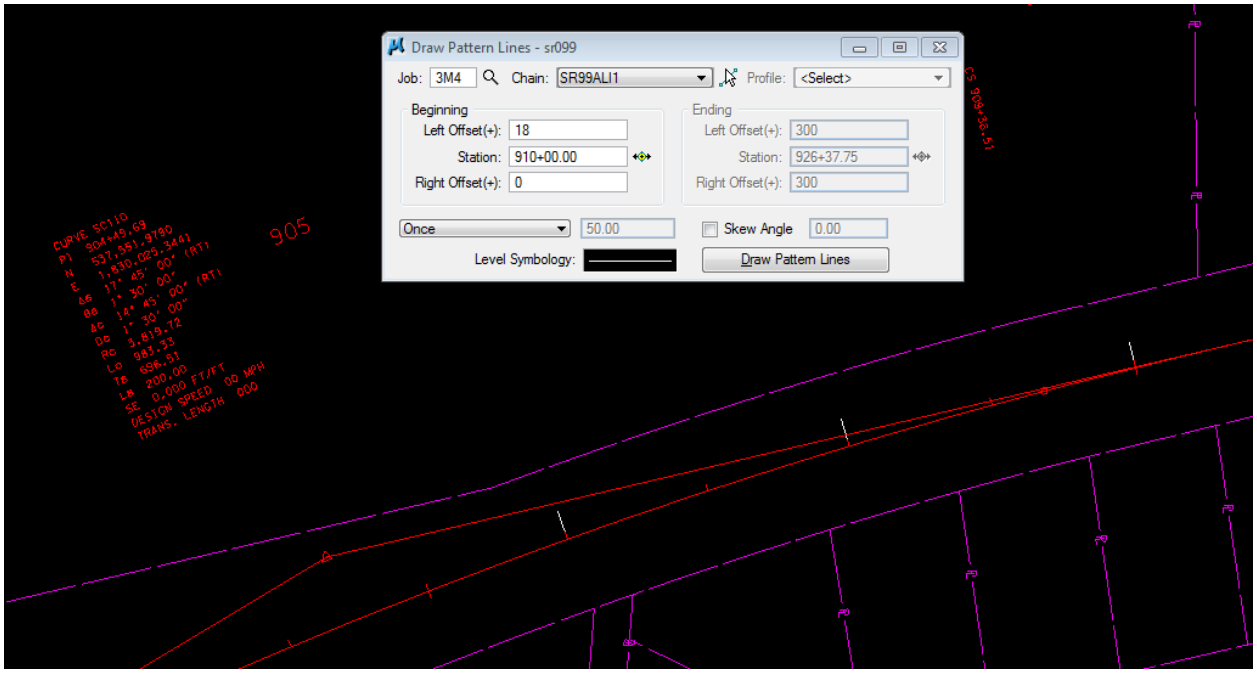
Before running proposed cross-sections, go back into file RFSR099RoadwayPattern.dgn and change symbology on pattern lines before beginning station and after end station of vertical alignment. Change those lines to co =3.

MODIFY HORIZONTAL ALIGNMENT

When the preliminary cross sections are run we can see that the slope lines encroach on the subdivision to the right from approximately sta. 904+00 to sta. 912+00. We need to adjust the alignment so that the slope lines stay inside the existing Right of Way, about 10 feet. The survey file shows that the existing ROW is offset a constant 50 feet from the centerline. Go back into the MainlineXSection file and check the section at 906+00. The offset of the right slope line is 60.30, or 10.30 feet outside of ROW. Therefore, we need to shift the alignment a little over 20 feet to the left at that station. Now, check a couple more stations, say, 908+00 and 910+00. In the same manner, you can see that the alignment will need to be shifted approximately 19 and 18 feet, respectively, at those stations.

In the Alignments file, go to Project Manager, select Draw Pattern and make sure the correct chain SR99ALI1 is selected. Change the symbology to Lv: DESIGN-SCRATCH-User 1, Co, Lc, and Wt to 0. For the increment select Once, Left Offset 20, and Station 906+00 and Draw Pattern Line at that

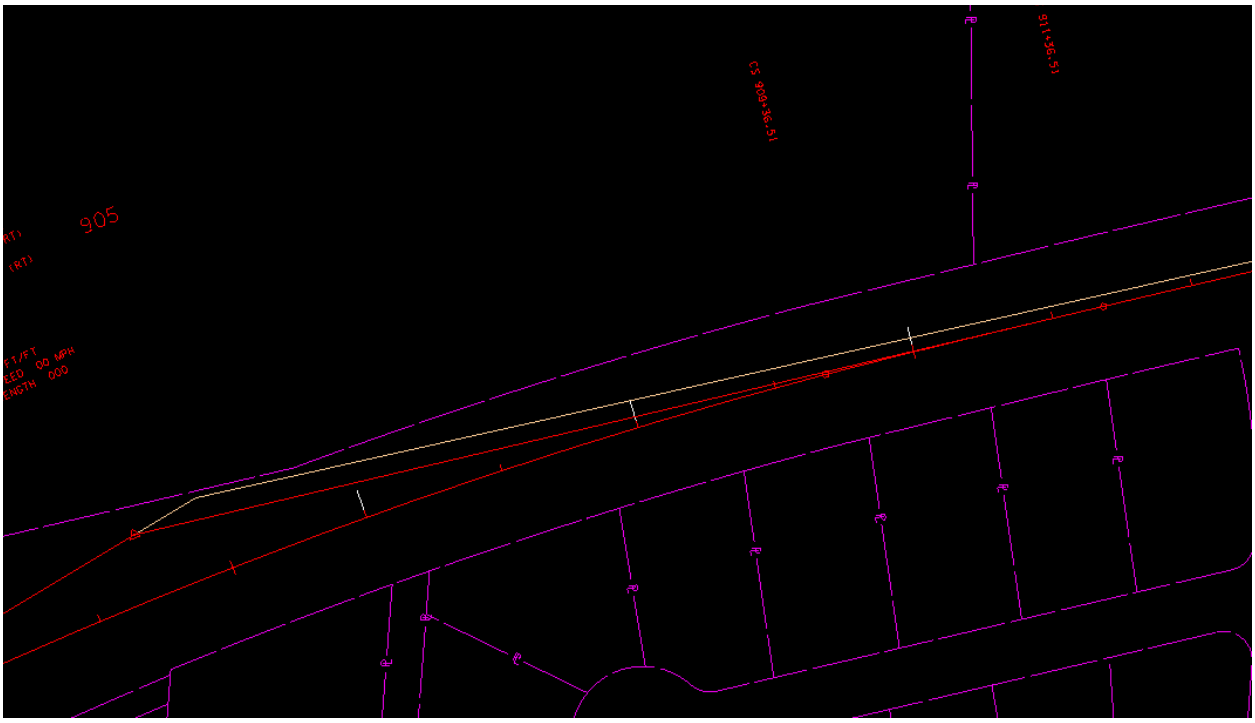
station. Then draw pattern lines at 908+00 and 910+00 with the offsets 19 and 18, respectively. These lines give some points that the alignment needs to hit.



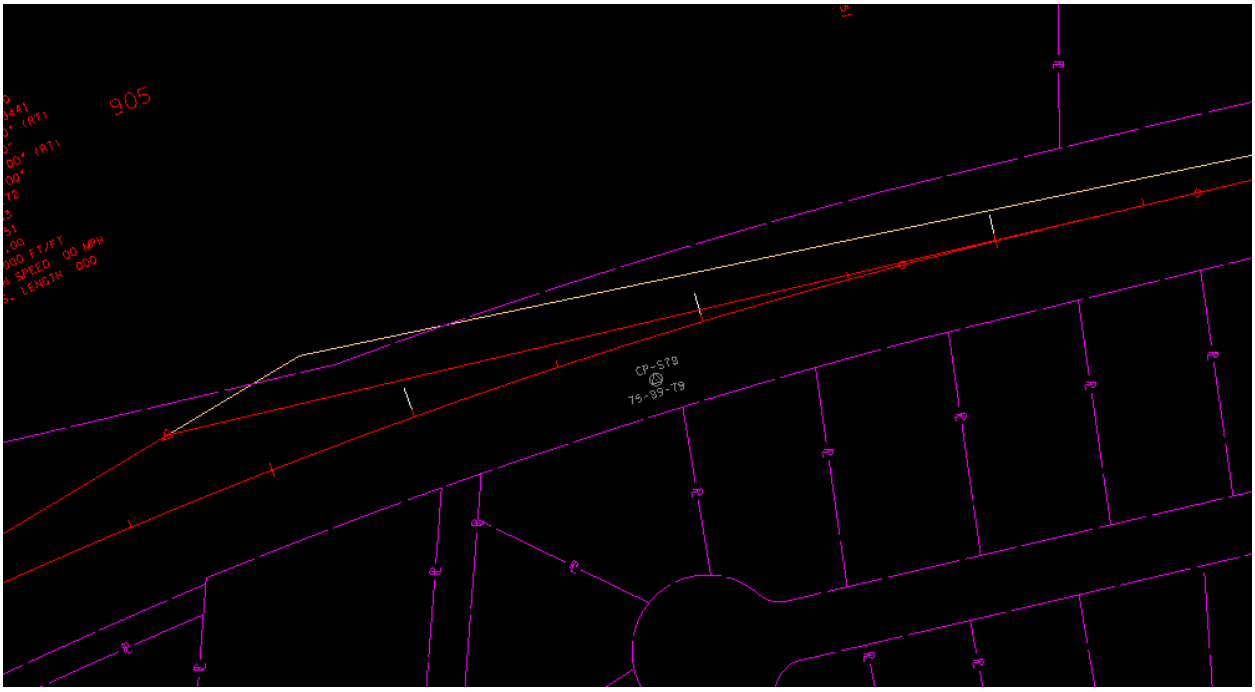
To accomplish the shifting of the alignment, it will be necessary to move the PI point at approximately sta.904+50. The best way to do this is to graphically draw an alignment and use trial-and-error to determine the best location.

Copy the back tangent and extend it approximately 50 feet. Use Modify Element to change the color to 2 and move the line to a scratch level. From the end point, draw another line to tie back in to the alignment before the St. Andrews Drive intersecting road at about sta. 918+50. We want to end the project before that road.

With the lines intersected, it is noticeable at first glance that the second tangent is not moved out enough at sta. 910+00.

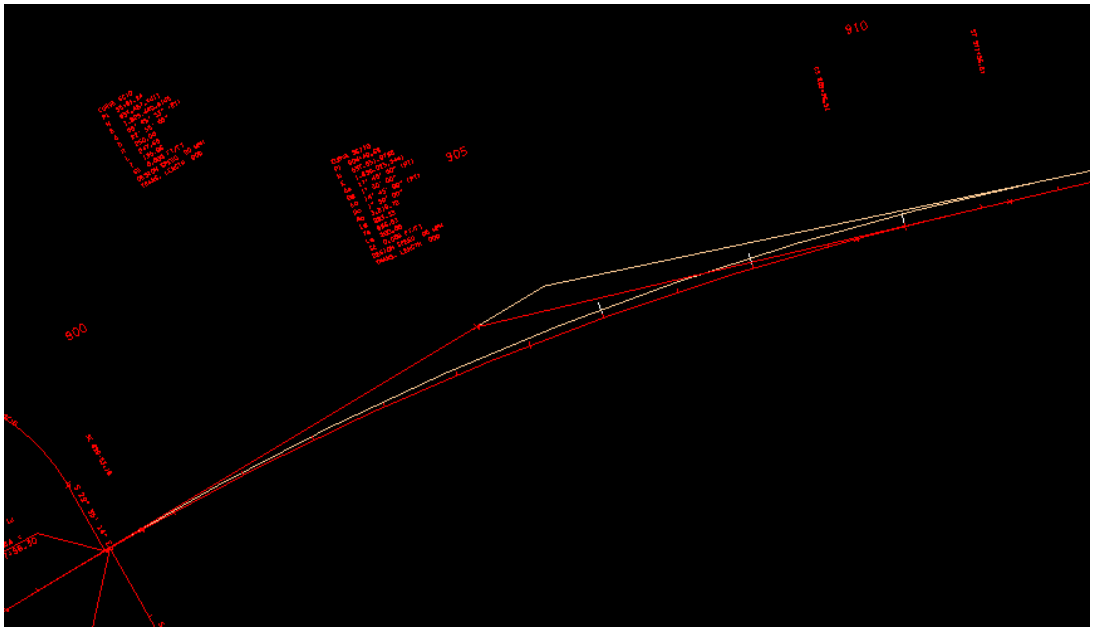


Modify the line so that it hits near the end of the third perpendicular line (910+00), and then intersect it with the first tangent.

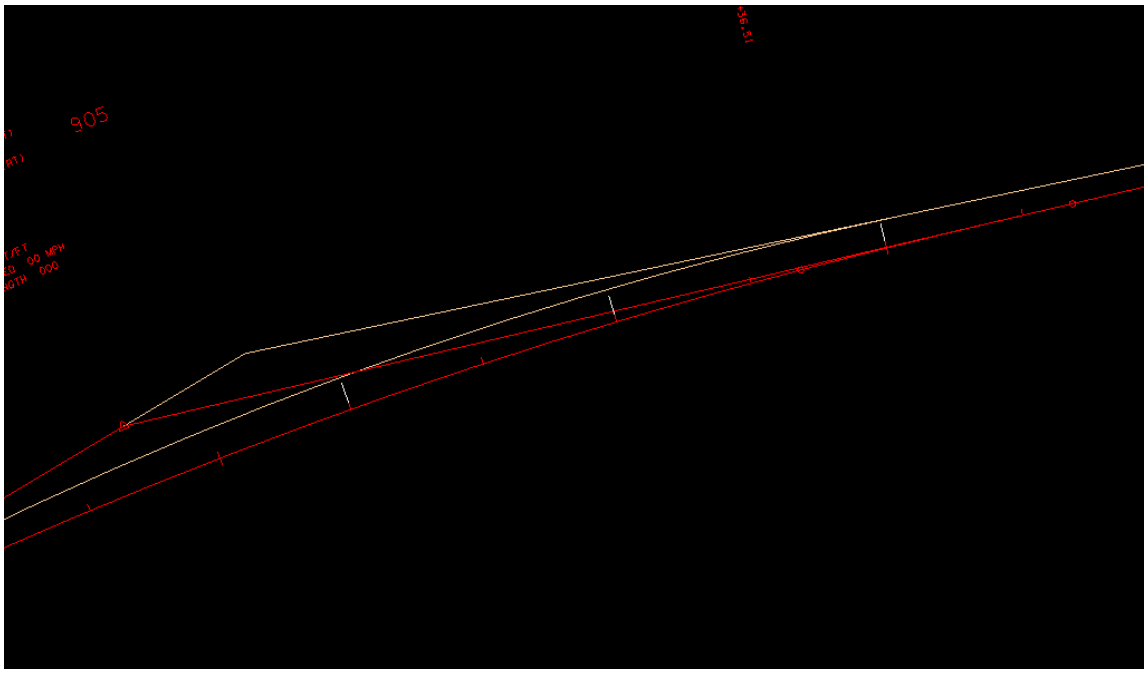


Measuring from the original PI to the intersection, the distance is 101.34’.

Now the original curve is a radius of 3,820’ so using Microstation Construct Circular Fillet command place a curve of that radius using the two tangents.



It is obvious that the radius is inadequate so we will need a shorter curve. Looking at standard Drawing RD01-SE-2 for E max =0.04, the next curve under the 3,820 radius is 2,865, so place a new curve at that radius.



So, it looks like without a lot of trial-and-error we have found our solution!

Open the alignment file
C:\Projects\Rutherford\SR099\RFSR099Alignments.dgn.
Reference the survey file RF099-03Survey.dgn if it is not already referenced in. Turn all the levels off in the Survey file except for:

SURVEY – CENTERLINE – Preliminary
SURVEY – CENTERLINE – Preliminary Curve Text
SURVEY – CENTERLINE – Preliminary Text

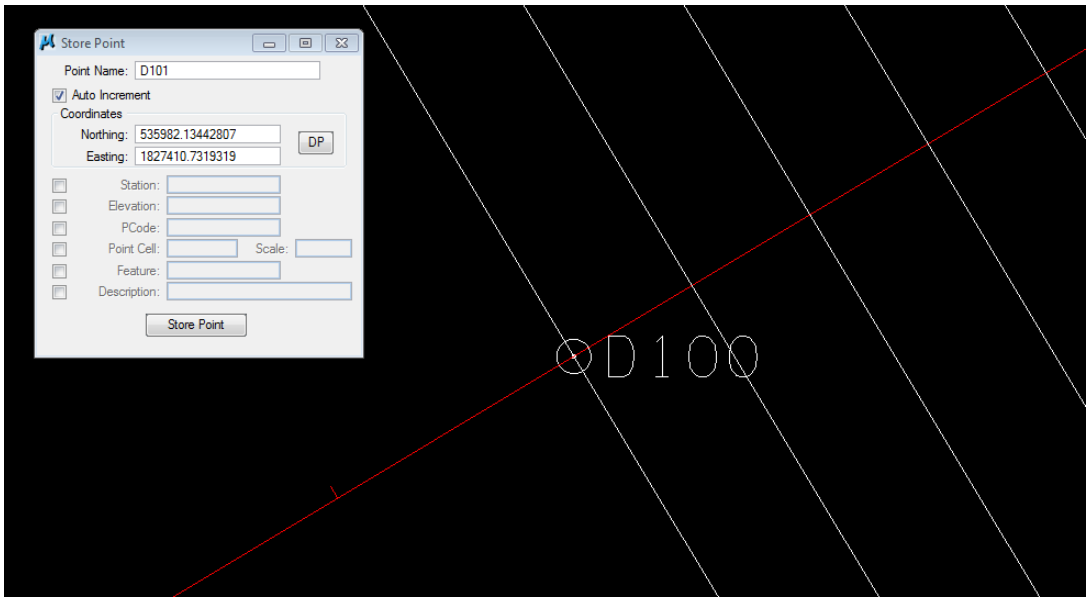
Also, attach the file RFSR099RoadwayPattern.dgn as a reference.

Now, notice that the original centerline is much longer than what we need for the project. We only need the section in the area in which we have previously cut pattern lines and cross sections – sta. 874+00 to 928+00.

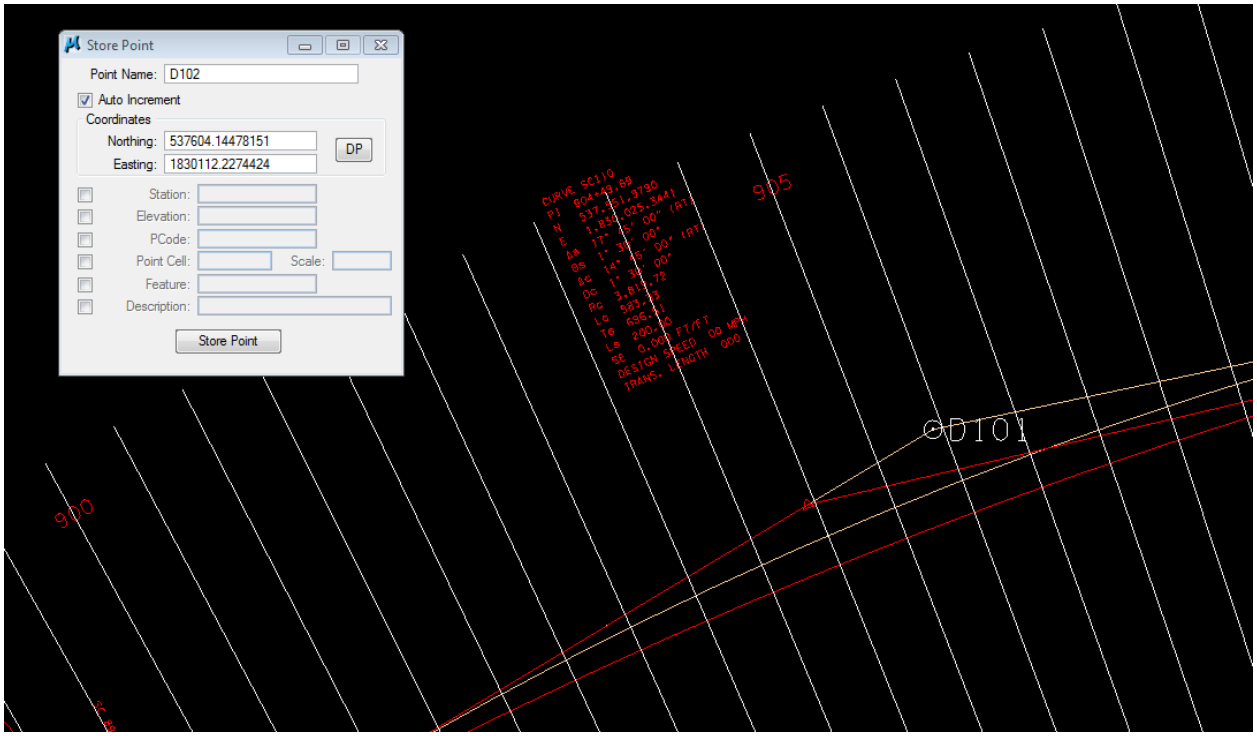
Exercise 4 of the GEOPAK Road Manual contains some helpful information to assist in modifying the alignment. The original alignment needs to stay as is so it needs to be renamed SR99ALI1PRE. Delete the old chain SR99ALI1 then create a new chain called SR99ALI1.

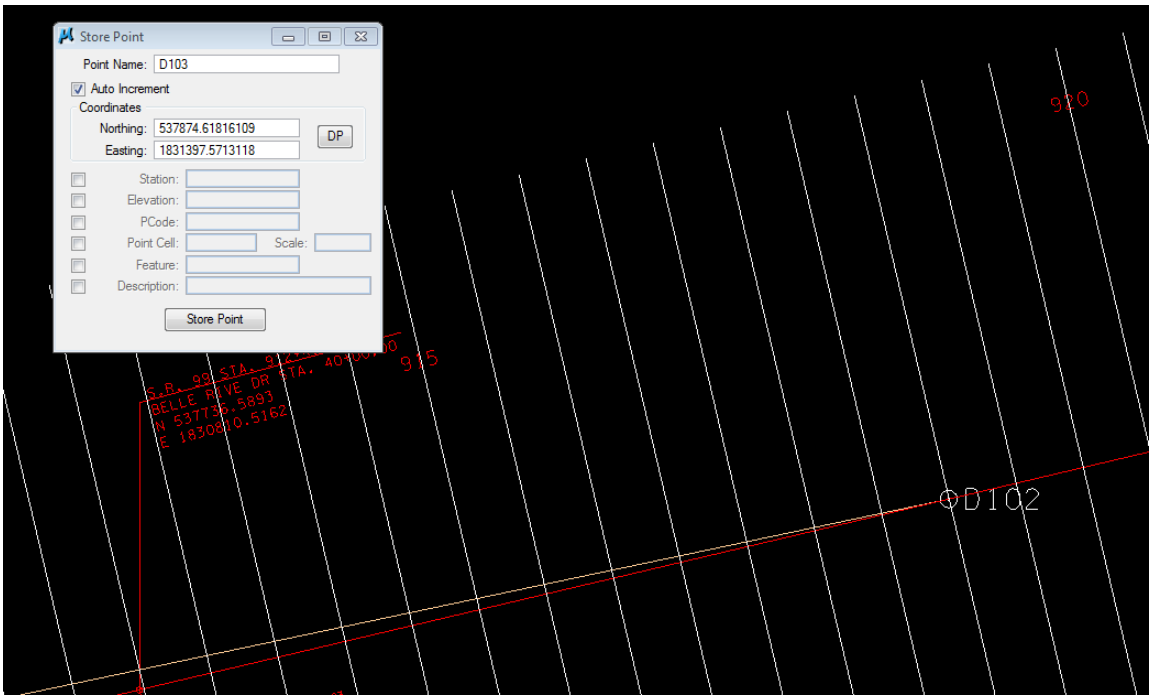
First create horizontal alignment points and curves.

For “Point Name” enter D100 and snap to the intersection of the first pattern line with the centerline then click “Store Point”.

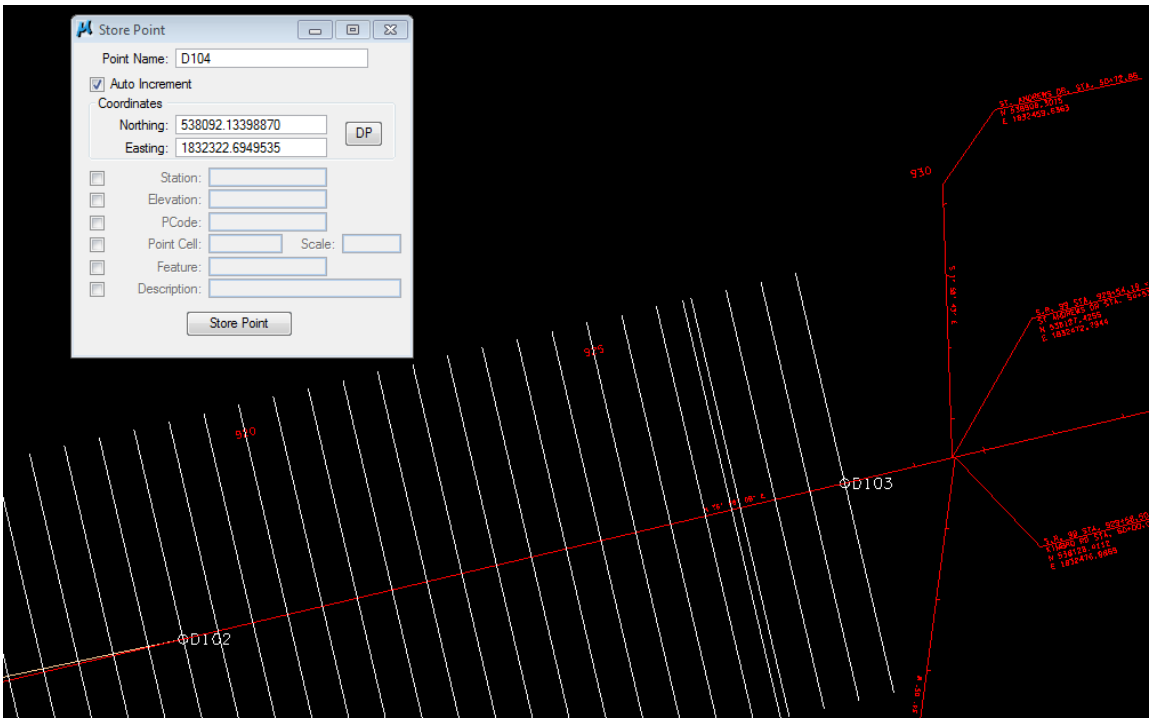


In a similar manner locate points D101 and D102 at the new PI locations.



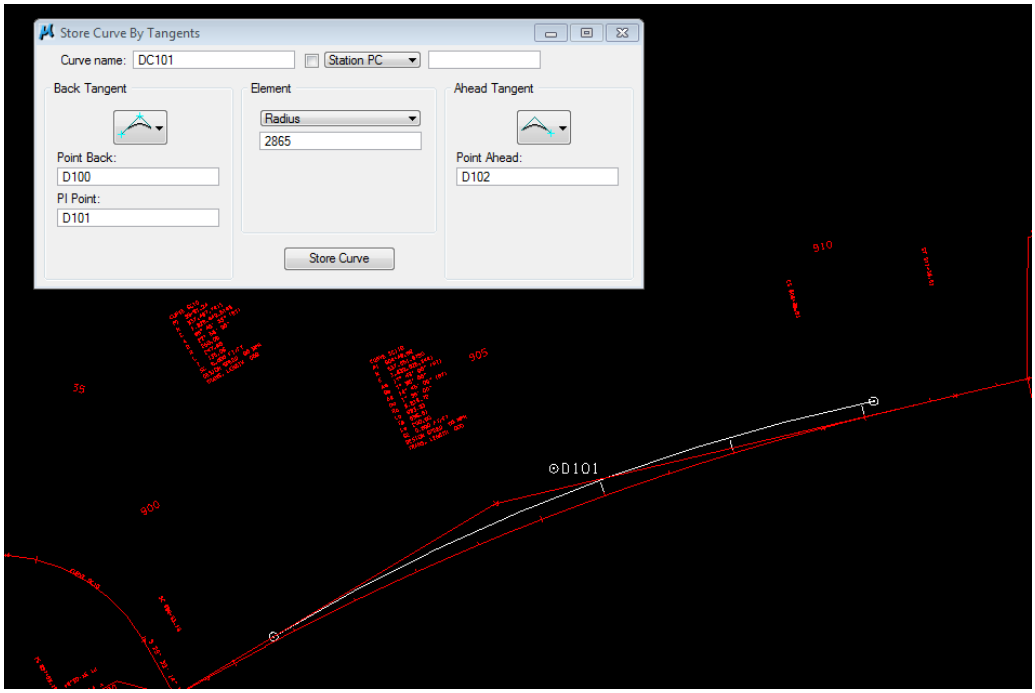


5.8) Then locate D103 at the intersection of the last pattern line with the centerline.

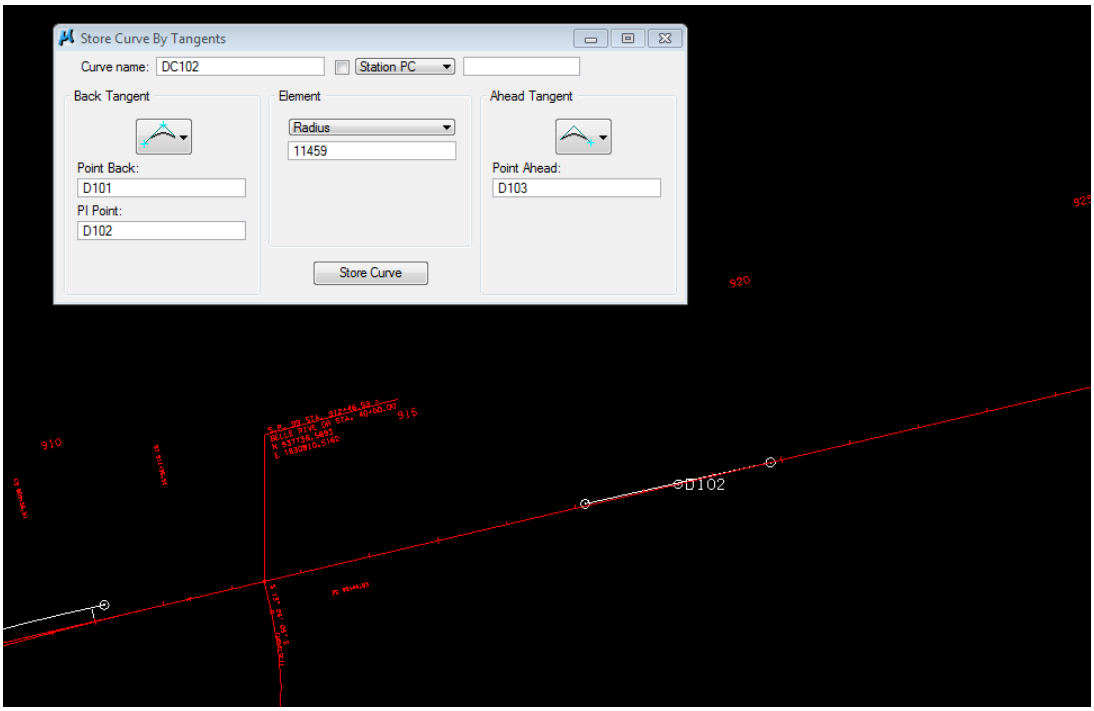


5.9) Now we need to store the curves at the PI points D101 and D102, which will be named DC101 and DC102.

As we determined earlier, the curve at point D101 will have a radius of 2,865 ft.

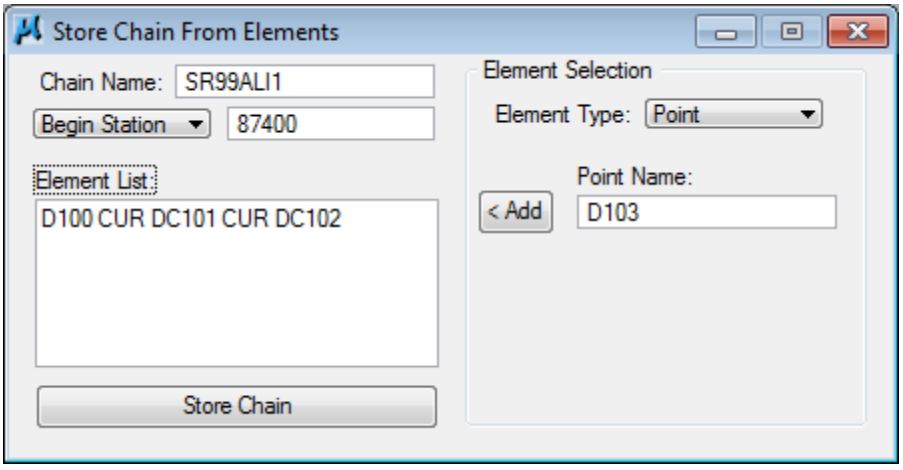


5.10) In a similar manner, store curve DC102:

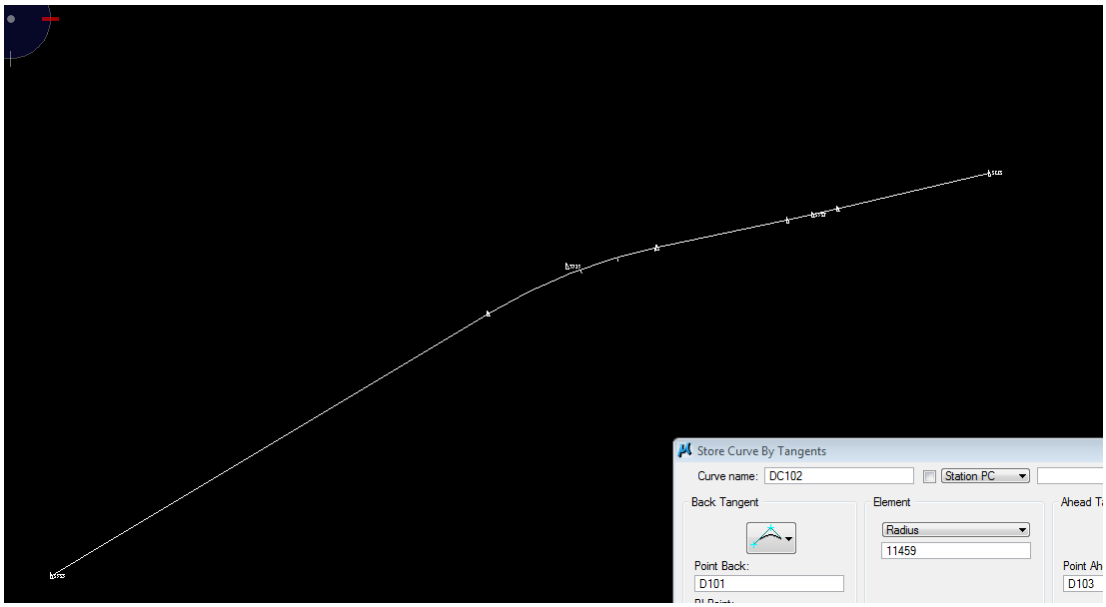


5.11) Once the curves have been stored the new alignment SR99ALI1 can be created.

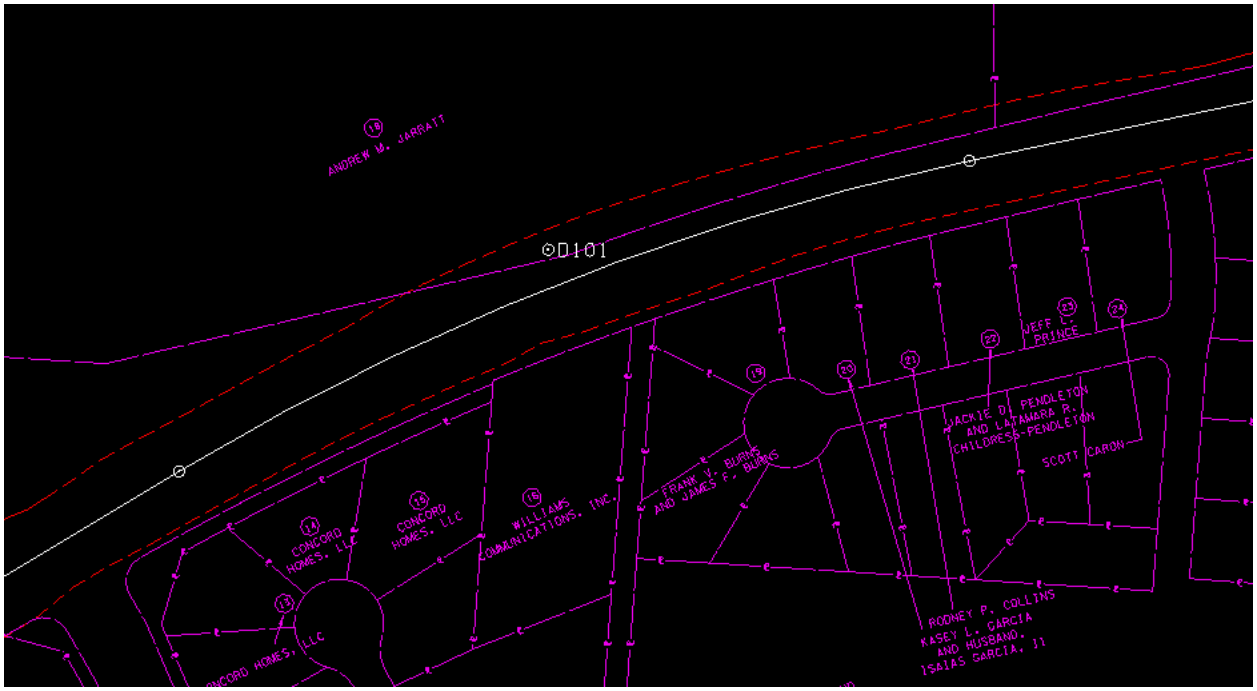
Open up the COGO Dialog and select “Store Chain From Elements”



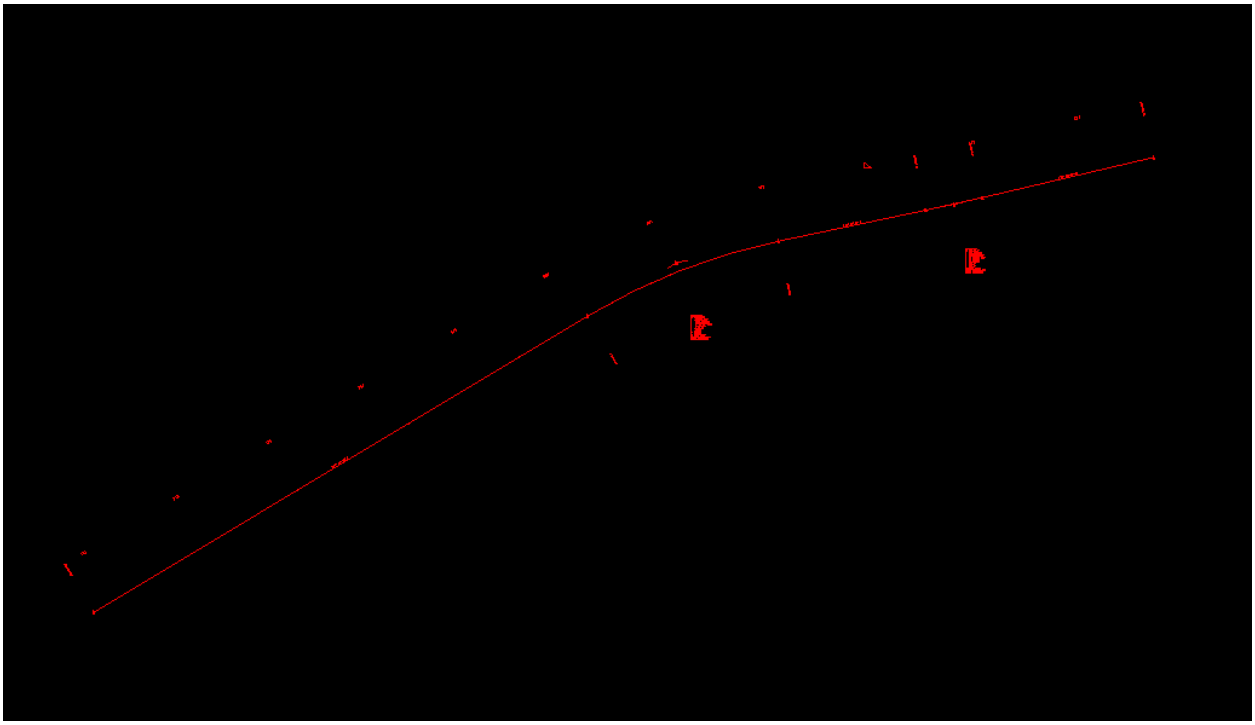
5.12) Make sure “Redefine” is checked on, Permanent Visualization is selected, and the alignment is displayed in the Alignments file.



5.13) Cut cross sections again as before. Delete proposed cross sections generated earlier first. It is also a good idea to either delete the slope lines generated before in the Proposed file or move them to another level first.



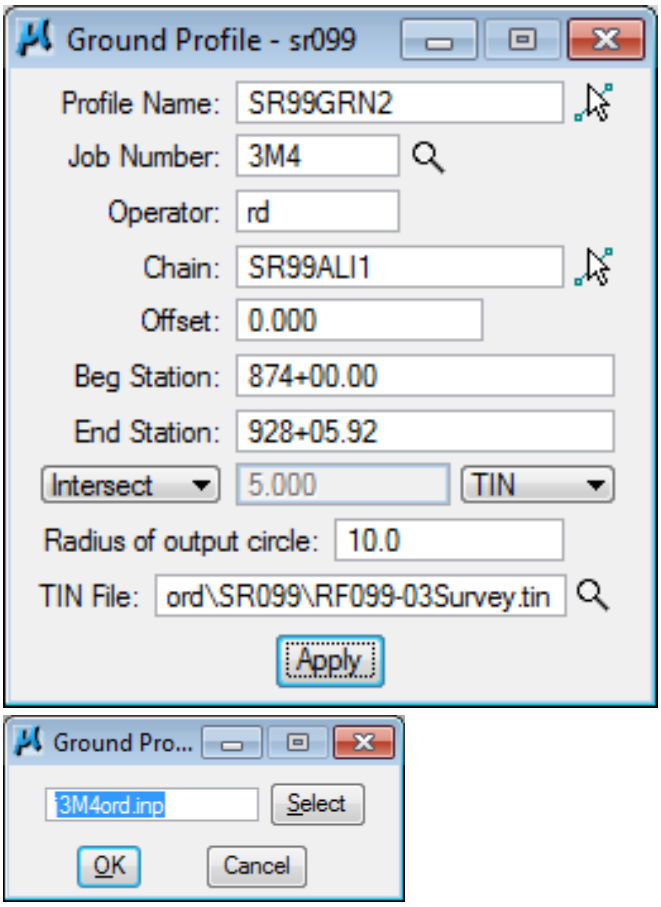
5.14) The slope lines are no longer encroaching on the subdivision. Now, go to D & C Manager and display the horizontal alignment and stationing. Turn off scratch levels and Proposed GPK Visualizations and save settings first.



5.15) At this point it will be necessary to send the GEOPAK file with the modified alignment back to Survey so they can change the ROW offset flags, etc. Information on what to do is found on page 6-7 of the CADD Manual.

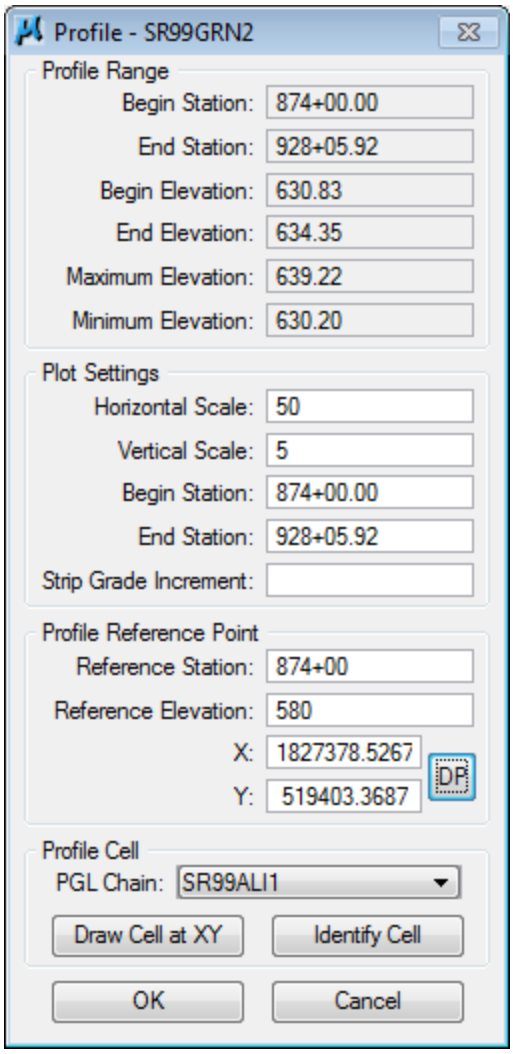
PROFILES

With the change in horizontal alignment, a new existing ground profile will need to be generated. Refer to Exercise 6 of the GEOPAK Road Manual for guidance.

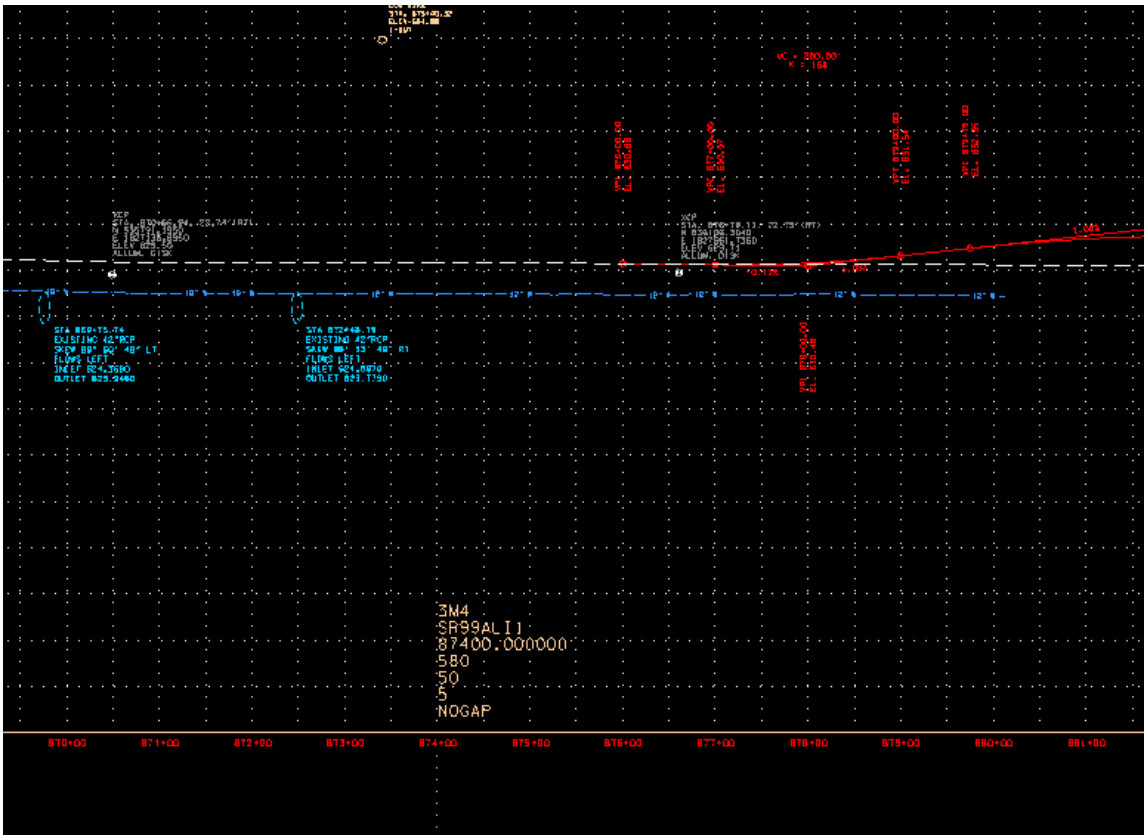


6.1) Call the new profile SR99GRN2 to distinguish from the original survey profile named SR99GRN.

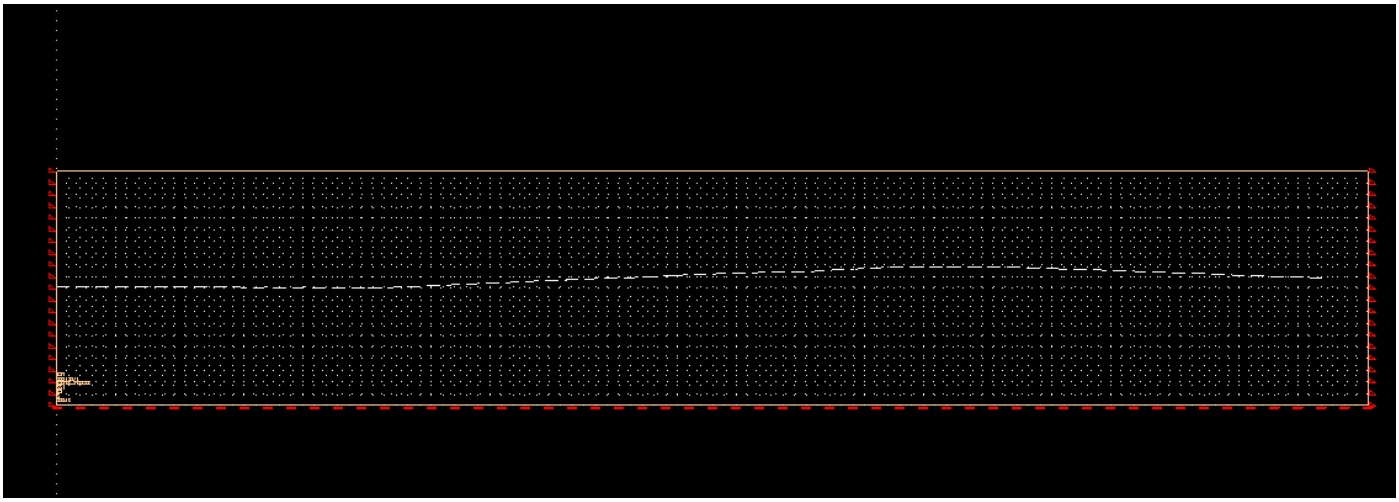
6.2) After the existing profile has been stored, then go to D & C Manager to display the groundline in the file RFSR099Alignments.dgn. Window area to where the existing survey profile is displayed. You may have to turn the Survey file reference on to see it.



6.3) Select DP and snap to sta 874+00 on the survey profile grid and place the cell there.

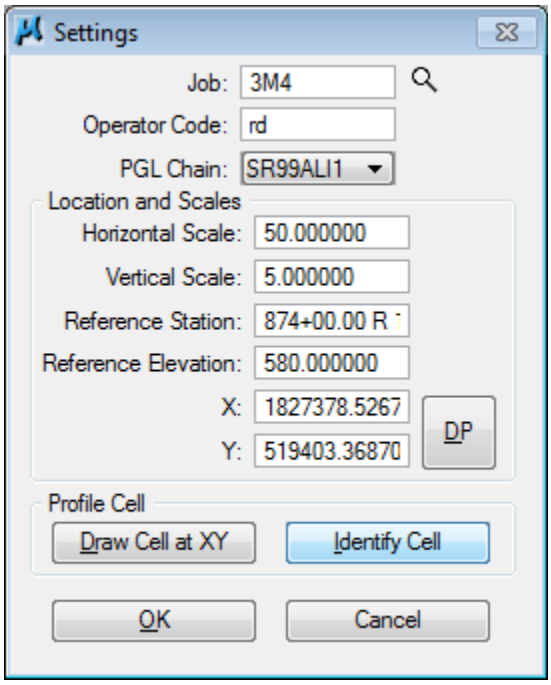


6.4) Display existing ground profile, SR99GRN2 , and new grid (Survey reference and graphics of proposed profile created in section 3 are turned off):

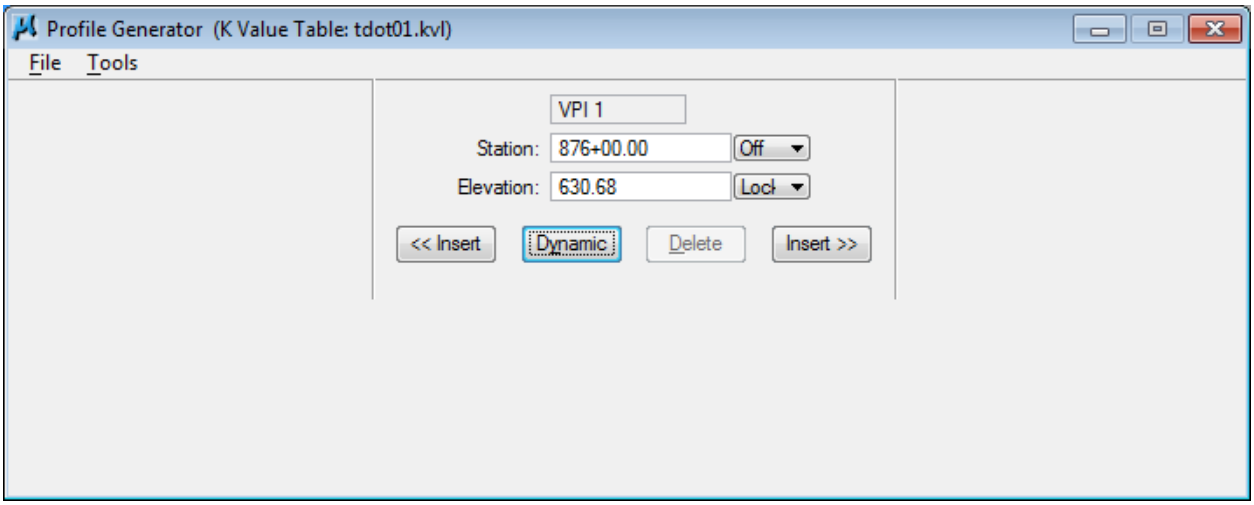


We need to recheck our beginning and ending points against the new alignment. The beginning will still be 876+00, but the ending station, originally 926+37.75 is 926+43.67 on the new alignment.
We have a proposed vertical alignment that was created in section 3. That profile is associated with the profile cell in the Survey file. We will need to draw a new profile using the new cell. The stations and elevations of the points will be the same as before. Only the end station will be different. If the graphics are still there you can snap to the VPI points to input them or you can key them in. Remember the new end station is 926+43.67.

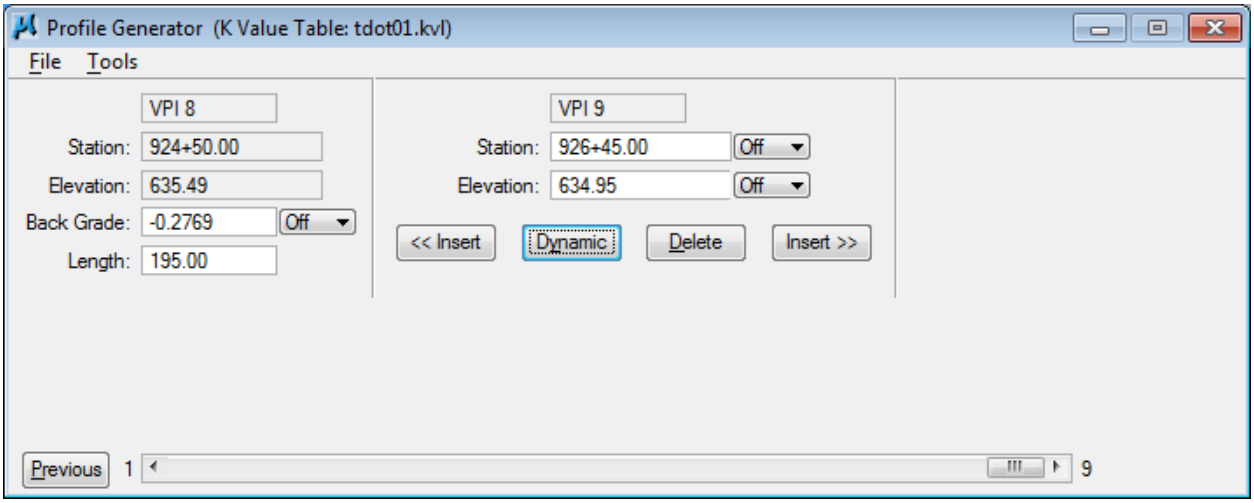
6.5) Identify cell placed in step 6.3:



6.6) Input VPI points 1-8 as before:



The last point can be rounded to an even station number:



6.7) Input the same vertical curve lengths for each VPI, save profile (use original name or a new one) then re-display proposed profile. (Delete original graphics first)

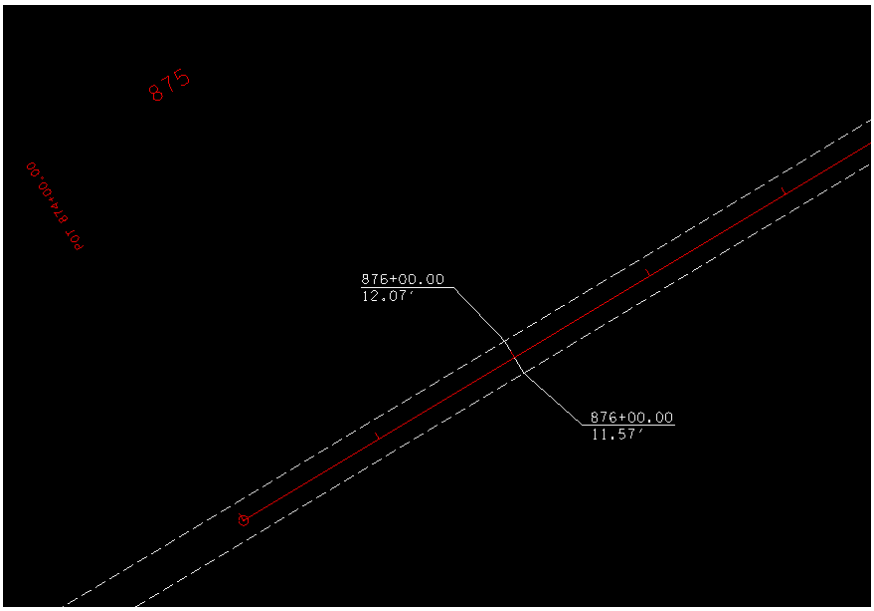
6.8) Since we have a different ending station on the vertical alignment , we will need to cut existing and proposed cross sections again.

a) Go to RFSR099MainlineSections.dgn, delete all graphics then compress design.
b) Go to RFSR099RoadwayPattern.dgn and delete pattern lines drawn previously. Compress design.
c) Go to RFSR099Proposed.dgn, delete slope lines drawn in step 5.13
d) Redraw pattern lines, first at 50 foot intervals, then draw a single pattern line at 926+45.
e) Go to RFSR099MainlineSections.dgn, draw existing cross sections.
f) Go to RFSR099RoadwayPattern.dgn ,change symbology on lines before 876+00 and after 926+45 to co=3
g) Go to RFSR099MainlineSections.dgn, draw existing cross sections. In Project Manager, select Proposed Cross Sections. Under Shape Clusters, change ending station to 926+45.00 for both LT and RT.
h) Run Proposed Cross Sections.

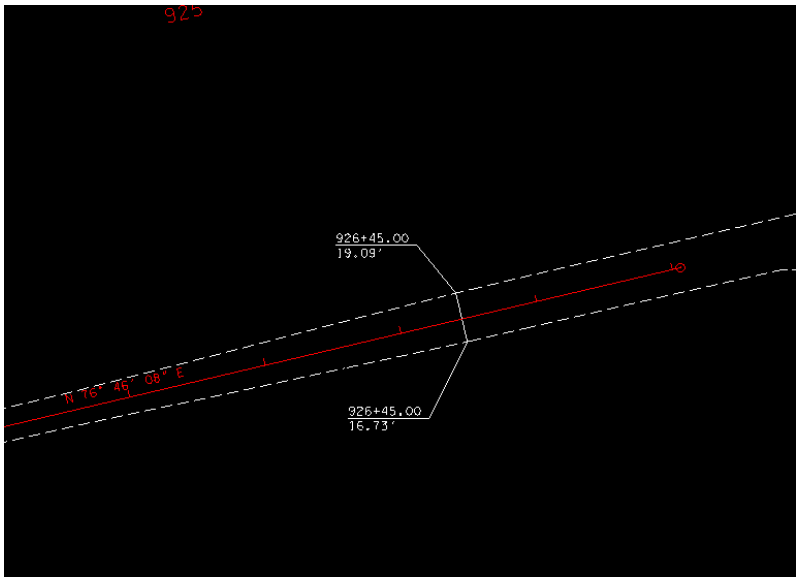
PROPOSED PAVEMENT LINES AND TRANSITIONS

Open file RFSR099Proposed.dgn. You can turn off the all the levels in the Survey reference file except for SURVEY-TRANSPORTATION-Roads but leave the Alignments reference displayed as is.

In Chapter 1, the length of project, transition lengths and stations were determined. With the modifying of the horizontal alignment some minor changes may be necessary. The beginning station can stay the same, 876+00. In the previous section, the ending station was reset to 926+45. Start out by drawing pattern lines at both beginning and ending station, but with left and right offsets at 10 feet. Then extend the lines to intersection with the existing pavement lines. Use the Station/Offset tool to find the offset distances



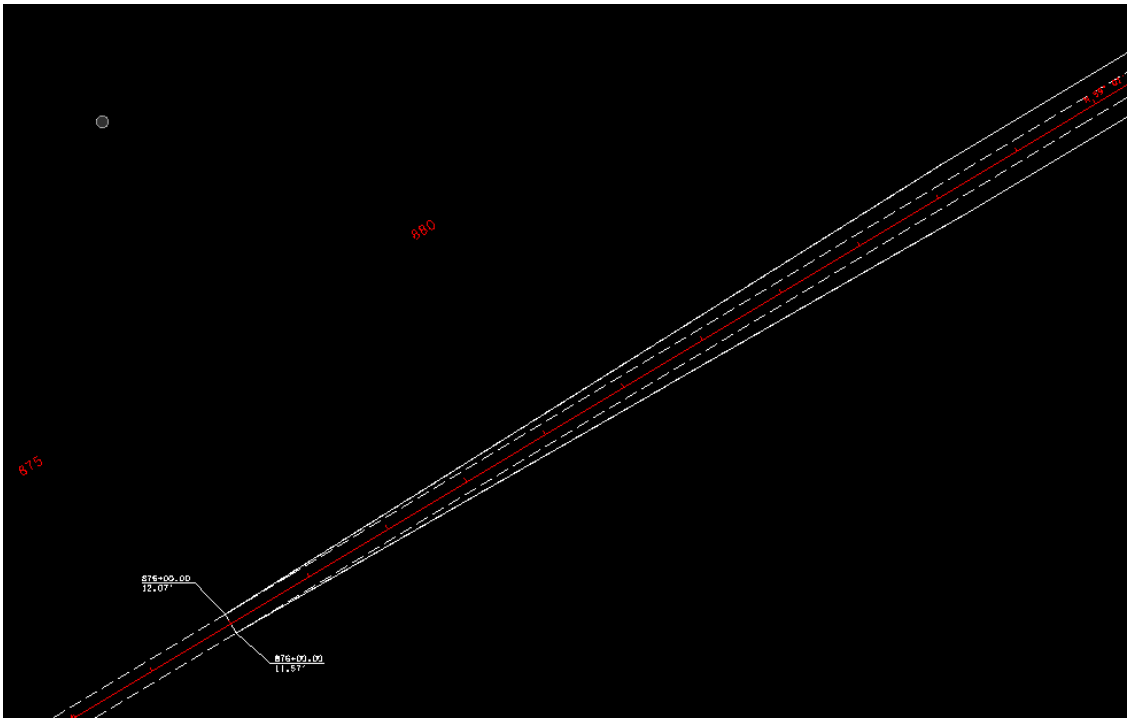
Offsets at the beginning station



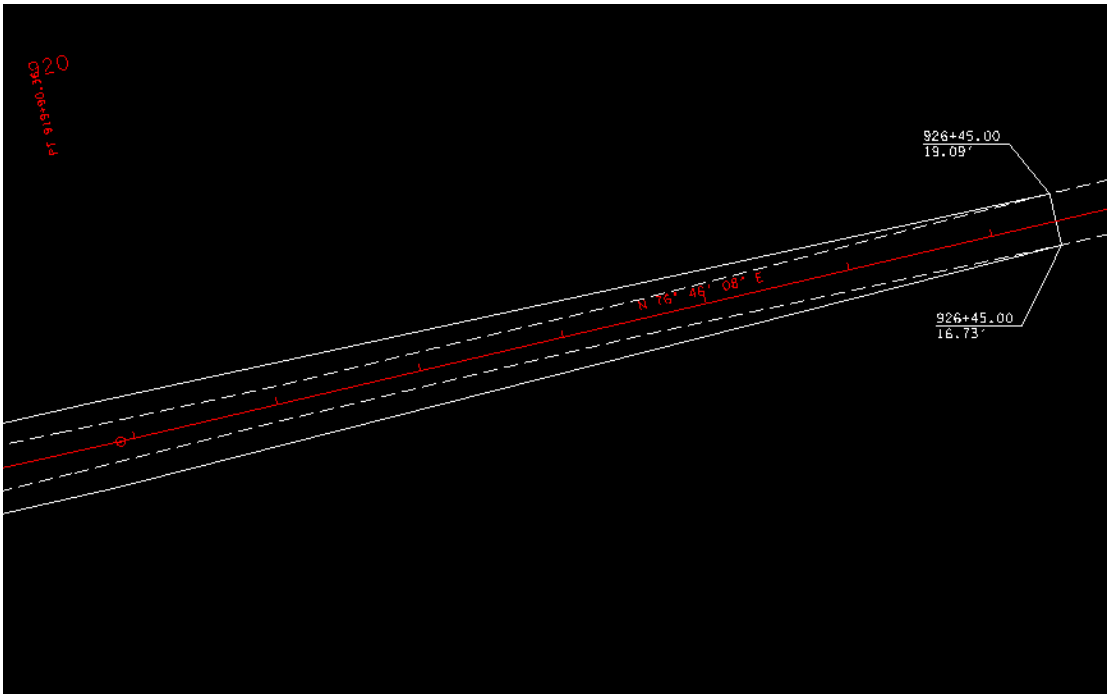
Offsets at the end station

At each end the pavement transitions from the existing width to 60 feet (30 ft. either side of centerline). As shown in section 2 the equation is L=WS. At the beginning use the smaller of the offsets to determine the minimum transition length (W=30-11.57=18.43). Design speed is 50, so
L=18.43 x 50=921.5, round up to 925 to make it an even station. Similarly, the transition at the other end will be 665 ft.

For the next steps in drawing pavement lines, shoulders and curb and gutter using D & C Manager refer to GEOPAK Road Manual, Exercise 12.



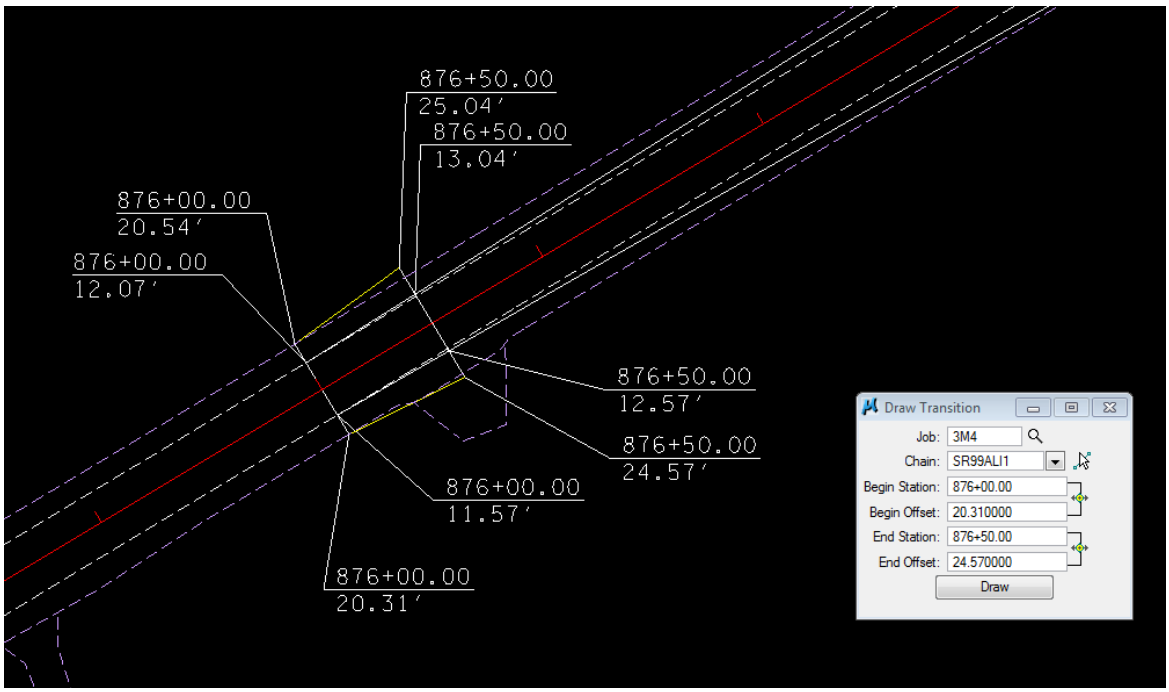
Beginning Pavement Transition, station 876+00 to 885+25



End Pavement Transition, station 919+80 to 926+45

Drawing Shoulder Lines

The shoulders are 12 feet wide except at the ends where they will transition from the existing widths.



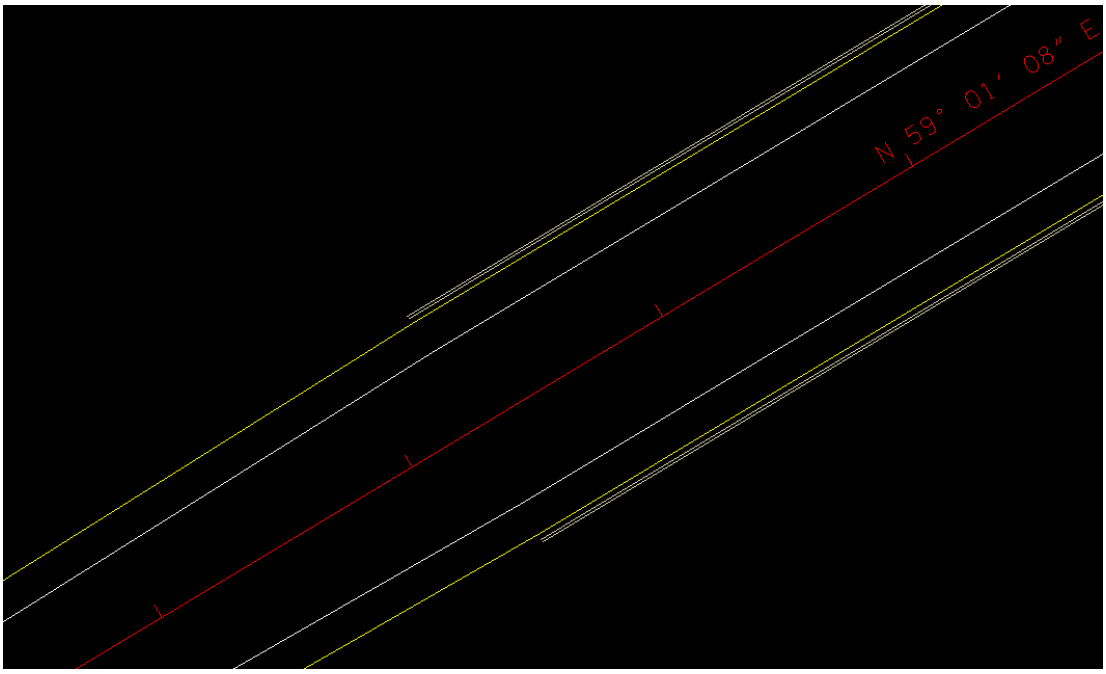
Drawing of shoulder transitions from existing width to 12 feet wide using 50 foot transititon.

Draw the rest of the shoulder lines in. On the left side , station 876+50 to 885+25 will transition from -25.04 to -42. Station 885+25 to 919+80, -42 feet. Station 919+80 to 925+95, transition from -42 to -31.91. Station 925+95 to 926+45, transition from -31.91 to -27.49.

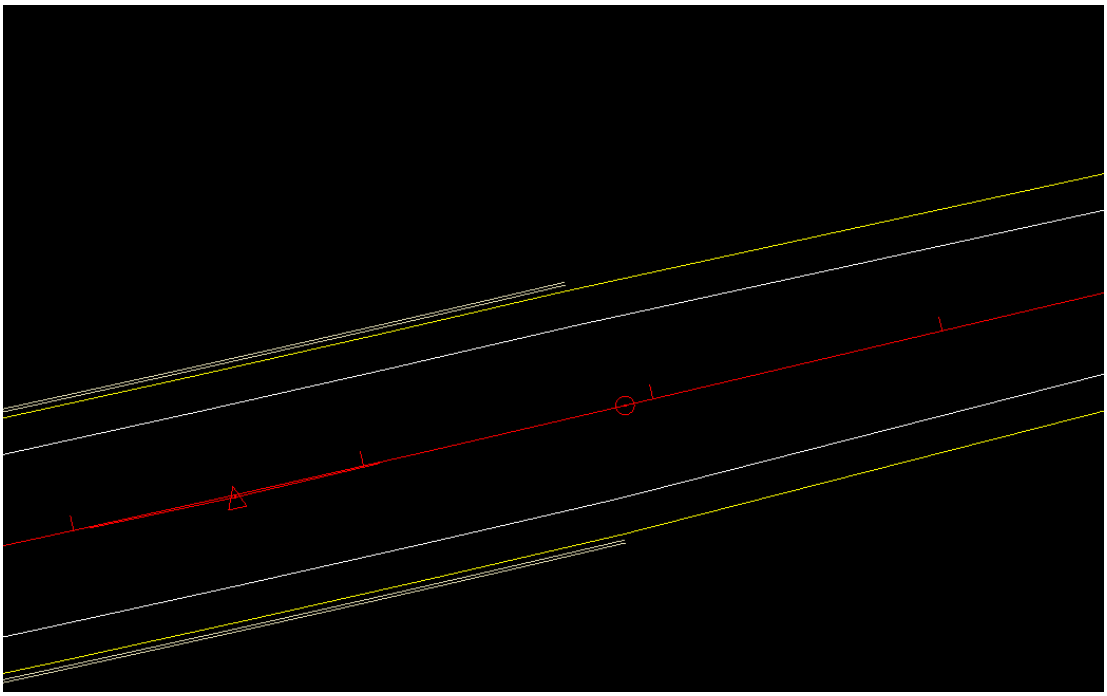
On the right side , station 876+50 to 885+25 will transition from 24.57 to 42. Station 885+25 to 919+80, 42 feet. Station 919+80 to 925+95, transition from 42 to 29.73. Station 925+95 to 926+45, transition from 29.73 to 25.03.

Drawing Curb & Gutter

Curb and Gutter will be drawn at an offset of 44 feet on both sides from station 885+25 to 919+80. Don't forget to "flip" the pattern on the right side.



Sta. 885+25



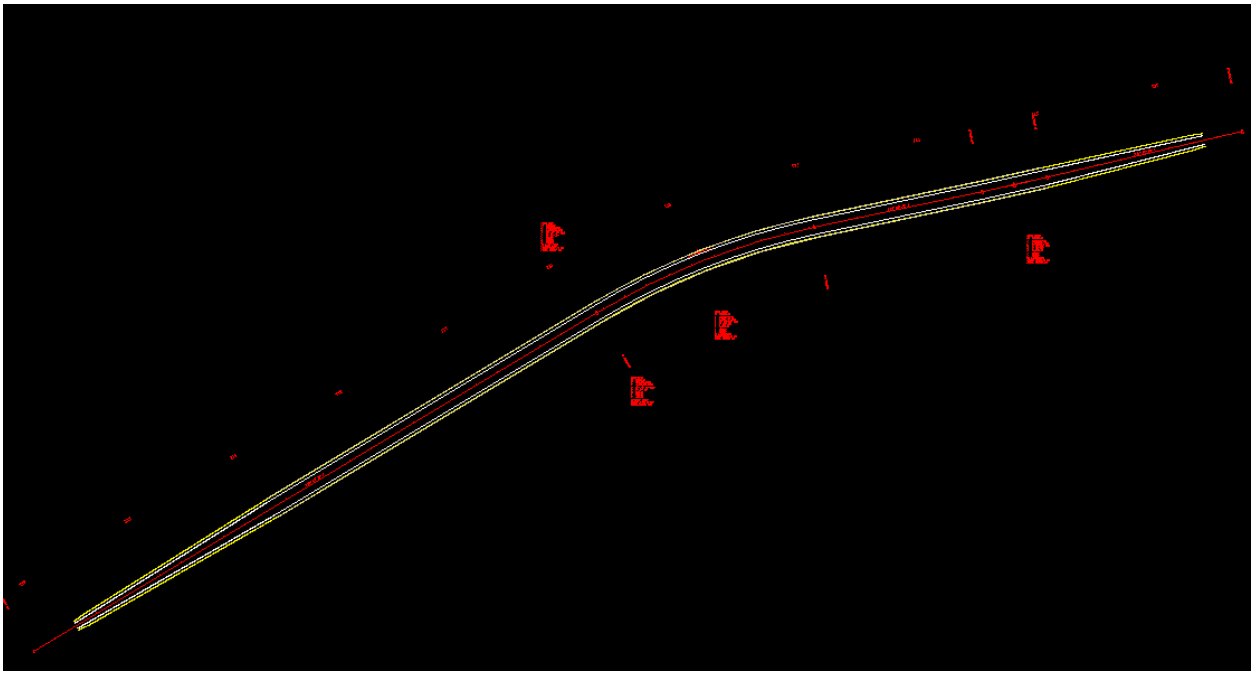
Sta. 919+80

SUPERELEVATION AND PROPOSED SURFACE CREATION

Now that pavement lines have been set, cross sections will need to be run again, with superelevation applied. Refer to Exercise 13 of Geopak Road manual for the creation of superelevation shapes.

Superelevation Shapes:

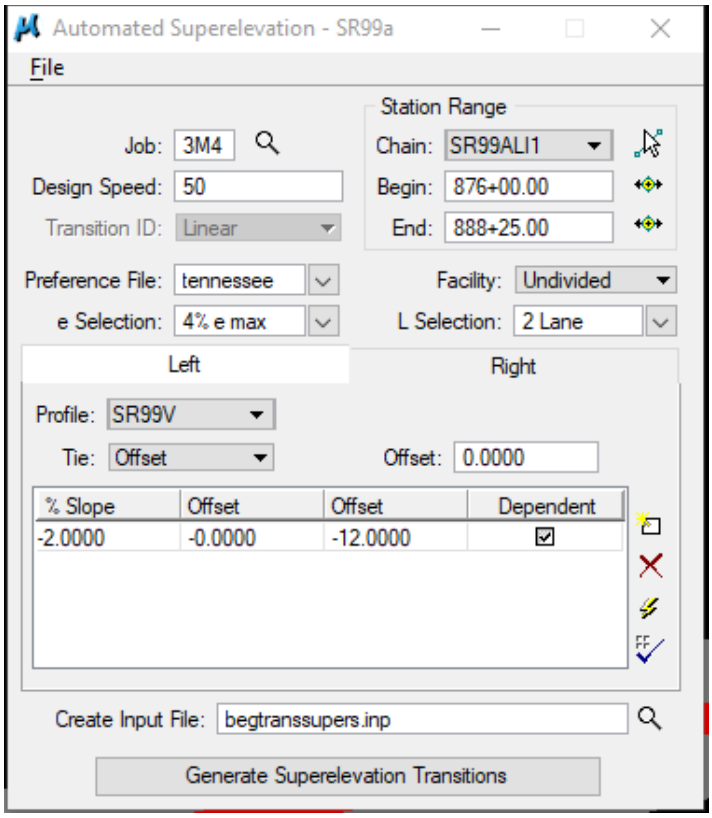
Open file RFSR099SEShapes.dgn. Attach files RFSR099Alignments.dgn and RFSR099Proposed.dgn as references and fit view or window area to horizontal alignment area.



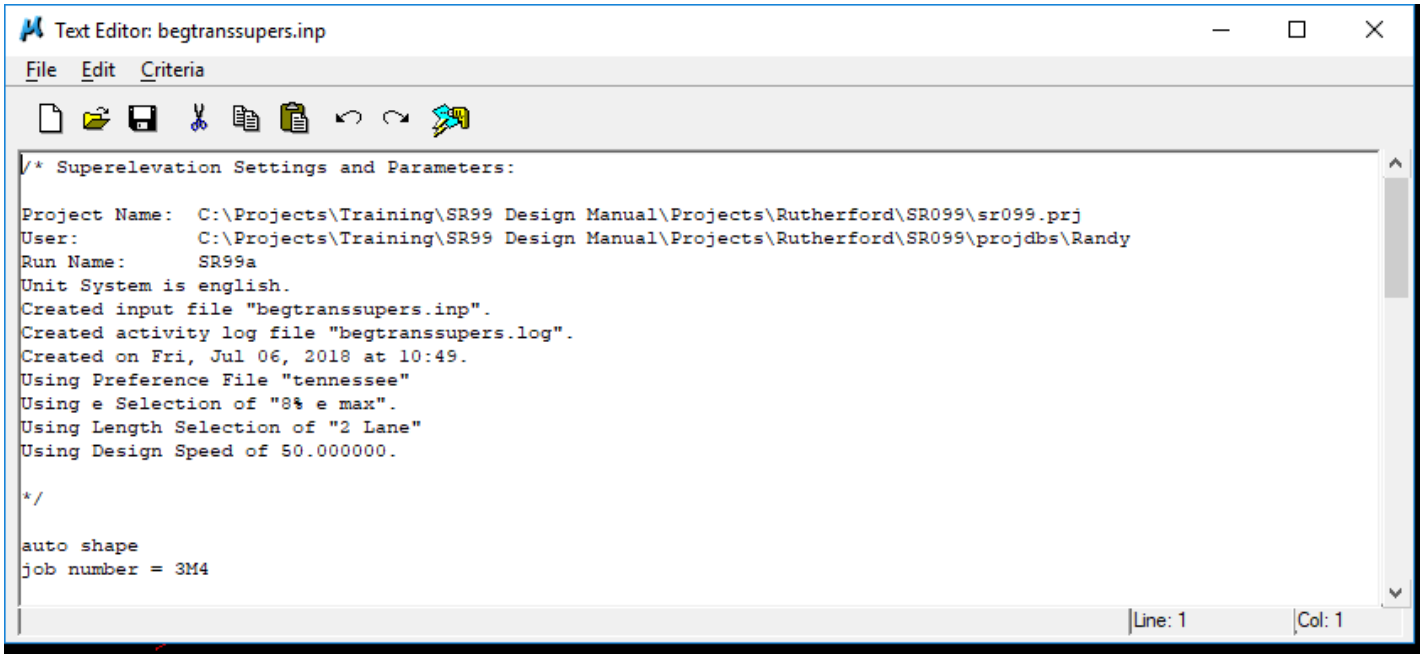
In Project Manager:

1) select Calculate Superelevation
2) Create Run SR99a. Since there are three sections – beginning transition, Curb& Gutter, End transition. There will be three separate super runs

Make settings as shown below. Beginning and end stations are for the proposed vertical alignment (SR99V). The design is urban curb and gutter section, so 4 % e max is used.



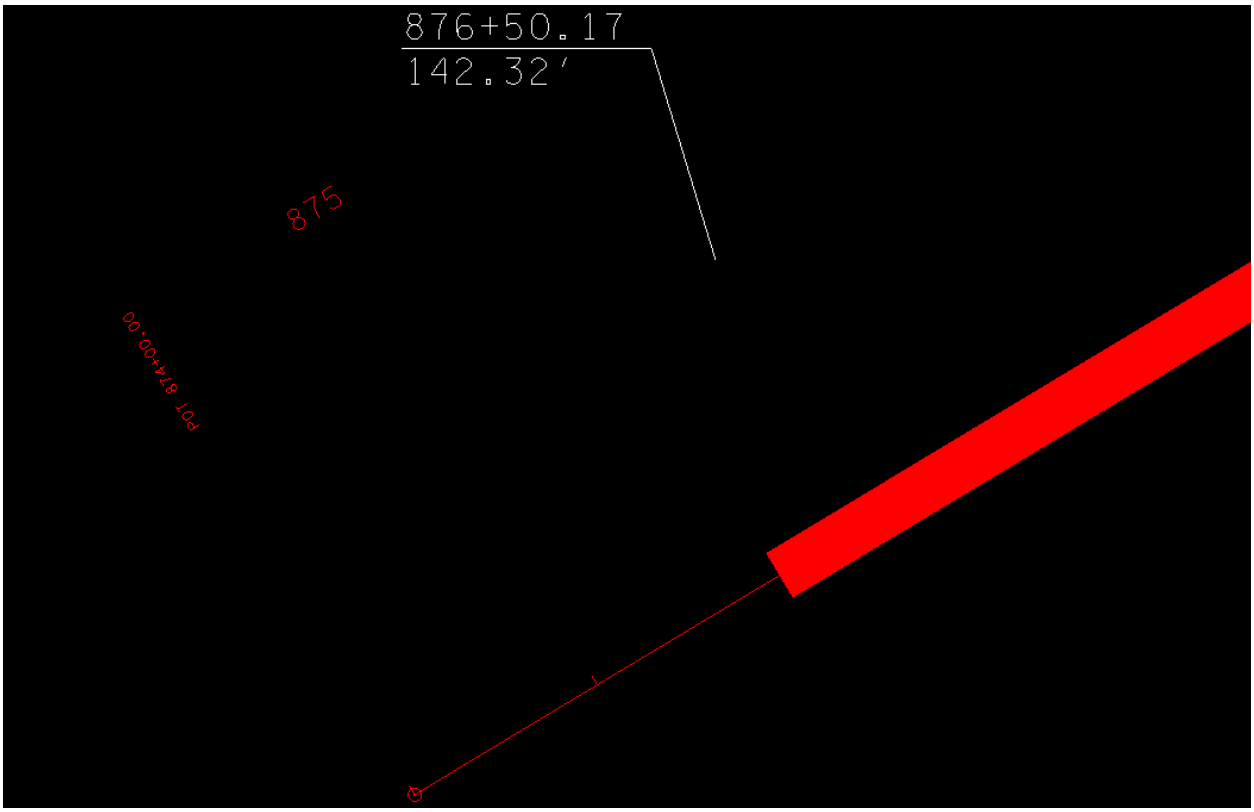
Press “Generate Superelevation Transitions” to create the file “begtranssupers.inp”



Check the beginning section (sta. 876+00 in the cross section file). The proposed normal crown cross slopes appears to match the existing pavement.

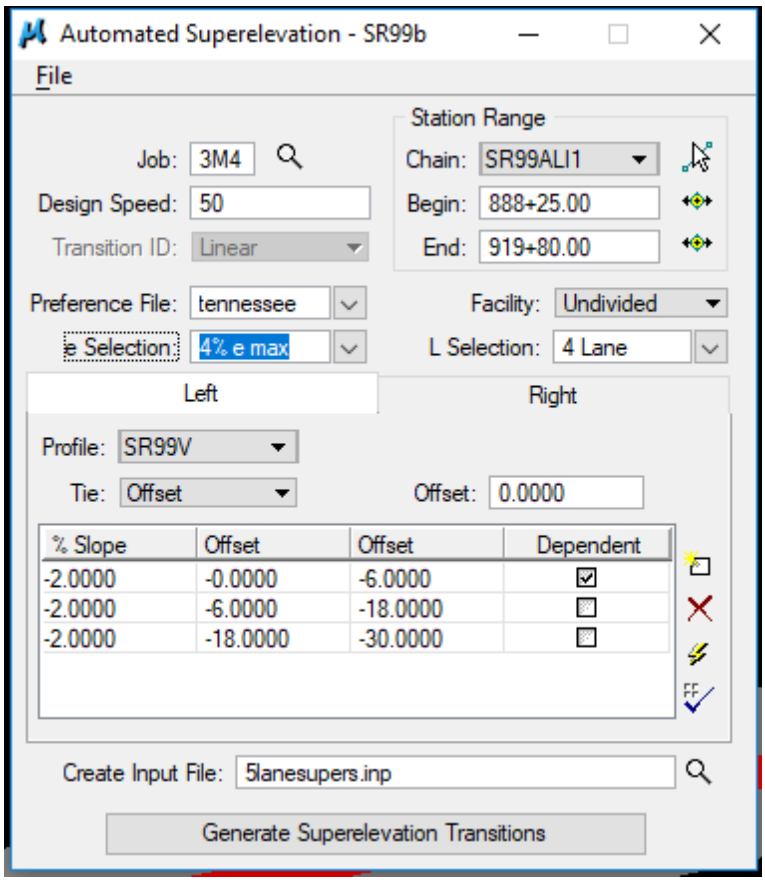
If that was not the case, the file begtranssupers.inp could be edited to show a transition from existing cross slope to proposed at each end.

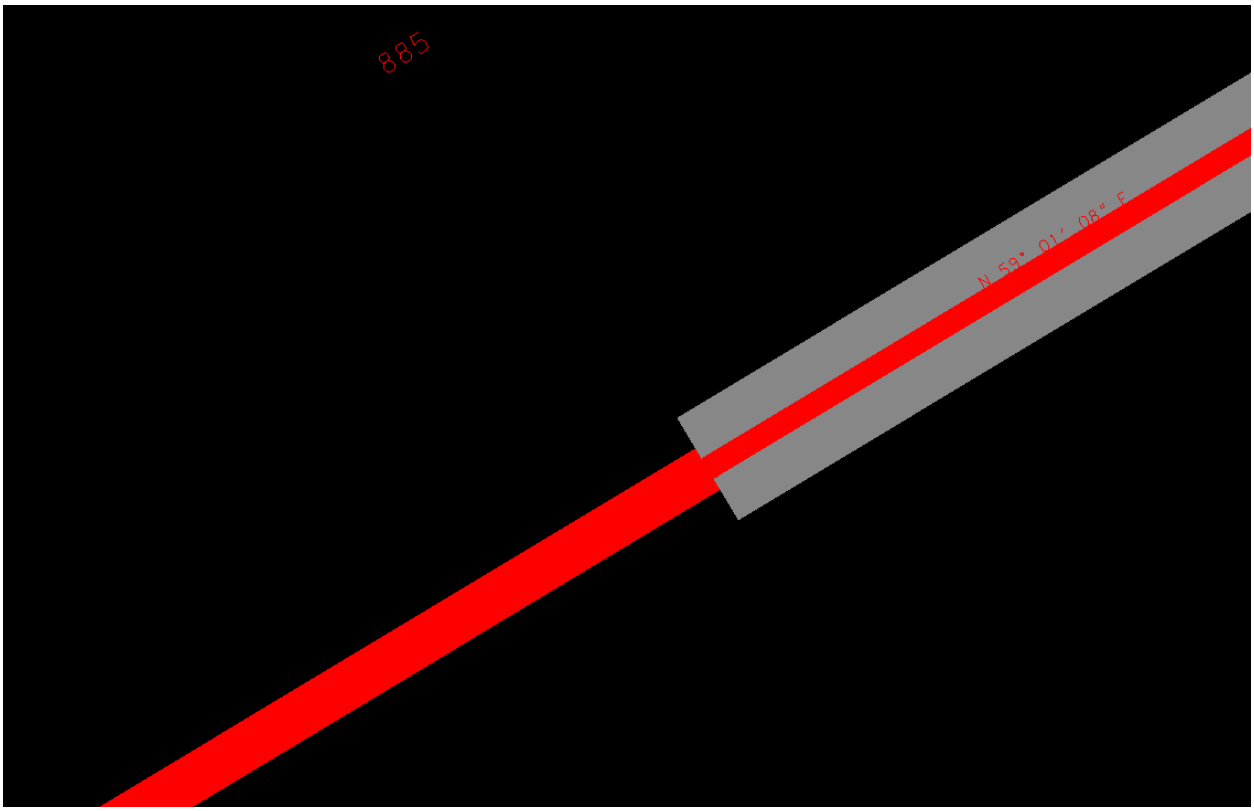
Create Superelevation Shapes:



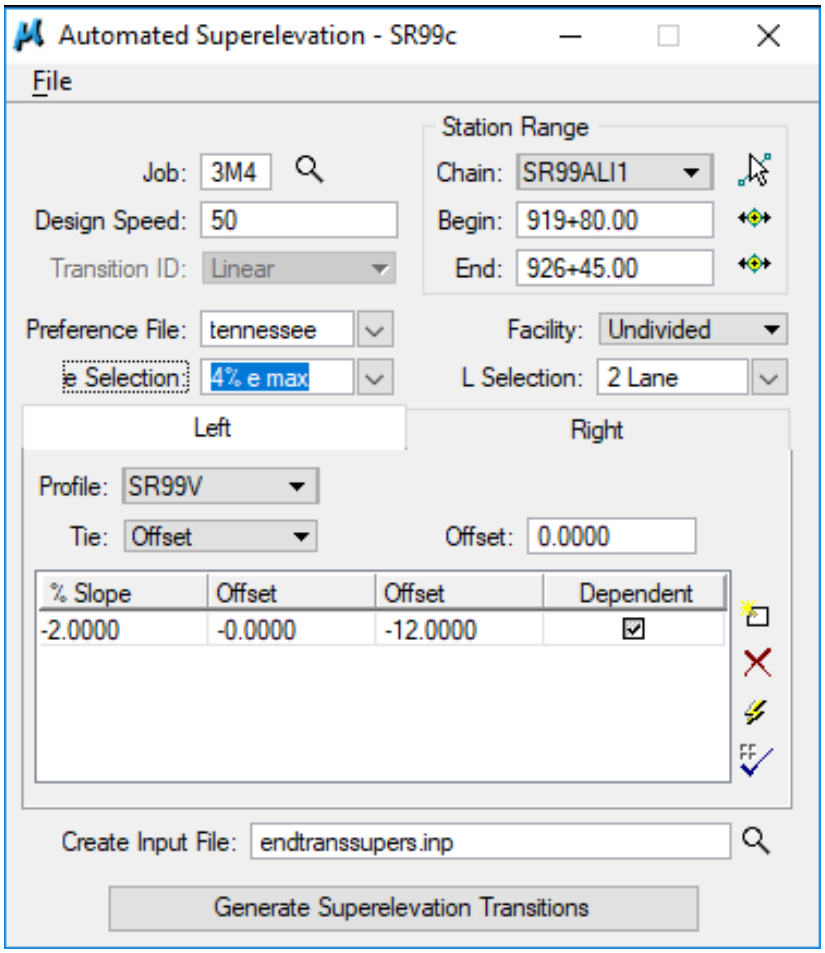
Now create runs SR99b, and SR99c

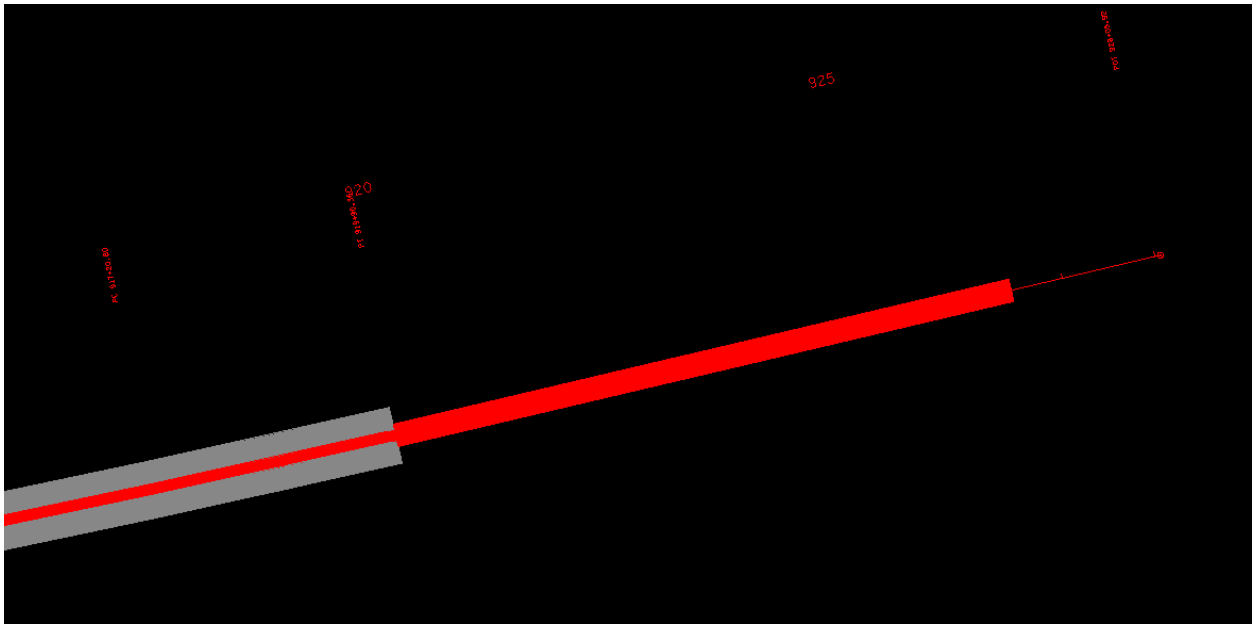
SR99b:


Automated Superelevation - SR99b
File
Station Range
Job: 3M4
Chain: SR99ALI1
Design Speed: 50
Begin: 888+25.00
Transition ID: Linear
End: 919+80.00
Preference File: tennessee
Facility: Undivided
e Selection: 4% e max
L Selection: 4 Lane
Left
Right
Profile: SR99V
Tie: Offset
Offset: 0.0000
% Slope
Offset
Offset
Dependent
-2.0000
-0.0000
-6.0000
-2.0000
-6.0000
-18.0000
-2.0000
-18.0000
-30.0000
Create Input File: 5lanesupers.inp
Generate Superelevation Transitions



SR99c:


Automated Superelevation - SR99c
File
Station Range
Job: 3M4
Chain: SR99ALI1
Design Speed: 50
Begin: 919+80.00
Transition ID: Linear
End: 926+45.00
Preference File: tennessee
Facility: Undivided
e Selection: 4% e max
L Selection: 2 Lane
Left
Right
Profile: SR99V
Tie: Offset
Offset: 0.0000
% Slope
Offset
Offset
Dependent
-2.0000
-0.0000
-12.0000
Create Input File: endtranssupers.inp
Generate Superelevation Transitions


925

Define “Shapes” in Working Alignment – Refer p. 13-20 on GEOPAK Road Manual

Now that Pavement lines are drawn and Superelevation shapes have been created we need to once again redraw both existing and proposed cross sections.

Repeat steps a,b ,c and d in section 6.8.of Chapter 6.

Use Text Editor to open the file 5lanesupers.inp. Stations are shown where normal crown begins and ends and where superelevation begins and ends for both left and right sides.

Left side (minus offset):

```
   chain  /  offset
      SR99ALI1    -30.0000
      SR99ALI1    -18.0000
   filler line station / slope
      876+00.000000       -2.0000
      899+84.080215       -2.0000
      901+54.080215       2.7000      /* Curve DC101 */
      909+39.040694       2.7000      /* Curve DC101 */
      911+09.040694       -2.0000
      926+45.000000       -2.0000

auto shape set
   shape cluster baseline    = SR99ALI1
   shape cluster profile     = SR99V
```

Right side (plus offset):

```
auto shape set
   shape cluster baseline   = SR99ALI1
   shape cluster profile    = SR99V
   shape cluster tie        = 0.0000
   dependent shape
   chain  /  offset
      SR99ALI1   0.0000
      SR99ALI1   6.0000
   filler line station / slope
      876+00.000000      -2.0000
      901+28.761066      -2.0000
      901+54.080215      -2.7000     /* Curve DC101 */
      909+39.040694      -2.7000     /* Curve DC101 */
      909+64.359843      -2.0000
      926+45.000000      -2.0000

auto shape set
   shape cluster baseline   = SR99ALI1
   shape cluster profile    = SR99V
```

Place single pattern lines at the stations:

899+84.08 (end normal crown left side)
901+28.76 (end normal crown right side)
901+54.08 (begin full super)
909+39.04 (end full super)
909+64.36 (begin normal crown right side)
911+09.04 (begin normal crown left side)

In addition a pattern line needs to be placed where there is a cross slope of 0. This condition will occur on the left side between end of normal crown and beginning of full super and between end of full super and beginning of normal crown.

The first occurrence of zero slope is found by determining the rate of change in slope:

.027- (-.020)=.047 (change in cross slope from normal crown)
90154.08 – 89984.08 = 170 (Transition Length)
0.047/170 = .00028 (Rate of change in cross slope)

Difference in cross slope (from normal Crown):
0.020 – 0.000 = 0.020
0.020/.00028 = 71.42

Add distance to end of normal crown station:
89984.08 + 71.42 = 90055.51

This is where zero cross slope occurs as the roadway transitions from tangent to super.

At the other end the distance will be the same so subtract from begin normal crown station:
91109.04 – 71.42 = 91037.58

This is where zero cross slope occurs as the roadway transitions from super back to tangent.

Now, place single pattern lines at 900+55.51 and 910+37.58

In addition, place single pattern lines at 885+25 and 919+80. These are the beginning and end curb and gutter sections

Open file RFSR099MainlineXSections.dgn and, in Project Manager, select Existing Ground Cross Sections, run SR099, and draw cross sections.

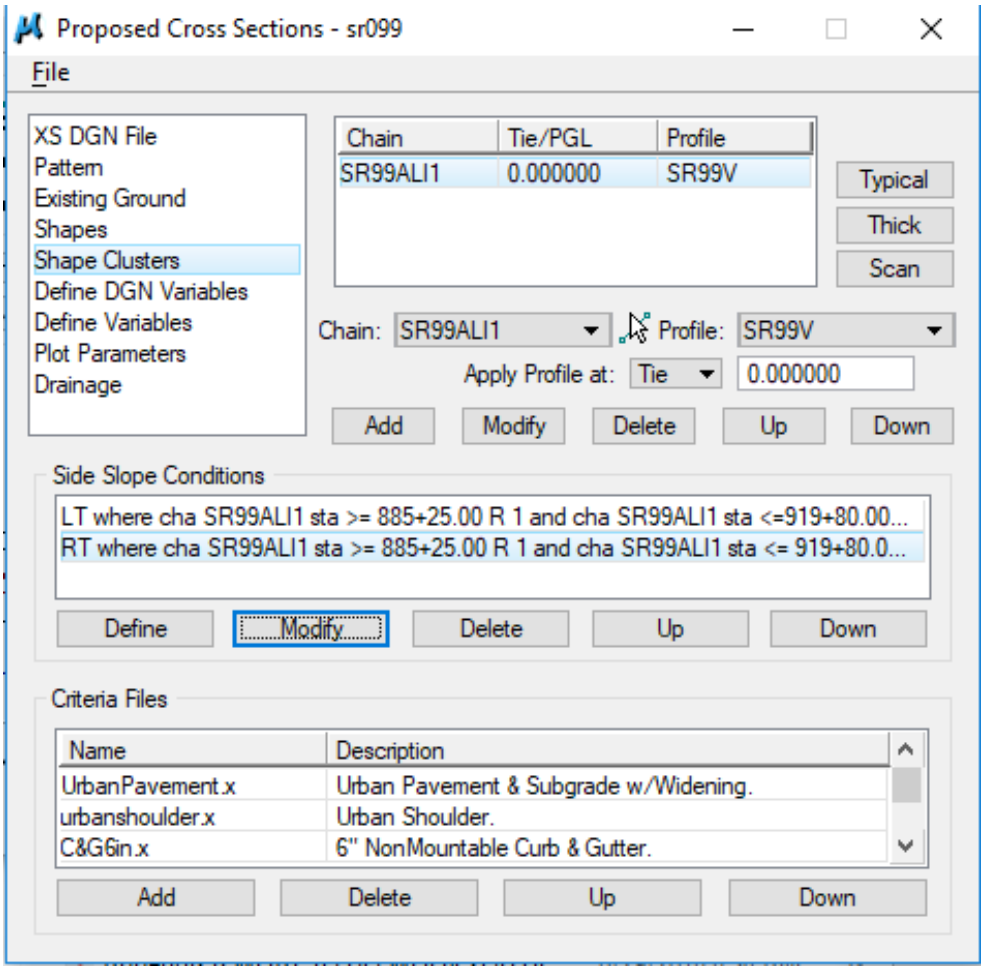
Open file RFSR099RoadwayPattern.dgn ,change symbology on lines before 876+00 and after 926+45 to co=3

Open file RFSR099MainlineXSections.dgn and, in Project Manager, select Proposed Cross Sections, run SR099.

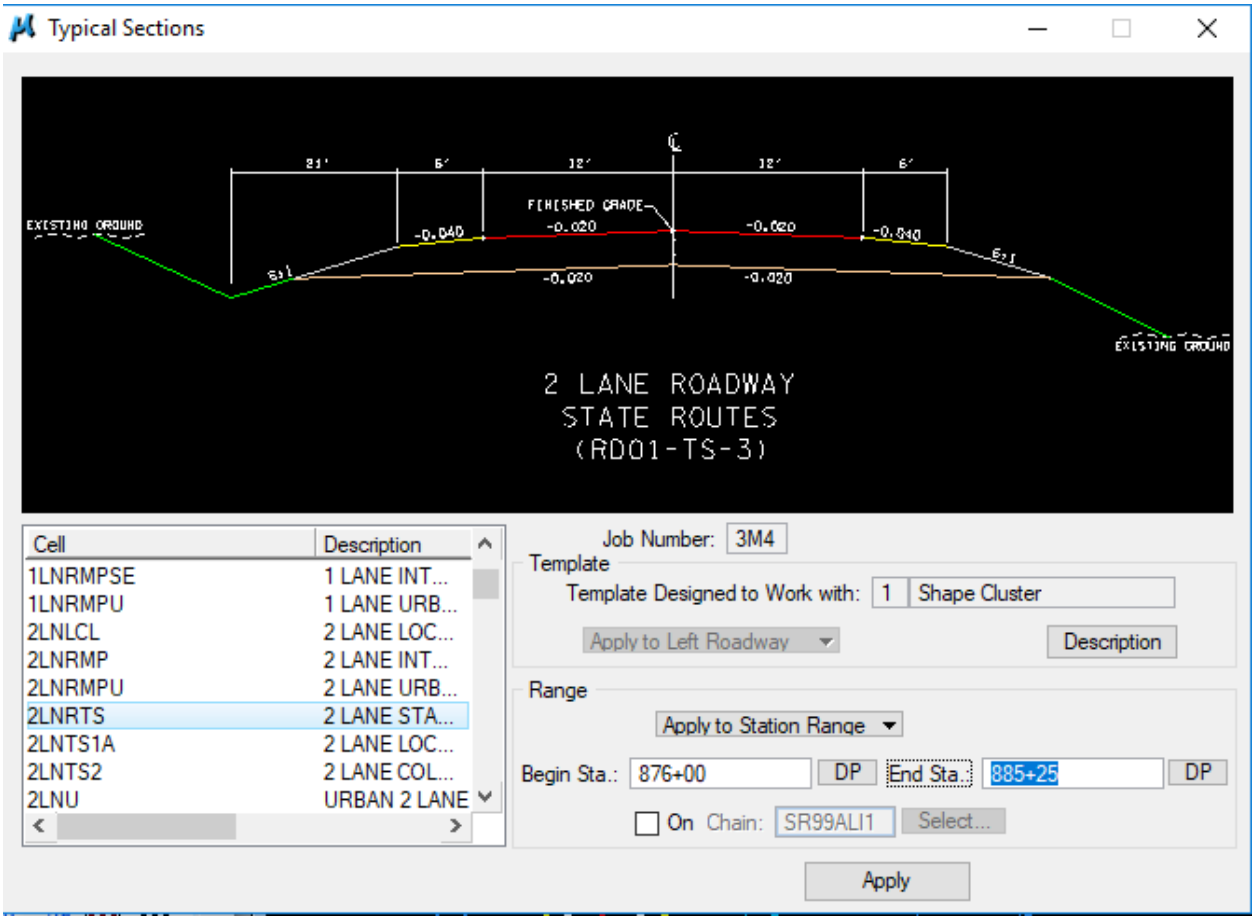
Some changes need to be made before proposed cross sections are run again.:

Select Shapes and check “Use Working Alignment Definition” .

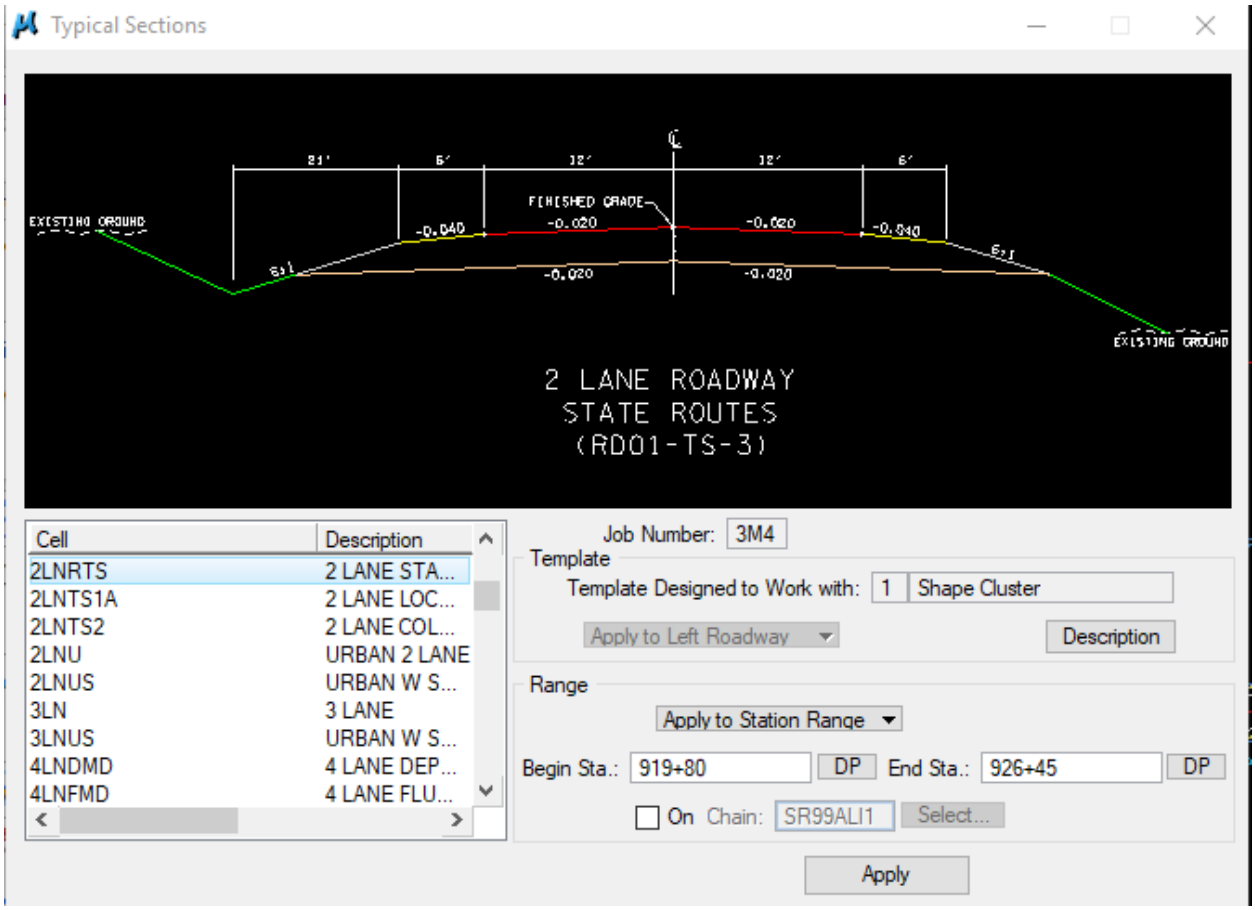
Shape Clusters:
Adjust for the transitions at the beginning and end. In the preliminary run the curb and gutter template was applied for the entire alignment. First change the beginning and end stations to the original shape cluster to the stations for beginning and end of curb and gutter:



Add a new template for the beginning transition section:

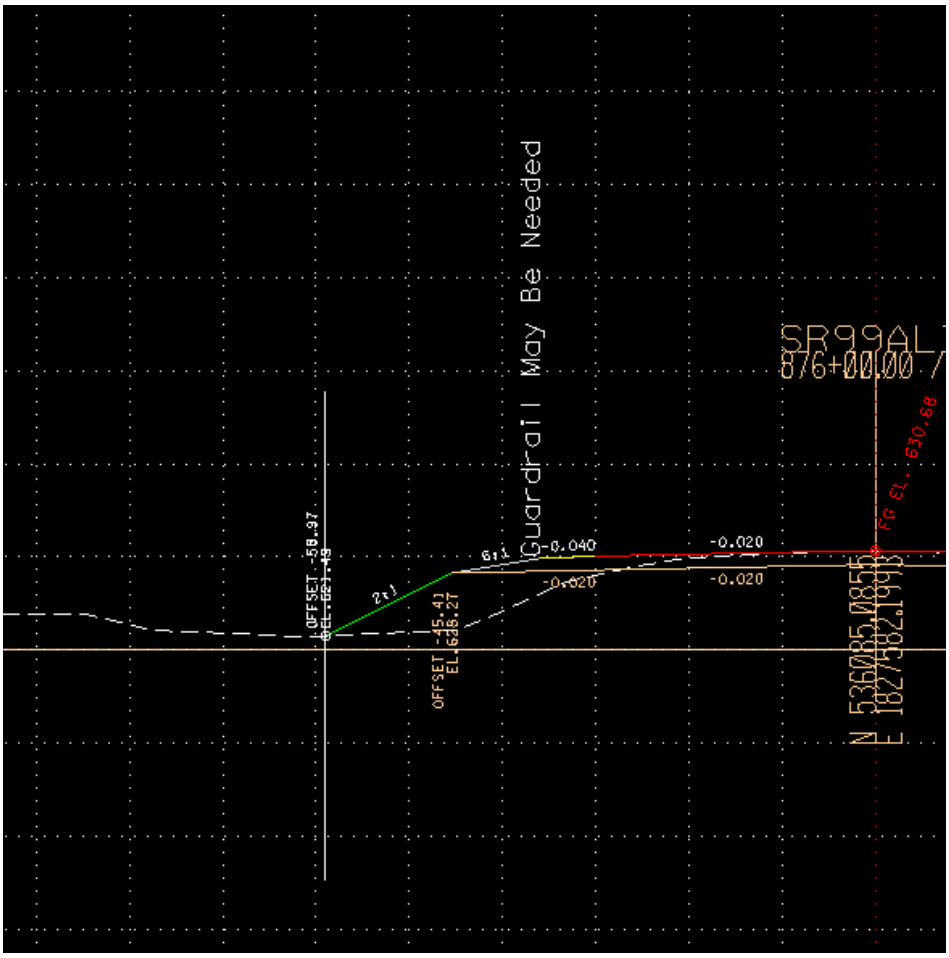


Then add same template for end transition section:



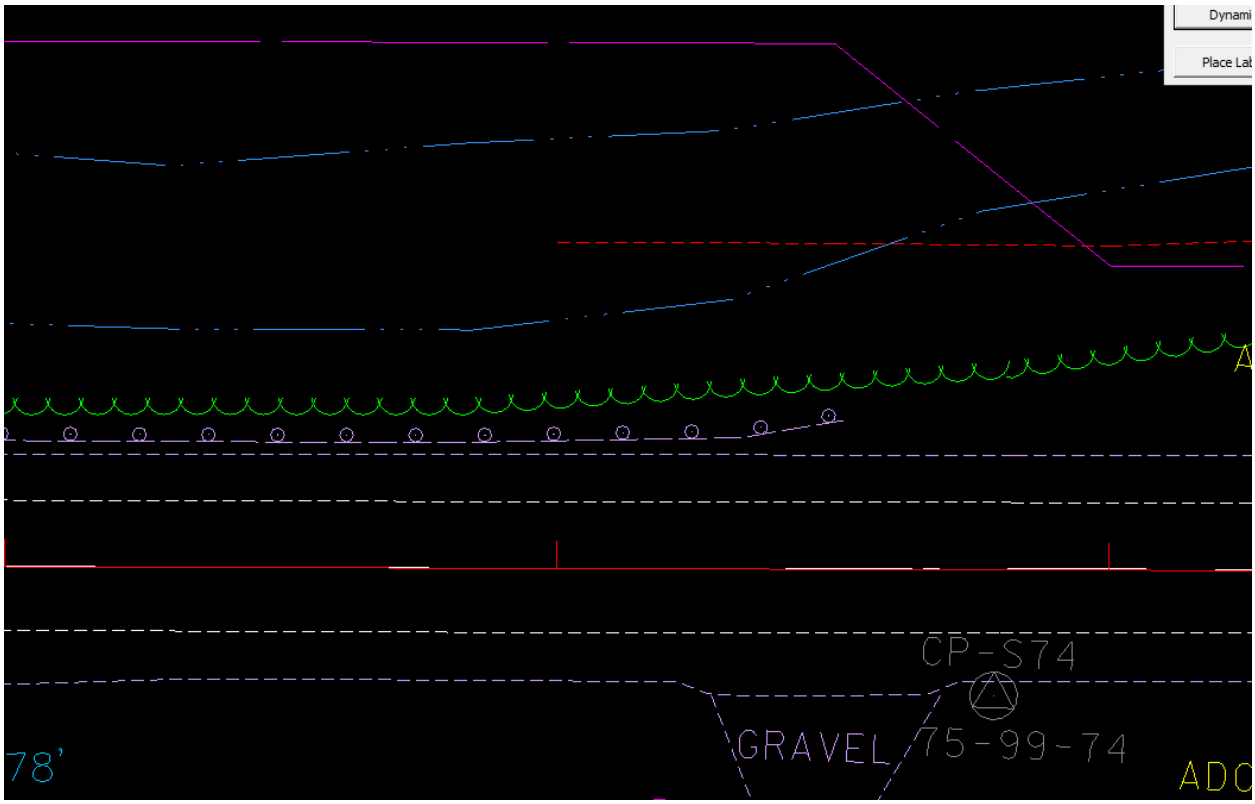
To get the cross sections to run properly it was necessary to create three separate runs for each section – the beginning transition , curb and gutter, and end transition. Also the side slopes for the curb and gutter section were fixed at 3:1. It may not always be necessary to make separate runs.

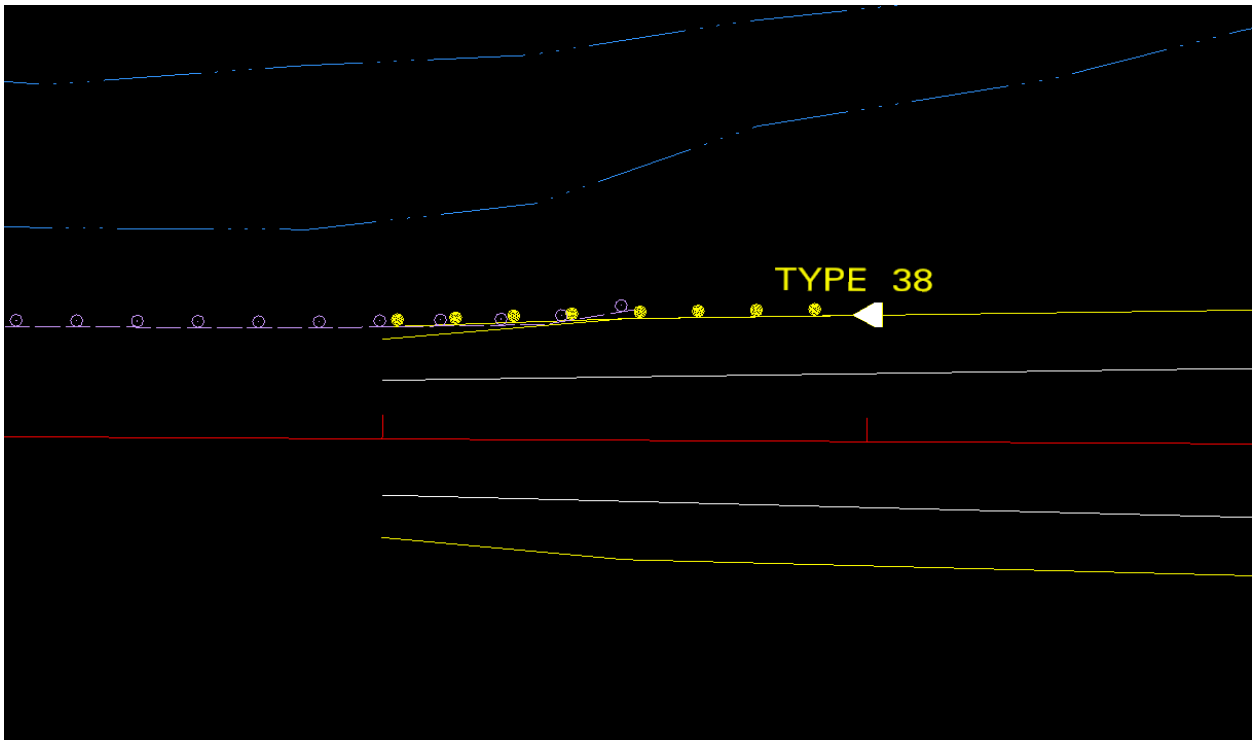
Beginning trans. Section, 876+00 – 885+25:
Some of the cross sections in this range show a message “Guardrail may be needed”



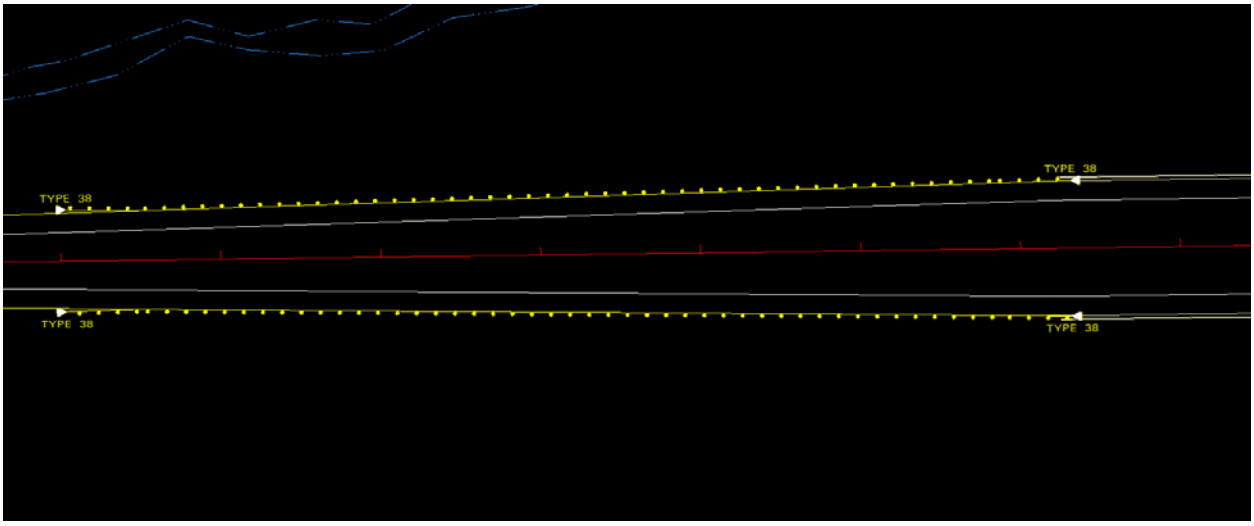
The sections that show this message are 876+00, 876+50, 879+50-885+25 on left, 879+50 – 884+50 on right

At 876+00 lt,, the beginning of construction, there is existing guard rail. Proposed guardrail can tie to the existing at this station.



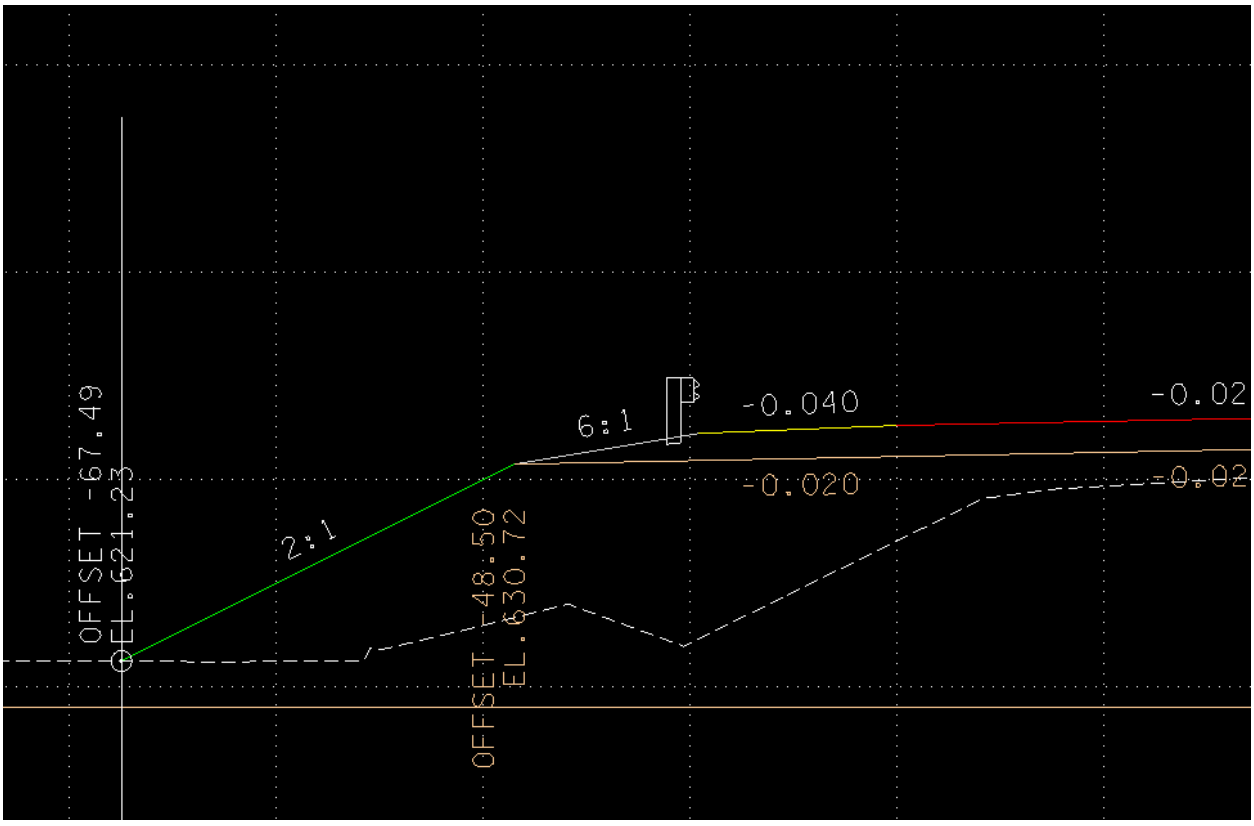


Proposed guardrail w/type 38 end terminal and showing exist. guardrail



Proposed guardrail w/type 38 end terminals from 879+50 to 885+25, both sides

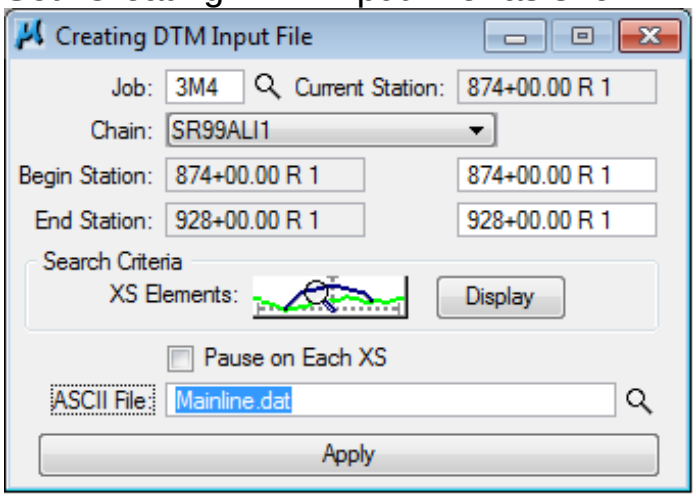
Now that guardrail has been placed,run proposed cross sections again:



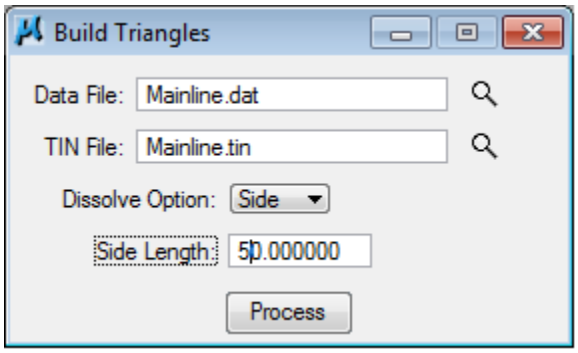
Guardrail placed on cross sections

Save proposed surface from cross sections just created. Refer Section II of Exercise 22 in GEOPAK Road Manual

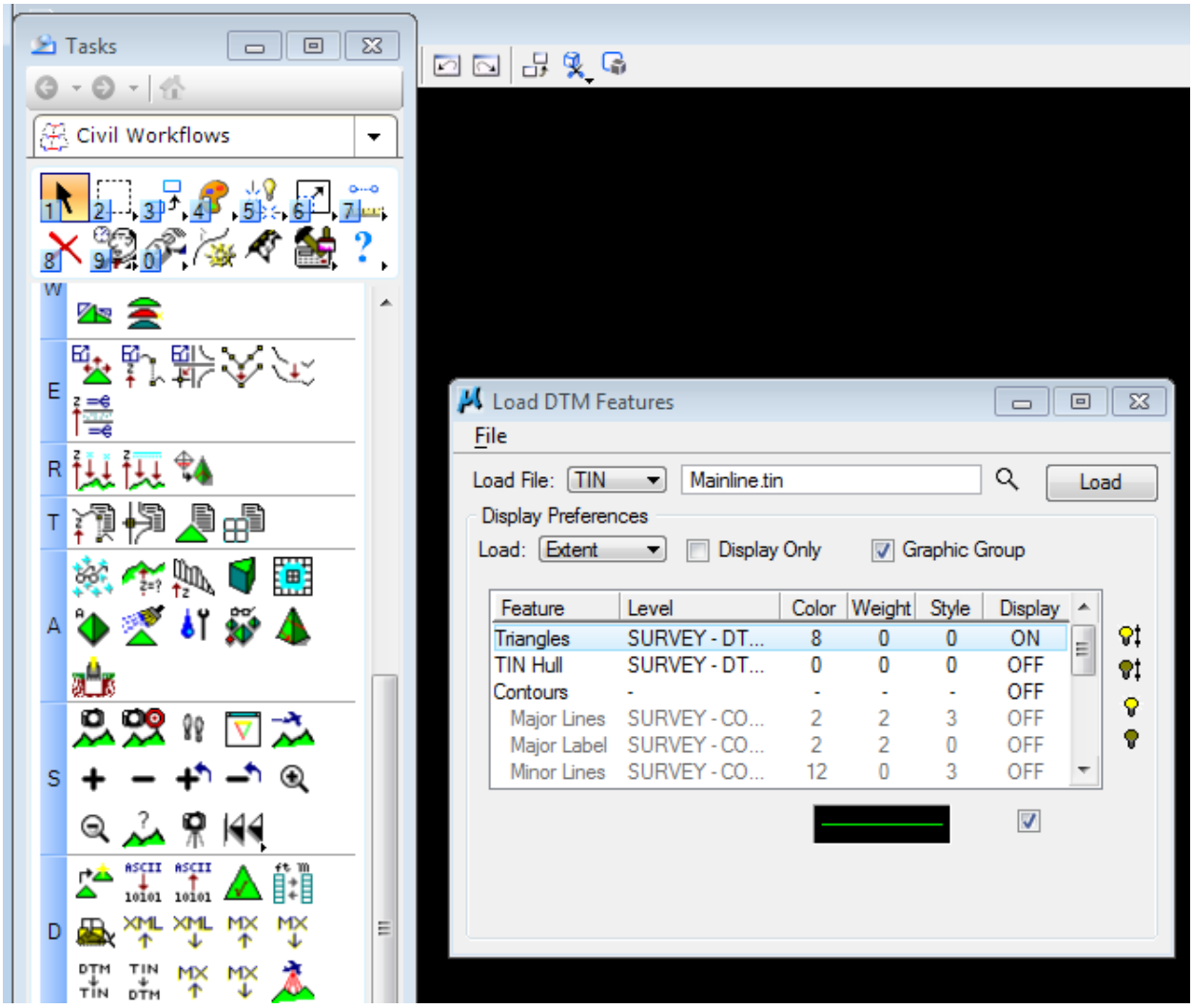
Set “Creating DTM Input File” as shown:

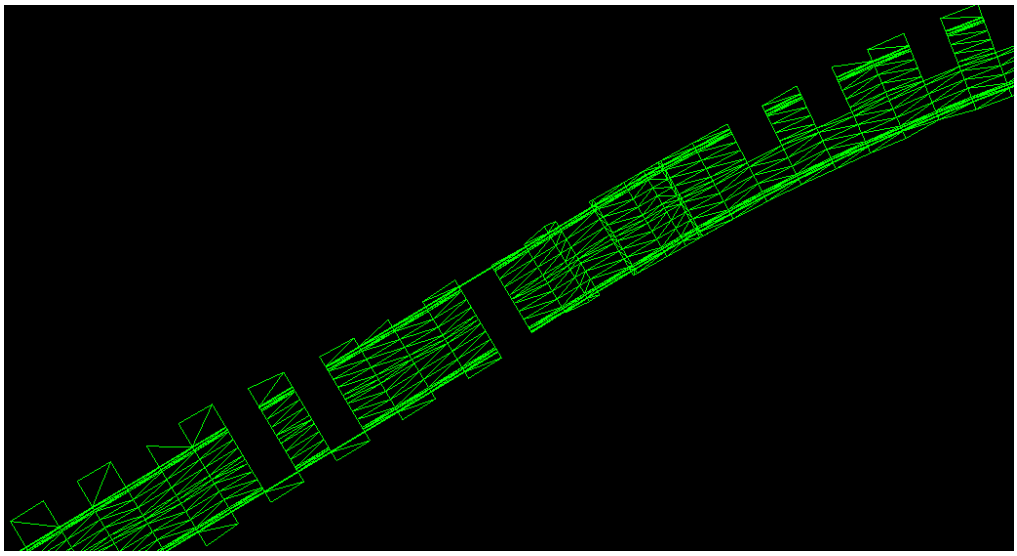


Set “Bulid Triangles” as shown, and process:



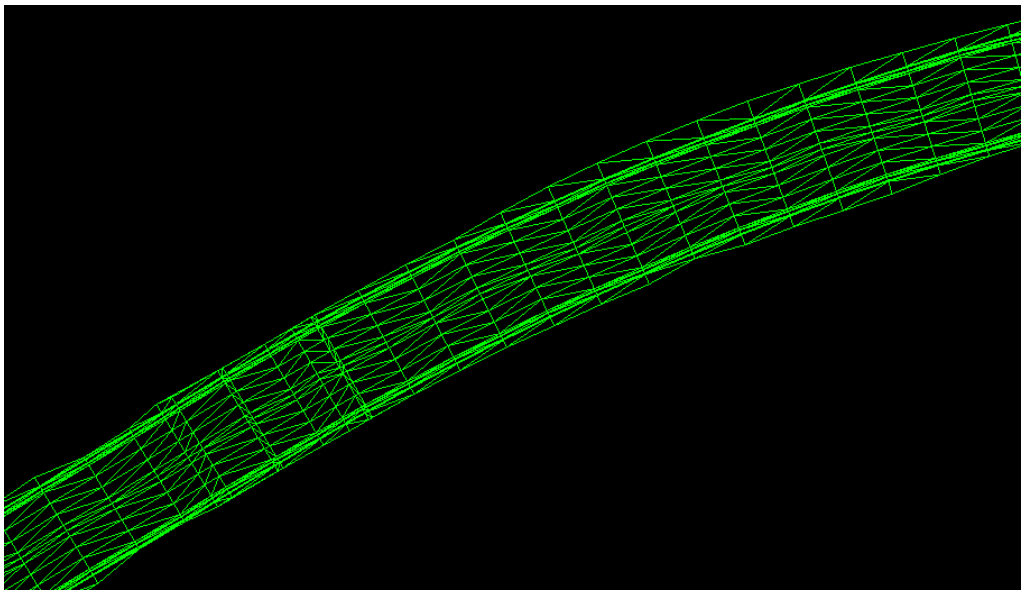
Create new dgn file “Triangles.dgn” w/ seed2D.dgn seed file. Select “Load DTM Features” to display newly created surface. Turn all features off except triangles. Fit View to see triangles.





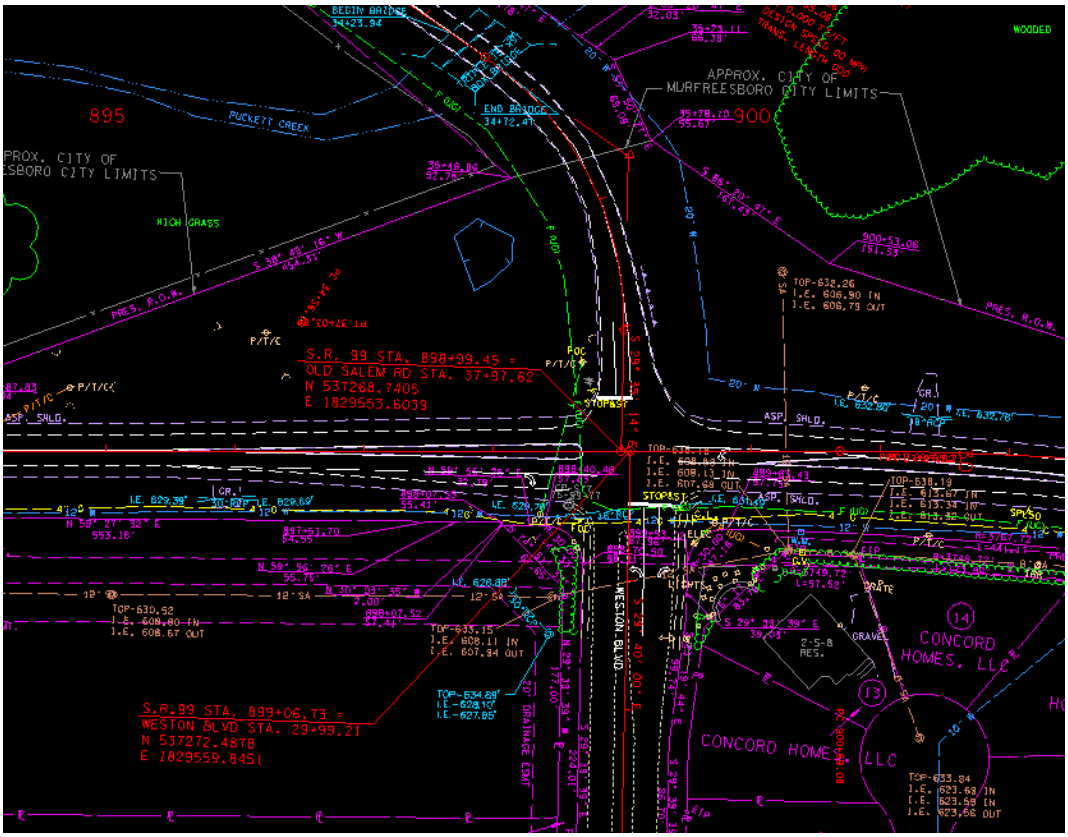
If you see gaps in the surface, you need to build triangles again with a different value for “Side Length”

Delete triangles w /Graphic Group lock, run Build Triangles again with Side Length = 75.



SIDE ROADS

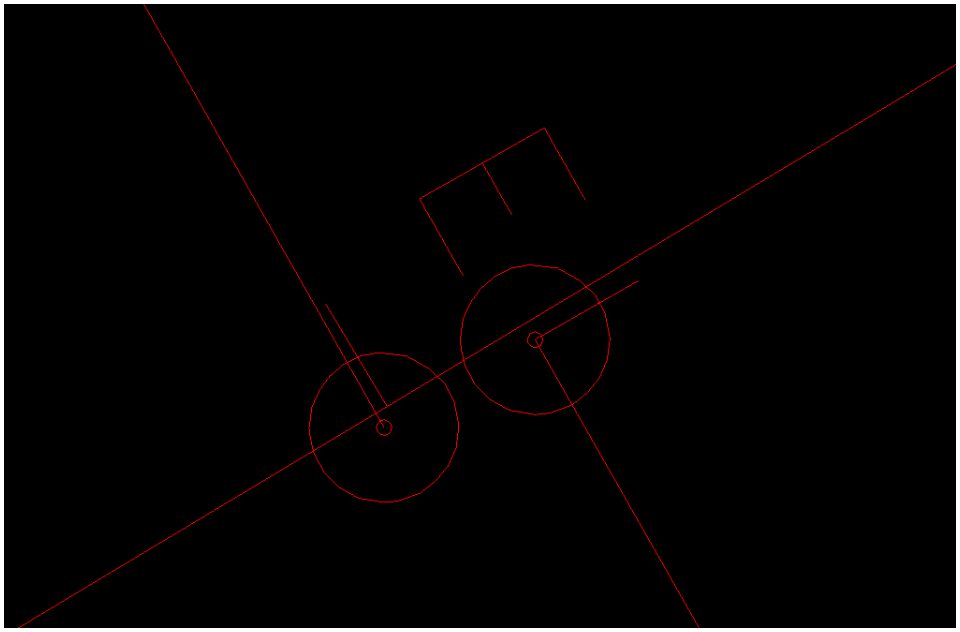
The side roads Old Salem Highway and Weston Blvd. intersect the mainline approximately at station 899+00 as shown:



There are two other side roads in this section of S. R. 99. To simplify this manual, we will not consider those two.

The mainline and side road alignments were displayed in the file RFSR099Alignment.dgn using D&C Manager. The mainline is the updated SR99 Alignment. The side roads are the preliminary alignments provided by survey.

On closer inspection, it is found that the preliminary side road centerlines do not intersect the new mainline centerline.



Old Salem Highway and Weston Blvd.

Similarly, as was done with the mainline, new side road centerlines will need to be created, intersecting with the mainline.

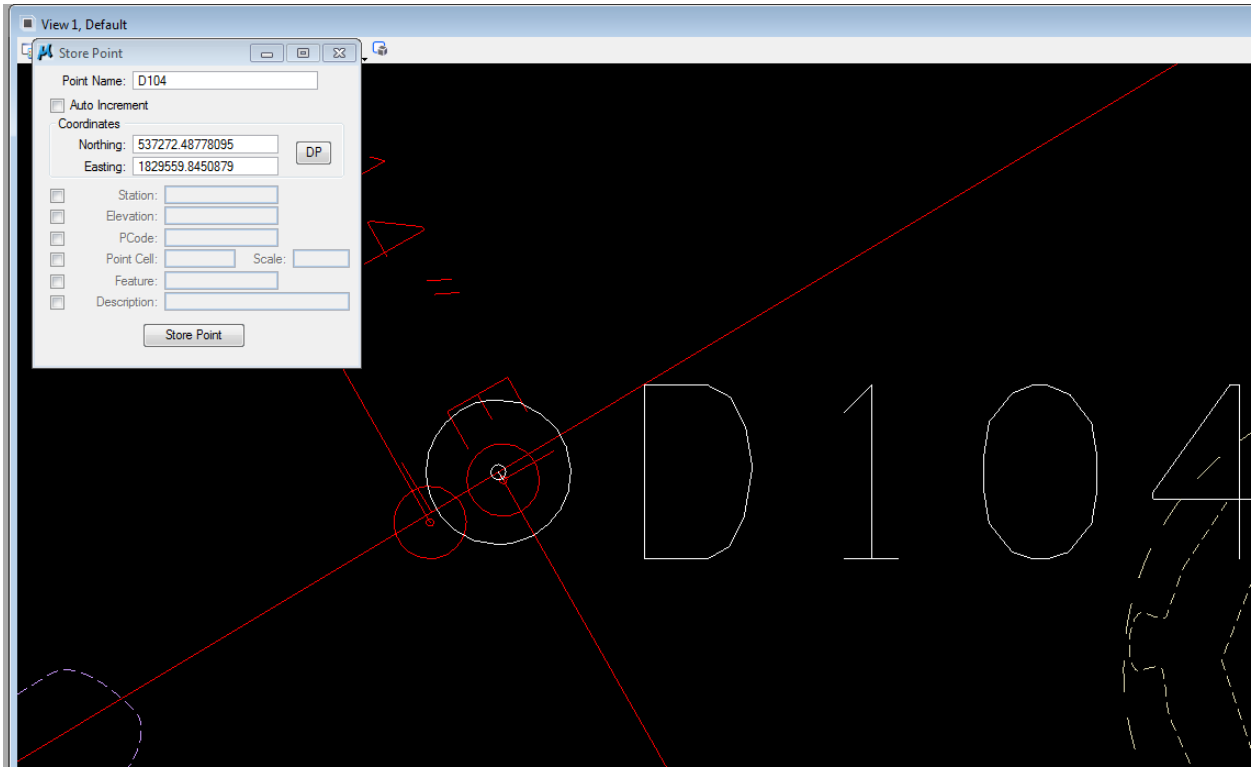
Old Salem Road and Weston Blvd. w/existing EOP

In Navigator, describe chain OLDSALEM:

Chain OLDSALEM contains:
S21109 CUR SC10 S21105

Redefine Old Salem Road

Graphically extend the tangent line on Weston Blvd. to intersect mainline and locate point D104 at intersection. D104 will be the new ending point for Old Salem and the new beginning point for Weston.



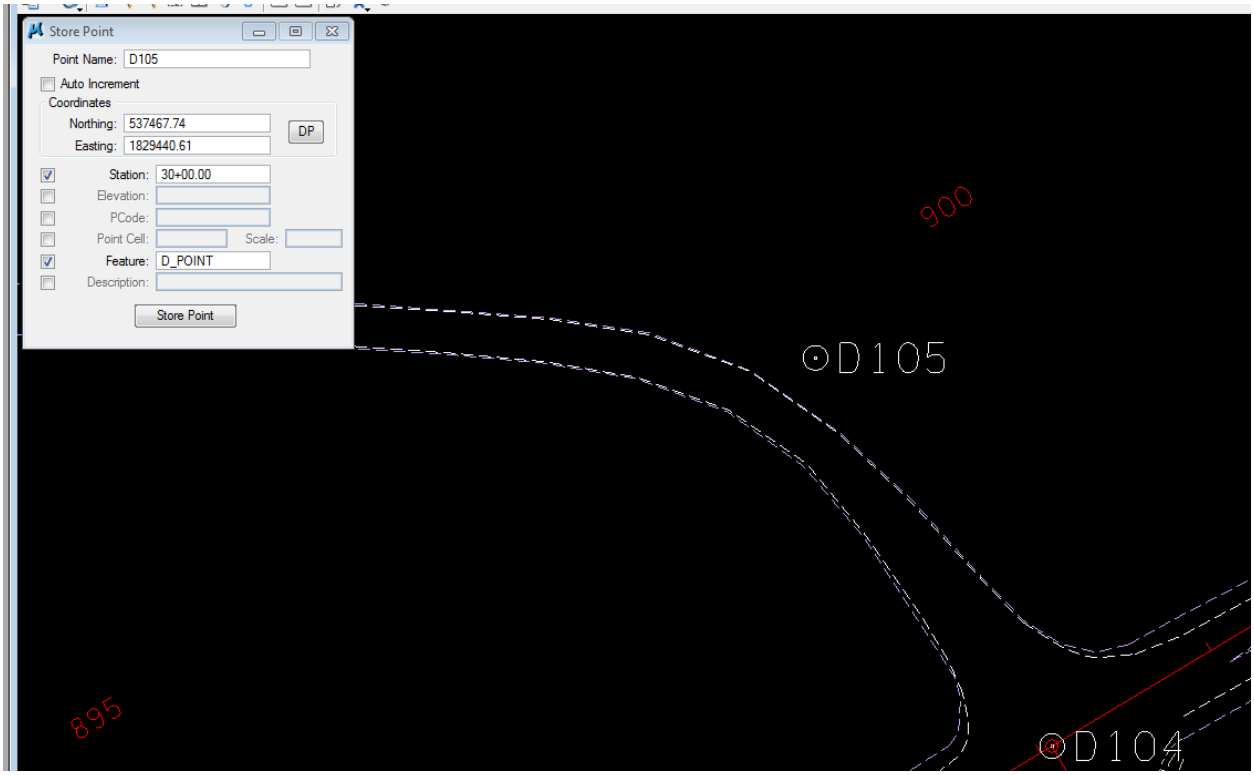
In COGO Navigator, select chain OLDSALEM and save as “OLDSALEMPRE” by selecting the “Store Chain” option

The new chain “OLDSALEM” will intersect the mainline SR99 at point D104. In addition the curve, now SC10 will need to be redefined since the tangent from the PI of the curve to the ending point at the intersection has changed. Describe curve SC10 in Navigator:

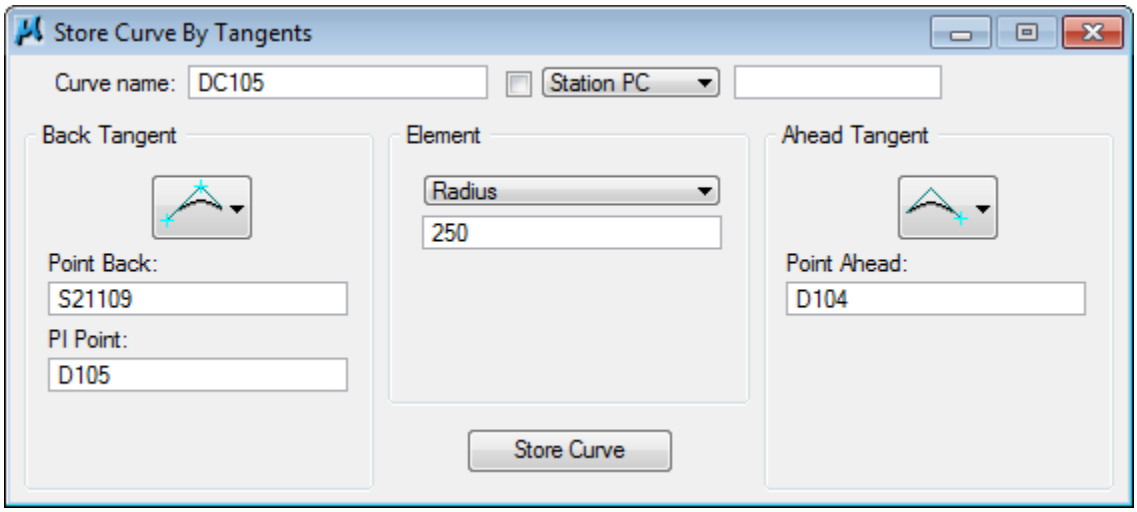
Curve SC10
P.I. Station 35+91.24 N 537,467.74 E 1,829,440.61
Delta = 56° 45' 33" (RT)
Degree = 22° 55' 05"
Tangent = 135.06

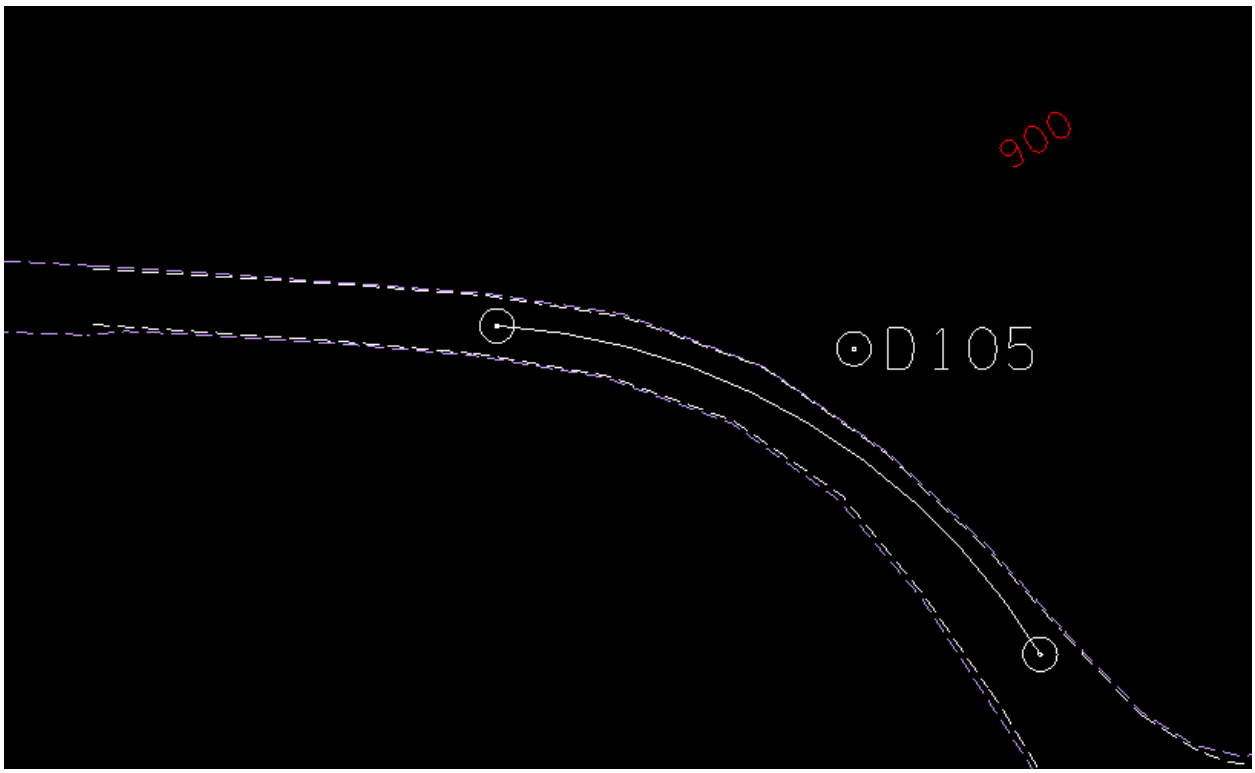
Length = 247.66
Radius = 250.00
External = 34.15
Long Chord = 237.66
Mid. Ord. = 30.05
P.C. Station 34+56.18 N 537,476.35 E 1,829,305.83
P.T. Station 37+03.84 N 537,350.29 E 1,829,507.30
C.C. N 537,226.85 E 1,829,289.90
Back = S 86° 20' 47" E
Ahead = S 29° 35' 14" E
Chord Bear = S 57° 58' 00" E

Define a new point, “D105” locate it at the same NE coordinates as the PI for curve SC10

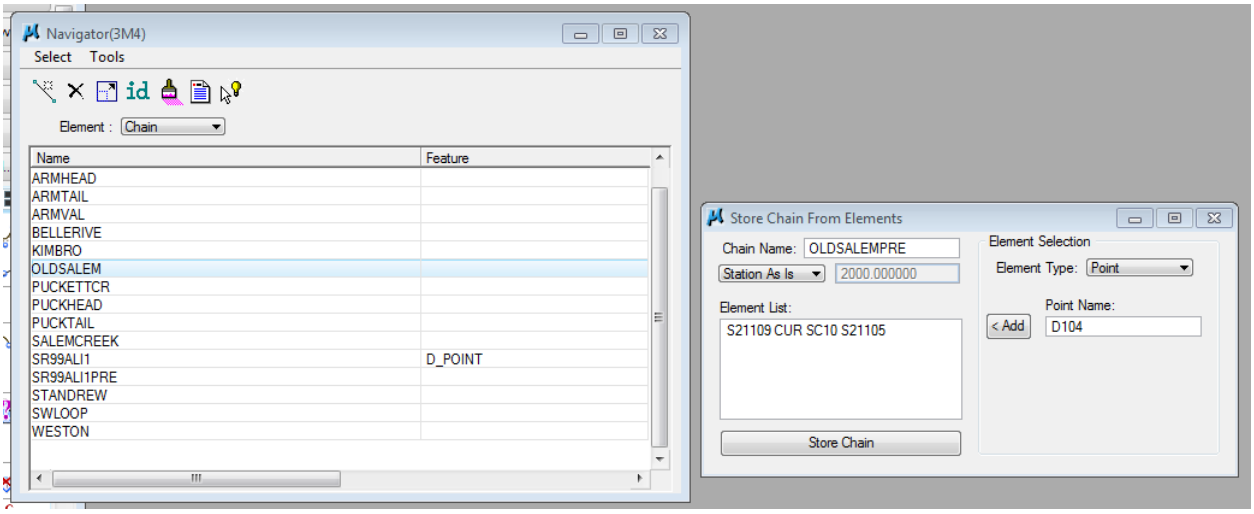


Define new curve “DC105”:

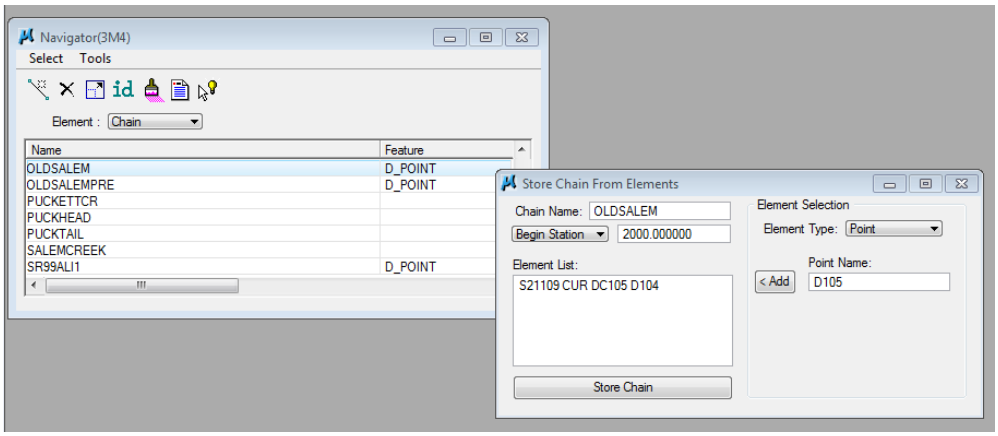

Store Curve By Tangents
Curve name:
DC105
Station PC
Back Tangent
Point Back:
S21109
PI Point:
D105
Element
Radius
250
Store Curve
Ahead Tangent
Point Ahead:
D104


900
D105

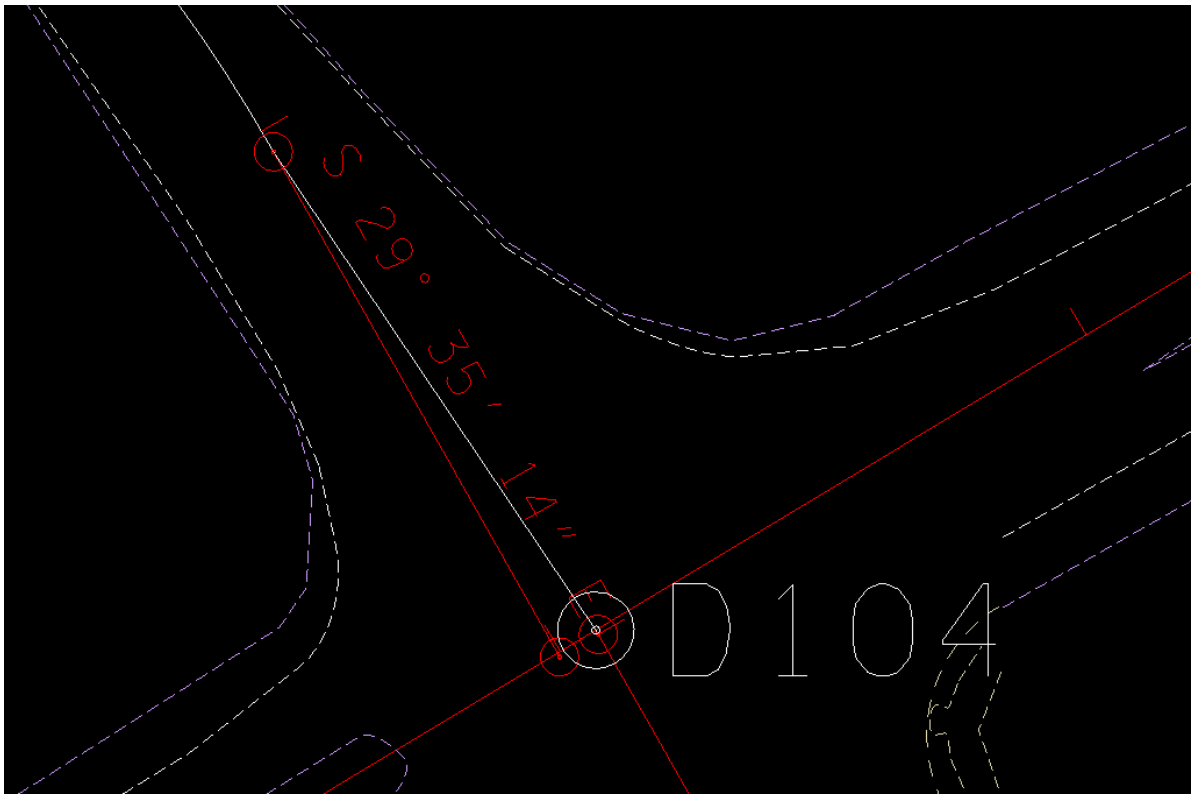
Again select OLDSALEM in Navigator:



Replace point S21105 with D104 and curve SC10 with DC105. Set “Begin Station” to 2000. This is the original beginning station for Old Salem Road. Ensure that “Redefine” is selected in main COGO dialog.



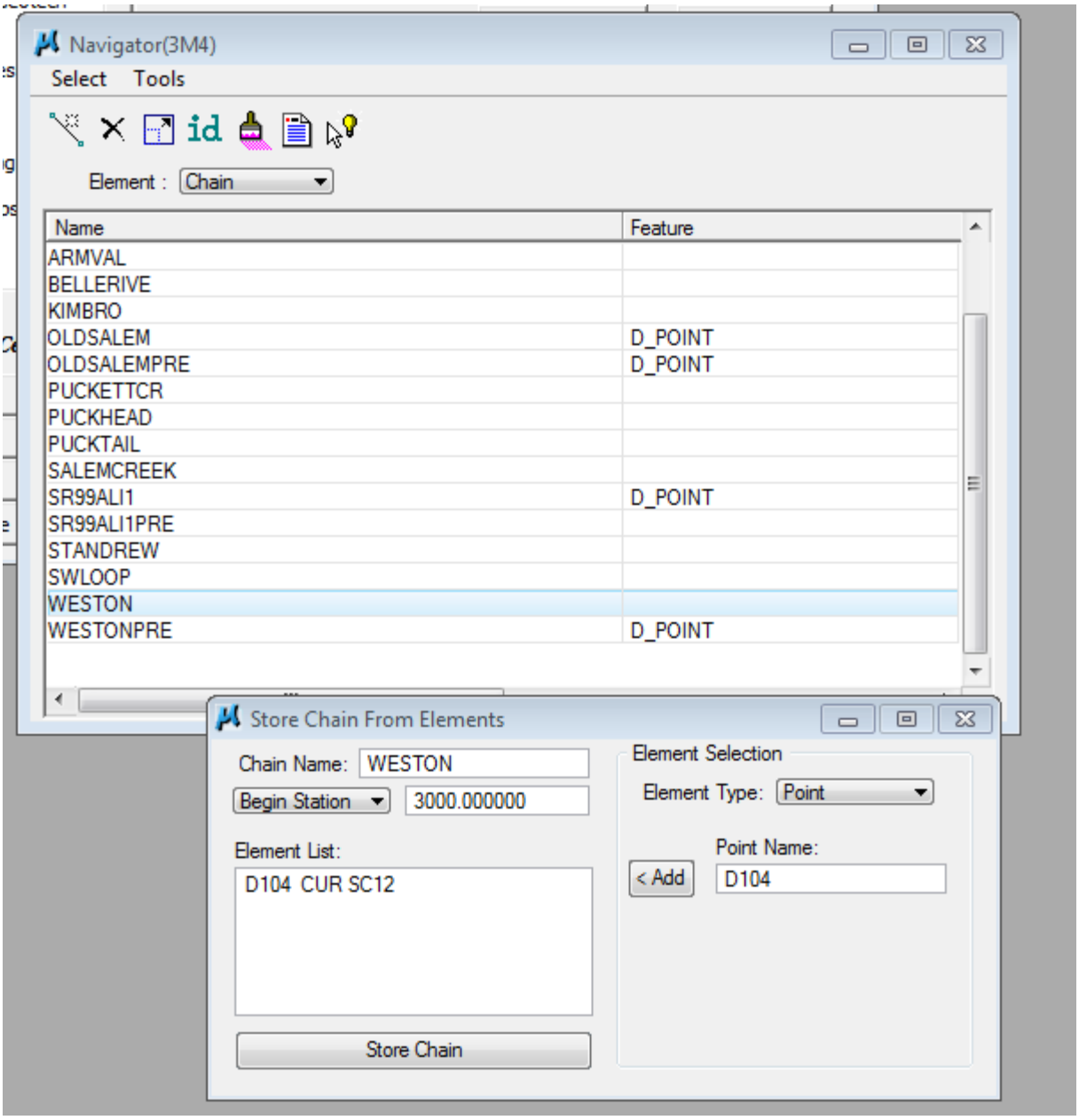
When “Store Chain” is selected the new “oldsalem” alignment is displayed in white, aligned with Weston Blvd. the original alignment is still displayed in red.

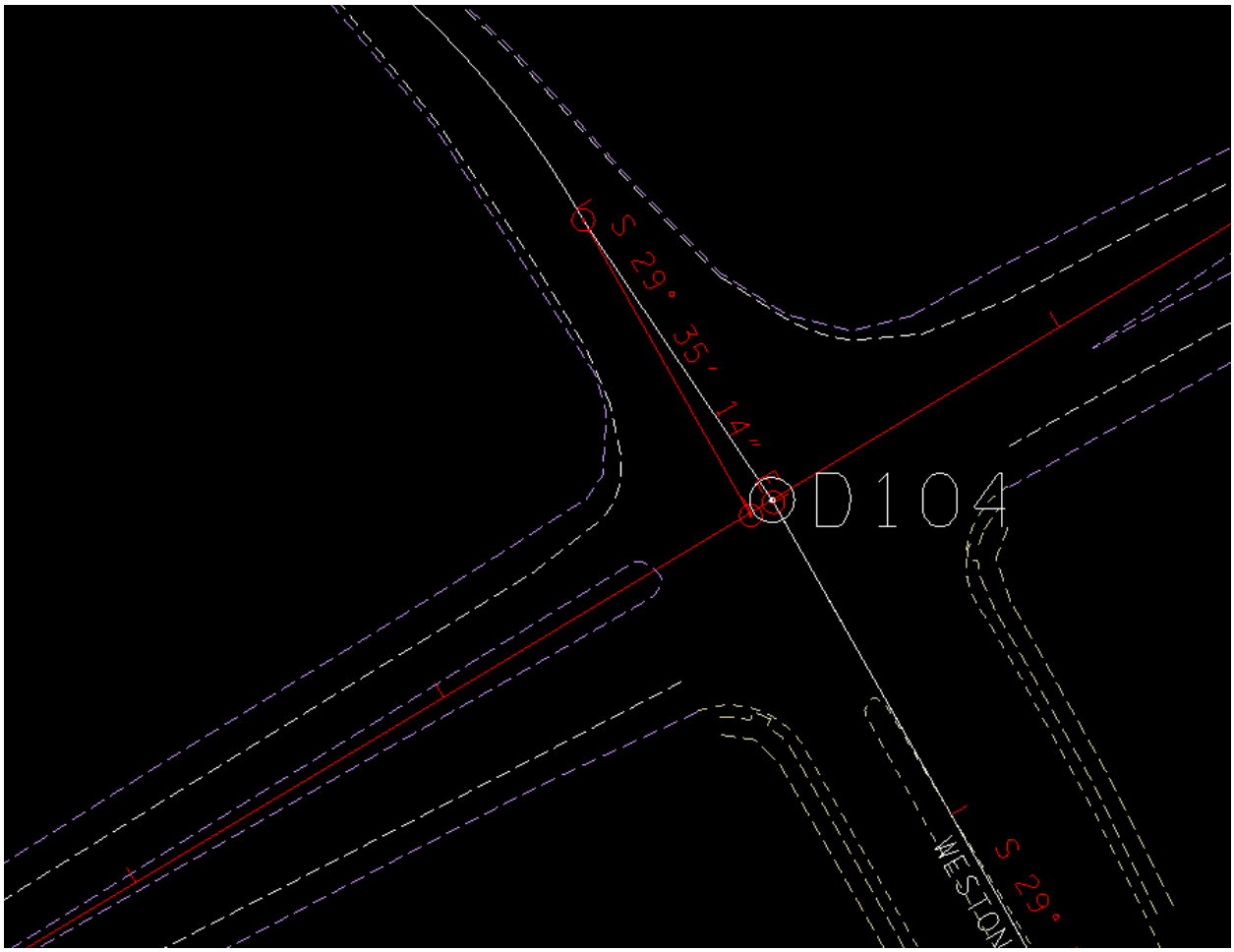


Redefine Weston Blvd.

As previously, in COGO Navigator select chain WESTON and save as “WESTONPRE”

Select chain WESTON, define Begin Station as 3000. Replace point S21117 with D104. Ensure that “Redefine” is selected in main COGO dialog.

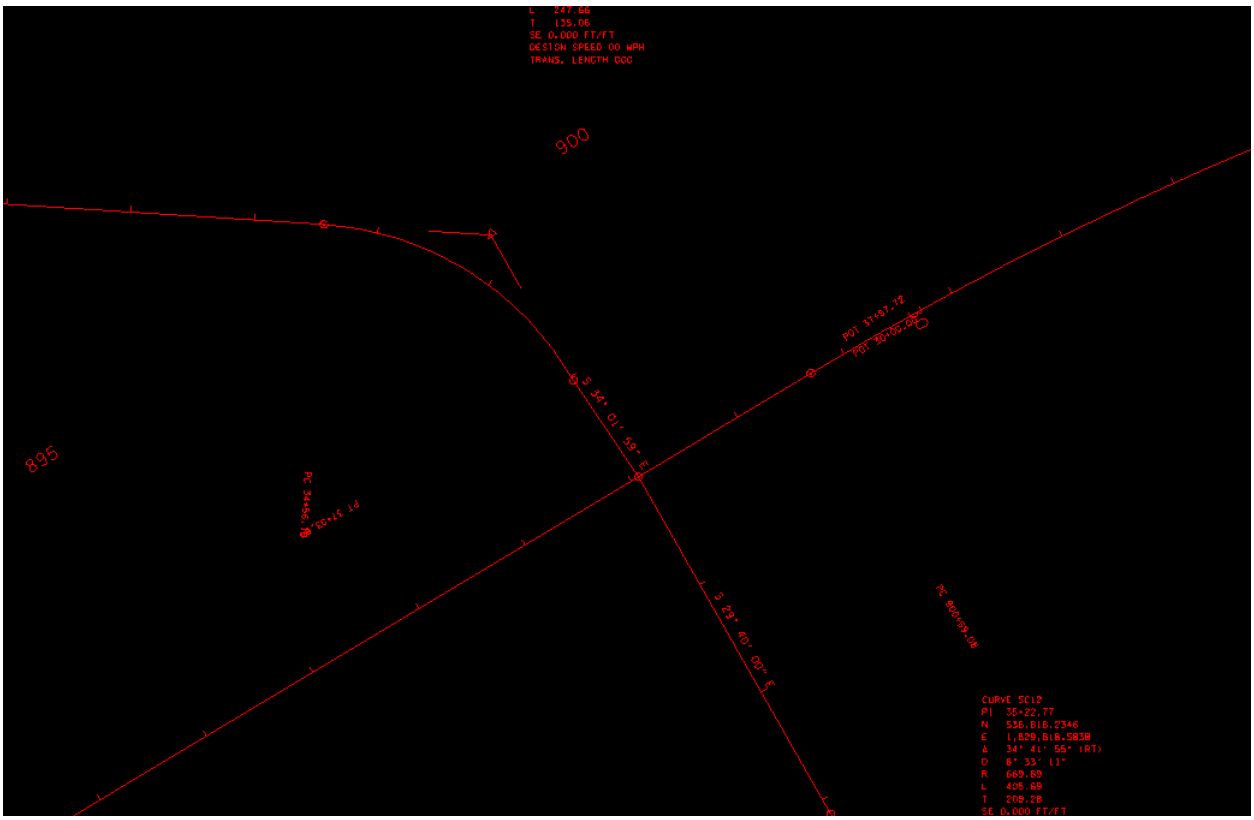

Navigator(3M4)
Select Tools
Element : Chain
Name
Feature
ARMVAL
BELLERIVE
KIMBRO
OLDSALEM
D_POINT
OLDSALEMPRE
D_POINT
PUCKETTCR
PUCKHEAD
PUCKTAIL
SALEMCREEK
SR99ALI1
D_POINT
SR99ALI1PRE
STANDREW
SWLOOP
WESTON
WESTONPRE
D_POINT
Store Chain From Elements
Chain Name: WESTON
Begin Station
3000.000000
Element List:
D104 CUR SC12
Store Chain
Element Selection
Element Type: Point
Point Name:
< Add
D104



The new “Oldsalem” and “Weston” alignments, intersecting the mainline at D104.

Display new Side Road alignments

In the file RFSR099Alignment.dgn, turn off the level DESIGN-CENTERLINE-Proposed GPK Visualizations. Delete all graphics of the original alignments of the side roads. Use D&C Manager to display Chains, Stationing, and Points for each side road.



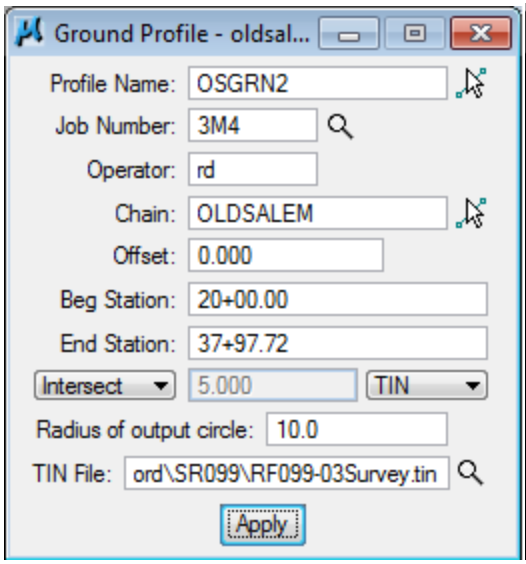
D&C Manager display of Old Salem and Weston

Create Side Road Ground Line Profiles

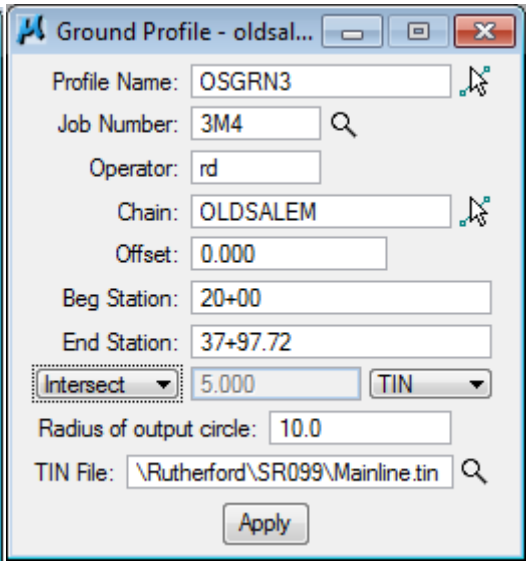
Create Existing Ground Line profiles for both the existing road and proposed mainline for each side road by making settings as shown:

Old Salem:

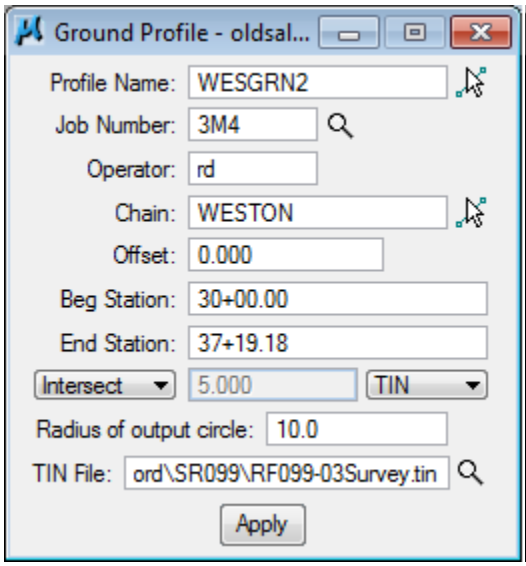
Ground line

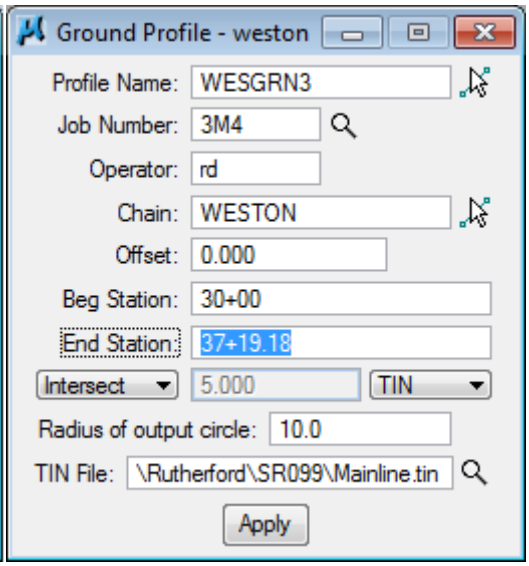


Mainline



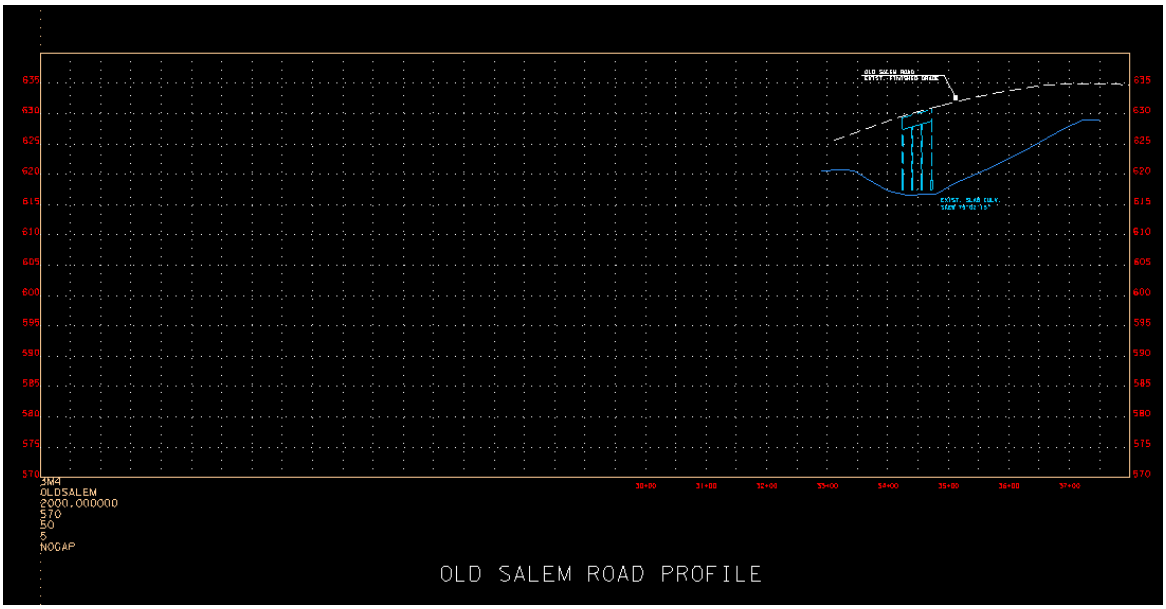
Weston:



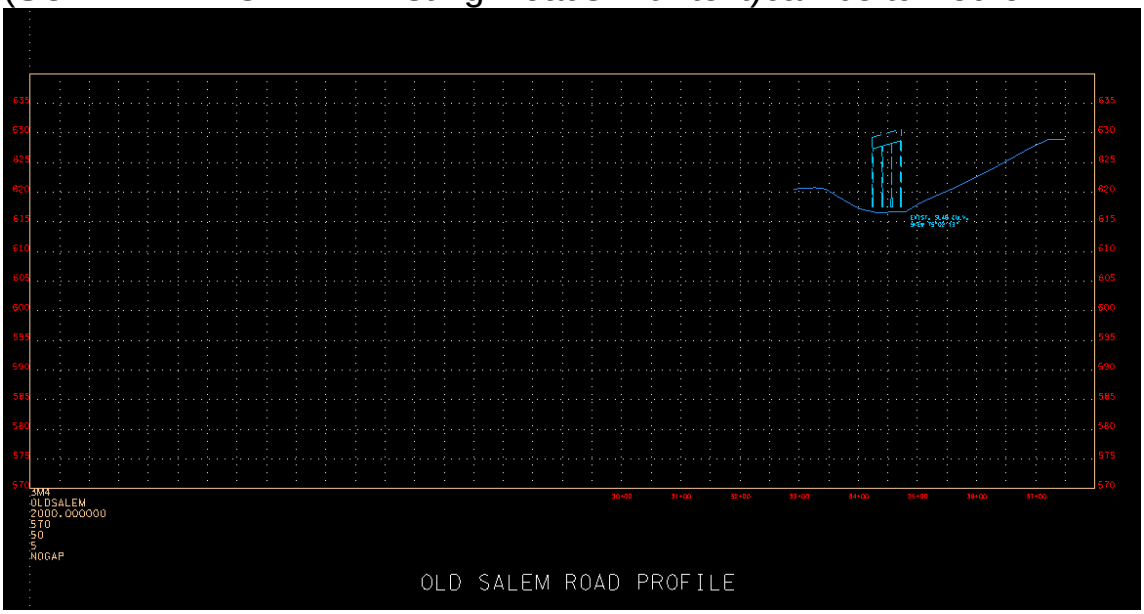


Display Ground Line Profiles

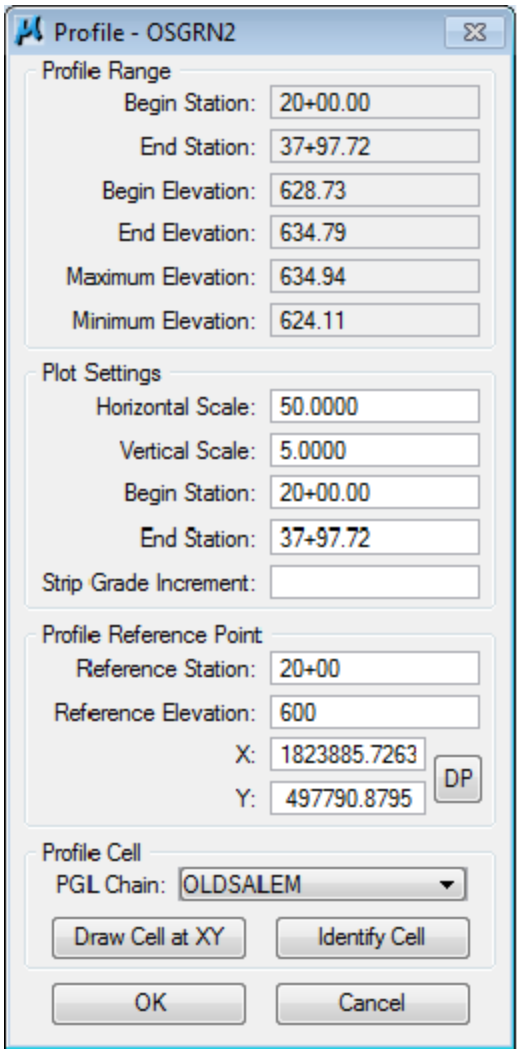
Old Salem:
In File RFSR099Alignments.dgn, turn on display for Survey reference file and locate the Old Salem Road Profile. In Level Display, select master file and Survey reference. Select Filters and Sheets-Profile to display the needed levels.

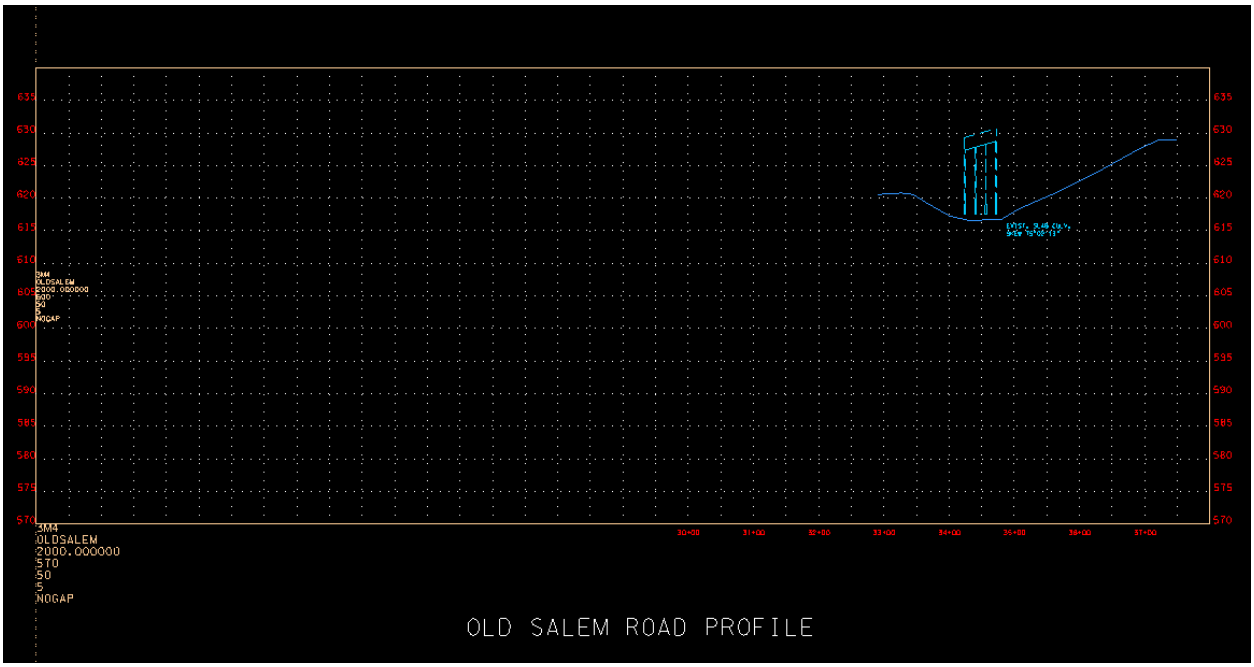


This in the profile of the original alignment. Since the horizontal alignment has changed the ground line shown is not needed so that reference level (SURVEY-PROFILE-Existing Roads with text)can be turned off

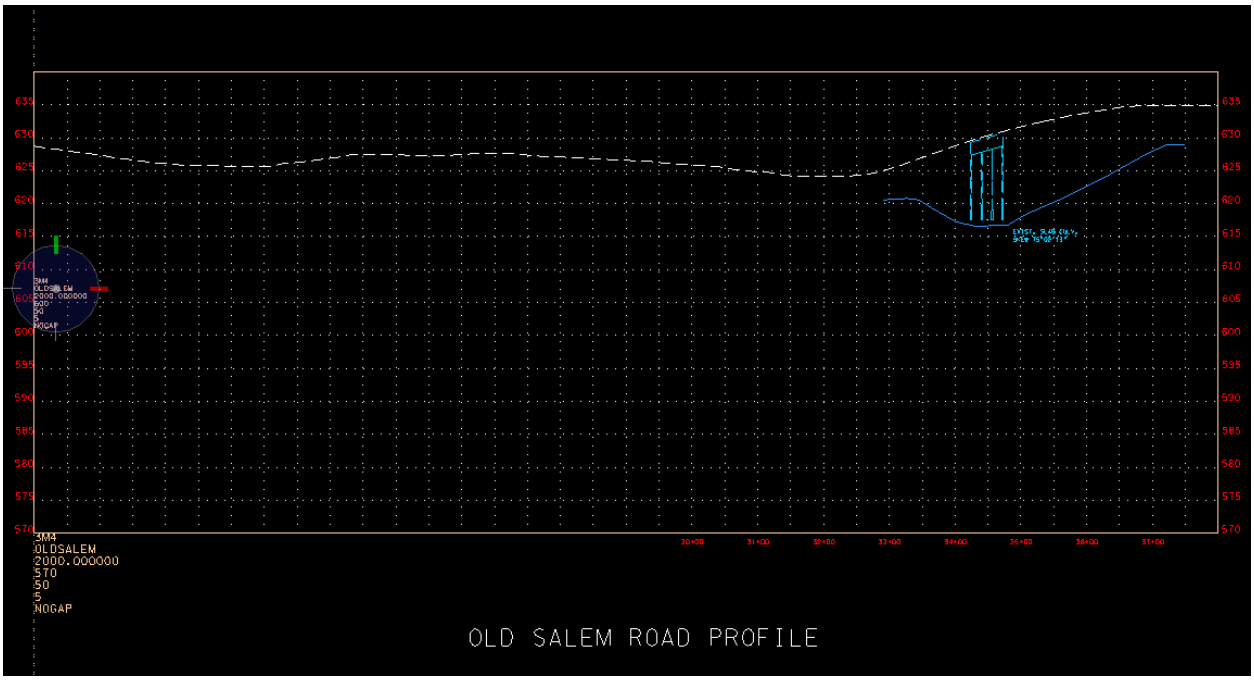


In D&C Manager, Exist Profiles – Exist Ground, select the profile OSGRN2. Select DP and snap to the 600 elevation point on the left side of the grid., then pick “Draw Cell at XY”:

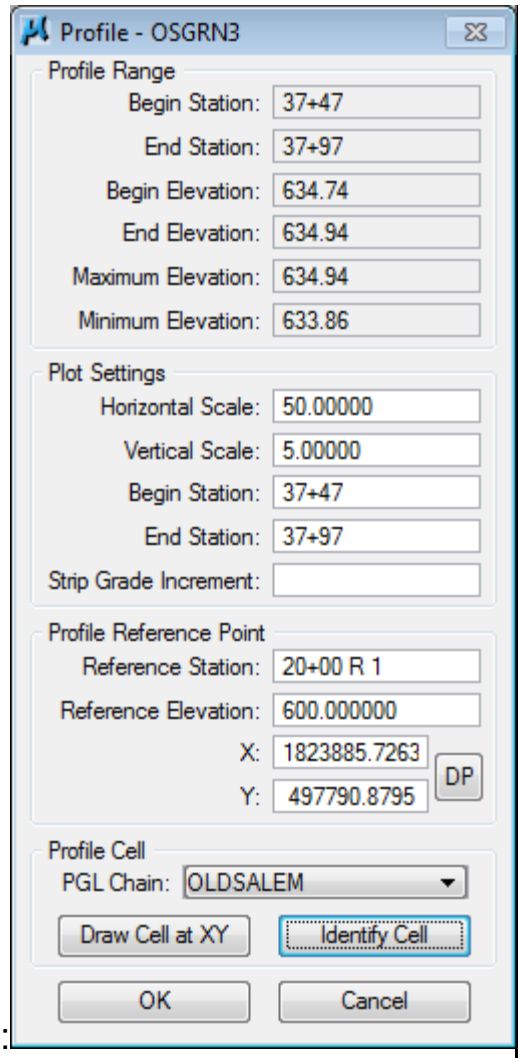




Then OK to draw ground line:



Draw profile for mainline intersection (profile OSGRN3):

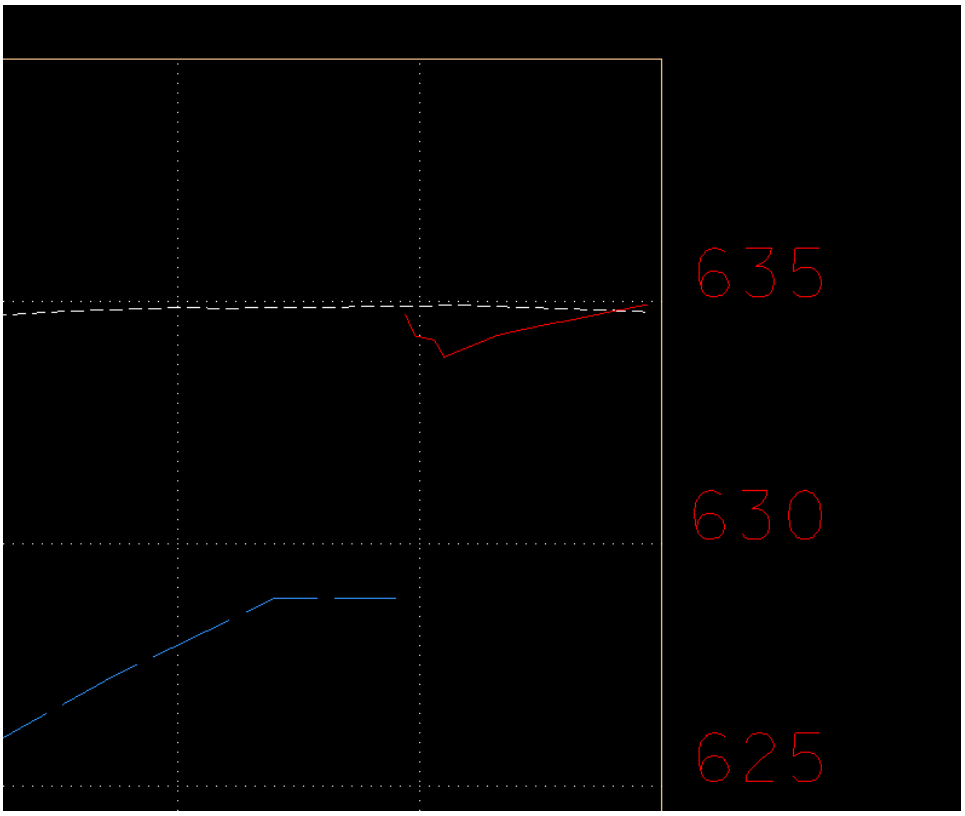


:

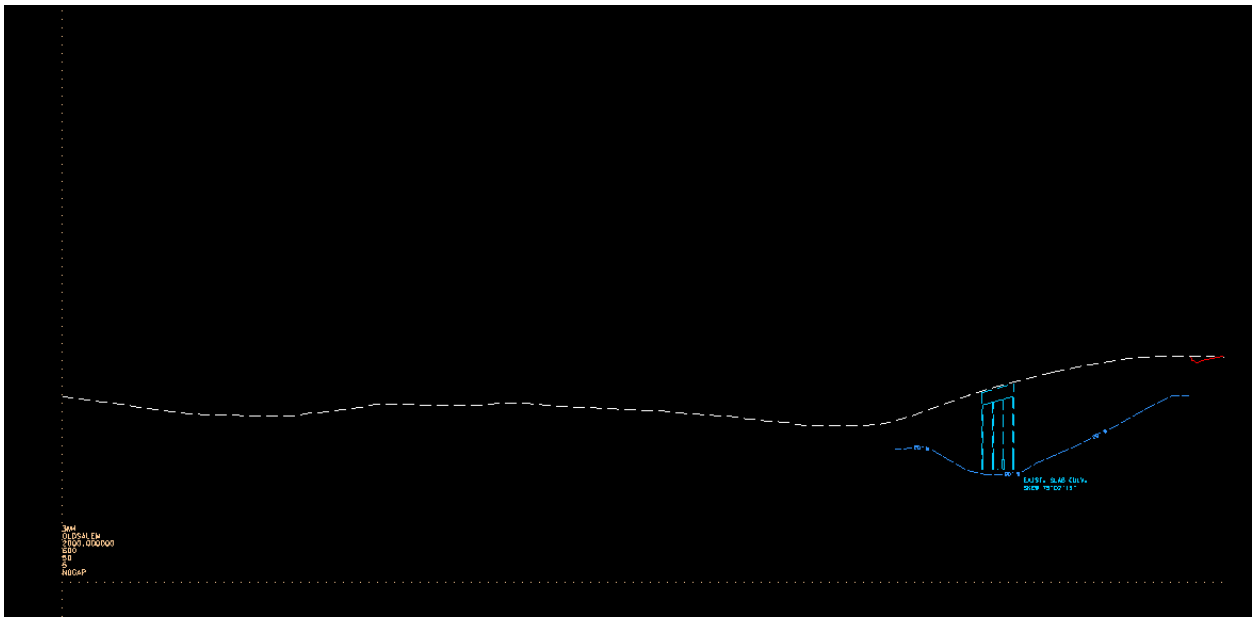
Identify Cell and OK to draw profile

Change Symbology:

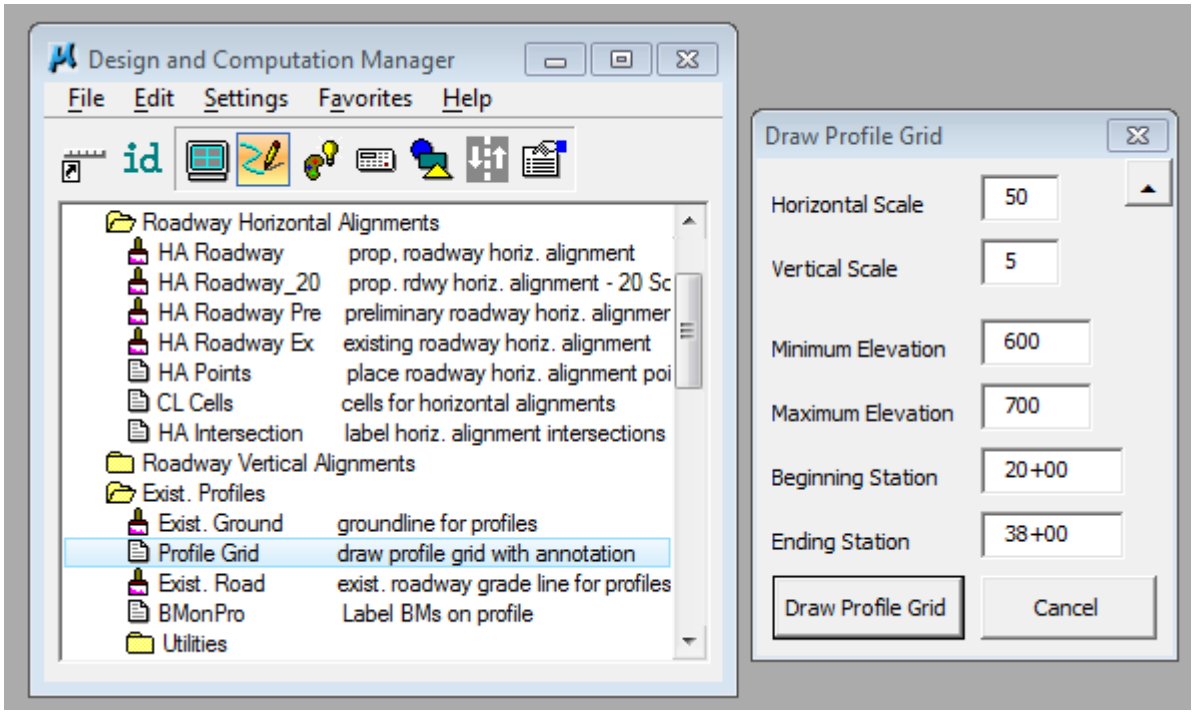
LV- DESIGN-PROFILE-Proposed
CO – 6
LC – 0
WT – 10



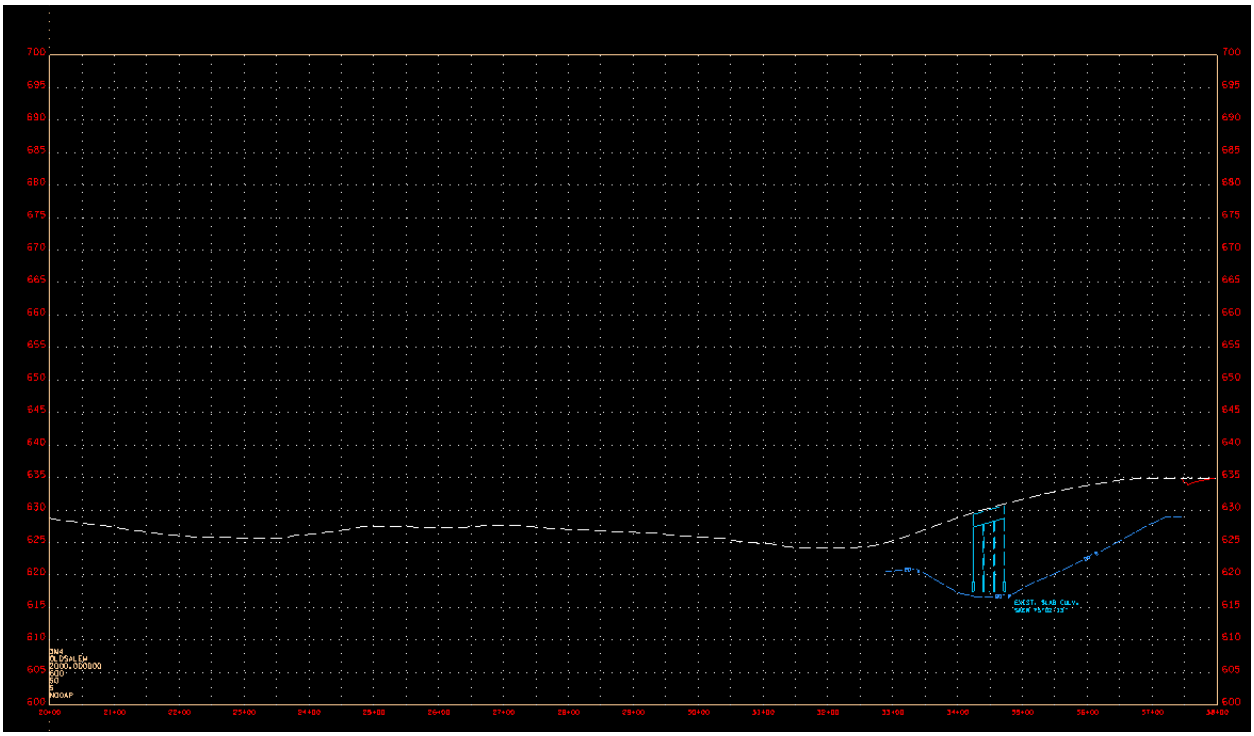
Now, turn off “DESIGN-SHEET” levels in the survey reference file and save the view.



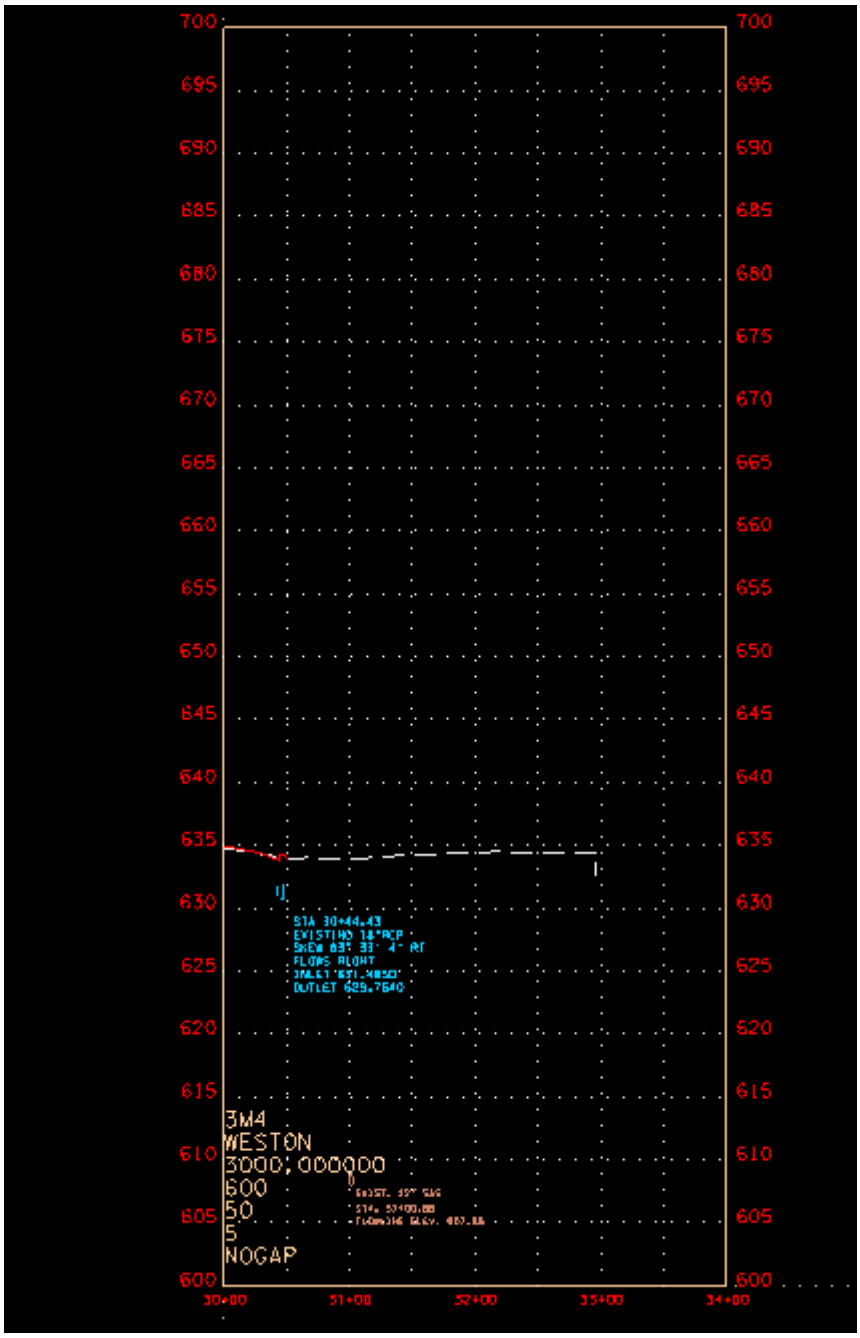
Use D&C Manager to place grid in the file RFSR099Alignments.dgn:



Draw Profile Grid and snap to cell origin



Now repeat this procedure for Weston Blvd.


700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600
30+00
31+00
32+00
33+00
34+00
STA 30+44.43
EXISTING 18"RCP
SKEW 83° 33' 4" RT
FLOWS RIGHT
OUTLET 629.754Q
3M4
WESTON
3000,000000
600
50
5
NOCAP

Weston Blvd.

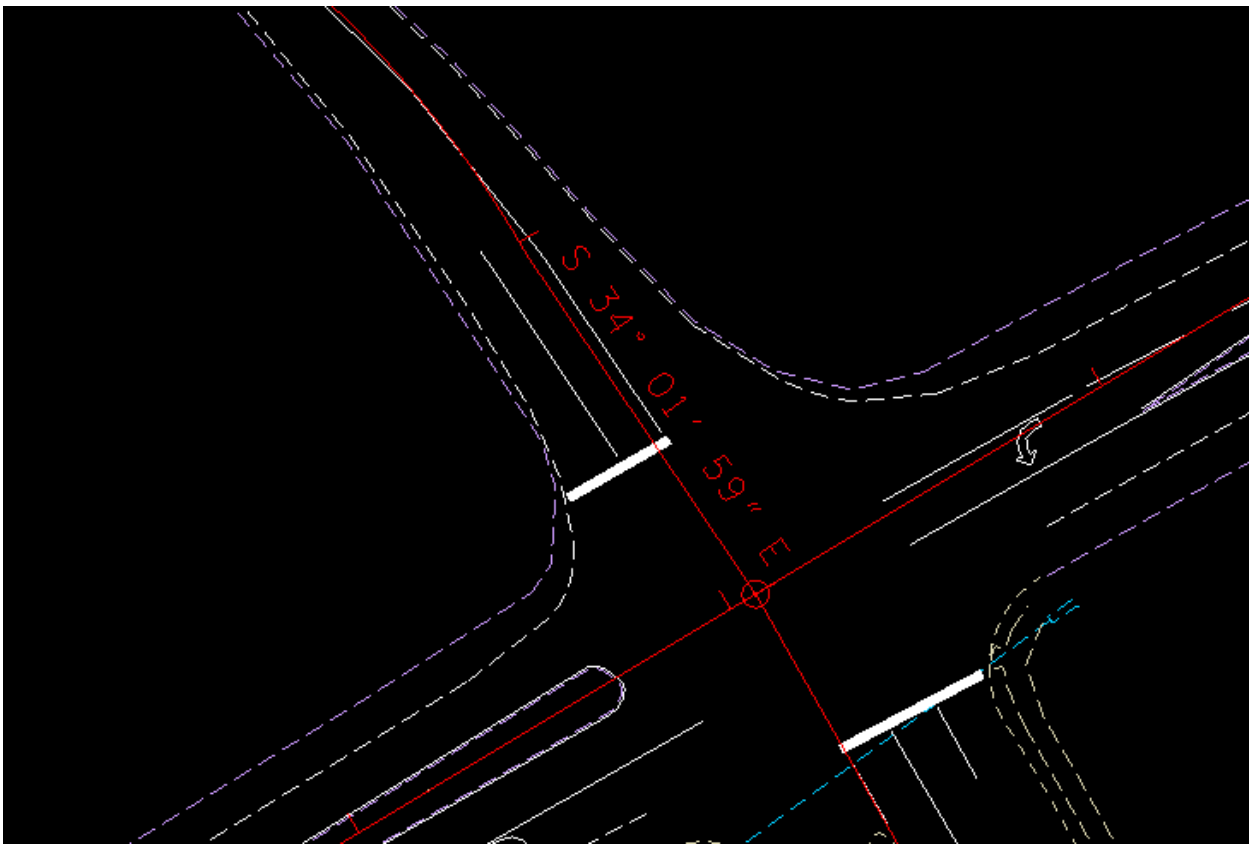
Determine Length of Side Roads

Before the Vertical Alignment for the side roads can be designed, the length of road to be improved needs to be determined. This will be a similar procedure to what was used for the mainline.

Old Salem Road transitions from two lanes to three lanes (left turn lane in center) as it intersects with SR99. Figure 2-15 of RDG shows the configuration of a roadway where a turn lane is added showing he approach taper, bay taper and storage lane length.

Storage Lane

Fig 2-18A – Fig 2-20F of the RDG show the warrant for left turn lanes and storage lengths for different design speeds and percentage of left turns. Since the minimum design speed covered is 40 mph and Old Salem Road is 30 mph, we will assume the current length is adequate. Measuring in the design file, this length is about 60 feet.



Existing Pavement Markings

Approach Taper (Ref. TDOT Design Guidelines, p.2-37)

For a design speed of less than 45 mph, L= W x S. Since the turn lane Is centered on the center line, W is half the lane width which would be 6 feet. S=30, so L= 6 x 30 = 180.

Bay Taper (Ref. TDOT Design Guidelines, p.2-37)

L=WS/3
= 6 x 30/3 = 60

The total of the tapers plus storage length is 60 + 180 + 60 = 300 feet.

The location of the stop line is at approximately station 37+13.54

The existing pavement width is 20 feet. The length required to transition to the proposed 24 foot width is:

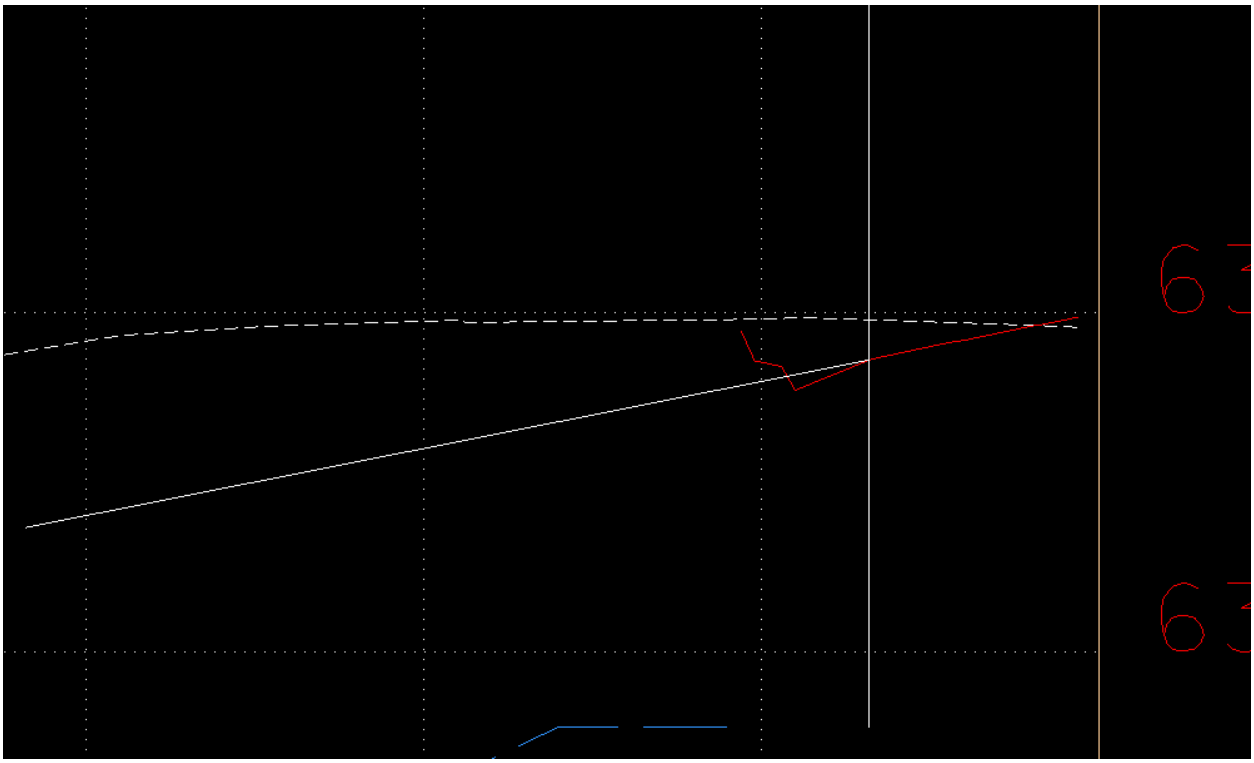
24-20 =4
4/2 = 2
2 X 30 =60

The Station at which proposed work will tie in to the existing roadway:

3713.54 – 300 – 60 = 3353.54
Make it an even station – 33+50.00

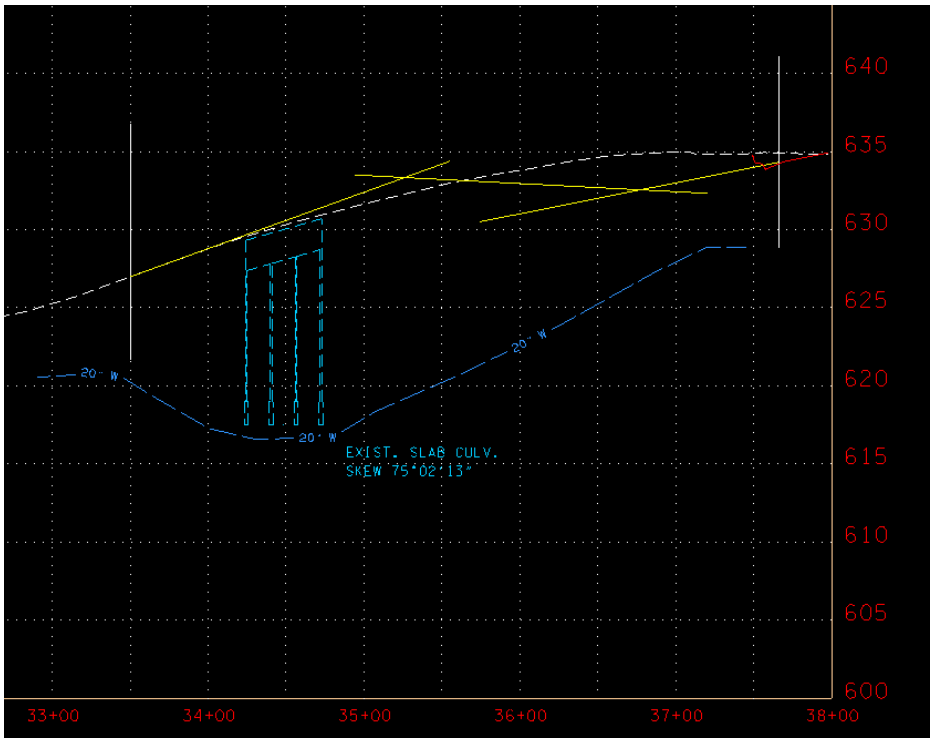
Vertical Alignments

First, determine where on the mainline the side road profile needs to tie in. This will usually be where the pavement of the mainline breaks at the shoulder.



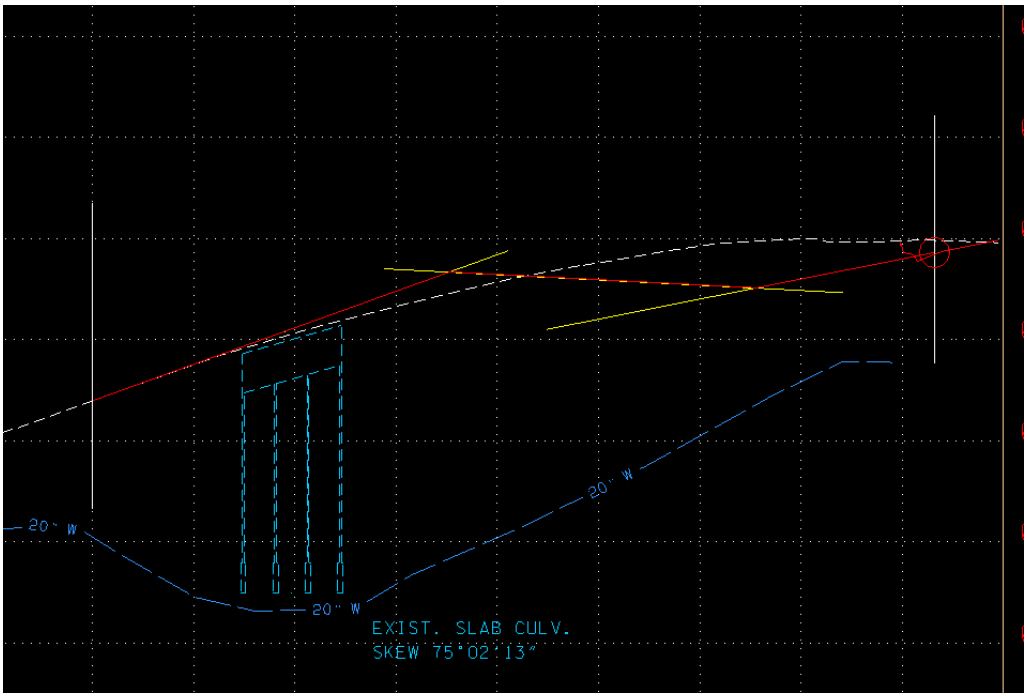
The tie-in grade will be approximately equal to the cross slope on the mainline at the tie in point.

Draw some more grades to get an idea where the profile will tie in to the existing road and for the locations of the VPI's to input in Geopak,

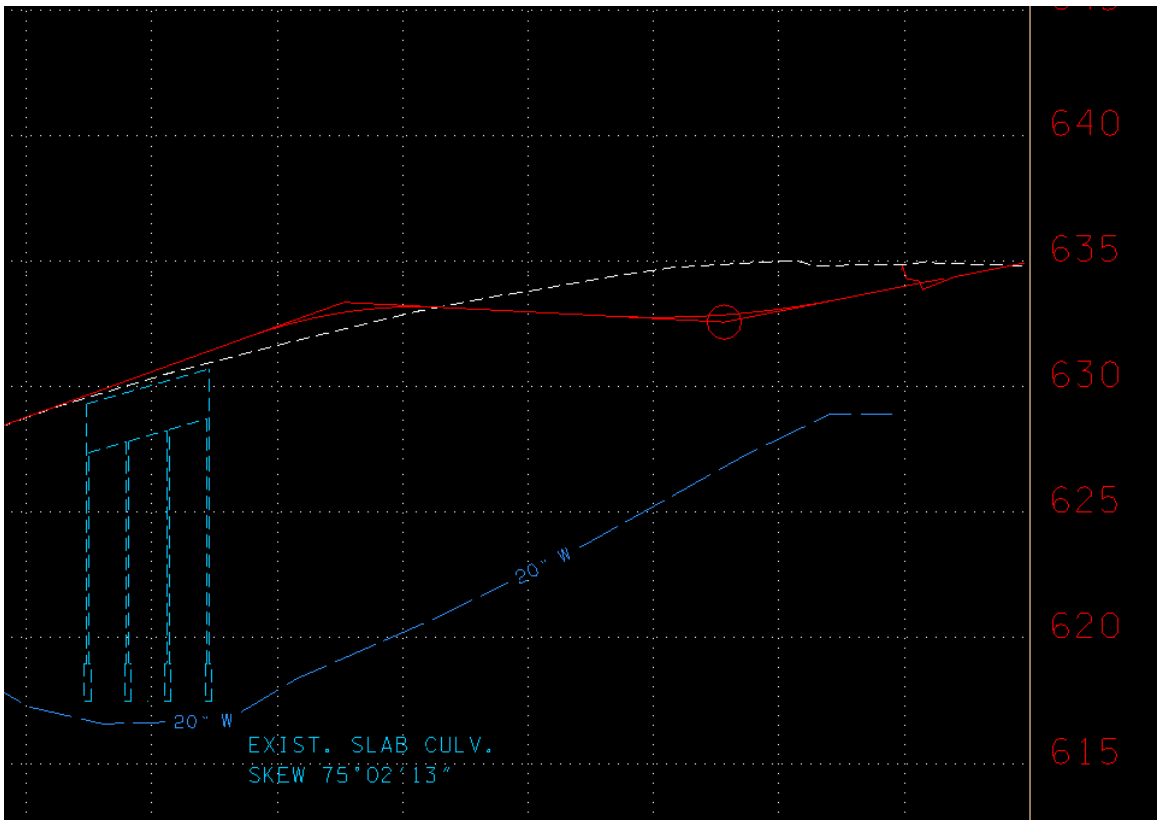


These lines are drawn on a scratch level so they can be turned off later, or deleted.

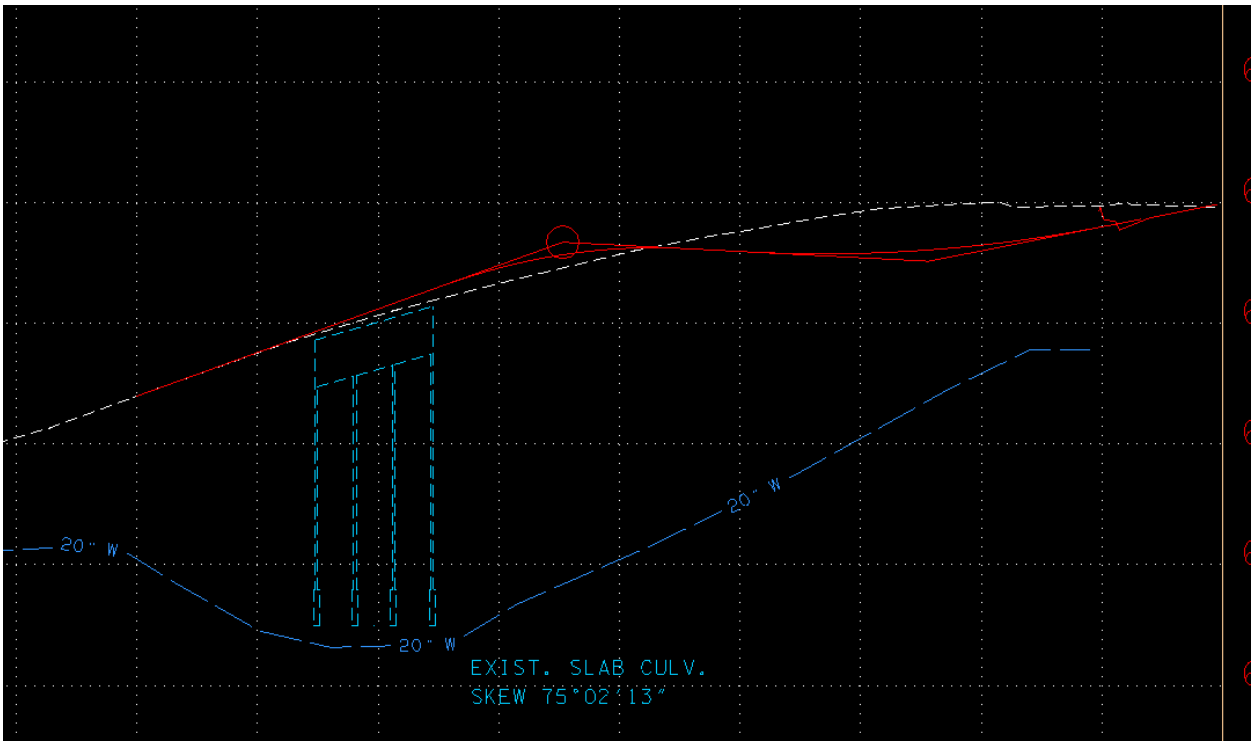
Input 4 VPI points following the procedure outlined in Exercise 7 of Geopak Road Manual. Rather than keying in station and elevation, use Dynamic place using the lines drawn previously as a guide.



Input Vertical curves for VPI's 2 and 3 using a design speed of 30. (This is the signed speed on Old Salem Road).

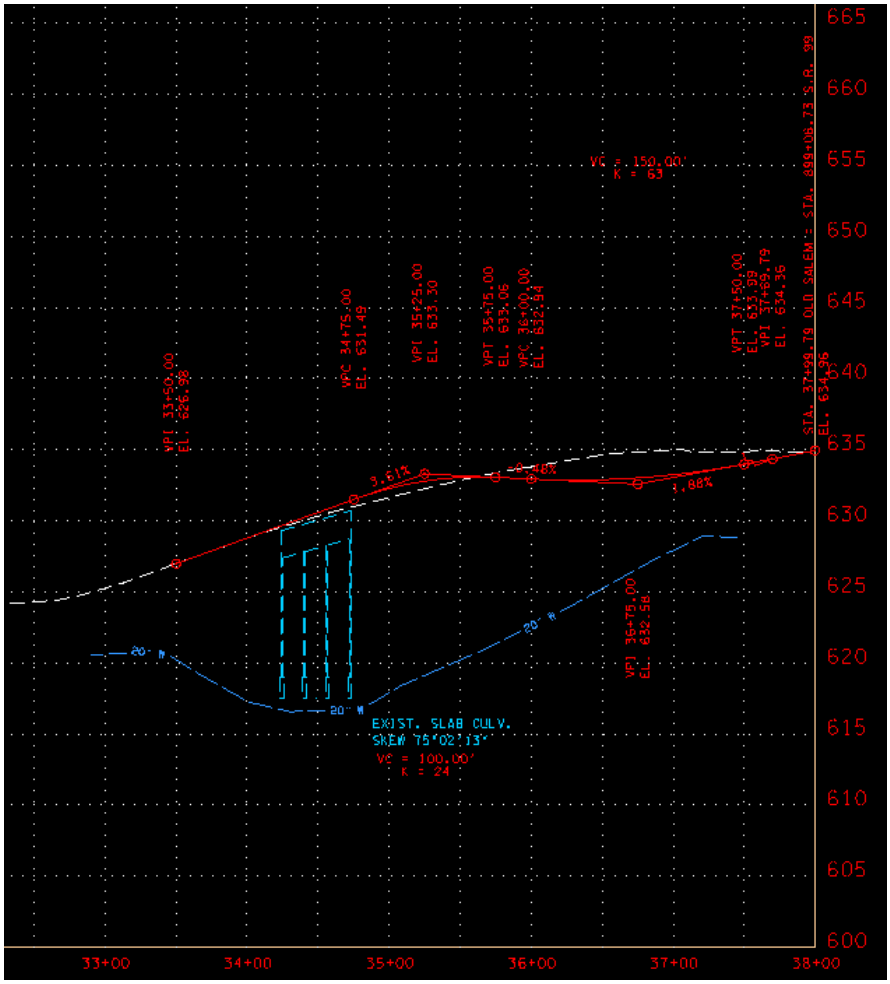


The curve lengths are 78 and 93 for VPI 2 and VPI3 respectively.It is desired to have even lengths for vertical curves, so change lengths to 100 and 150, respectively.

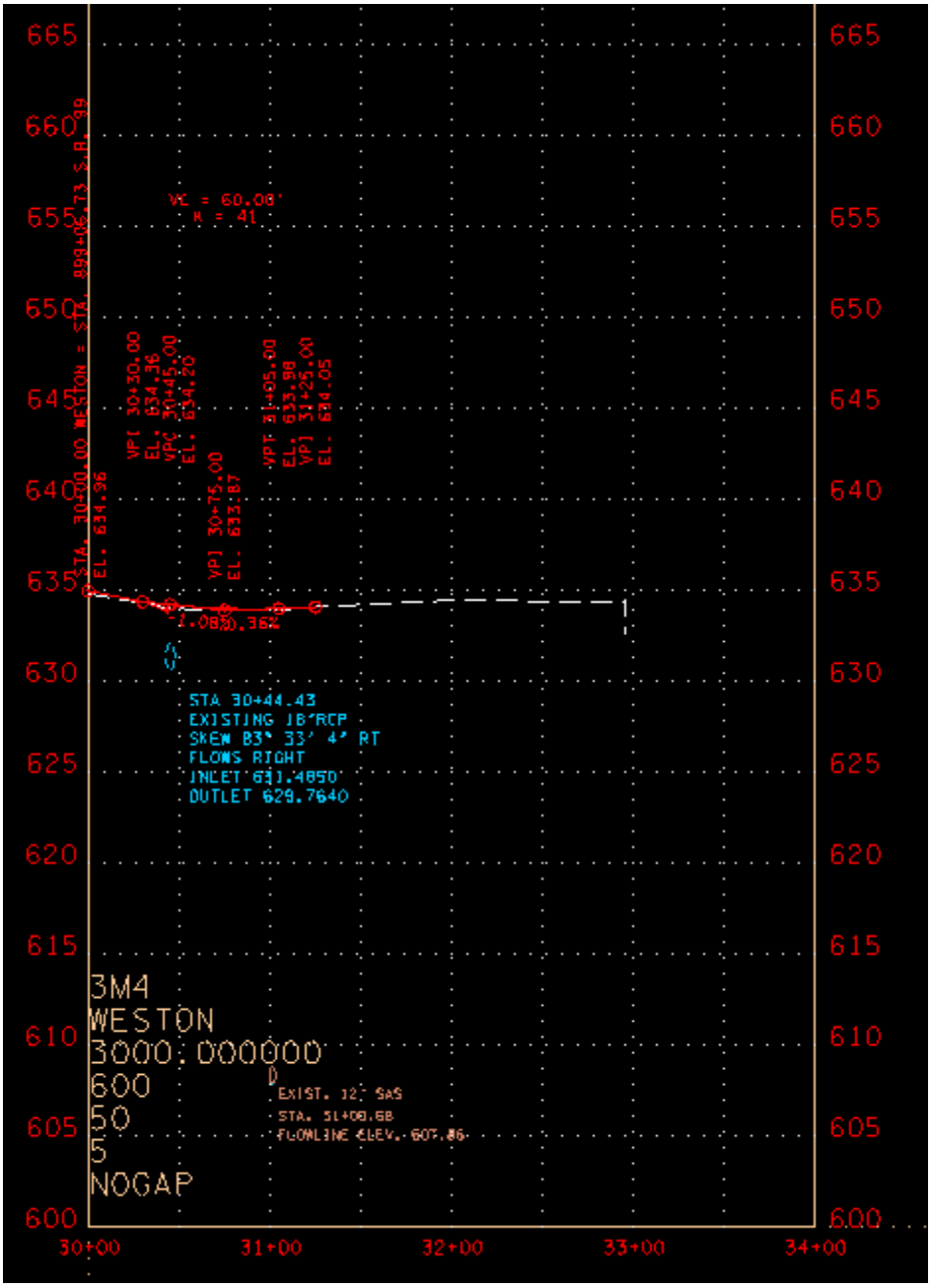


An important thing to keep in mind at this point is the maximum allowable grade. Looking at the profile it is highly doubtful that the maximum allowable is being exceeded , but referencing the standard drawing RD01-TS-1 (Local Roads and Streets) shows the maximum for 30 MPH, rolling terrain is 10%.
From Profile Generator, the grades are
VP1 - VP2 +3.61
VP2 - VP3 -0.52
VP3 – VP4 +1.99

Lastly, move VPI2 and VPI3 to even stations. Their current locations are 35+26.52 and 36+78.20. Move VPI2 to 35+25.00 and VPI3 to 36+75. Then save Vertical Alignment and display using D&C Manager.



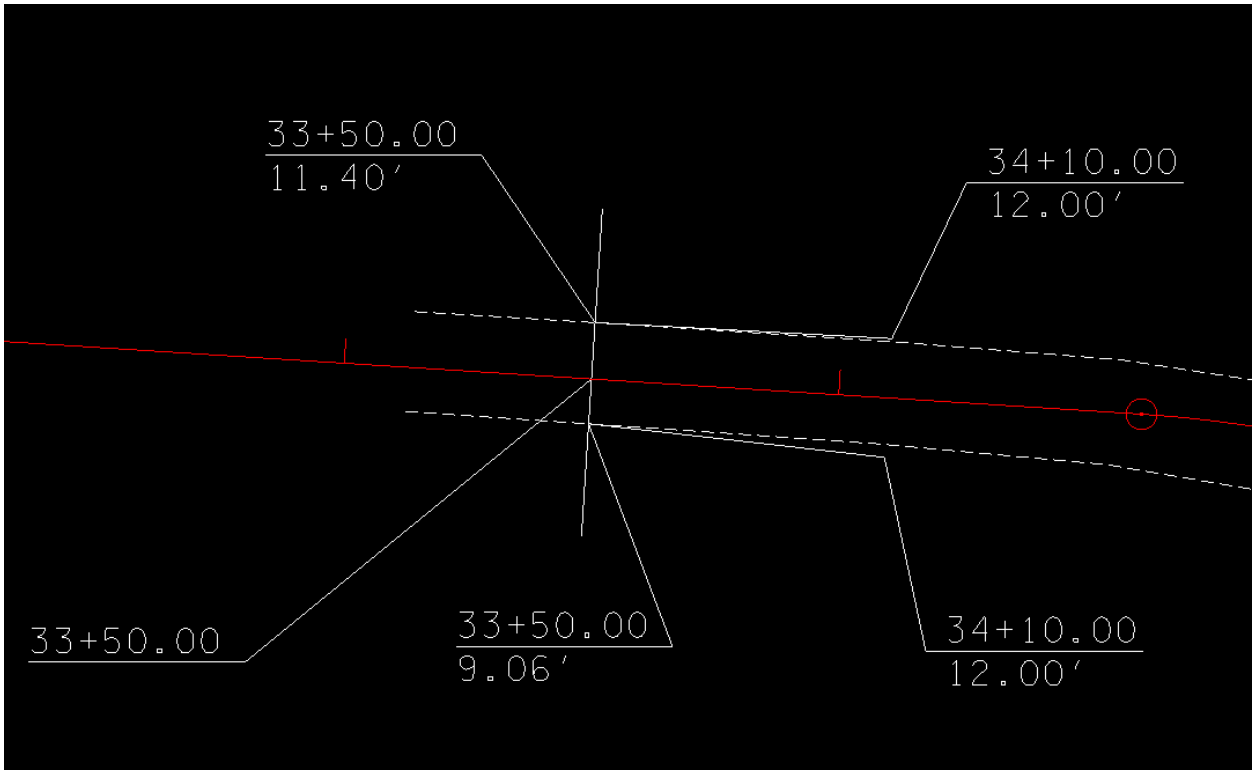
Profile of Old Salem Road



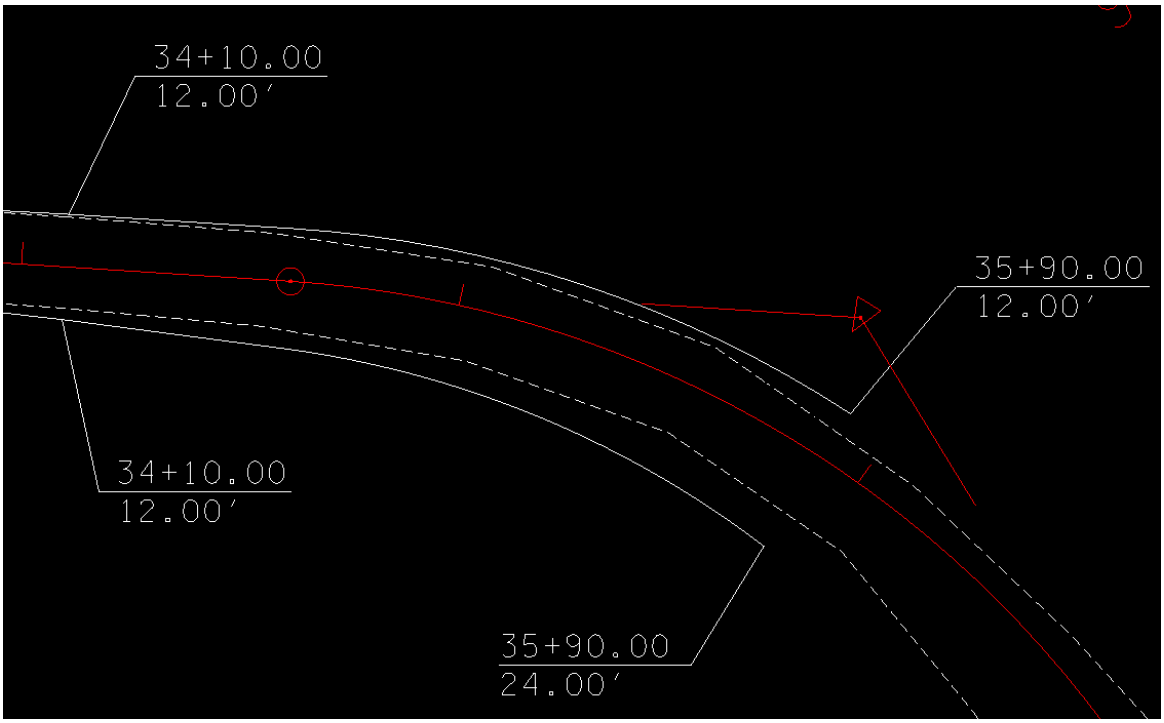
Profile of Weston Blvd., 30 mph design speed

Pavement Lines

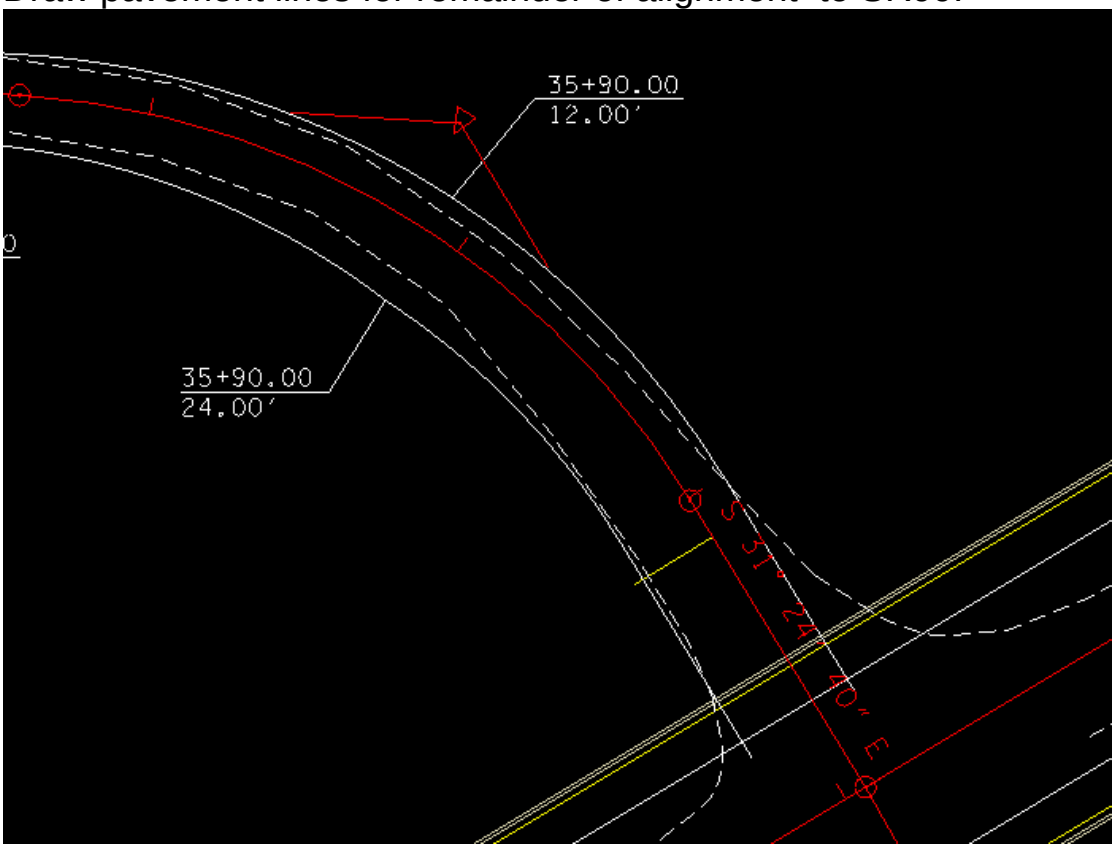
For Old Salem Road, use D&C Manager to draw pavement lines. When the vertical alignment was designed, it was determined that the tie-in point will be at station 33+50. At this point, the existing pavement is 20 feet wide and to transition to a 24 foot total width will take a length of 60 feet. Reference Exercise 12 of Geopak Road Manual for instructions on drawing pavement transitions.



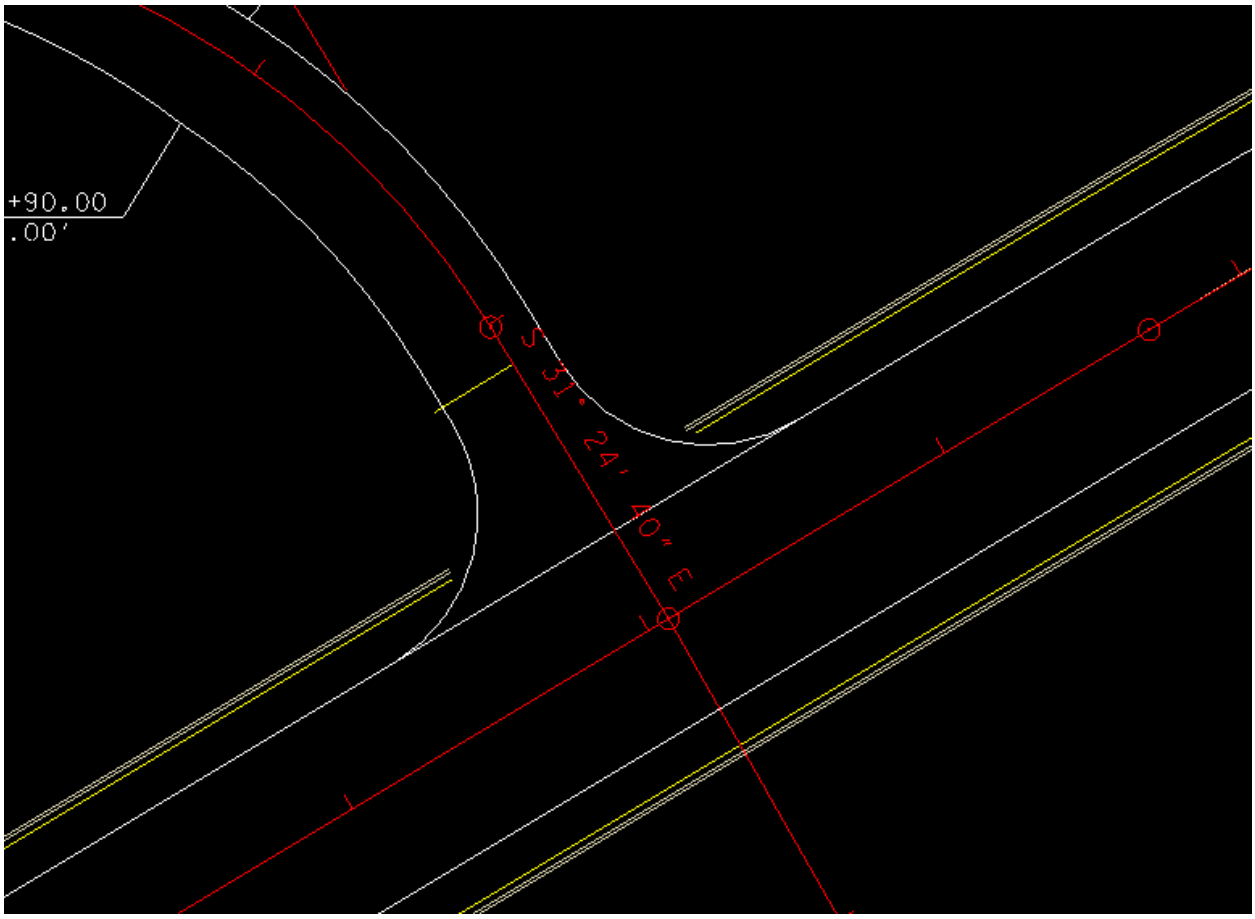
Next, the approach taper where the pavement transitions from two to three lanes will be drawn. Earlier, this length was determined to be 180 feet. One lane will be on the left of the center line and two lanes will be on the right:



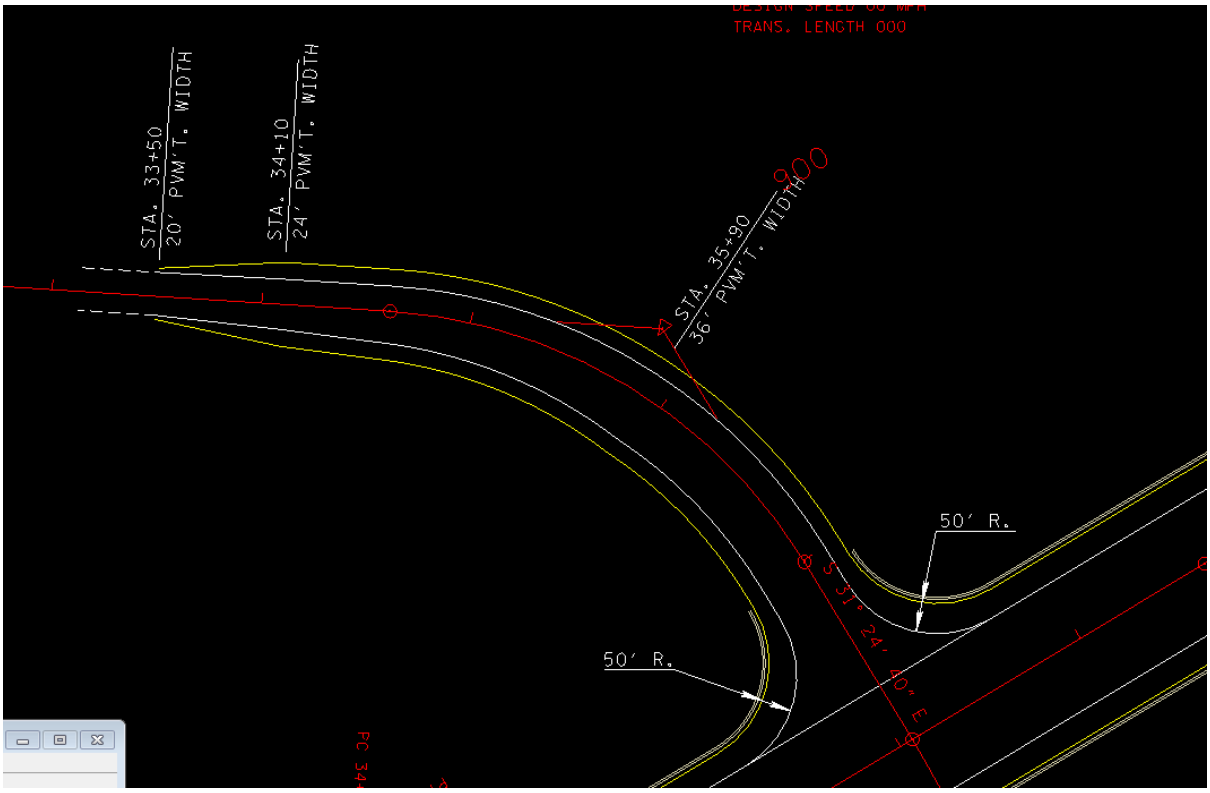
Draw pavement lines for remainder of alignment to SR99:

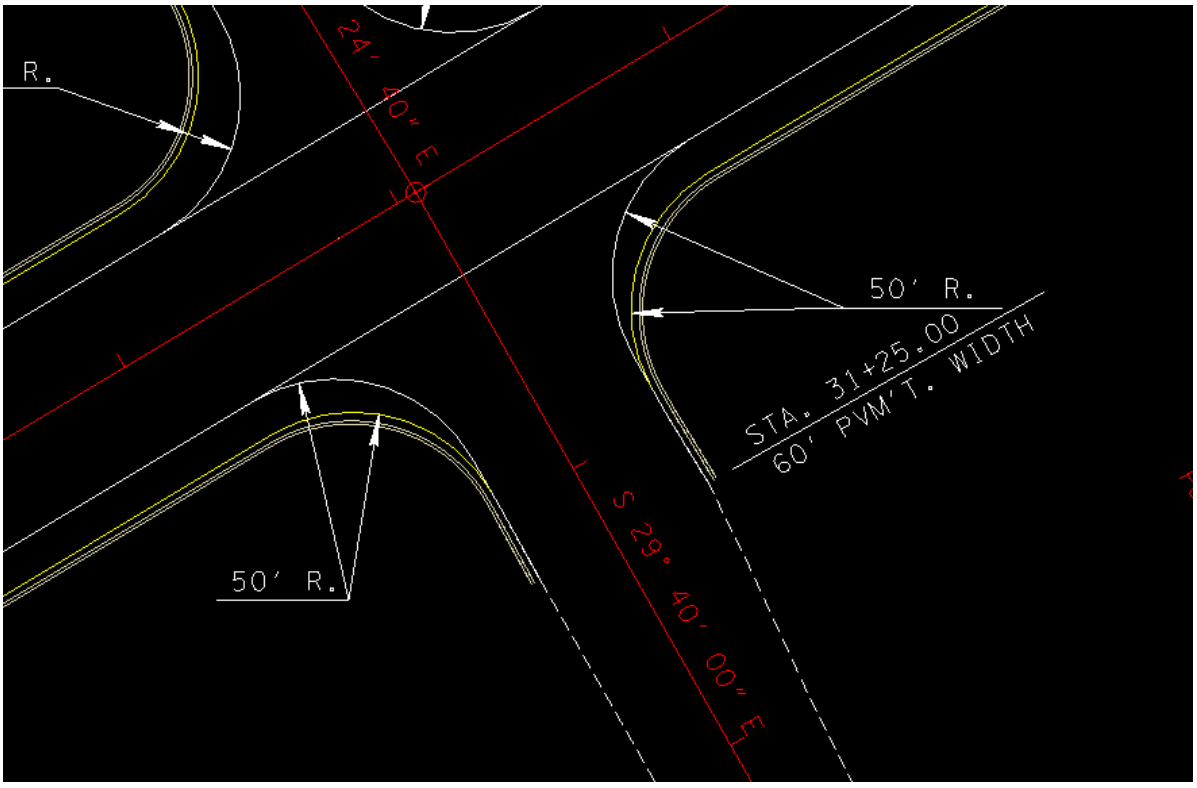


Ensure that Place Influence is still on in D&C Manager and place 50 foot radii at the inter sections of the edge of pavement lines for Old Salem Road and SR 99. Turn off Place Influence and partial delete the SR99 Shoulder and Curb & Gutter lines:



Once again, using D&C Manager, draw Shoulder lines for Old Salem Road. According to RD01-TS-01, the shoulder width will be 8 feet. This is for the Design ADT of over 2,000. At the tie-in the existing shoulder width is 2 feet, so transition from 2 to 8 feet from 33+50 to 34+10 on both sides:

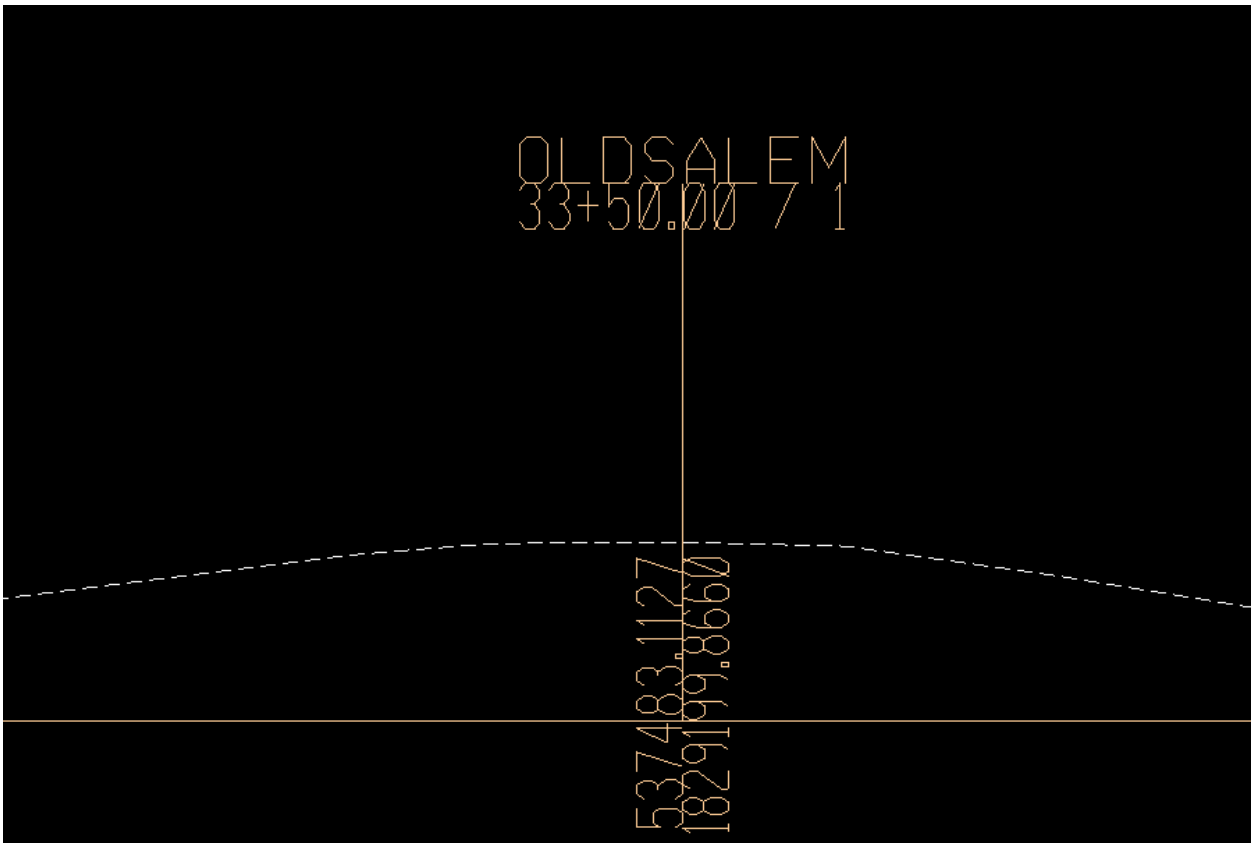




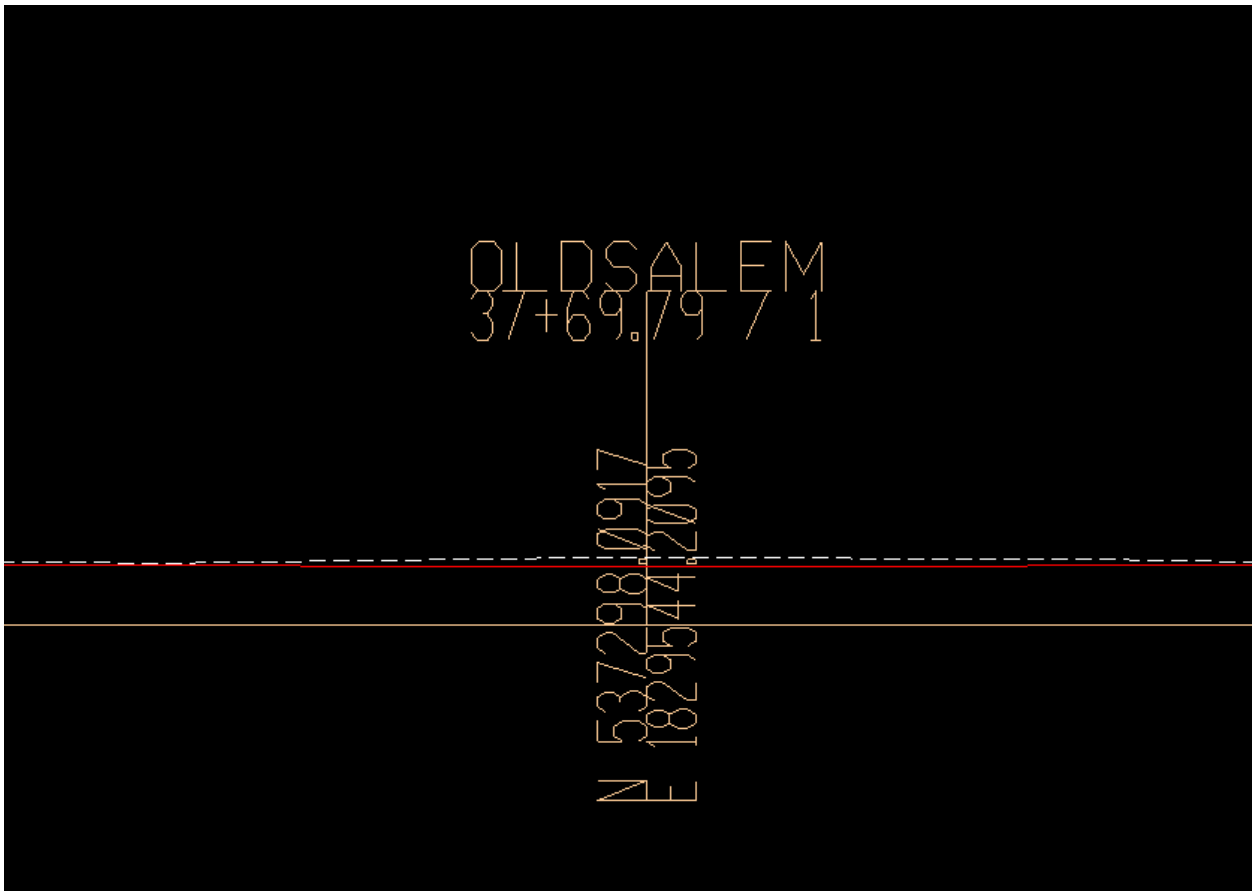
Pavement lines for Weston Blvd.

At this point, you are ready to calculate superelevations and cut cross sections for the side roads. A more detailed procedure for side road cross sections is described in Appendix C. Also reference the appropriate chapters in the Geopak v8i Road Manual. When drawing pattern lines for the side roads, include the station at which the side road alignment intersects with the SR99 edge of pavement. For Old Salem Road this station will be 37+69.79 , and this will be the last station. This will be the first station for Weston Blvd., 30+30.00 . Also include a pattern line at the beginning or end of curve radius at the intersections. At Old Salem Road this station is 37+08.31 For Weston Blvd., station 30+95.81. The reason for this will be explained later, when Proposed sections are cut. When you cut existing sections, define not only the existing ground surface, but also the mainline.tin surface, so that you can determine what the superelevation rate is where the side road intersects with the mainline edge of pavement.

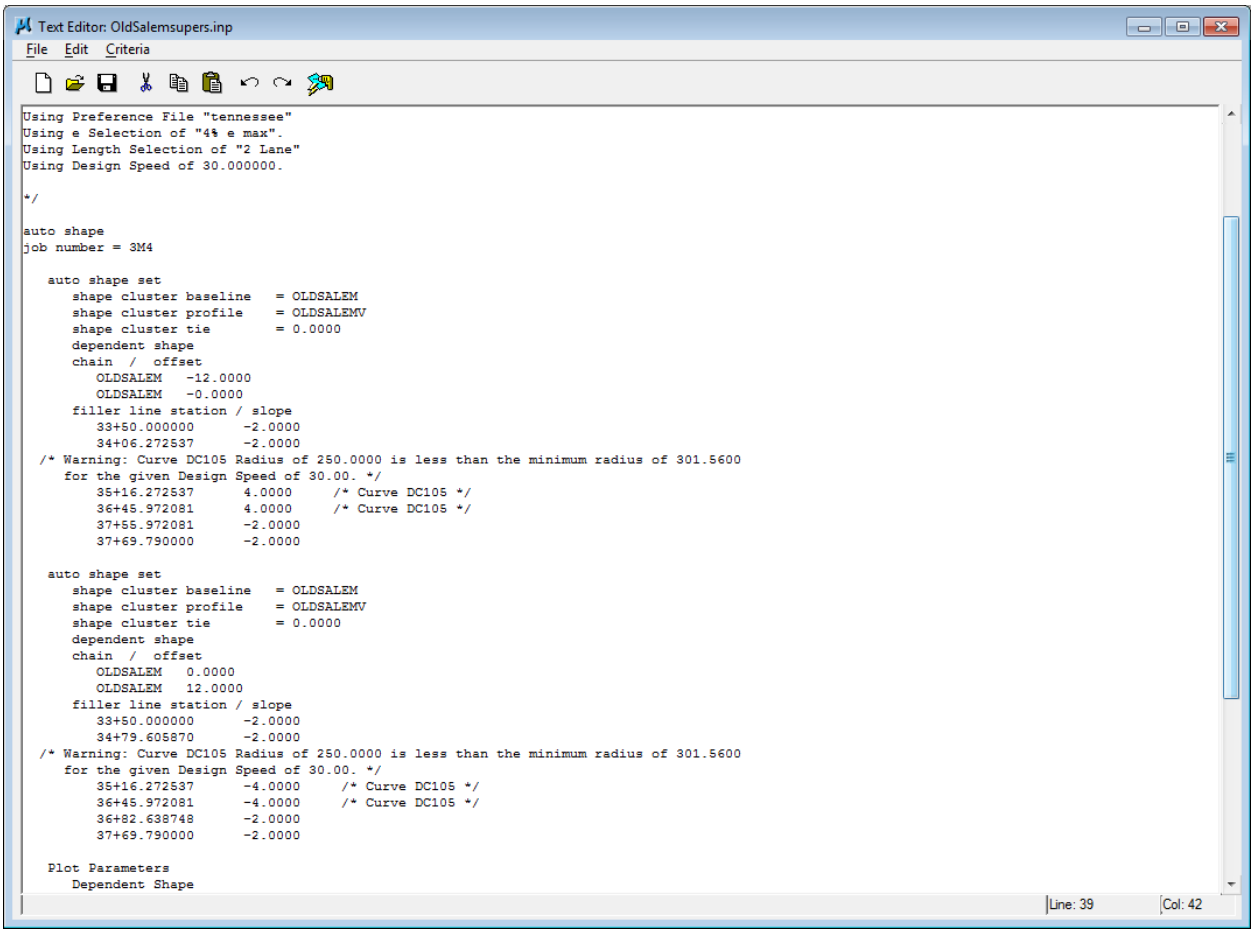
When the existing cross sections for Old Salem Road are cut, measure the cross slopes on the existing ground at the tie in point at station 33+50. The cross slopes appear to be -.006 for the left and -.023 for the right.



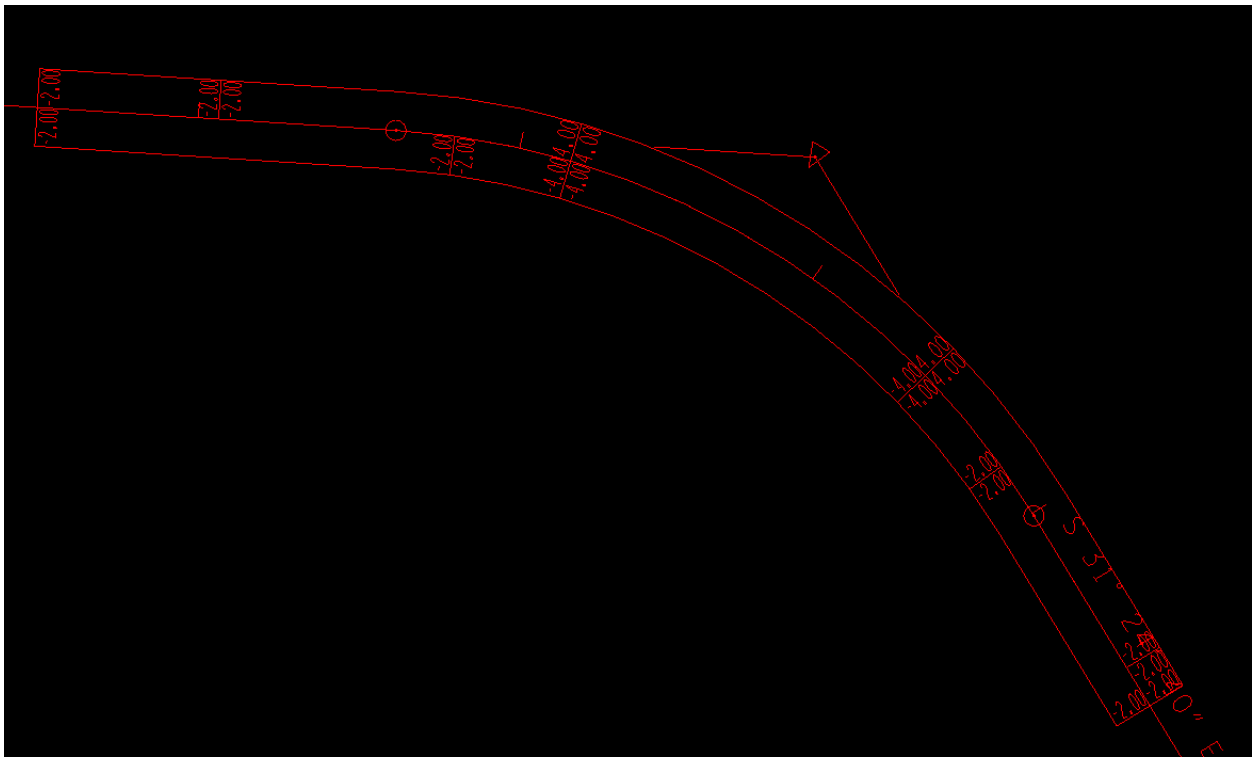
At the other end at the proposed EOP for SR99 (red line) at station 37+69.79, the cross slopes are +.002 left and -.002 right.



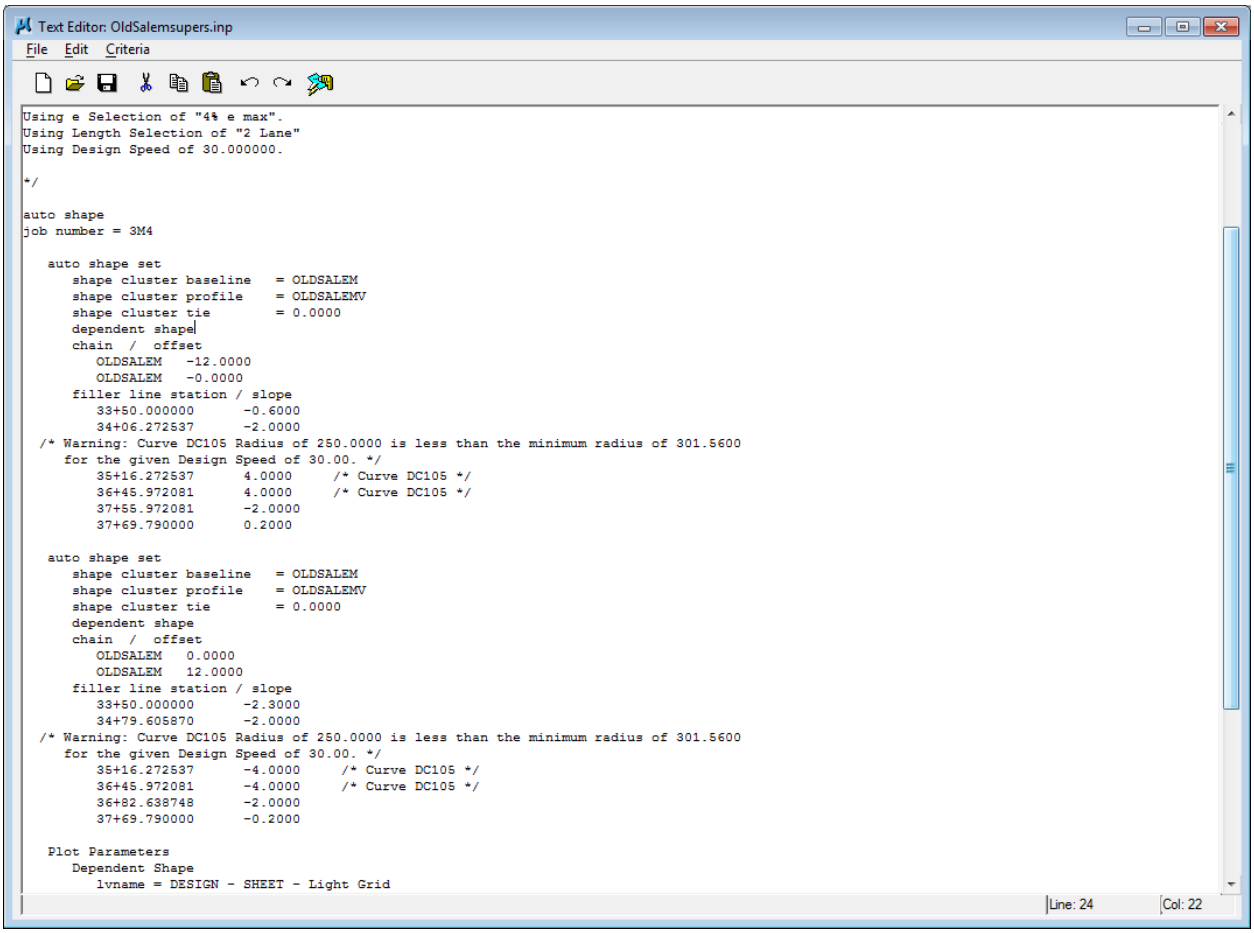
Run the Superelevation calculation in Geopak, the input file appears as follows.:



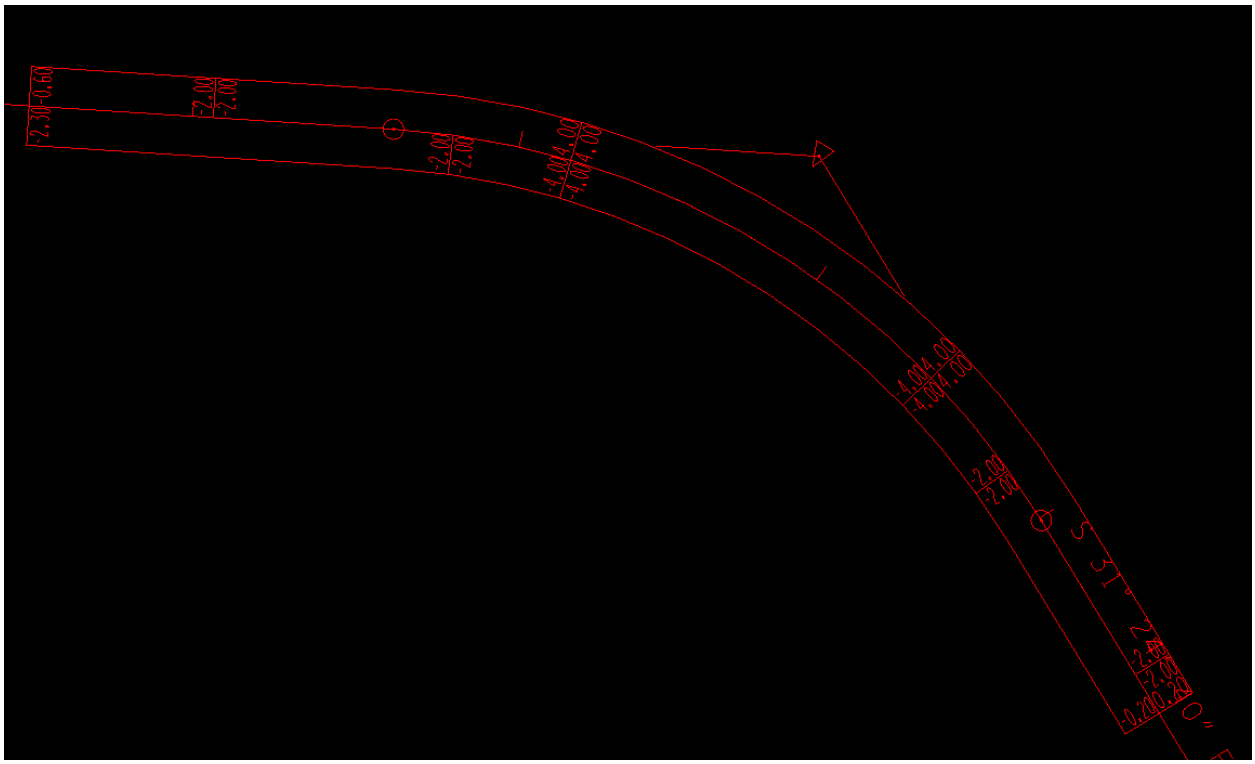
Then draw the shapes in the design file. Notice that it has placed normal crown (-2.00/-2.00) at each end.:



The input file can be edited to match the existing conditions at each end. The first part is for the left side. Edit the slope at Station 33+50 to read -0.6000. Edit the slope at station 37+69.79 to read 0.2000. For the right side edit the slope at 33+50 to read -2.3000 and -0.2000 at 37+69.79.:



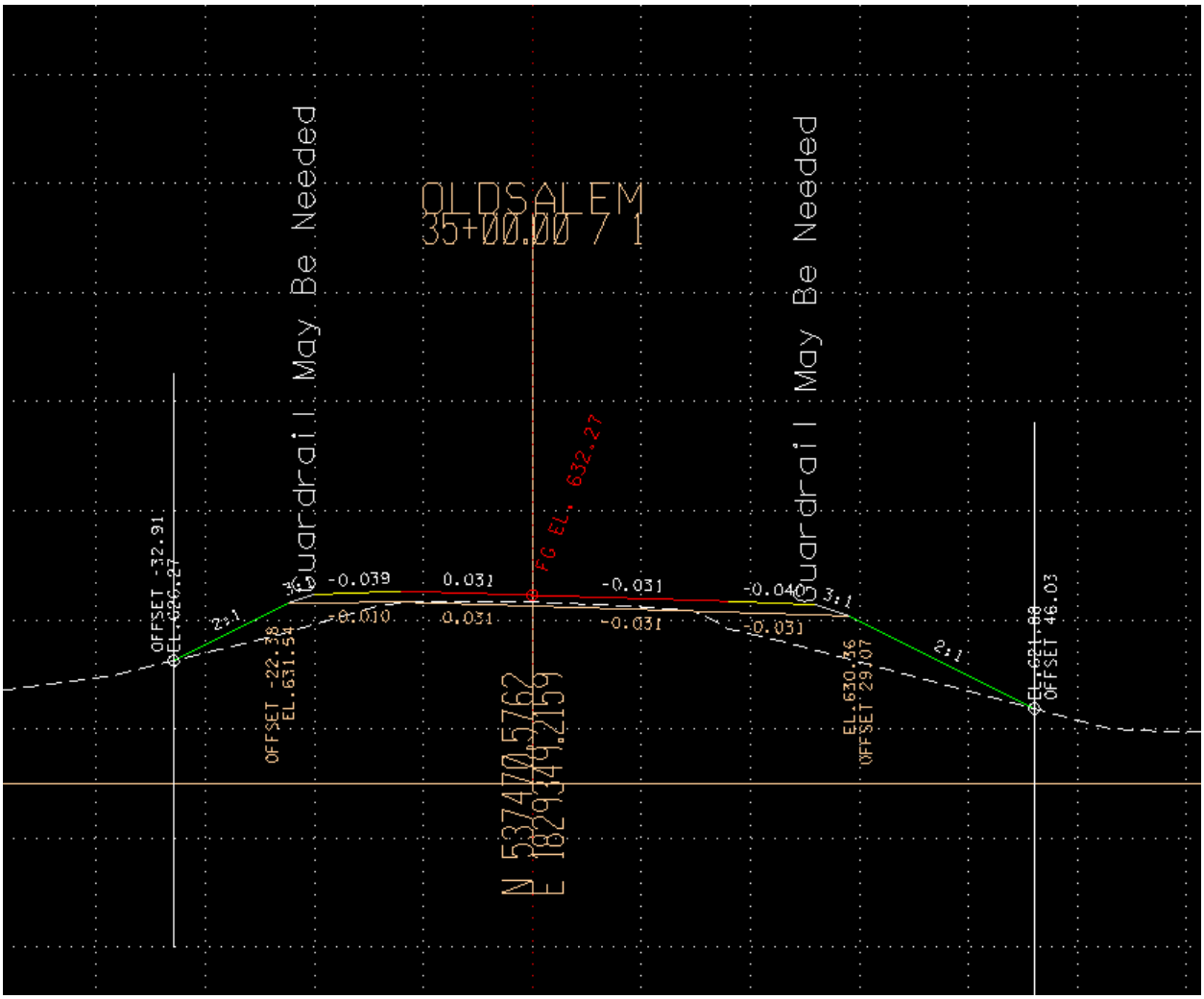
Then re-draw the shapes in the dgn file.:



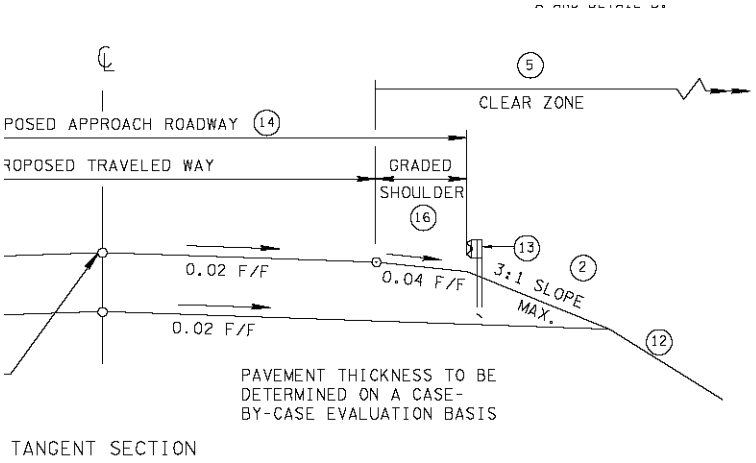
Repeat this procedure for Weston Blvd.

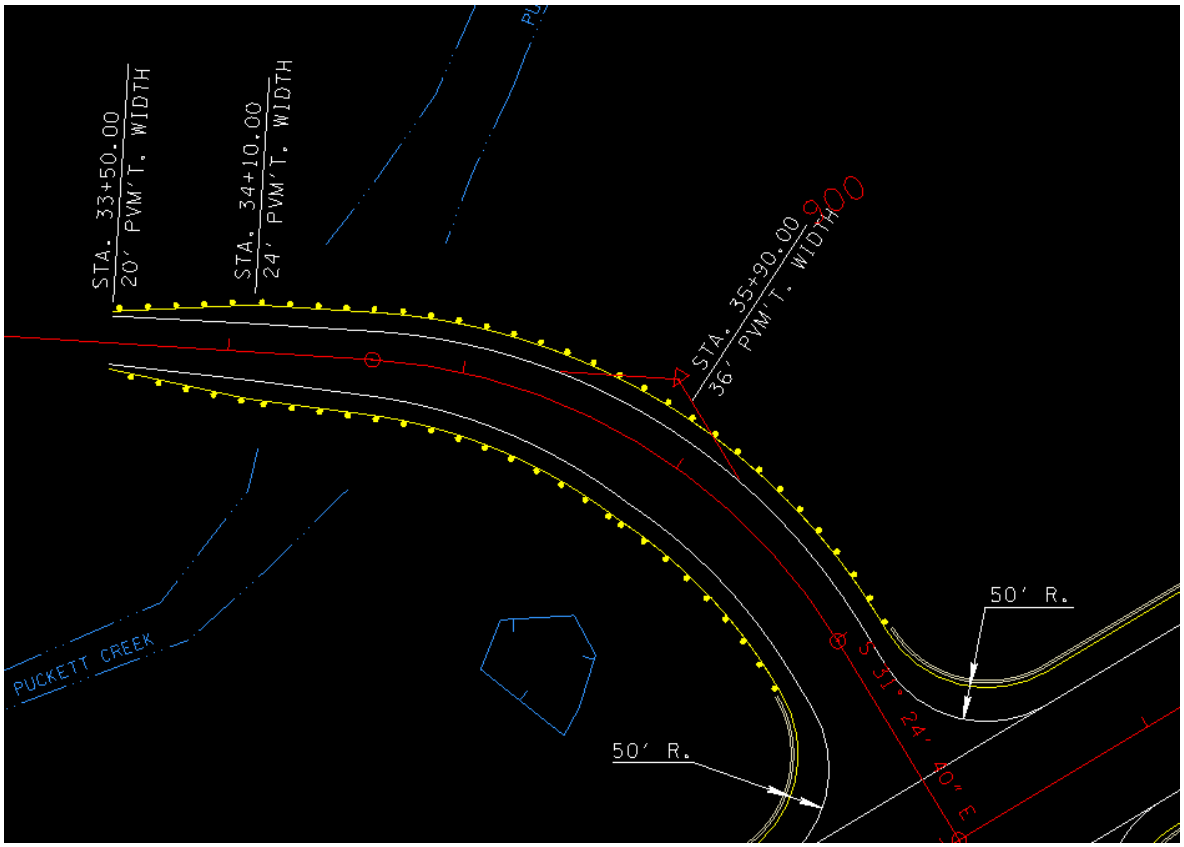
Cut Proposed Cross Sections for each side road. Process only the stations between the existing tie in and beginning or end of curve radius.
For Old Salem Road, this would be station 33+50 to 37+08.31
For Weston Blvd., Station 30+95.81 to 31+25

Old Salem Road has proposed side slopes of 2:1 and 3:1 which will warrant location of guardrail. (Roadside Design Guide, Fig. 5.1b)(AASHTO)



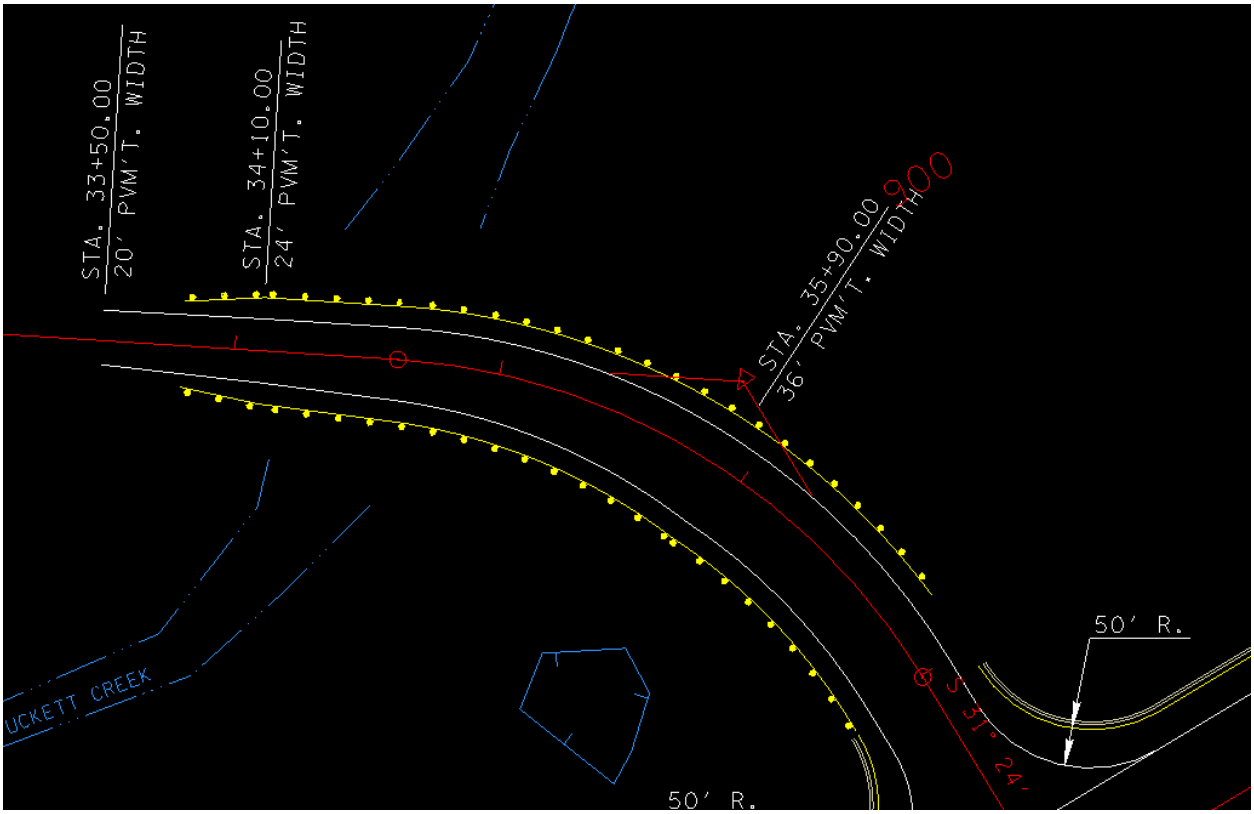
In the proposed.dgn file, draw the guardrail along the proposed shoulder line. This is the location as shown on Standard Drawing RD01-TS-1.



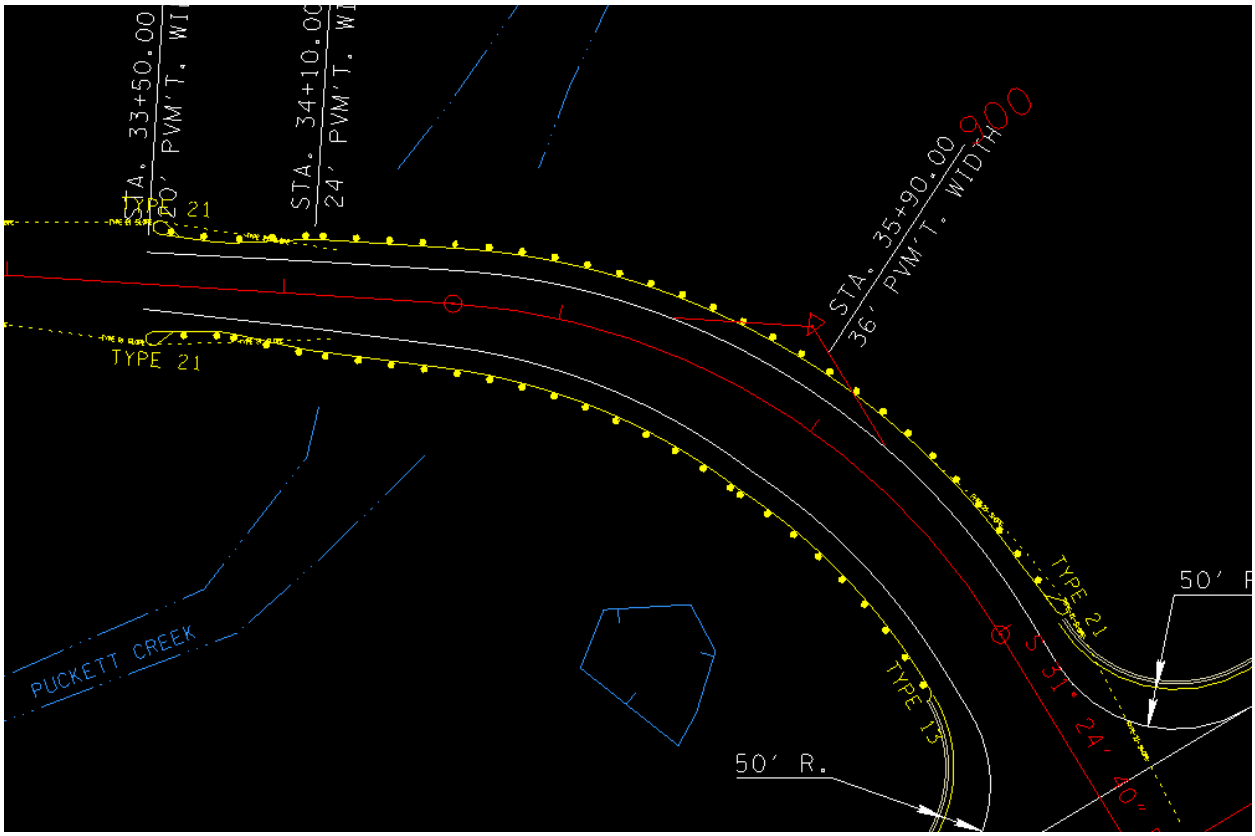


Old Salem Road is a local (non-numbered) road with a design speed of less than 40 mph, Type 21 end terminals will need to be used on the approach ends. (Ref RDG 4-706.20). On the trailing ends, at 33+50, Type 21 shall be used because it is inside the clear zone of oncoming traffic. (See Std. Dwg. S-CZ-1). At 37+25, the trailing end is outside the clear zone of oncoming traffic, so a Type 13 can be used.

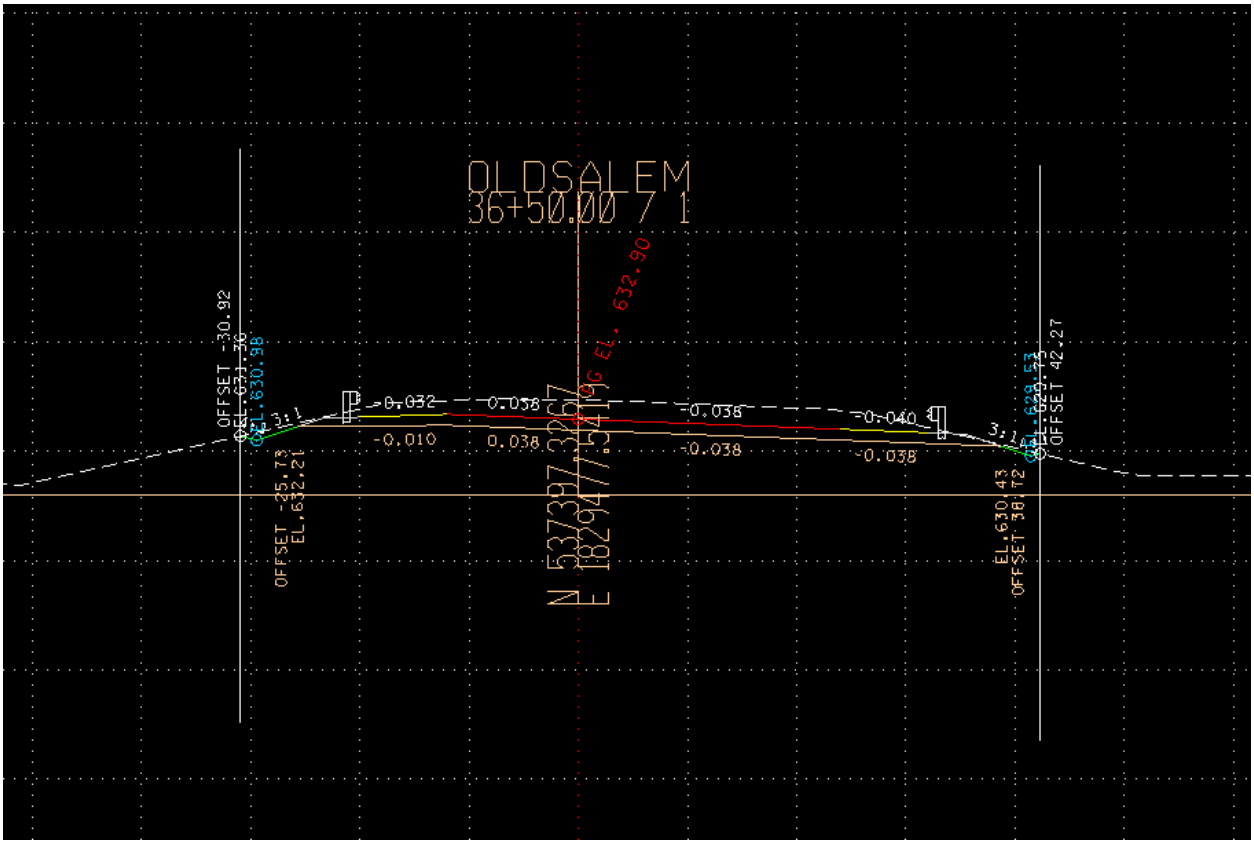
The length of type 21 terminal is approx.. 30’ so shorten the guardrail drawn by that distance at the locations where type 21 terminals are needed.



Then use D&C Manager to draw the terminals. Reference Exercise 12 in Geopak Road Manual.



Cross Sections can now be cut along the side road.



Cross section showing guardrail

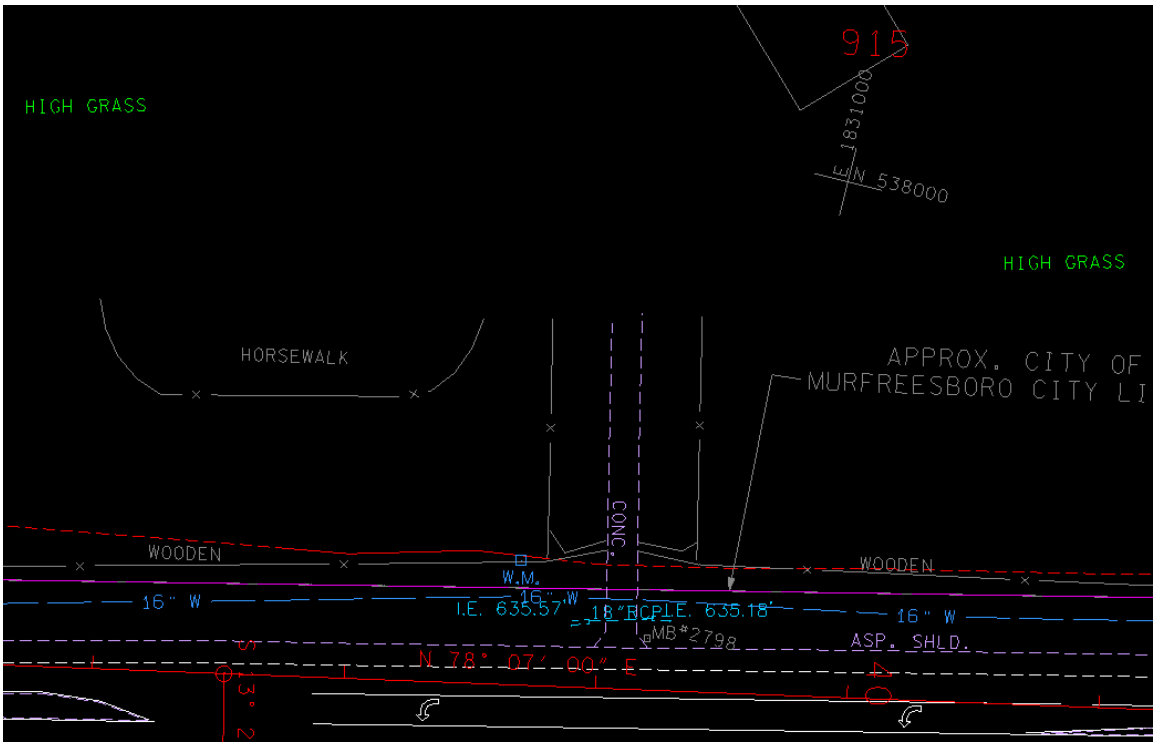
Merge the dtms created of the side roads (oldsalem.tin and weston.tin) with the proposed surface of the mainline (mainline.tin) to create a proposed surface (proposed.tin)

PRIVATE DRIVES

Private Drives, Field and Business Entrances are located where there are existing drives. In addition drives will be located on tracts where a drive is not currently located.

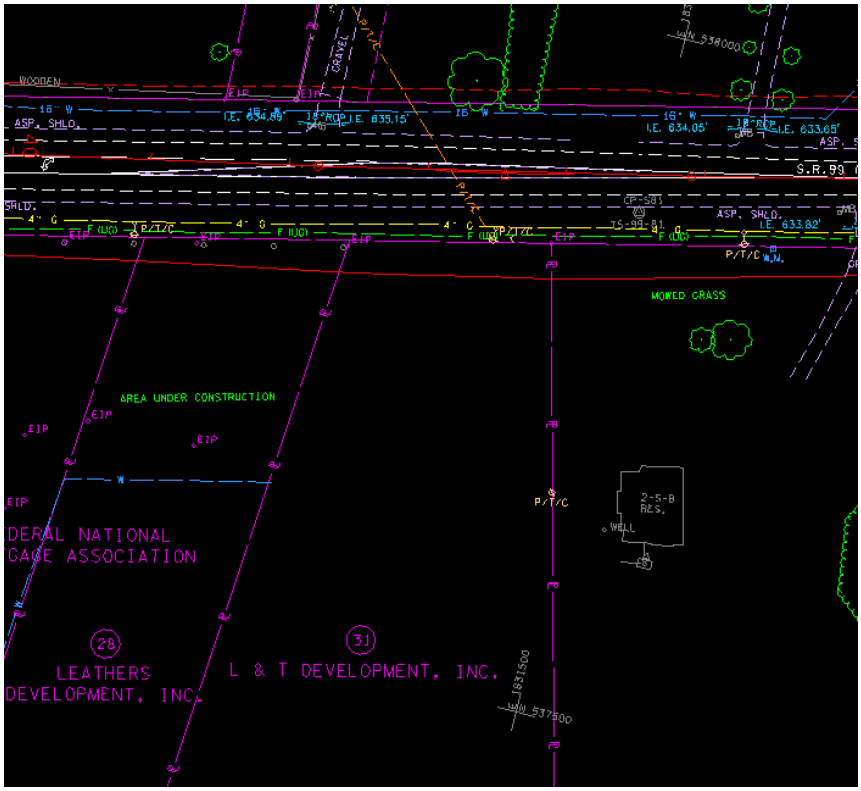
This section of SR 99 has many potential locations for drives. This manual will show the method for locating two or three drives.

Existing drive location:



Drive to be located at approximately 914+07 Lt.

Tract showing no present drive:

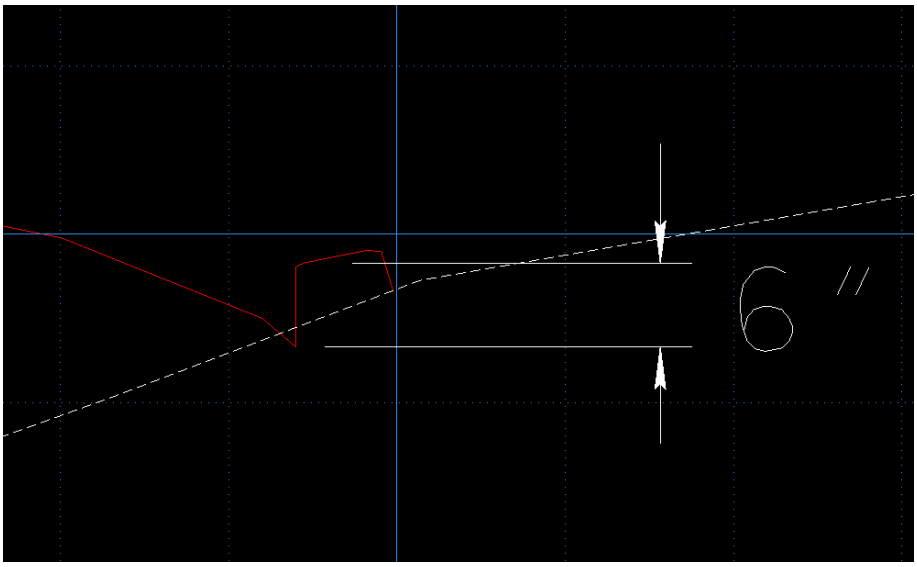


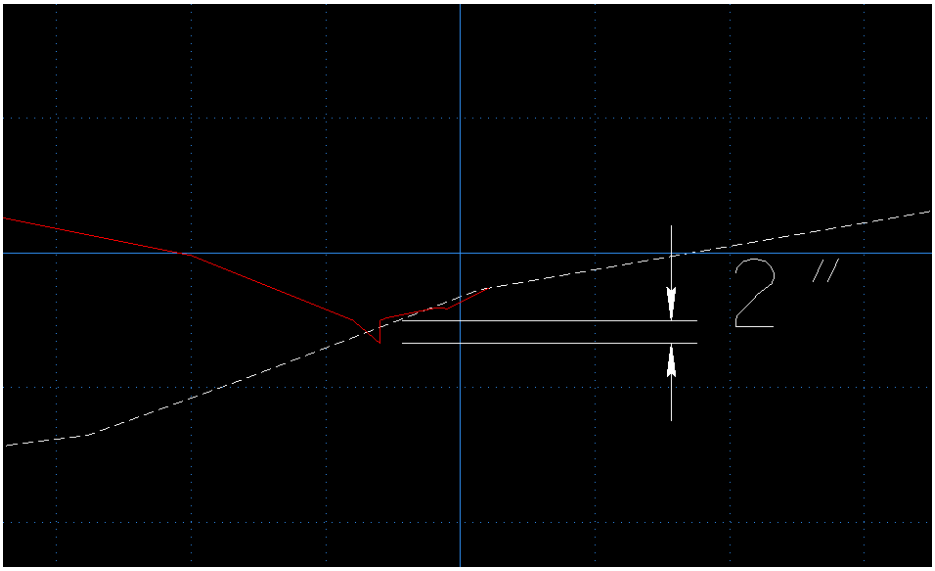
Drive to be located at approximately 917+99 Rt.

The procedure for setting up Private Drives is documented at the link:

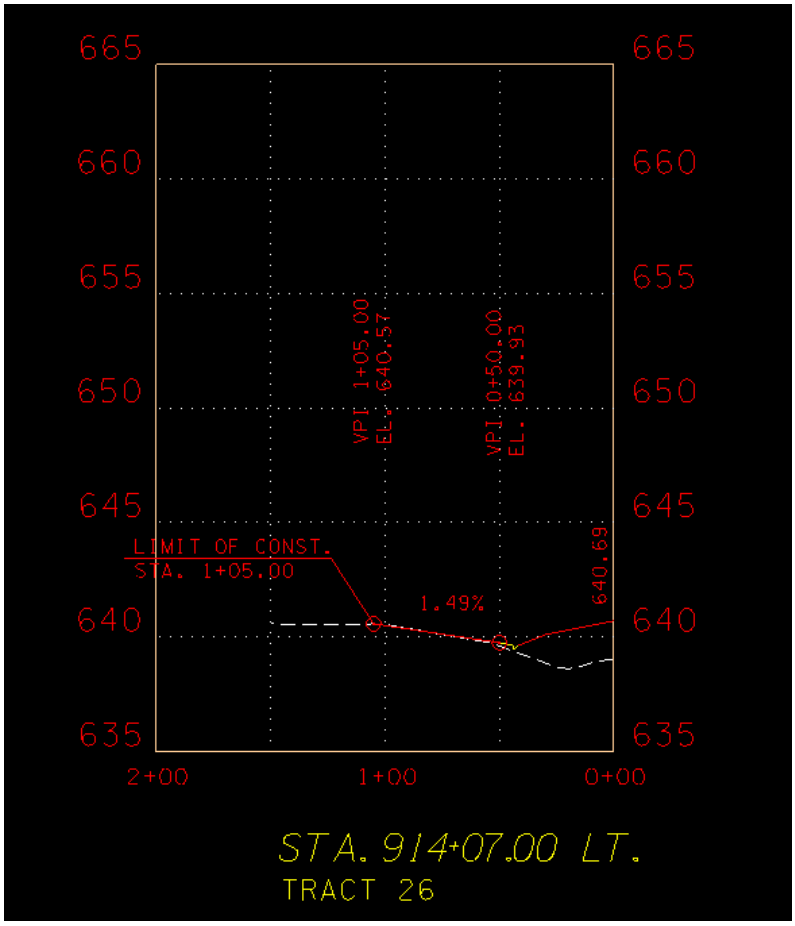
https://www.tn.gov/content/dam/tn/tdot/roadway-design/documents/cadd_files/documents/Private%20Drive%20Profiles.pdf

For drives in curb and gutter sections, lower the curb to tie the drive in:

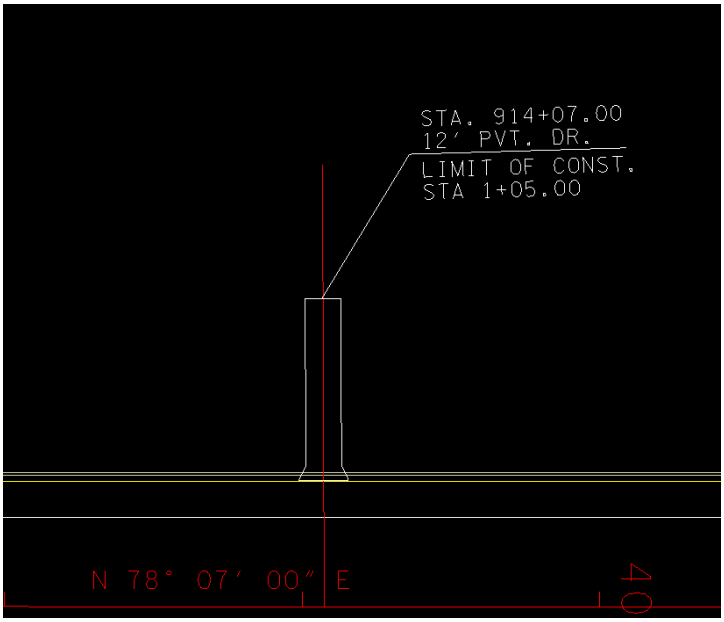




914+07 Lt., Profile view:

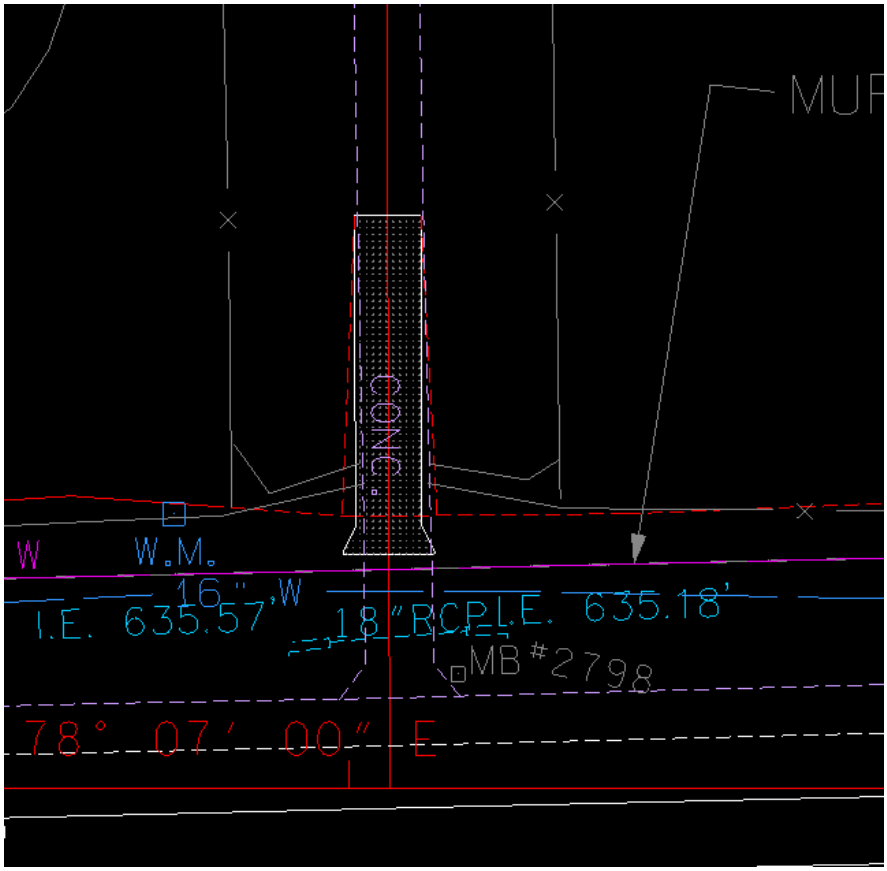


Proposed Layout view:



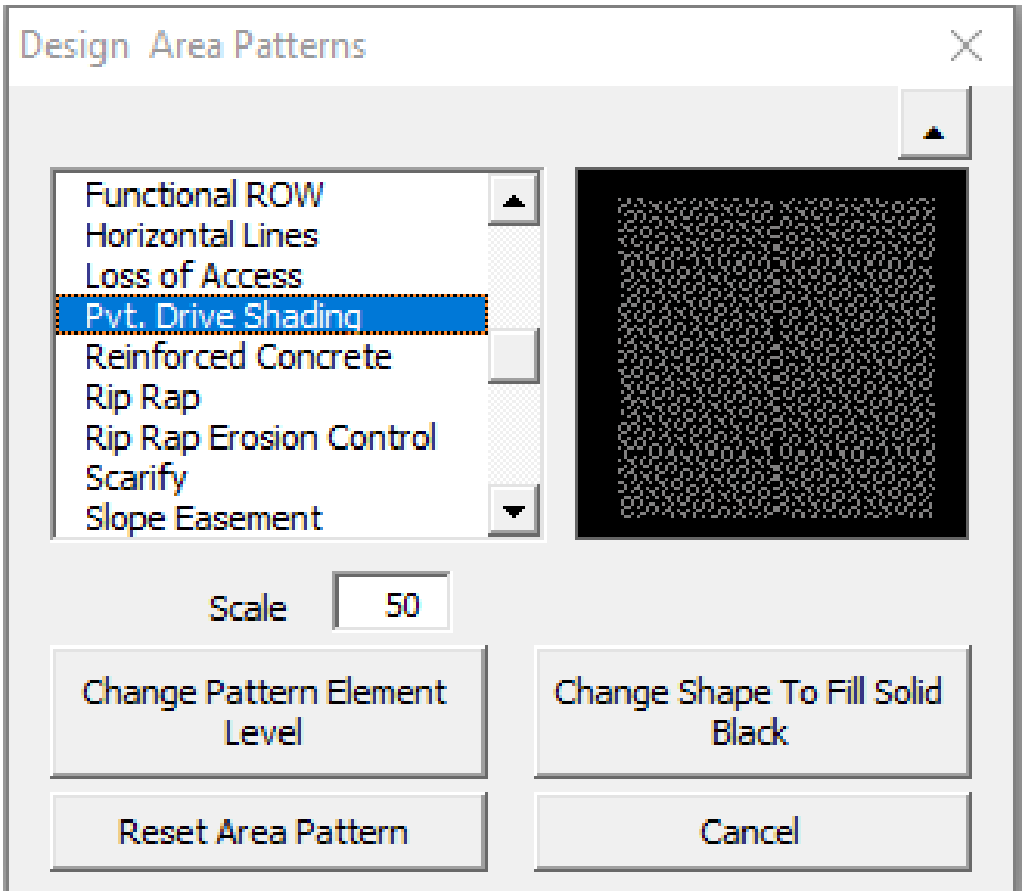
For the width, match the existing drive width.

Present Layout view:

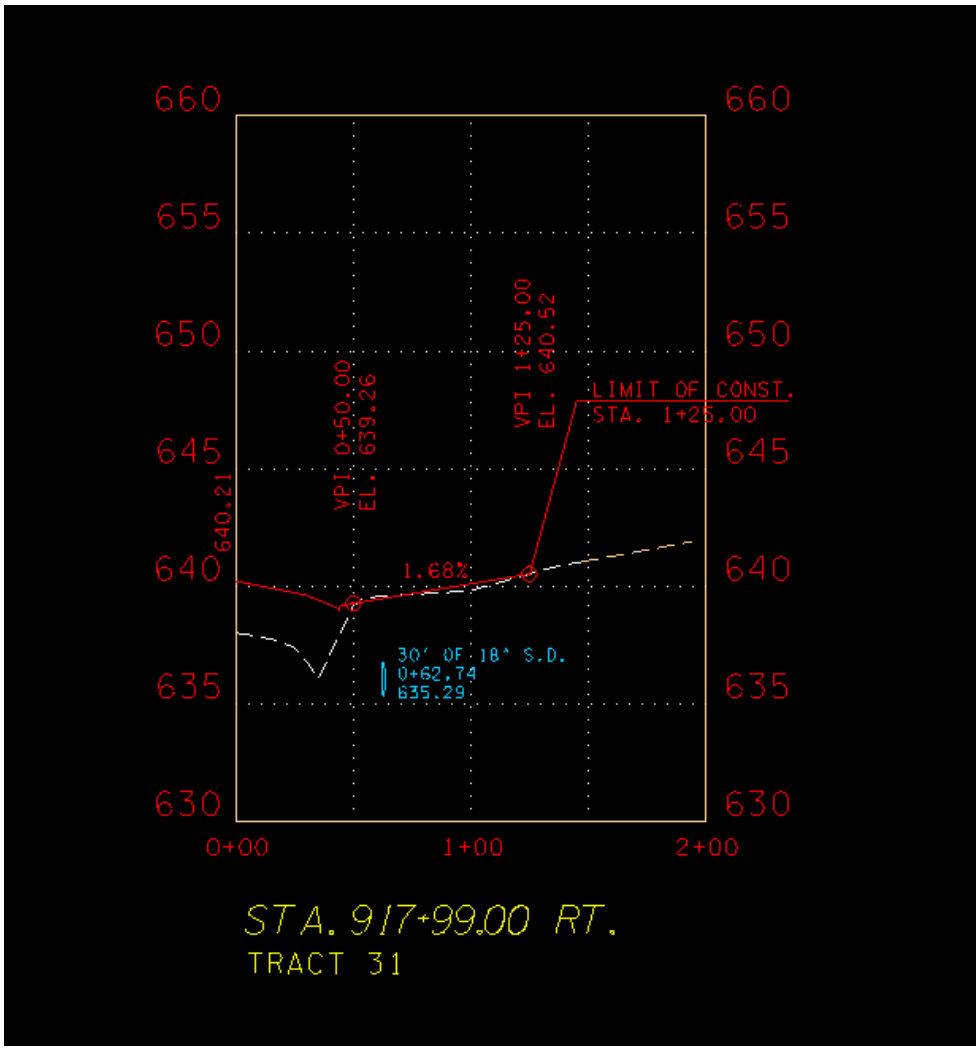


To shade the drive use setting:

T.D.O.T.> Area Patterns > Design Area Patterns:

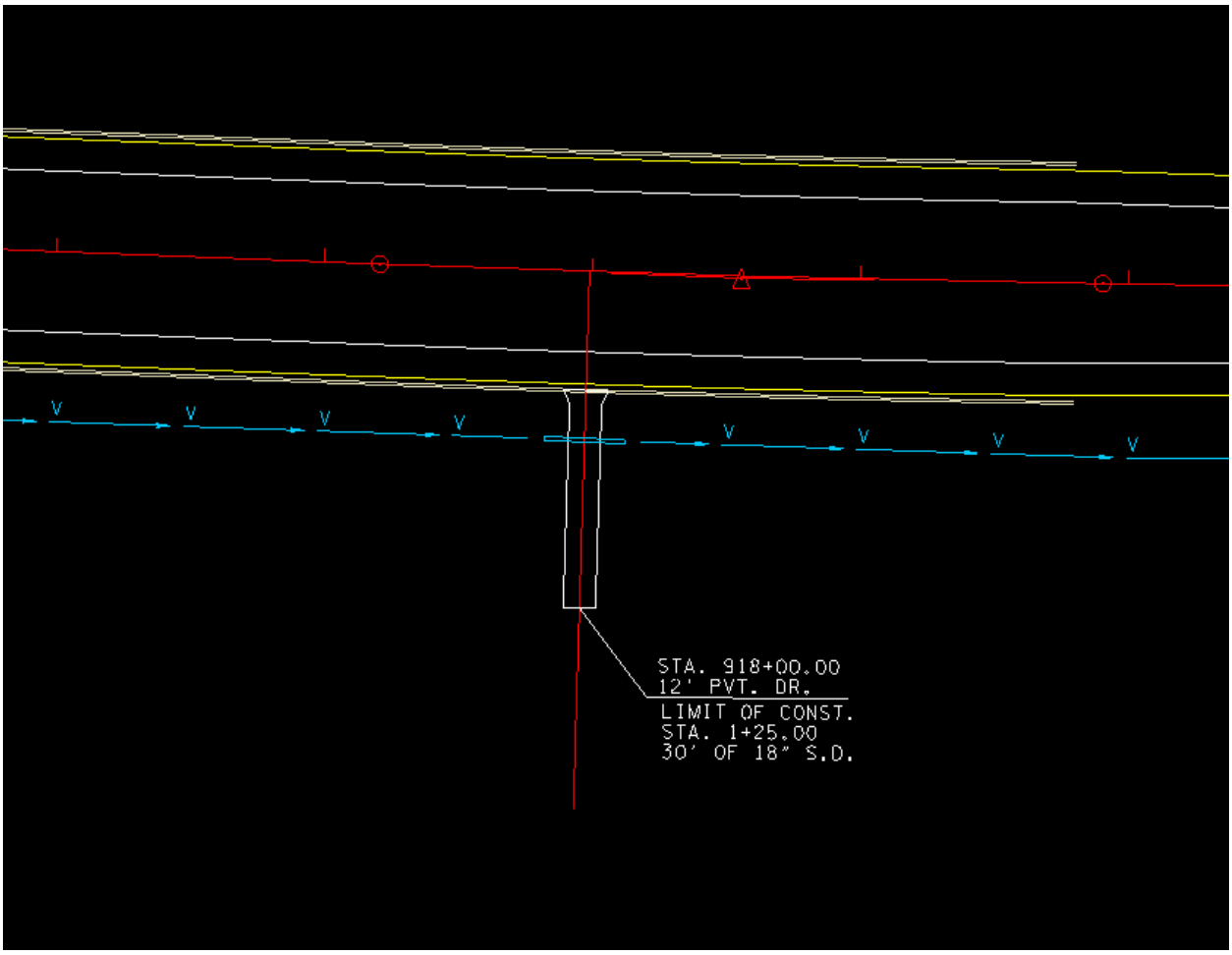


917+99 Rt., Profile view:



The side drain is located in the ditch line. The size of pipe based on flow in ditch. Downstream cross drain is 18” so 18” side drain will work here.

Proposed Layout view:



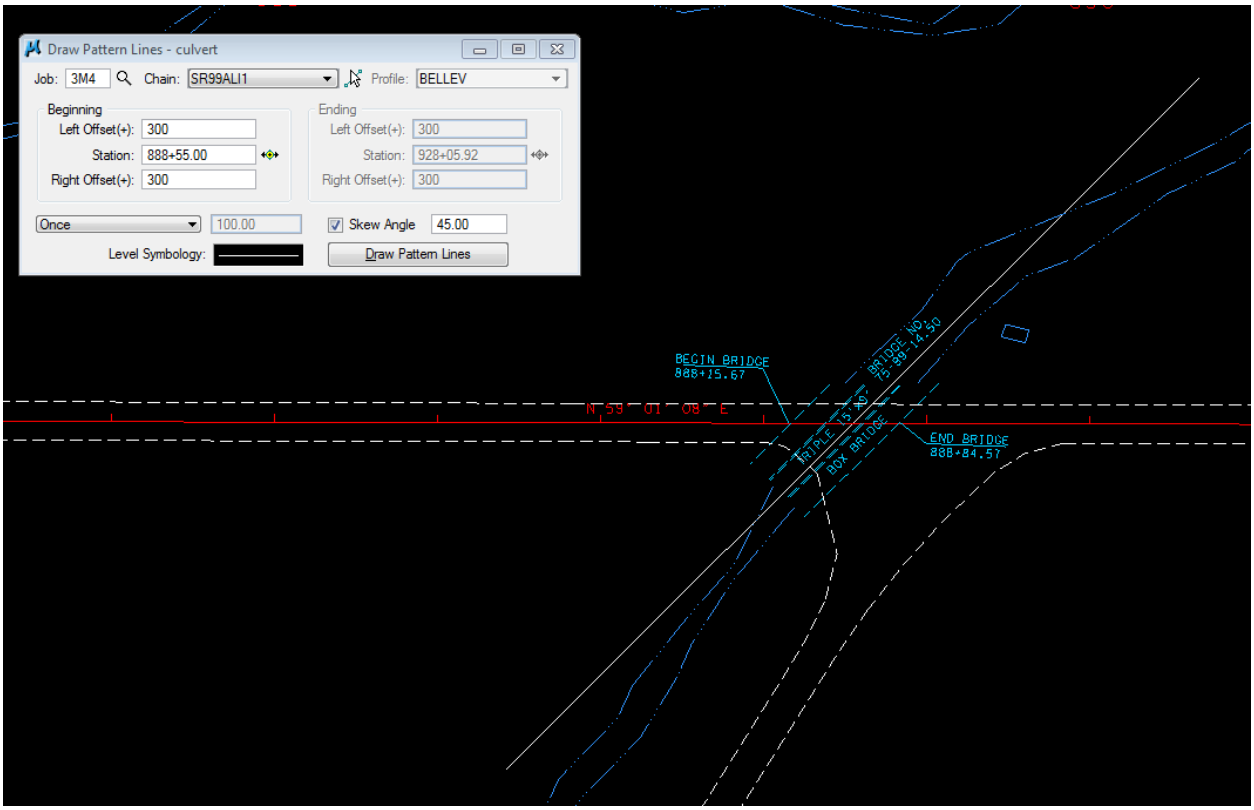
The length of the side drain is based on 2:1 side slopes and the height difference between the ditch or side drain elevation and the surface of the drive.

CULVERTS AND DITCHES

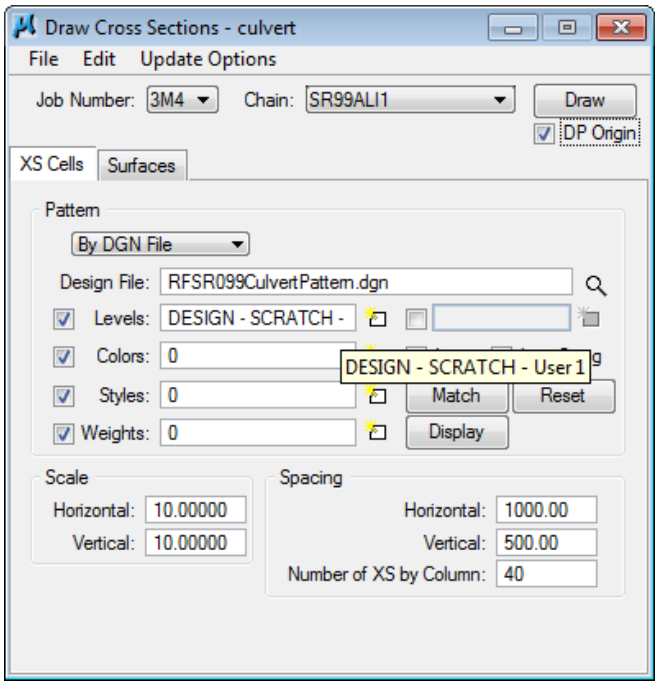
The Grade Approval (Appendix B) contains relevant information about the existing box culverts and box bridges on the project. The designer can use this information to generate culvert cross sections and place the proposed information on the plans. The structure at station 965+60 is outside the limits for this manual.

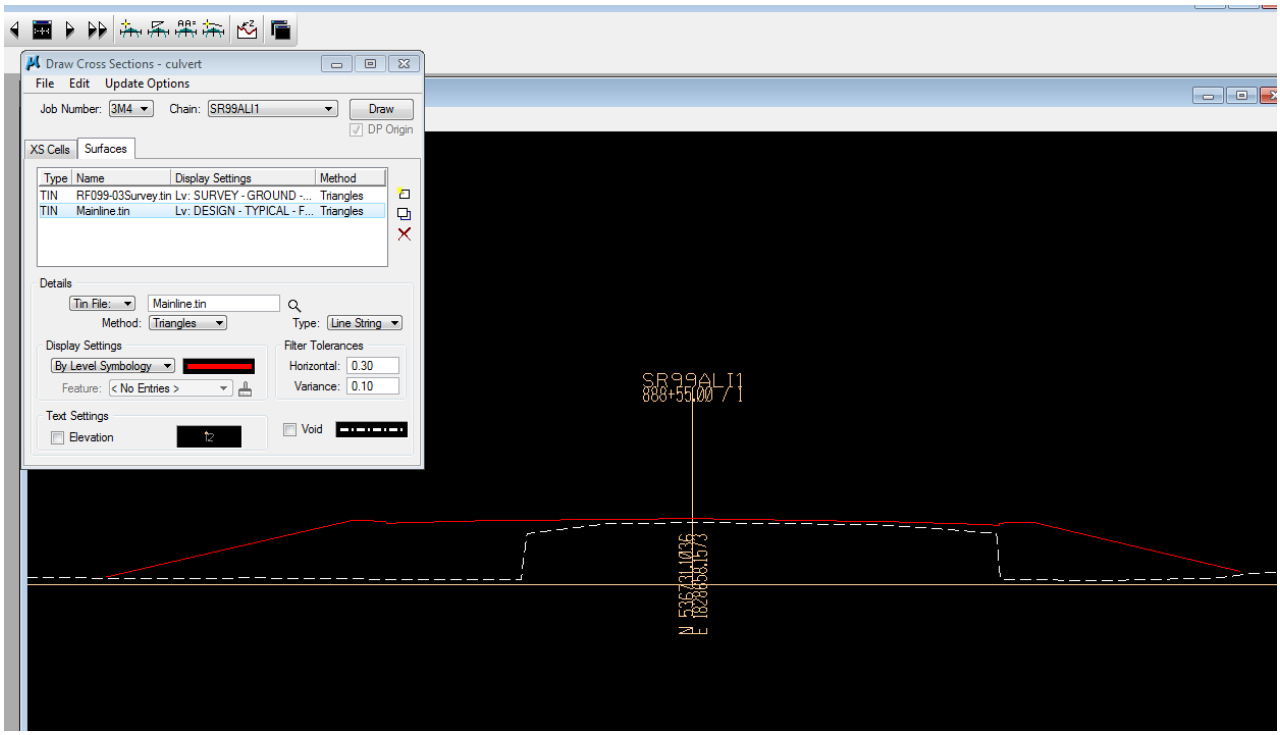
First draw culvert sections for each structure required.

3@15x9 Box Bridge at Station 888+55:
Draw a skewed pattern line in the file RFSR099CulvertPattern.dgn

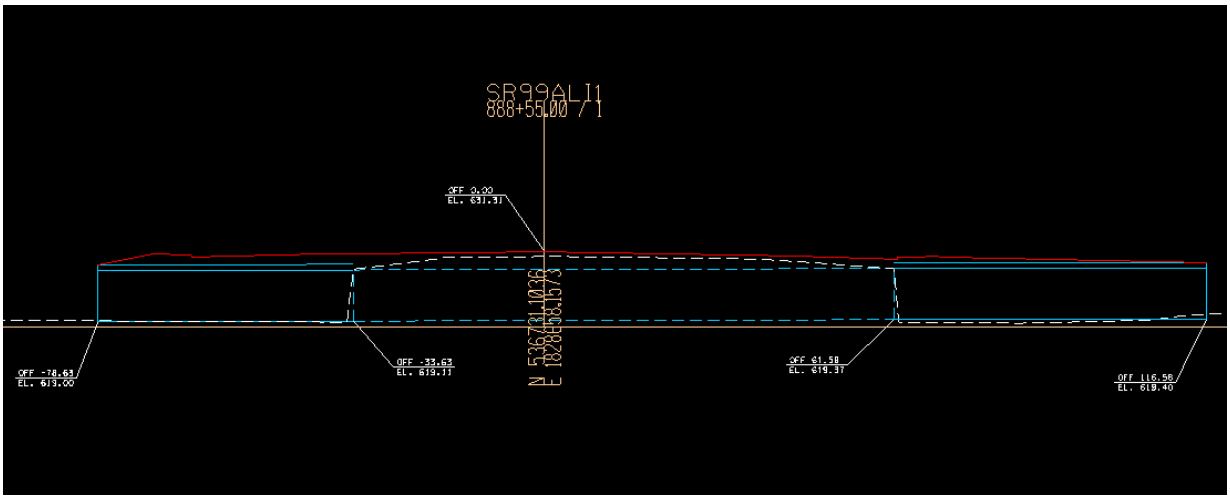


Go to the file RFSR099 CulvertXSections.dgn and draw cross section with the existing and proposed surface:


Draw Cross Sections - culvert
File Edit Update Options
Job Number: 3M4
Chain: SR99ALI1
Draw
DP Origin
XS Cells
Surfaces
Pattern
By DGN File
Design File: RFSR099CulvertPattern.dgn
Levels: DESIGN - SCRATCH -
Colors: 0
DESIGN - SCRATCH - User 1
Styles: 0
Weights: 0
Match
Reset
Display
Scale
Horizontal: 10.00000
Vertical: 10.00000
Spacing
Horizontal: 1000.00
Vertical: 500.00
Number of XS by Column: 40

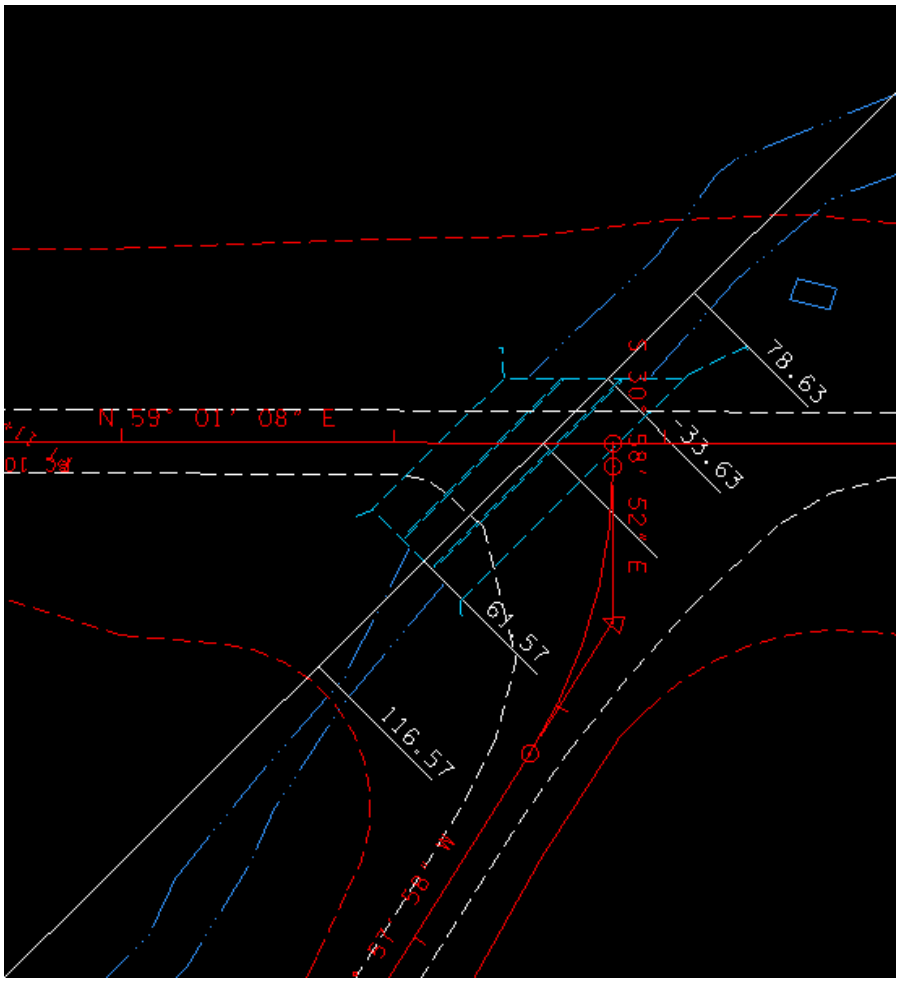

Draw Cross Sections - culvert
File Edit Update Options
Job Number: 3M4
Chain: SR99ALI1
Draw
DP Origin
XS Cells
Surfaces
Type Name Display Settings Method
TIN RF099-03Survey.tin Lv: SURVEY - GROUND -... Triangles
TIN Mainline.tin Lv: DESIGN - TYPICAL - F... Triangles
Details
Tin File:
Mainline.tin
Method: Triangles
Type: Line String
Display Settings
By Level Symbology
Feature: < No Entries >
Filter Tolerances
Horizontal: 0.30
Variance: 0.10
Text Settings
Elevation
Void
SR99ALI1
888+55.00

Draw Existing and proposed culvert using information provided on the Grade approval:

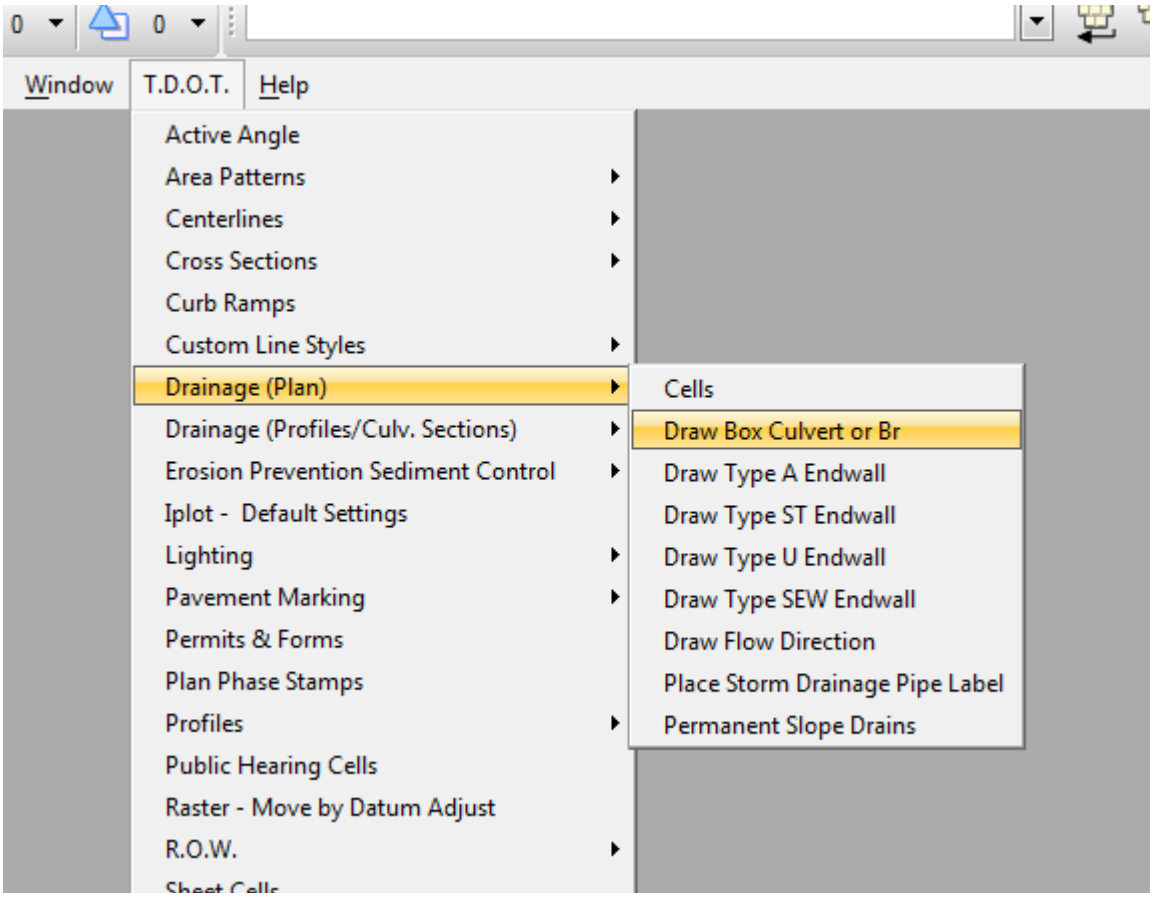


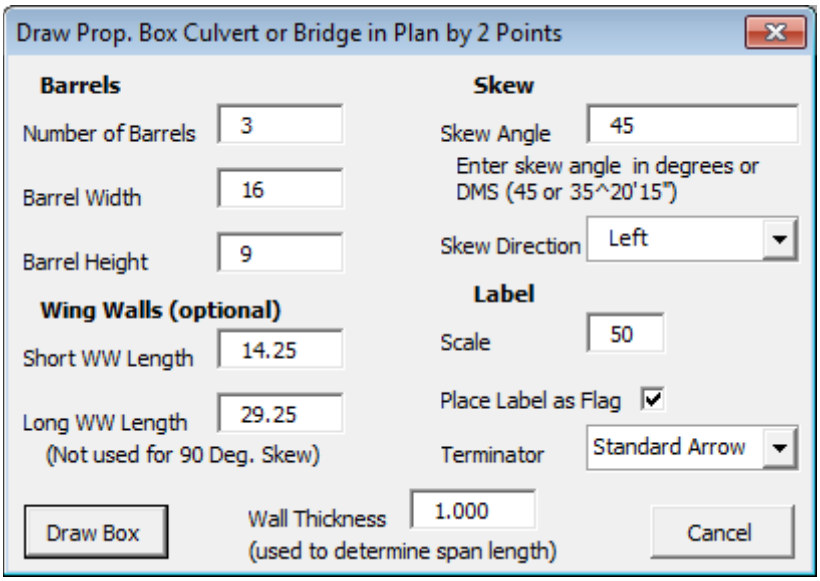
Using the offset distances and elevations on the cross section,and grade approval information, draw the proposed extended box bridge on the plan view, in the file RFSR099Proposed.dgn. (The Culvert Pattern dgn file is referenced)

The offsets for the ends are marked along the pattern line

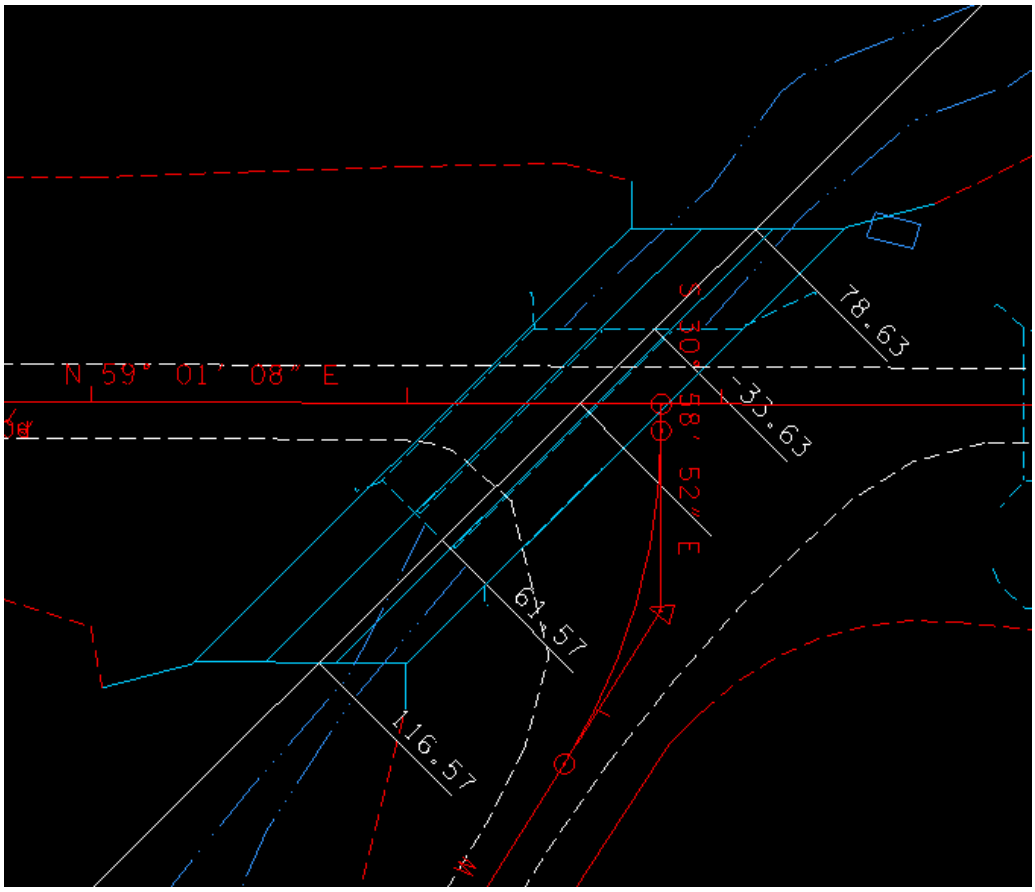


Draw Proposed Box Bridge using TDOT drop down menu


Window
T.D.O.T.
Help
Active Angle
Area Patterns
Centerlines
Cross Sections
Curb Ramps
Custom Line Styles
Drainage (Plan)
Drainage (Profiles/Culv. Sections)
Erosion Prevention Sediment Control
Iplot - Default Settings
Lighting
Pavement Marking
Permits & Forms
Plan Phase Stamps
Profiles
Public Hearing Cells
Raster - Move by Datum Adjust
R.O.W.
Cells
Draw Box Culvert or Br
Draw Type A Endwall
Draw Type ST Endwall
Draw Type U Endwall
Draw Type SEW Endwall
Draw Flow Direction
Place Storm Drainage Pipe Label
Permanent Slope Drains

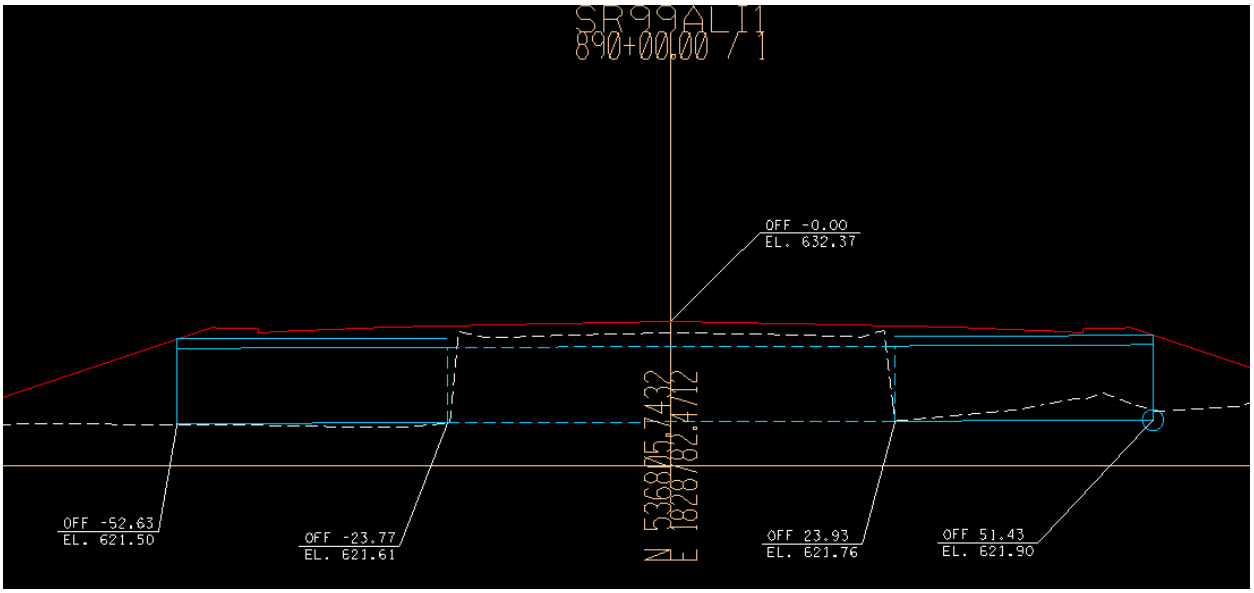

Draw Prop. Box Culvert or Bridge in Plan by 2 Points
Barrels
Number of Barrels
3
Barrel Width
16
Barrel Height
9
Wing Walls (optional)
Short WW Length
14.25
Long WW Length
29.25
(Not used for 90 Deg. Skew)
Skew
Skew Angle
45
Enter skew angle in degrees or DMS (45 or 35^20'15")
Skew Direction
Left
Label
Scale
50
Place Label as Flag
Terminator
Standard Arrow
Draw Box
Wall Thickness
1.000
(used to determine span length)
Cancel

The wingwall lengths are found in standard drawing STD-17-14, based on a slope of 3:1 and height of 10’ from the cross section at sta 888+00
The Standard Drawings have changed since this Grade Approval was issued so you will need to look up the proper drawings on the State website.

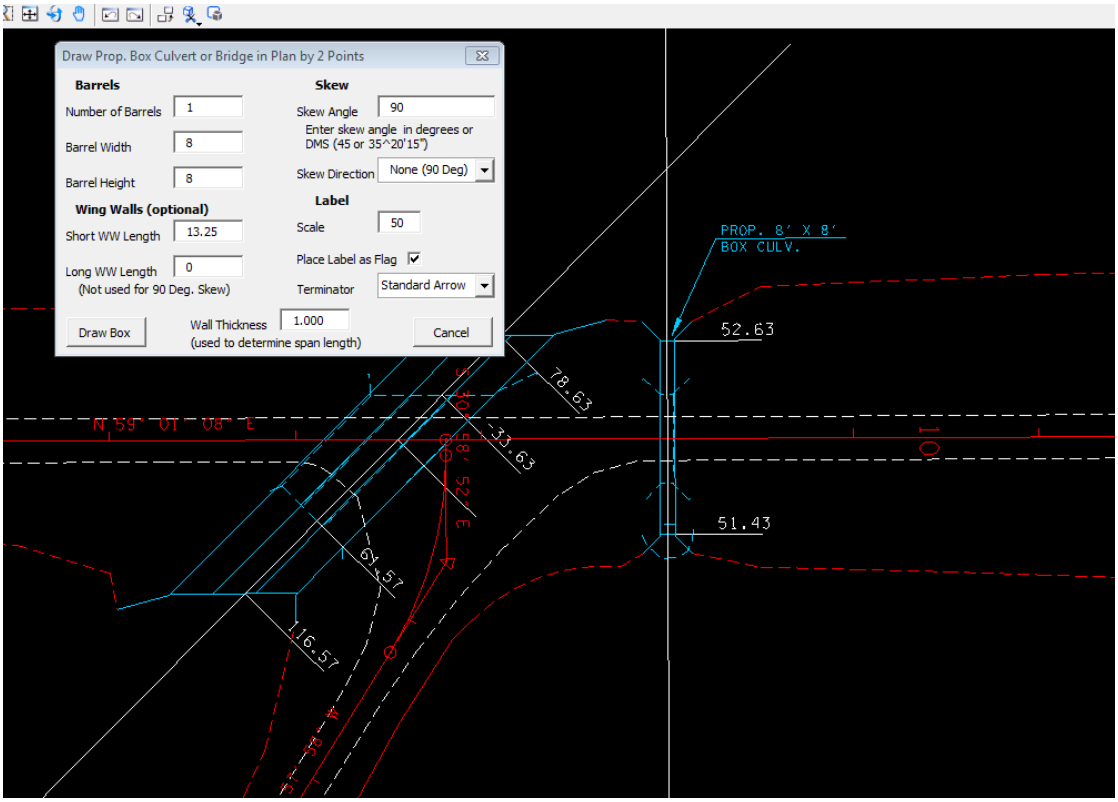


Proposed Box Bridge at Station 888+55. The slope lines have been modified to turn in to the wingwalls.

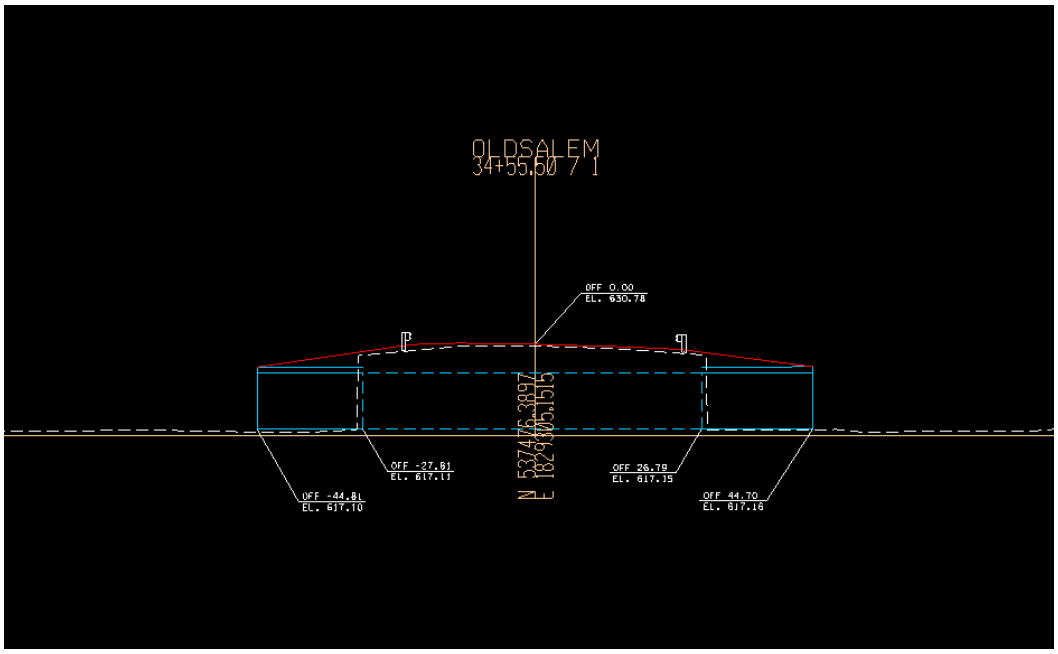
.



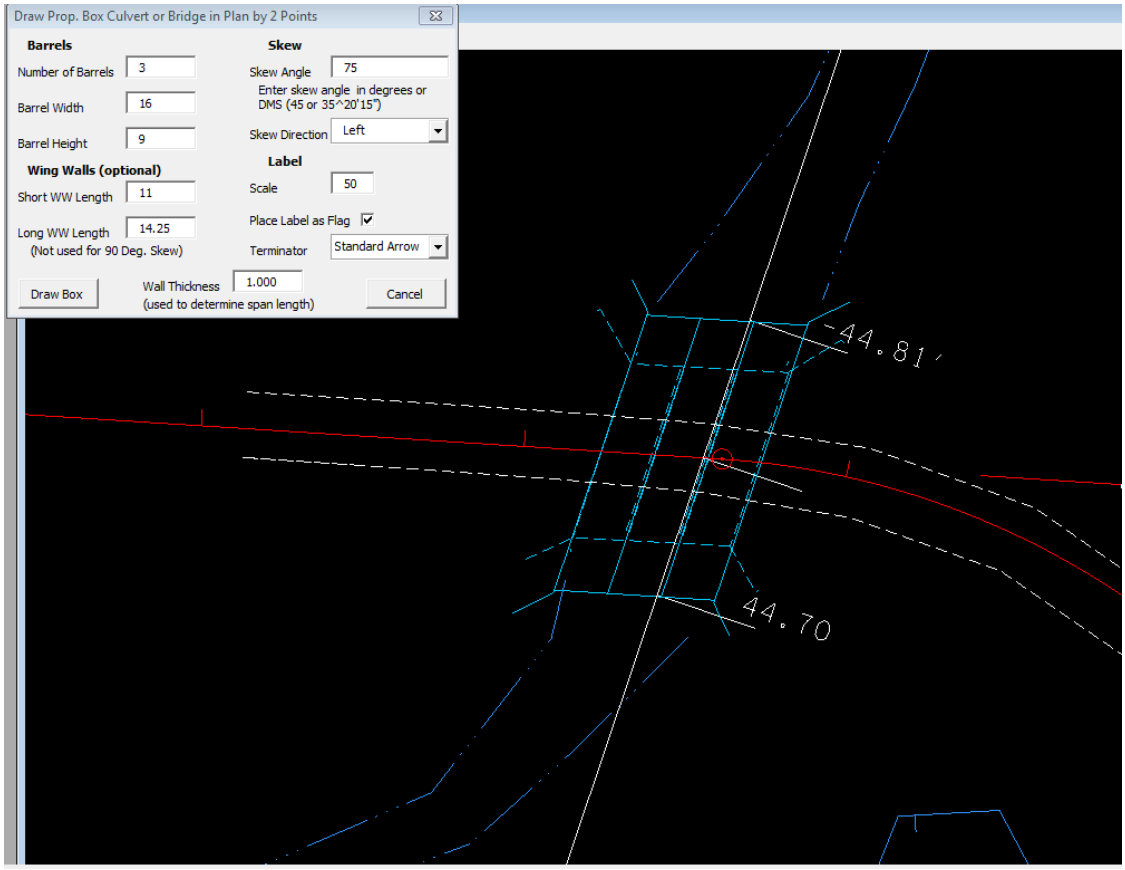
Cross section of 8x8 box culvert at Station 890+00



Plan view of 8x8 box culvert at Station 890+00. Wingwall lengths based on std. dwg. STD-17-11, 3:1 slope.

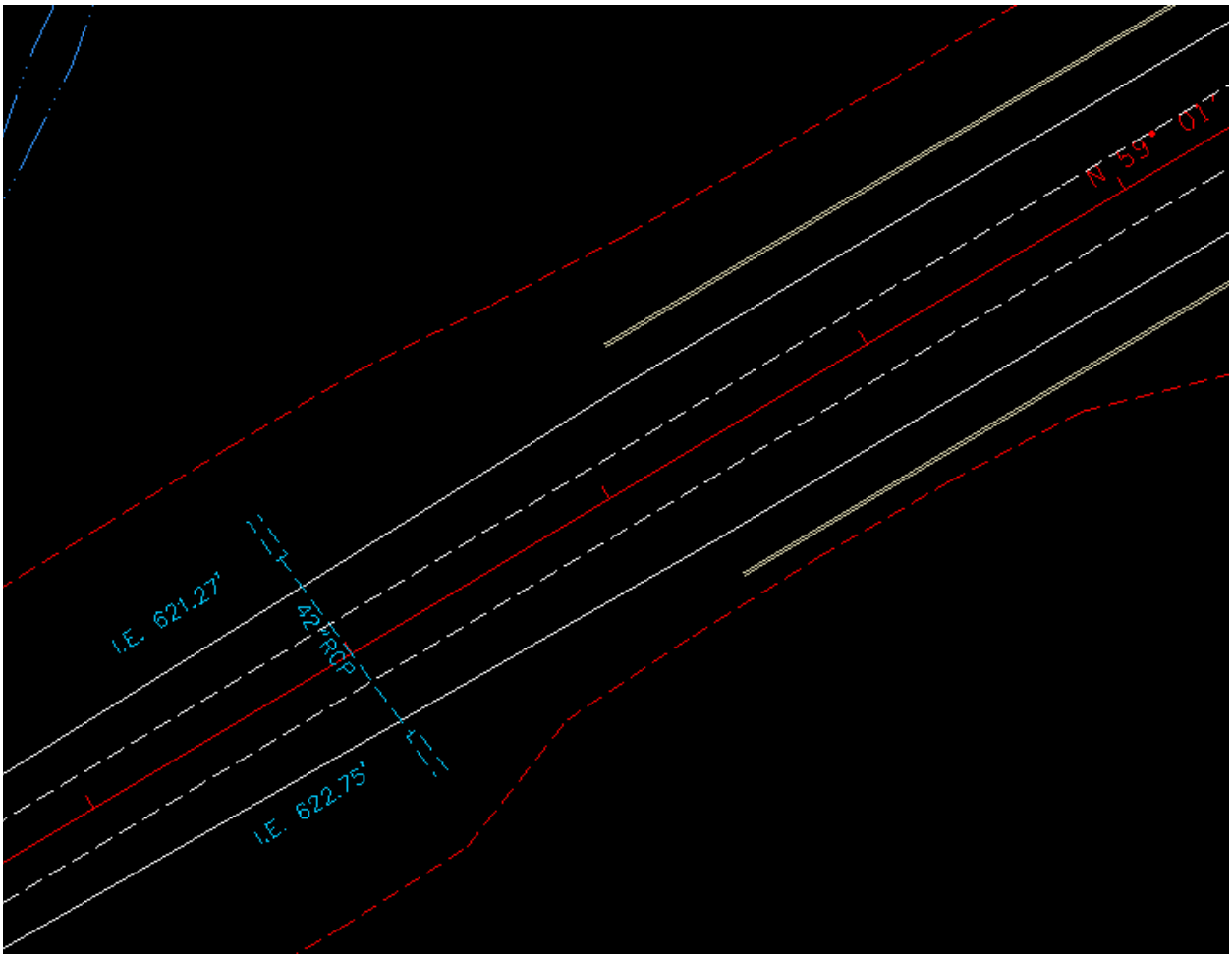


Cross section of 3@15 x 9 box bridge at Station 34+55.50

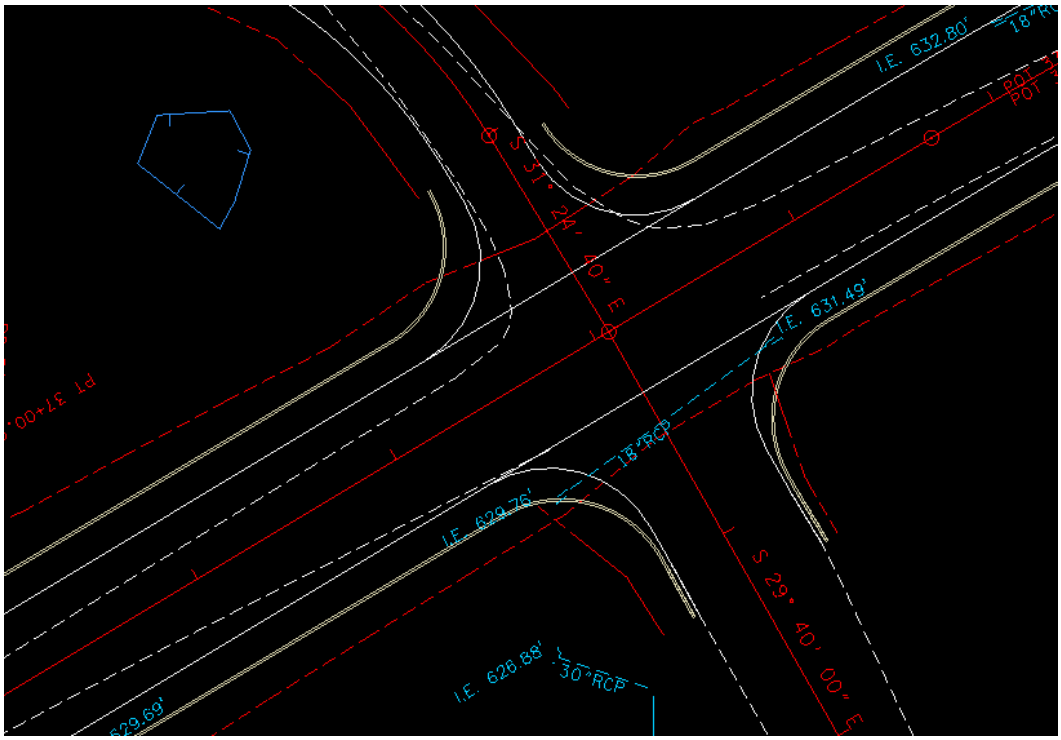


Plan view of 3@15 x 9 box bridge at Station 34+55.50

Now it needs to be determined where any other culvert crossings might be needed. On inspection of the Survey dgn file it is seen there is an existing 42 “ culvert at station 884+00 and an 18” culvert crossing Weston Blvd.



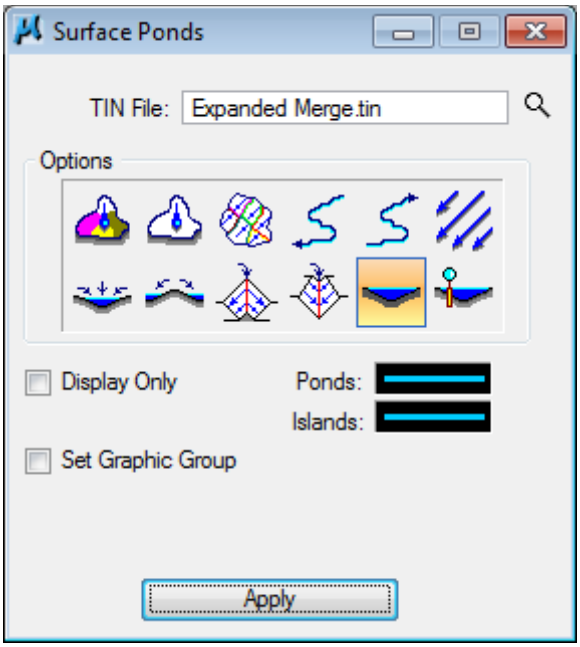
Station 884+00, Mainline



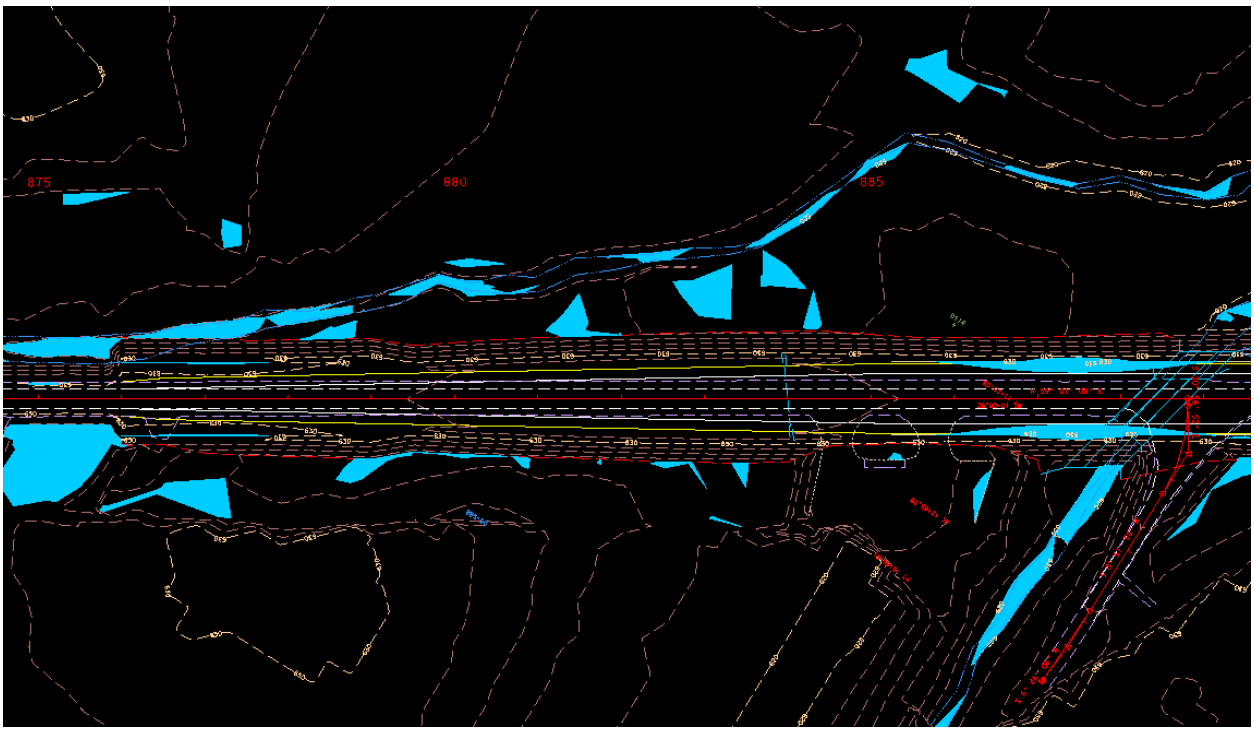
Weston Blvd.

Before proceeding note that the survey tin file is inadequate to cover all the drainage areas given in the survey file. Follow the procedure outlined in Appendix B of the GEOPAK Drainage Manual in order to add more DTM information. Give the new tin file a name of you choosing. For this manual we will call it “Expanded Survey.tin”. Then merge the proposed.tin surface created in the previous section and call it “Expanded Merge.tin”

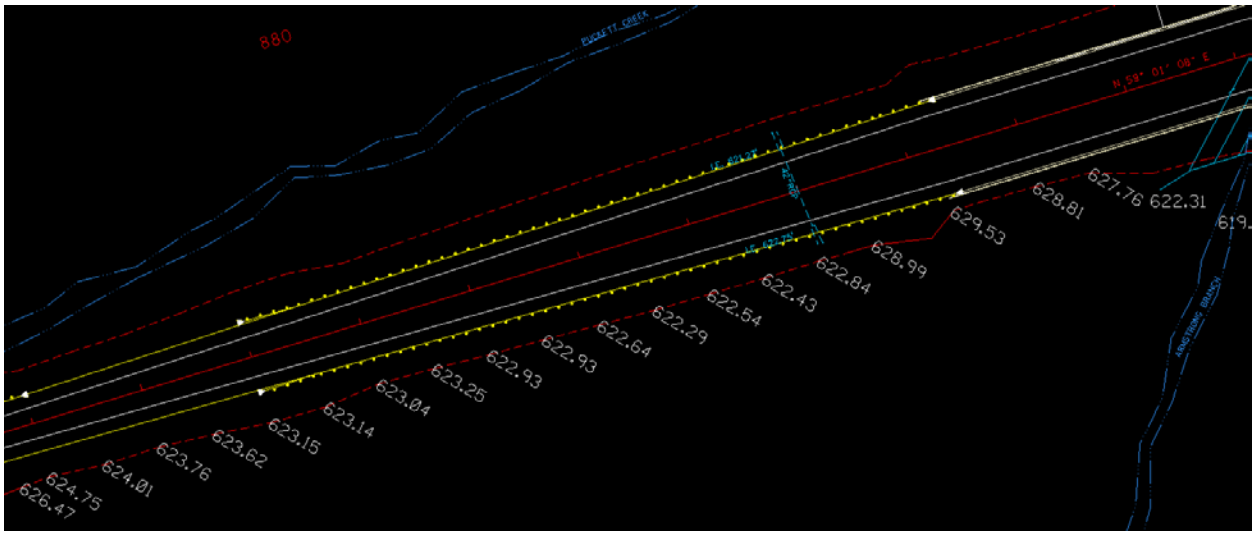
Now use the drainage tools in the DTM tool box to display ponding areas for the merged surface.



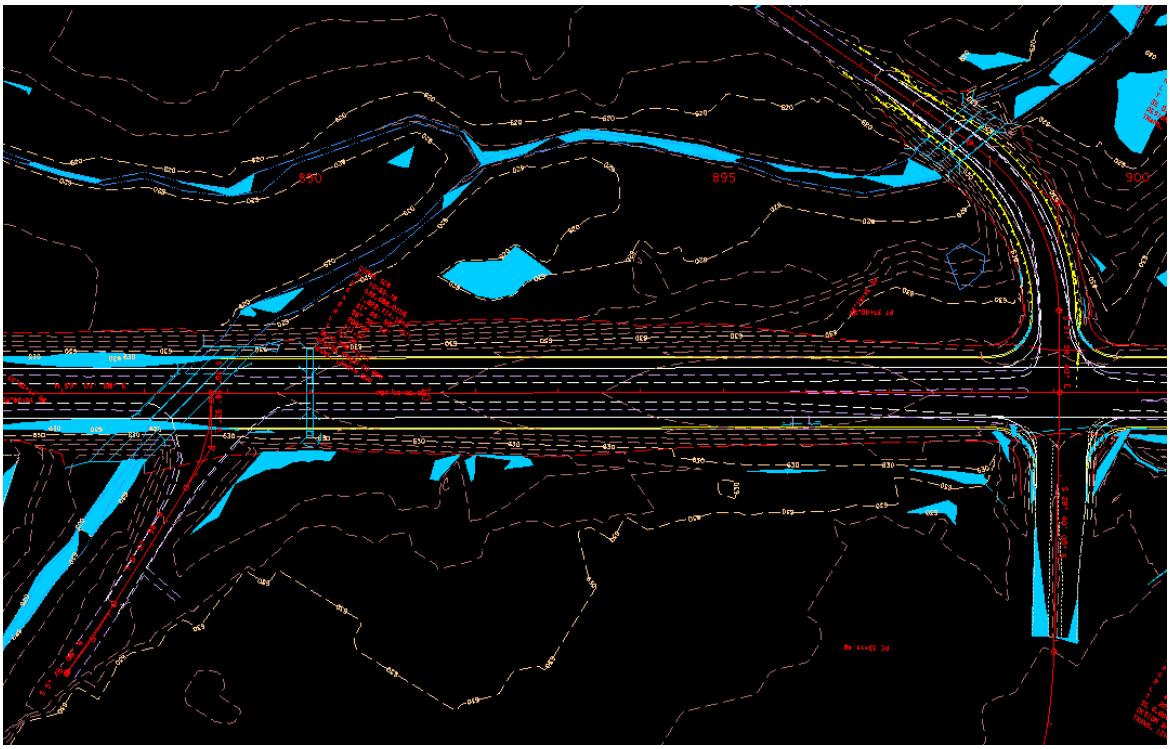
Ponding along the slope lines (displayed in blue) will need either a cross drain or special ditch.



Area from Sta 876+00 (Begin. Project) to Box Bridge
In this area, much ponding is seen along the slope lines on both sides.
In this area, extend the existing culvert at sta. 884+00 on both ends. Run a ditch on the right side from approx. sta 879+00 to approx. sta. 884+00. This ditch will drain into the inlet of the extended culvert. On the left side , run a ditch from approx. 878+50 to approx. sta 888+50. Drainage from the culvert will run into the ditch on the left side into the creek at the box bridge outlet. Ordinarily we would want to drain directly into the creek at 884+00 but the elevations indicate we can not do that so that is why the ditch on the left is needed to go all the way to the box bridge.

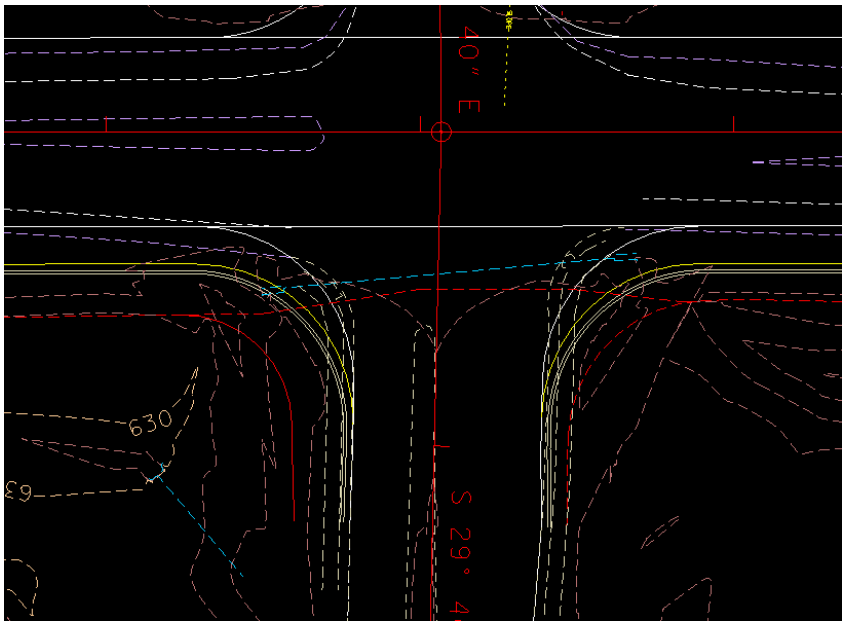


By looking at the toe of slope elevations, you can see the elevations do not consistently run in one direction. This also indicates that a ditch is needed at the toe of slope from approx. 879+00 to the box culvert.

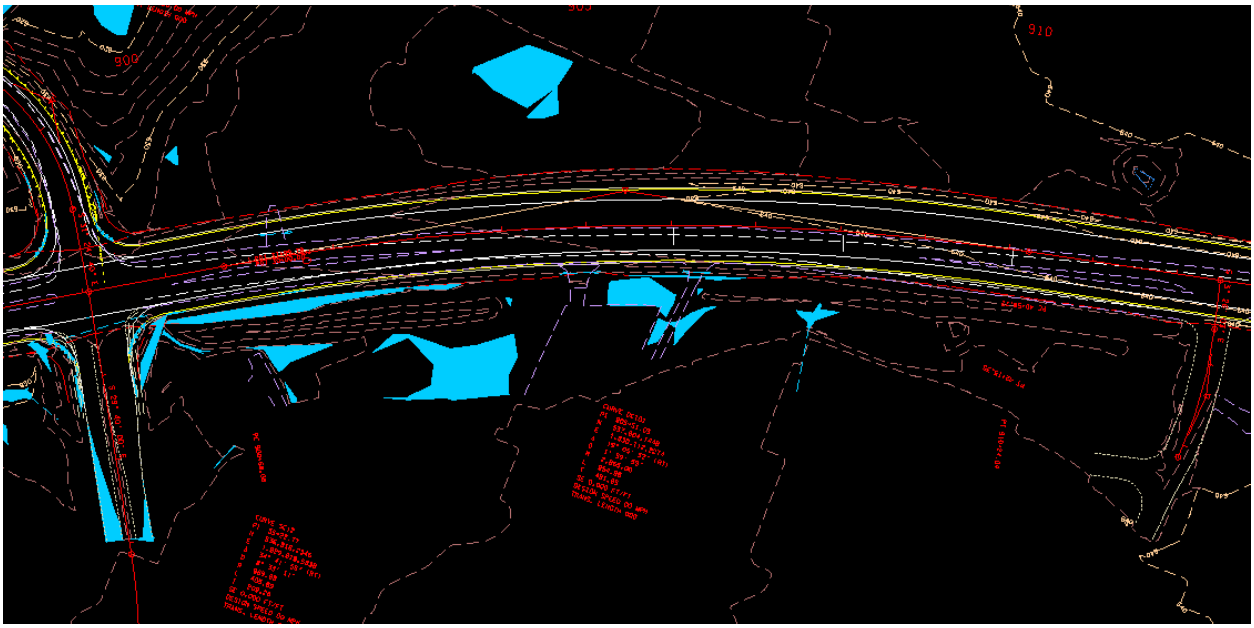


Area from Box Bridge to Old Salem/Weston

In this area the ponding that we will be concerned with is on the right at approx. 892+50, so run ditch from 892+50 back to 890+00 to drain to the inlet area of the box culvert. The cross drain on Weston at approx. sta 30+45 will need to be relocated.

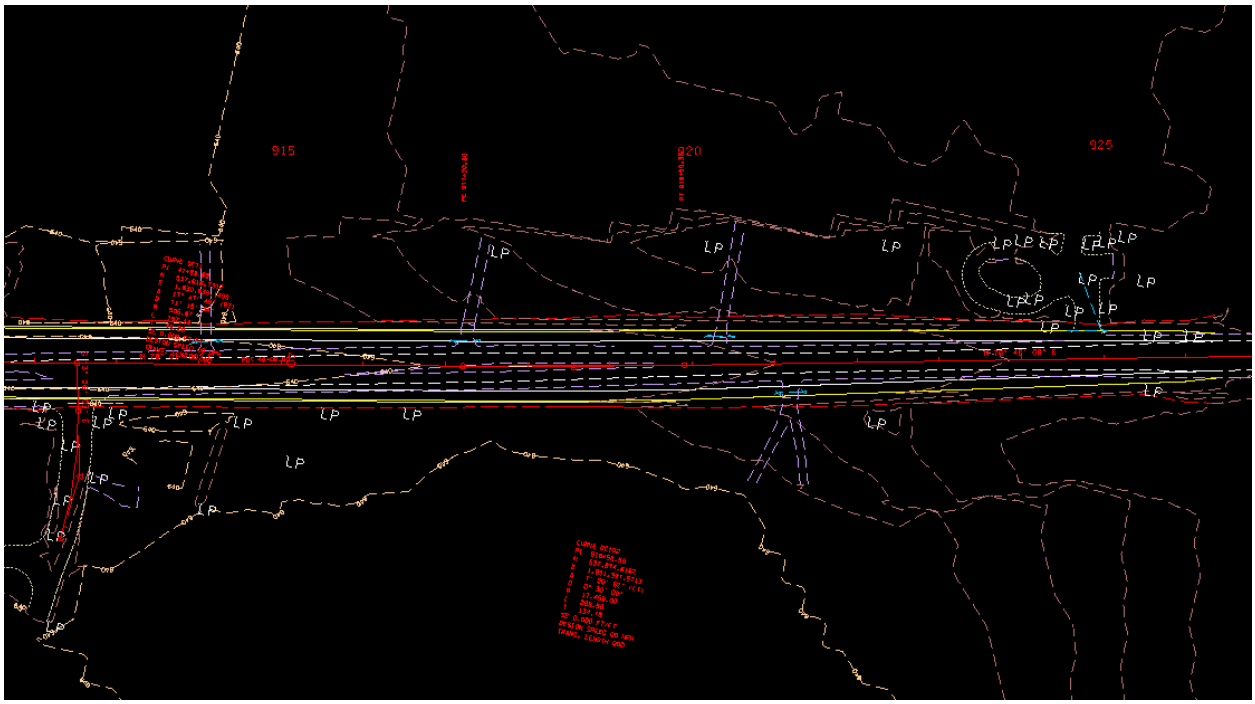


Existing cross drain at Weston Blvd. , sta. 30+45



Area from Old Salem/Weston to Belle Rive

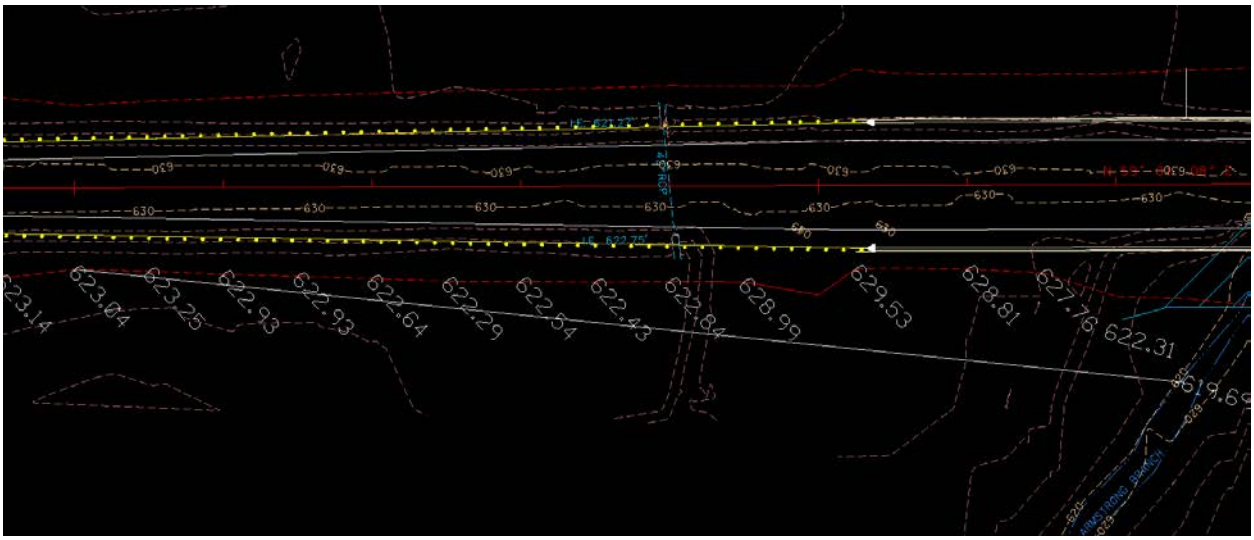
In this area there is ponding at the slope lines on the right side from 900+00 to 907+00. We will likely need a ditch draining from 907+00 along slope line into the relocated cross drain at Weston Blvd. Then continue this ditch back to 892+50 so there is a continuous ditch from 907+00 to 890+00.



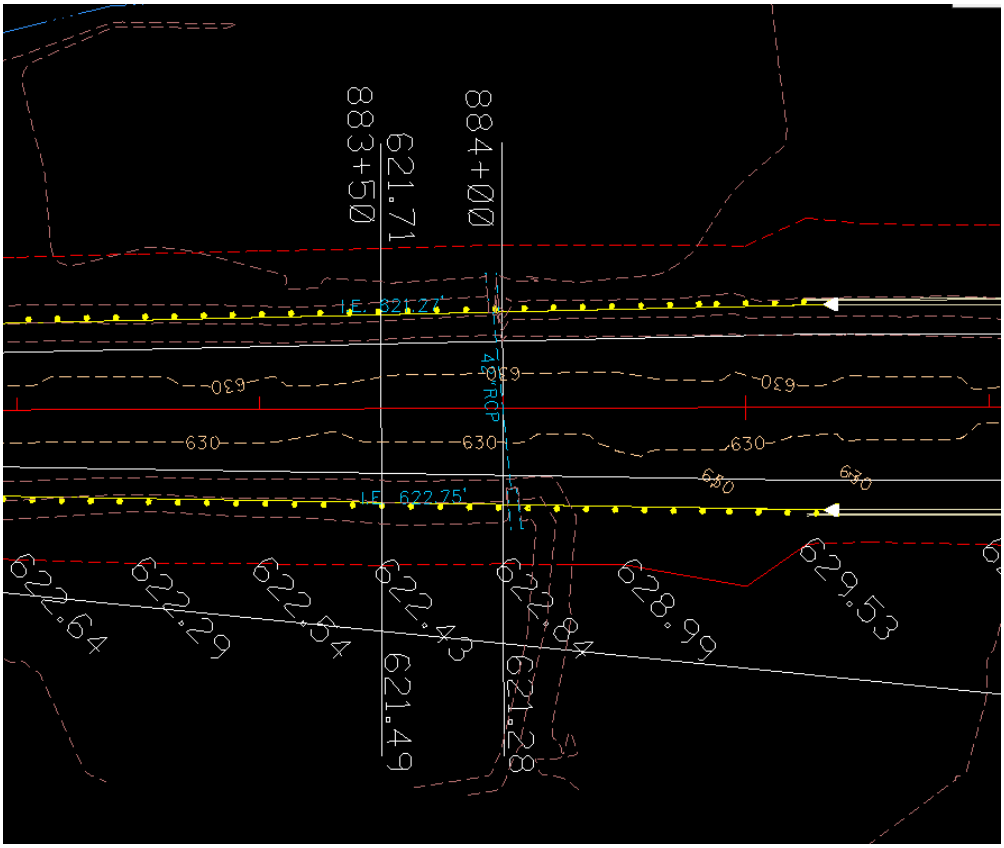
Area from Belle Rive to Sta. 926 +50 (End of Project). In this area no ponding was shown, but we delineated the low points (LP), and there are some showing up in the vicinity of the toe of slope on the right side. Here the existing ground slopes toward the end of the project, so locate a ditch at the slope line from the vicinity of Belle Rive to the end of project.

Ditch 1 – 879+00 to 884+00, Right side

Sketch a line from the toe of slope at 880+00 (low point at toe of slope, el. 623.04) to the box bridge inlet area approx. 887+50 on the right to determine what grade of the ditch you will need. Use DTM Height/Slope tool to find the elevations

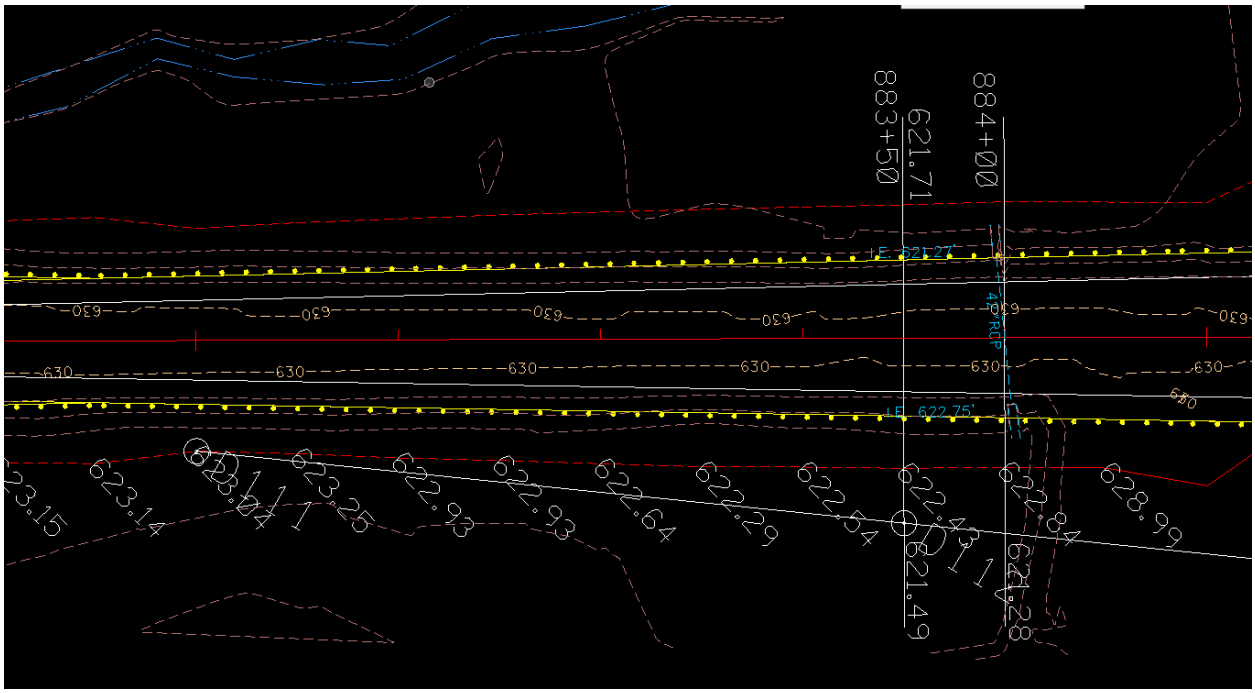


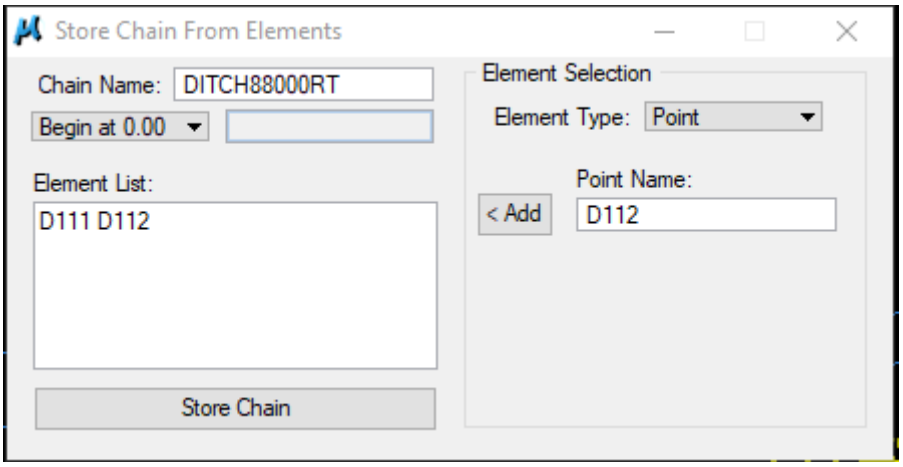
Measure the line to find that the length is 749.21. Therefore the grade is (623.04 – 619.69)/749.21 = .0044, or 0.44 %

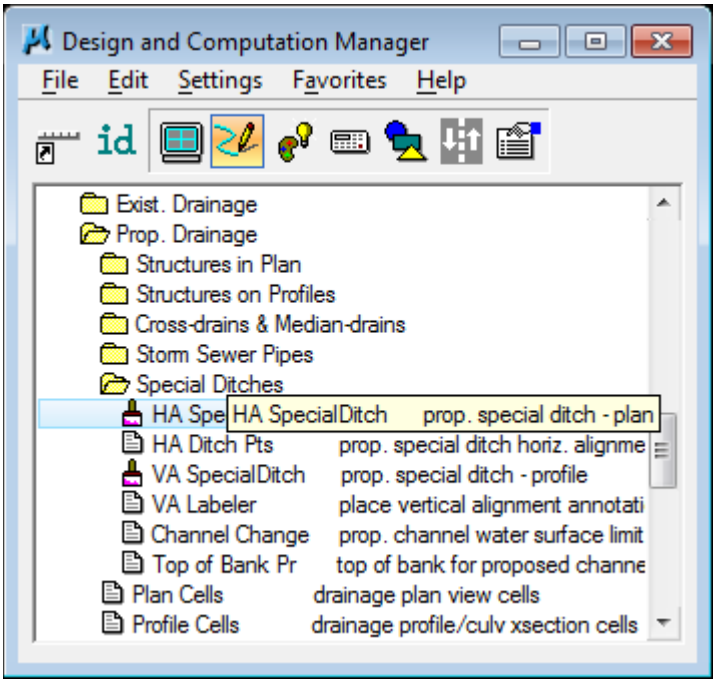


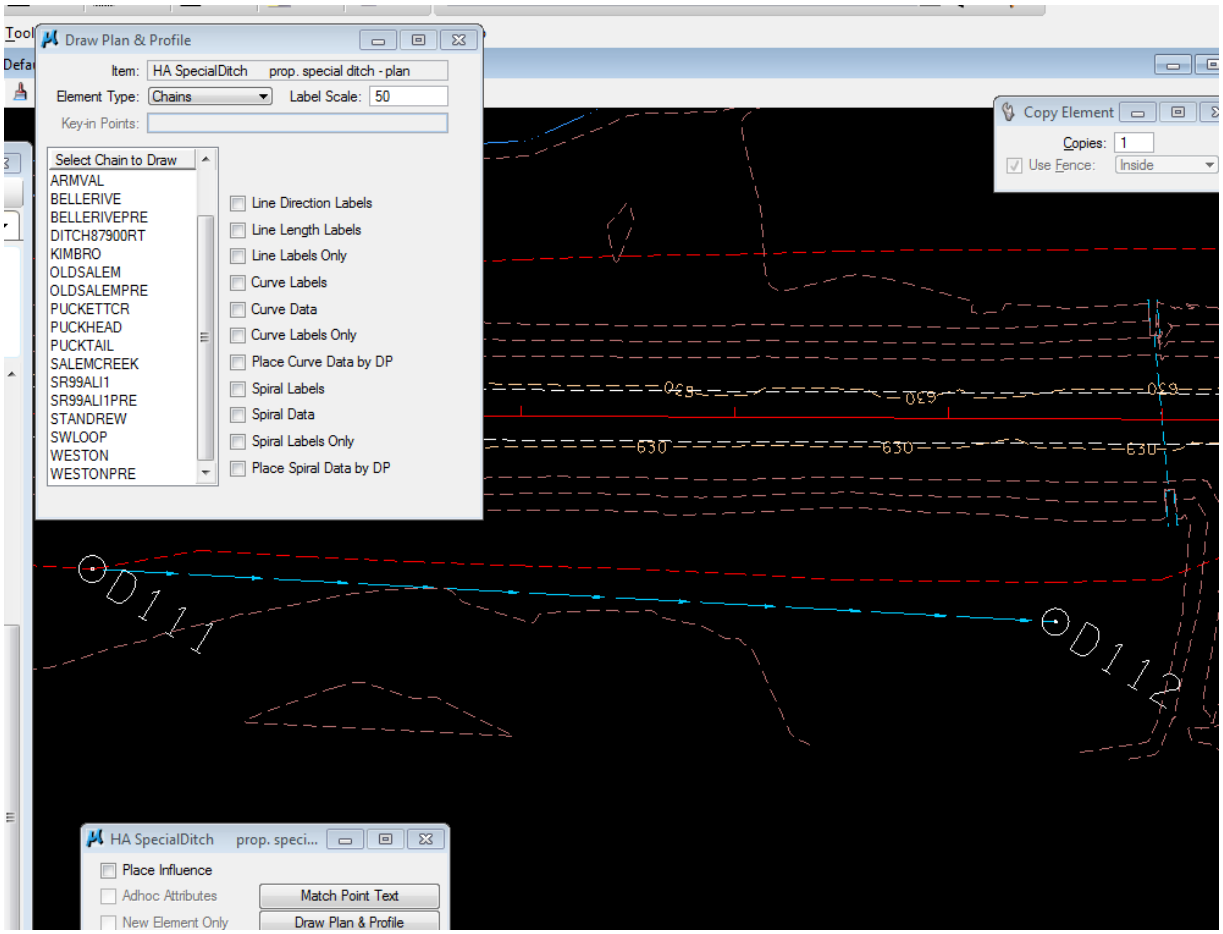
Elevations at toe of fill slope are shown to illustrate that a ditch is needed on the right side of the roadway. The proposed ditch elevation at 884+00 is 621.28 calculated on a 0.44% grade. This is lower than the existing inlet invert of the culvert. This means that the culvert can not be extended and drain properly since it drains from right to left. The culvert can be relocated to 883+50 (inlet el. 621.49), but an elevation check shows that the ground on the other side is higher (el. 621.71) than what the proposed inlet would be. It has already been determined that a ditch is needed on the other side, so make sure the elevation in that ditch is lower than 621.28 at 883+50 .

Create alignment for special ditch
In GEOPAK, Coordinate Geometry, Locate points as shown, here they are D111 and D112, but they can be named whatever the user prefers.

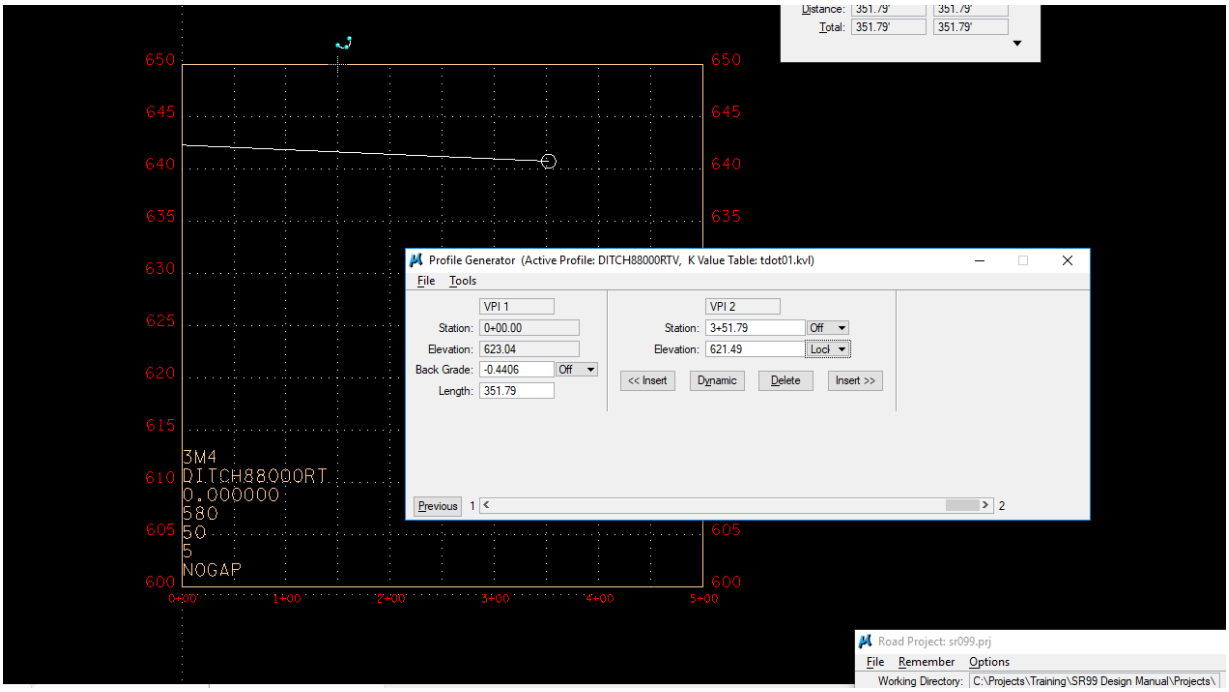



Store Chain From Elements
Chain Name: DITCH88000RT
Begin at 0.00
Element List:
D111 D112
Store Chain
Element Selection
Element Type: Point
Point Name:
< Add
D112

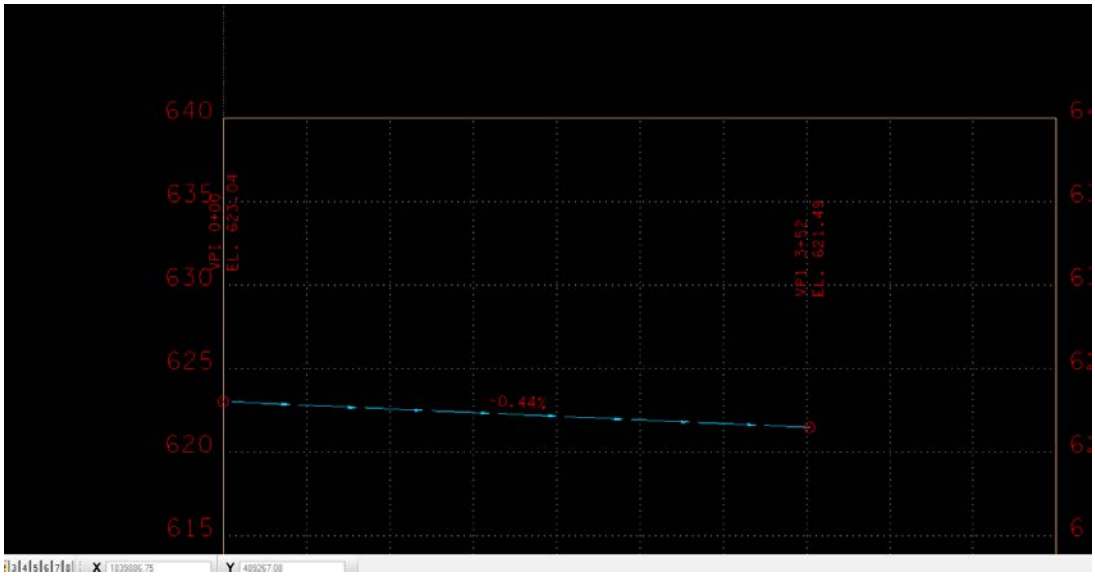

Design and Computation Manager
File Edit Settings Favorites Help
Exist. Drainage
Prop. Drainage
Structures in Plan
Structures on Profiles
Cross-drains & Median-drains
Storm Sewer Pipes
Special Ditches
HA Spe HA SpecialDitch prop. special ditch - plan
HA Ditch Pts prop. special ditch horiz. alignme
VA SpecialDitch prop. special ditch - profile
VA Labeler place vertical alignment annotati
Channel Change prop. channel water surface limit
Top of Bank Pr top of bank for proposed channe
Plan Cells drainage plan view cells
Profile Cells drainage profile/culv xsection cells


Draw Plan & Profile
Item: HA SpecialDitch prop. special ditch - plan
Element Type: Chains
Label Scale: 50
Key-in Points:
Select Chain to Draw
ARMVAL
BELLERIVE
BELLERIVEPRE
DITCH87900RT
KIMBRO
OLDSALEM
OLDSALEMPRE
PUCKETTCR
PUCKHEAD
PUCKTAIL
SALEMCREEK
SR99ALI1
SR99ALI1PRE
STANDREW
SWLOOP
WESTON
WESTONPRE
Line Direction Labels
Line Length Labels
Line Labels Only
Curve Labels
Curve Data
Curve Labels Only
Place Curve Data by DP
Spiral Labels
Spiral Data
Spiral Labels Only
Place Spiral Data by DP
Copy Element
Copies: 1
Use Fence: Inside
630
D111
D112
HA SpecialDitch prop. speci...
Place Influence
Adhoc Attributes
New Element Only
Match Point Text
Draw Plan & Profile

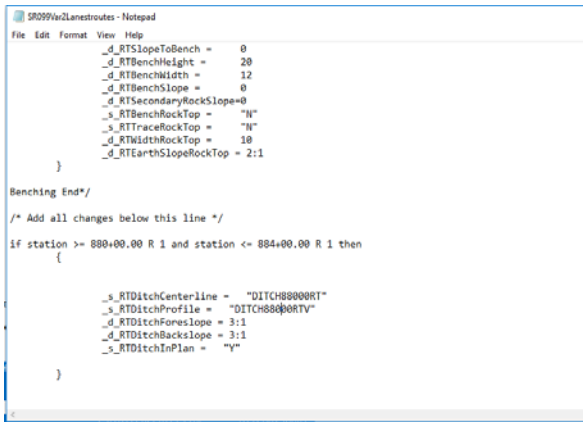
Create profile for special ditch:



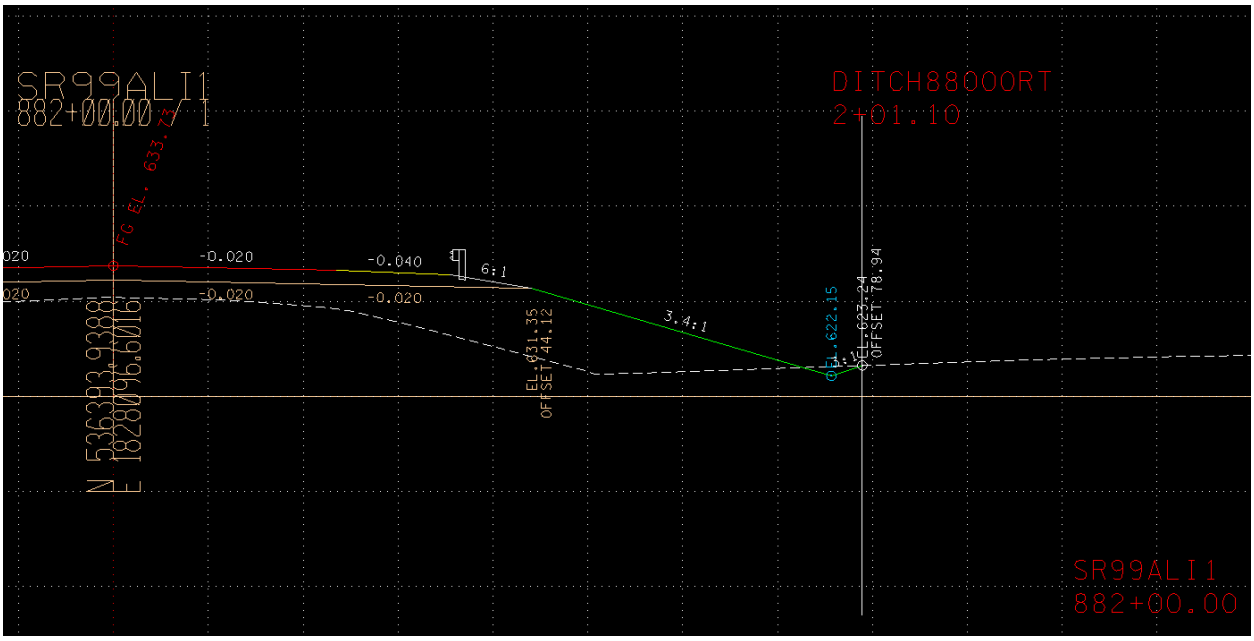
Display using D&C Manager:



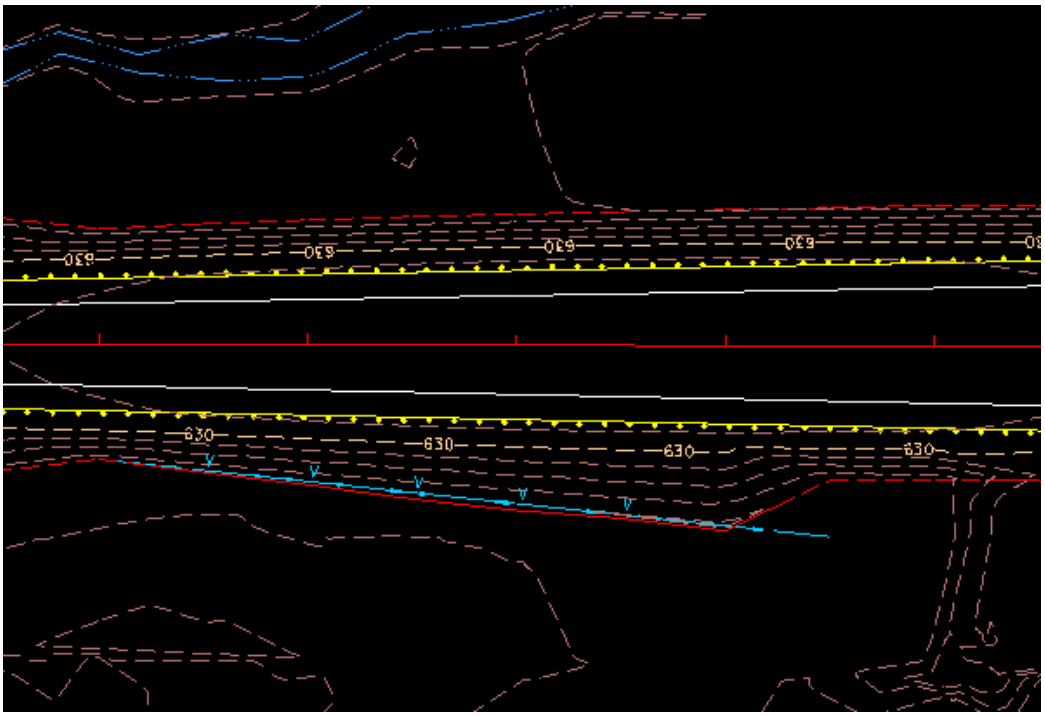
Modify cross sections to include special ditch. Reference Geopak Road Manual Exercise 14 to modify the criteria file “Var2Lanestroutes.x” as shown:



Then re run proposed cross sections with modified criteria file

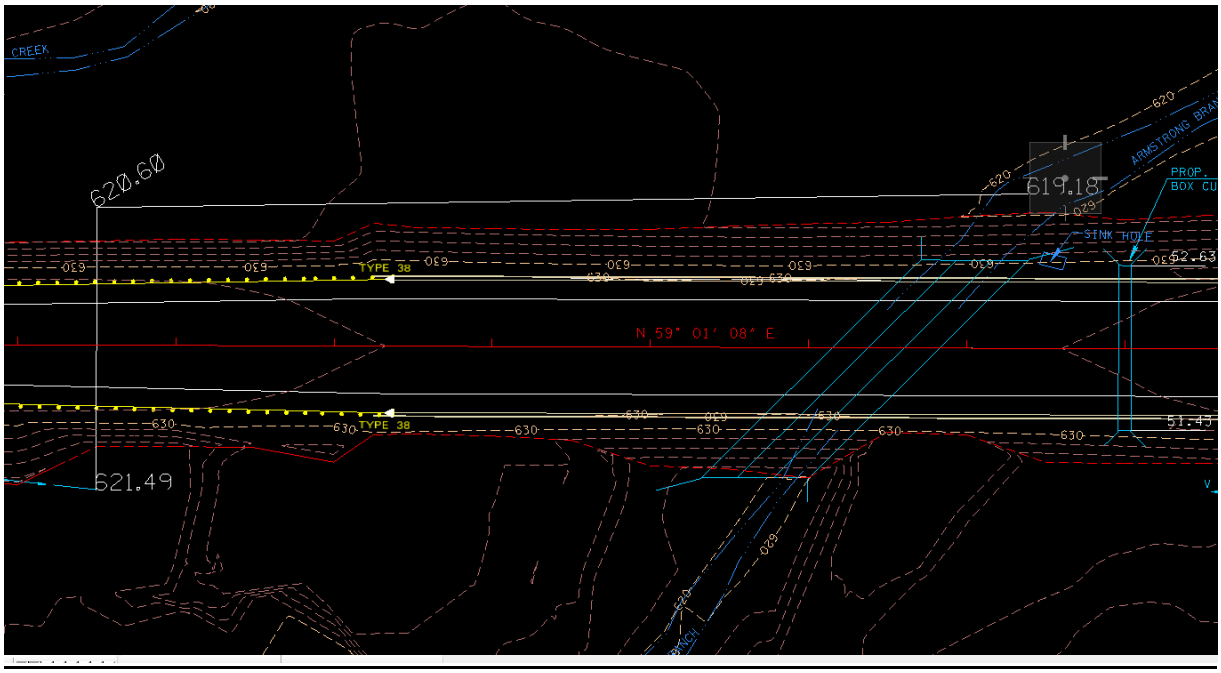


Cross Section with special ditch at sta 882+00



Plan View of special ditch, with slope lines

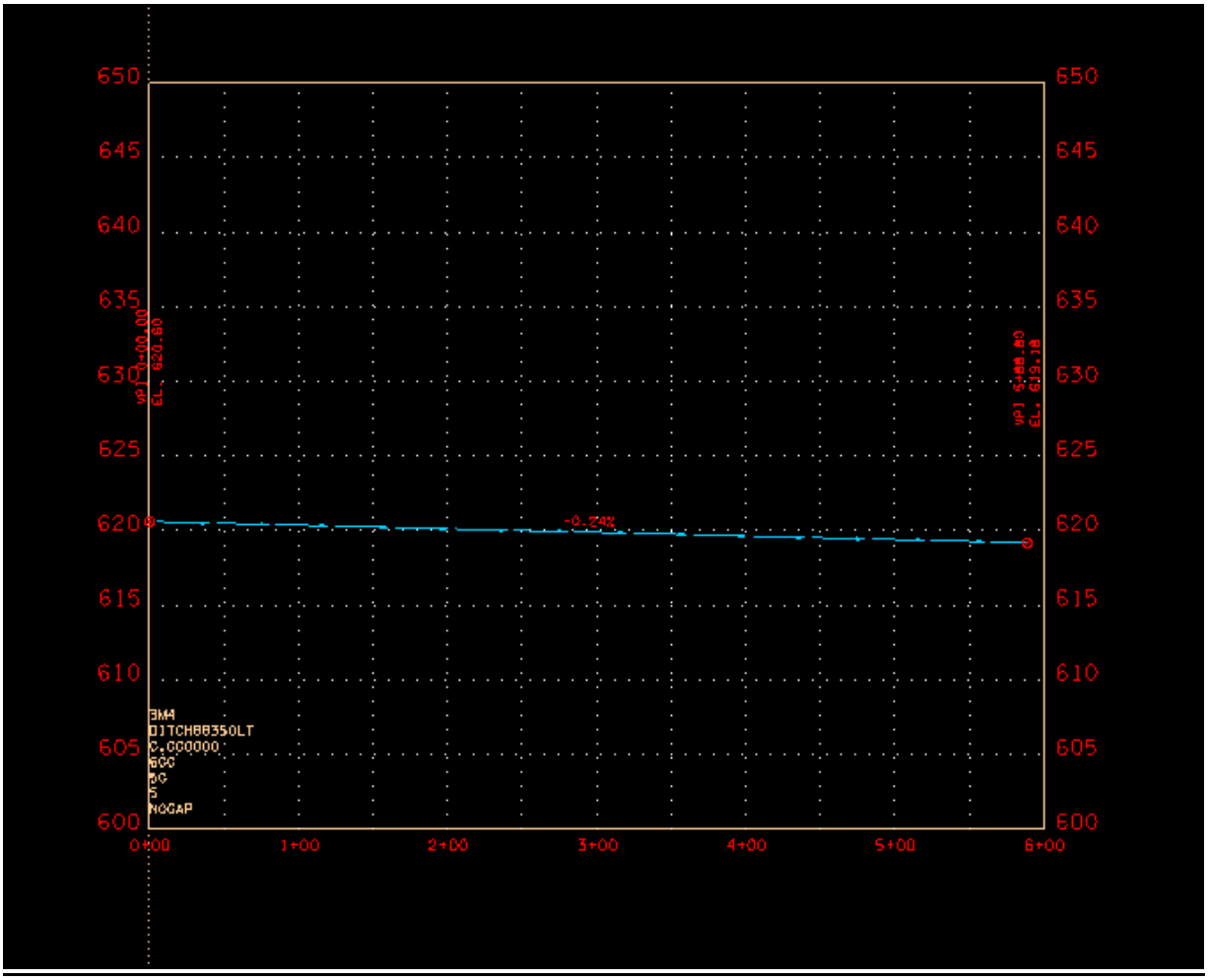
Ditch 2 – 878+50 to 888+50, Left side



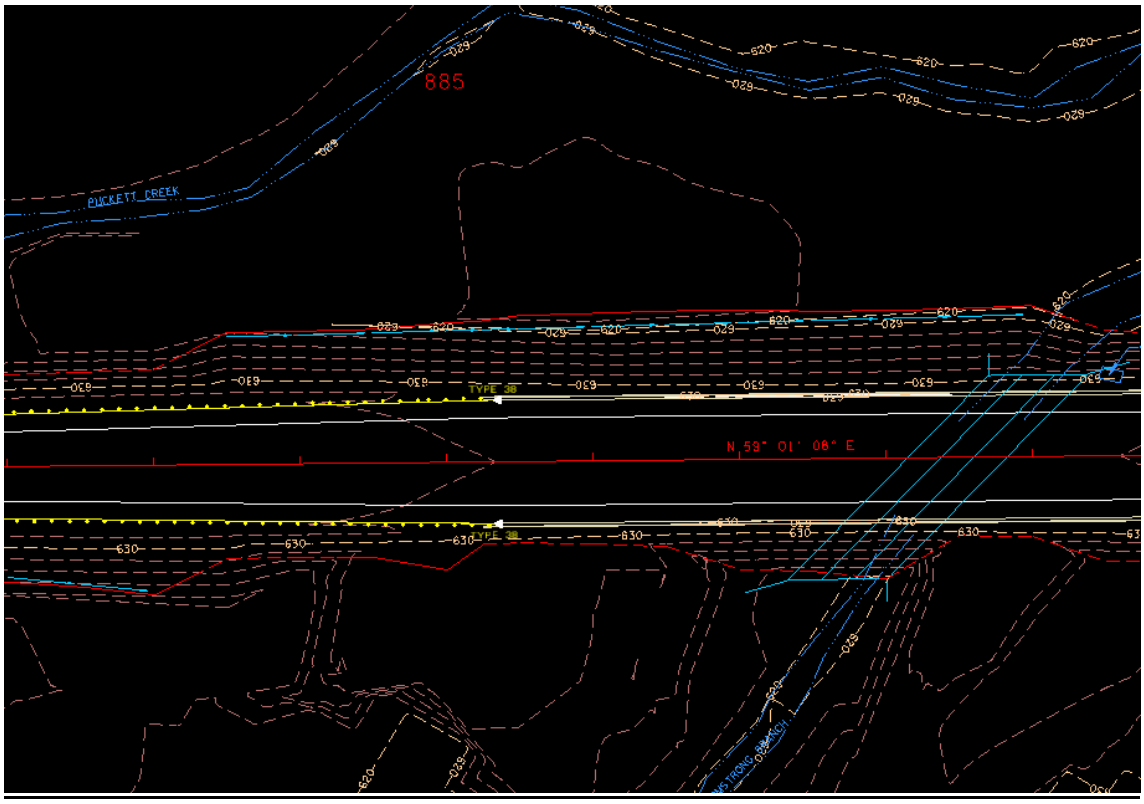
The beginning of the ditch, at 883+50 on the left is the outlet of the relocated culvert. The elevation is 620.60, calculated on a grade of 0.5%, based on a length of 178.44.

The proposed length of the ditch is 588.80’ from the culvert outlet to the creek. The grade is (620.60 – 619.18)/588.80 = .0024, or 0.24%

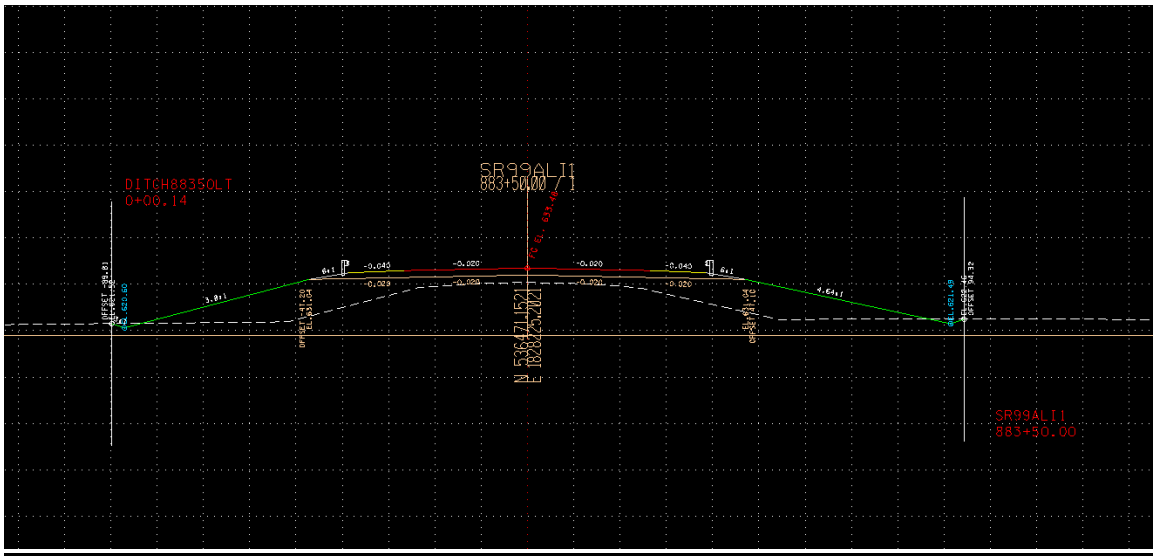
Ideally we would like to have at least 0.4% grade for optimum drainage, but that is impossible to obtain given the existing conditions.



Profile of ditch on left side from 883+50 to 889+00 +/-



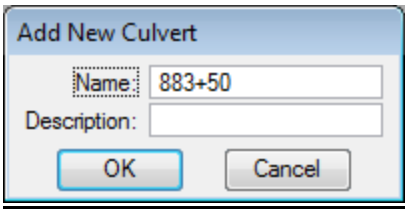
Plan view of ditch on also showing proposed contours

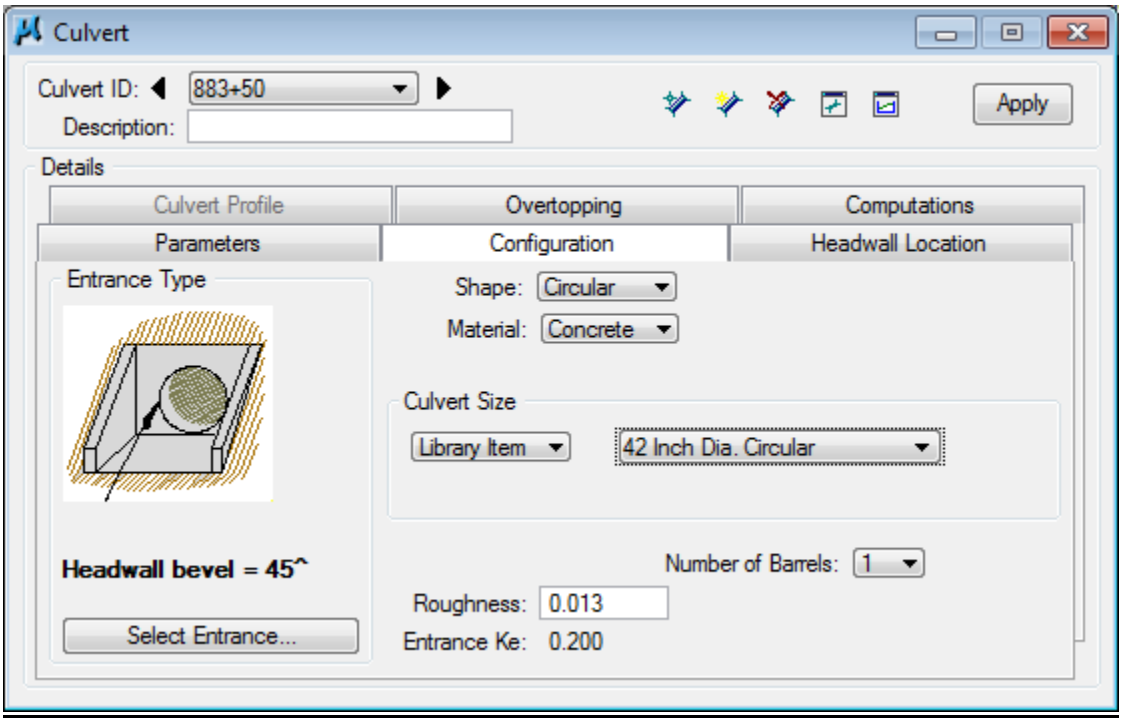


Cross Section showing ditchs at sta. 883+50

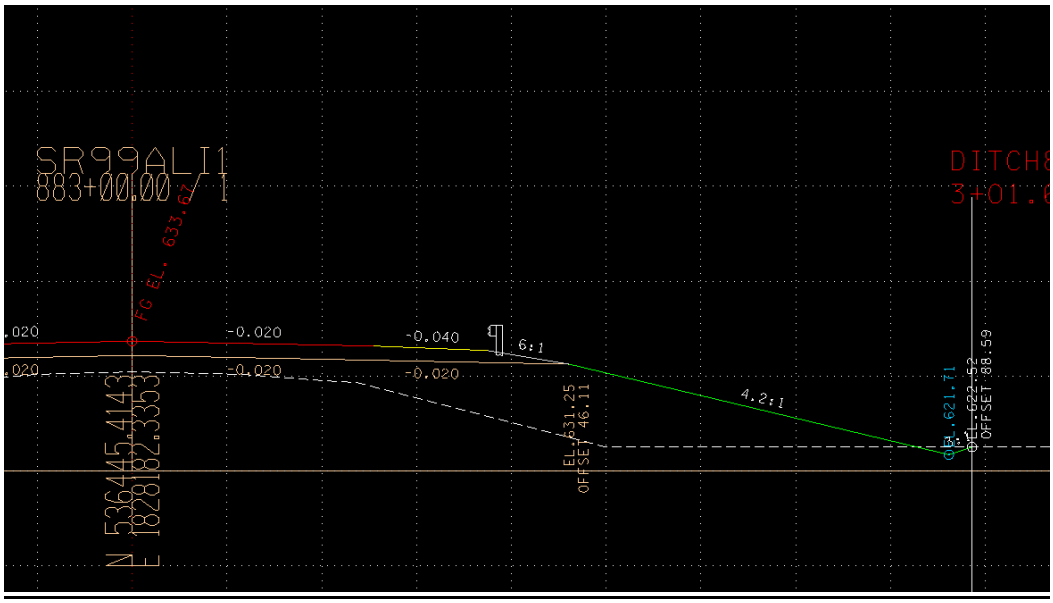
Locate Culvert

Using GEOPAK Drainage, add culvert



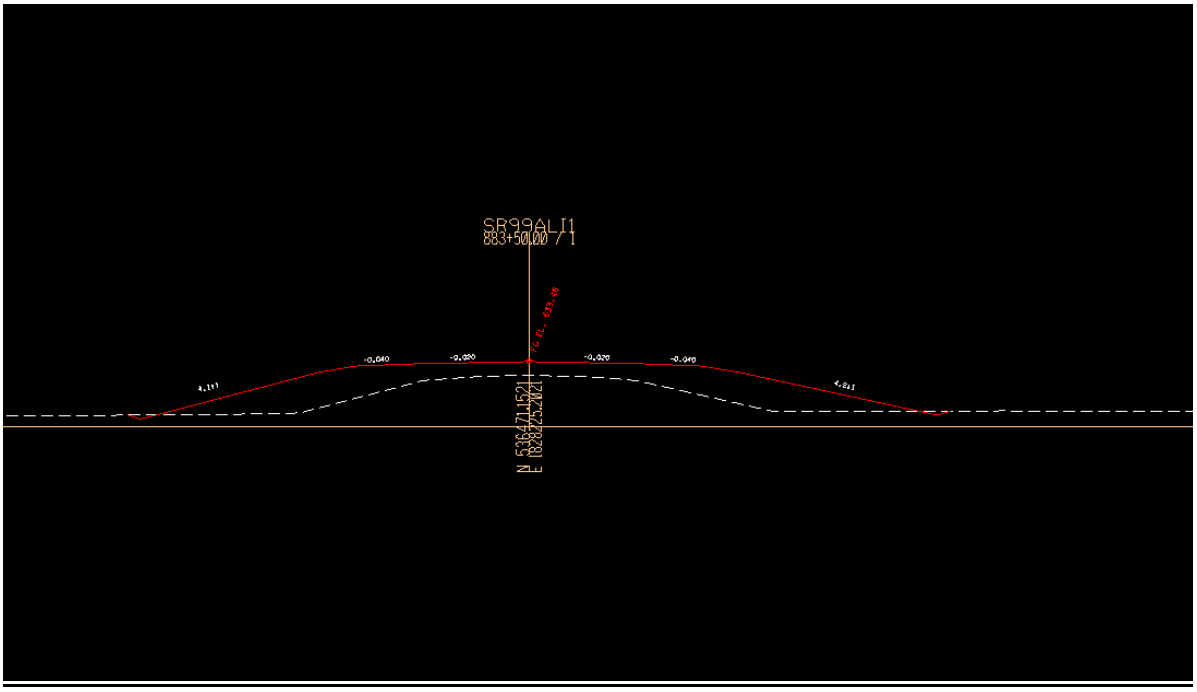


Culvert Configuration – Since the exist. culvert at 884+00 is 42”, we will specify that size for the new culvert.

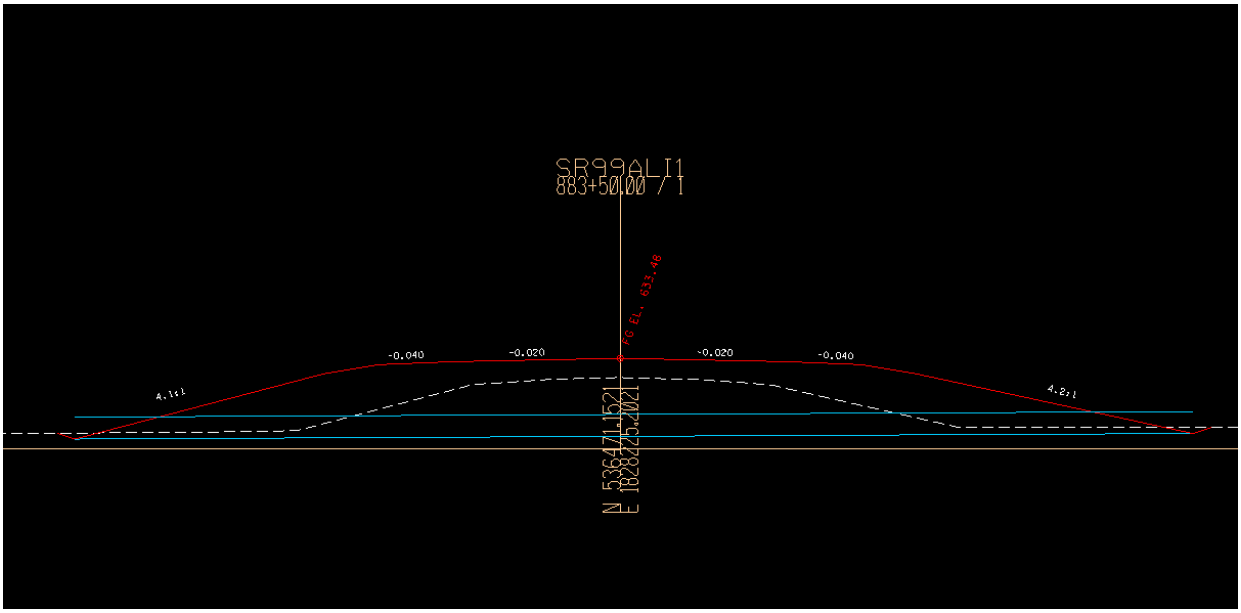


Section at 883+50, this is inlet end of culvert. The subgrade elevation is 631.25. The allowable headwater is 1 foot below subgrade elevation or 630.25 in this case. The overtopping elevation is the edge of shoulder elevation, 632.47.

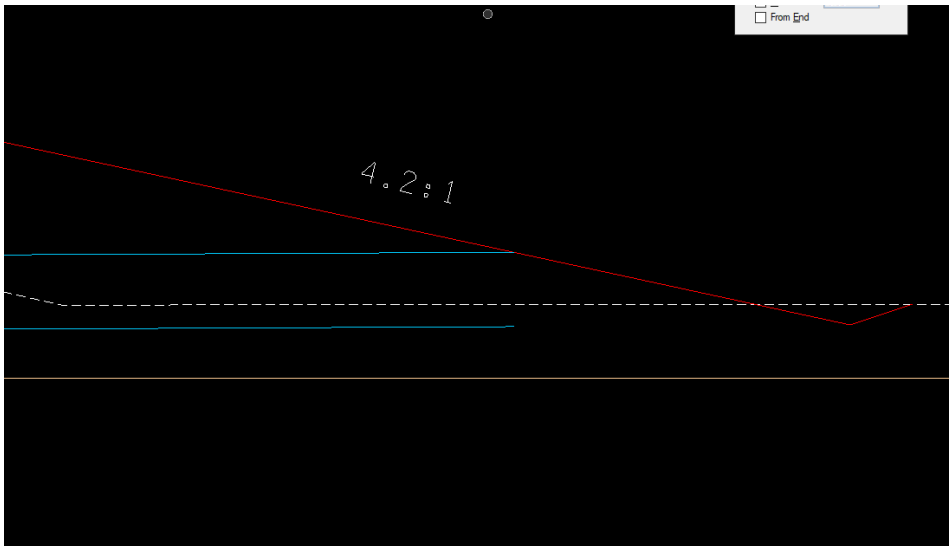
In file (RFSR099CulvertSections.dgn) draw the section at 883+50 using the original ground tin and proposed tin surfaces:



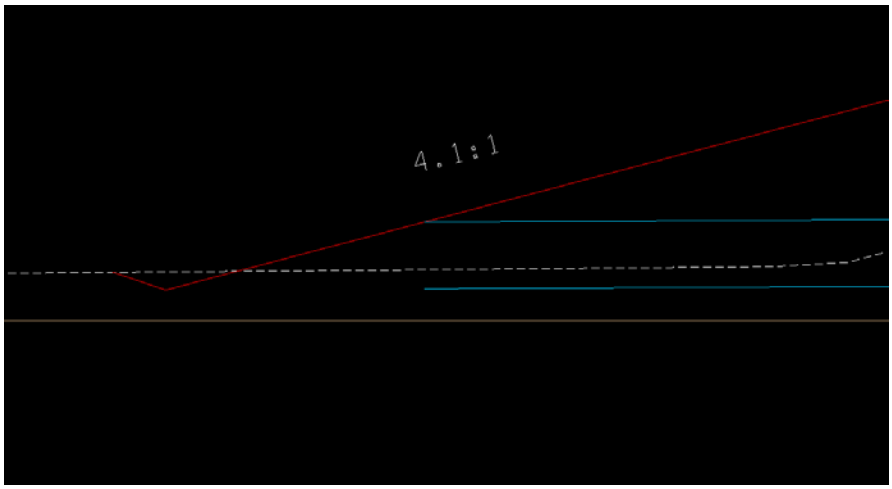
Draw a line to connect the ditch low points on each side of the cross section and copy line parallel 3.5 ft. This locates the grade of the pipe:



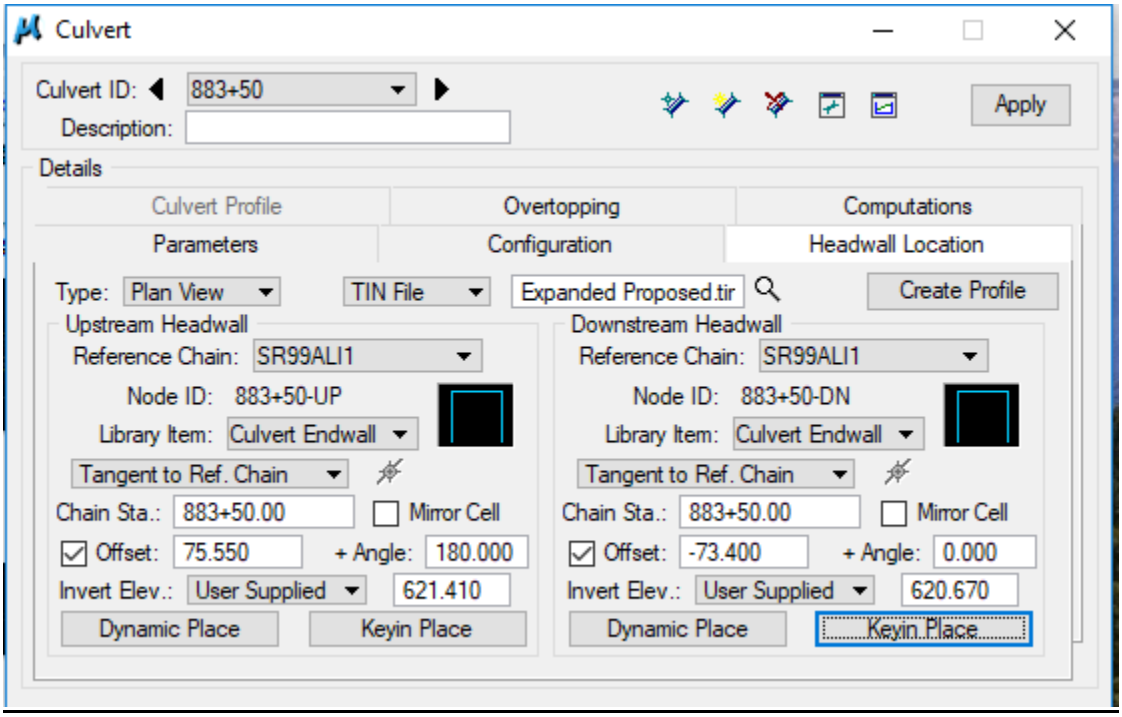
Intersect the top line with the side slopes and modify the lower line to be th same length as the top. This determines the offsets and elevations of the ends of the pipe.:



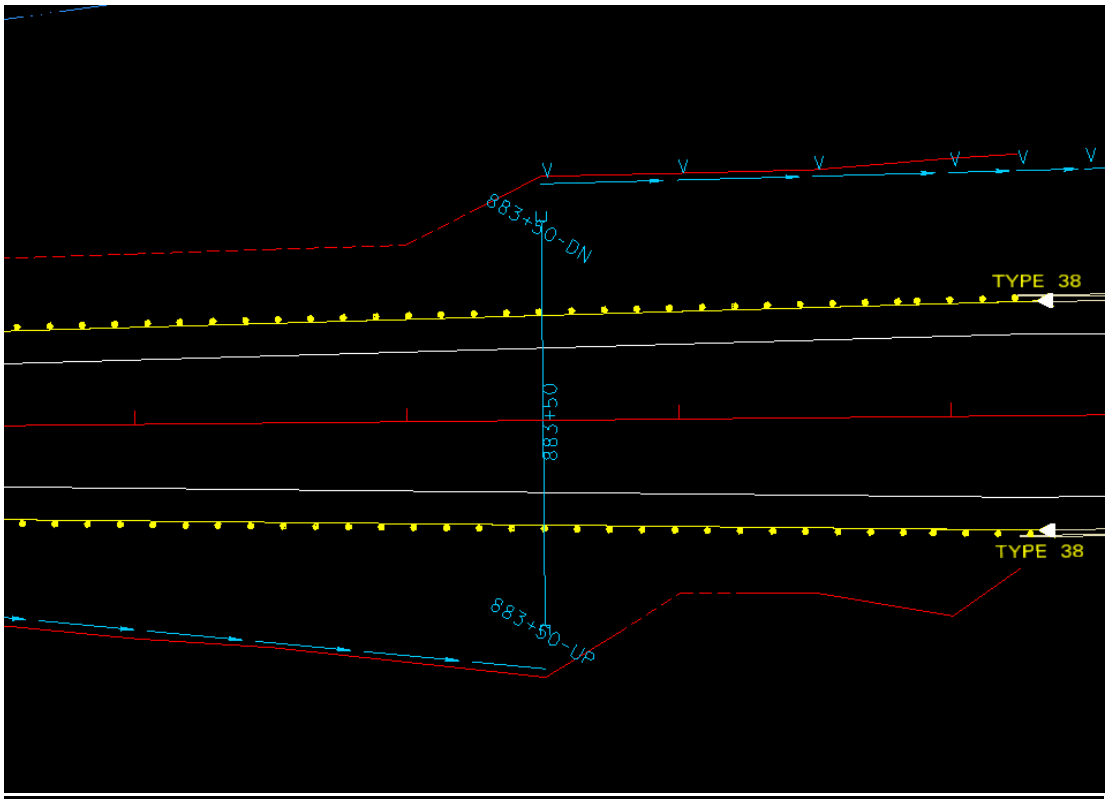
Inlet end, el. 621.41, offset 75.55



Outlet end, el. 620.67, offset -73.40

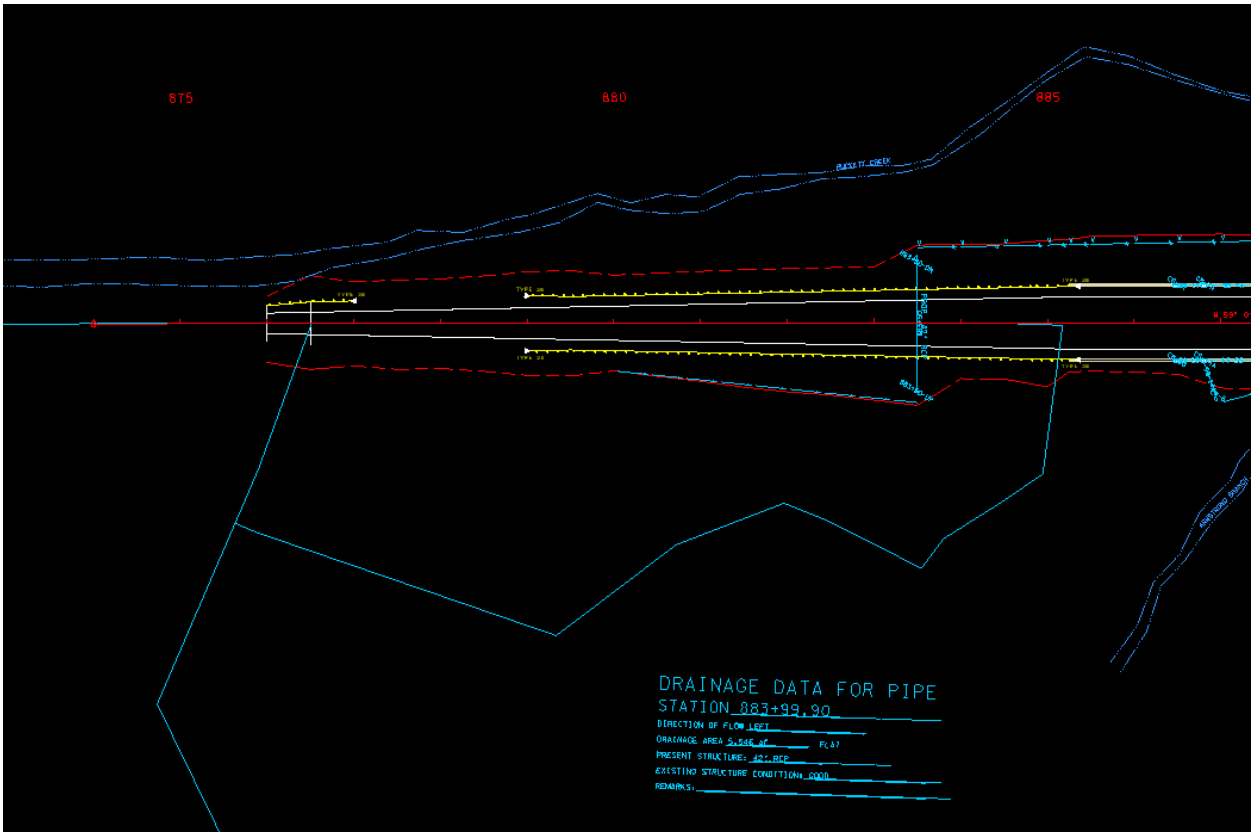


Headwall Locations



Drainage Area

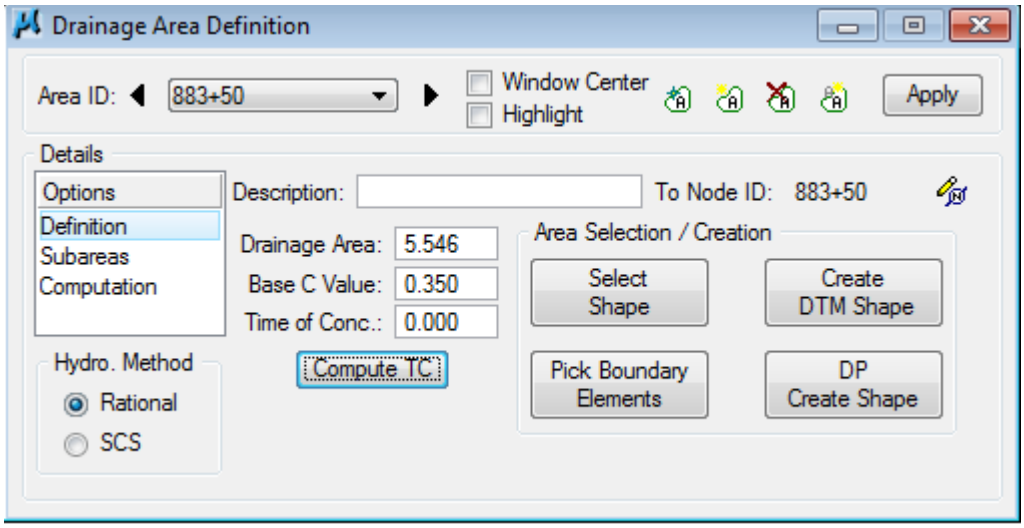
The drainage areas are found in the Survey reference file on the levels SURVEY-DRAINAGE-Area Shapes and SURVEY-DRAINAGE-Area Shapes Text. Turn the display on for these levels.



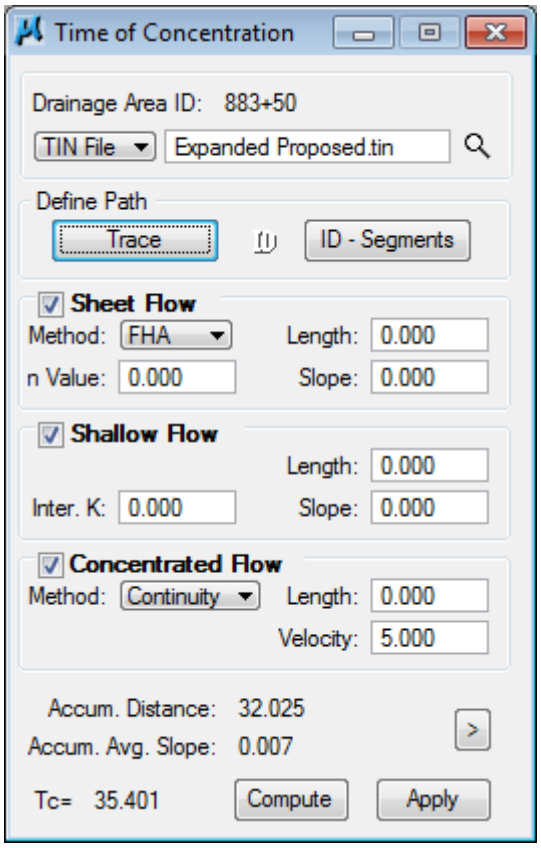
Create a Land Use file by following instructions in Exercise 2 of the GEOPAK Drainage Manual and attach it as a reference file to the Proposed dgn file.

Add the drainage area to the drainage project. You may need to reference Exercise 4 of the GEOPAK Drainage Manual. The area shown is in the Survey dgn file. Name it 883+50, the same as the culvert. The area is 5.546 Acres.

Use a base “C” of 0.350

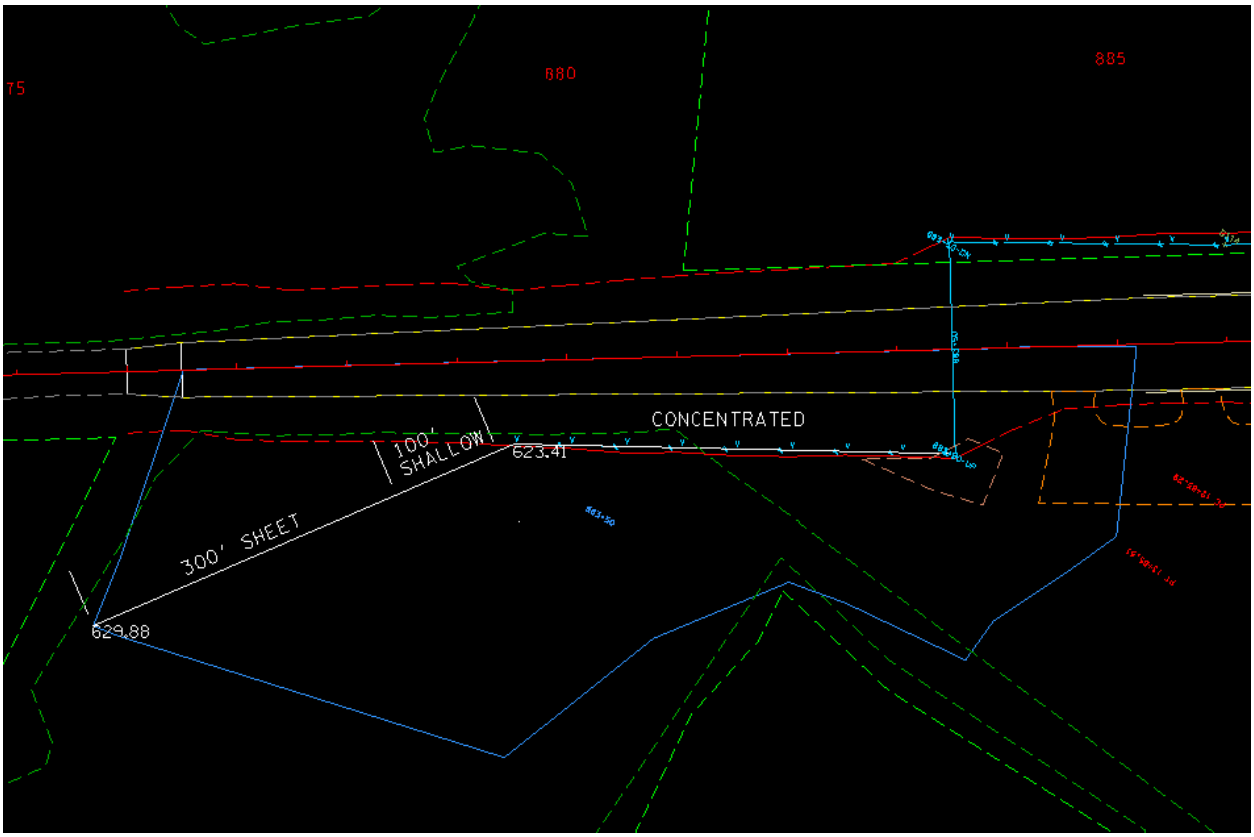


Calculate the Time of Concentration of the drainage area following the procedure in Exercise 4 of the GEOPAK Drainage manual.

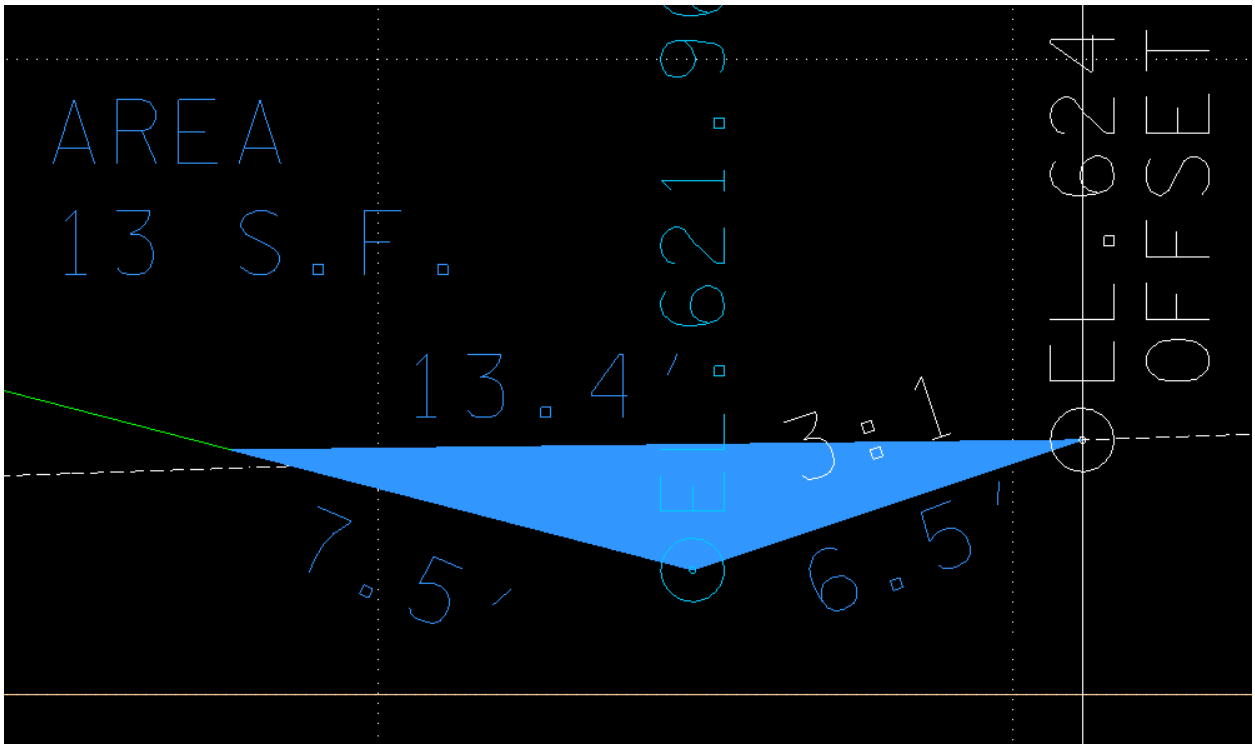


Be sure to specify the TIN file that contains additional surface data not included in the original survey file, the one that was created on page 10 of this chapter.

The picture below shows the drainage area with the flow path from the remote point drawn manually. Using the trace option fails to produce an adequate path, probably due to the unusual layout of the land. From the diagram the maximum values of 300 ft. for sheet flow and 100 ft. for shallow flow can be used. Where the flow is in the special ditch, that is Concentrated Flow.



For sheet flow , use 0.400 for the “”n” value. (Table4-3, TDOT Drainage Manual, Woods and Shrubbery)
For Shallow flow, use 0.457 for the “Inter K “ value.
The Concentrated Flow velocity can be calculated using Eqn. 4-9 in the TDOT Drainage Manual.

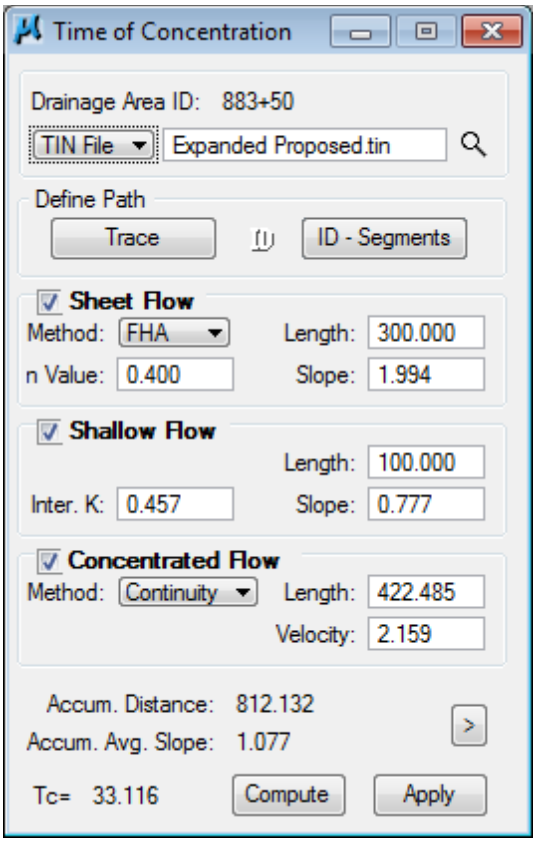


The cross section of the special ditch at station 881+50 shows that assuming the ditch is full, the cross section area (A) is 13 sq. ft..
Rh (Hydraulic Radius) = A/P , where P is the wetted perimeter
P= 7.5+6.5+13.4= 27.4 ft.
Rh = 13/27.4 = 0.47 ft.

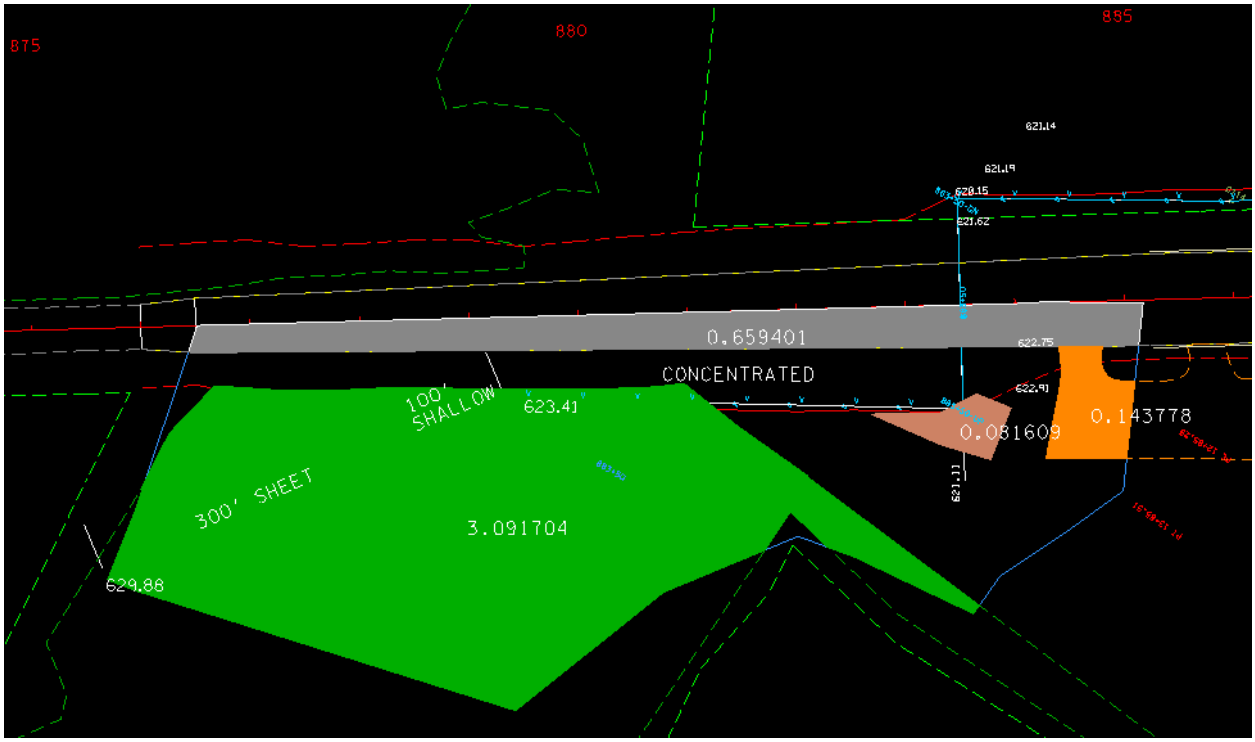
Sc (slope of ditch) = 0.42%, or .0042 ft./ft. (shown earlier on page 24)

n= 0.027 (Table 5A-1, TDOT Drainage Manual, assume grass lining)

From Eq. 4-9, the velocity for Concentrated Flow is 2.159

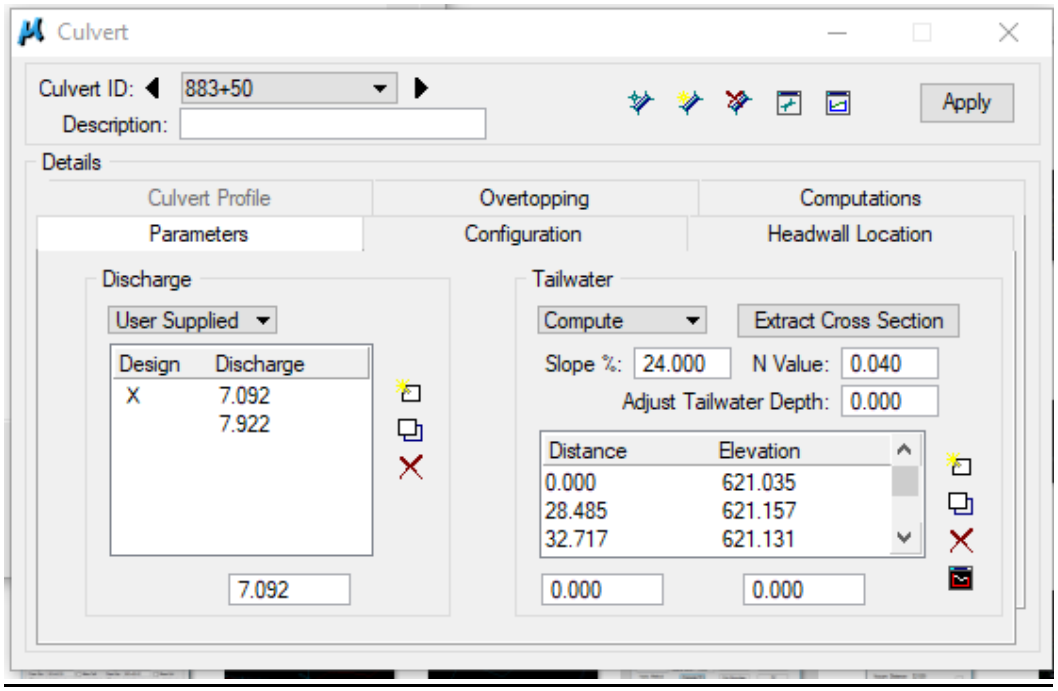


Under “Define Path, select ID and identify the line drawn previously.
The Time of Concentration should compute to about 33.1
After applying this to the drainage area follow procedure outlined in GEOPAK Drainage Manual to compute discharges for 50 and 100 year storms.

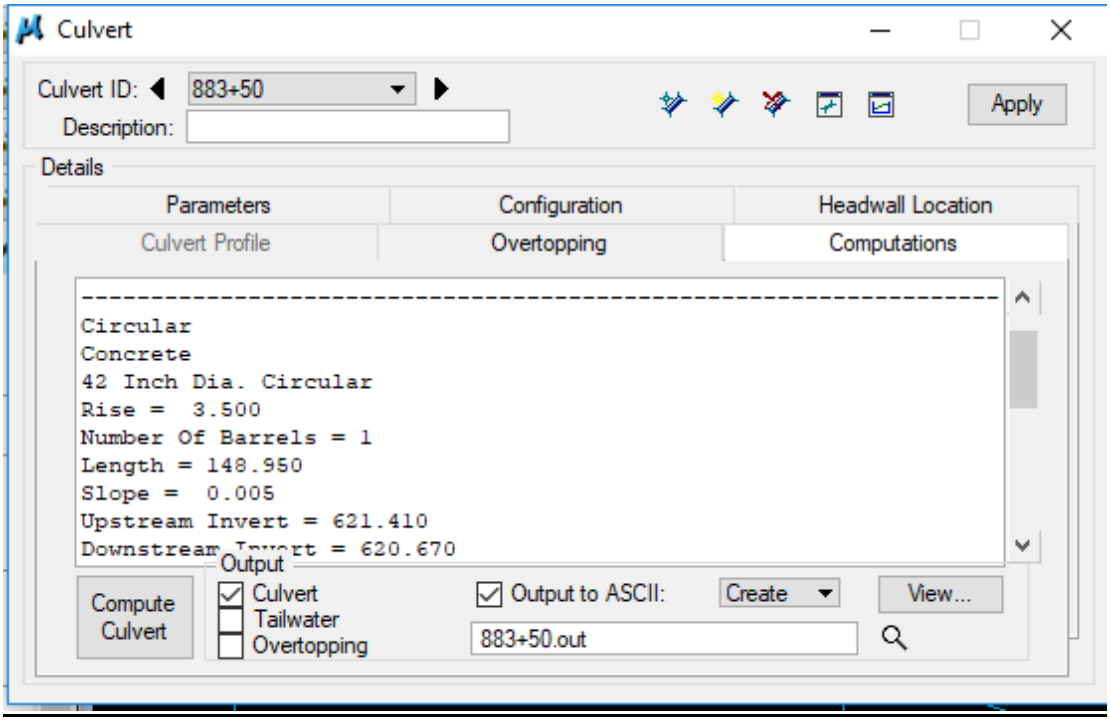


Subareas

The computed value for the 50 yr discharge is 7.092 cfs, for 100 yr the discharge is 7.922.



Culvert Parameters



Culvert Computations

```
------------------------------------------------------------------------
Culvert Analysis Results for 883+50
------------------------------------------------------------------------
Circular
Concrete
42 Inch Dia. Circular
Rise =  3.500
Number Of Barrels = 1
Length = 148.950
Slope =  0.005
Upstream Invert = 621.410
Downstream Invert = 620.670
N value =  0.013
Entrance KE value =  0.200
------------------------------------------------------------------------
Culvert     MAX     Inlet    Outlet   Tailwater
Discharge    HW       HW       HW       Elev.
--------- -------- -------- --------- ----------
7.092     622.365  622.365  622.365  620.861
7.922     622.439  622.439  622.439  620.875
------------------------------------------------------------------------
Culvert   Outlet   Uniform  Critical Critical Friction
Discharge Velocity Depth    Depth    Slope    Slope
--------- -------- -------- -------- -------- ---------
7.092     4.742    0.744    0.802    0.004     0.005
7.922     4.873    0.789    0.849    0.004     0.005
------------------------------------------------------------------------
```

PIPE CULVERT
STATION: 883 +50.00
STRUCTURE: 150 FT. OF 42" R.C.P.

SKEW	90	DEG.
DRAINAGE AREA	5.546	AC.
DESIGN DISCHARGE (Q50)	7.092	CFS
DESIGN DISCHARGE (Q100)	7.922	CFS
OVERTOPPING	632.47	ELEV.
ALLOWABLE HEADWATER	630.25	ELEV.
Q50 HEADWATER	622.365	ELEV.
Q100 HEADWATER	622.439	ELEV.
VELOCITY (Q50)	4.742	FT/S
VELOCITY (Q100)	4.843	FT/S

ENDWALLS REQUIRED:

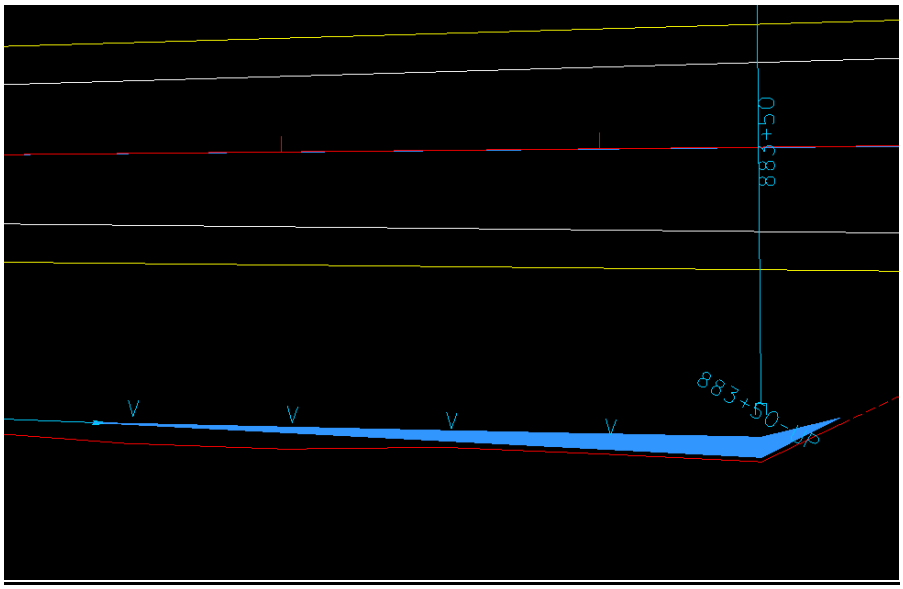
STANDARD DRAWING NOS.: D-PE-42A,D-PE-42B

QUANTITIES:

CLASS "A" CONCRETE		C.Y.
STEEL BAR REINFORCING		LB.
BEDDING MATERIAL		C.Y.

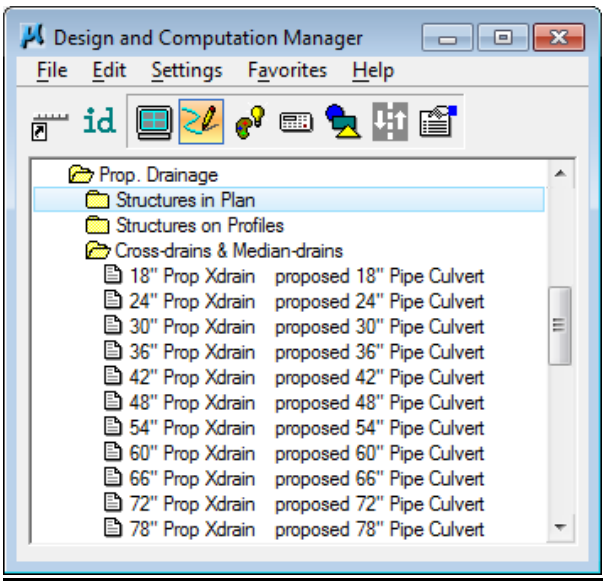
ENDWALL ITEM NOS.:

Hydraulic data for Culvert Section. This is a cell, DRCLV1 A, accessible by T.D.O.T.>Drainage(Profiles/Culv Sections)>Cells. This information goes on plans (Culvert Section)

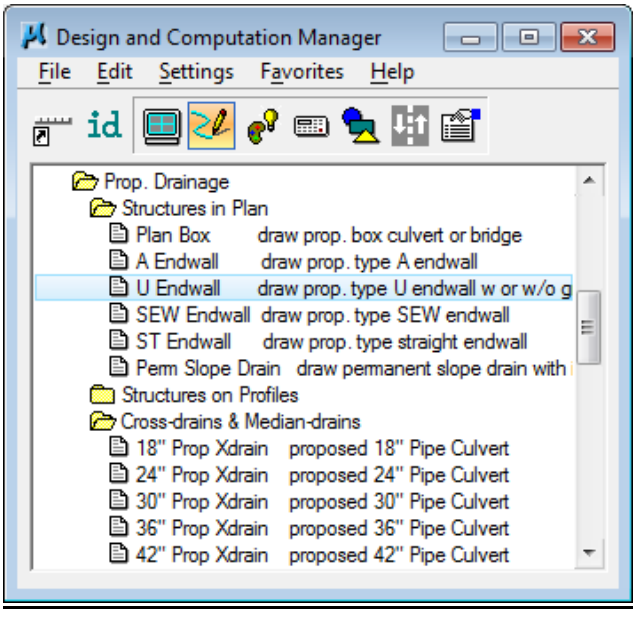


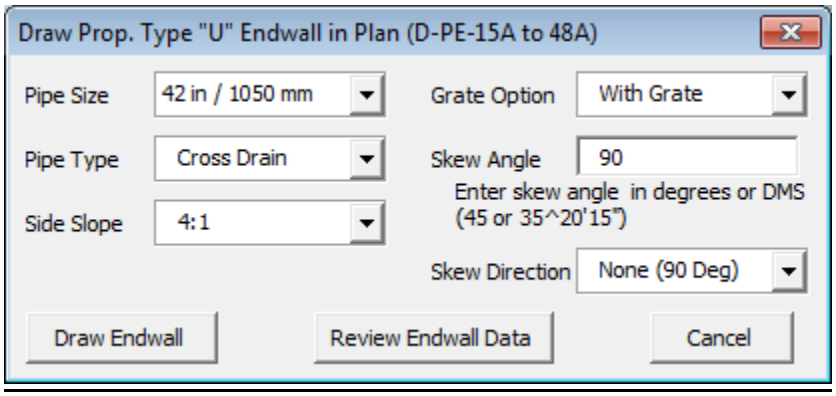
Ponding at the inlet for the 50 yr high water elevation (622.365 contour) This does not need to be shown on plans.

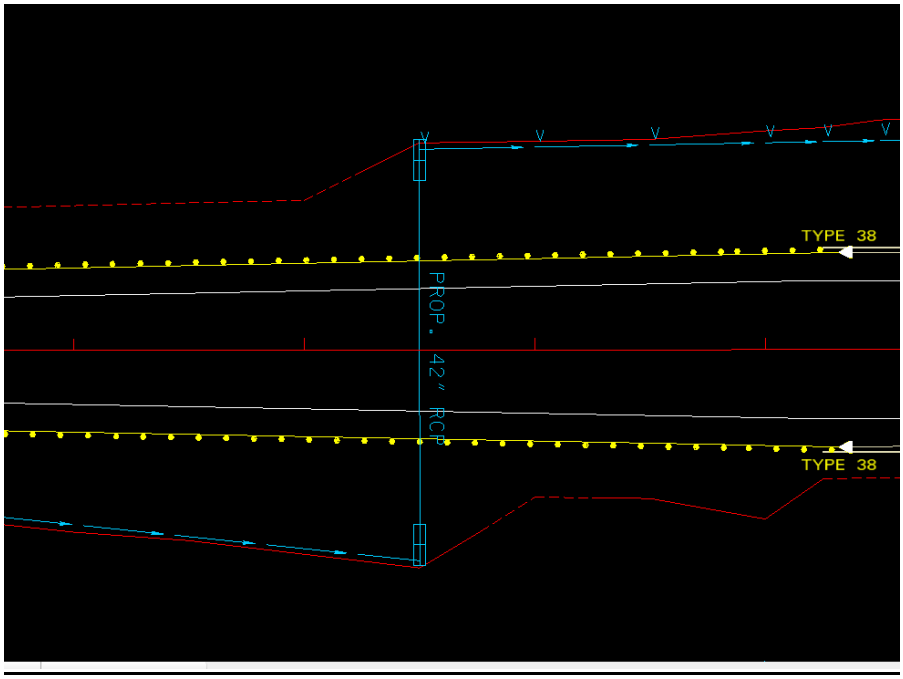
Though GEOPAK Drainage has placed the culvert on the plans, it is not on the right level so that it can be displayed on the plan sheet. In D&C Manager select “42 Prop Xdrain and draw a line over the culvert generated by Geopak.



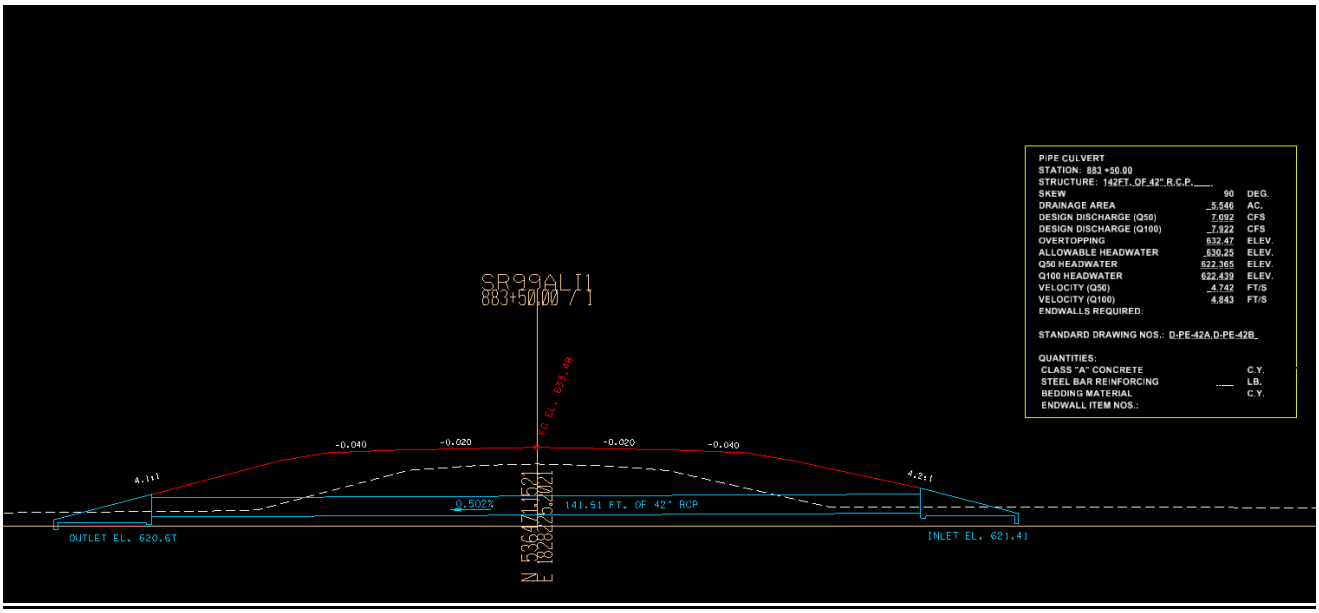
Next, draw the endwalls for the pipe size and side slope, using D&C Manager:



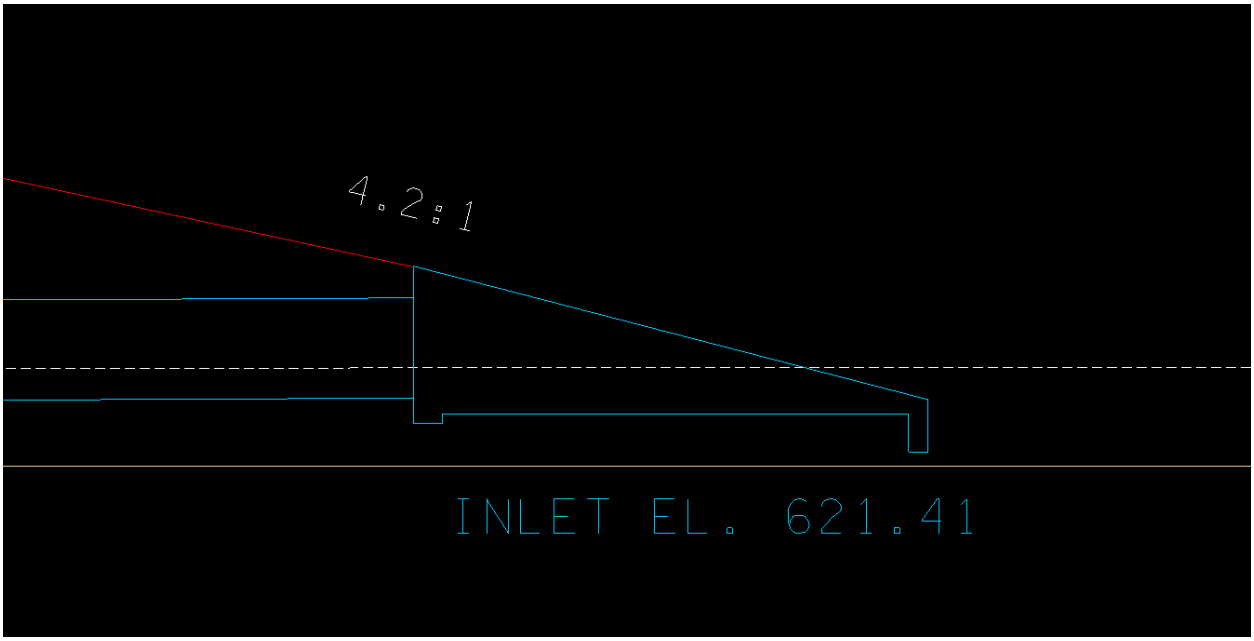




Plan view of proposed culvert at 883+50.

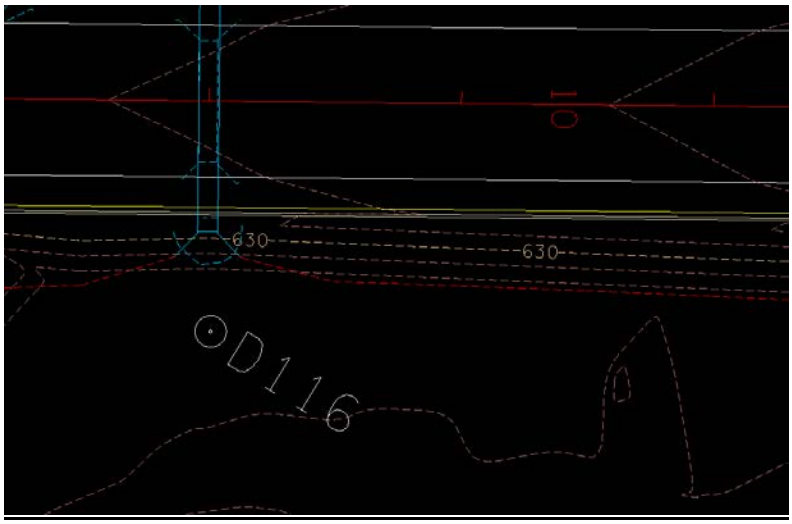


Culvert Section with endwalls and hydraulic data. Note that the length of pipe has changed after endwalls were drawn in

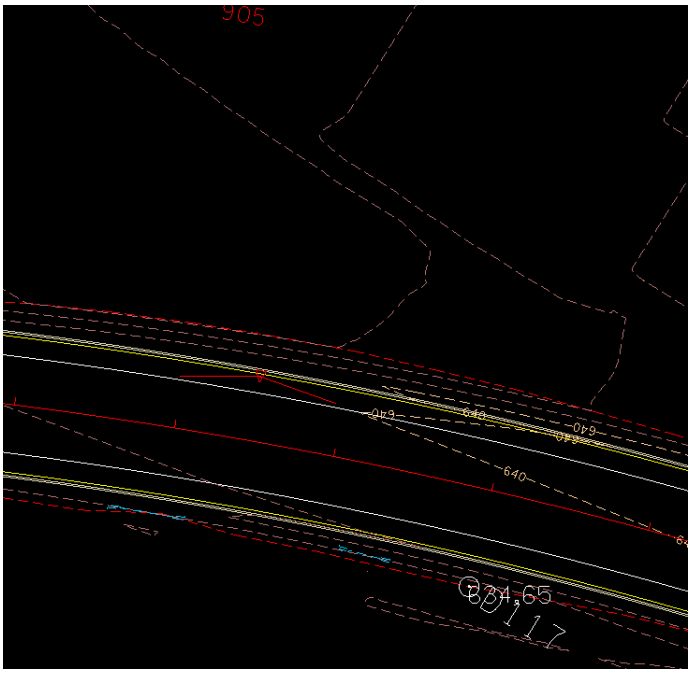


Endwall on inlet end. Drawn according to dimensions on standard drawing D-PE-42A (4:1 slope)

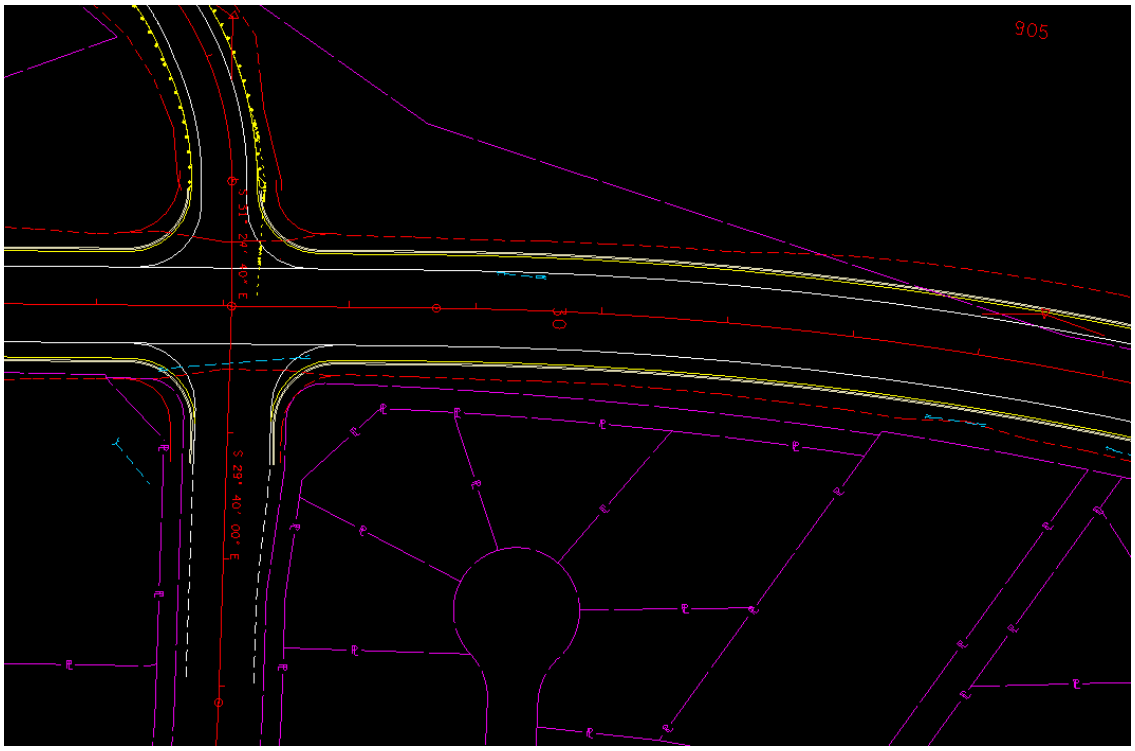
Ditch 3 – 890+00 to 907+00, Right side
Ditch is to drain from approx.. 907+00 back toward box culvert inlet at 890+00. Locate the ditch outlet point (D116) in the vicinity of the inlet of the proposed box culvert at 890+00.The inlet elevation of the box culvert is 621.90 which will be the elevation at the ditch outlet.:



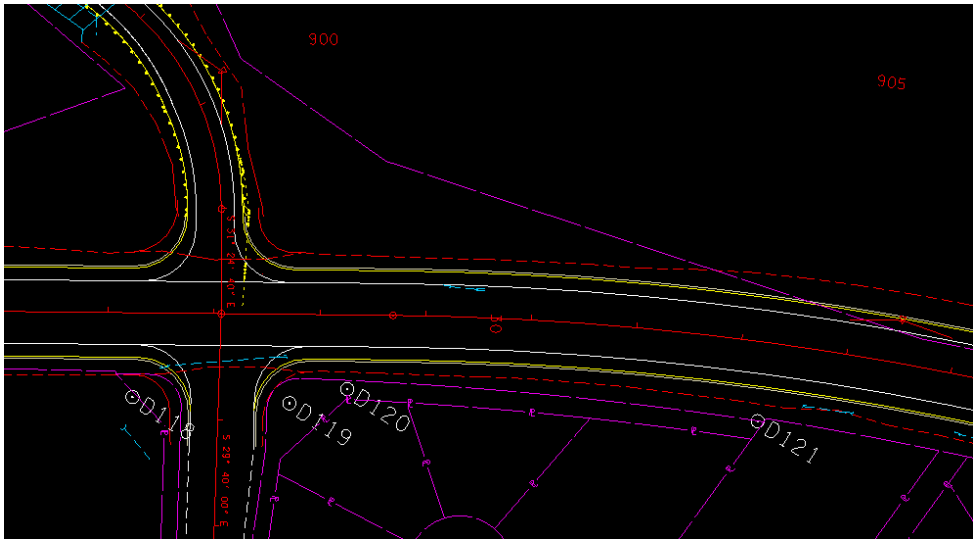
At the beginning of the proposed ditch, 907+00, locate point D117. The elevation here is 634.65.:



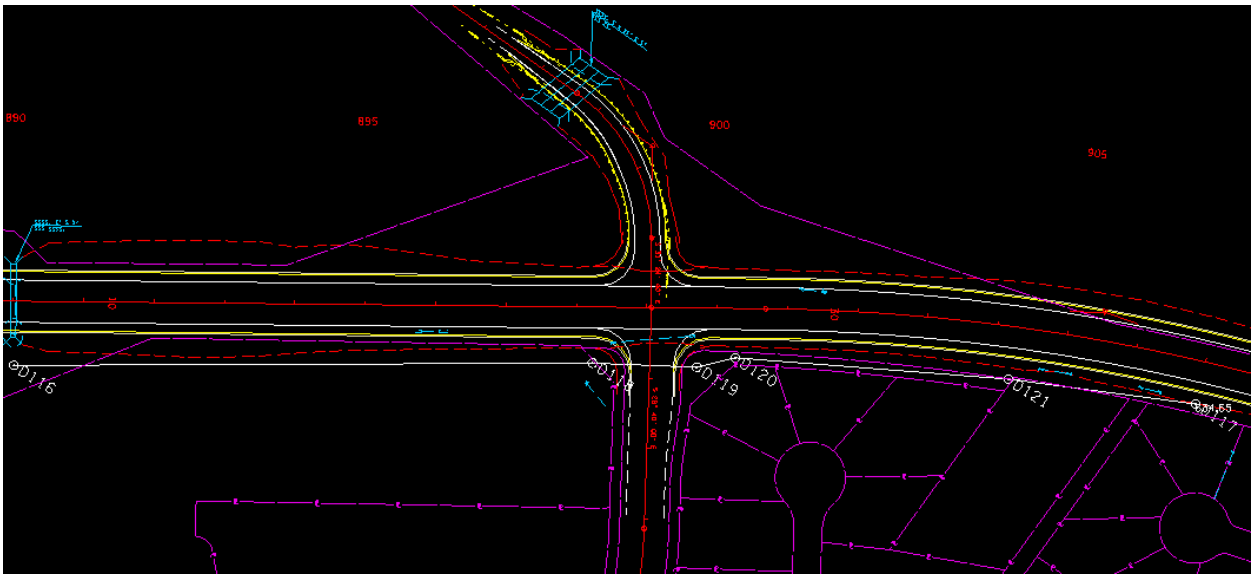
In the vicinity of Weston Blvd. we want to make sure the proposed ditch does not encroach on the subdivision. Existing ROW lines and Property lines are shown.:



Locate points D118-D120 approximately as shown:

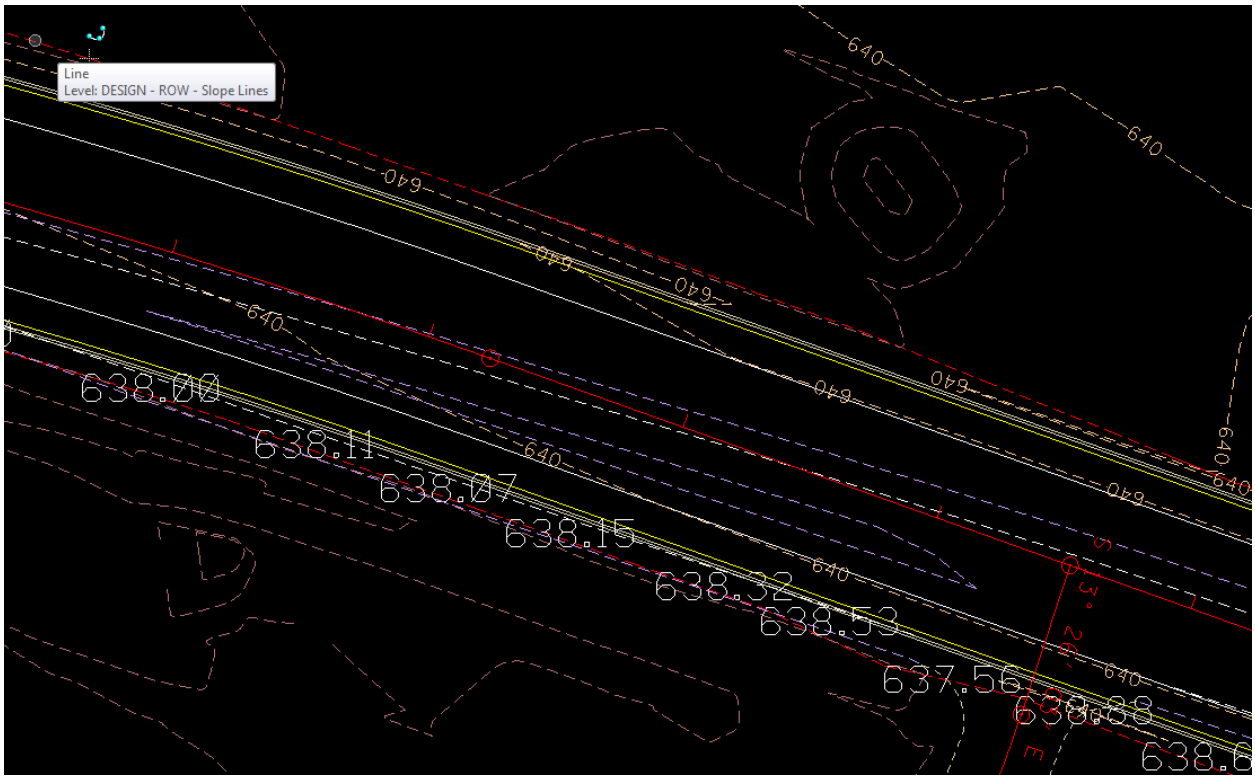


Then define the alignment for the ditch using the points, D116-D118-D119-D120-D117 :



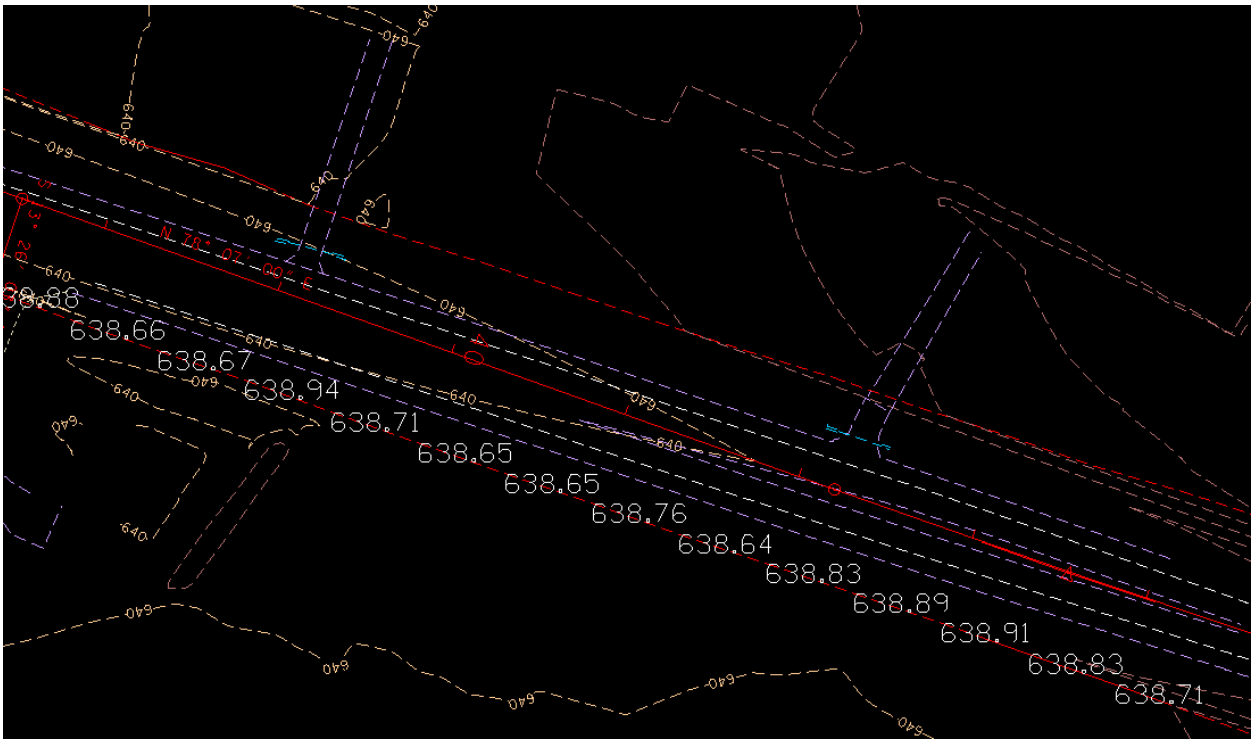
Preliminary layout of proposed ditch from 890+00 to 907+00 (Ditch 3). The cross drain at Weston Blvd. will be relocated to where the ditch crosses..

Ditch 4 -
No definite ponding areas were defined from about 907+00 to the end of the project on the right side. However if the toe of slope elevations are read it shows that there are several low spots that would need to be drained.



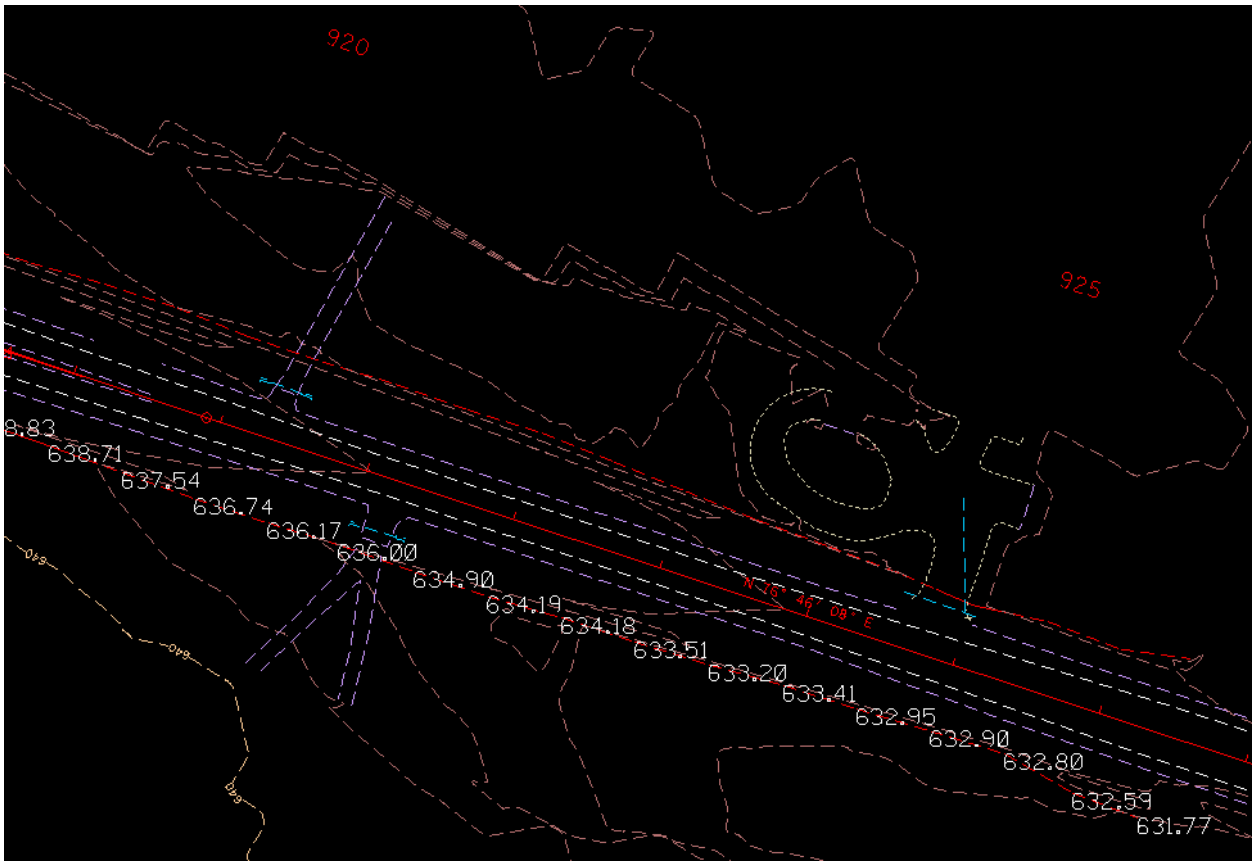
909+00 to 913 +00

There is a low spot at 910+00 (638.07), and another at 912+00 (637.56). For this manual, we are ignoring Belle Rive Rd. at 912+50. Otherwise we would locate a cross drain there. For the purpose of this manual instead we will locate a ditch beginning at the 638.07 elevation to drain forward along the alignment.

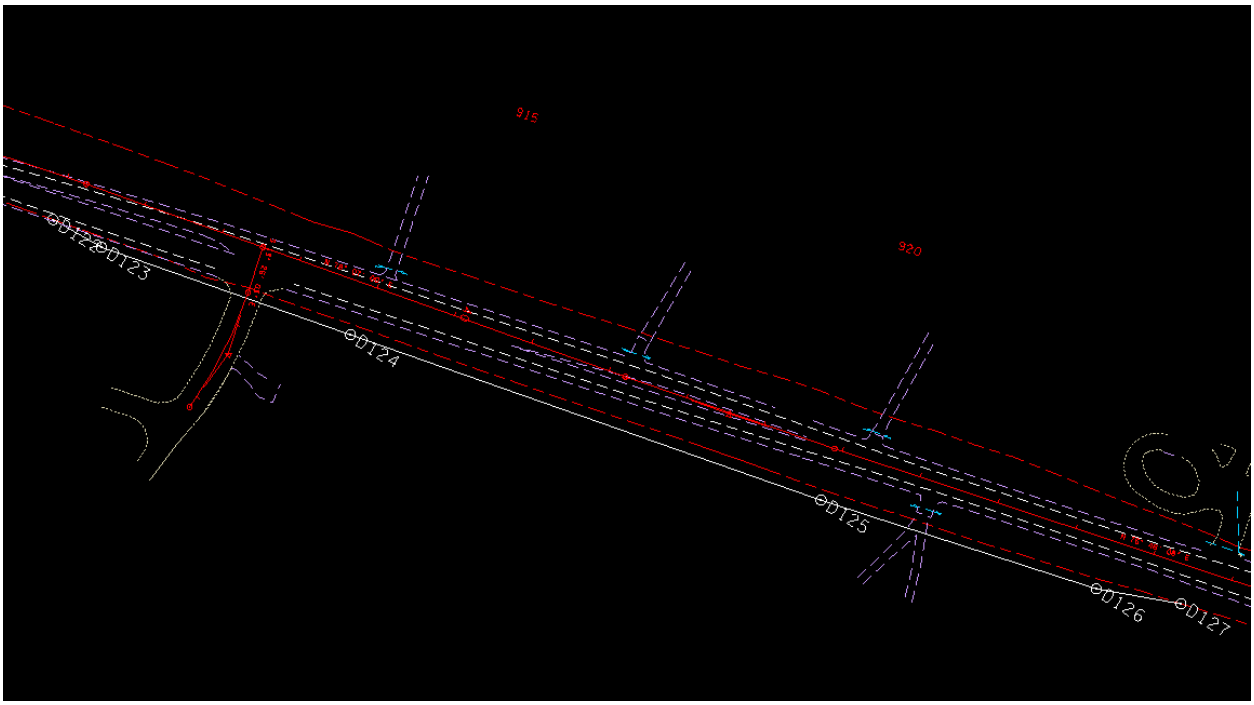


913+00 to 919+00

The slope elevations in this section indicate our proposed ditch would need to continue at least to 918+50 (638.83 elevation). The proposed pavement levels have been turned off in this view so that the elevations may be read easier.

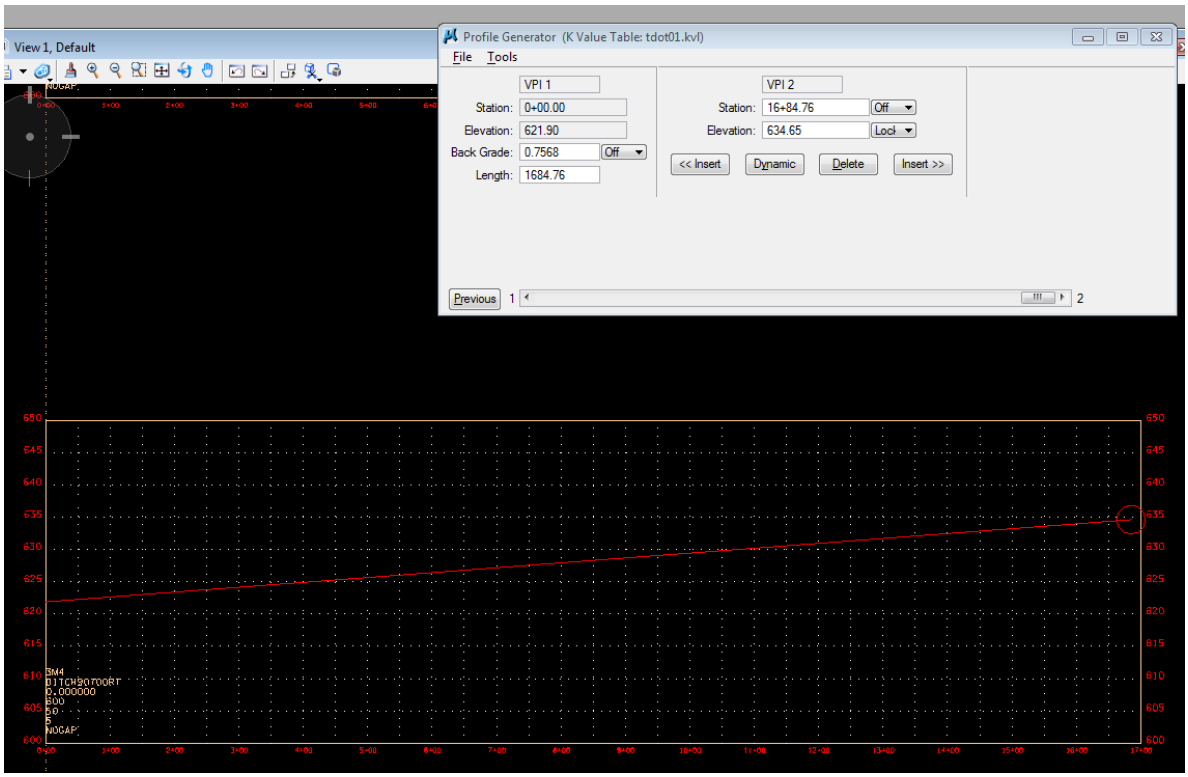


919+00 to end of project
Elevations trend down to 923+50 (633.20) , which is a low spot, then downward again from 924+00 to end of project. Continue ditch to end at 924+50 (632.95 elevation)



Determine ditch profiles

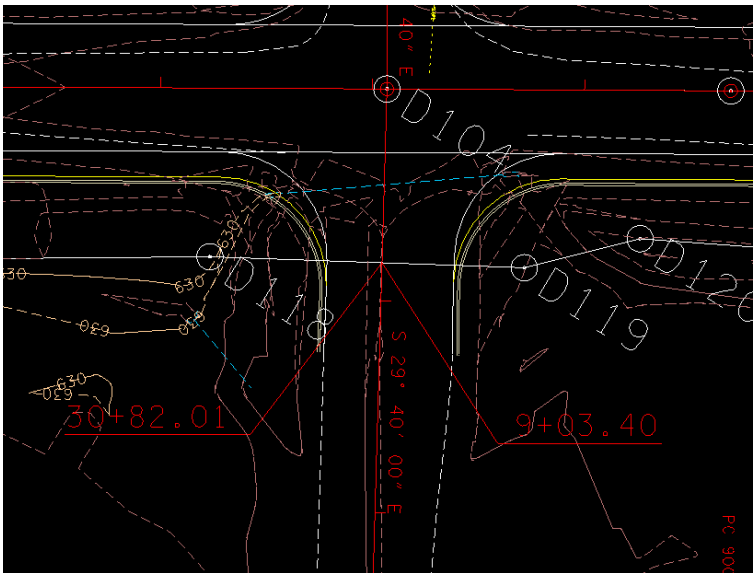
Ditch 3:



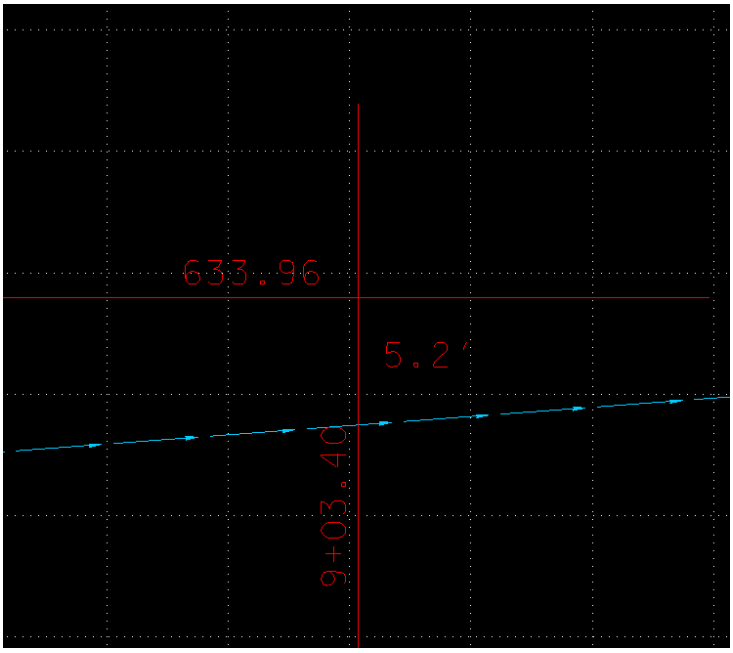
The ending station of the ditch is 16+84.76. Beginning and ending elevations are 621.90 and 634.65. the grade of the ditch is 0.76%.

Check elevations at side road crossings to ensure the culverts at the side roads will have enough clearance.

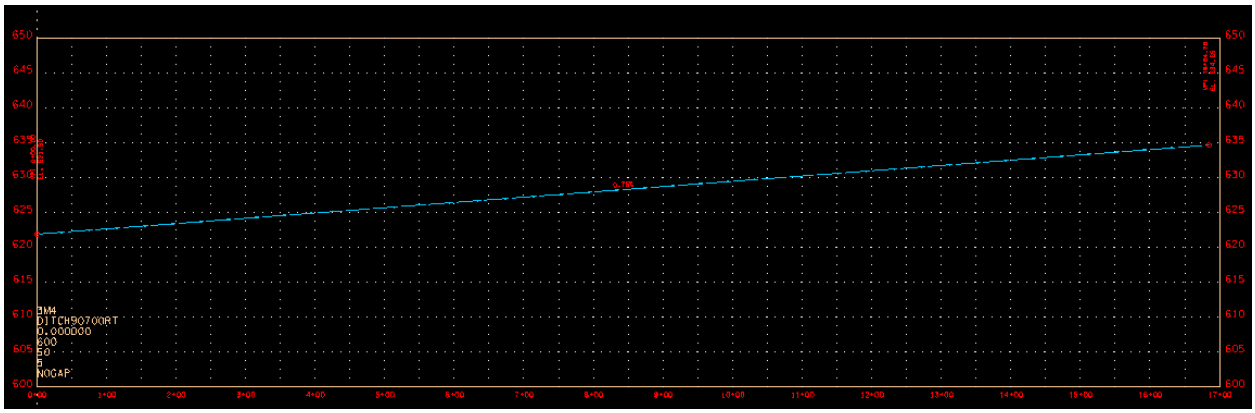
Weston Blvd.:



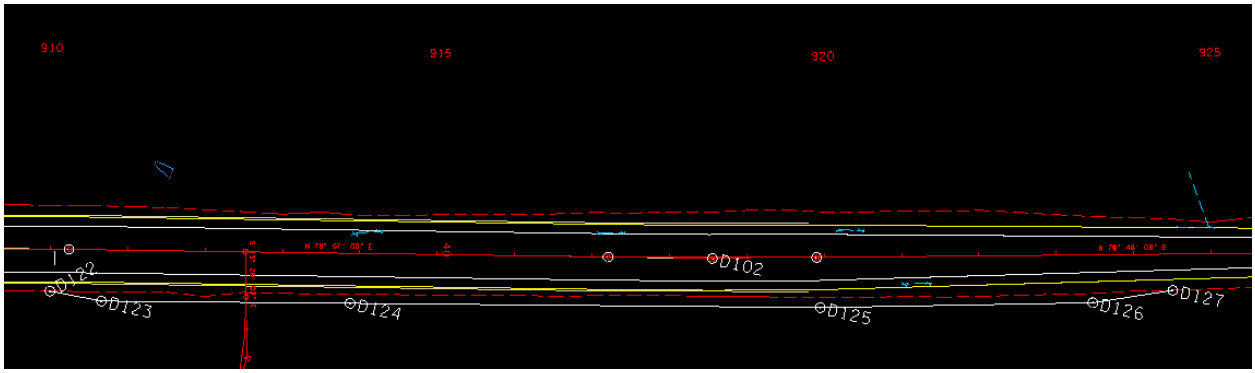
Using DTM Tools Height/Slope for the proposed tin surface the finished grade elevation is 633.96 at station 30+82.01 of Weston Blvd. and 9+03.40 of the ditch



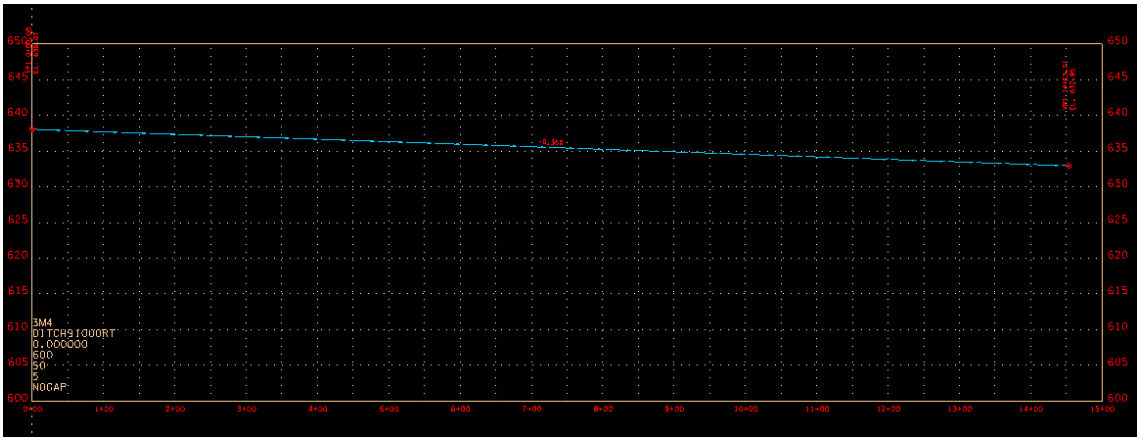
The elevation difference is 5.21 feet. Assuming a subgrade thickness of 1 ft and 18" culvert there is a clearance of 2.7 feet between the subgrade and top of culvert feet. At least 1 foot clearance is desirable.



Display of Ditch Profile, ditch 3 890+00 – 907+00 Rt. Beginning elevation is 621.90 at station 0+00 (890+00 on mainline). Ending elevation is 634.65 at station 16+84.76 (907+00). Grade is 0.76%.



Preliminary layout of proposed ditch from 910+00 to 924+50 (Ditch 4)., defined by points D122-D123-D124-D125-D126-D127. The points are located generally about 12 feet from toe of slope, with the exception of the first and last points.



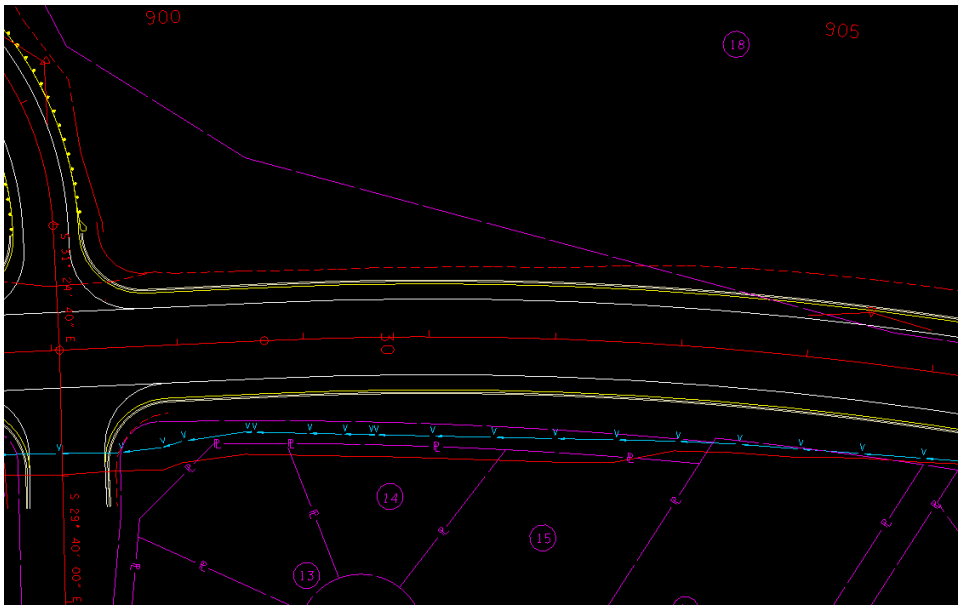
Display of Ditch Profile, ditch 4 910+00 – 924+50 Rt.. Beginning elevation is 638.07 at station 0+00 (910+00). Ending elevation is 632.95 at station 14+53.21 (924+50). Grade is 0.35%.

Edit criteria file to include the last two ditches:

```
        }

if station >= 890+00.00 R 1 and station <= 907+00.00 R 1 then
        {

                _s_RTDitchCenterline =   "DITCH90700RT"
                _s_RTDitchProfile =   "DITCH90700RTV"
                _d_RTDitchMinDepth =  0
                _d_RTDitchForeslope = 3:1
                _d_RTDitchBackslope = 3:1
                _s_RTDitchInPlan =   "Y"

        }

if station >= 910+00.00 R 1 and station <= 924+50.00 R 1 then
        {
                _s_RTDitchCenterline =   "DITCH91000RT"
                _s_RTDitchProfile =   "DITCH91000RTV"
                _d_RTDitchForeslope = 3:1
                _d_RTDitchBackslope = 3:1
                _s_RTDitchInPlan =   "Y"



        }
```

Now rerun the proposed cross sections to include ditch 3 and ditch 4. Save surface as “mainline.tin”. Merge with the side road surfaces and save as “proposed.tin”

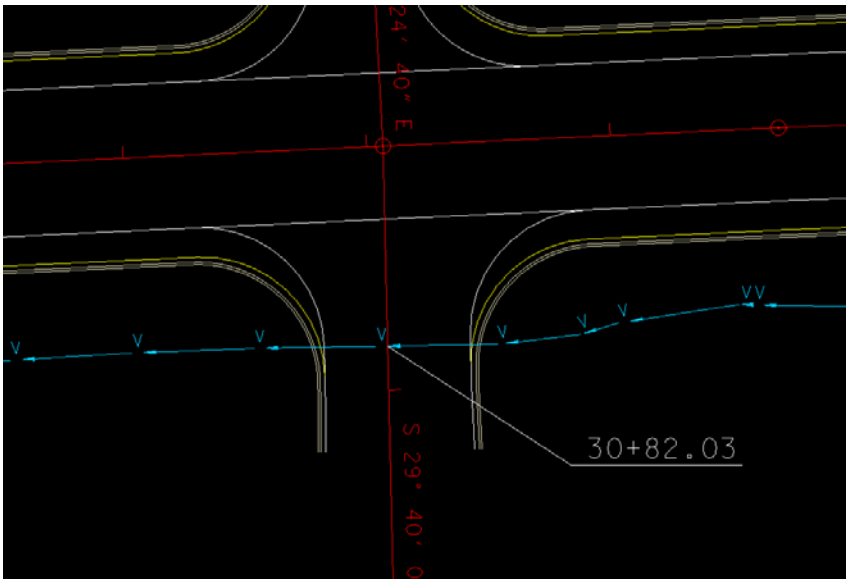
Upon closer inspection there are some areas where there is some additional encroachment:



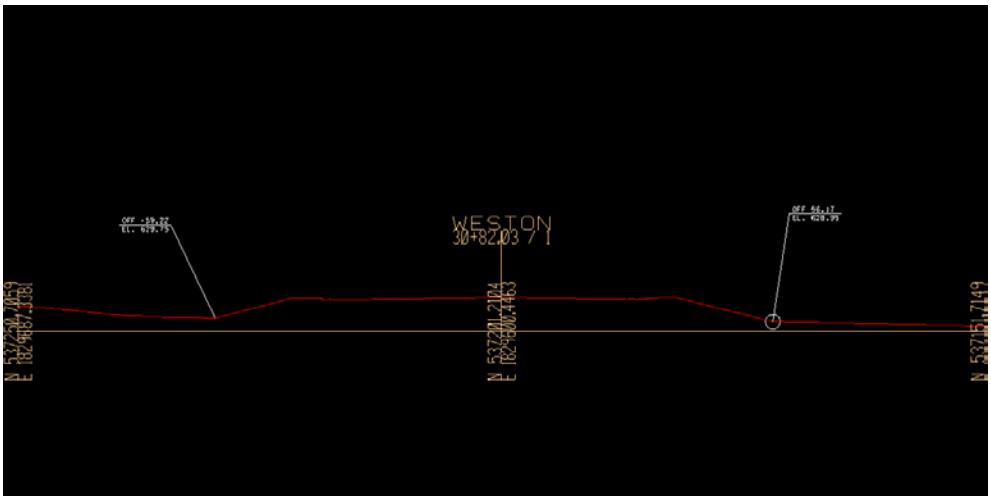
900+00 – 904+00 Rt.

If you check the cross sections at these stations it appears that the ditch can be moved closer to the mainline but we will leave these alone for now.

Place cross drain at Weston Blvd.

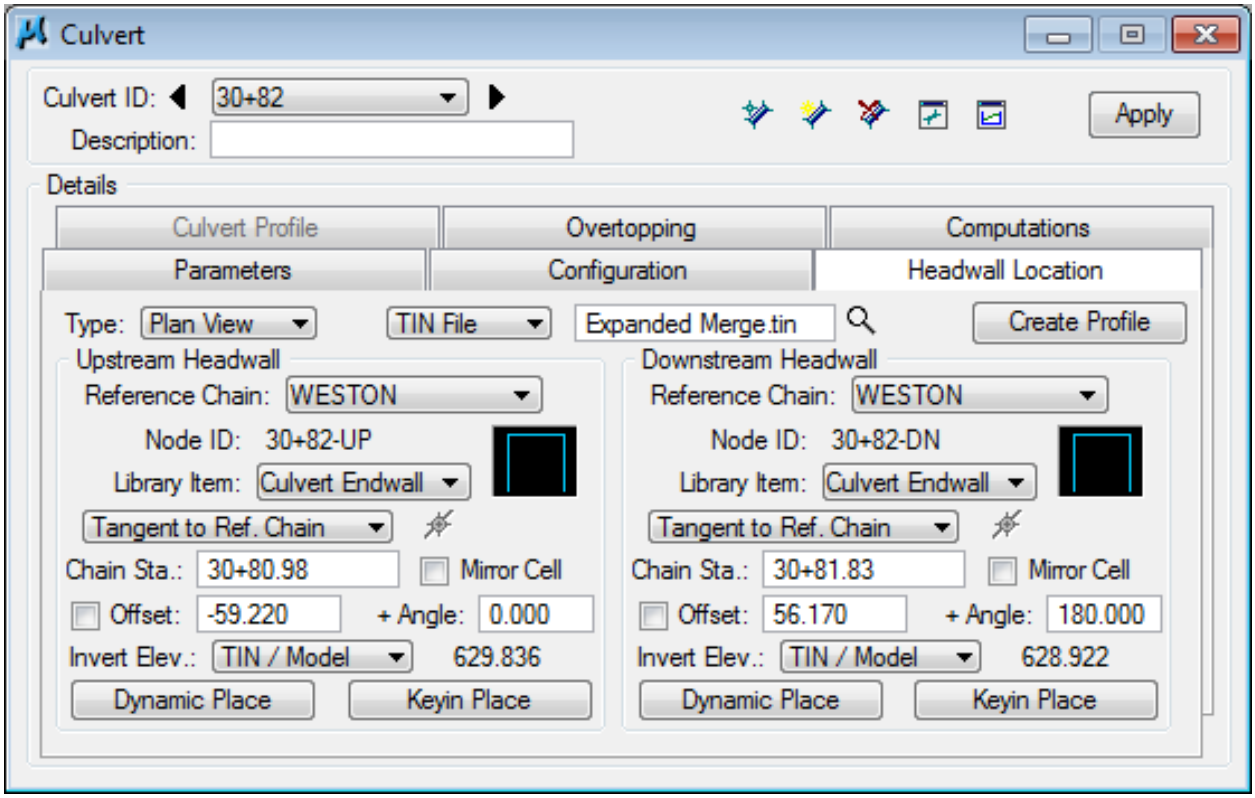


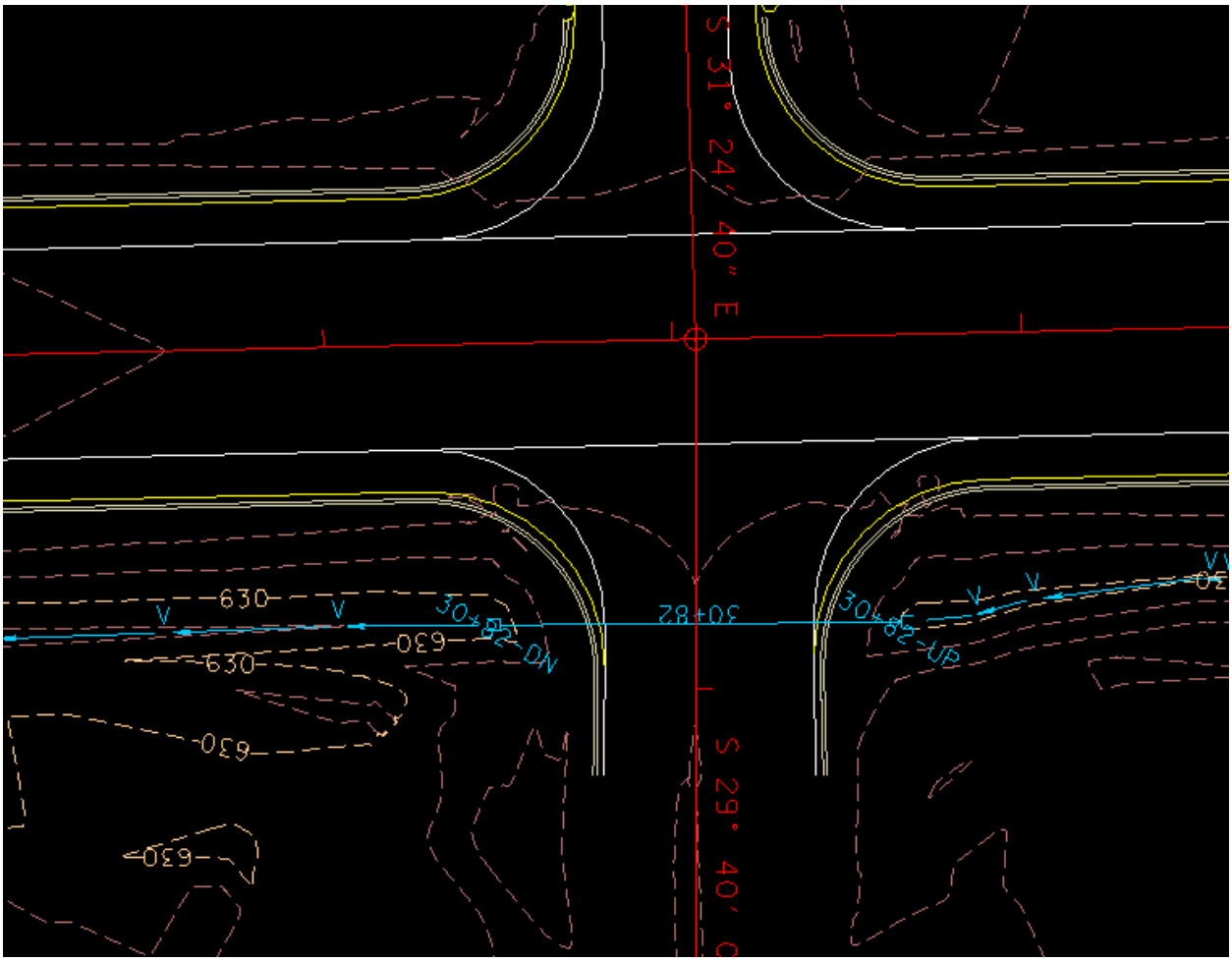
Plan view of culvert location at Weston (prop. ditch line) , crosses Weston at 30+82.03.

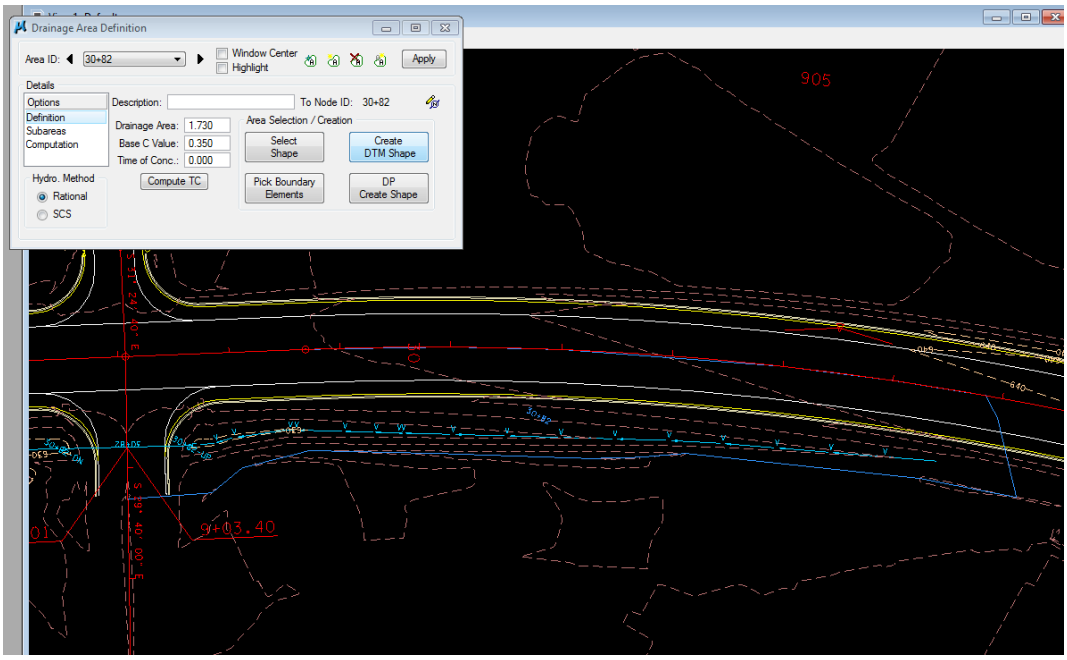


Cross section view of culvert locaton (using proposed.tin) With inlet and outlet elevations and offsets located.

Locate endwalls on plan view:



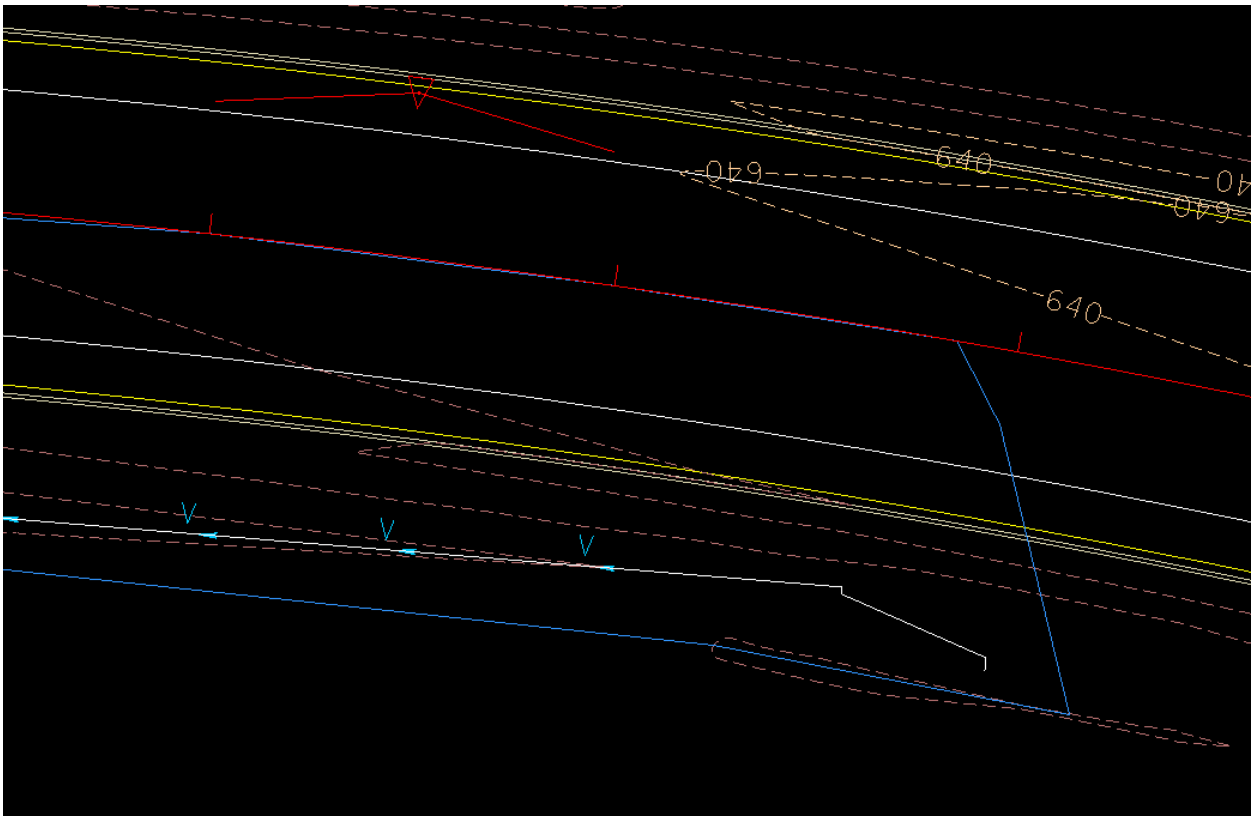

S 31° 24' 40" E
630
630
630
630
30+82
30+82
S 29° 40'



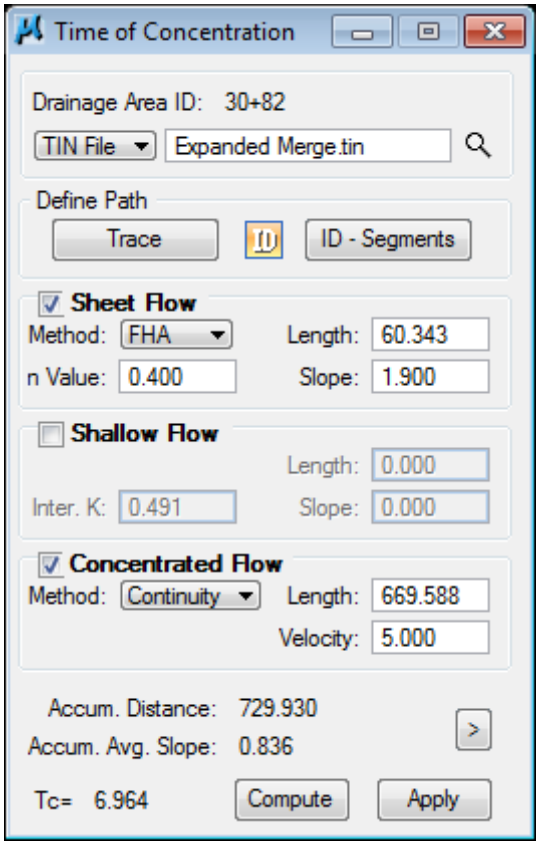
Drainage Area for 30+82 Weston Blvd. use “Downstream Trace” in Drainage Utilities to determine drainage area.

Time of Concentration:

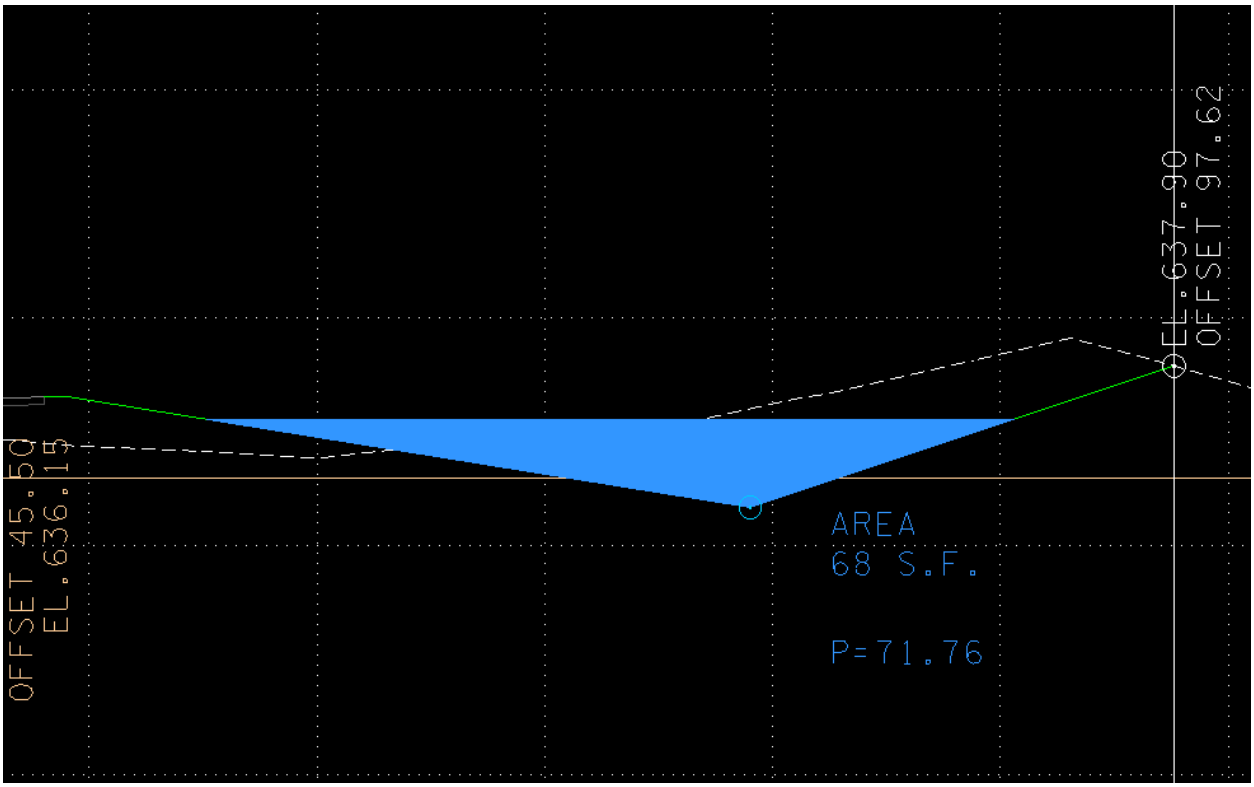
From the remote point of the drainage area, use “Downstream Trace” to determine the path of flow.:



It appears that the flow would do from sheet flow (distance of 80’) to concentrated flow in the proposed ditch. For sheet flow ‘n’value use 0.400 for grassed area.:



Use Eqn 4-9 in TDOT Drainage Manual to determine Velocity in Concentrated flow:



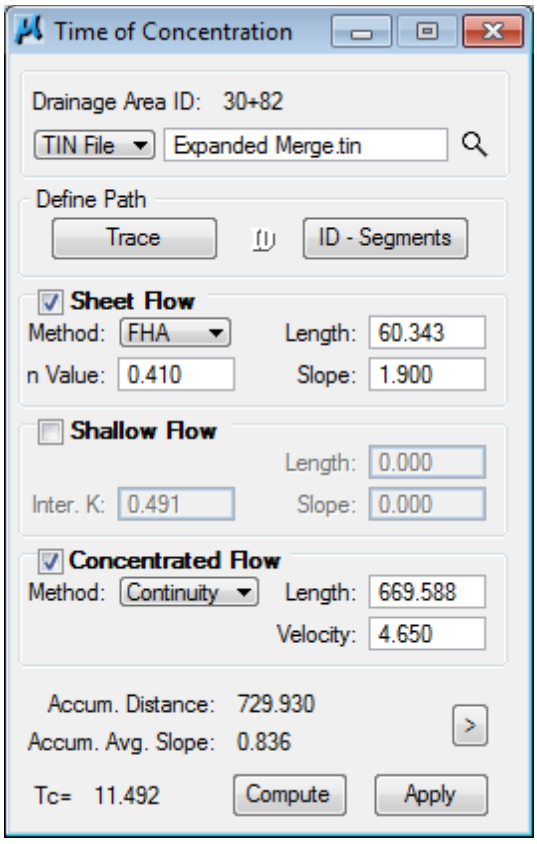
Typical Section of proposed ditch at sta. 903+00 rt.

Rh=A/P = 0.95

S= 0.76% = 0.0076

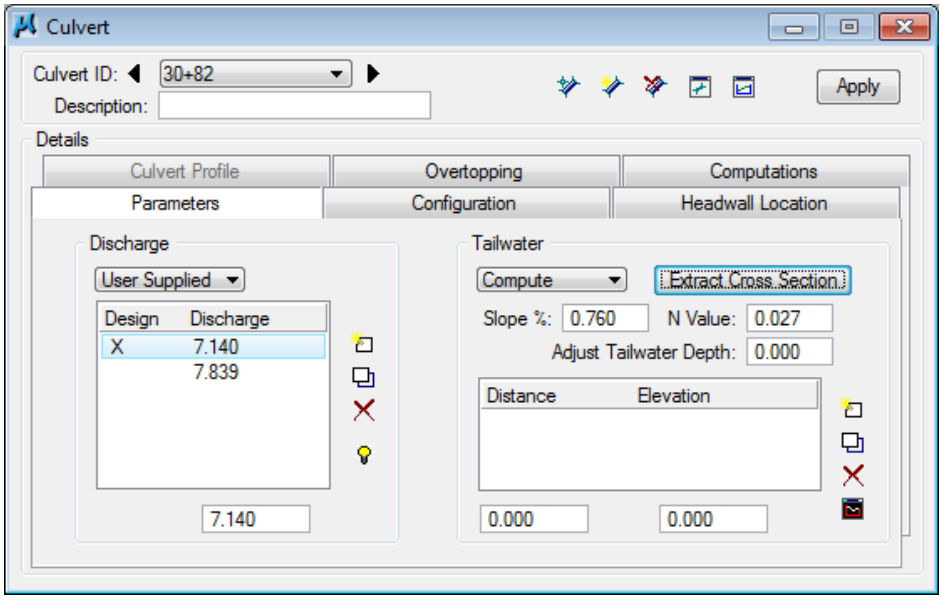
n= 0.027 (Excavated, straight, short grass)

V=4.65



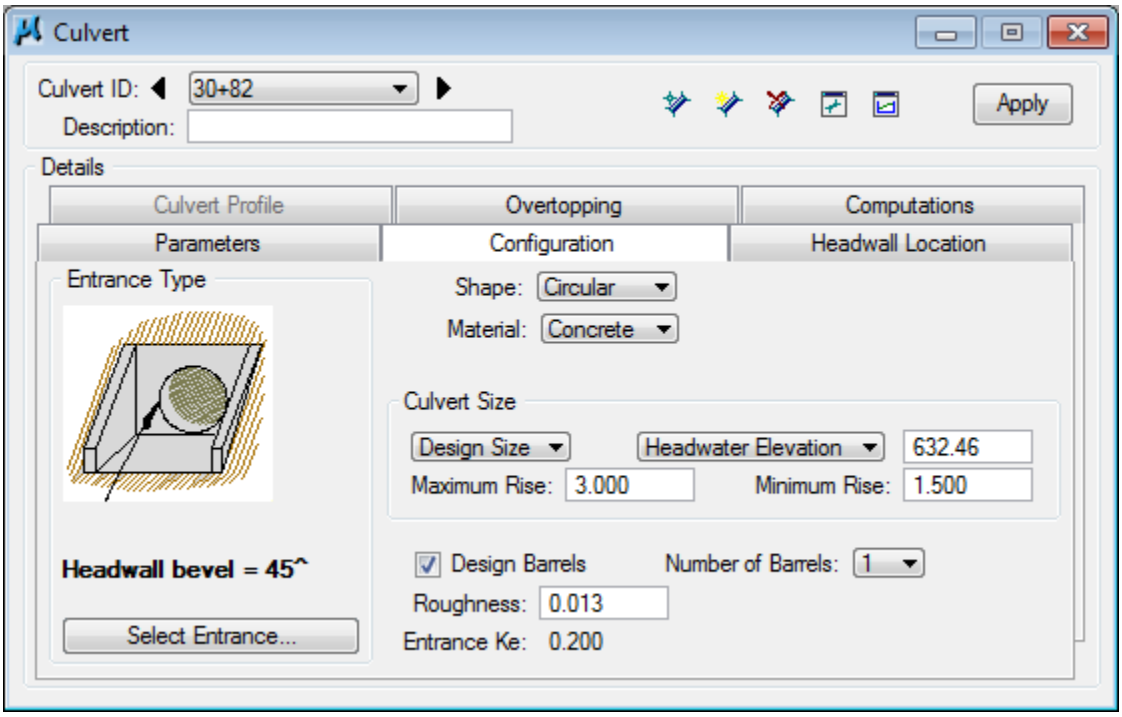
For the Sheet Flow “n”value , 0.410 is used , for grassed area. (Table 4-3, TDOT Drainage Manual, Manning’s n Values for Overland Flow)

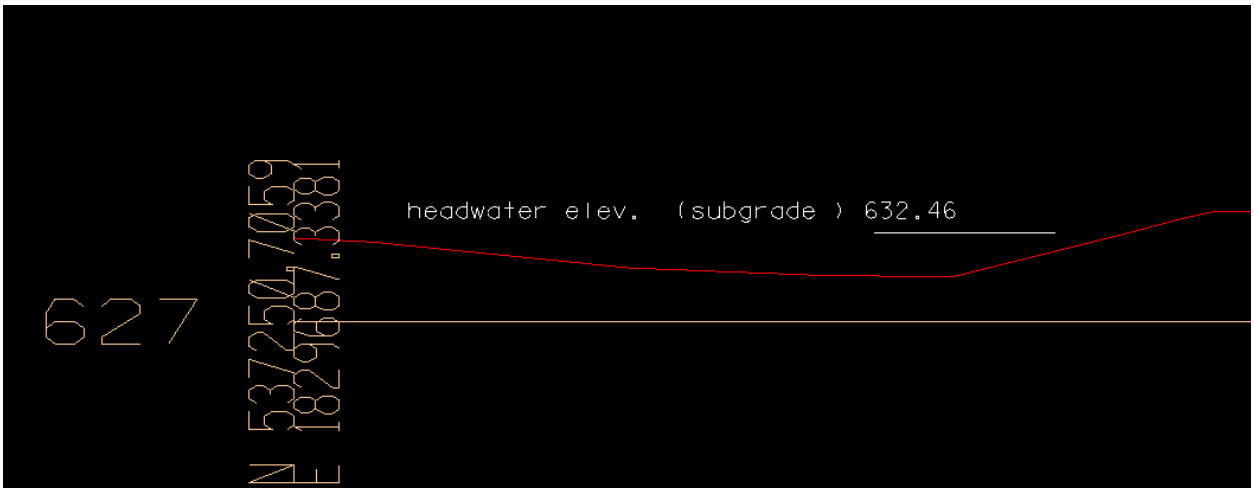
Using a computed Tc of 11.492, discharges are 7.140 for 50 yr. storm and 7.839 for 100 yr.



Refer to Geopak Drainage Manual, pages 4-13 and 4-14 to calculate tailwater. Slope= 0.76% (proposed ditch grade), N=0.027 (Table 5A-1, short grass)

Configuration (use same settings as Geopak Drainage Manual):

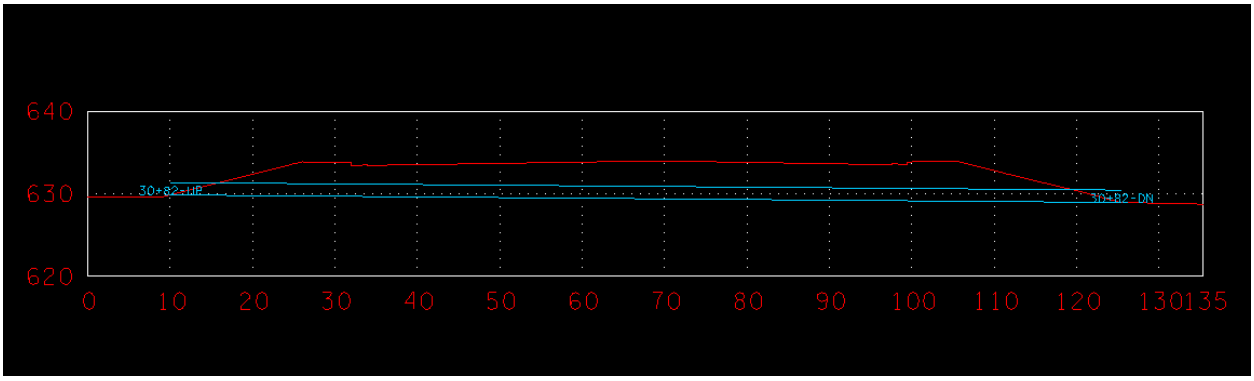




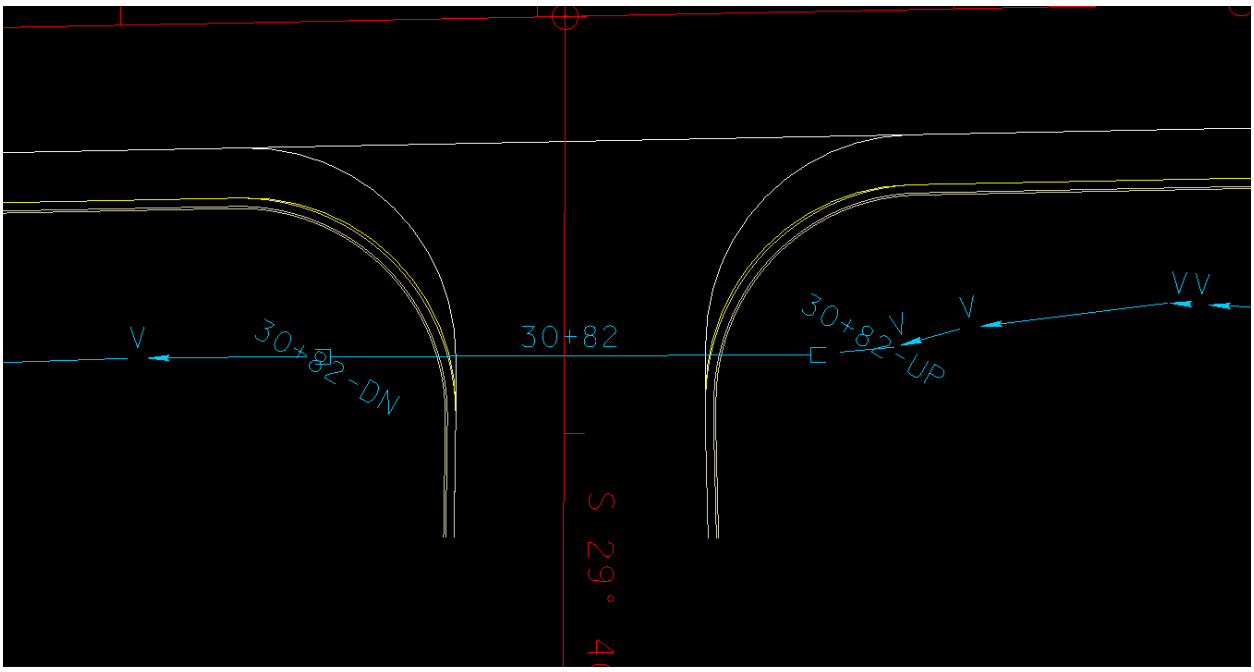
```
------------------------------------------------------------------------
Culvert Design Results for 30+82
------------------------------------------------------------------------
Circular
Concrete
------------------------------------------------------------------------
Suggested Design
------------------------------------------------------------------------
18 Inch Dia. Circular
Rise =  1.500
Number Of Barrels = 1
Length = 115.393
Slope =  0.008
Upstream Invert = 629.836
Downstream Invert = 628.922
N value =  0.013
Entrance KE value =  0.200
------------------------------------------------------------------------
Culvert    Allow.    MAX     Inlet    Outlet   Tailwater
Discharge    HW       HW       HW       HW        Elev.
--------- -------- -------- -------- --------- ----------
7.140     632.460  631.422  631.422  631.422  619.018
7.839     632.460  631.542  631.542  631.542  619.103
------------------------------------------------------------------------
Culvert   Outlet   Uniform  Critical Critical Friction
Discharge Velocity Depth    Depth    Slope    Slope
--------- -------- -------- -------- -------- ---------
7.140     5.844    0.979    1.035    0.007     0.008
7.839     5.896    1.056    1.085    0.007     0.008
------------------------------------------------------------------------
Alternate Designs
------------------------------------------------------------------------
Barrels Rise    Span    HW           Library Item
------- ------- ------- ------------ -------------------------
      1   1.250     n/a 632.108      15 Inch Dia. Circular
```

Culvert Computations for 30+82 Weston Blvd.

.Now that computations are complete. Reference Geopak Drainage Manual to adjust the length of the culverts on both the profile and plan view. Then draw the endwalls on both views.



Profile View (culvert Section)



Plan view

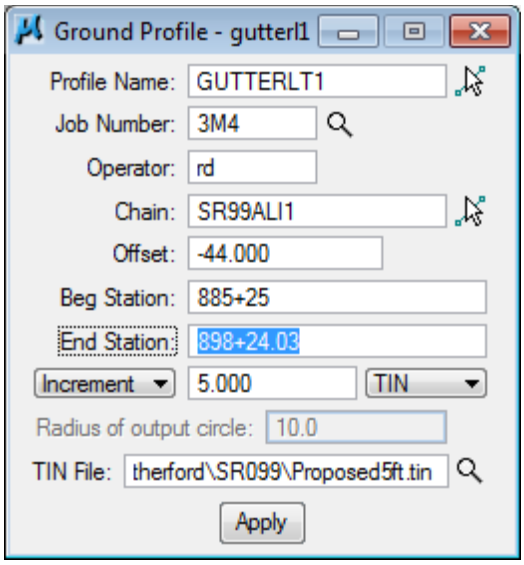
STORM DRAINAGE

Now that Culverts and ditches are located, the locations for the catch basins and their outlets can be determined. Catch basins will be located in the gutter line on each side of the roadway. Before doing this, if you have not already, it is a good idea to re run cross sections for the proposed roadway every 5 feet. This will ensure more accurate elevations for low points, etc.

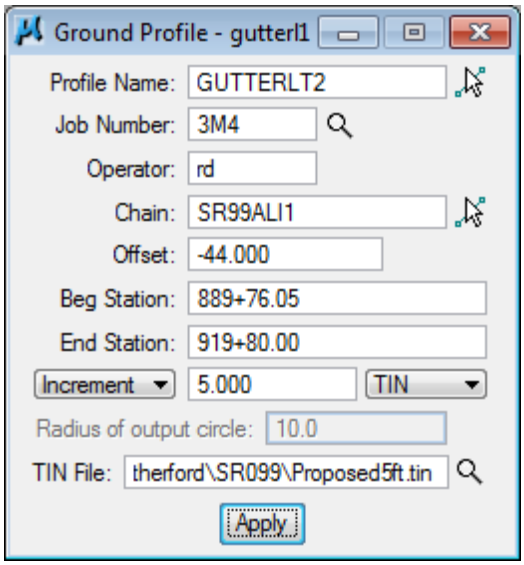
The procedure for running cross sections every 5 feet will not be discuissed here. The procedure is described in Exercise 22 of the Geopak Road Manual. Use your preference for file names.

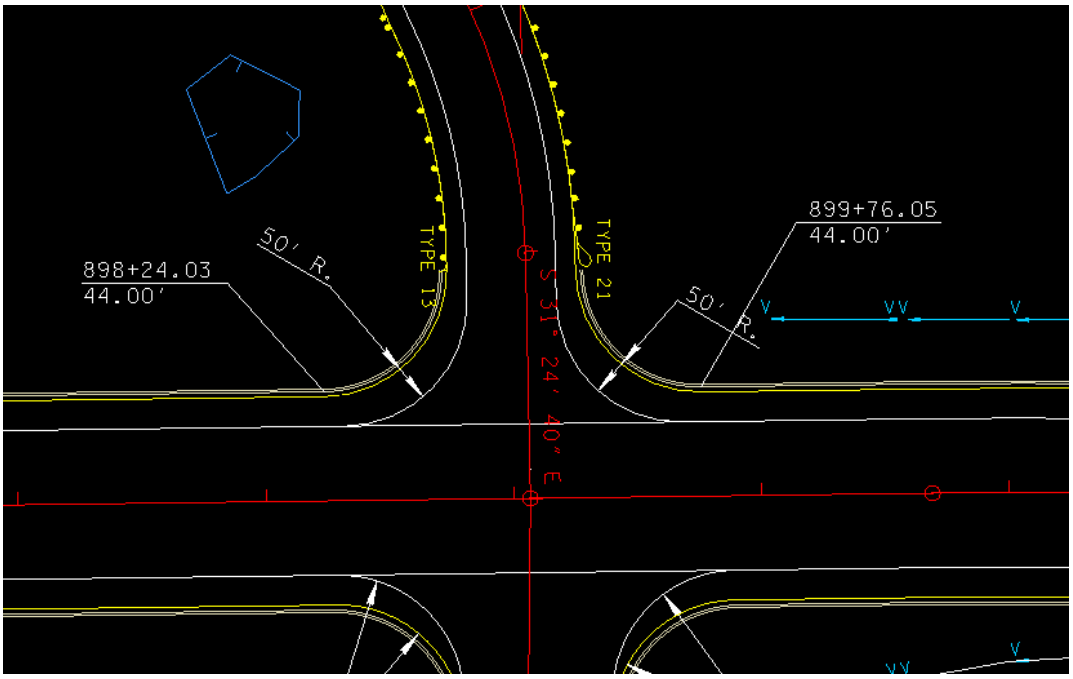
Then merge the side road surfaces with the new mainline surface , then merge with existing surface as before.

Once a new surface for the mainline has been created it is helpful to create a profile for each gutter line. This will give a good picture of where the high and low points are.
First, for the left gutter profile, in Existing Ground Profile, make settings similar to what is shown below. The first section runs from the beginning of curb and gutter (885+25) to the beginning of the radius at the Old Salem road intersection (898+24.03):

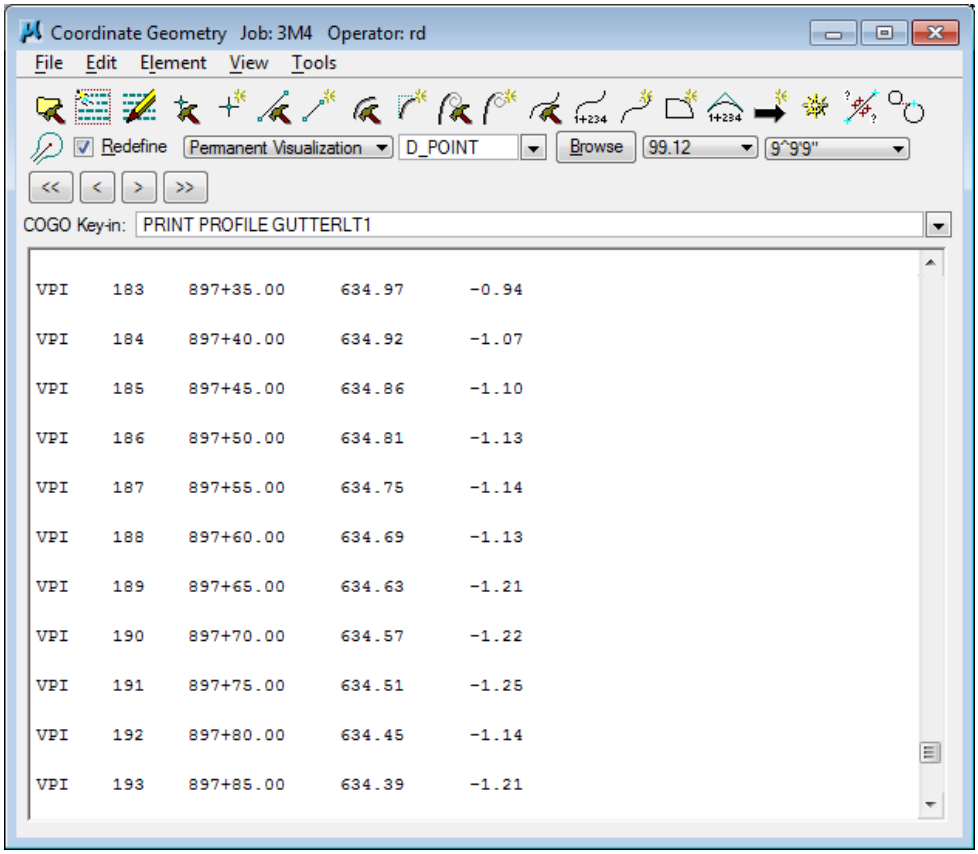


The second section runs from the end of the radius at the intersection (899+76.05) to the end of the curb and gutter (919+80):

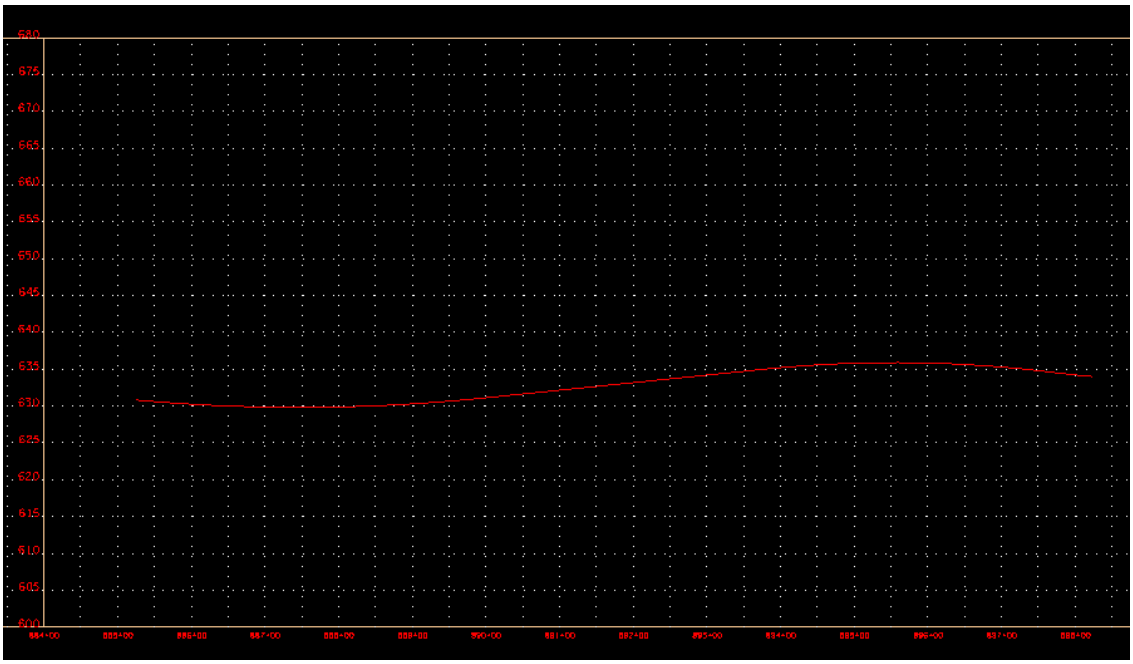




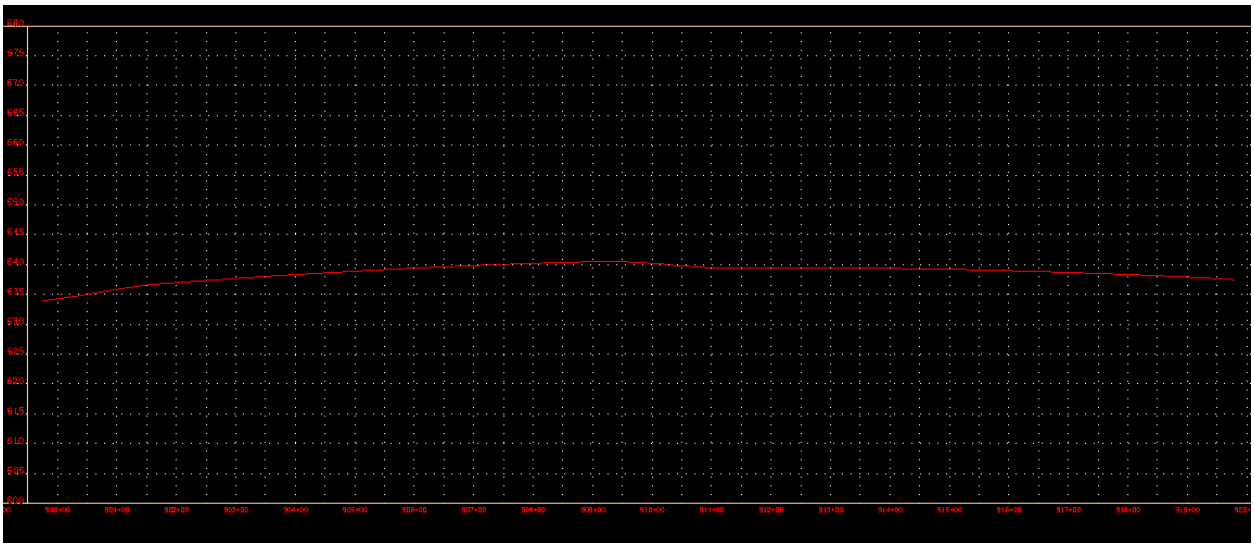
The TIN file Mainline with cross sections cut every 5 ft merged with the proposed side roads.. The gutter is at 44 ft offset from the center line (-44 for left) Begin and End stations for the curb and gutter differ from the roadway alignment



Description in Navigator of profile “GUTTERLT1”



Profile of “GUTTERLT1” plotted on grid.Since it was stored as existing ground the profile was drawn with that symbology. The symbology was changed to match that for proposed profile.



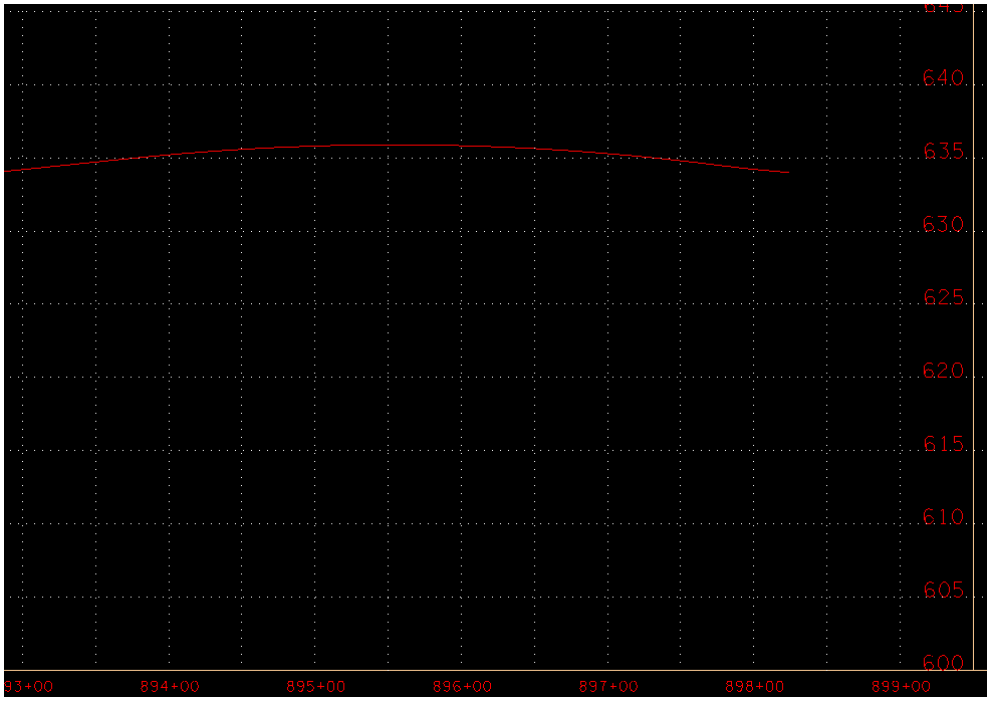
Profile of “GUTTERLT2” plotted on grid.

Catch Basins are located in the gutter line in low points, or sags, at the upper side of side road inter sections and private drives. Catch Basins are spaced at a maximum of 400 feet. For further guidance ,see TDOT Drainage Manual, Chapter 7, Section 7.04.1.2.

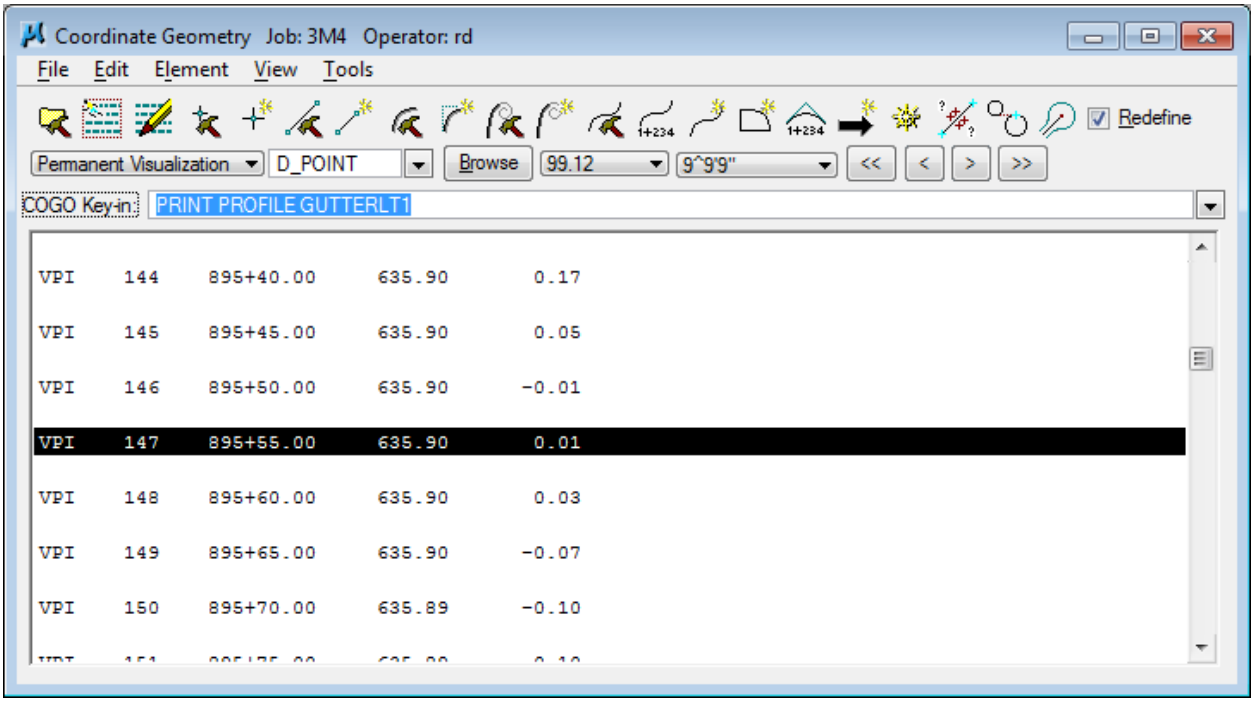
Locations are determined starting at high points and working toward low points, so first locate high and low points in the curb and gutter profile.

Now looking at the profiles and their descriptions, the high and low points in the gutter can be determined:

High Pts. (Station)	Elevation
885+25	630.82 (begin. of curb & gutter)
895+55	635.90
909+41	640.55

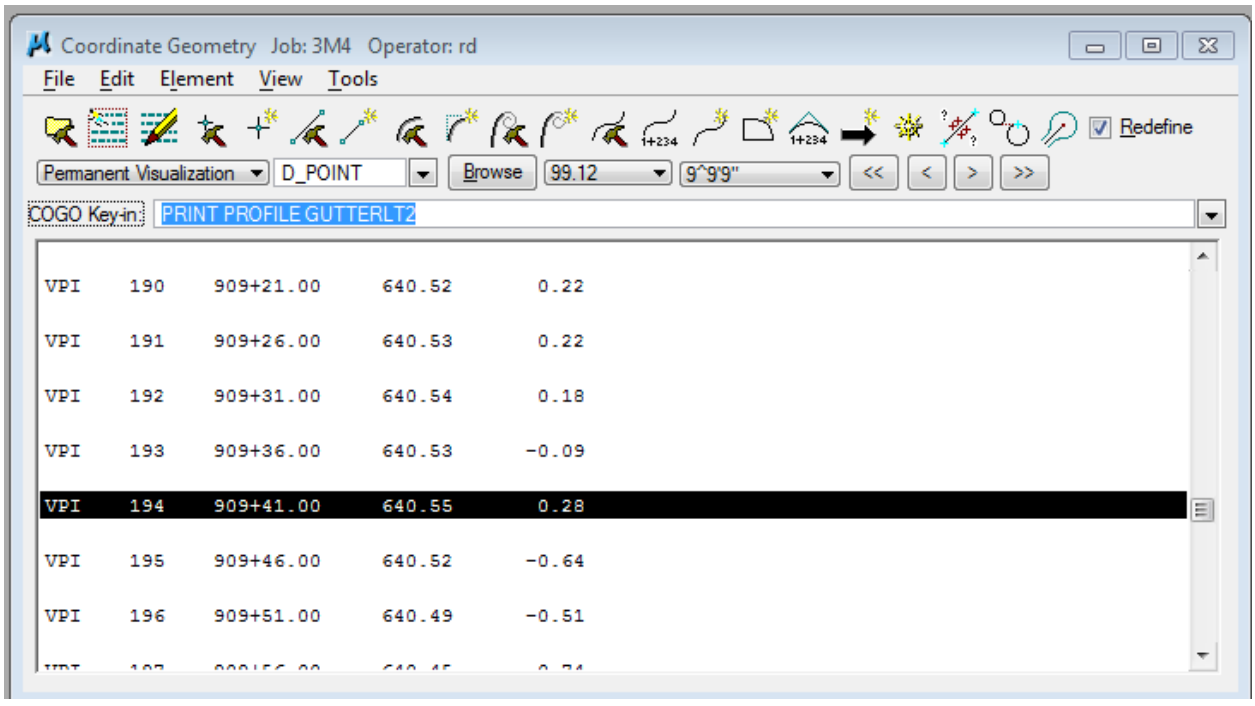


High pt. at 895+55, on profile



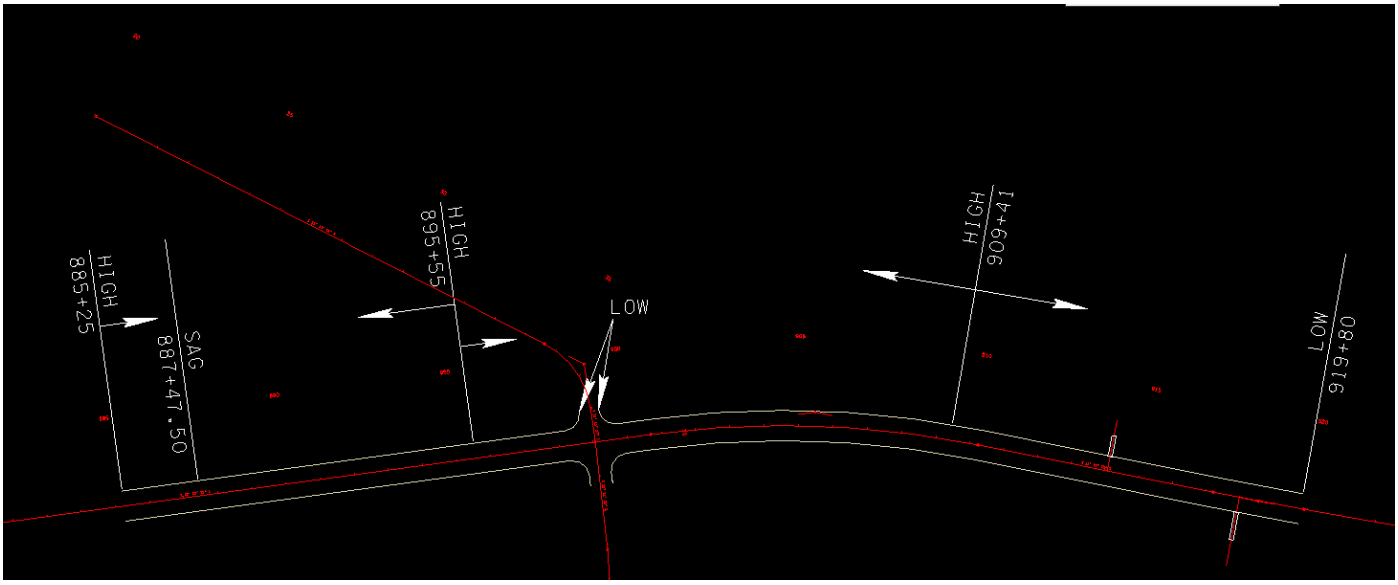
GUTTERLT1 description, showing high point at 895+55

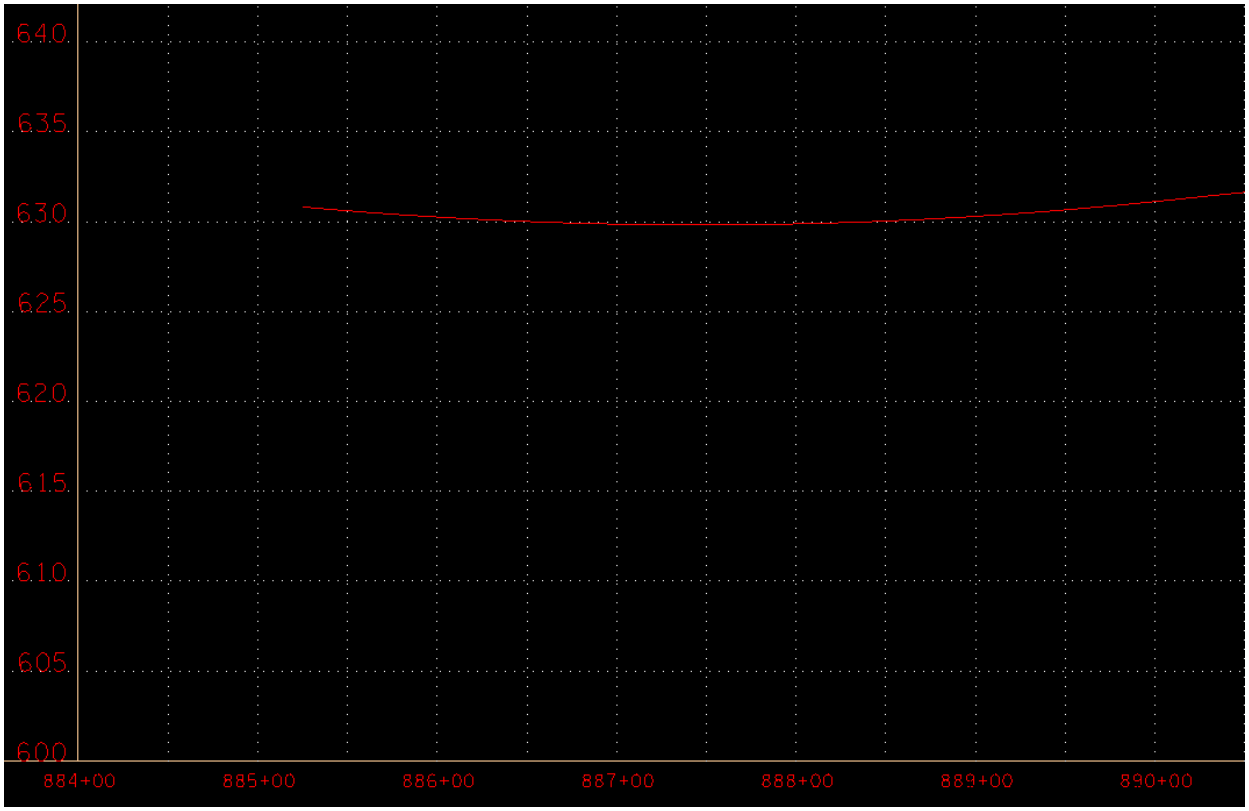
High pt. at 909+41, on profile



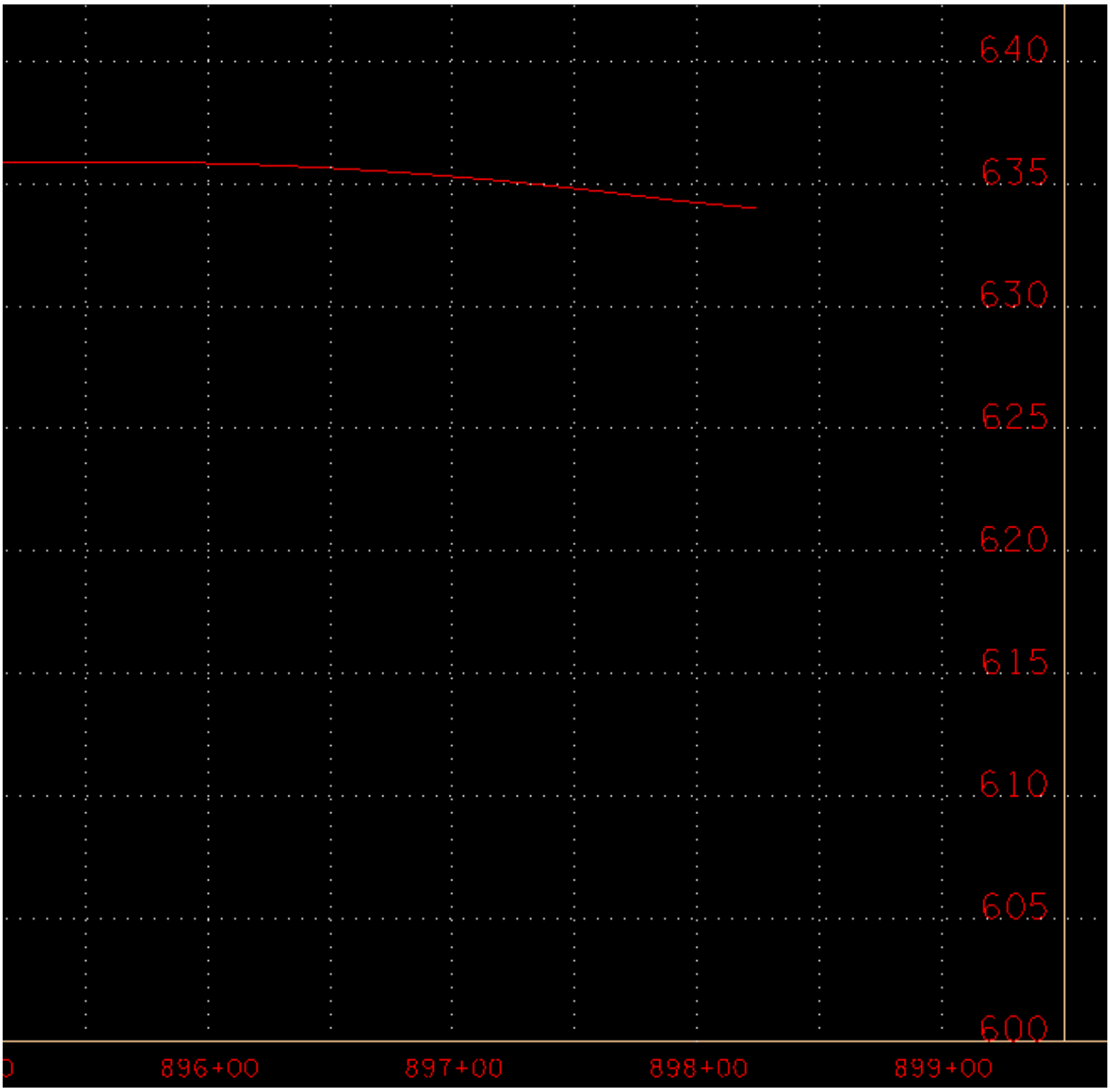
GUTTERLT2 description, showing high point at 909+41

Low Pts. (Station)	Elevation
887+47.50	629.82 (sag)
898+24.03	634.01 (begin. of radius at intersection)
899+76.05	633.94 (begin. of radius at intersection)
919+80	637.47 (end of curb & gutter)



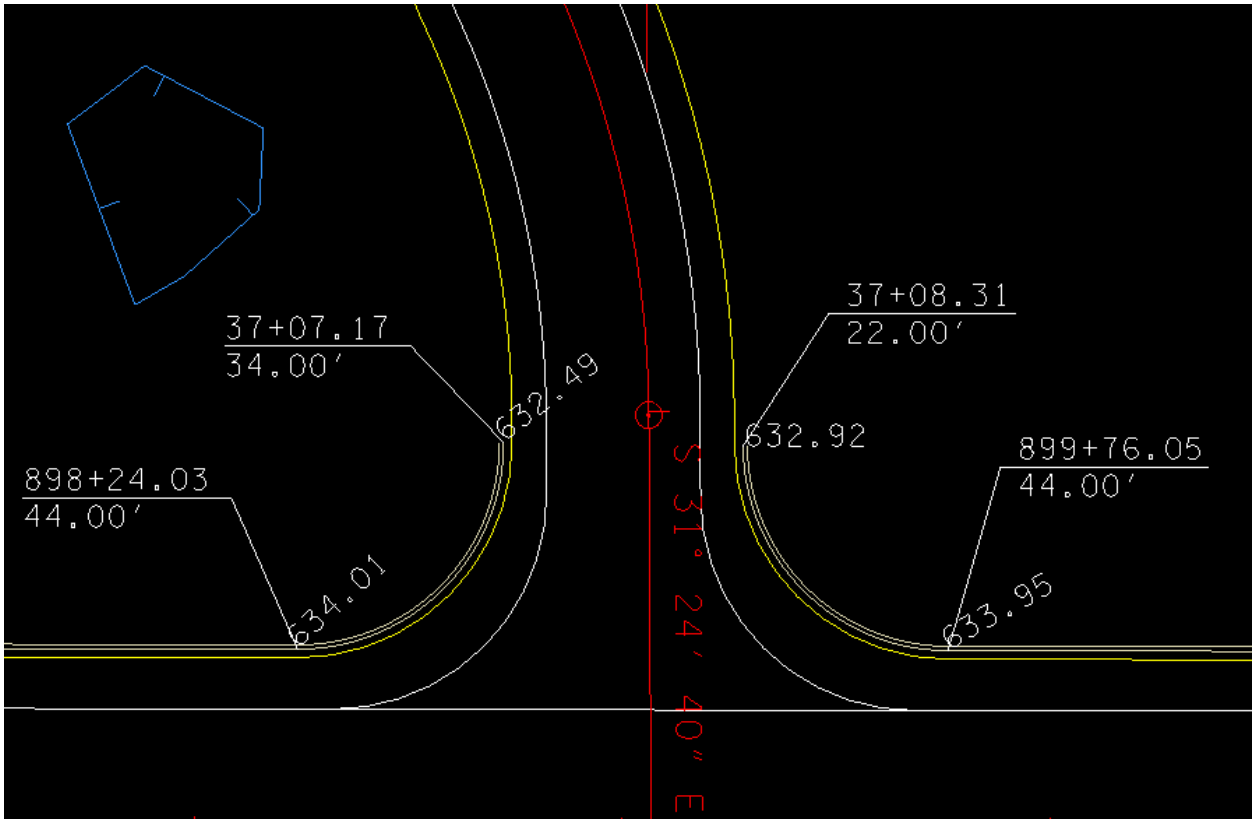


Sag in curb & gutter at 887+47.



898+24.03, at beginning of radius at Old Salem Rd. intersection

In addition to the low points listed above, locate catch basins at the ends of the radiuses at the Old Salem Rd. intersection.



Appendix C shows how the profiles of each radius was modified to slope down from the mainline, so locate a catch basin at the end of each radius.

At the sag points at stations 887+47.50 and 911+21, #14 Catch basins will be placed. At the other points #12 catch basins will be used since they are not sags.

First, let us place the #12 catch basins in the known locations:

CB-1, 898+24.03 LT., -44 offset

CB-2, 37+07.17 RT., Old Salem Rd., 34 offset, end of c&g in radius

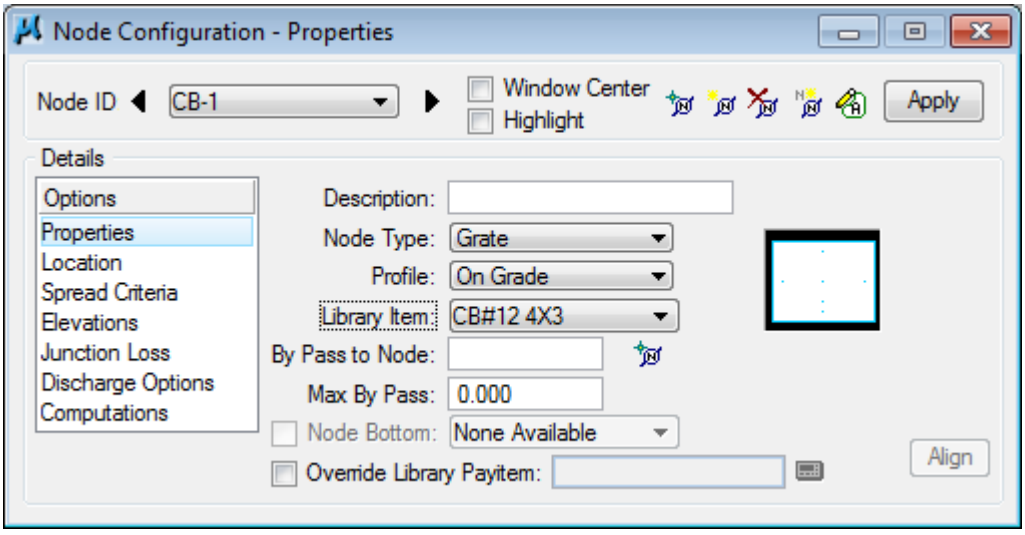
CB-3, 37+08.31 LT., Old Salem Rd., -22, end of c&g in radius

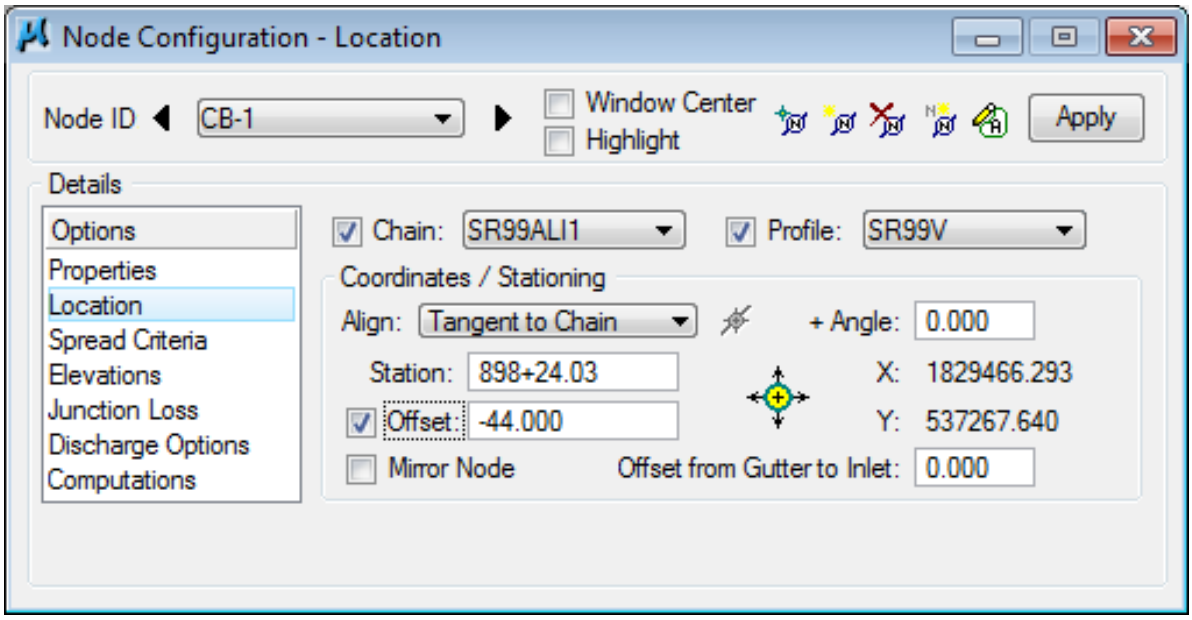
CB-4, 899+76.05 LT., -44

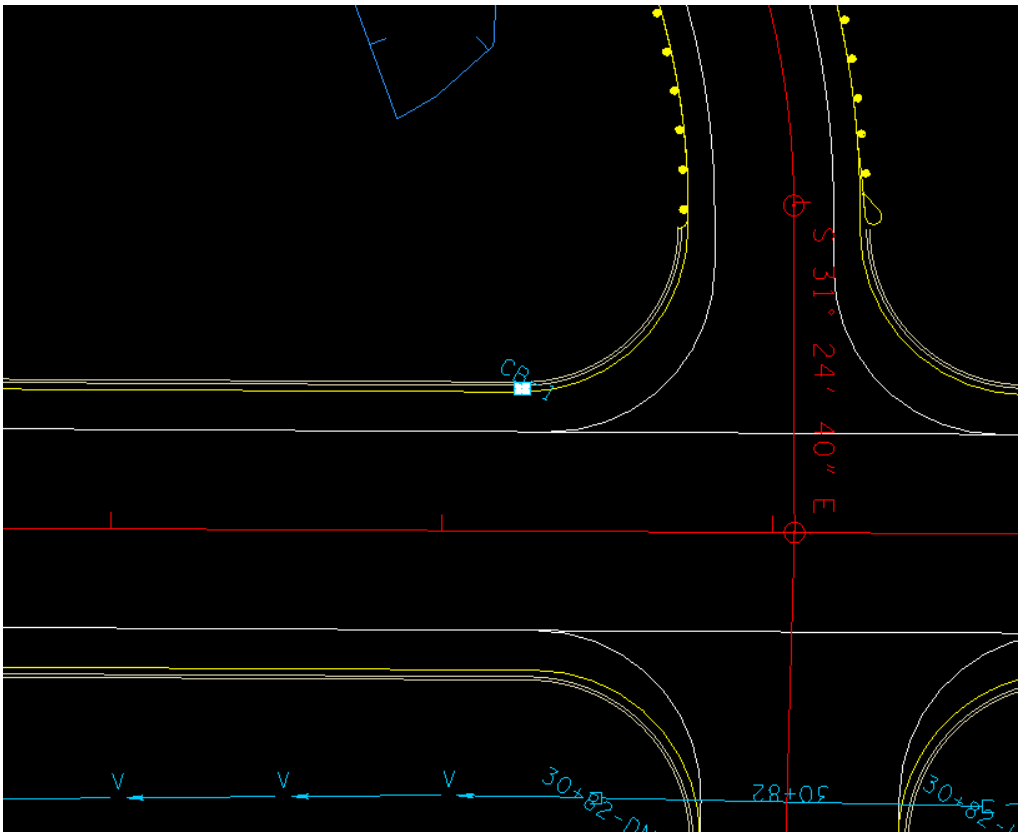
CB-5, 913+95 LT., -44 (upstream of private dr.)

CB-6, 919+80 LT., -44, end of c&g

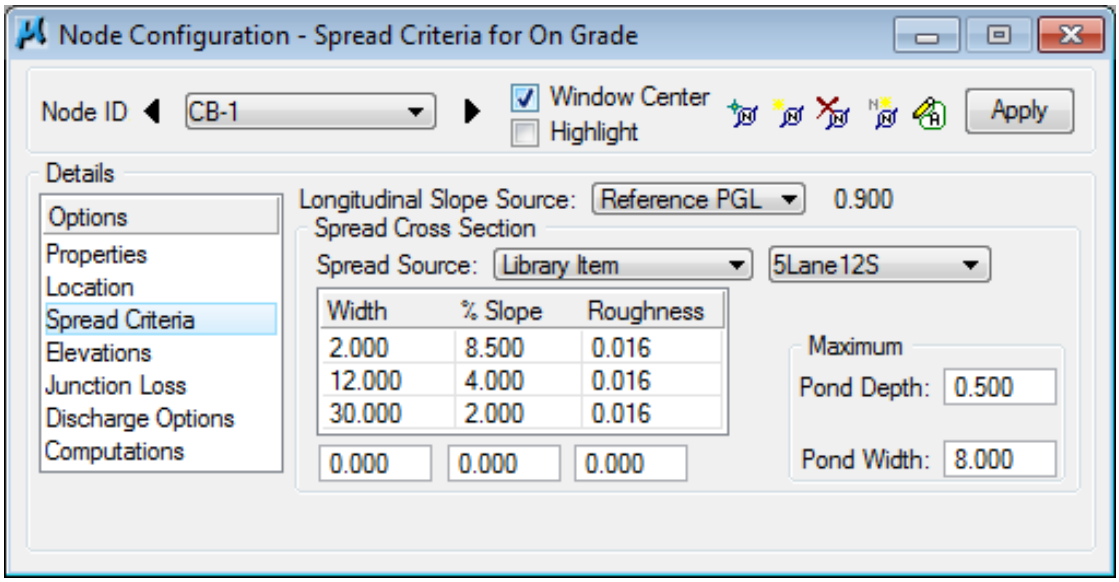
CB-1:

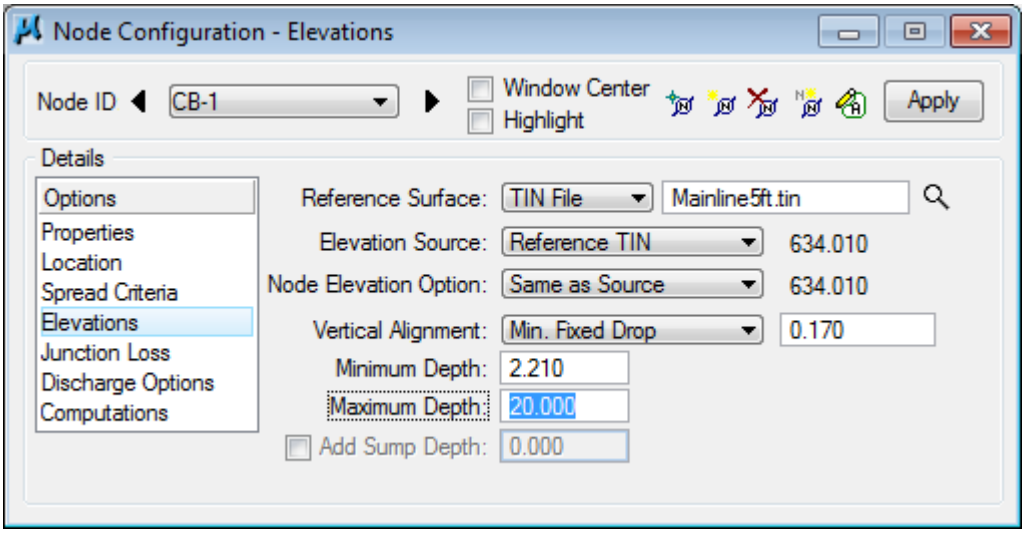



Node Configuration - Location
Node ID
CB-1
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Chain:
SR99ALI1
Profile:
SR99V
Coordinates / Stationing
Align:
Tangent to Chain
+ Angle:
0.000
Station:
898+24.03
X:
1829466.293
Offset:
-44.000
Y:
537267.640
Mirror Node
Offset from Gutter to Inlet:
0.000



Location of CB-1 on plan view at 898+24

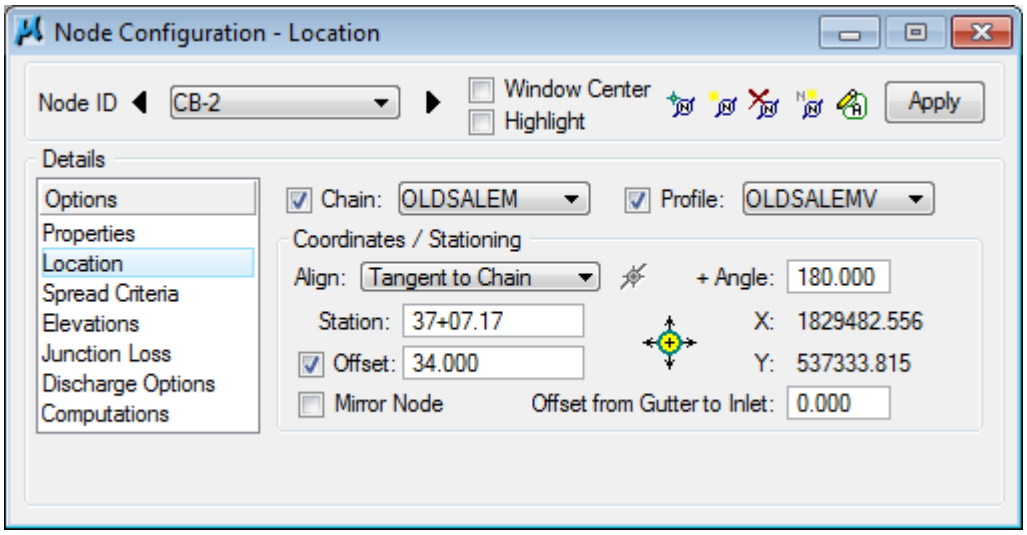

Node Configuration - Spread Criteria for On Grade
Node ID
CB-1
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Longitudinal Slope Source:
Reference PGL
0.900
Spread Cross Section
Spread Source:
Library Item
5Lane12S
Width
% Slope
Roughness
2.000
8.500
0.016
12.000
4.000
0.016
30.000
2.000
0.016
0.000
0.000
0.000
Maximum
Pond Depth:
0.500
Pond Width:
8.000

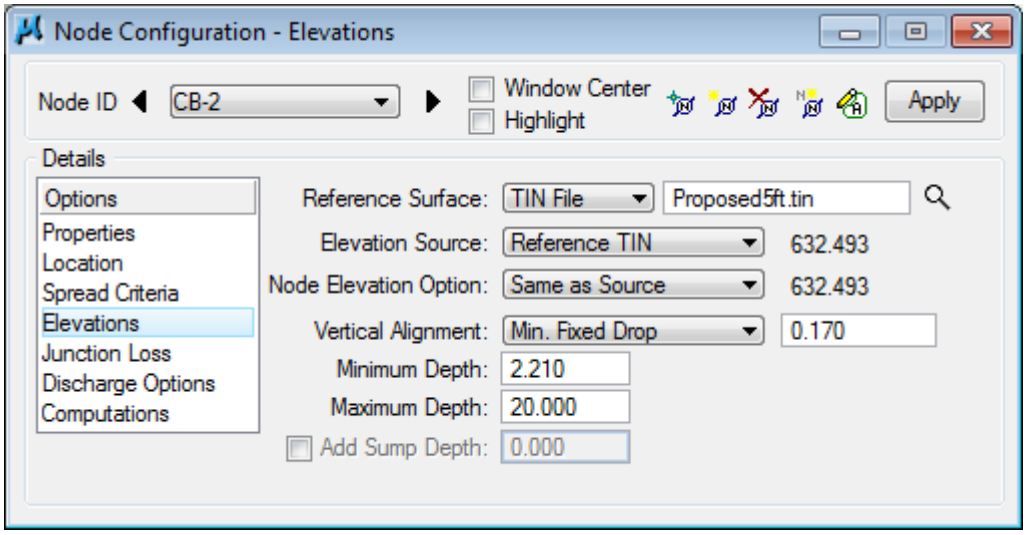


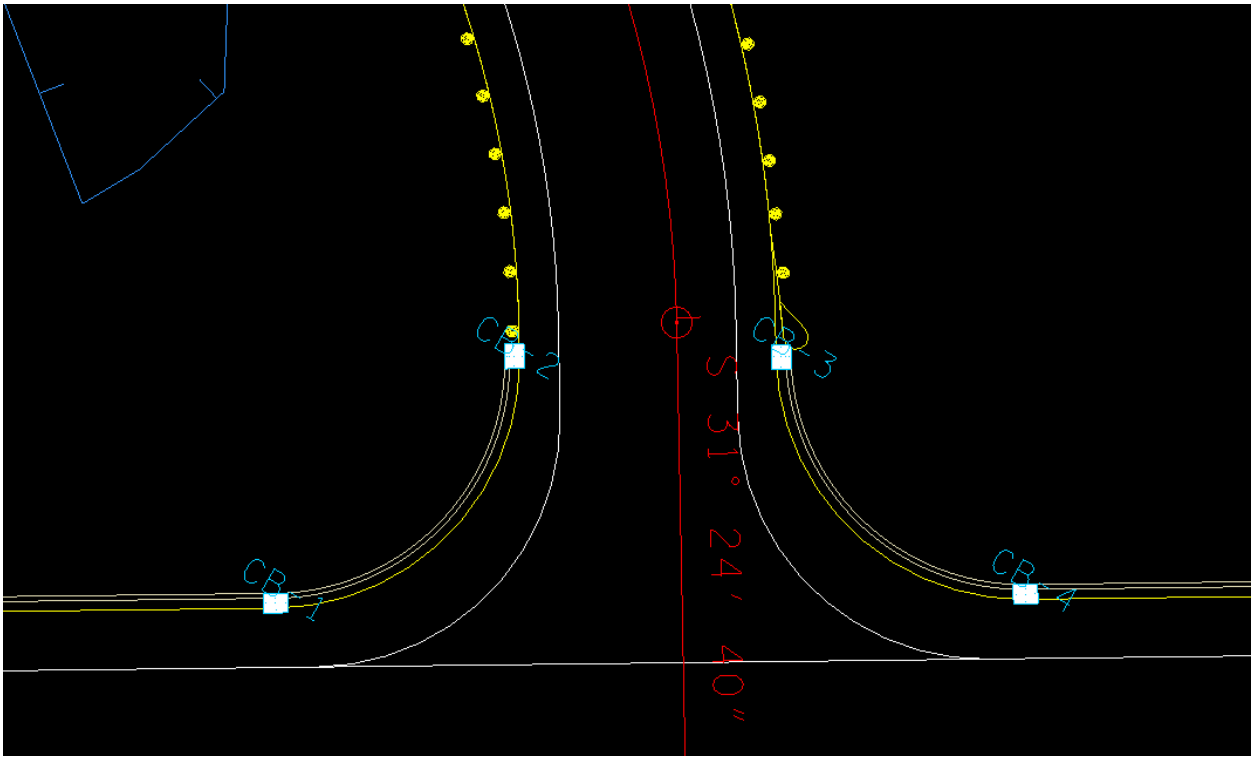
Ref. Appendix A of GEOPAK Drainage manual for drop and min. and max. elevations. Assume for 18" pipe.

Junction Loss and Discharge Options will stay at default values.

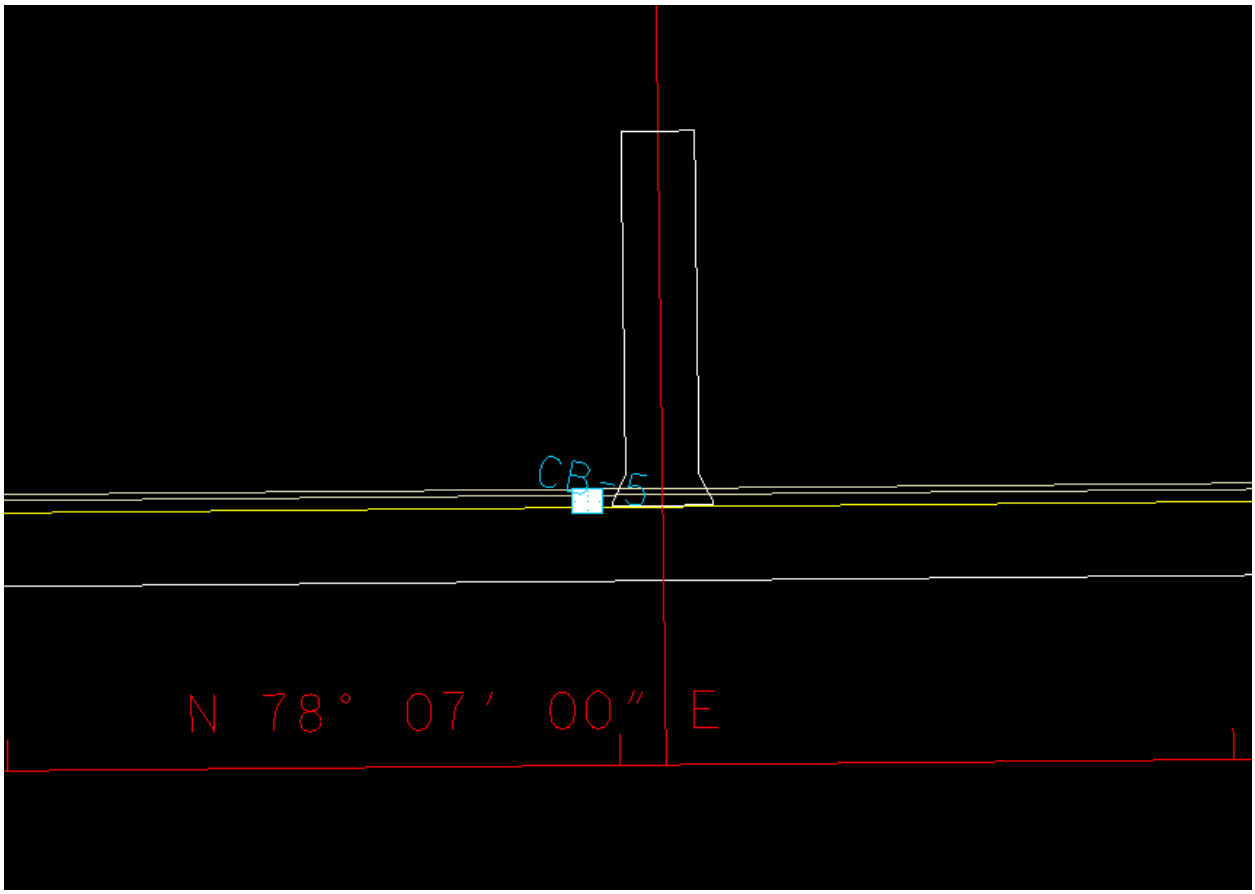
Now, similarly, locate CB's 2 -6. Reference the GEOPAK Drainage Manual for settings for the #12 CB's. The drainage areas will be added later.


Node Configuration - Location
Node ID
CB-2
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Chain:
OLDSALEM
Profile:
OLDSALEMV
Coordinates / Stationing
Align:
Tangent to Chain
+ Angle:
180.000
Station:
37+07.17
X:
1829482.556
Offset:
34.000
Y:
537333.815
Mirror Node
Offset from Gutter to Inlet:
0.000

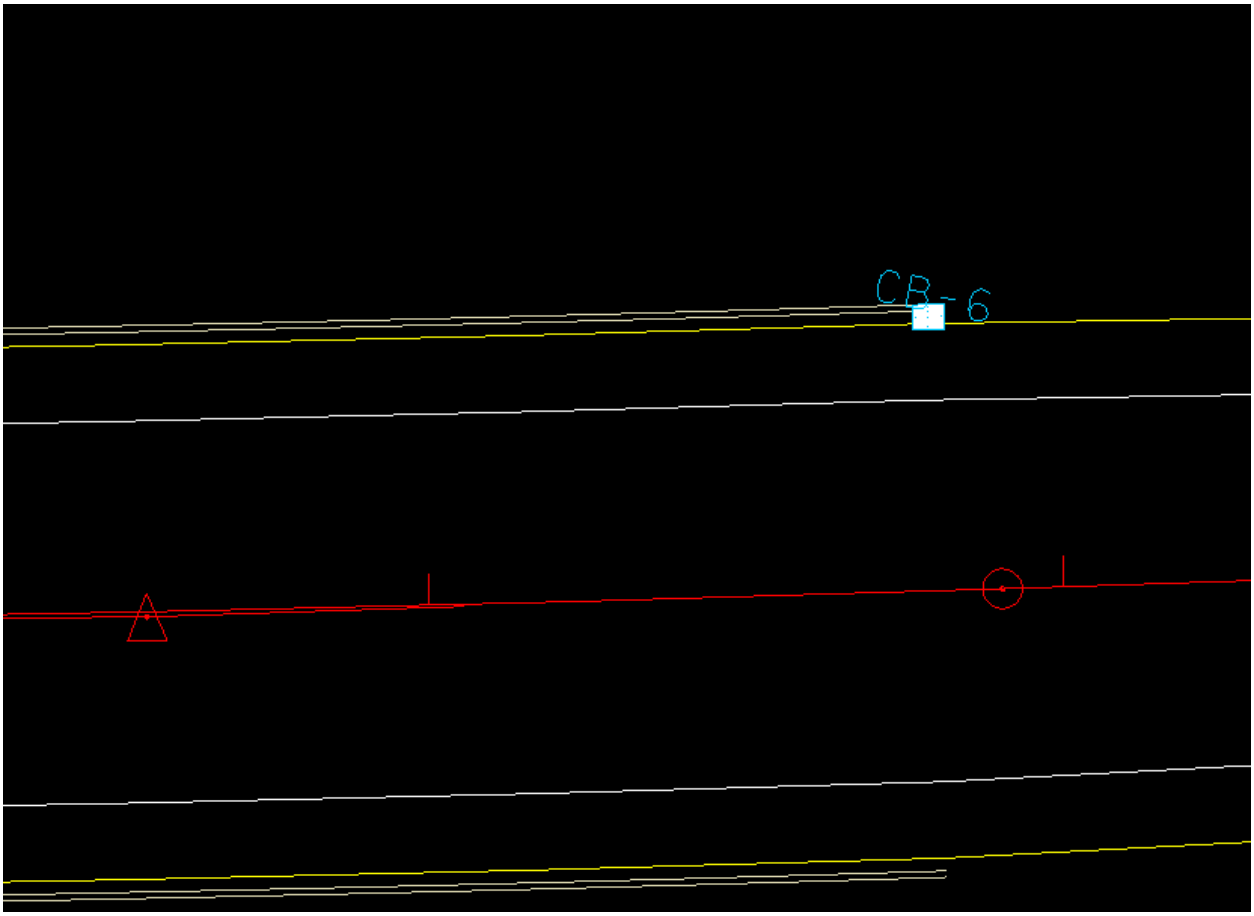

Node Configuration - Elevations
Node ID
CB-2
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Reference Surface:
TIN File
Proposed5ft.tin
Elevation Source:
Reference TIN
632.493
Node Elevation Option:
Same as Source
632.493
Vertical Alignment:
Min. Fixed Drop
0.170
Minimum Depth:
2.210
Maximum Depth:
20.000
Add Sump Depth:
0.000



Locations of CB-1, CB-2, CB-3, and CB-4



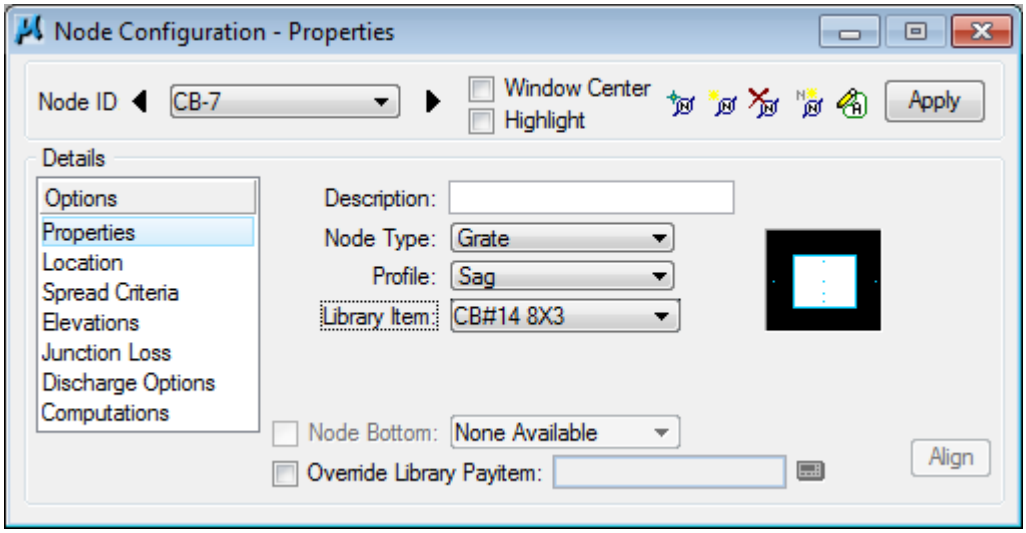
Location of CB-5

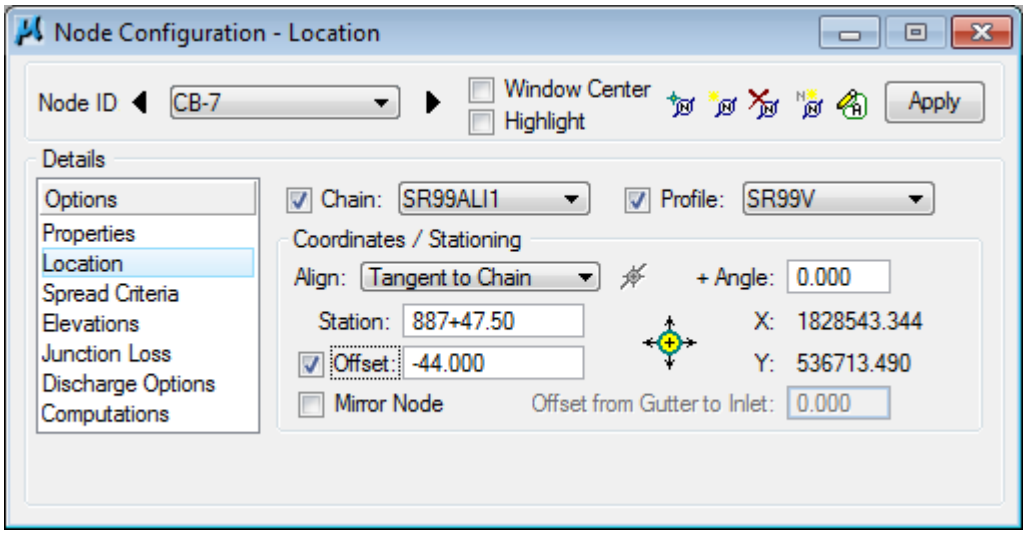


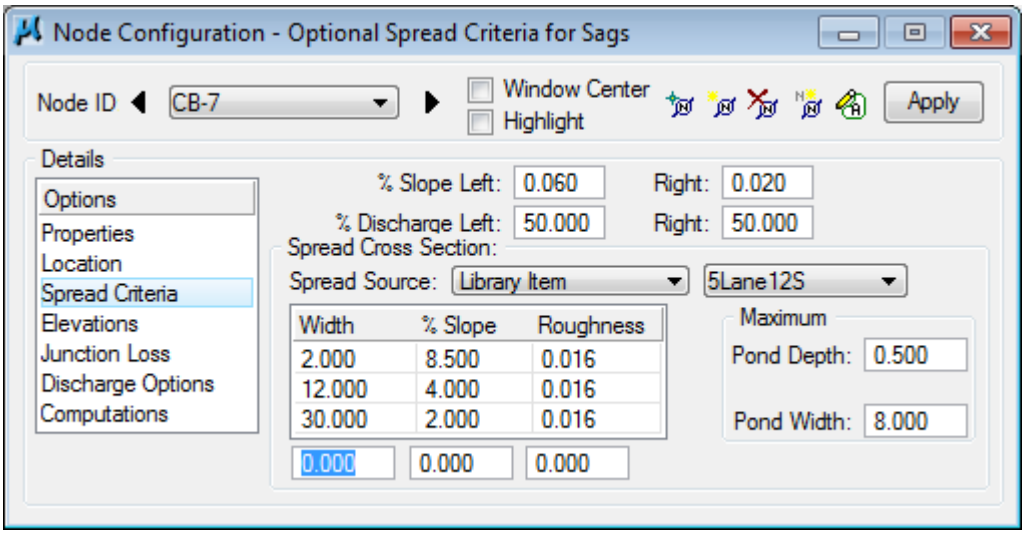
Location of CB-6

Now locate a #14 catch basins at the sag location, station 887+47.50 (CB-7).

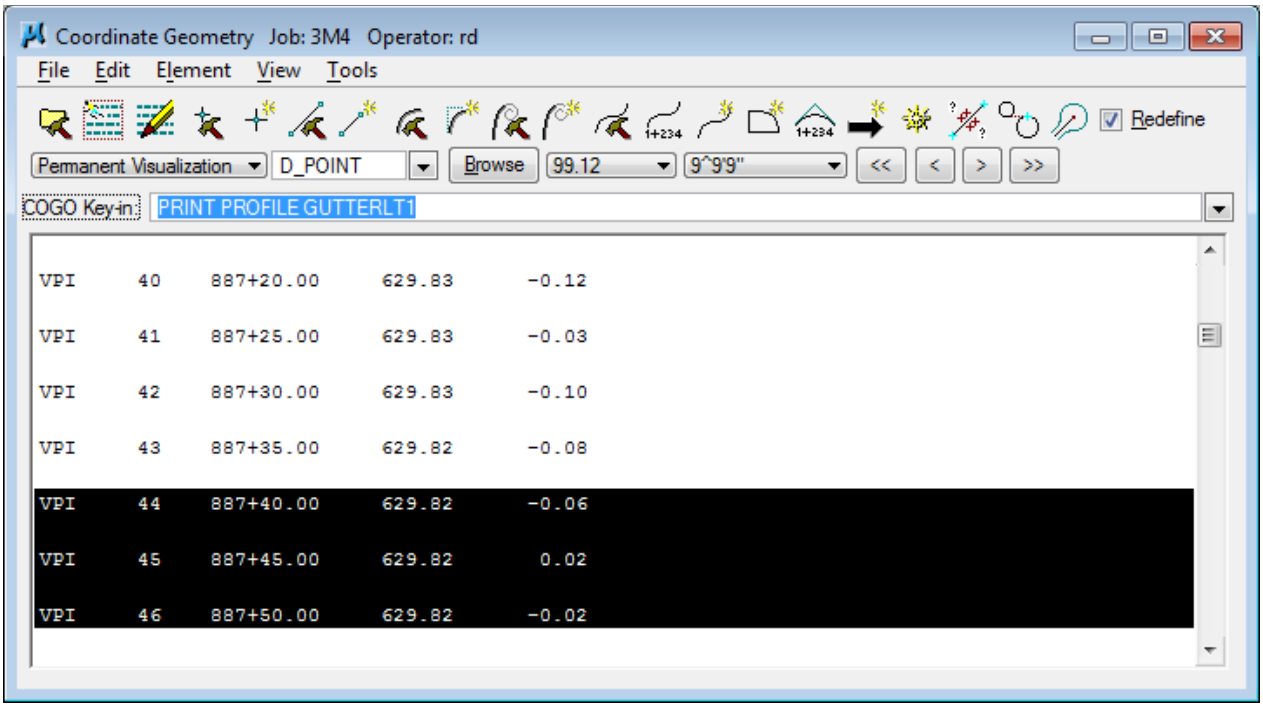
CB-7:

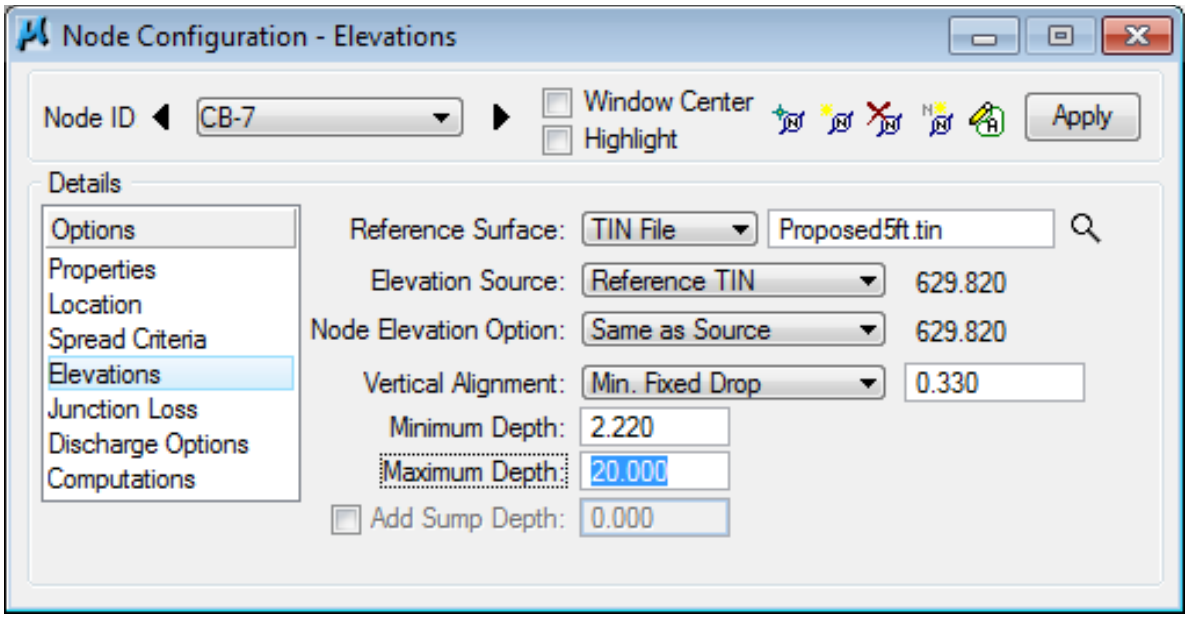


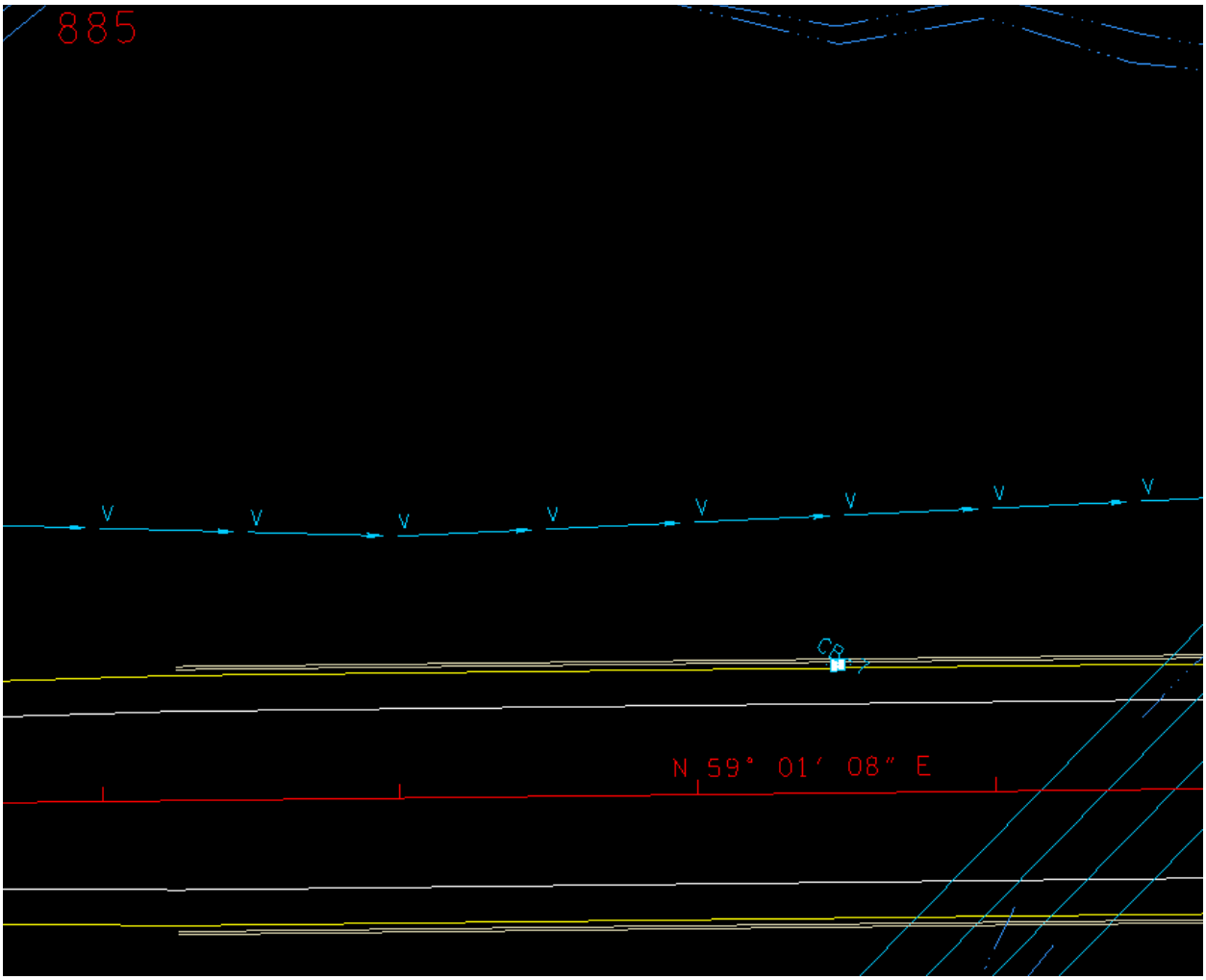




The Left and Right % slopes are found on the profile description:



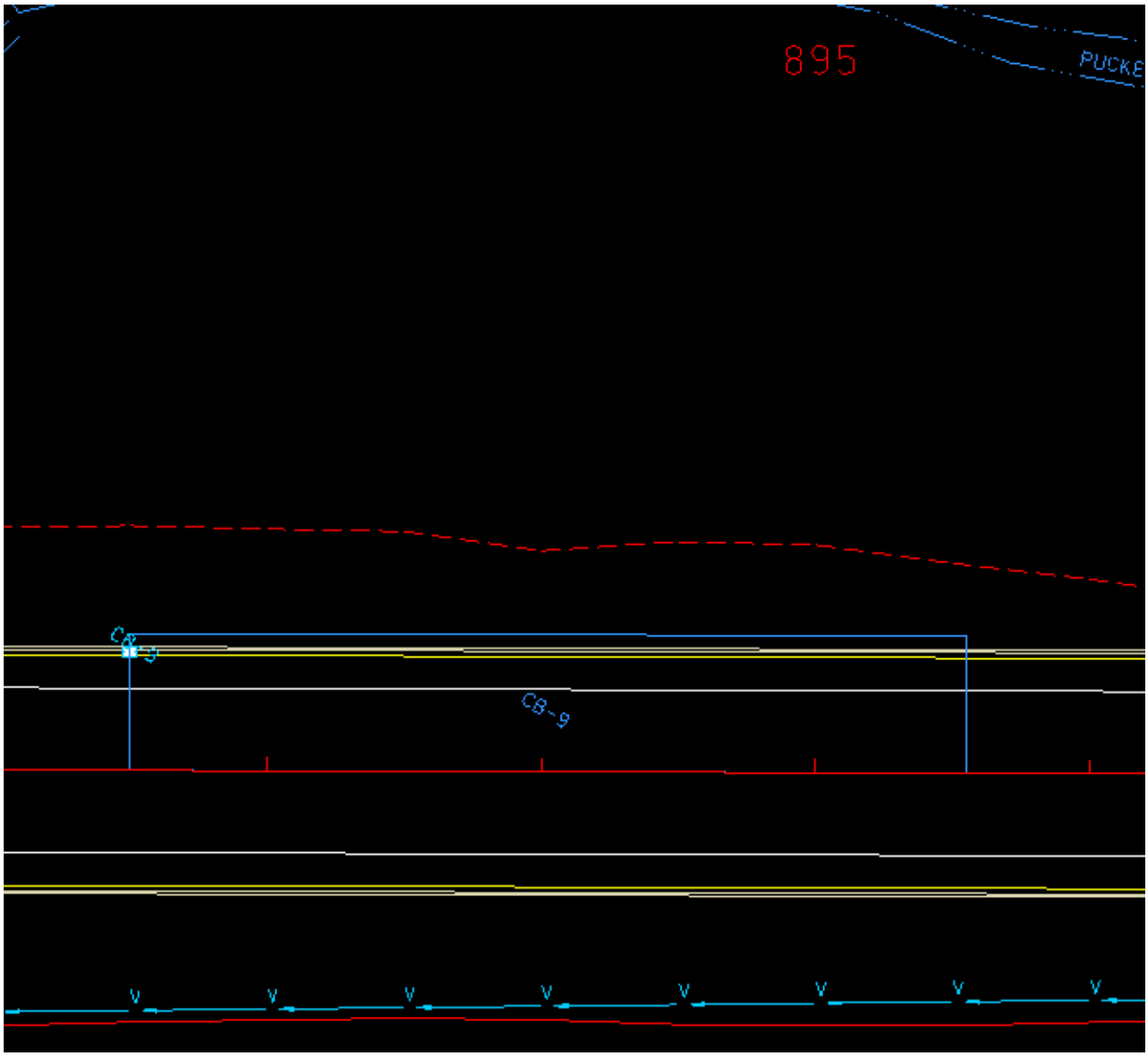

Node Configuration - Elevations
Node ID
CB-7
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Reference Surface:
TIN File
Proposed5ft.tin
Elevation Source:
Reference TIN
629.820
Node Elevation Option:
Same as Source
629.820
Vertical Alignment:
Min. Fixed Drop
0.330
Minimum Depth:
2.220
Maximum Depth:
20.000
Add Sump Depth:
0.000



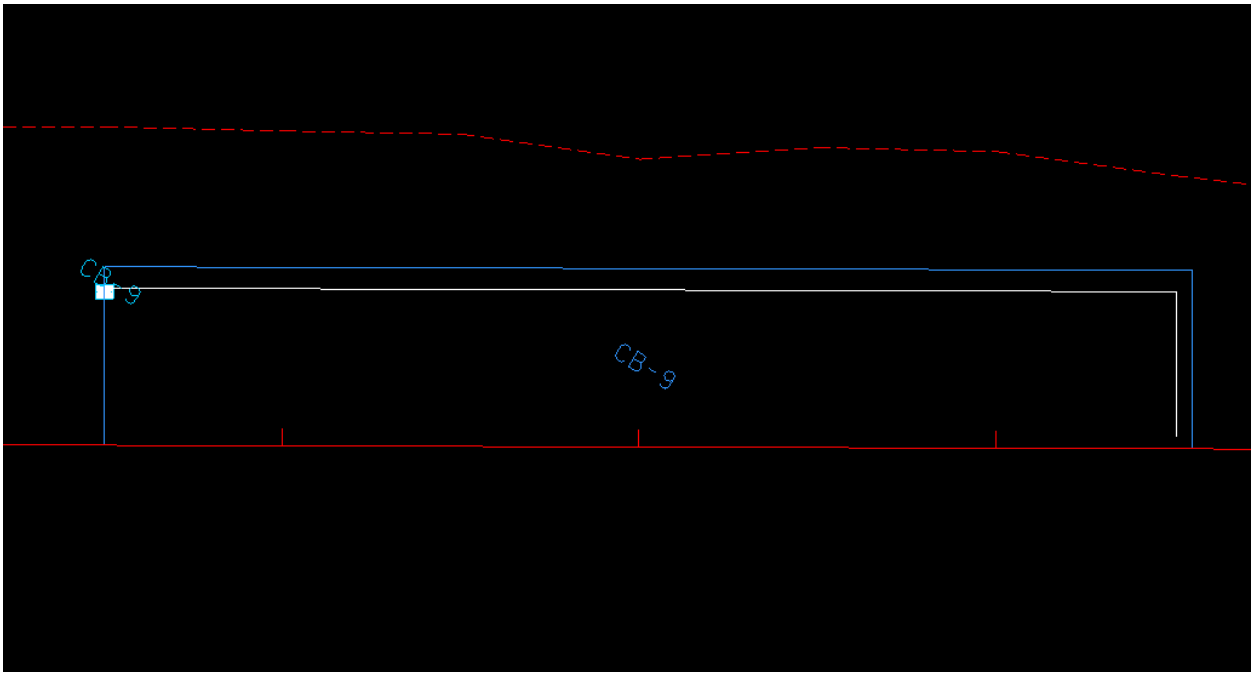
Location of CB-7

Locate the remainder of the catch basins by working from a high point to low point. Assume a location first, calculate discharge to determine the spread. If the spread is too high, move the catch basin up the grade and recalculate.

Start at the high point on the curb and gutter grade at sta 895+55, working back toward the beginning of the project, determine a preliminary location for a catch basin at 892+50. This will be CB-9.

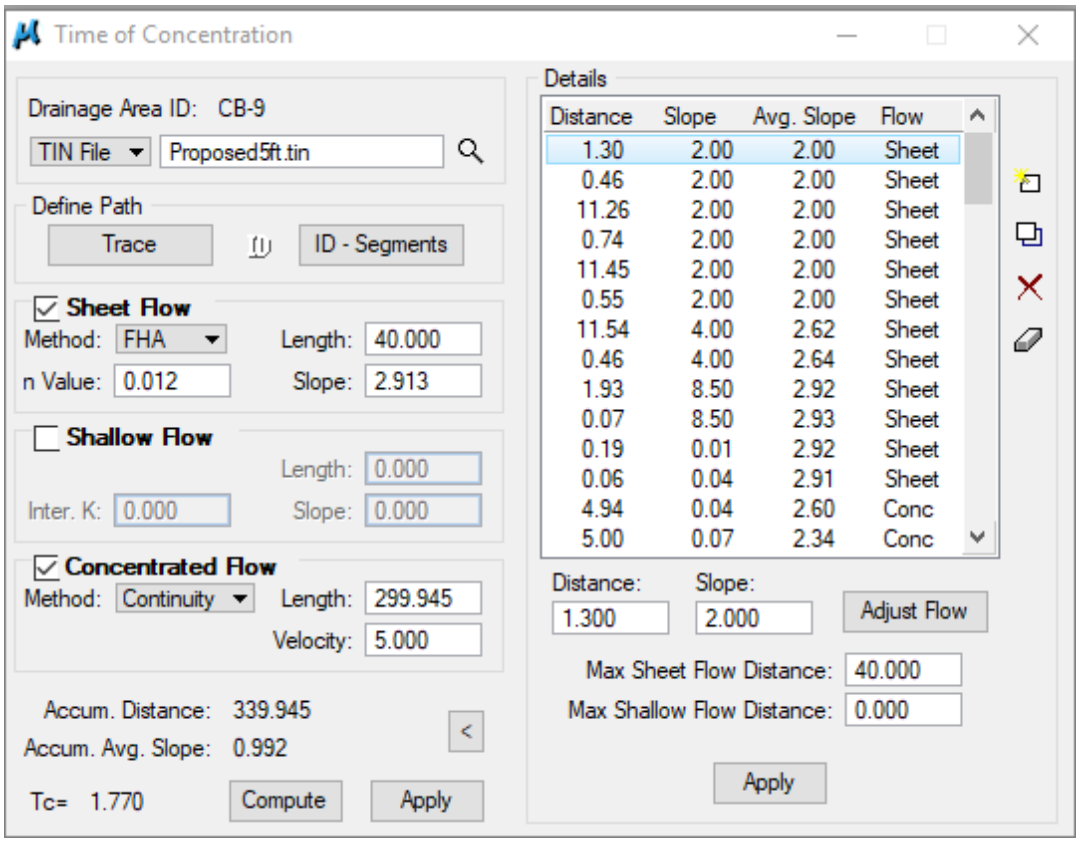


CB-9 with drainage area



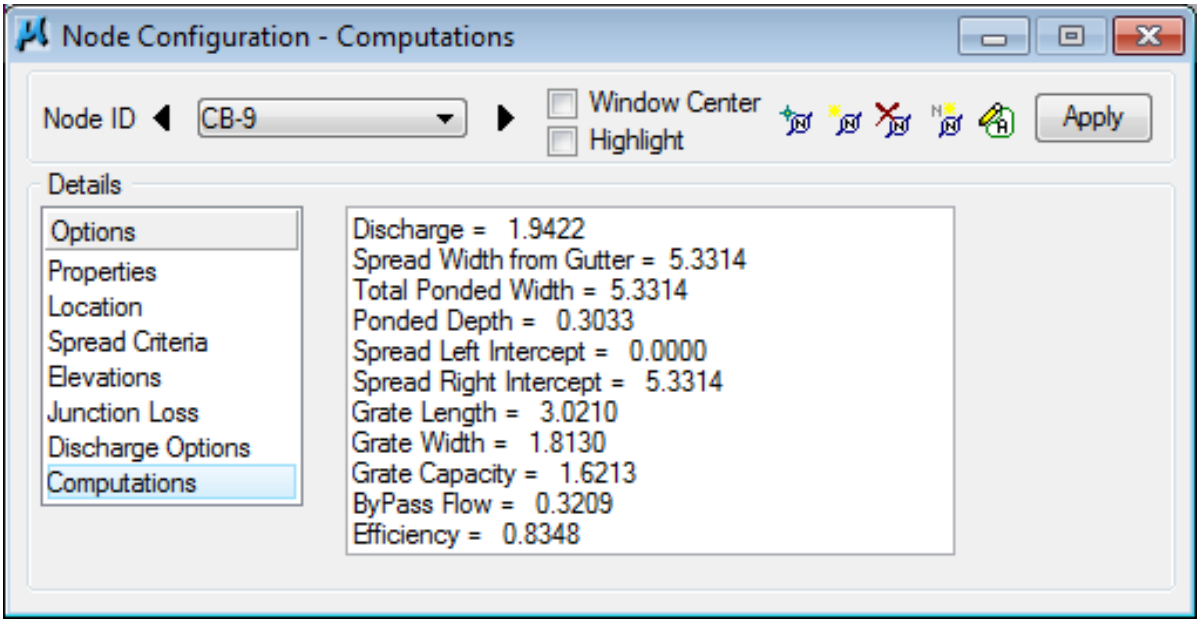
Trace path of flow using Utilities>Downstream Trace in

Reference Geopak Drainage Manual, section 5.12 to determine Tc and to compute discharge.

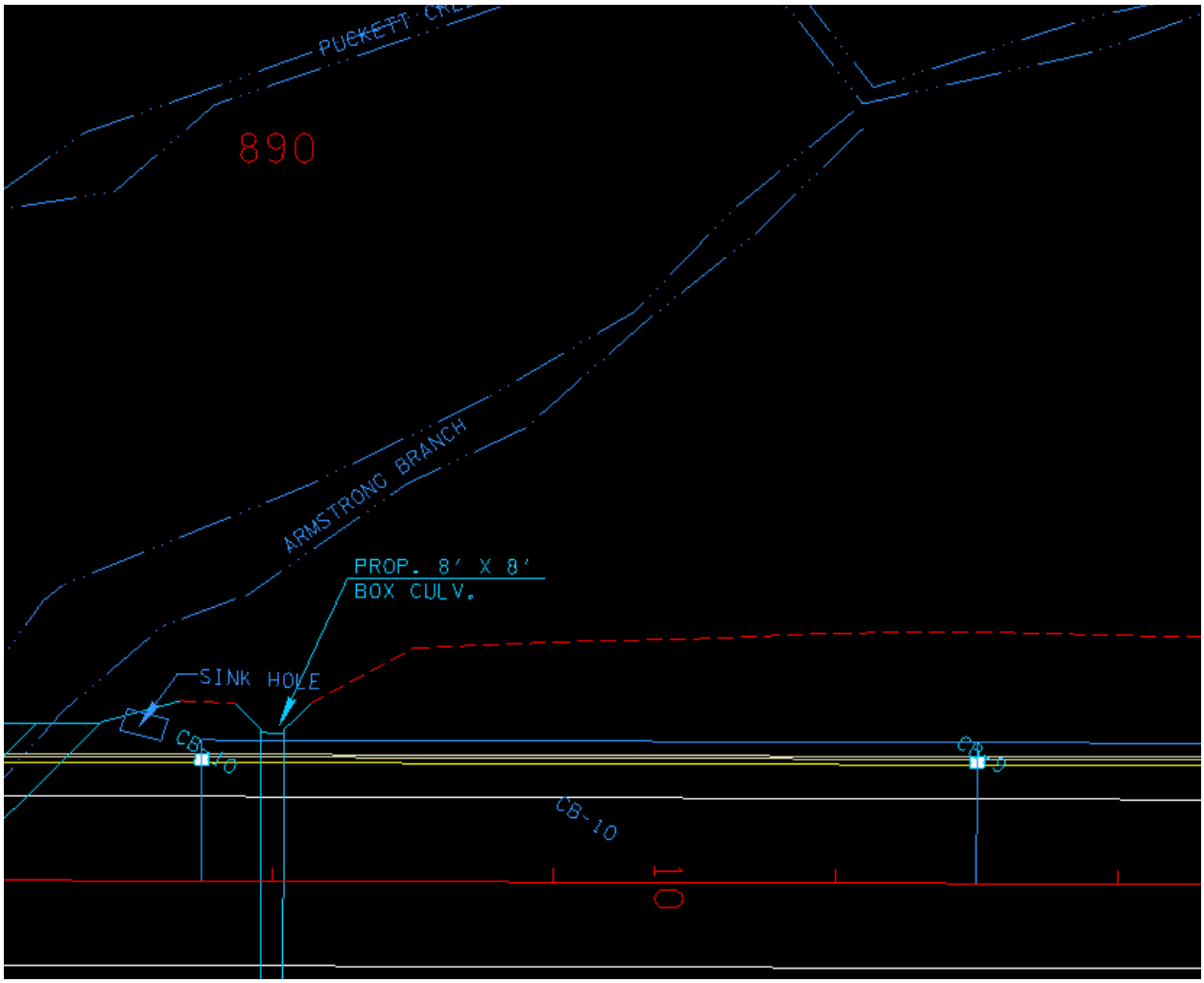


Tc is computed to be 1.770, but use 5

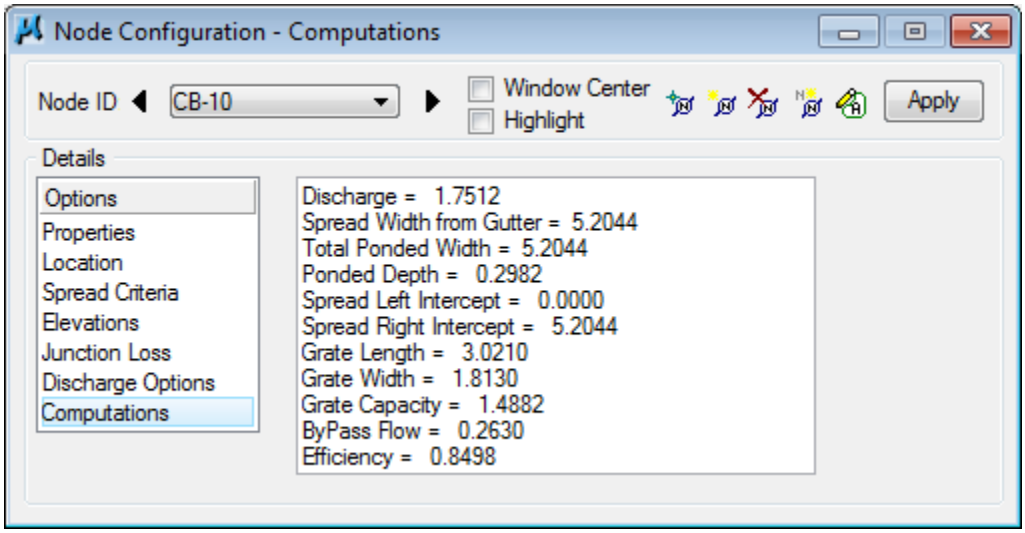
For this area the discharge for the 10 year storm is computed to be 1.942 cfs.



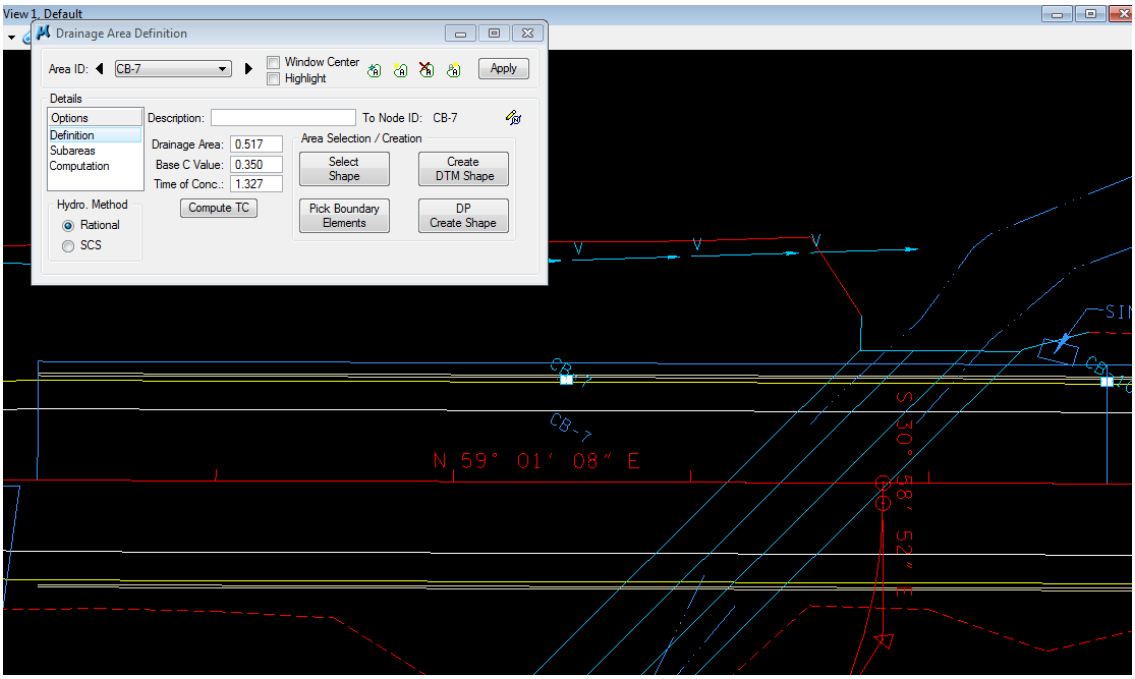
The ponded width and depth are an acceptable value.



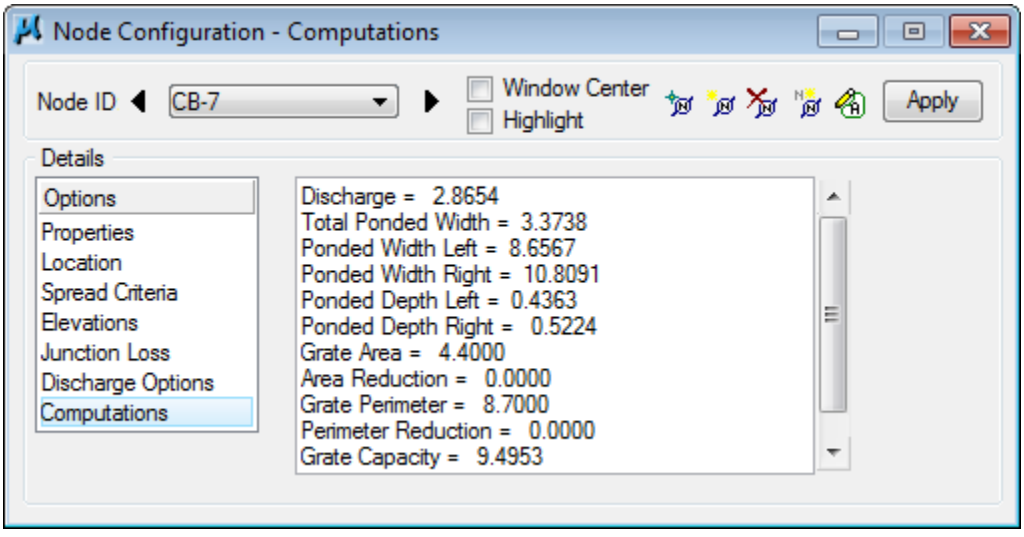
CB-10 and drainage area, located at 889+75.



Computations for CB-10

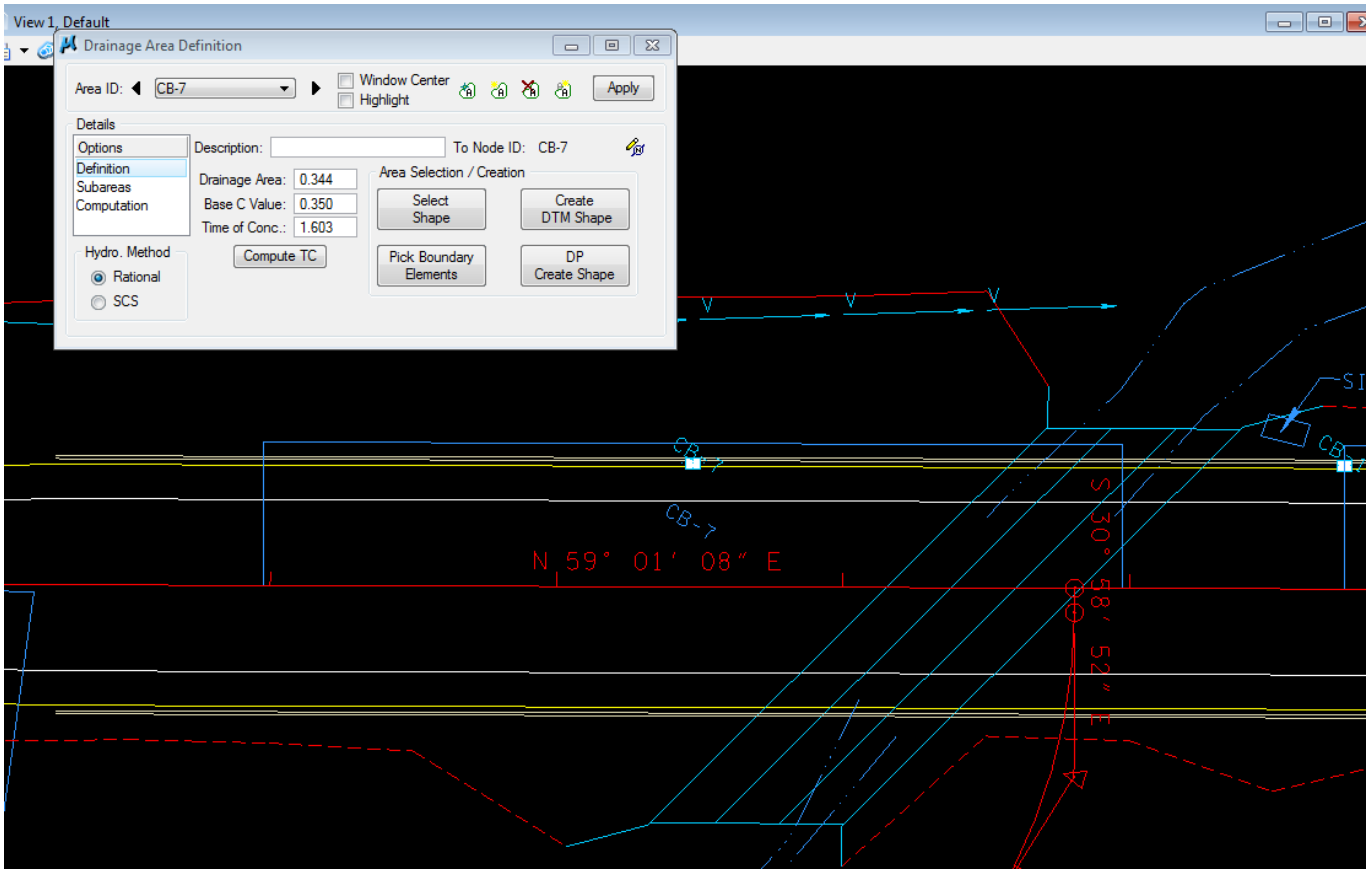


Drainage area for CB-7, sta. 888+47.50, 0.517 ac

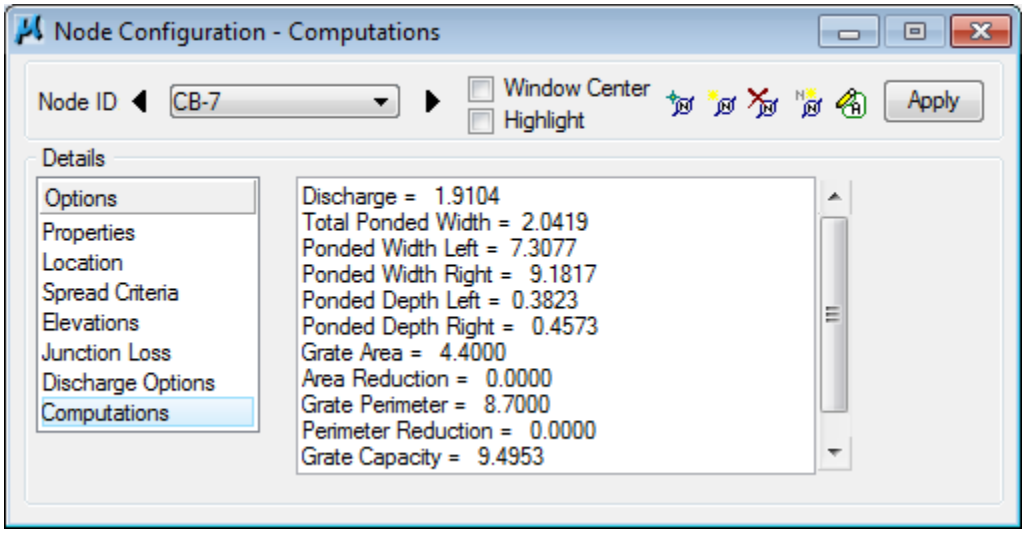


Computations for CB-7

According to the computations the ponded widths are more than allowable, so the drainage area can be revised to reduce the discharge.

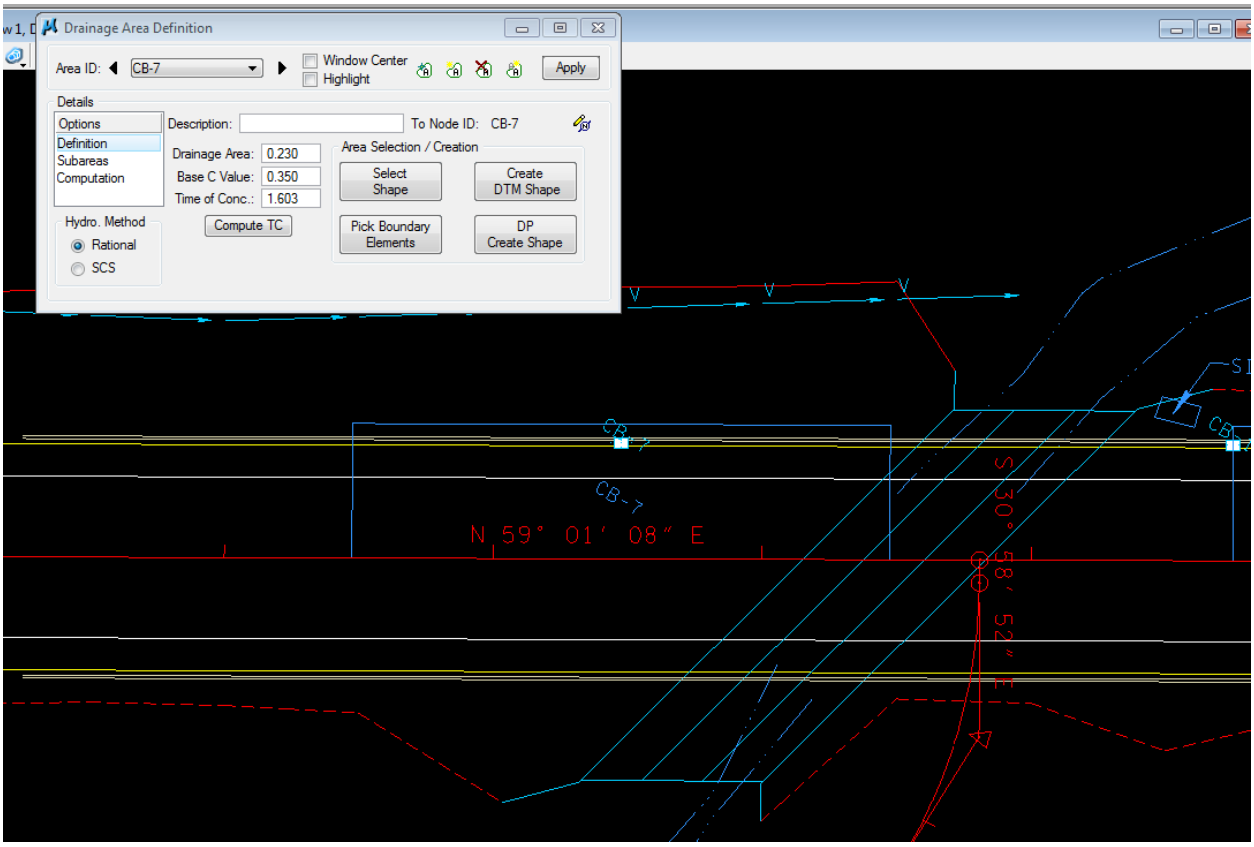


Revised drainage area for CB-7, 0.344 ac

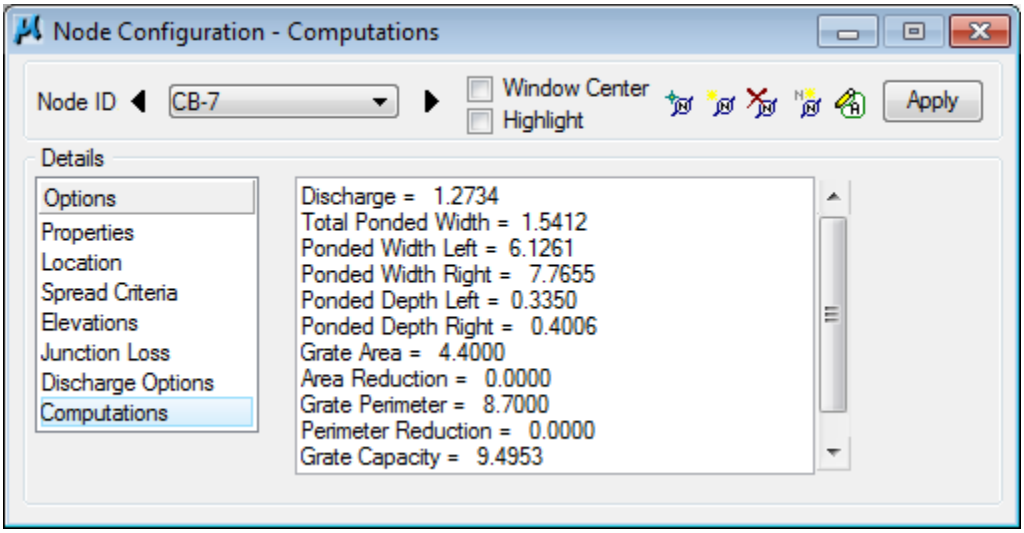


New computations for CB-7

Looks like the area needs to be reduced further.



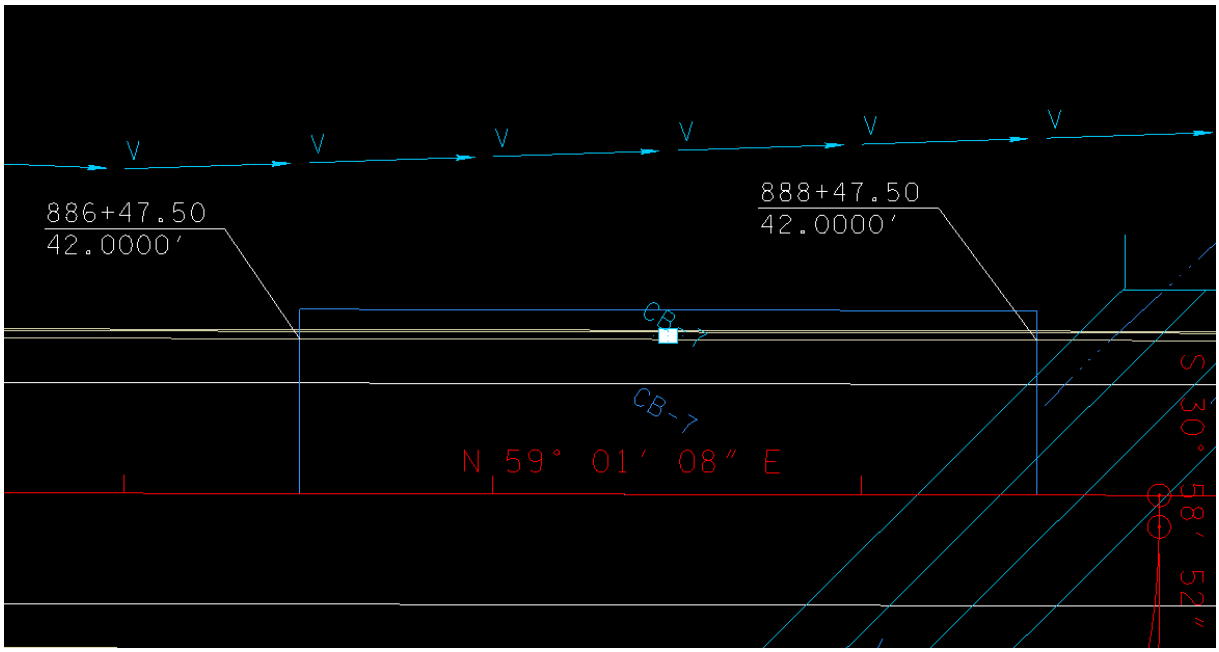
Revised drainage area for CB-7, 0.230 ac



New computations for CB-7. Ponded widths are under the 8 ft max. limit

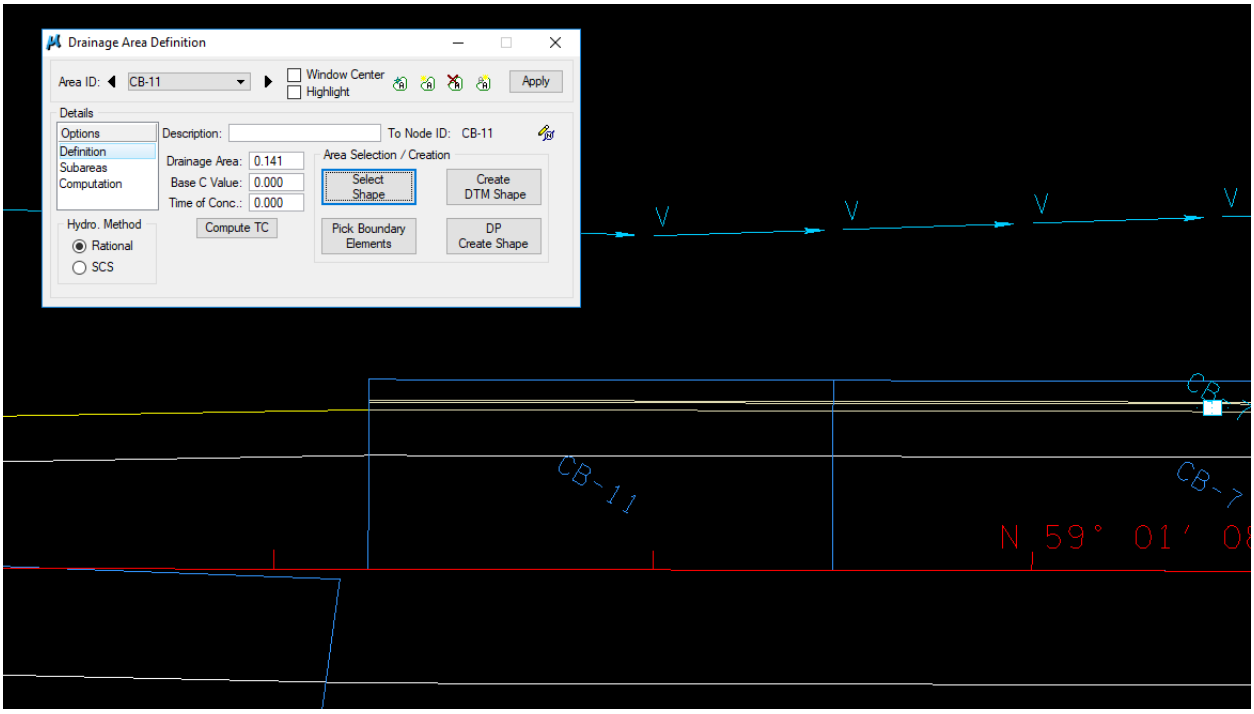
Where there are catch basins in a sag, there will need to be flanking catch basins on each side of the #14. The procedure for this is discussed in the Drainage Manual, Chapter 7,and will be handled later in this chapter.

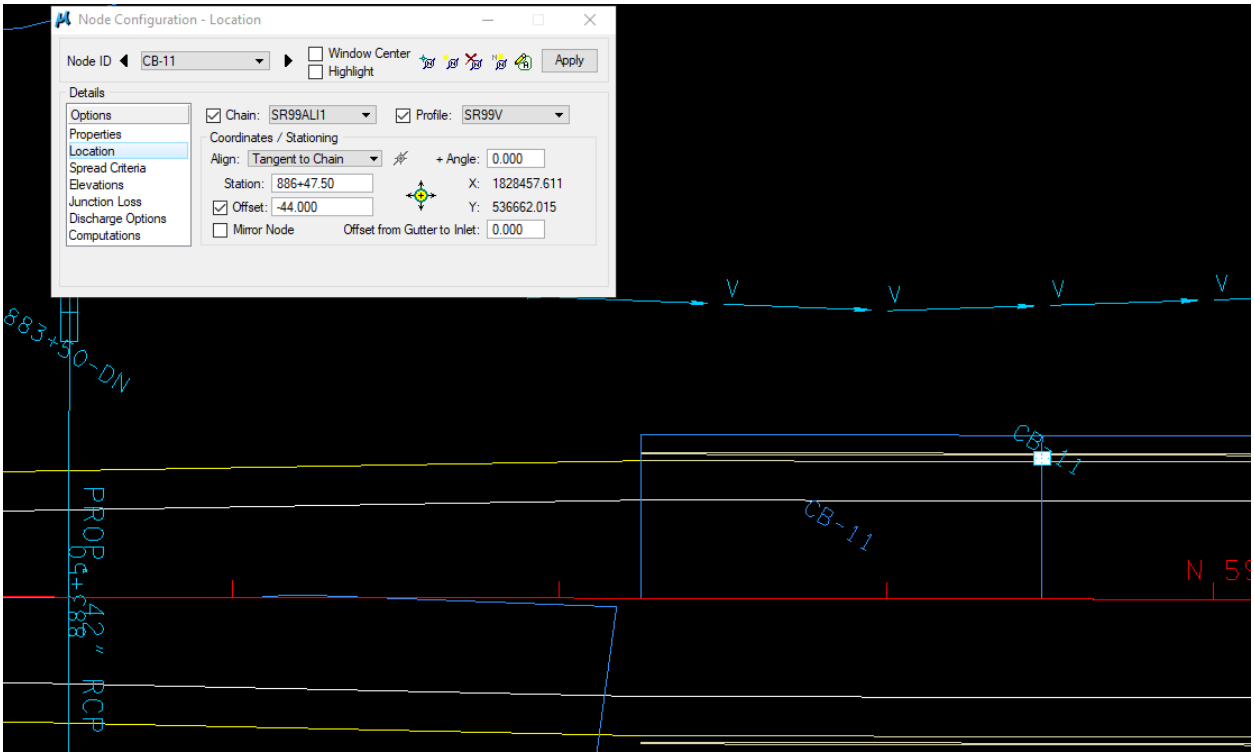
Additional #12's will need to be located now at outside edged of area CB-7, at stations 886+47.50 and 888+47.50.



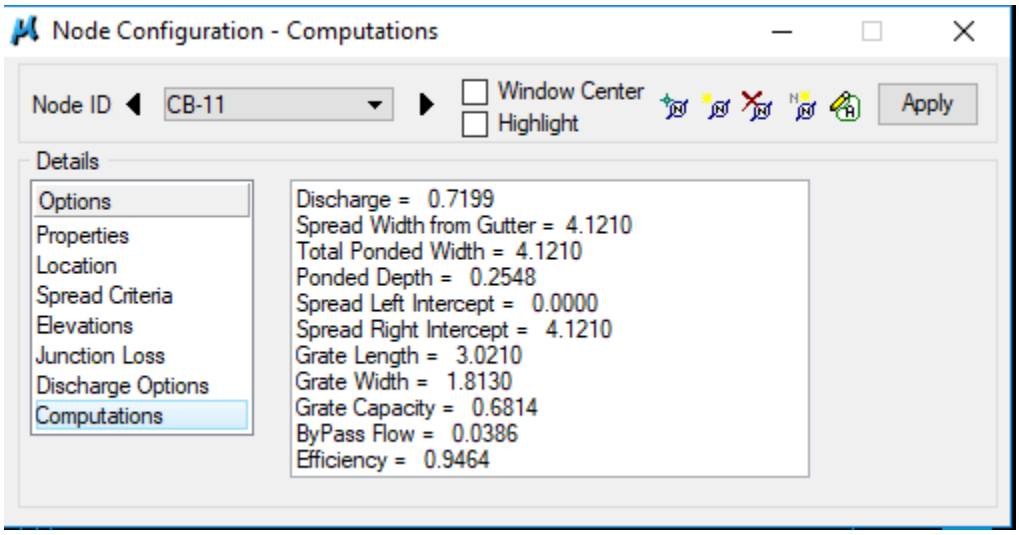
Locate CB-11 at 886+47.50

Drainage Area, CB-11



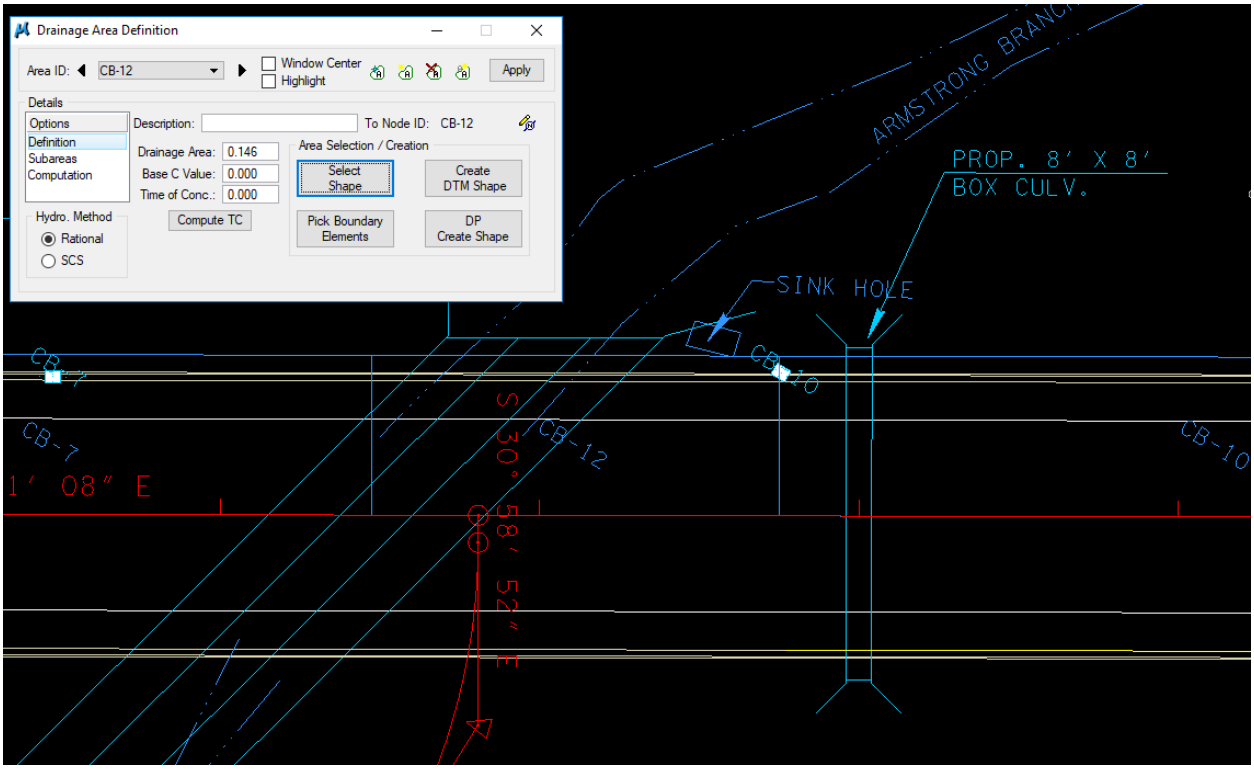


Using previous settings, Tc is computed to be 1.158 (use 5), and discharge is 0.720.

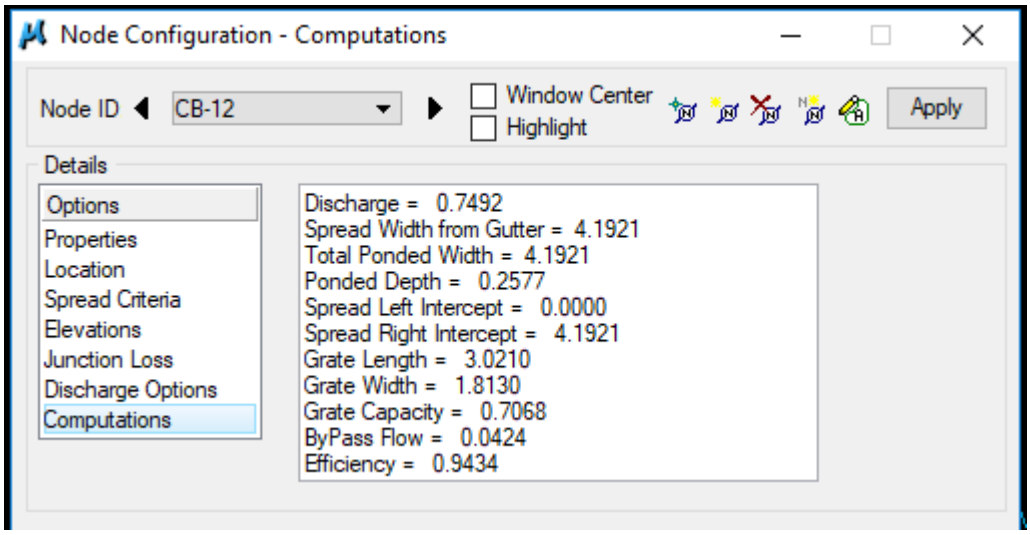


Locate CB-12 at 888+47.50

Drainage Area, CB-12



Using previous settings, Tc is computed to be 1.173 (use 5), and discharge is 0.749



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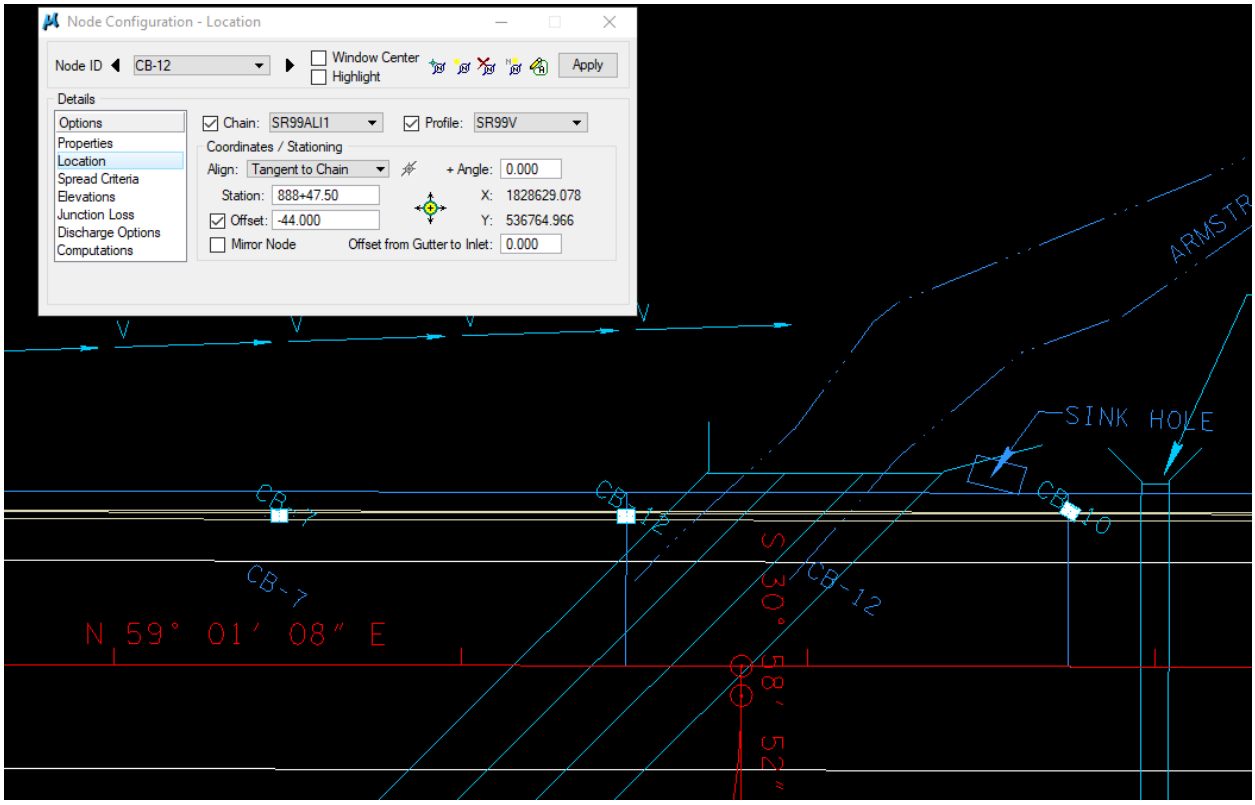
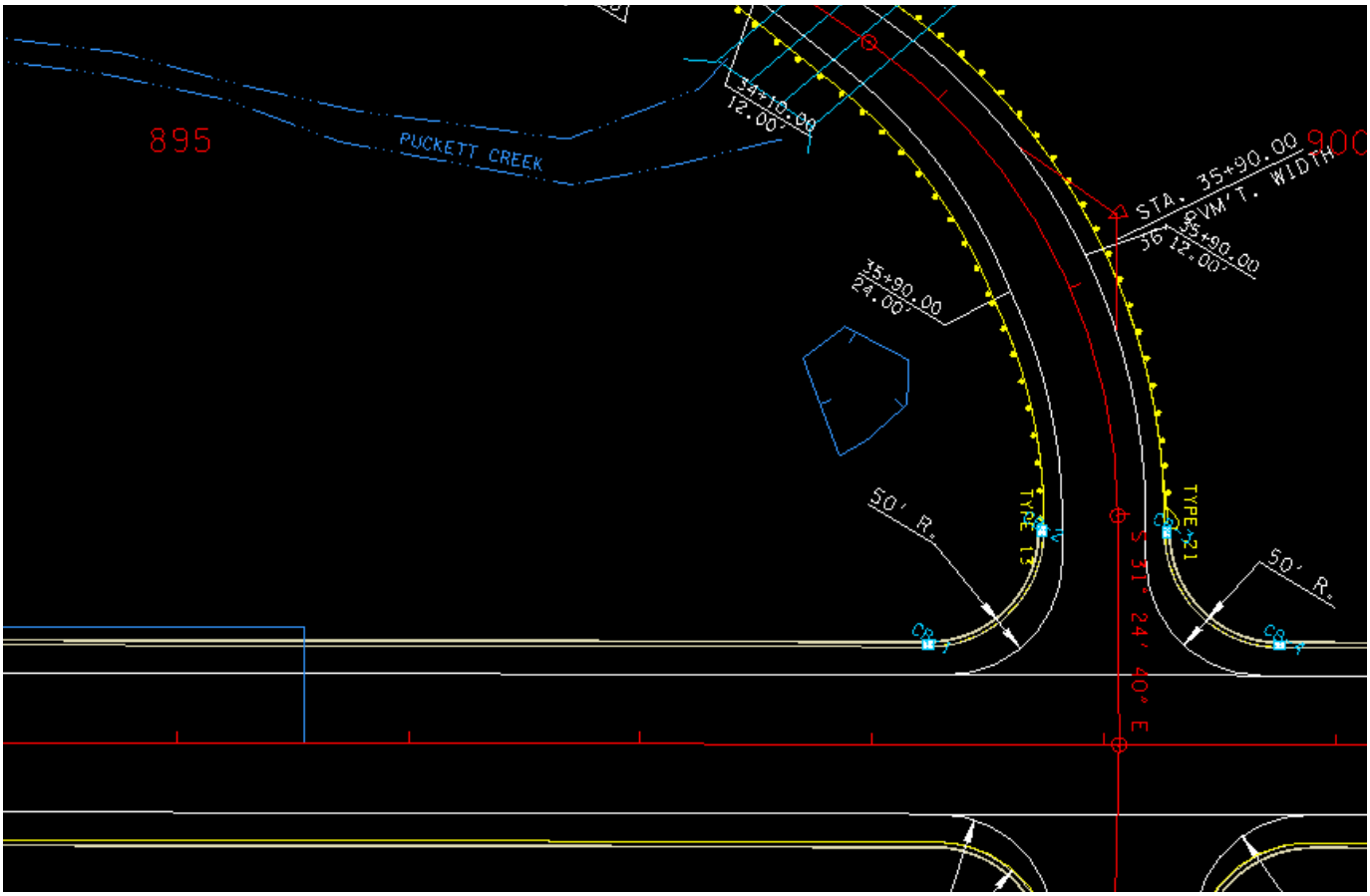
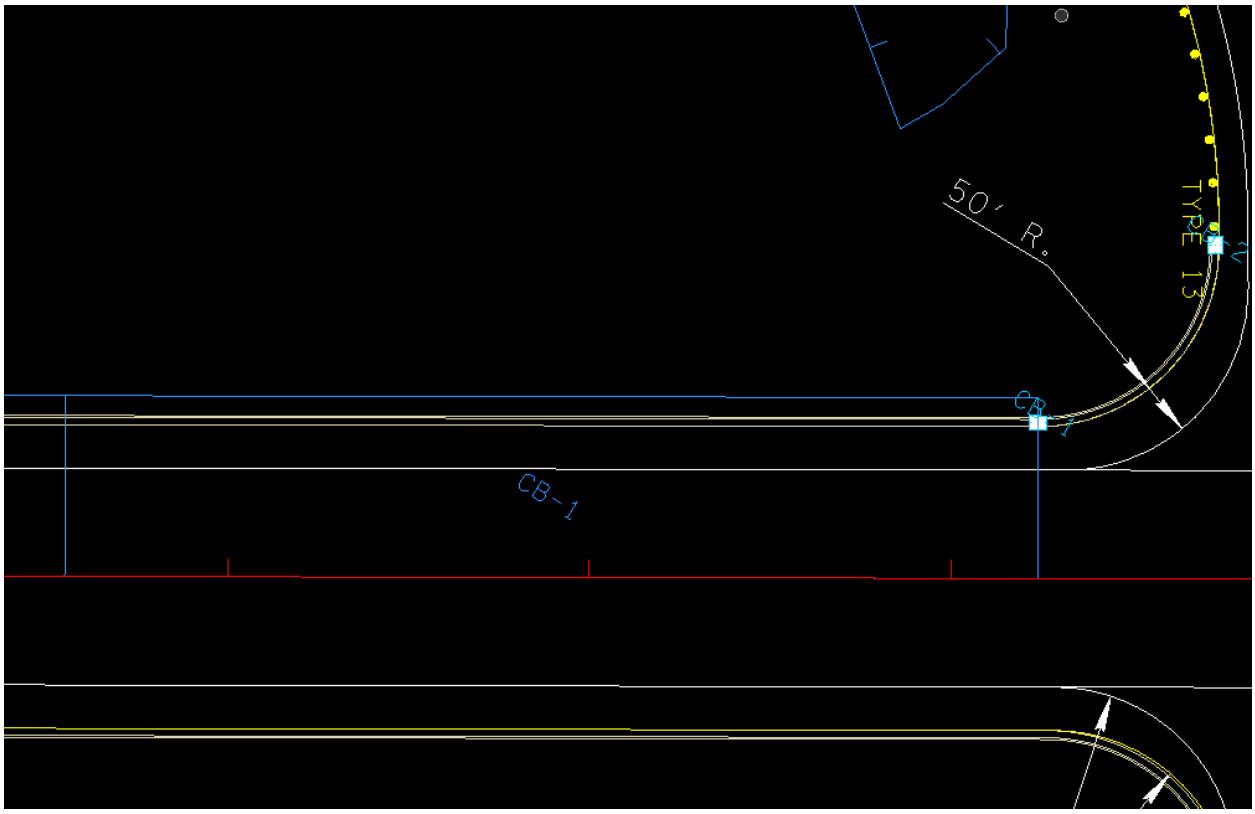


Now work back toward the end of the project from the high point at 895+55:

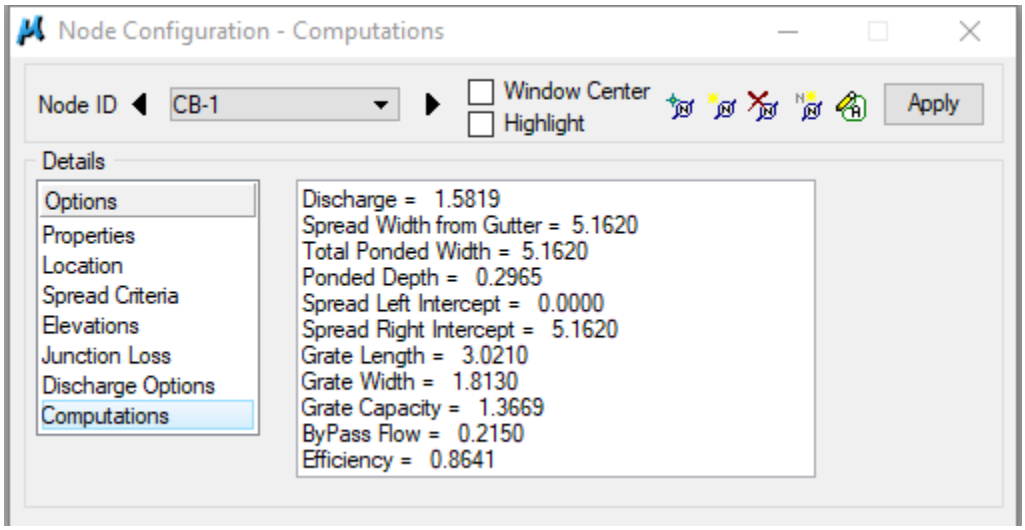


CB-1 is located at the beginning of radius of the intersection so locate area CB-1:

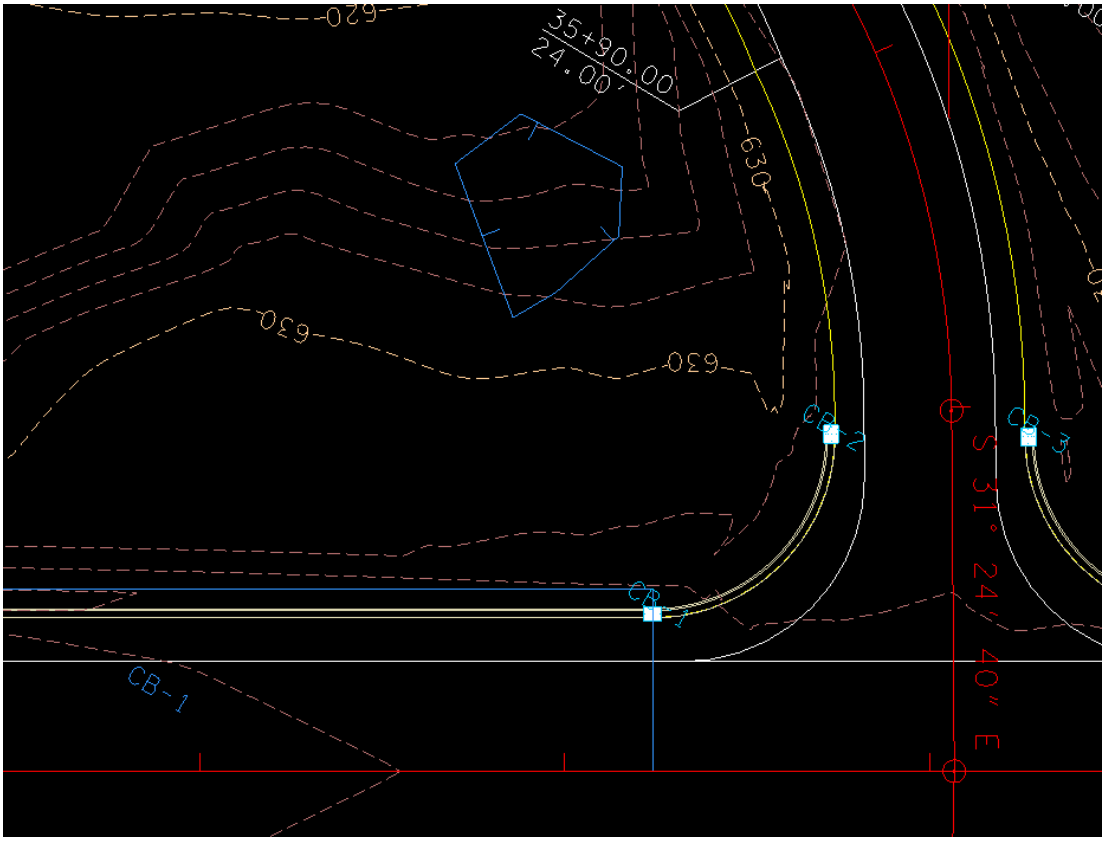


Using previous settings, Tc is computed to be 1.648

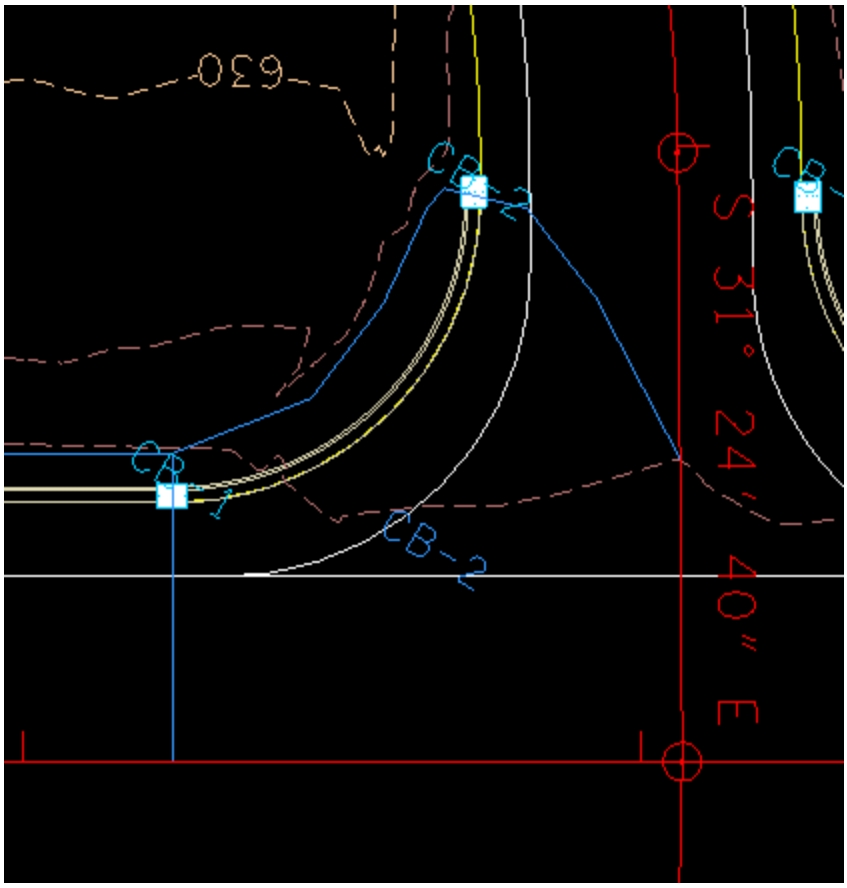
(use 5), and discharge is 1.582

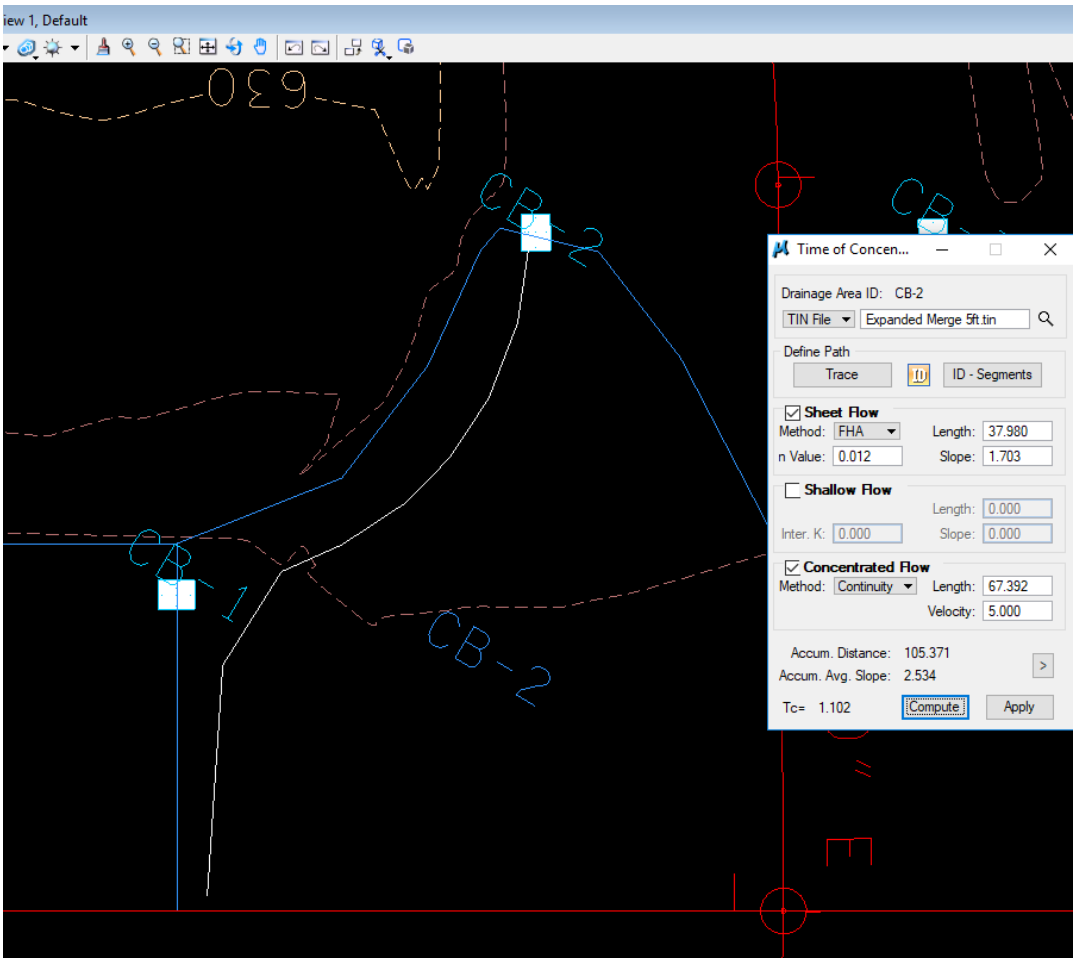


Determine drainage area CB-2:

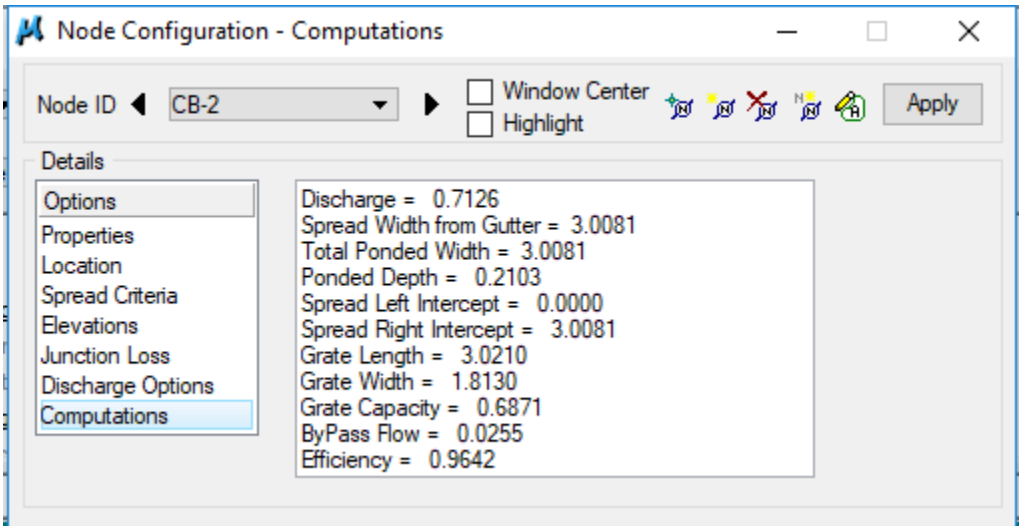


Using the drainage tools and judging from the contours the drainage area for CB-2 is located

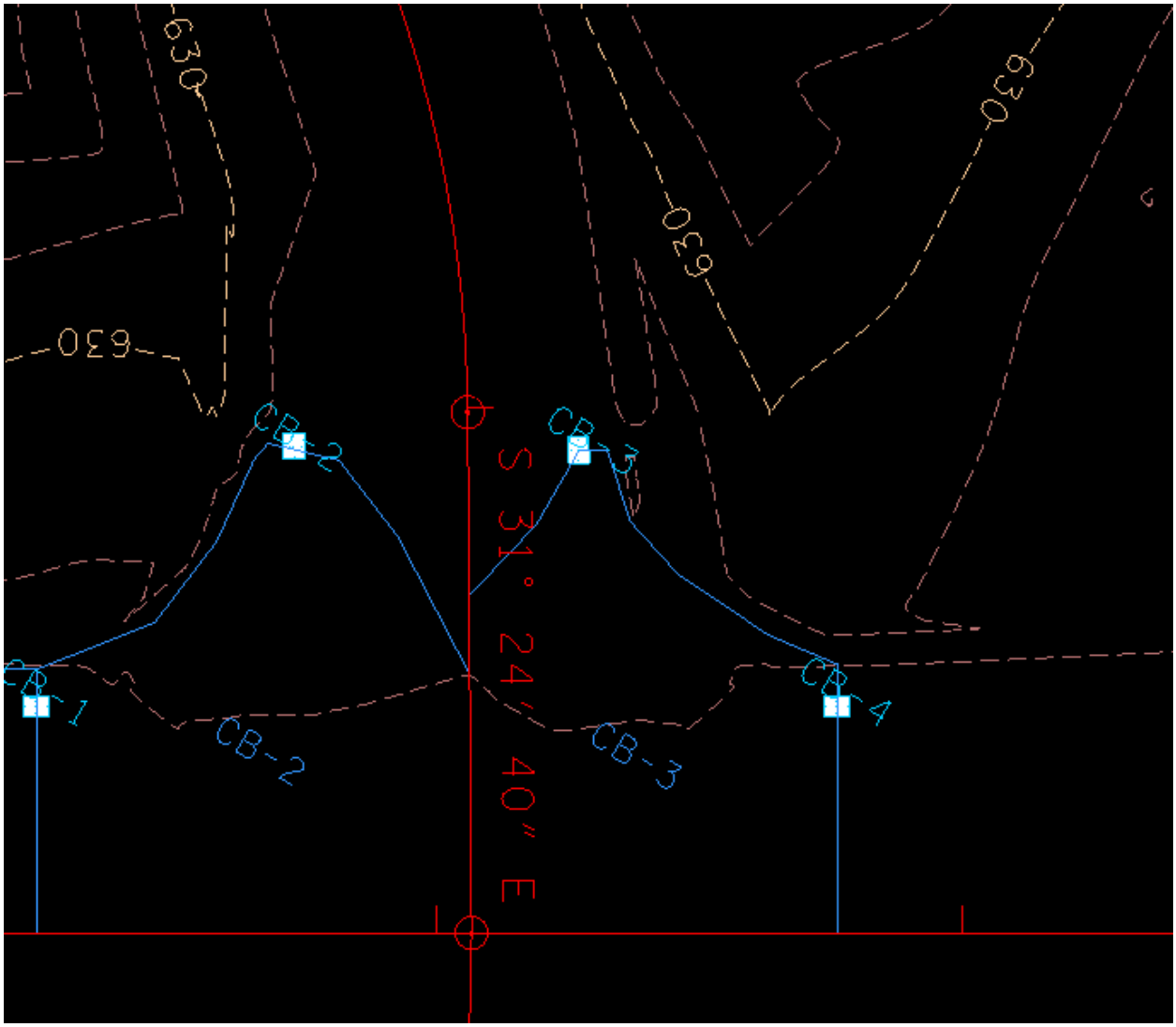

630
CB-2
CB
S 31° 24' 40" E
CB
CB-2

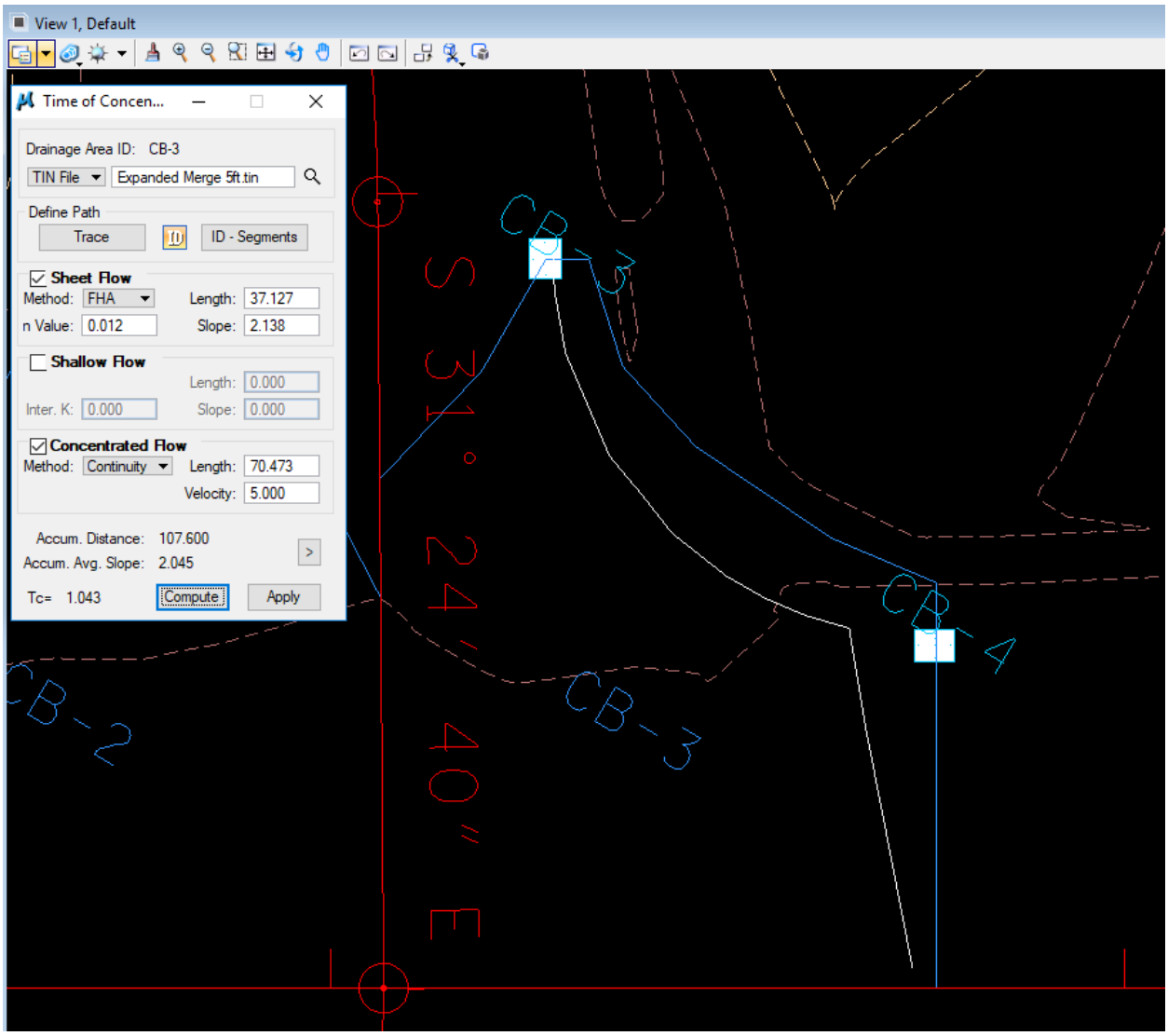


Using previous settings, Tc is computed to be 1.102 (use 5), and discharge is 0.713

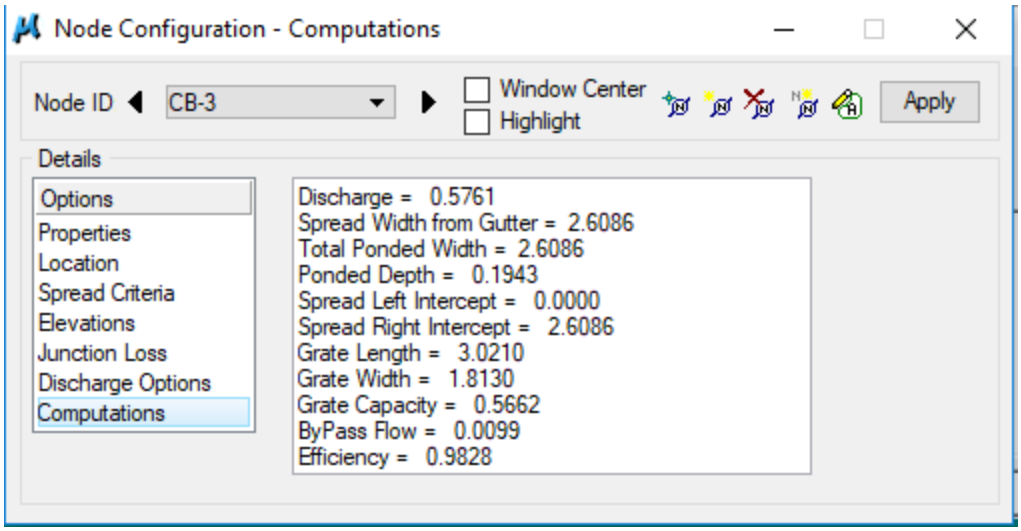


In the same manner as CB-2, the drainage area for CB-3 is located:

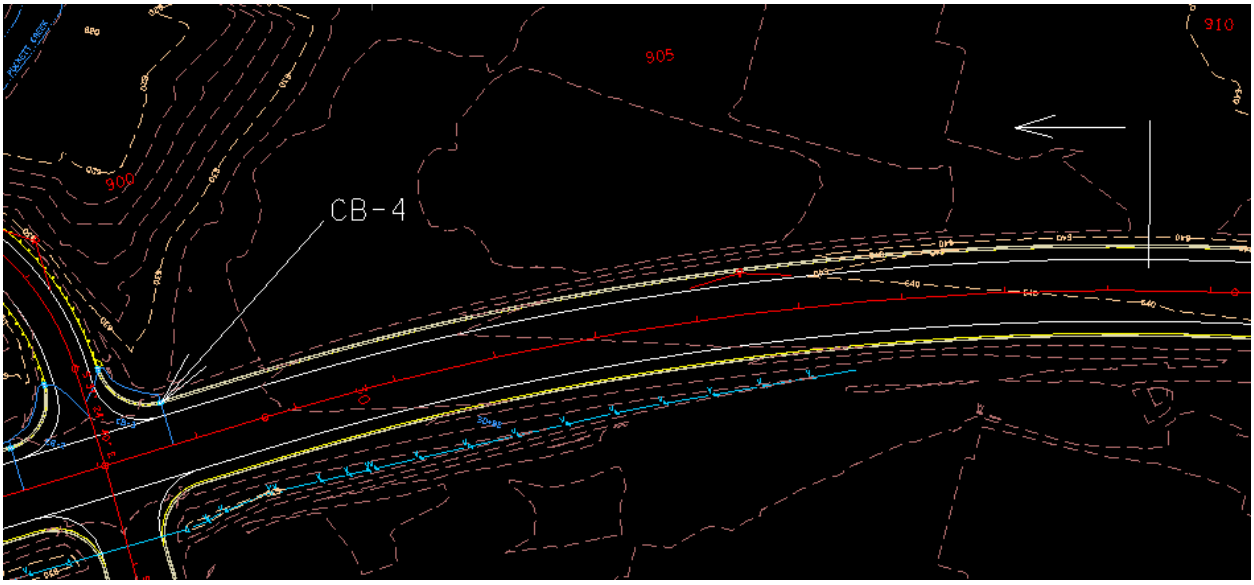




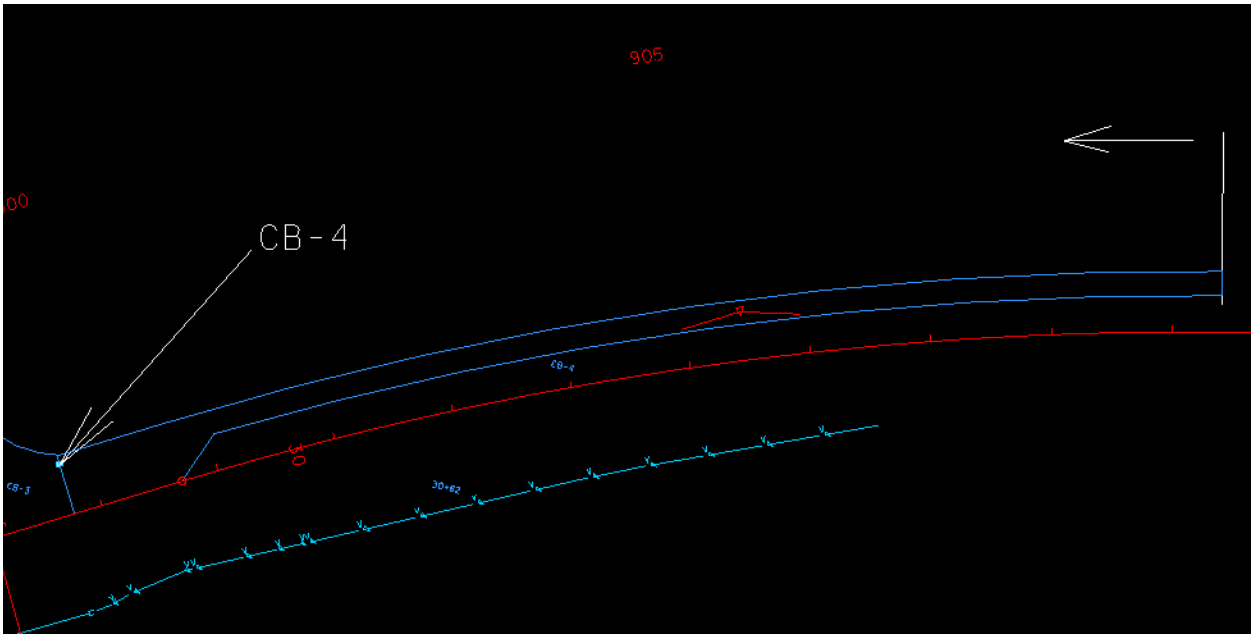
Using previous settings, Tc is computed to be 1.043 (use 5), and discharge is 0.576


Node Configuration - Computations
Node ID
CB-3
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Discharge = 0.5761
Spread Width from Gutter = 2.6086
Total Ponded Width = 2.6086
Ponded Depth = 0.1943
Spread Left Intercept = 0.0000
Spread Right Intercept = 2.6086
Grate Length = 3.0210
Grate Width = 1.8130
Grate Capacity = 0.5662
ByPass Flow = 0.0099
Efficiency = 0.9828

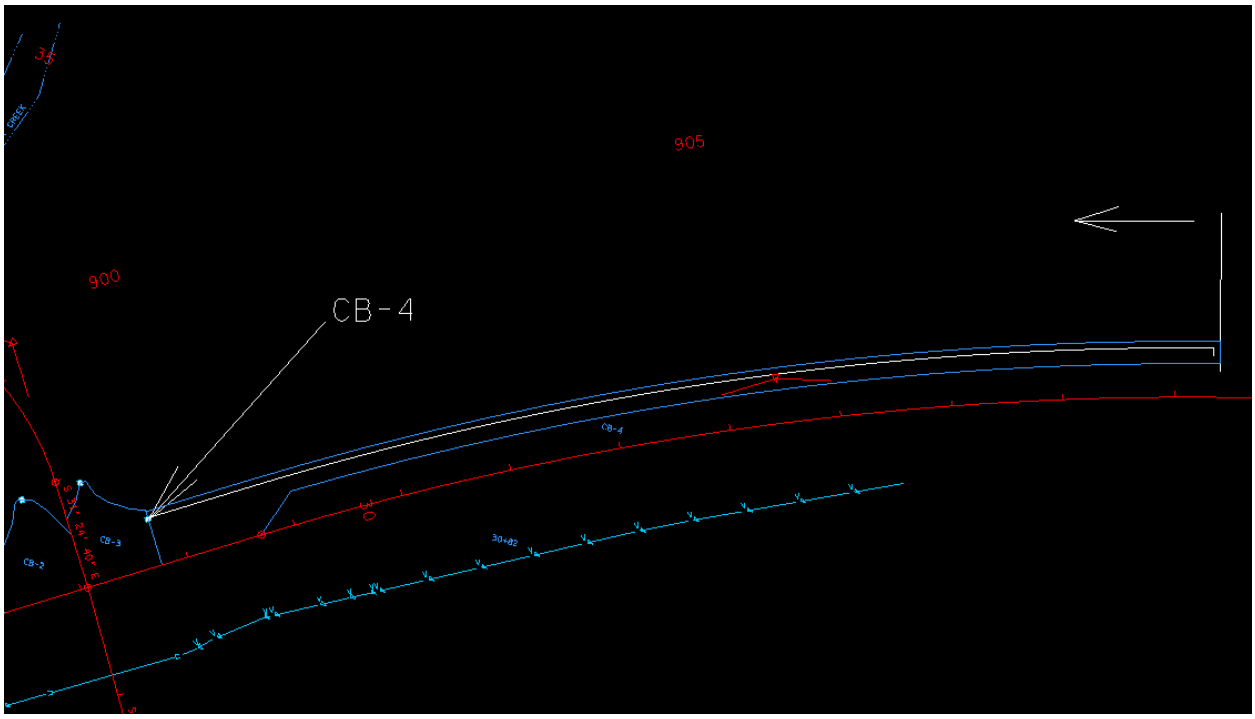
Now move to the next high point , sta 909+41, and work back toward CB-4.



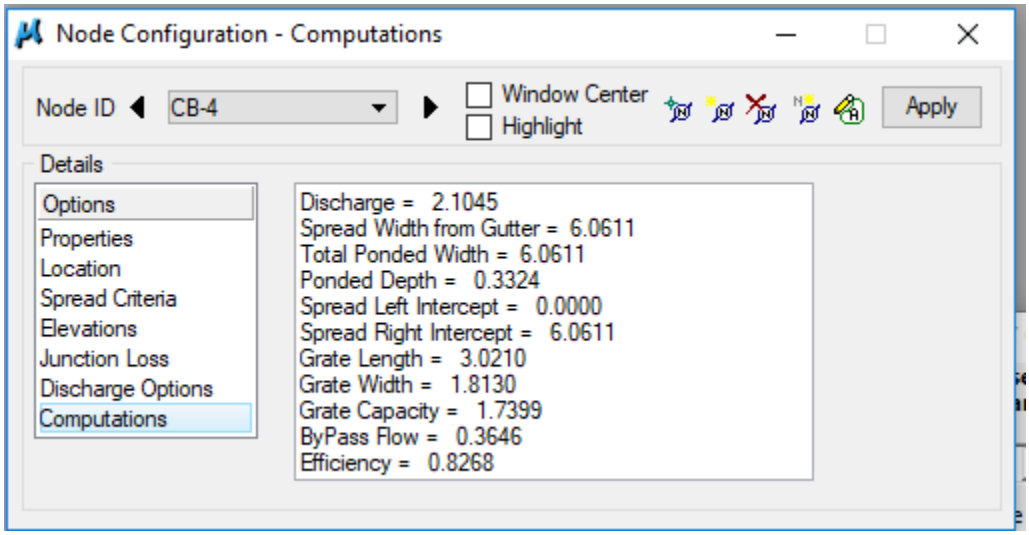
Note that the majority of this area is a superelevated section, the left side is the high side so only the shoulder would be in the drainage area. In this case no other catch basins may be needed between the high point and CB-4.



Drainage area CB-4

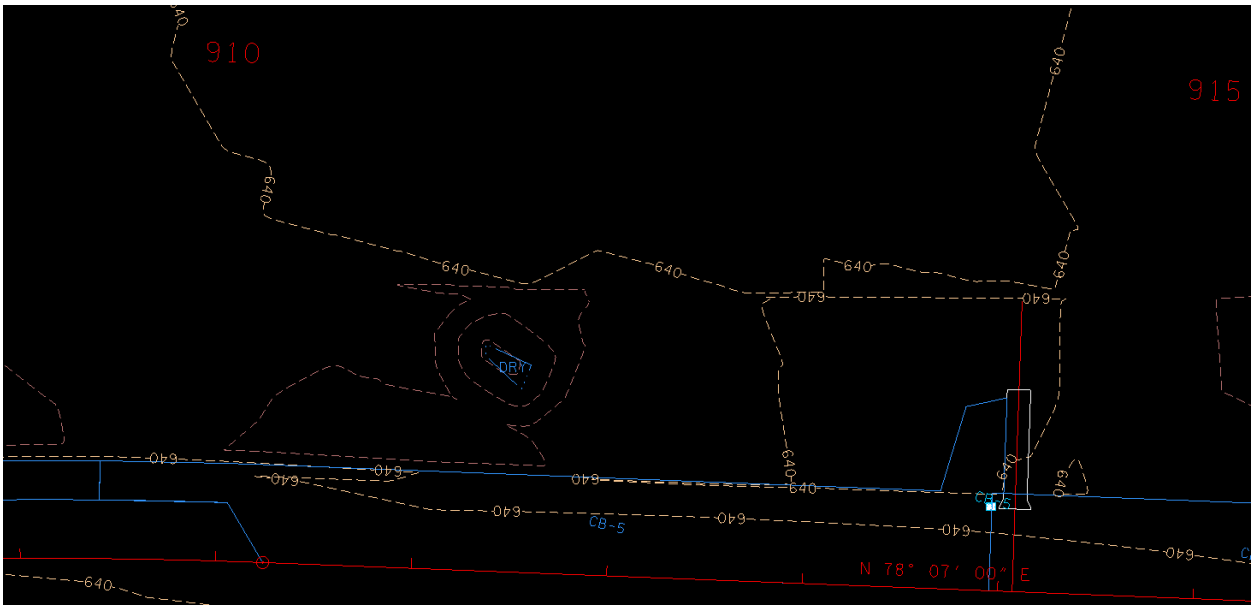


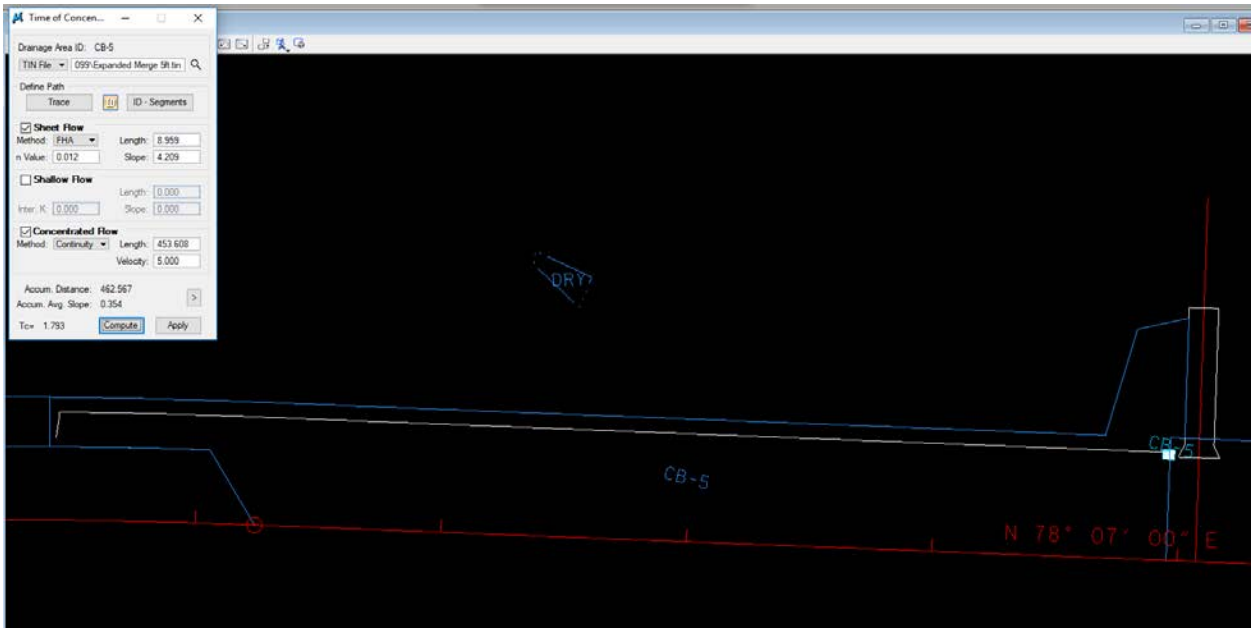
Using previous settings, Tc is computed to be 3.536 (use 5), and discharge is 2.104



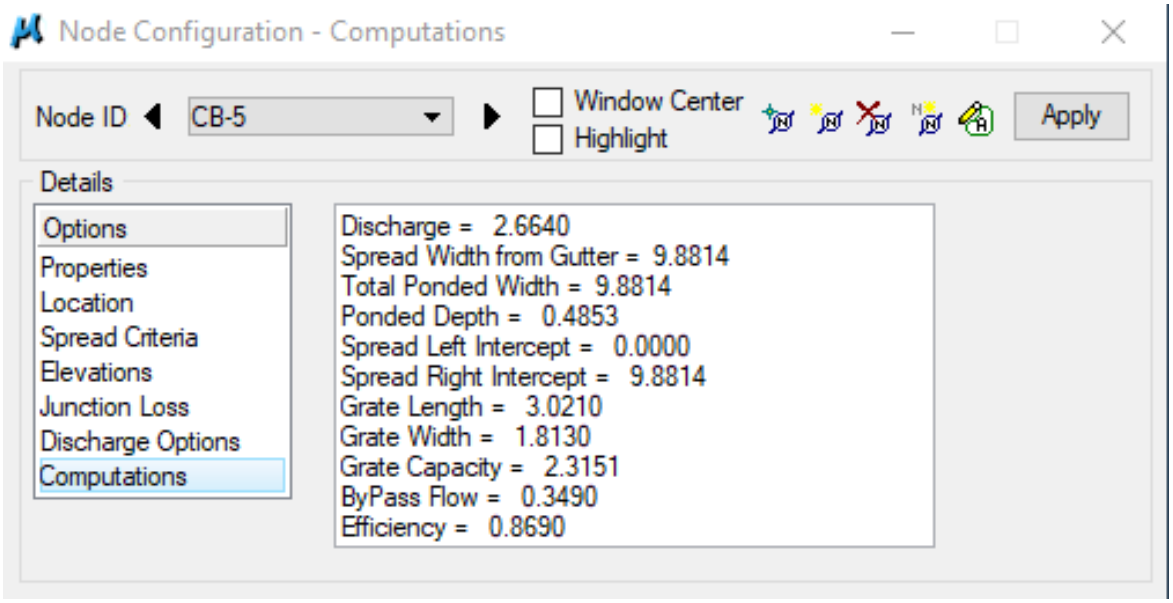
Drainage area CB-5:

For the catch basin (CB-5) located just before the private drive, initially the drainage area will be the area between the last high point at sta 909+41 and sta 913+95. There will also be a small area outside the pavement and sidewalk area also included.



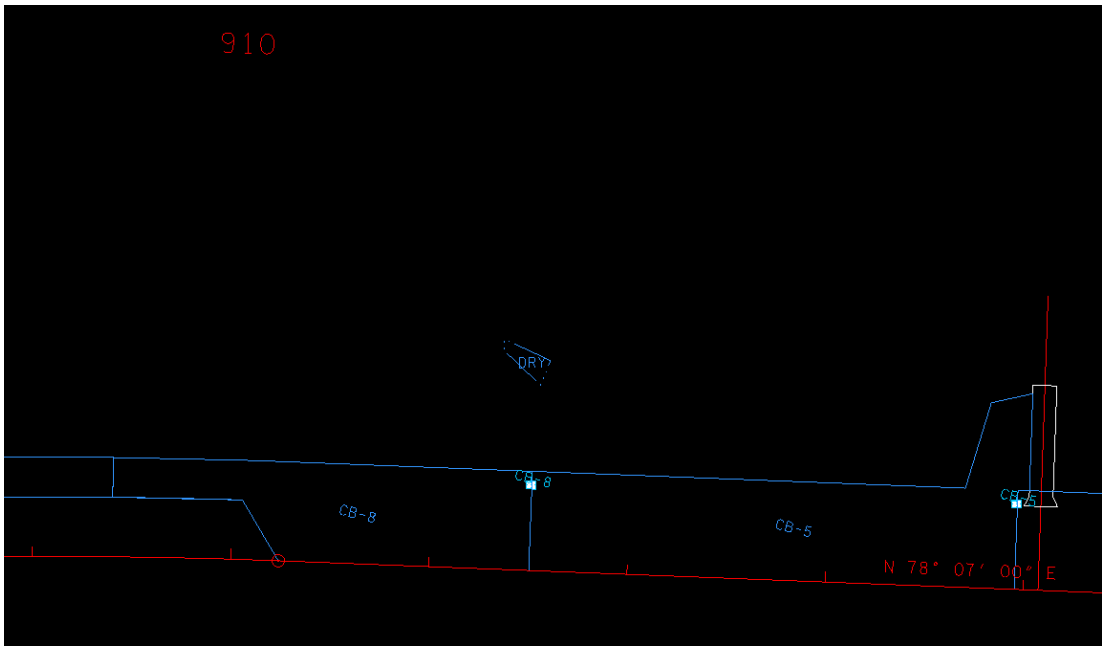


Using previous settings, Tc is computed to be 1.793 (use 5), and discharge is 2.664



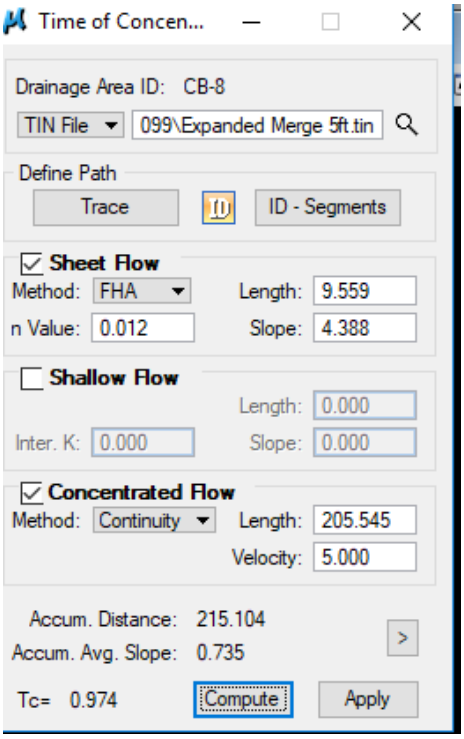
The ponded width is above the acceptable limit, therefore another catch basin will need to be added upstream from CB-5

Here is not a CB-8 located yet, so locate this catch basin at 911+50:

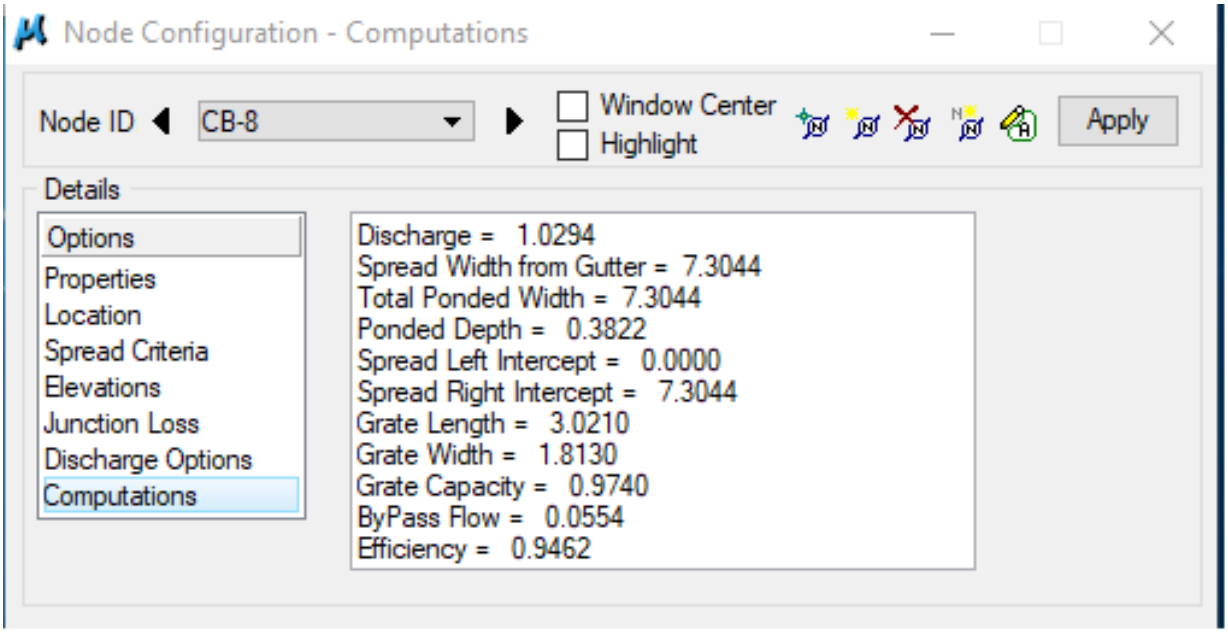


Drainage Area CB-8 and revised area CB-5

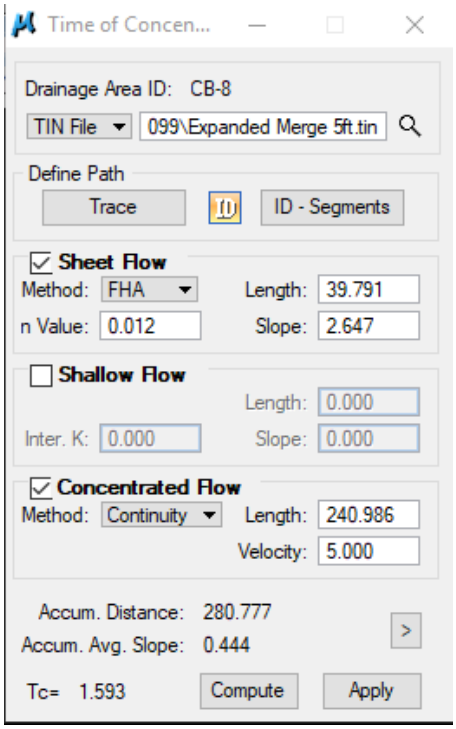
Tc for CB-8 is 0.974 (5):



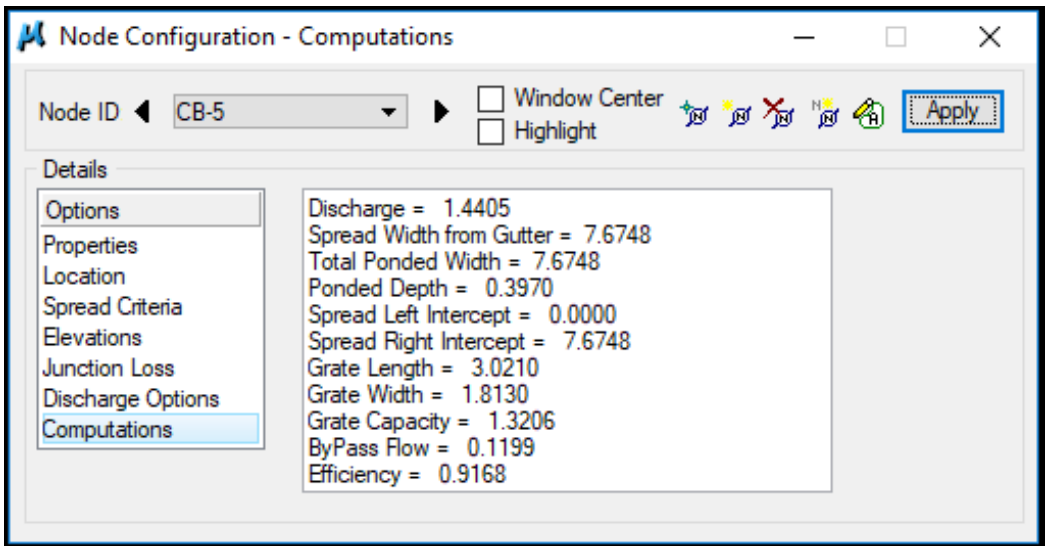
Discharge for CB-8 is 1.029:



The new Tc for CB-5 is 1.593 (5)



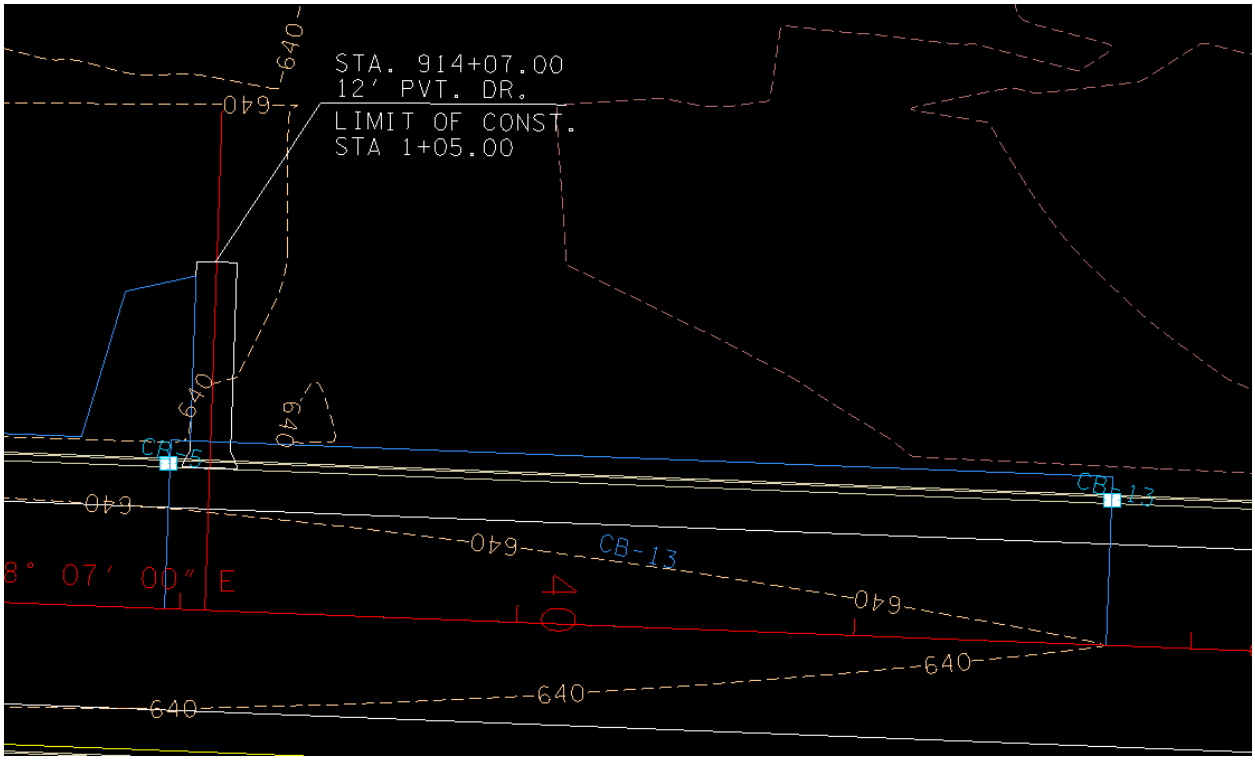
Discharge for CB-5 is 1.440



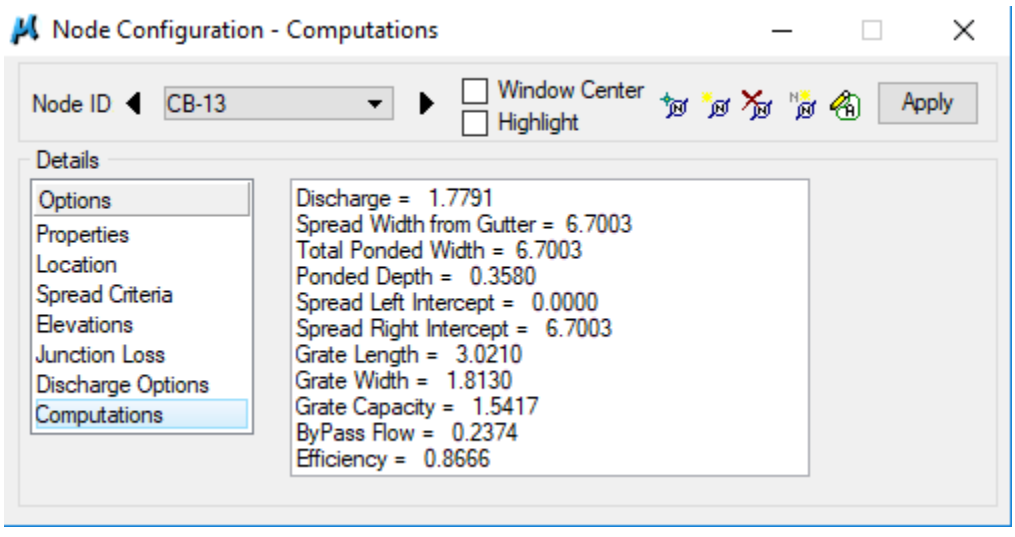
It can be seen the ponding widths for both CB-5 and CB-8 are within the allowable limits

Catch basin CB-6 is located at the end of the curb and gutter section. Since CB-6 and CB-5 are more than 400 feet apart, another catch basin, CB-13, will be located about halfway between the two, at sta 916+75.

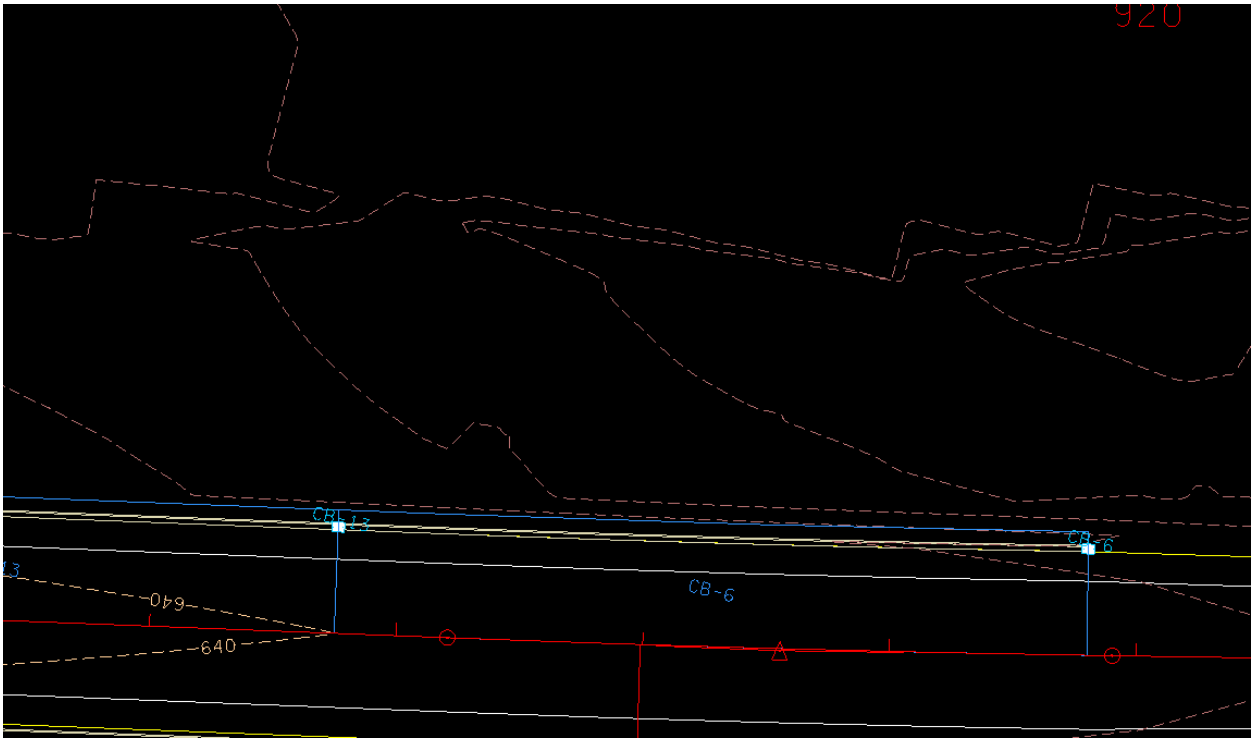
Drainage area CB-13:



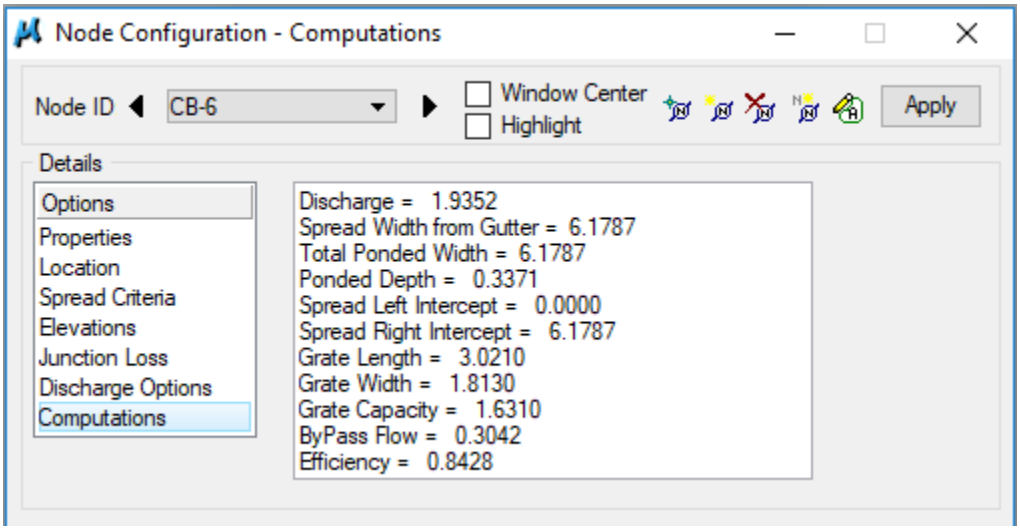
Using previous settings, Tc is computed to be 1.680 (use 5), and discharge is 1.779



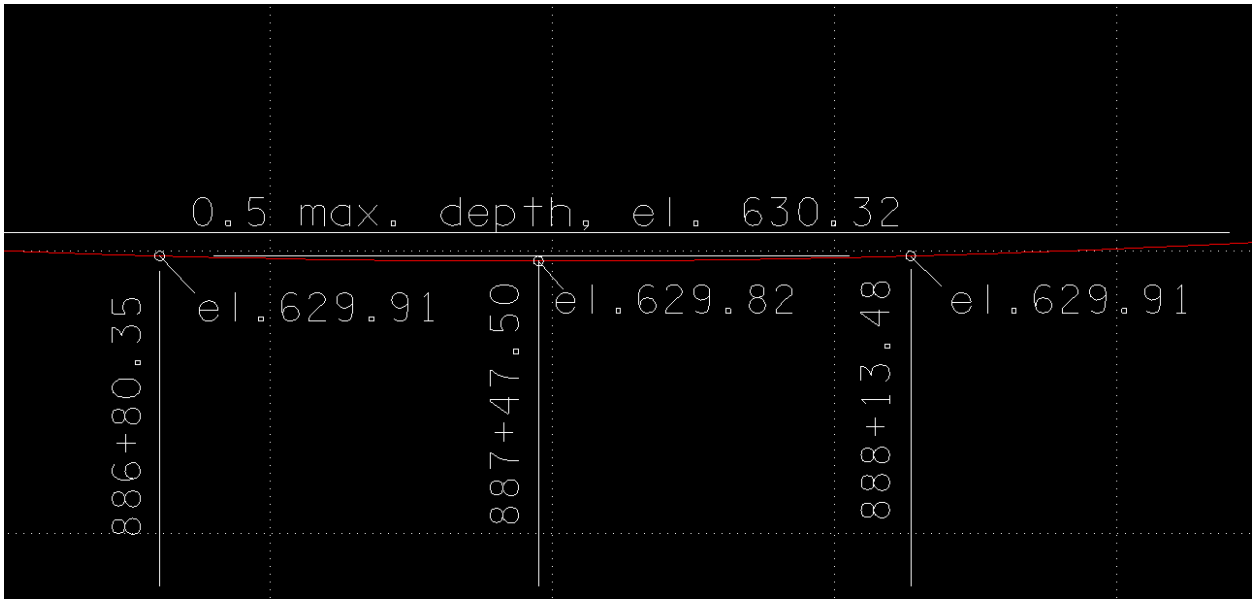
Drainage area CB-6:



Using previous settings, Tc is computed to be 1.753 (use 5), and discharge is 1.935



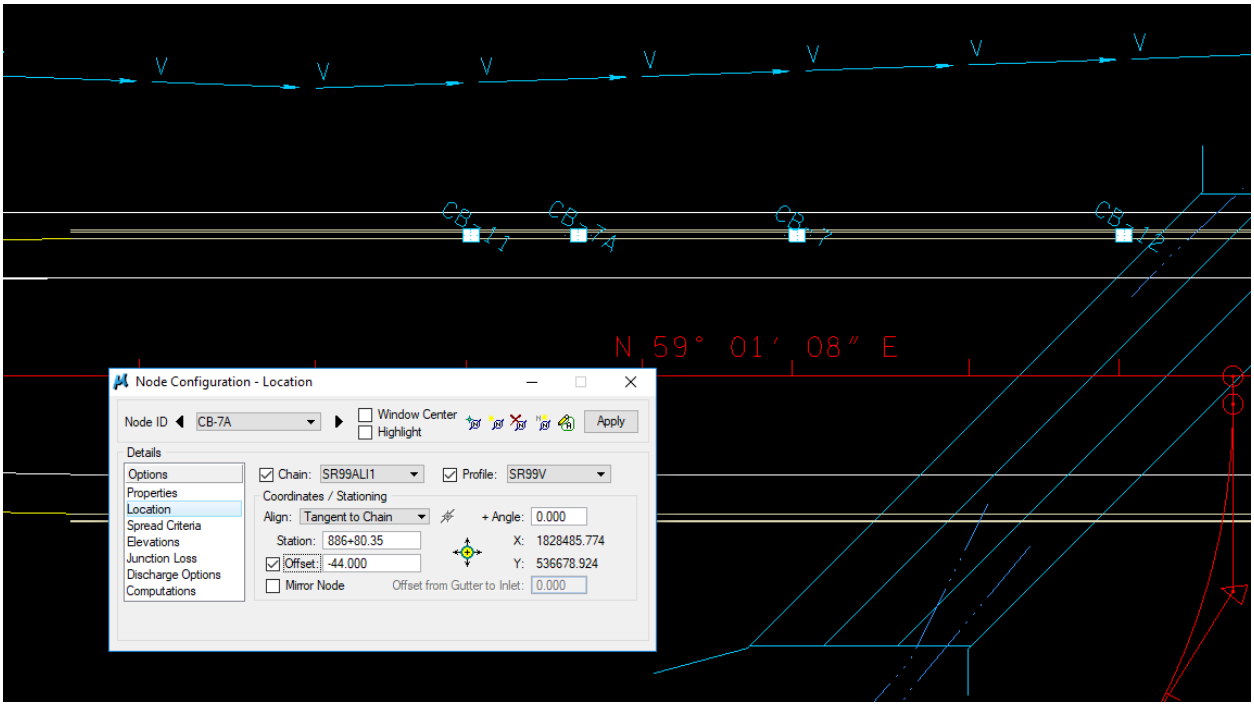
Flanking CB's for CB-7 :

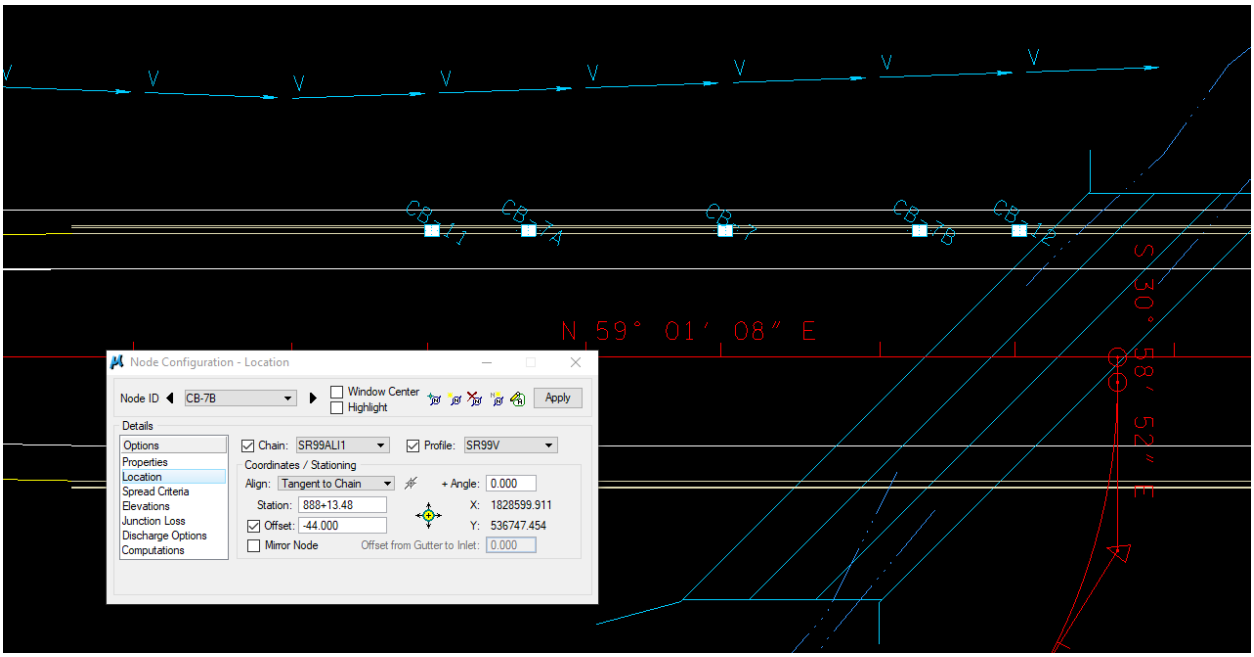


The left gutter profile at CB-7 location shows the location and elevations for the flanking catch basins. The difference in elevation from the maximum depth is 0.41 ft,, which is 82% of the total maximum depth.

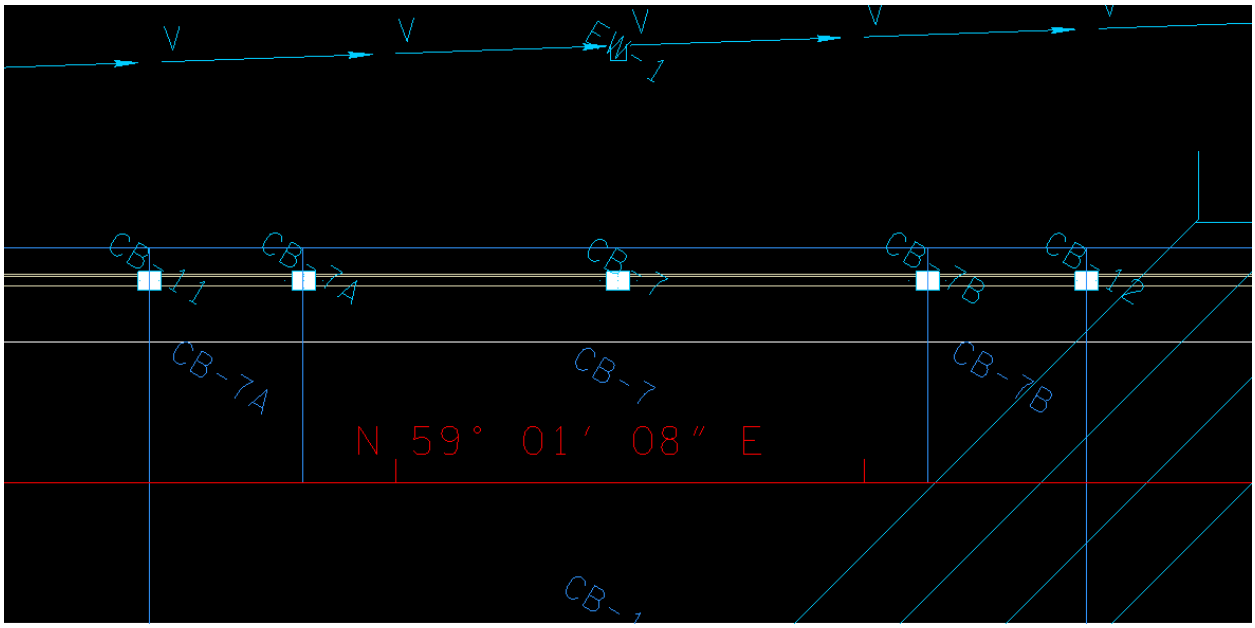
Ref. Drainage Manual 7.03.3.2

Locate catch basins CB-7A and CB-7B



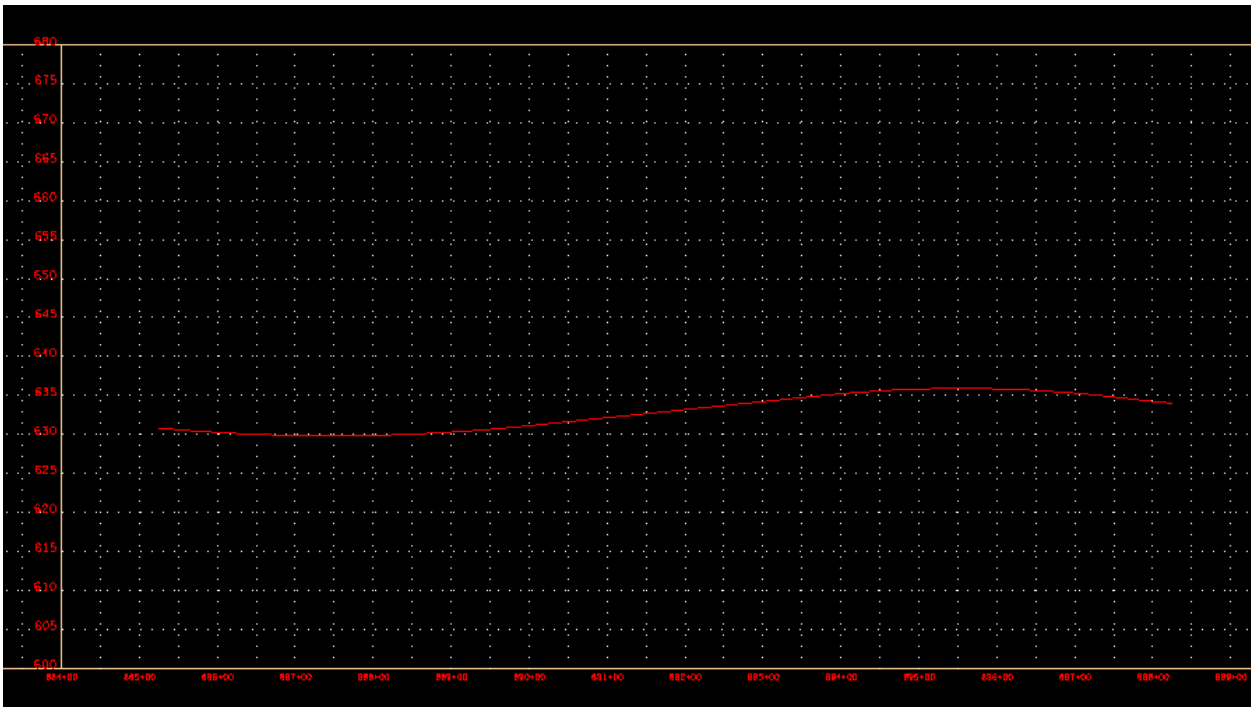


Also add drainage areas for CB' s 7A and 7B:

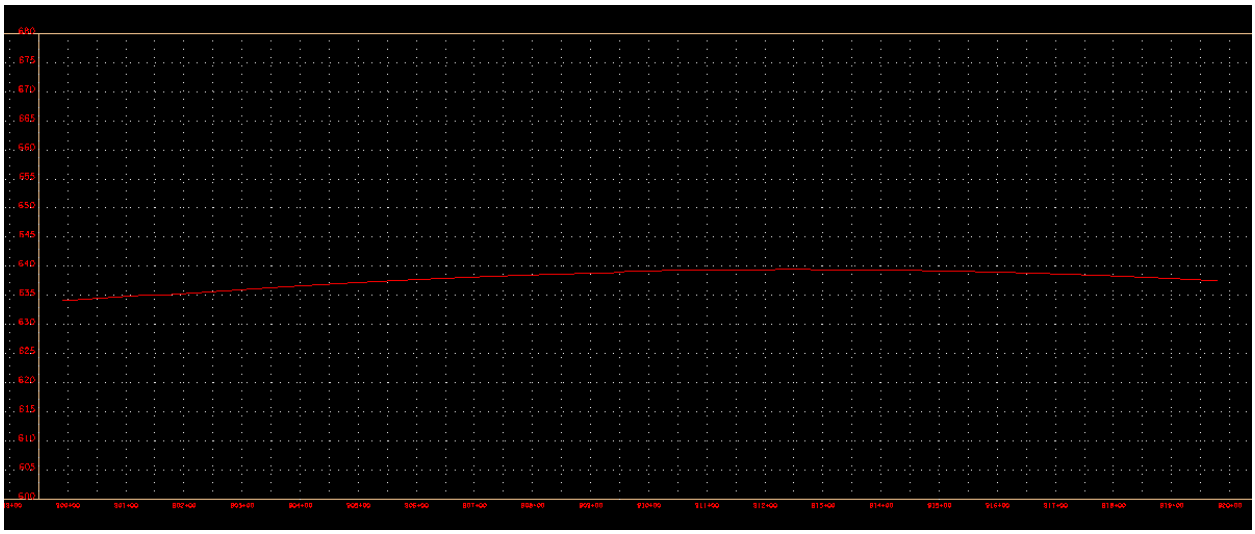


Now that catch basins are located for the left side, the ones on the right side can now be located. A profile for the right side gutter can be made in a similar manner to the one for the left side.

The gutter profile from the beginning of the project to Weston Blvd. is identical to the left side:

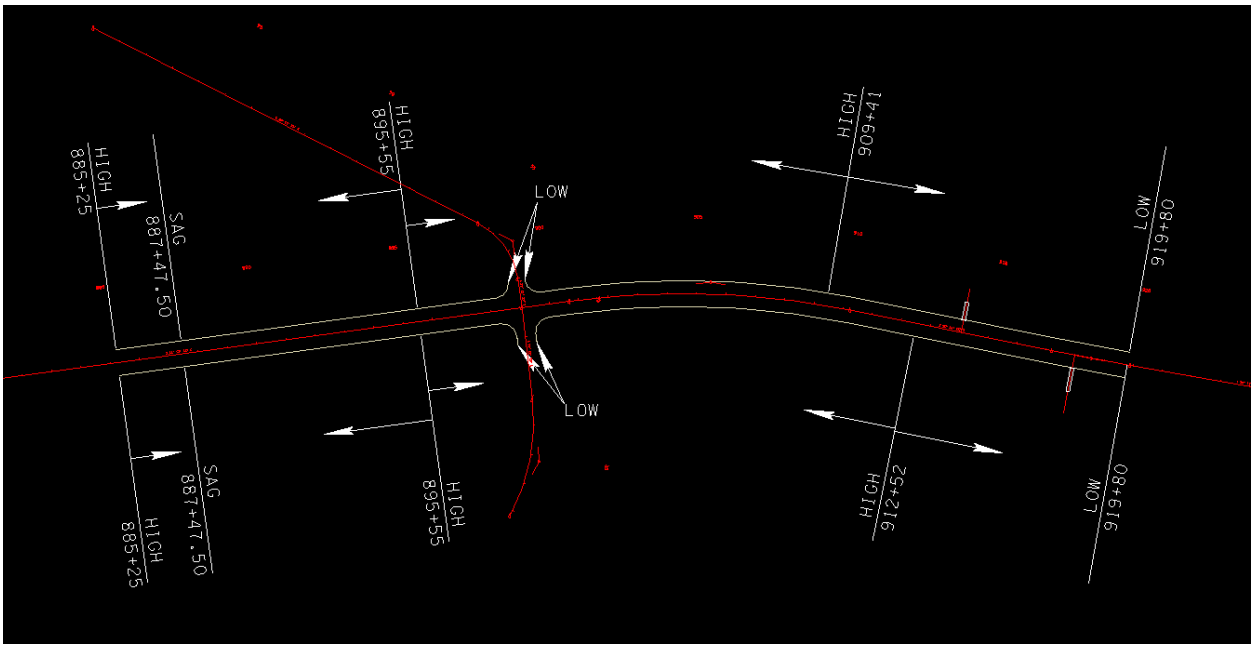


The gutter profile from Weston Blvd. to the end of project:



High Pts. (Station)	Elevation
885+25	630.82 (begin. of curb & gutter)
895+55	635.90
912+52	639.43

Low Pts. (Station)	Elevation
887+47.50	629.82 (sag)
898+26.55	633.99 (begin. of radius at intersection)
899+90.60	634.05 (begin. of radius at intersection)
919+80	637.47 (end of curb & gutter)



The last catch basin placed on the left was CB-13, so lets place catch basins first in the known locations on the right:

CB-14, 887+47.50, 44 offset, #14

The rest will be #12's:

CB-15, 898+26.55, 44 offset (begin. of radius at intersection)

CB-16, 31+25 RT., Weston Blvd.., 28 offset, end of c&g in radius

CB-17, 31+25 LT., Weston Blvd.., -36.70 offset, end of c&g in radius

CB-18, 917+85 RT., 44 (upstream of private dr.)

CB-19, 919+80 RT., 44 offset (end of c&g)

High Point to High Point 885+25 to 895+55:

A check of the contours show that there is no flow from off the roadway in this section . The drainage areas are contained entirely within the pavement area.

Since the gutter profile is identical with the left side,additional catch basins can be located on the right side corresponding with those on the left. These are all #12 cb's

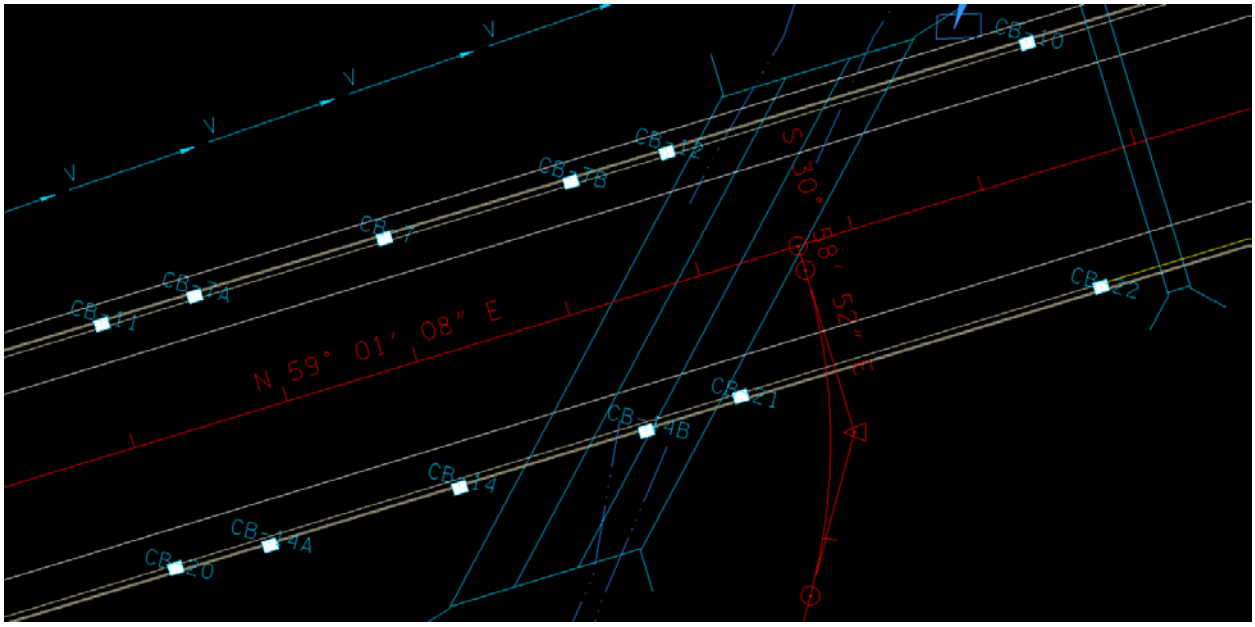
CB-20, 886+47.50, 44 offset

CB-21, 888+47.50, 44 offset

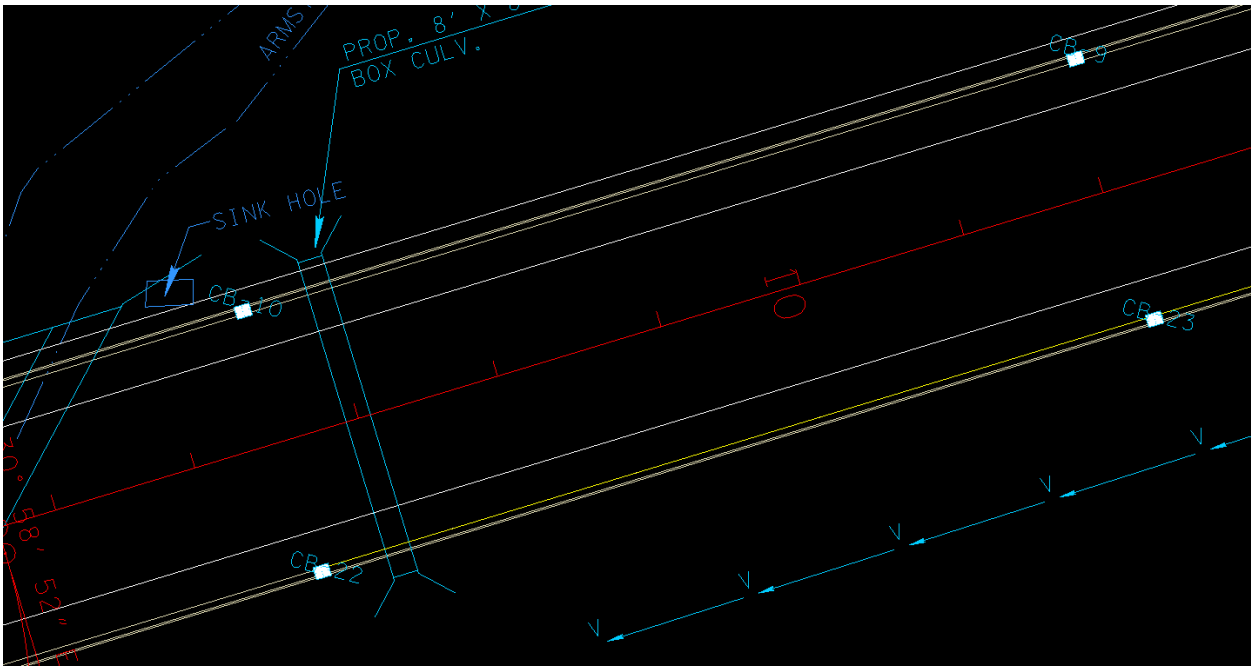
CB-22, 889+75, 44 offset

CB-23, 892+50, 44 offset

In addition, locate flanking cb's CB-14A and CB-14B at 886+80.35 and 888+13.48, respectively.

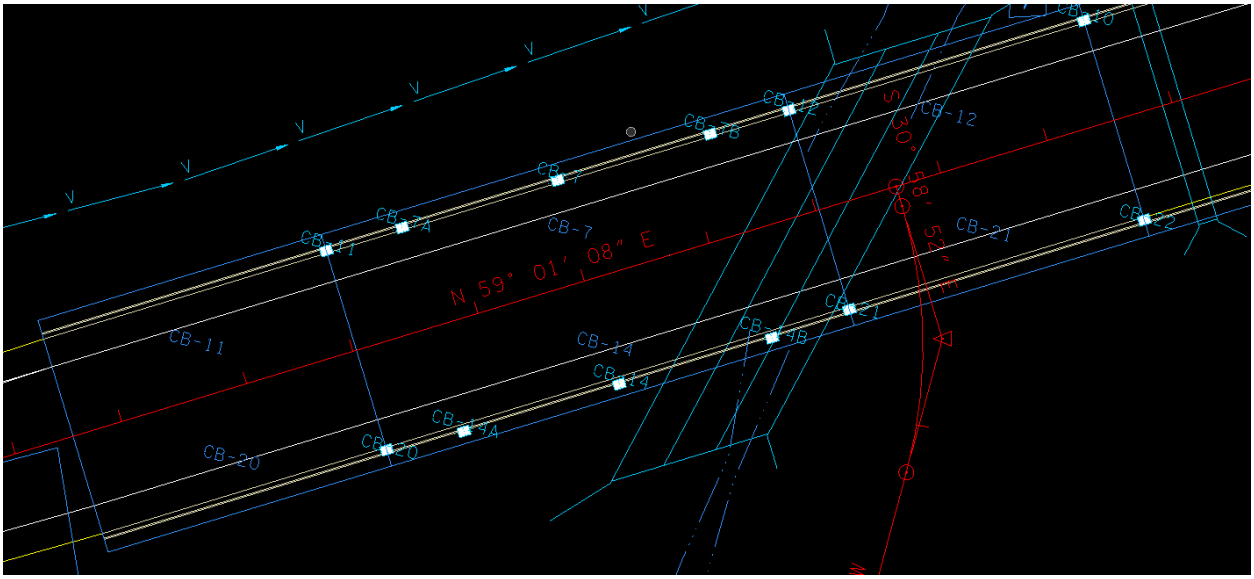


CB-14, CB-14A, CB-14B, CB-20, CB-21 on right side, corresponding to cb's on left side



CB-22 and CB-23 on right side, corresponding to cb's of left side

Drainage areas also will correspond to those on the left side and their discharge values should also be the same.

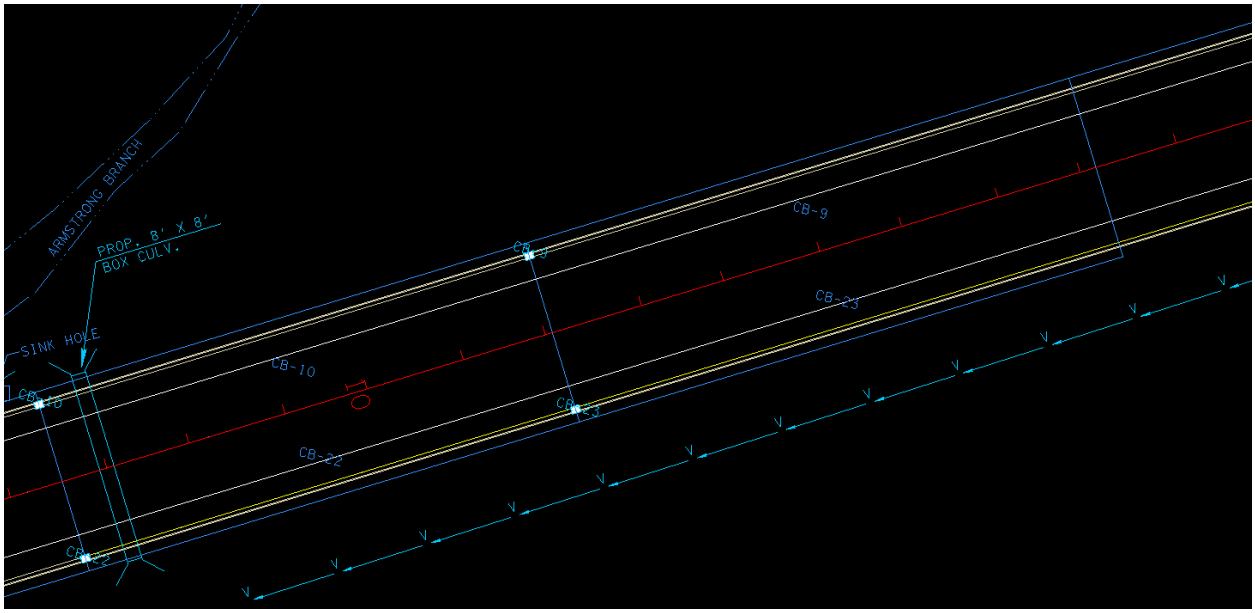


Drainage Area CB-14, q= 1.310

Drainage Area CB-20, q= 0.793

Drainage Area CB-21, q= 0.876

Ponding widths are all in the acceptable range

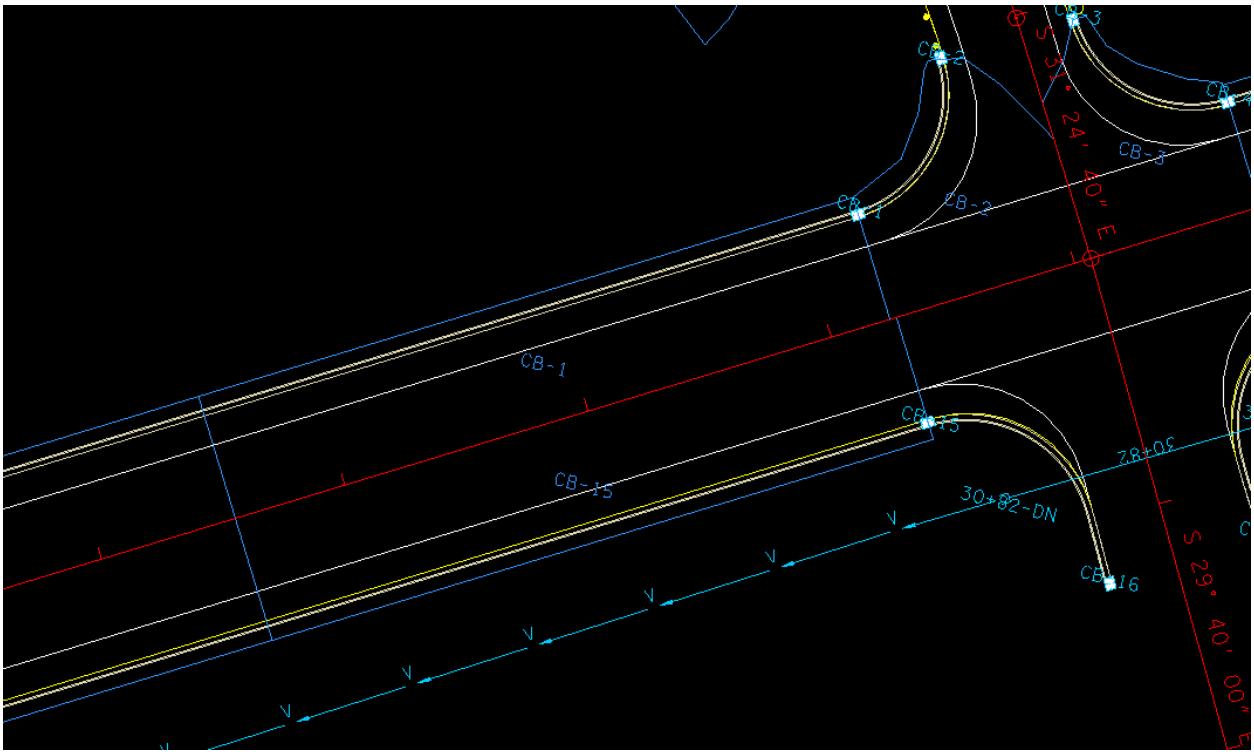


Drainage Area CB-22, q= 1.751

Drainage Area CB-23, q= 1.944

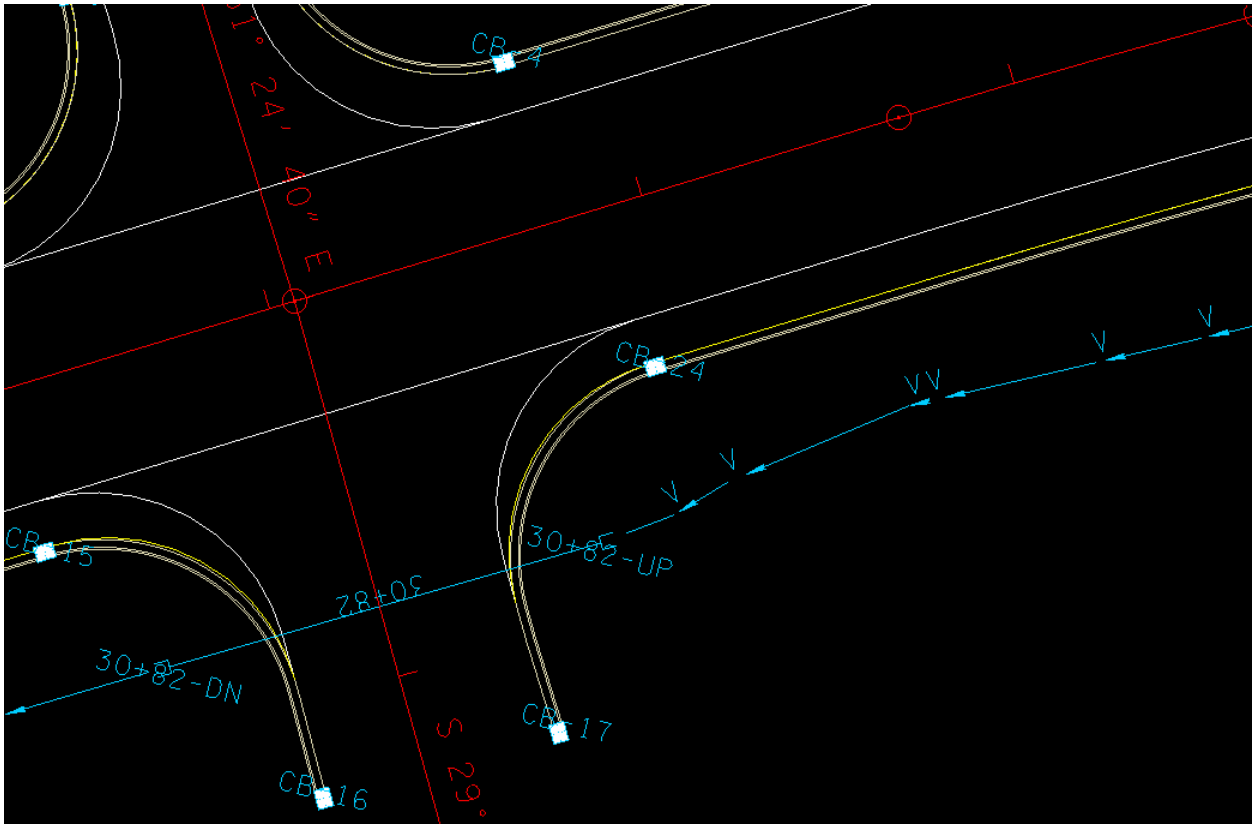
Ponding widths are in the acceptable range

Now, working from the high point at 895+55 toward end of project, CB-15 is located at the beginning of the radius with the intersection, sta 898+26.55, add drainage area CB-15:

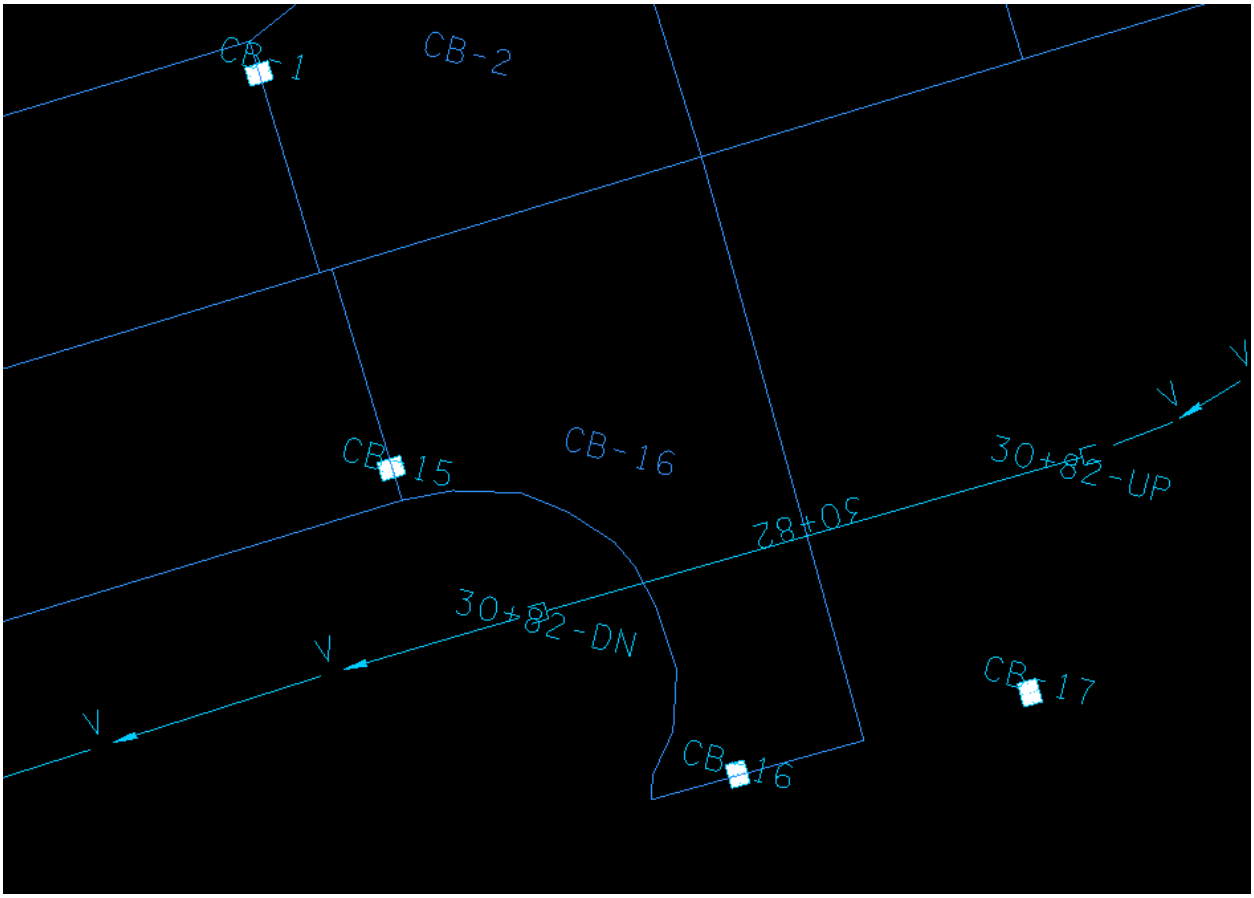


For CB-15, q=1.730, ponding width <8

Before we look at the drainage areas for CB-16 and CB-17, add CB-24 at sta 899+90.60. This is the point upstream from the beginning of the radius at the intersection:

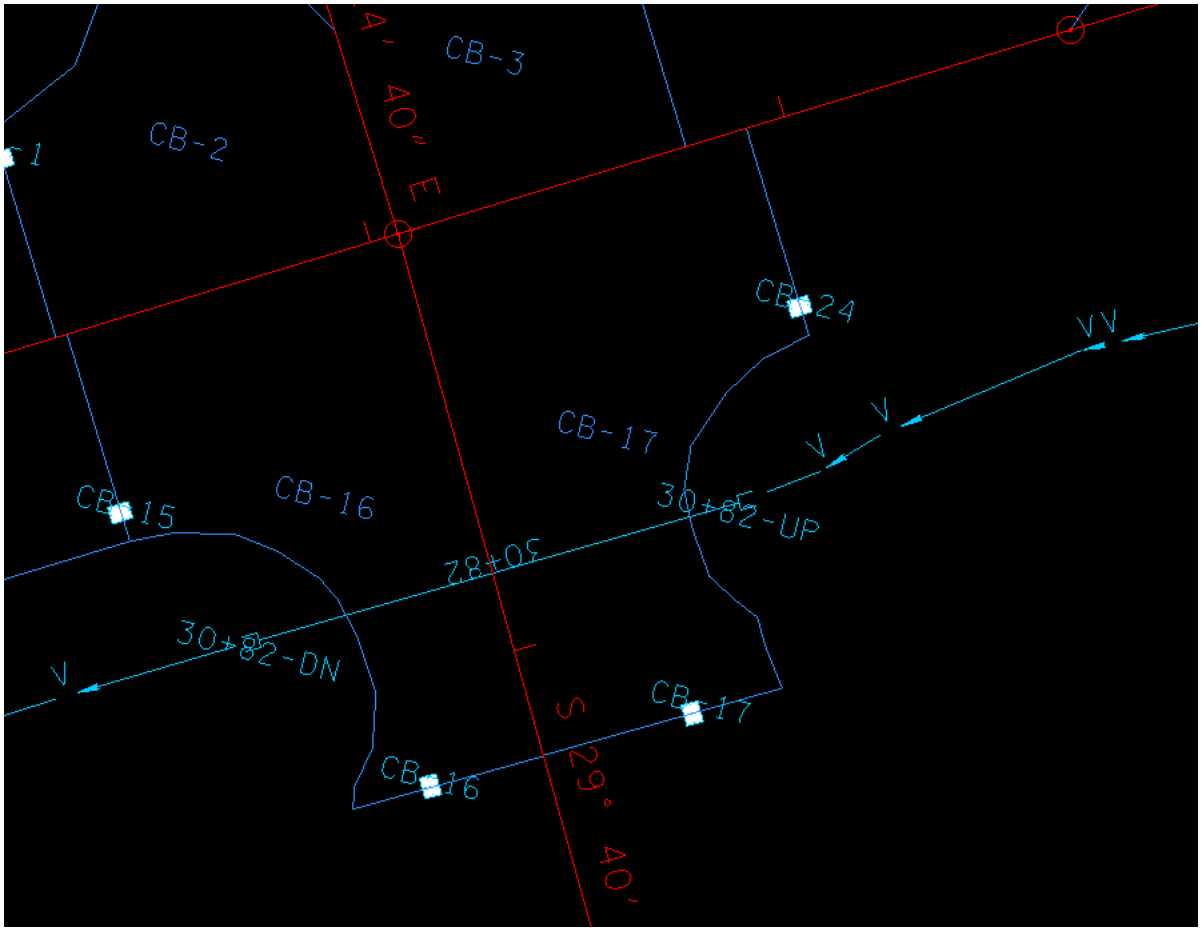

CB 14
CB 15
CB 16
CB 17
28+05
30+82-DN
30+82-UP
S 29°

Area CB-16:

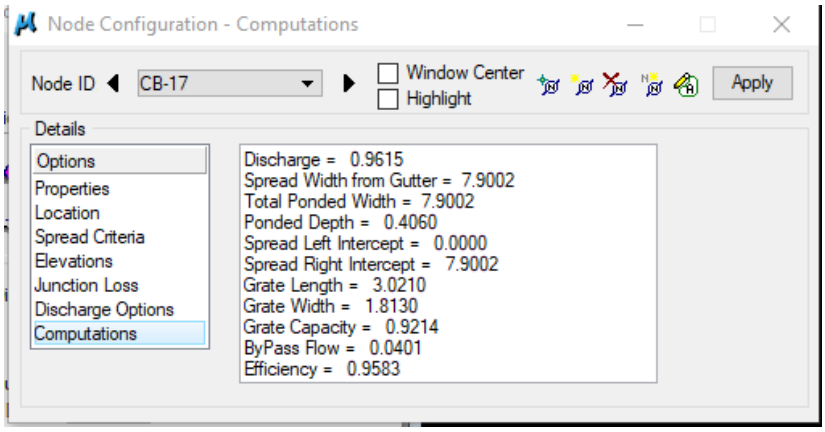


Q=0.841, Ponded width <8

Area CB-17:

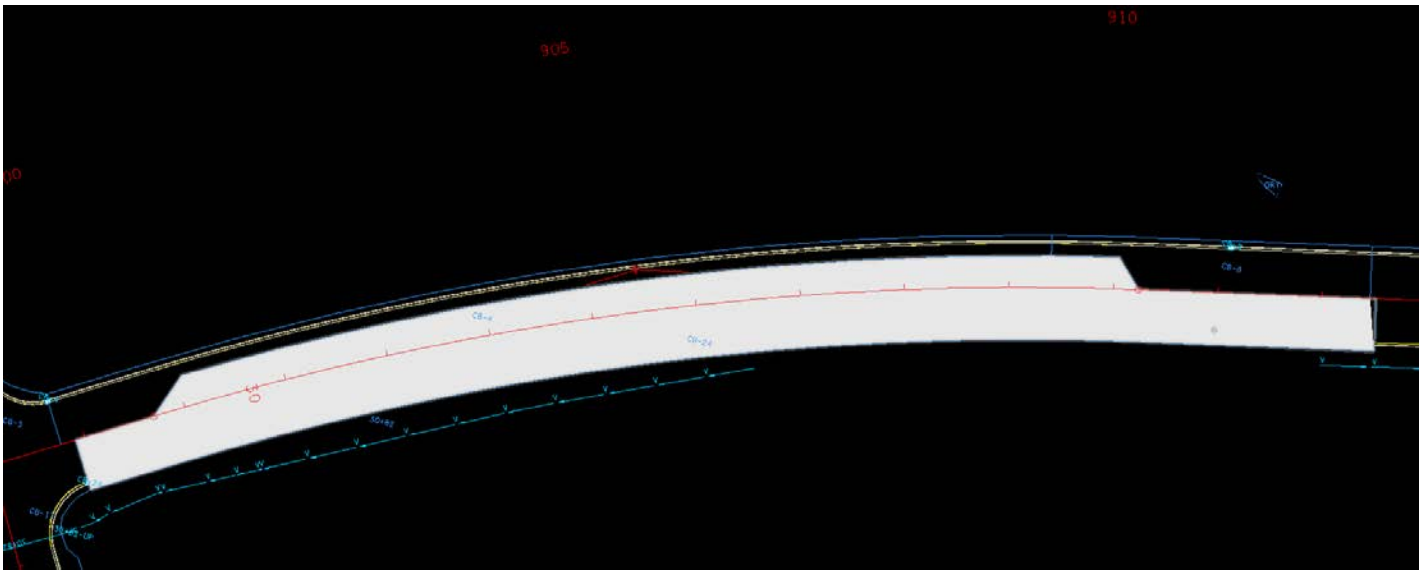


Q=0.962, Ponding width <8



This one's cutting it close!

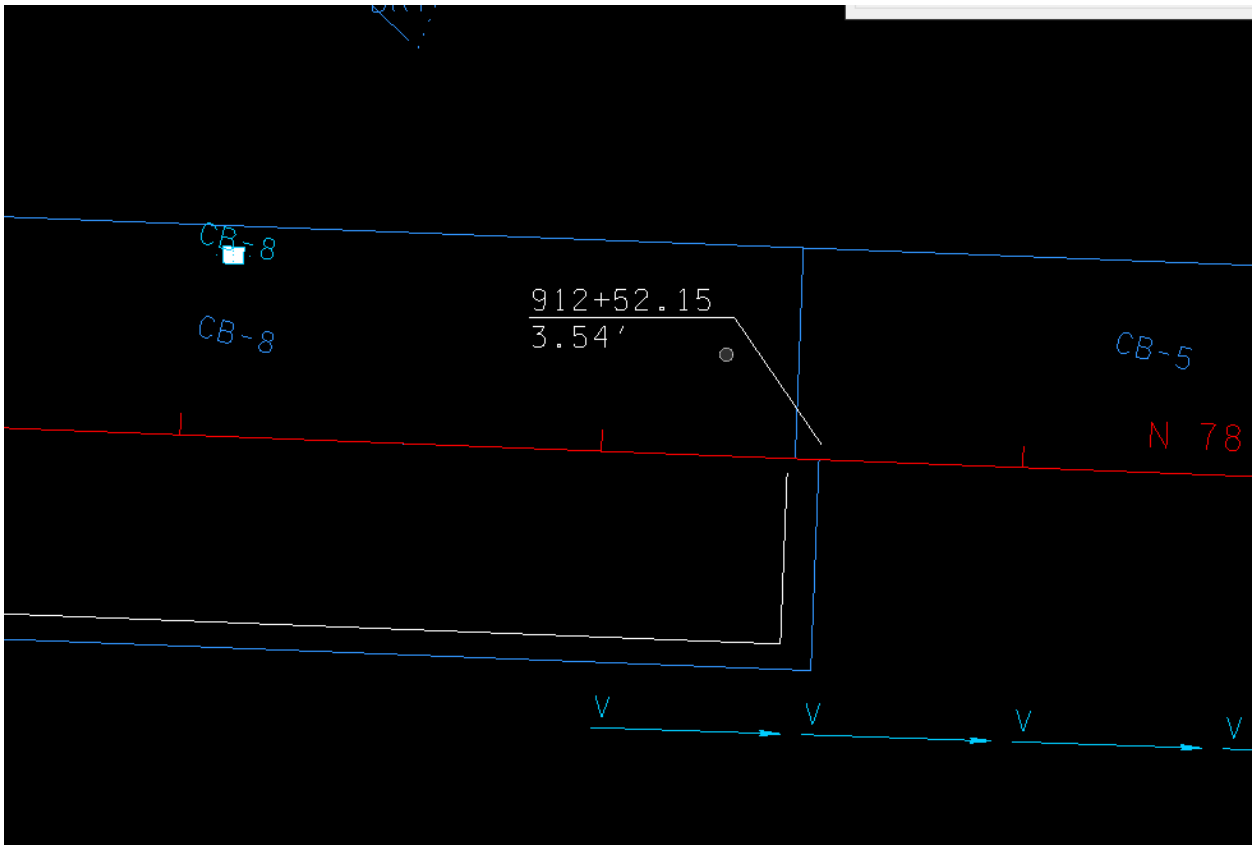
Area CB-24 (outlined in white) from CB-24 at sta 899+90.60 to the high point at sta 912+52, area is 2.079 Ac:

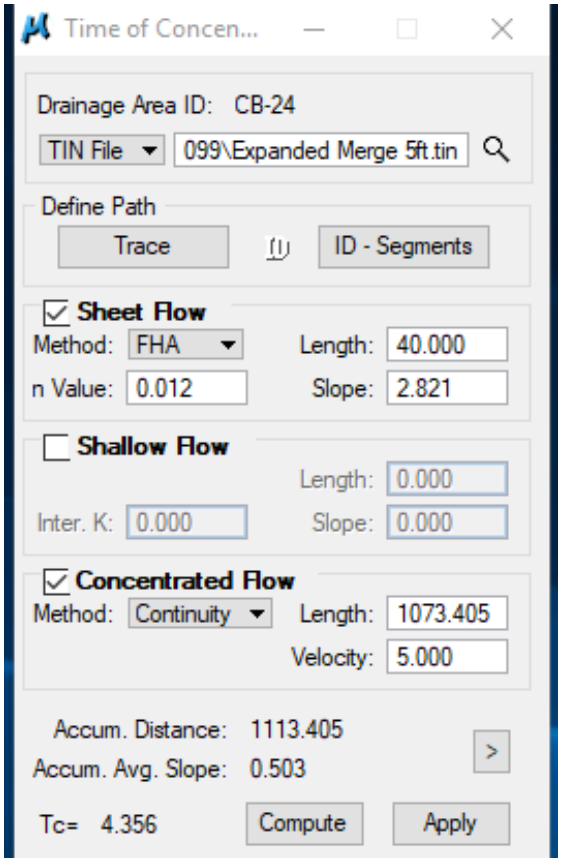


First the discharge wil be calculated for the area to check the ponding width. If necessary more catch basins will be added and to break up the area into smaller areas.

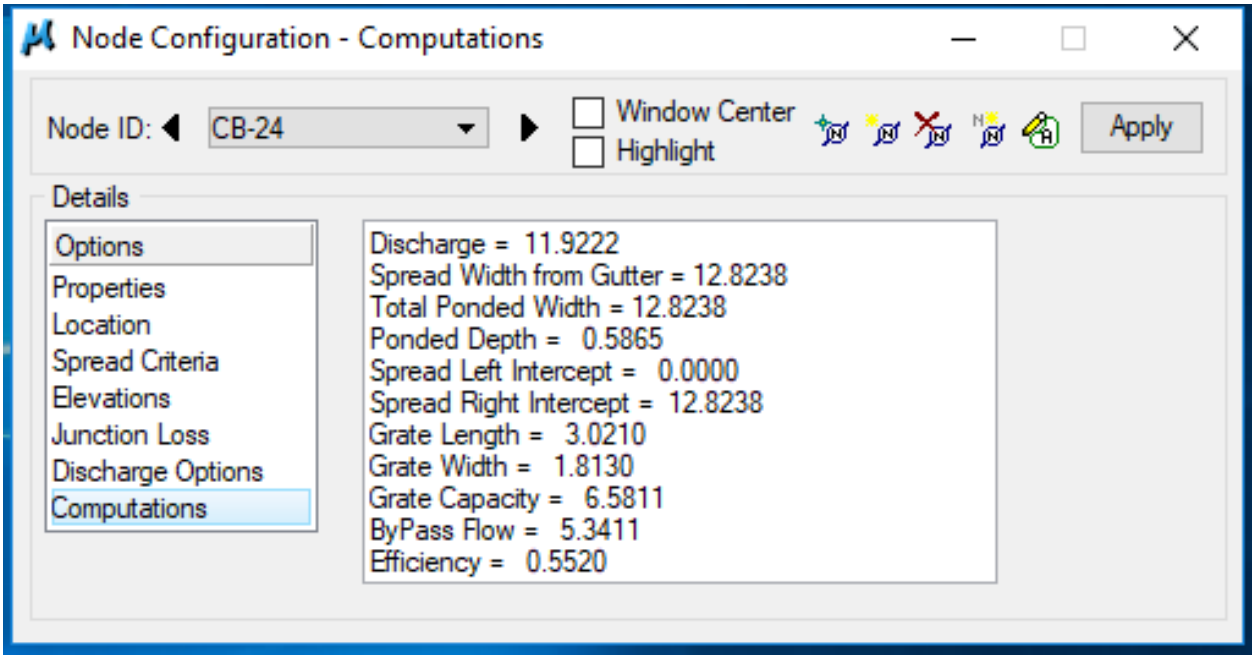
Tc for area CB-24 = 4.356 (5)

Begin trace path at other end of area near sta 921+52;

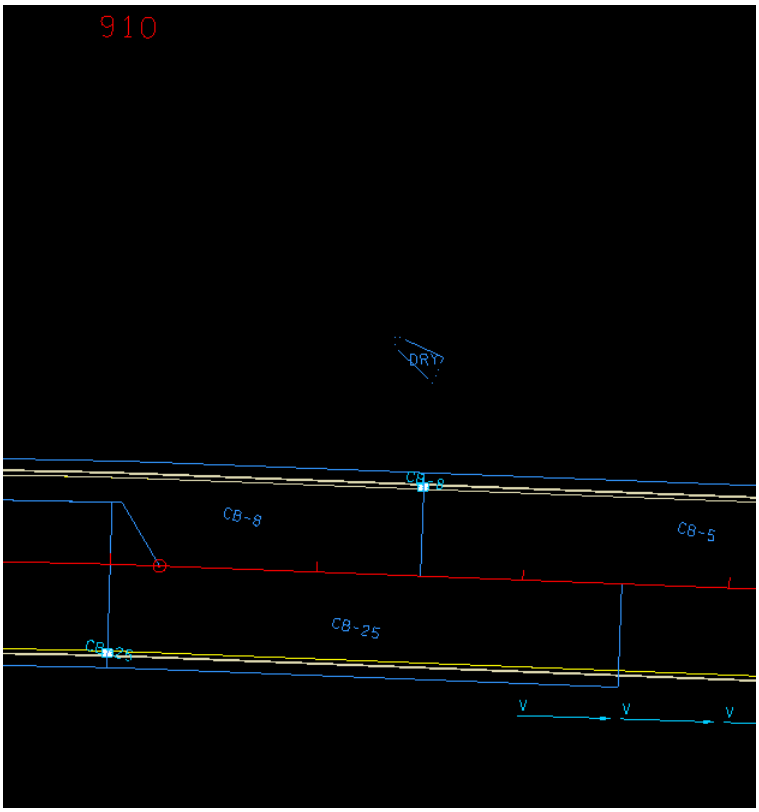

CB-8
CB-8
912+52.15
3.54'
CB-5
N 78
V
V
V
V


Time of Concen...
Drainage Area ID: CB-24
TIN File
099\Expanded Merge 5ft.tin
Define Path
Trace
ID - Segments
Sheet Flow
Method: FHA
Length: 40.000
n Value: 0.012
Slope: 2.821
Shallow Flow
Length: 0.000
Inter. K: 0.000
Slope: 0.000
Concentrated Flow
Method: Continuity
Length: 1073.405
Velocity: 5.000
Accum. Distance: 1113.405
Accum. Avg. Slope: 0.503
Tc= 4.356
Compute
Apply

As expected, the ponded width for CB-24 is over the acceptable limit:

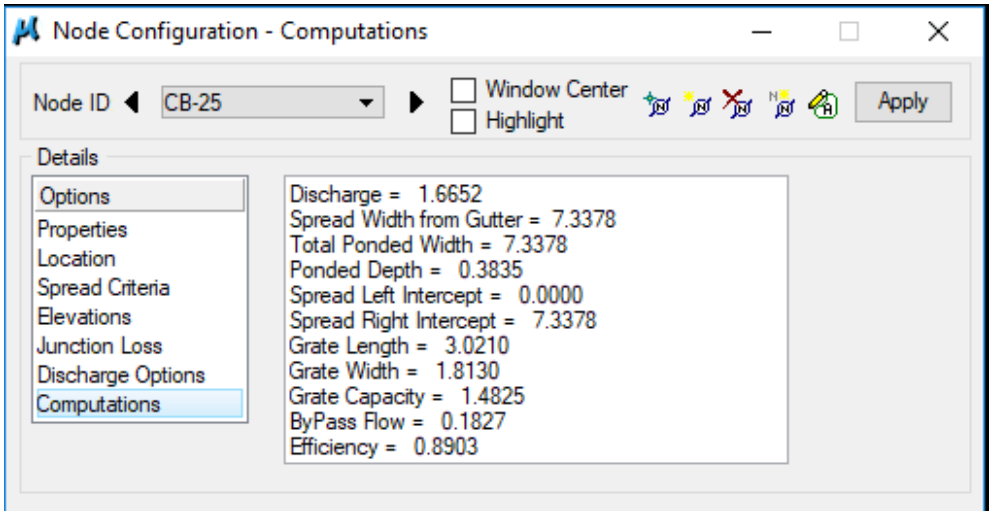


Locate CB-25 at sta 910+00:

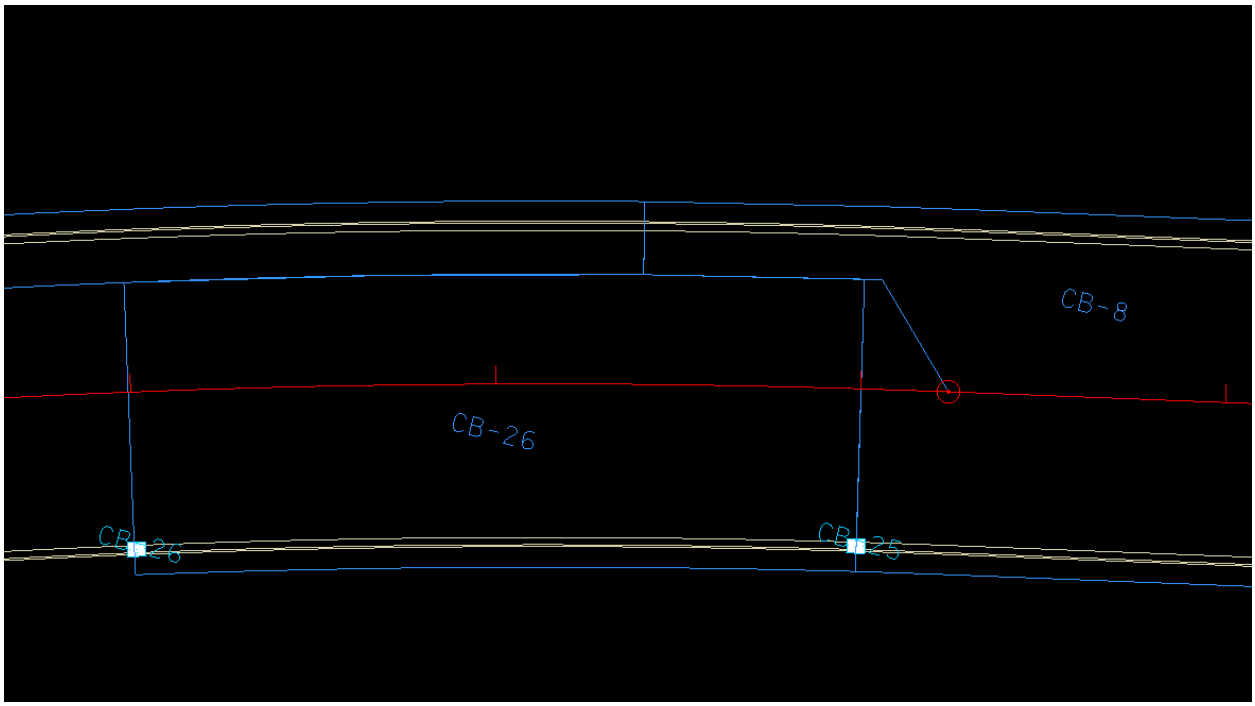


Tc for area CB-25 = 1.558 (5)

Discharge is 1.665

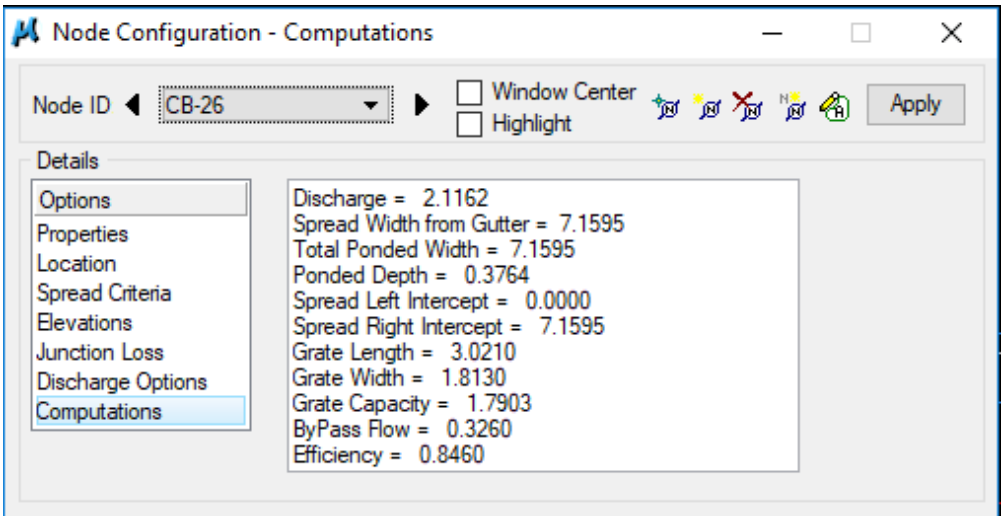


Locate CB-26 at staa 908+00:



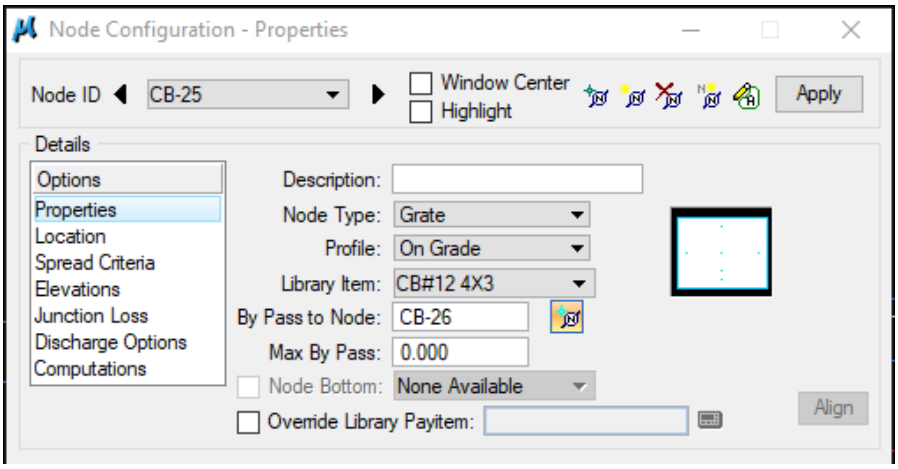
Tc =1.805 (5)

Discharge is 2.116

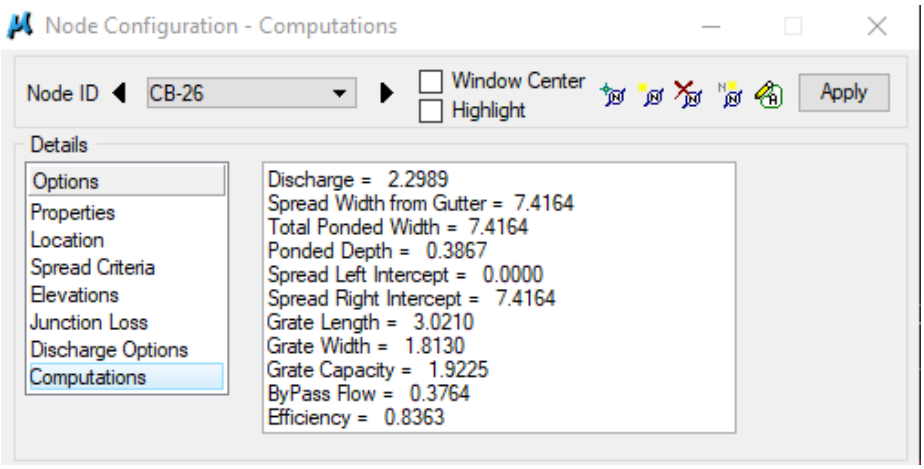


Ponding width is within acceptable limit.

It should be noted that when the ponding width is close to 8 feet like these last couple of catch basins, it would be advisable to go ahead and addin the bypass flow from the upstream catch bain, in this case CB-25:



Then check the computations for CB-26 again:



After recalculating, the ponding width for CB-26 is still good

For the remaining area between CB-24 and CB-26 (approx. 800 ft.) it would appear that a spacing of between 150 and 200 feet should be good, so locate the following catch basins:

CB-27, sta 906+25 rt

CB-28, sta 904+50 rt

CB-29, sta 903+00 rt

CB-30, sta 901+50 rt

Also assign bypass flows CB-26 to CB-27, CB-27 to CB-28, etc., CB-30 to CB-24

Using procedures outlined previously the calculations can be performed for the areas CB-24 and CB-27 thru CB-30:

CB-27, Tc= 1.537(5), q=1.827(2.203 incl. byp. from CB-26), pond. w = 6.78

CB-28, Tc= 1.615(5), q=1.857(2.231 incl. byp. from CB-27), pond. w = 6.46

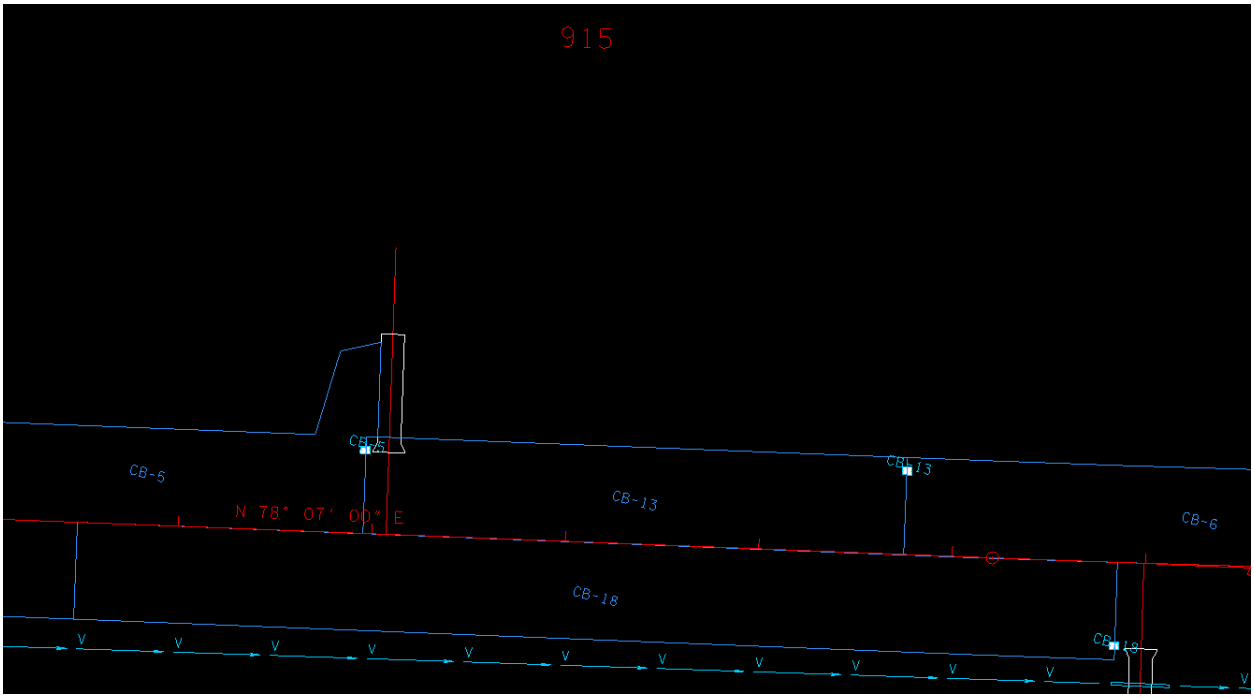
CB-29, Tc= 1.525(5), q=1.557(1.953 incl. byp. from CB-28), pond. w = 5.86

CB-30, Tc= 1.509(5), q=1.571(1.889 incl. byp. from CB-29), pond. w = 5.77

CB-24, Tc= 1.539(5), q=1.277(1.576 incl. byp. from CB-30), pond. w = 5.31

High point (921+52) to end of curb and gutter (919+80) :

The drainage area for CB-18, from high point to 917+85 :



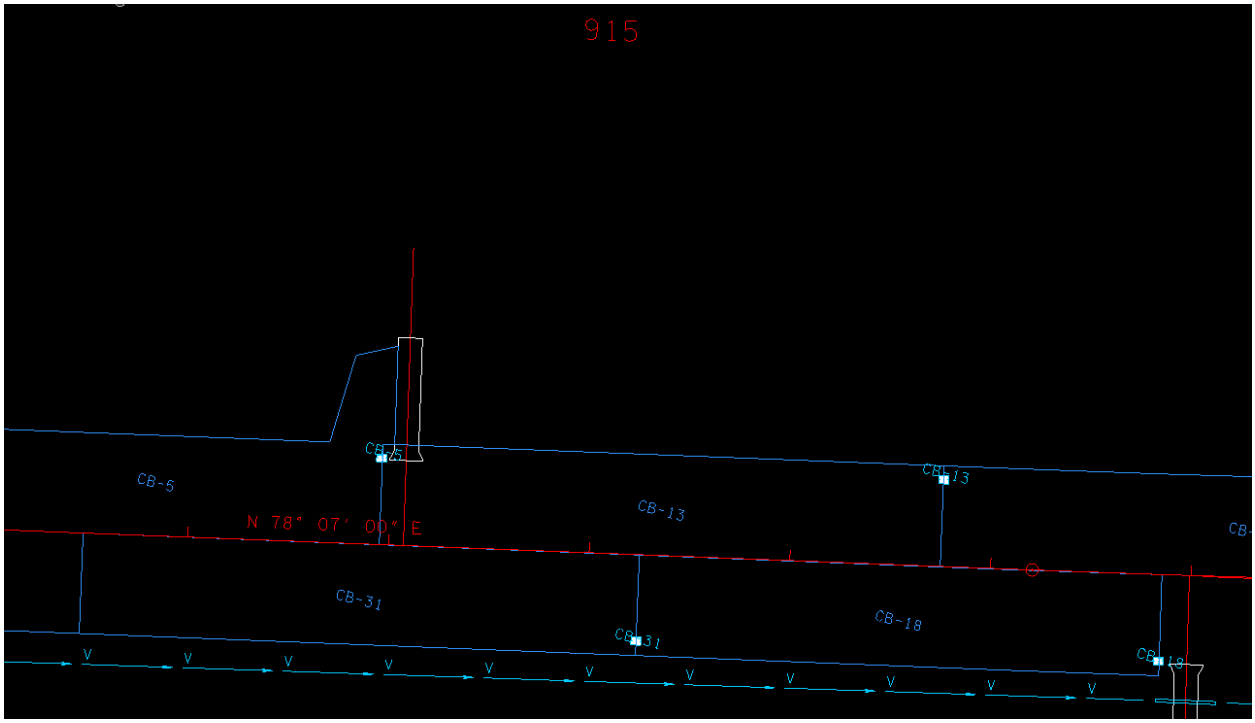
There will be no runoff from outside, due to special ditch

Using procedure outlined previously:

Tc = 2.526 (5), q=3.451, pond. Width = 8.45

Then locate another catch basin (CB-31) at 915+25, and add drainage area

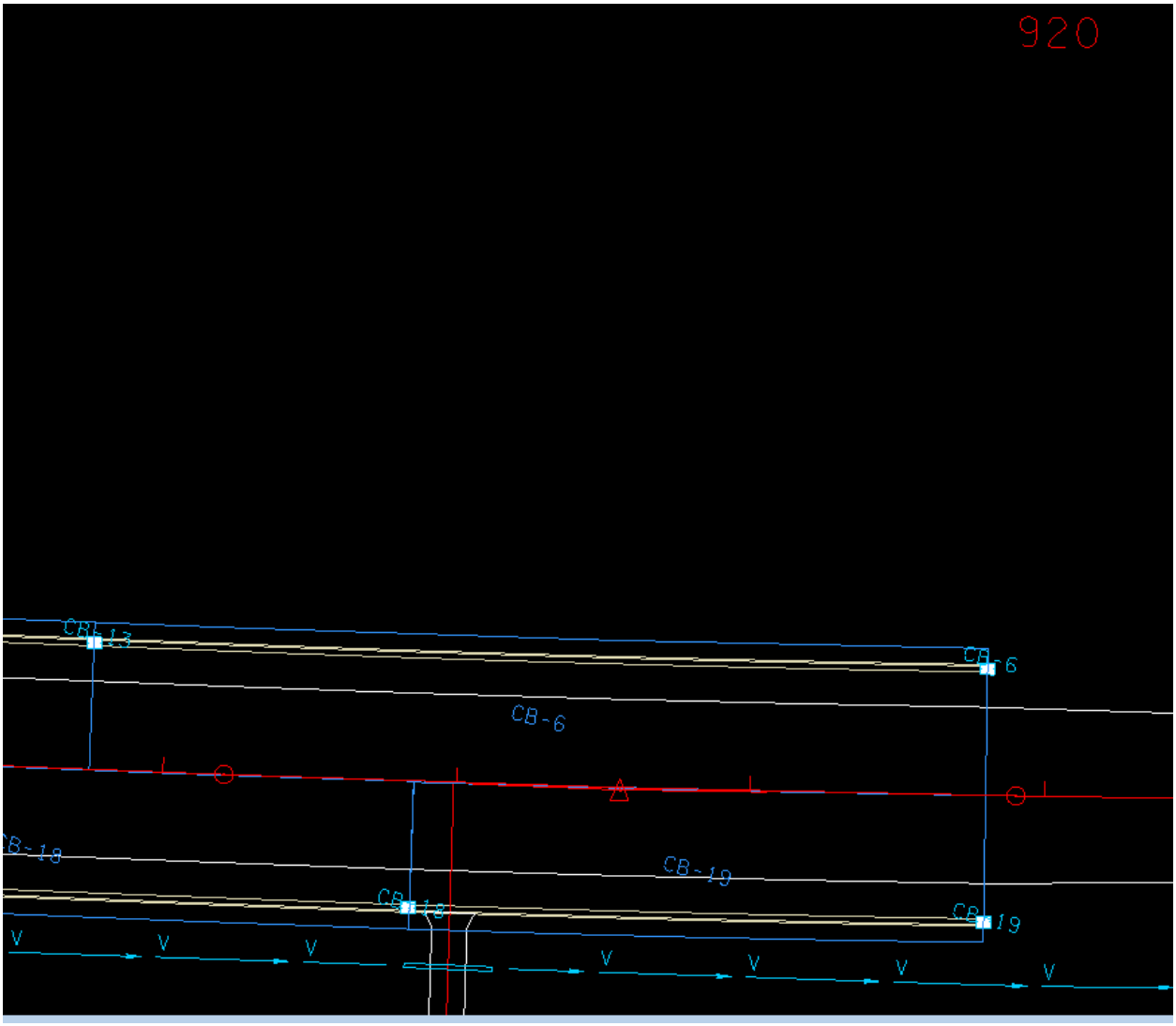
Remember to set the bypass for CB-31 to CB-18:



CB-31, Tc= 1.669 (5), q=1.797, pond. w = 7.39

CB-18, Tc= 1.606(5), q=1.654(1.871 incl. byp. from CB-31), pond. w = 6.52

CB-19, at 919+80 (end of curb and gutter):



There will be no runoff from outside, due to special ditch

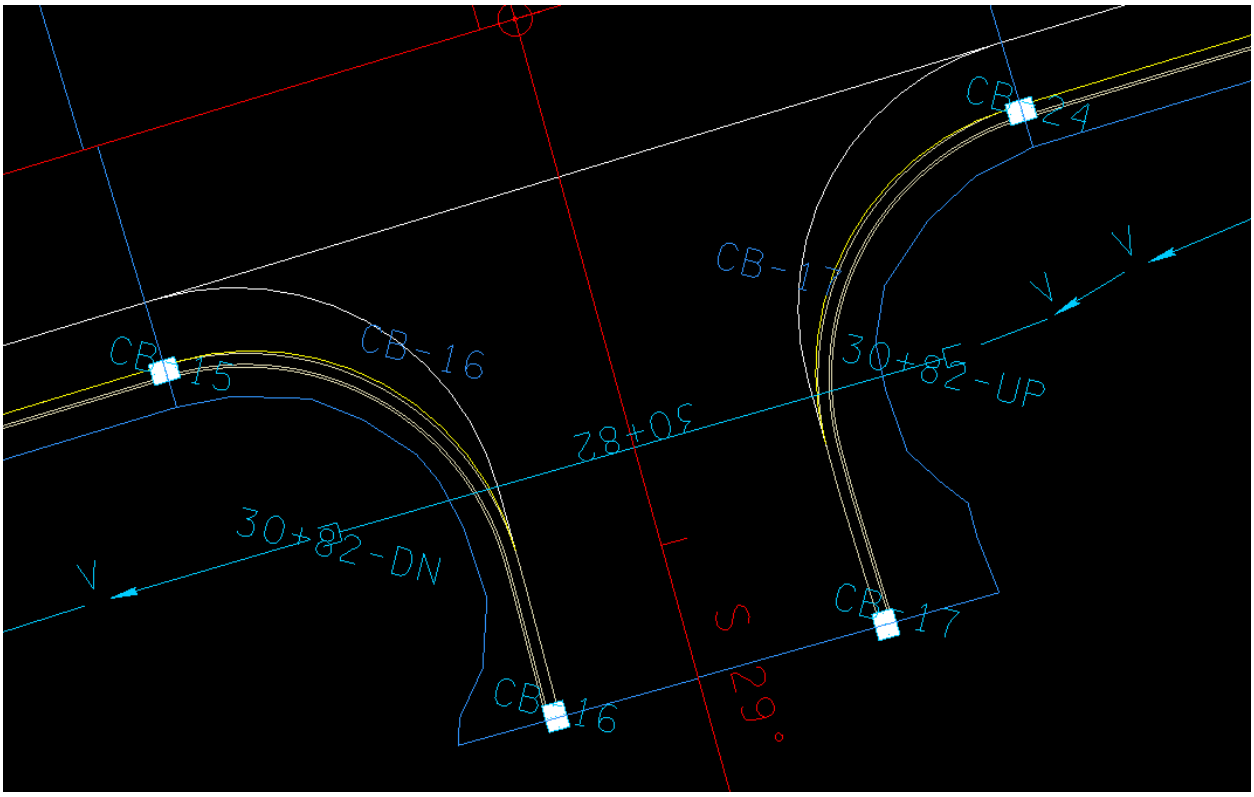
Using procedure outlined previously:

CB-19, Tc= 1.380(5), q=1.238(1.510 incl. byp. from CB-31), pond. w = 5.52

All the catch basins located now, but earlier ones located did not have bypasses defined so this would be a good time to check that before we go any further to see if it be necessary to reposition or add some more catch basins.

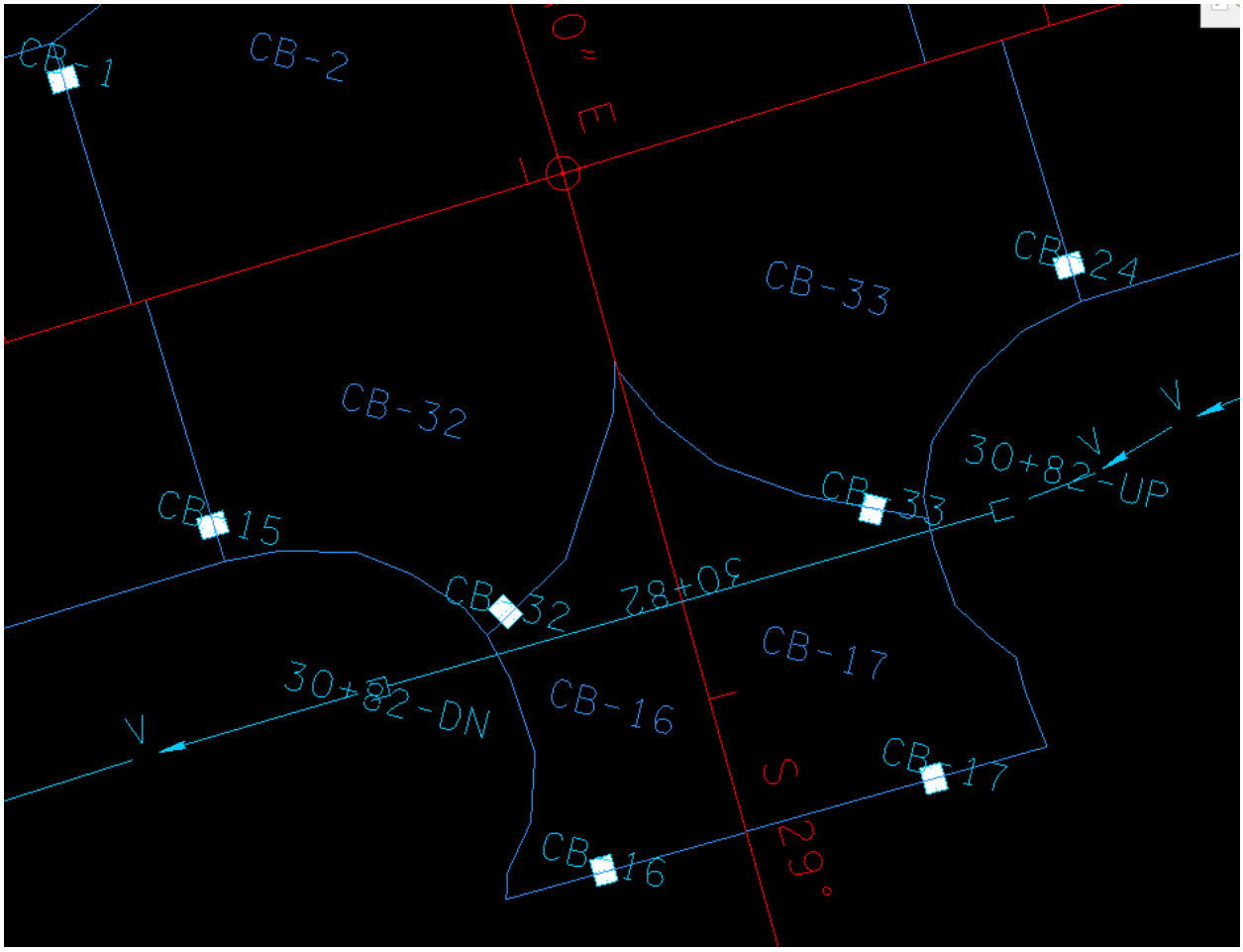
	bypass to	discharge	pond. Width
CB-1	CB-2	1.582	5.16
CB-2	n/a	0.928	3.52
CB-3	n/a	0.941	3.53
CB-4	CB-3	2.105	6.06
CB-5	CB-13	1.496	7.80
CB-6	n/a	2.204	6.54
CB-7	n/a	1.412	1.65
CB-8	CB-5	1.029	7.30
CB-9	CB-10	1.942	5.33
CB-10	CB-12	2.072	5.63
CB-11	CB-7	0.720	4.12
CB-12	CB-7	1.111	5.09
CB-13	CB-6	1.907	6.90
CB-14	n/a	1.484	1.71
CB-15	CB-16	1.730	5.42
CB-16	n/a	1.096	8.34
CB-17	n/a	1.174	8.58
CB-18	CB-19	1.871	6.52
CB-19	n/a	1.510	5.52
CB-20	CB-14	0.793	4.33
CB-21	CB-14	1.238	5.36
CB-22	CB-21	2.072	5.63
CB-23	CB-22	1.942	5.33
CB-24	CB-17	1.576	5.31
CB-25	CB-26	1.665	7.34
CB-26	CB-27	2.299	7.42
CB-27	CB-28	2.203	6.78
CB-28	CB-29	2.231	6.46
CB-29	CB-30	1.953	5.86
CB-30	CB-24	1.889	5.77
CB-31	CB-18	1.797	7.38

CB-16 and CB-17 are the only locations where the ponded width is more than allowable.



This can be corrected by adding extra catch basin in the radius

CB-32 and CB-33 at sta 30+75 Rt. And Lt.:



Using procedures outlined previously the calculations can be performed for the drainage areas:

CB-16, Tc= 1.051(5), q=0.211(0.246 incl. byp. from CB-32), pond. w = 4.24

CB-17, Tc= 1.076(5), q=0.275(0.310 incl. byp. from CB-33), pond. w = 4.76

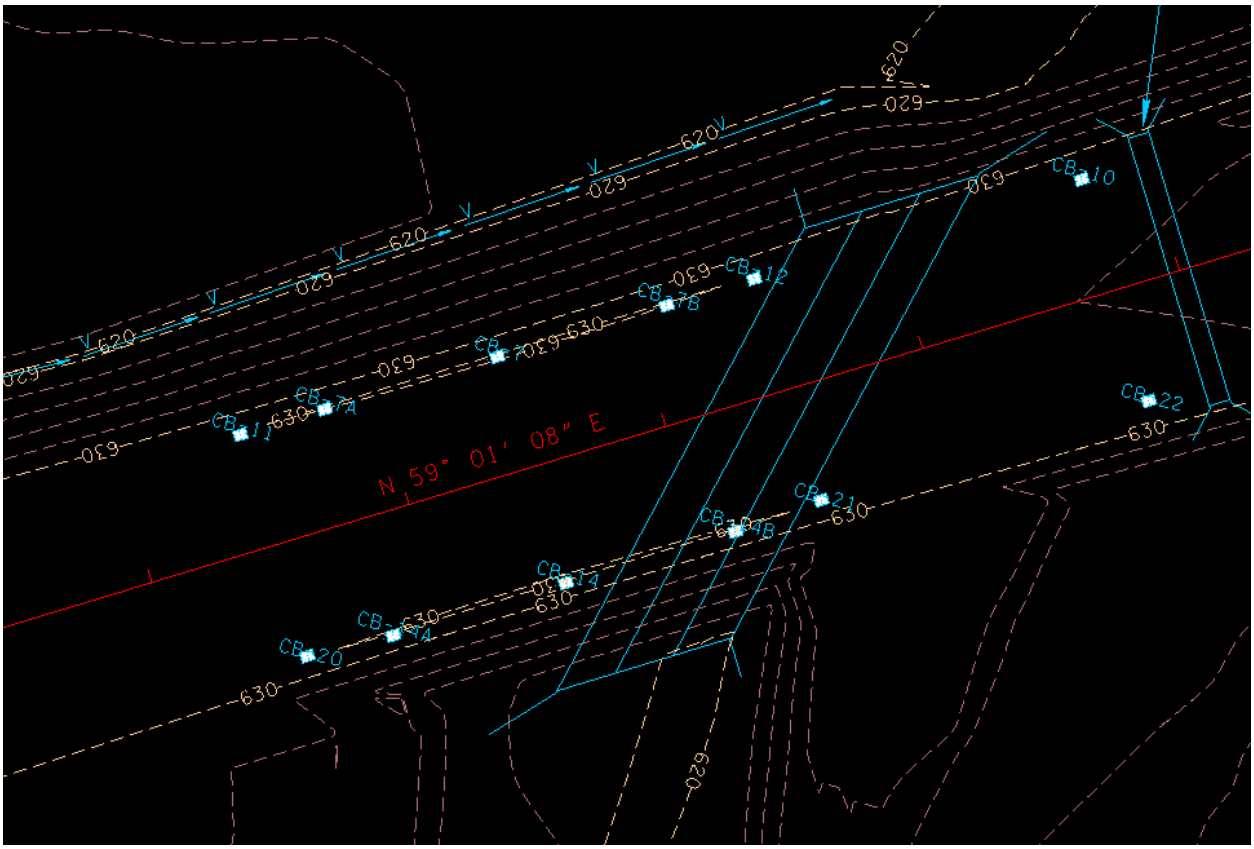
CB-32, Tc= 0.889(5), q=0.629(0.885 incl. byp. from CB-15), pond. w = 7.63

CB-33, Tc= 0.891(5), q=0.687(0.889 incl. byp. from CB-16), pond. w = 7.68

Linking the catch basins

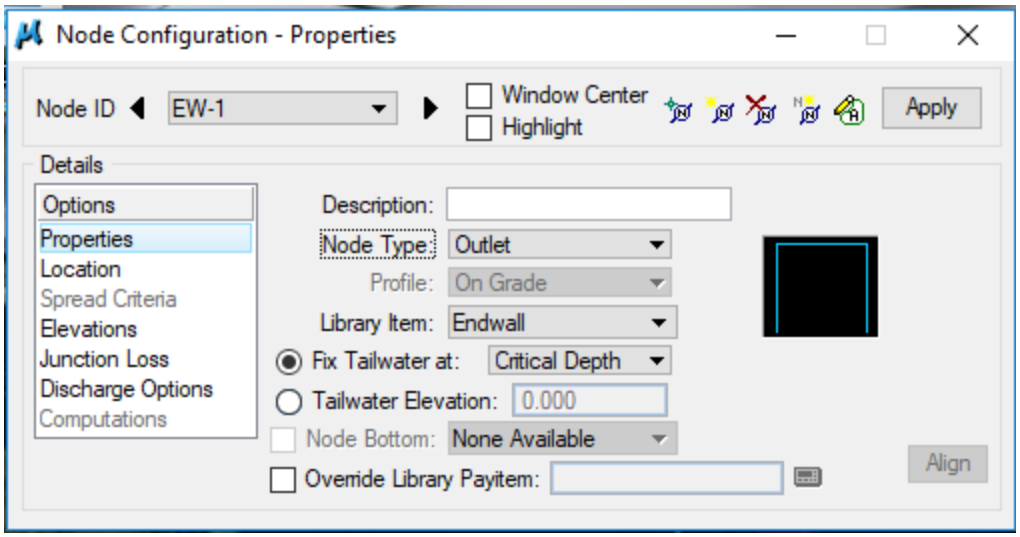
Now that all catch basins are located and there is no excessive ponding, it is time to create storm drainage networks by linking the catch basins so that each network has a separate outlet.

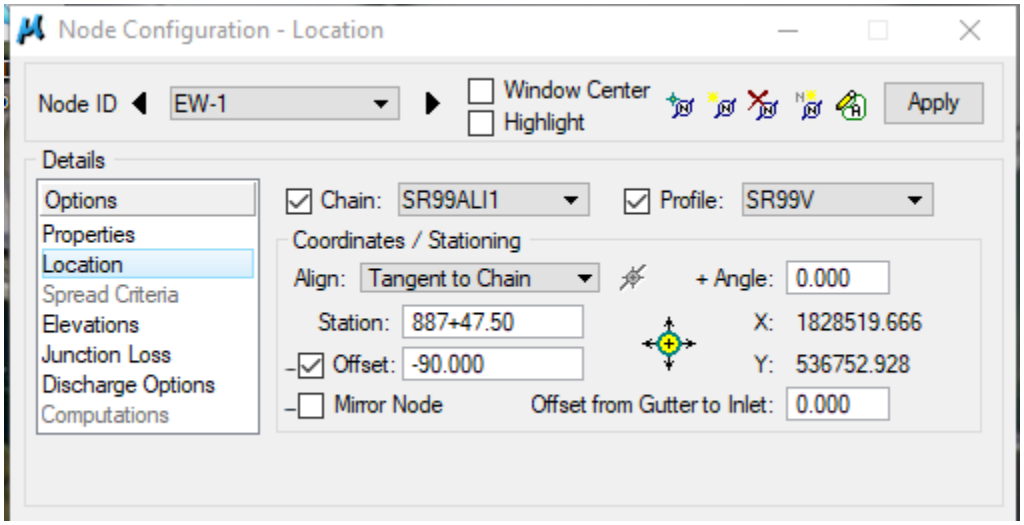
Start first by determining where would be good places for outlets.

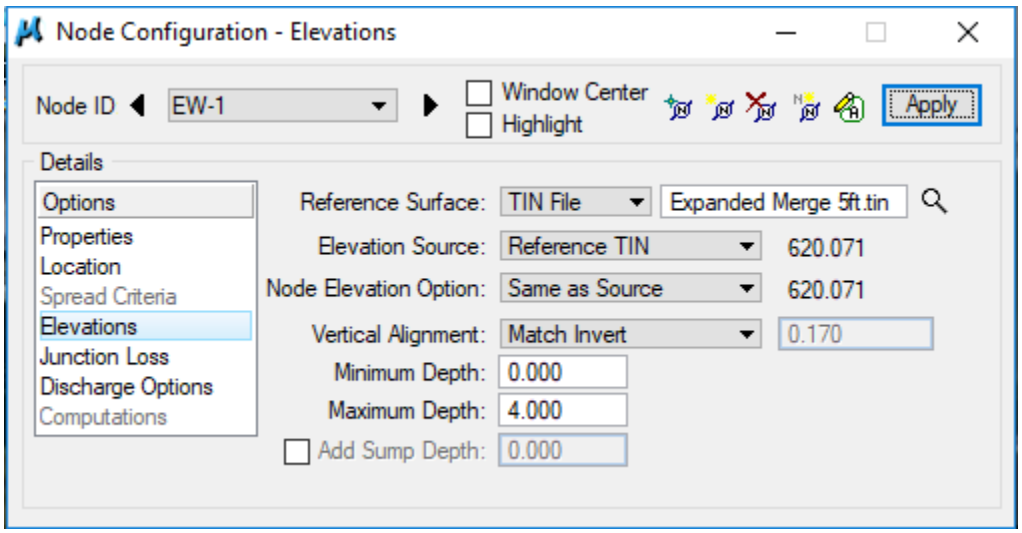


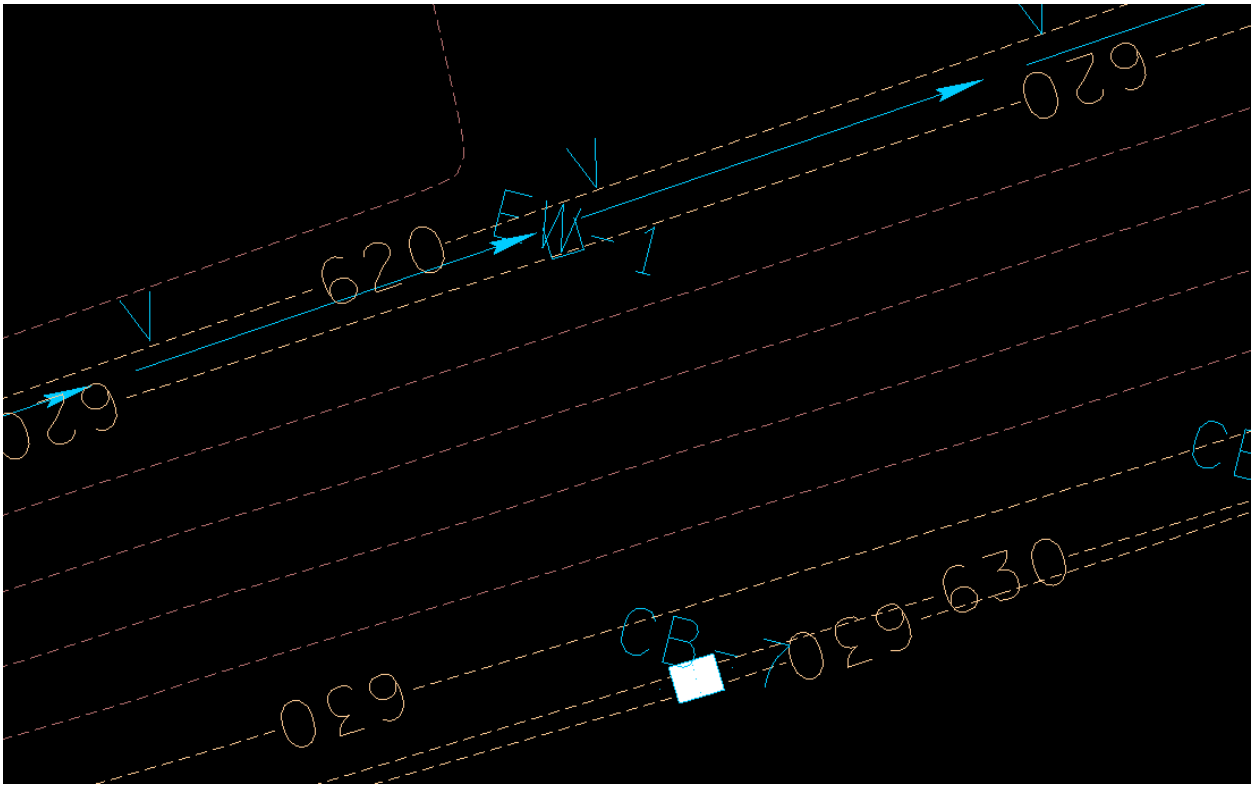
From the contours, it is evident there can be an outlet in the ditch as the CB's 7A, 7B, 11 and 12 drain into CB-7, and CB-7 can outlet into the ditch. This will be the first network.

Locate outlet (EW-1) in ditch at same station as CB-7

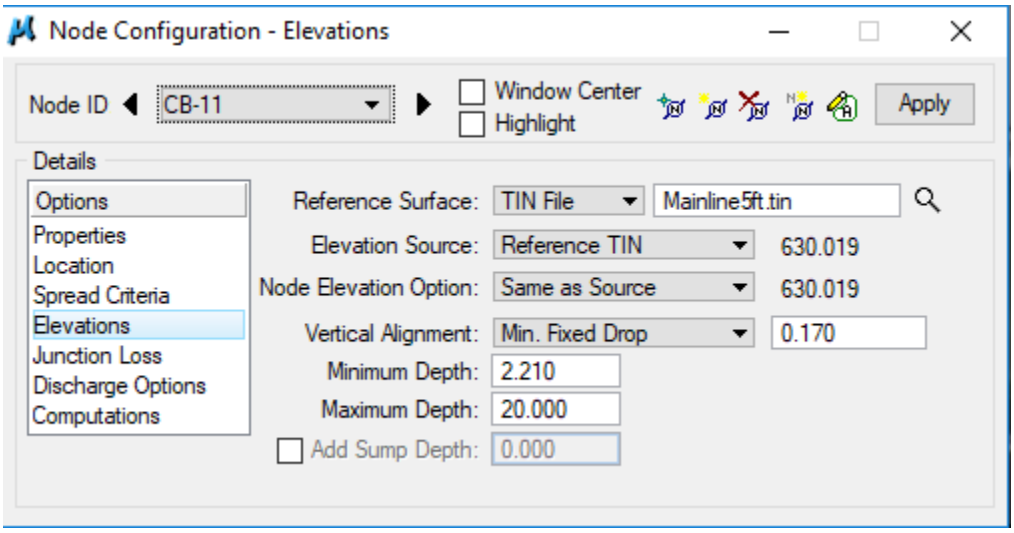

Node Configuration - Properties
Node ID
EW-1
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Description:
Node Type:
Outlet
Profile:
On Grade
Library Item:
Endwall
Fix Tailwater at:
Critical Depth
Tailwater Elevation:
0.000
Node Bottom:
None Available
Override Library Payitem:
Align


Node Configuration - Location
Node ID
EW-1
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Chain:
SR99ALI1
Profile:
SR99V
Coordinates / Stationing
Align:
Tangent to Chain
+ Angle:
0.000
Station:
887+47.50
Offset:
-90.000
X:
1828519.666
Y:
536752.928
Mirror Node
Offset from Gutter to Inlet:
0.000


Node Configuration - Elevations
Node ID
EW-1
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Reference Surface:
TIN File
Expanded Merge 5ft.tin
Elevation Source:
Reference TIN
620.071
Node Elevation Option:
Same as Source
620.071
Vertical Alignment:
Match Invert
0.170
Minimum Depth:
0.000
Maximum Depth:
4.000
Add Sump Depth:
0.000



Before proceeding, remember that the elevations specified on the CB's were for minimum depth, that is assuming there will be an inlet and outlet. This is not the case for CB-11 and CB-12. They will be outlet only, so the min. drop distance needs to be added to the minimum depth for those nodes.

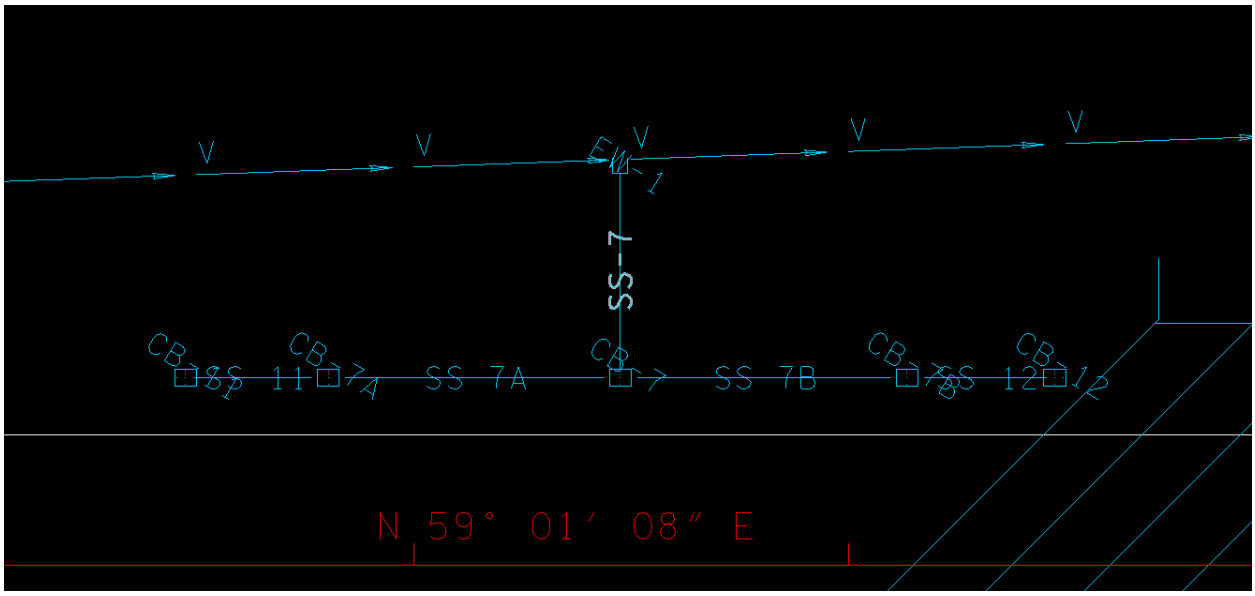


The minimum depth for CB-11 and CB-12 should be changed to 2.38. The others can remain as set.

Now, for link configurations, refer to GEOPAK Drainage Manual, Section 6 for the settings. Then make link connections as shown below:

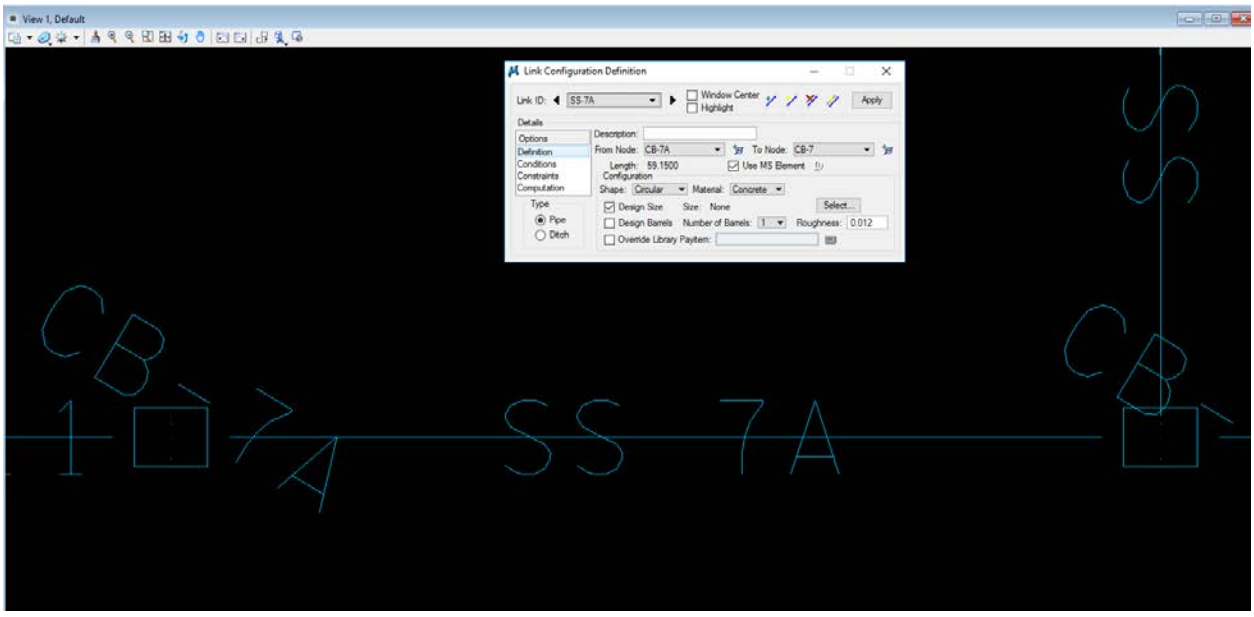
link	From	To
SS-11	CB-11	CB-7A
SS-7A	CB-7A	CB-7
SS-7B	CB-7B	CB-7
SS-12	CB-12	CB-7B
SS-7	CB-7	EW-1

This will be the first network, named 88750LT, for the location of the outlet

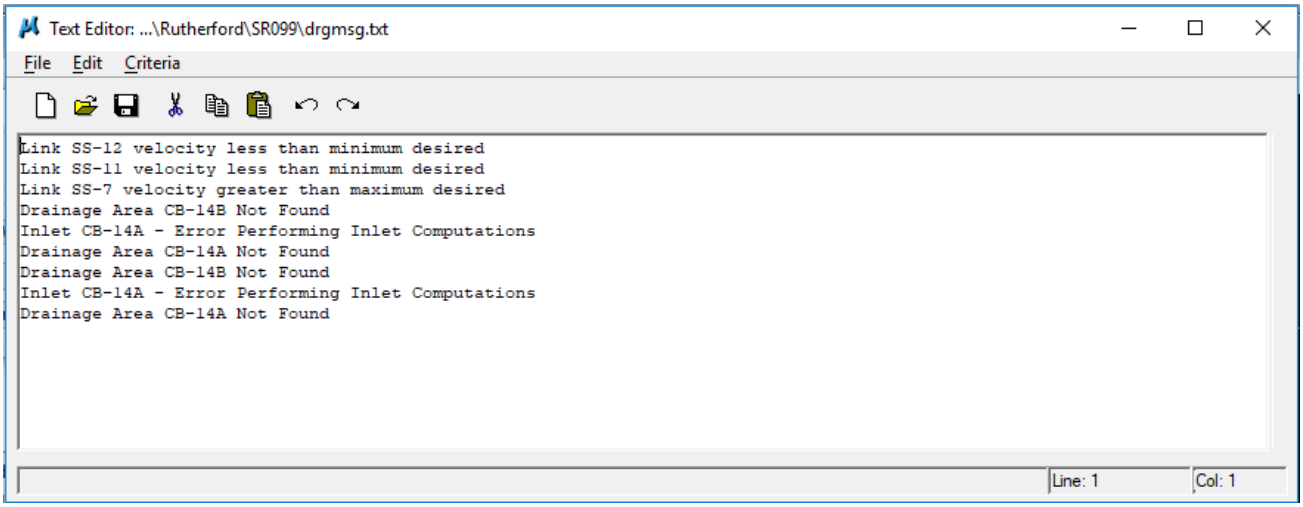


Network with outlet, EW-1, curb and gutter level display has been turned off

Onte other thing to consider when locating drainage outlets, is the existing conditions. Turn the present layout levels on for the survey reference to make sure for example you won't be running water onto somebody's house

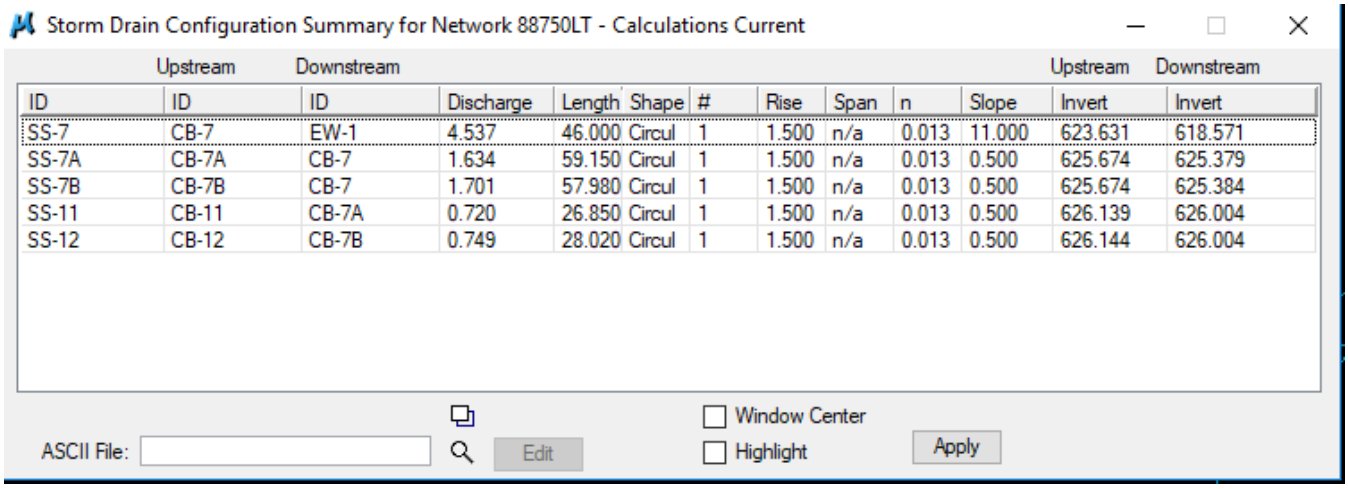


Note that “MS Element” was used when storing the links. The link ID method outlined in the Geopak Drainage manual would not connect to the proper node points on the #14 CB’s



After running the network, some warnings were found. The velocity in SS-7 can be reduced by reducing or increasing the slopes in the links. The errors concerning CB-14A and 14 B can be ignored since those nodes are not part of the network.

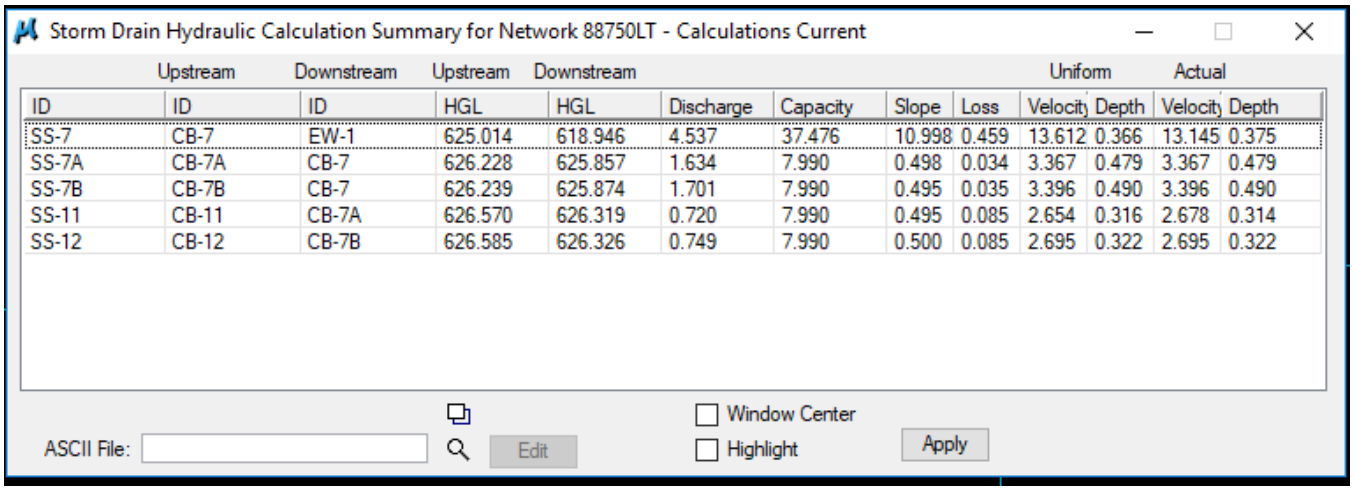
Reports>Storm Drains/Links>Link Configuration:



	Upstream	Downstream									Upstream	Downstream
ID	ID	ID	Discharge	Length	Shape	#	Rise	Span	n	Slope	Invert	Invert
SS-7	CB-7	EW-1	4.537	46.000	Circul	1	1.500	n/a	0.013	11.000	623.631	618.571
SS-7A	CB-7A	CB-7	1.634	59.150	Circul	1	1.500	n/a	0.013	0.500	625.674	625.379
SS-7B	CB-7B	CB-7	1.701	57.980	Circul	1	1.500	n/a	0.013	0.500	625.674	625.384
SS-11	CB-11	CB-7A	0.720	26.850	Circul	1	1.500	n/a	0.013	0.500	626.139	626.004
SS-12	CB-12	CB-7B	0.749	28.020	Circul	1	1.500	n/a	0.013	0.500	626.144	626.004

Checking the rise value on all links, the system designed all links at 18” so no minimum elevation settings need to be adjusted

Reports>Storm Drains/Links>Link Hydraulic Computations:

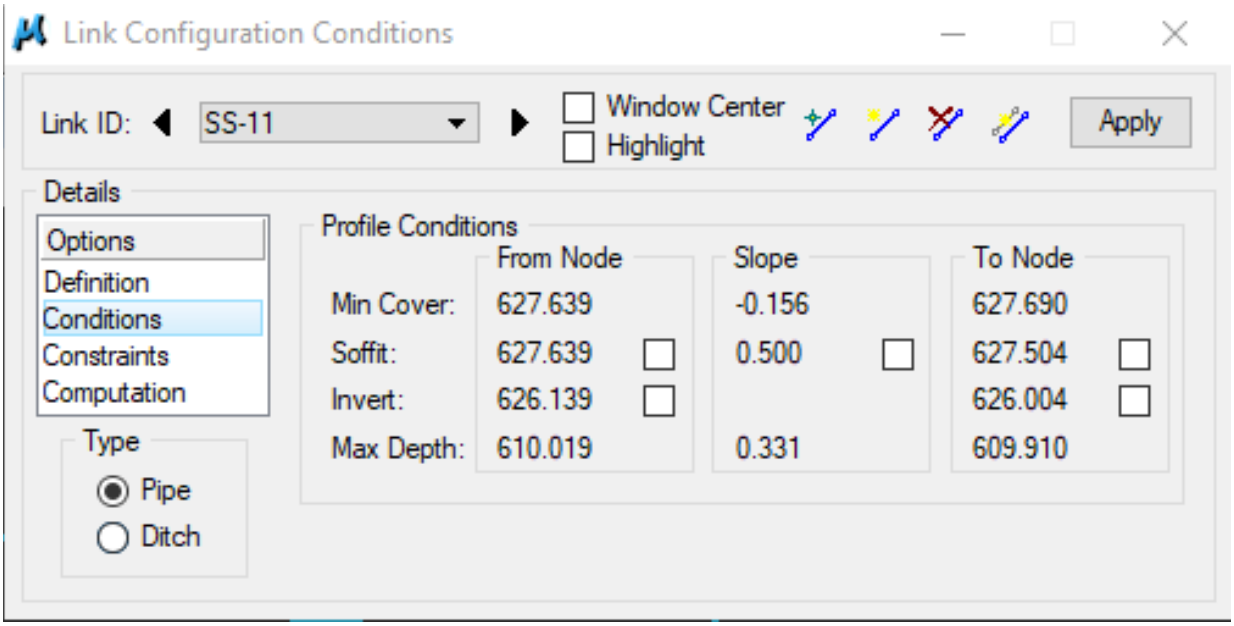


	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-7	CB-7	EW-1	625.014	618.946	4.537	37.476	10.998	0.459	13.612	0.366	13.145	0.375
SS-7A	CB-7A	CB-7	626.228	625.857	1.634	7.990	0.498	0.034	3.367	0.479	3.367	0.479
SS-7B	CB-7B	CB-7	626.239	625.874	1.701	7.990	0.495	0.035	3.396	0.490	3.396	0.490
SS-11	CB-11	CB-7A	626.570	626.319	0.720	7.990	0.495	0.085	2.654	0.316	2.678	0.314
SS-12	CB-12	CB-7B	626.585	626.326	0.749	7.990	0.500	0.085	2.695	0.322	2.695	0.322

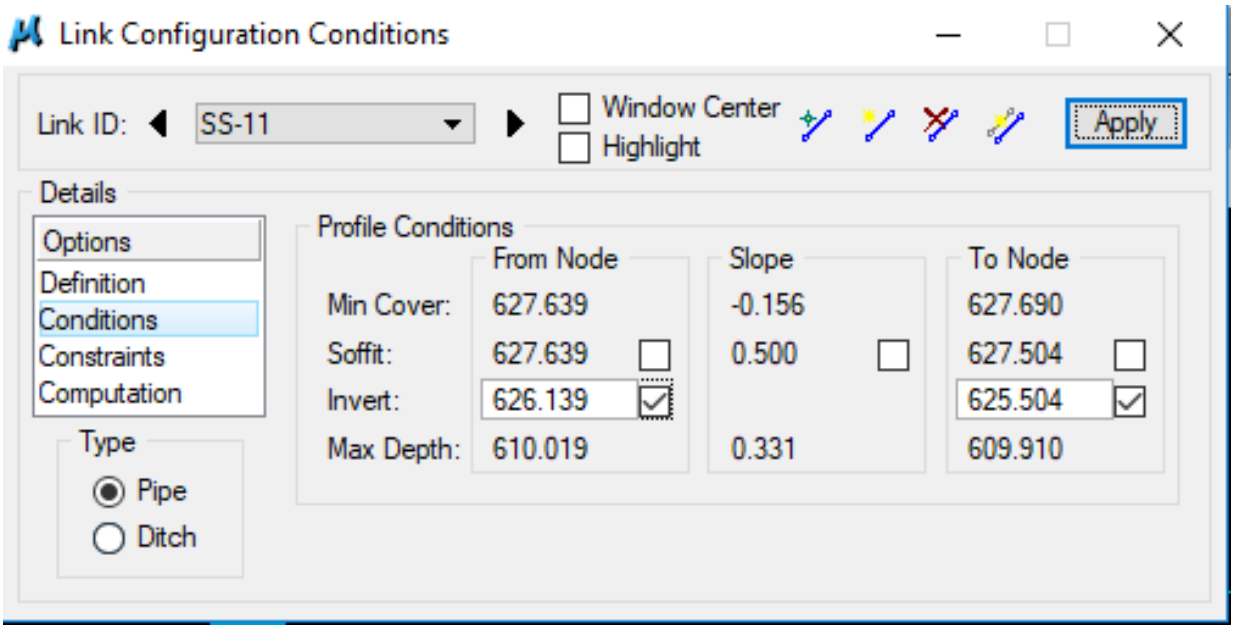
The velocity in SS-7 is greater than the maximum value of 12 and the velocities in links SS-11 and SS-12 are slightly under the minimum value of 3.

The slope on SS-11 and SS-12 is .5%, the minimum value, so it can be increased by lowering the invert elevations

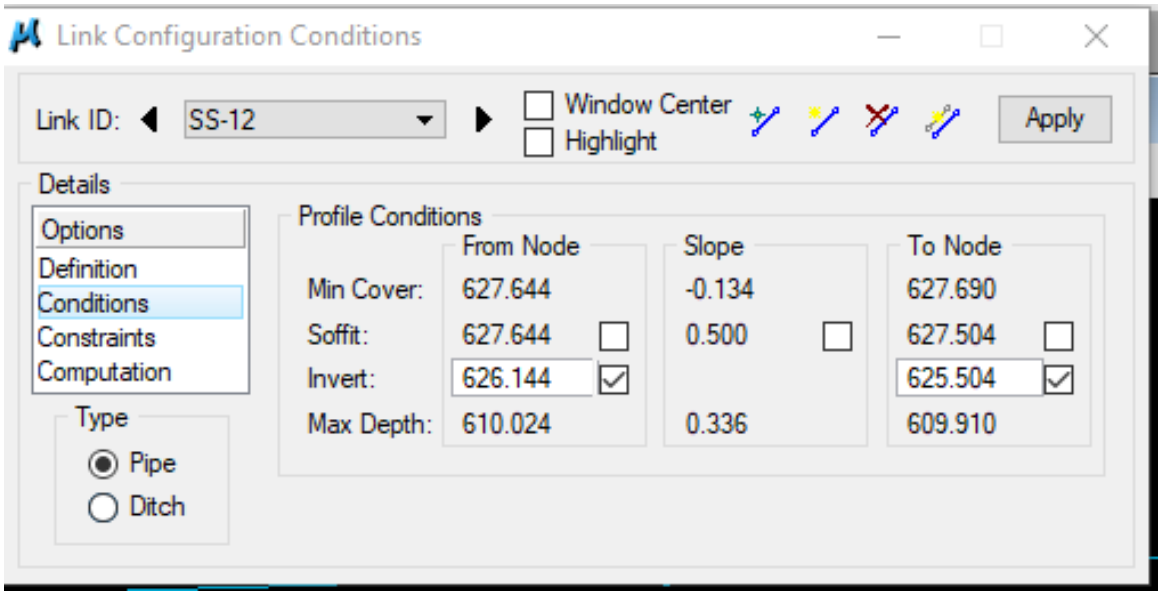
SS-11 current settings:



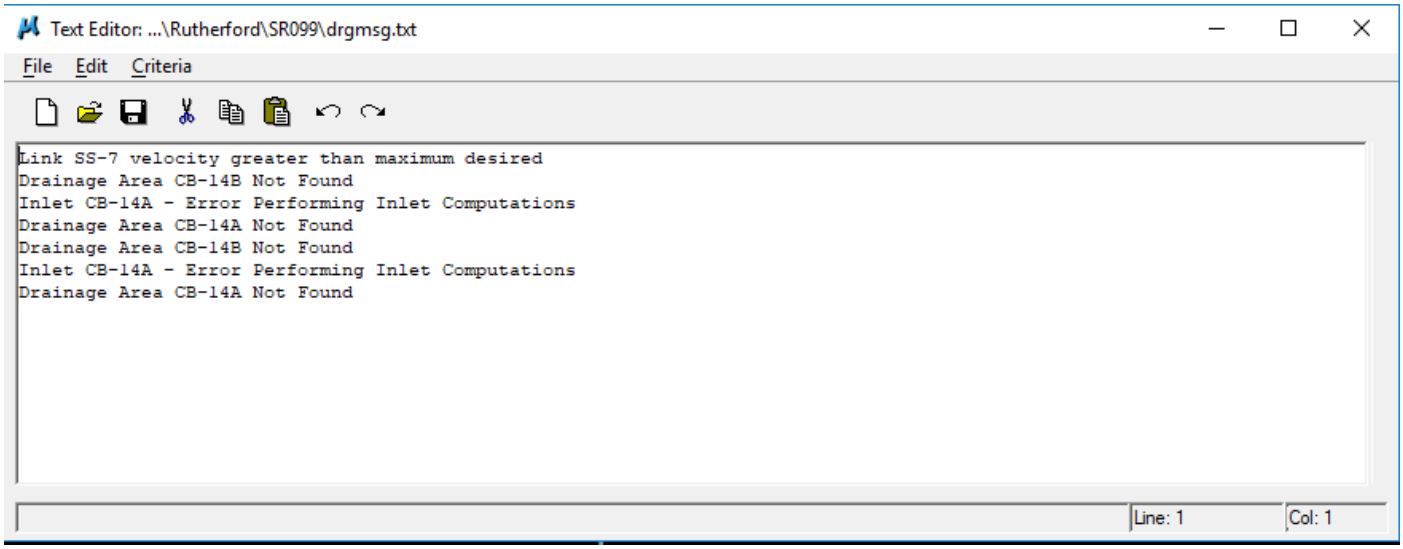
Lower the outlet invert by .5 and fix both upper and lower inverts:



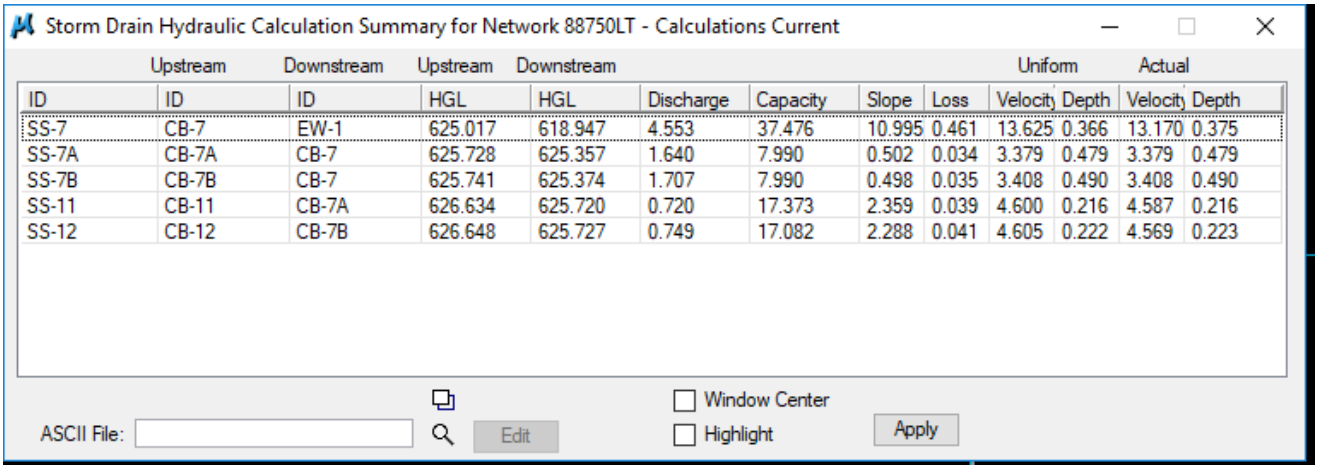
For SS-12, do the same:



Re-run Network:

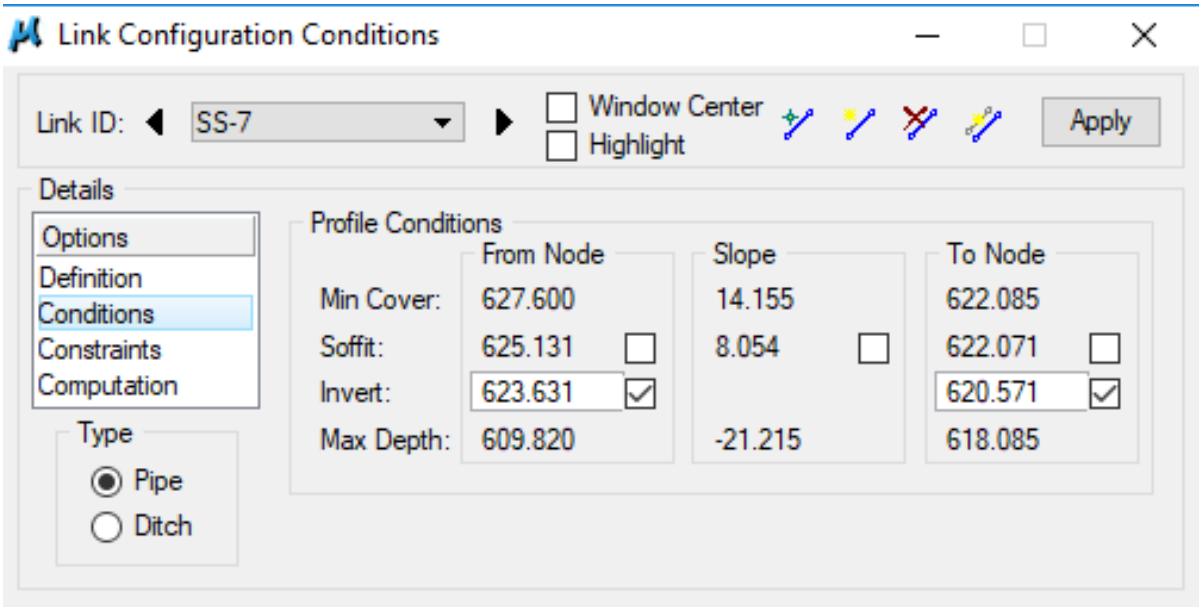


Reports>Storm Drains/Links>Link Hydraulic Computations:



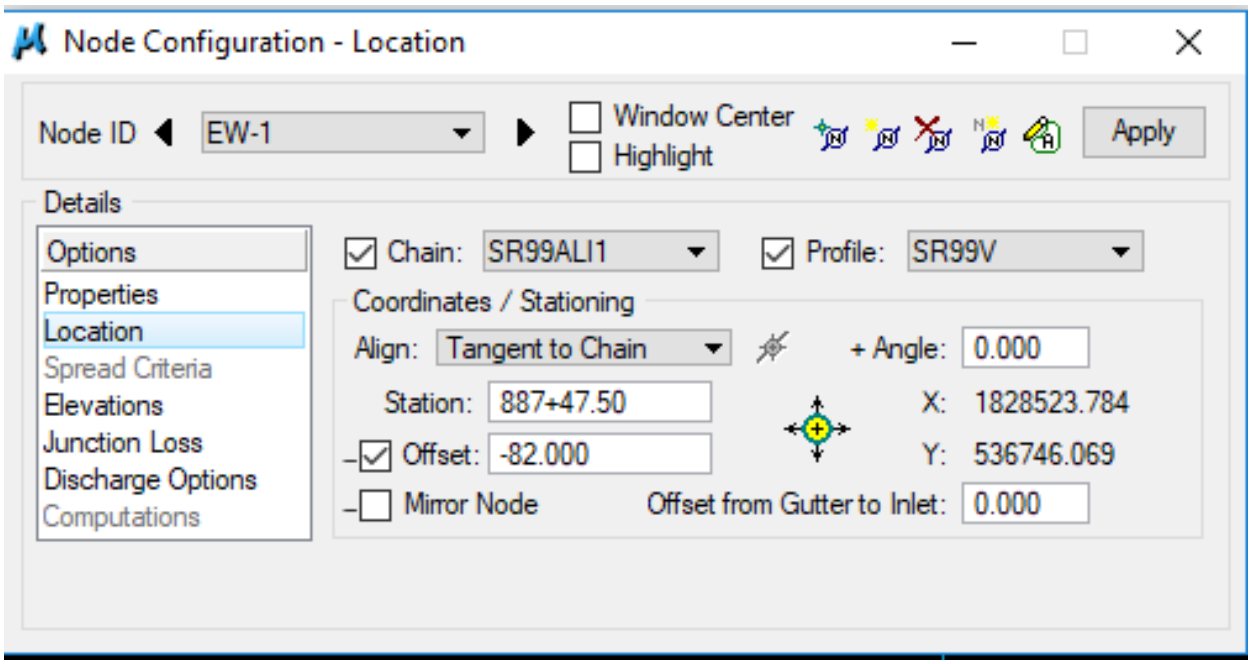
The velocities have been corrected in SS-11 and SS-12 ,but SS-7 is still over the maximum

Edit link SS-7:

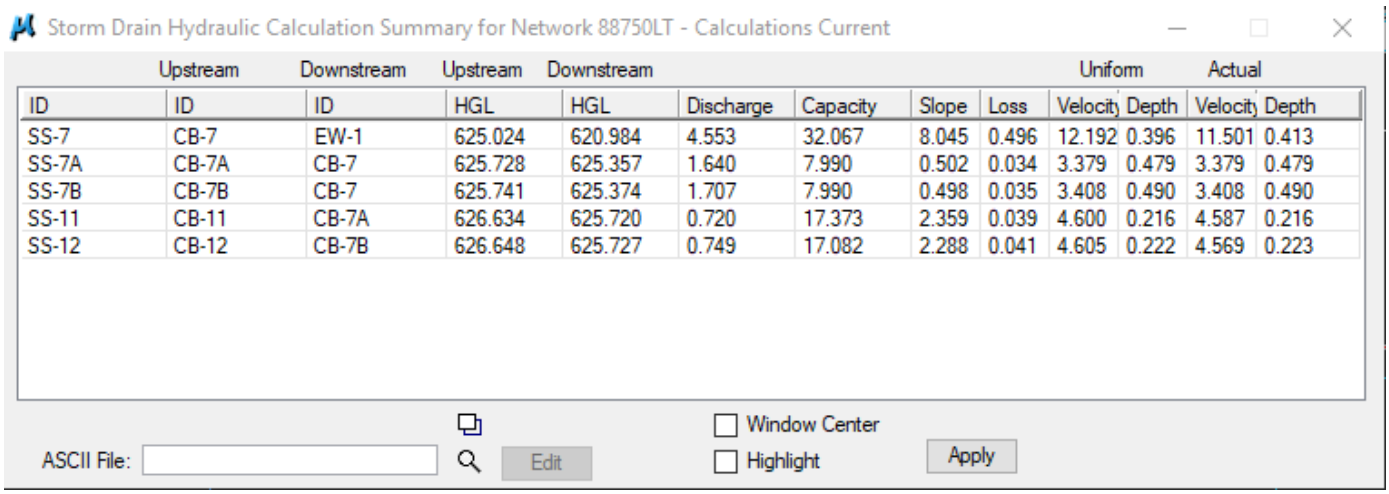


The lower invert has been raised 2’ (was 618.571), and both upper and lower inverts elevation fixed

In addition, change the offset on EW-1 from -90 to -86 (1’ vertical change on 4:1 slope):



After running the network again, the velocity in SS-7 is now 11.5, this is under the maximum:



Making these corrections is a trial and error procedure and several guesses may need to be made to make all the numbers come out right

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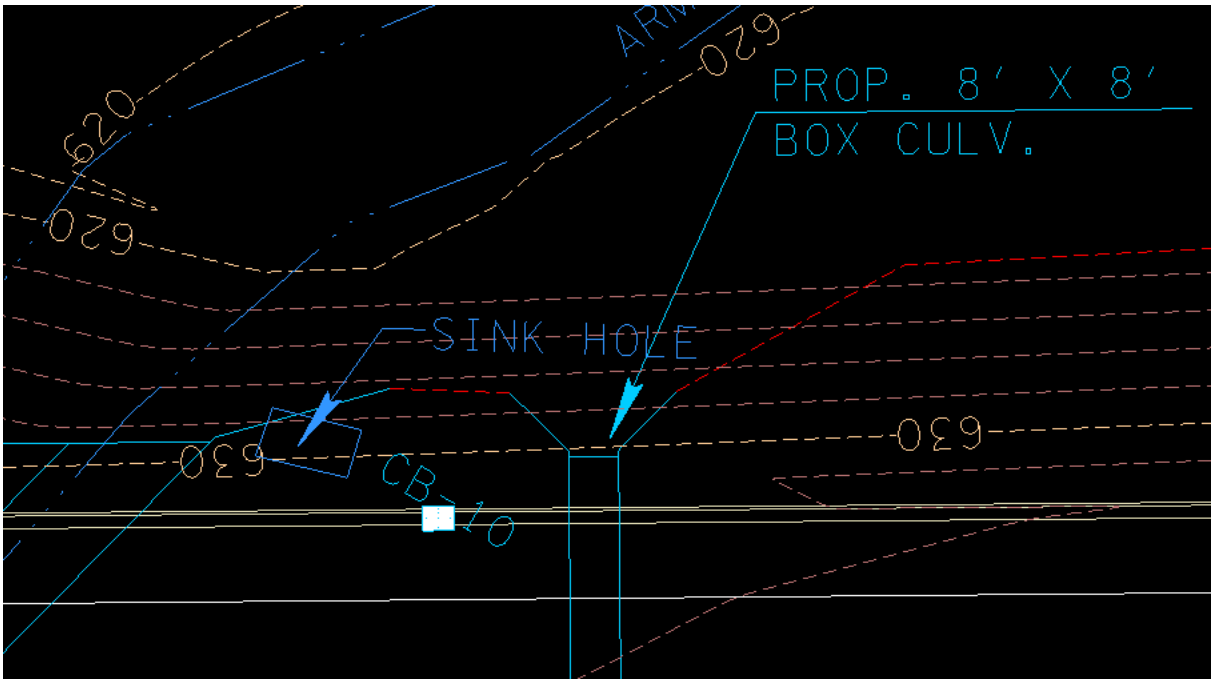
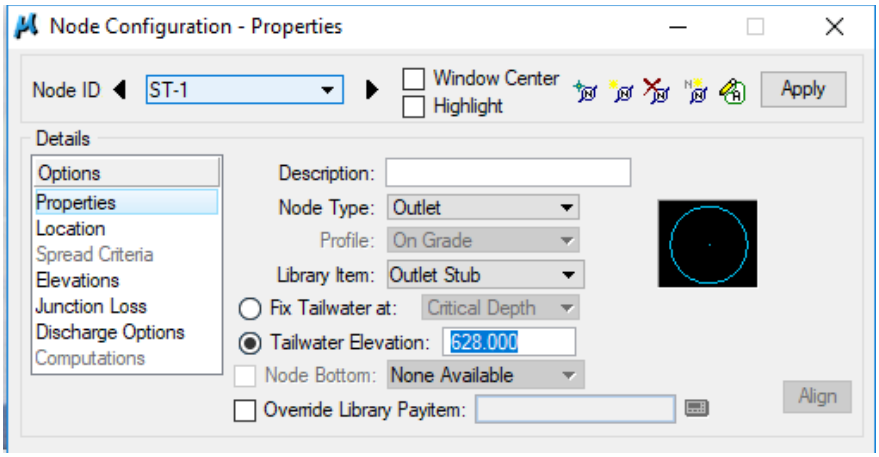
Other Networks:

2) CB-10 (889+75 Lt.)

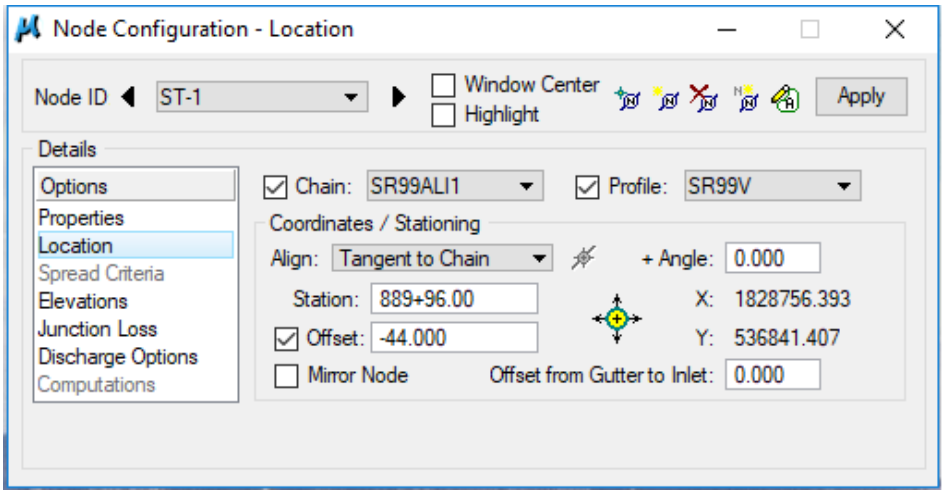


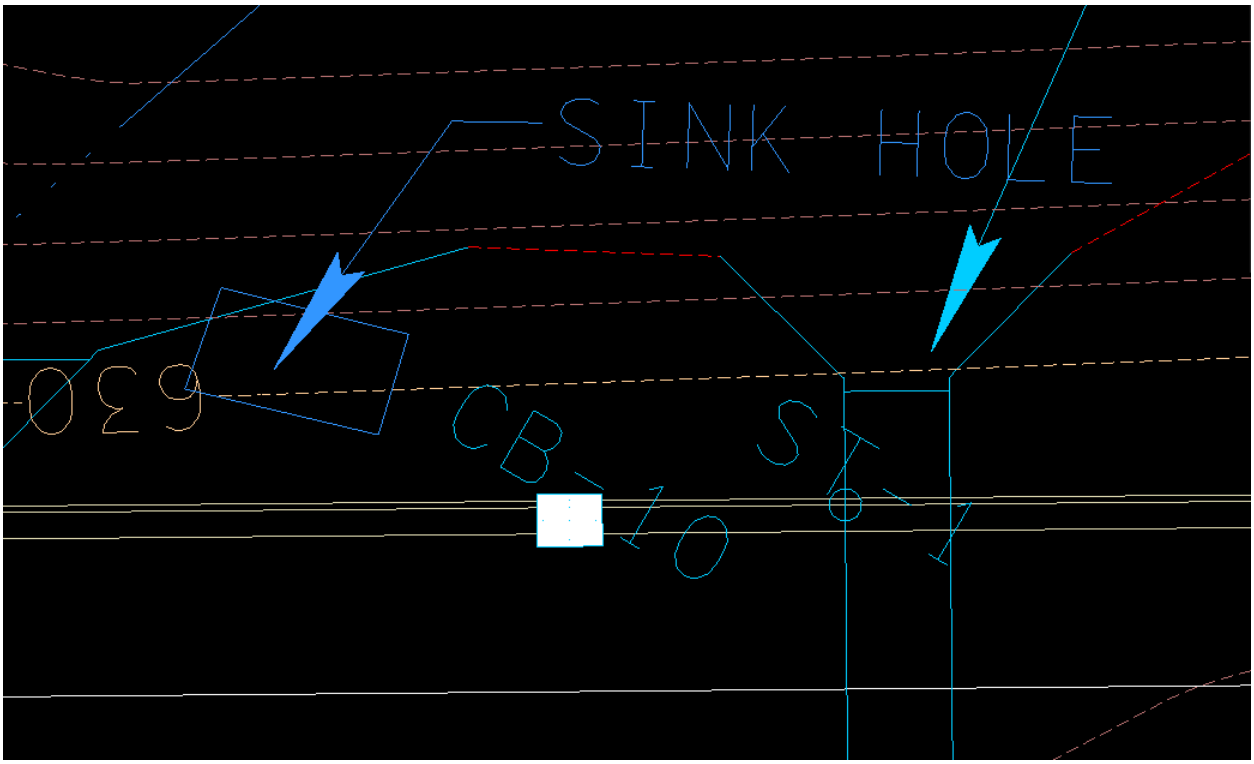
The location of this catch basin between the box bridge and the box culvert dictates that this one will stand by itself. The outlet can be located either at the toe of slope or stub into the box culvert. One other thing to consider when deciding on an outlet is the elevation relative to the bottom of the catch basin. Thr grate elevation of CB-10 is 630.875. the bottom of the CB is 626.995 (630.875-2.38-1.5). The elevation of the toe of slope is 626.67. The bottom of the box culvert is 621.50. The stub elevation would be 622..50 or above.

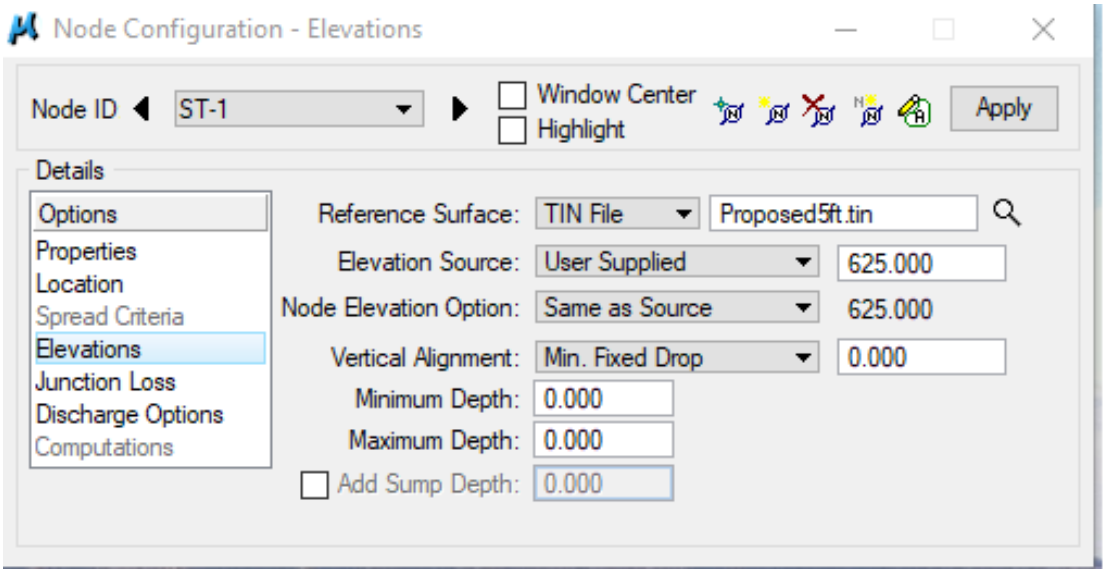
Locate stub “ST-1”



From the grade approval letter (Appendix B), 100 yr water elevation for the box culvert at 889+00 is 629.28. for 10 yr ,assume to be 628.00.





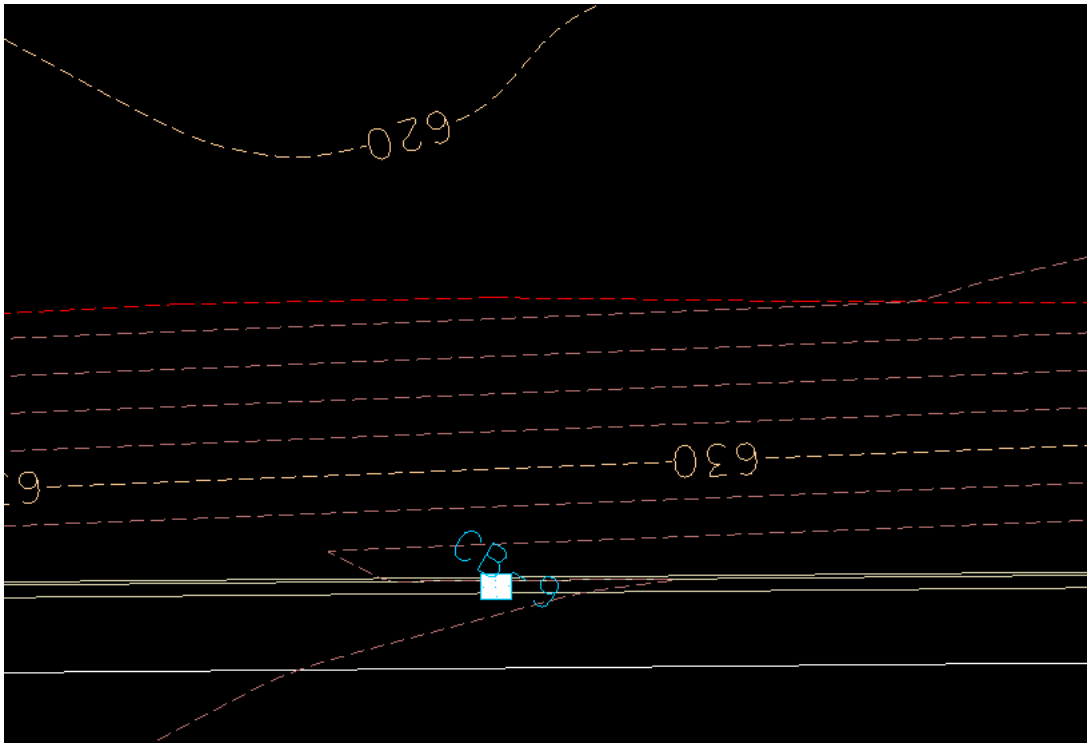


Pick 625.00 for the outlet elevation it can be adjusted later if need be

Then locate link SS-10 from CB-10 to ST-1

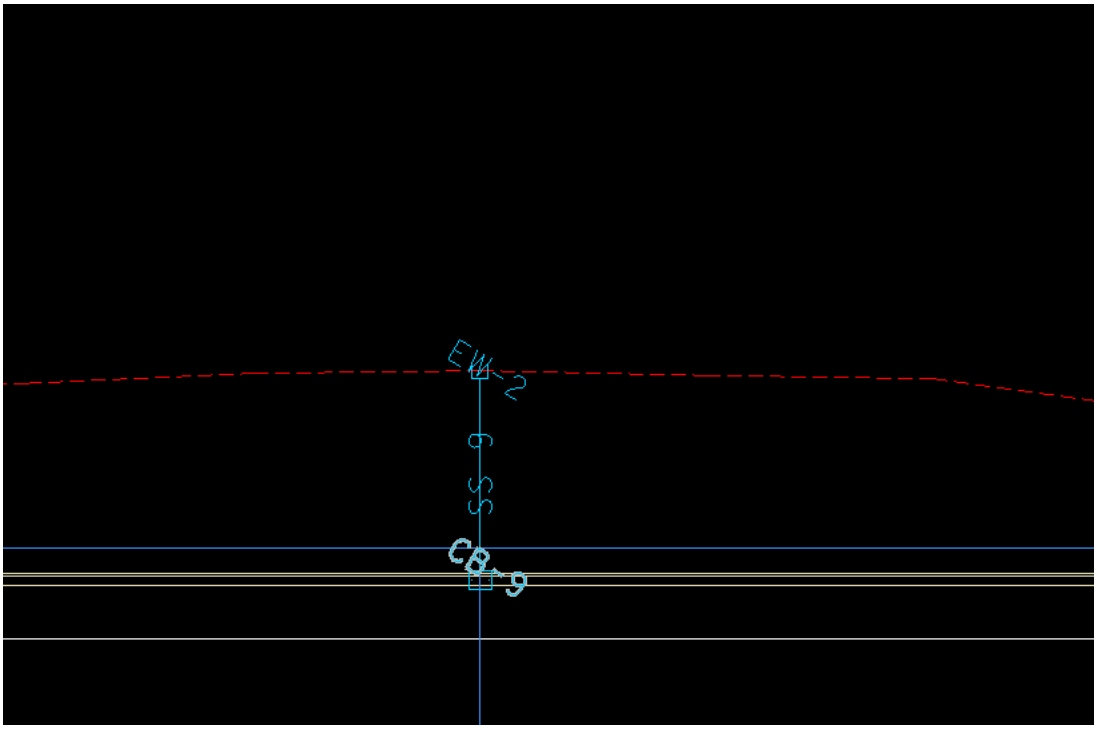
Network name could be 89000LT, outlet ST-1

3) CB-9 (892+50 Lt.)



This one also will most likely stand by itself. It is the last CB before the high point around Sta. 895+50. It can outlet at the toe of slope.
Bottom CB elev. 629.812
Outlet el. 621.10

Locate outlet EW-2 at toe of slope
Sta. 892+50, offset -87.5
Fix Tailwater at Critical Depth
Link SS-9 from CB-9 to EW-2
CB-9 Minimum depth 2.38



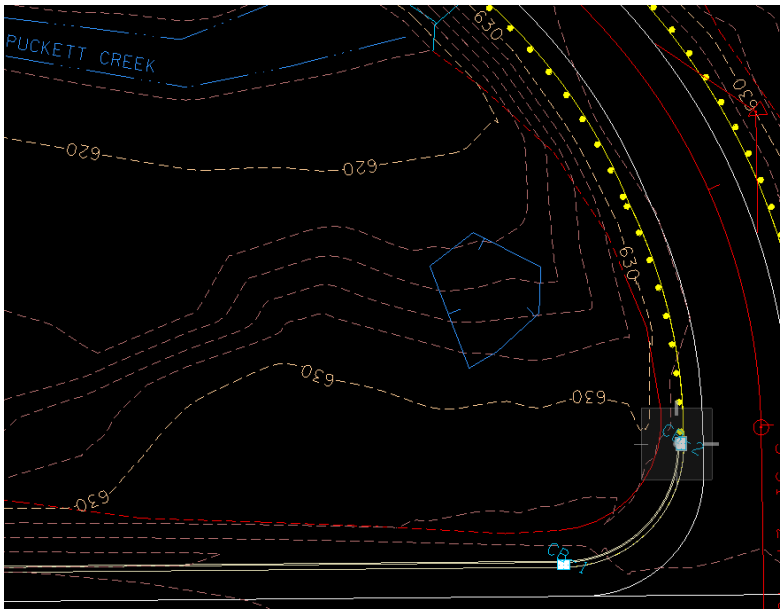
Network: 89250LT

Storm Drain Hydraulic Calculation Summary for Network 89250LT - Calculations Current

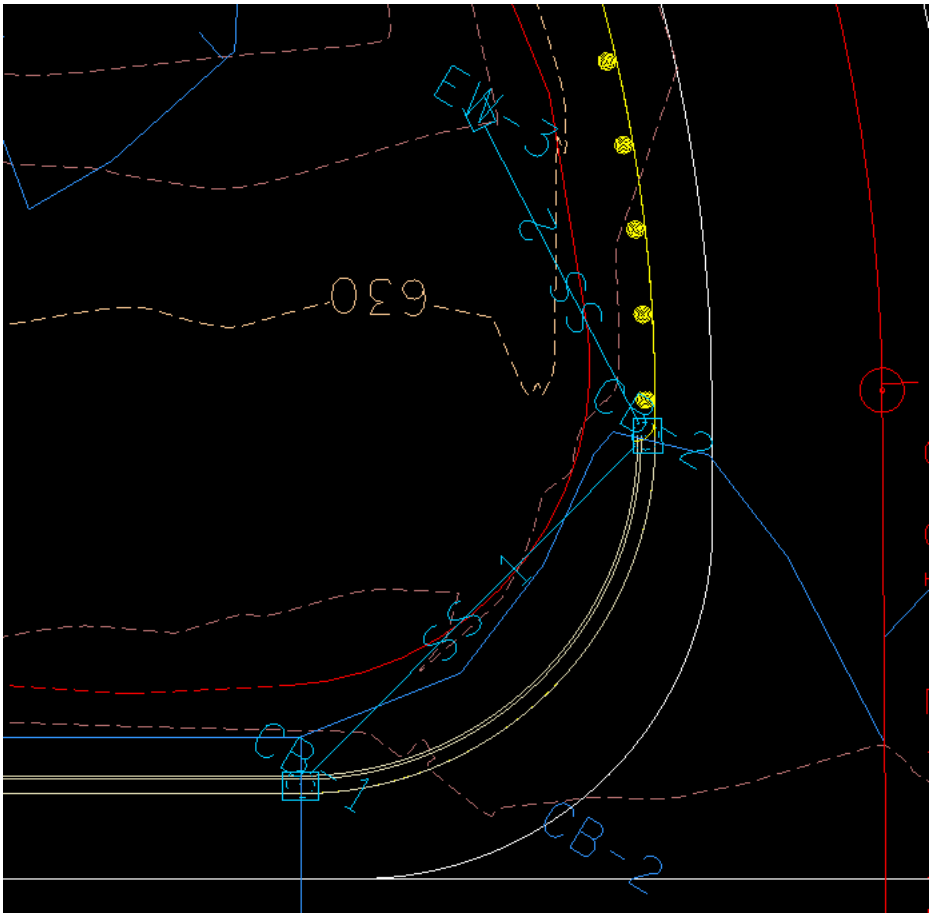
	Upstream	Downstream	Upstream	Downstream					Uniform	Actual
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity Depth	Velocity Depth
SS-9	CB-9	EW-2	625.455	620.188	1.942	37.476	11.000	0.093	10.612 0.240	10.497 0.242

ASCII File: Edit Window Center Highlight Apply

4) CB-1 and CB-2 (898+25 Lt.)



Bottom CB elev. (min. Depth)
CB-1 630.130
CB-2 628.613
The outlet can be located out from CB-2 toward Puckett Creek (EW-3)
Outlet el. < 627.00
Change CB-1 and CB-2 to CB#12 4' DIA, CB-1 Minimum Depth to 2.38
Link SS-1, CB-1 to CB-2
Link SS-2, CB-2 to EW-3



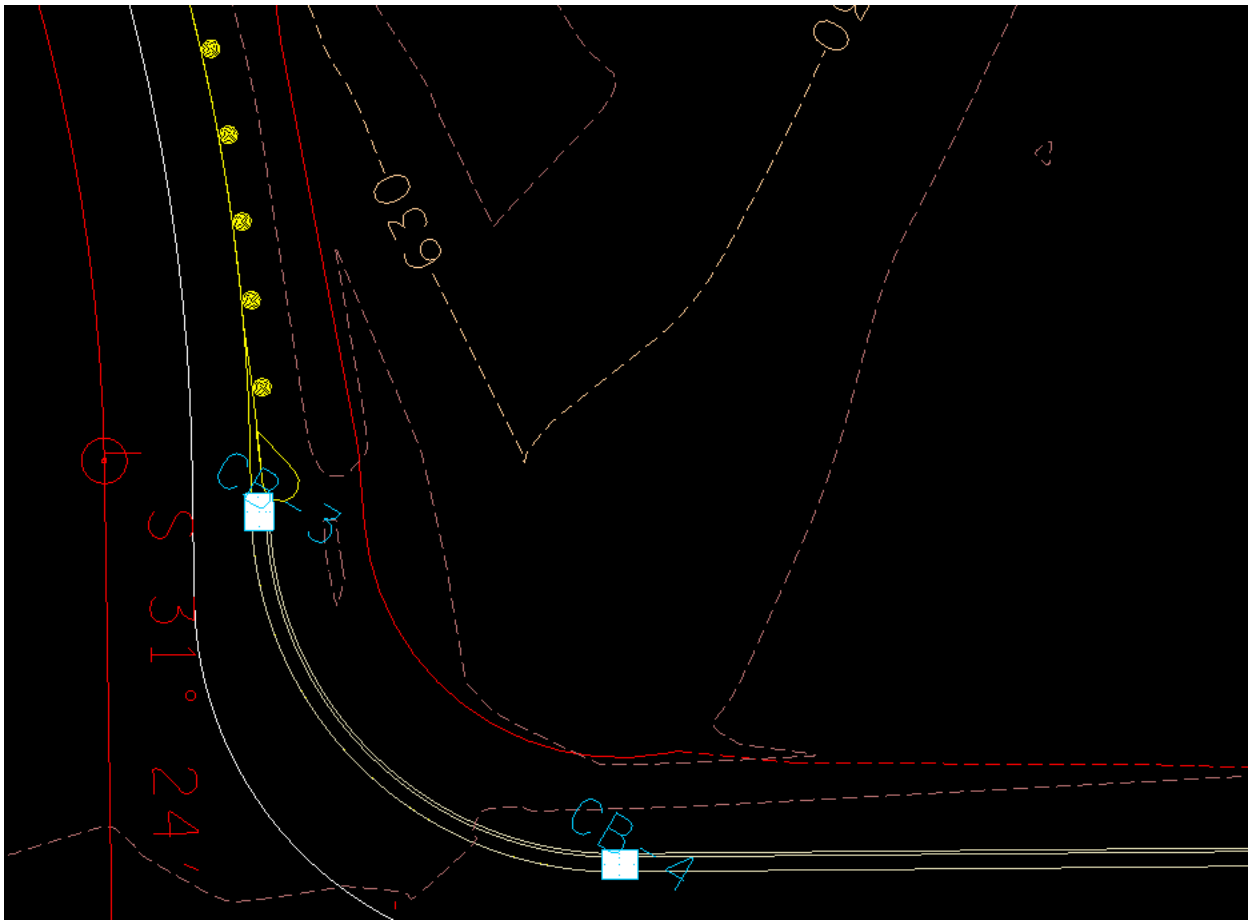
Network: 89850LT

Storm Drain Hydraulic Calculation Summary for Network 89850LT - Calculations Current

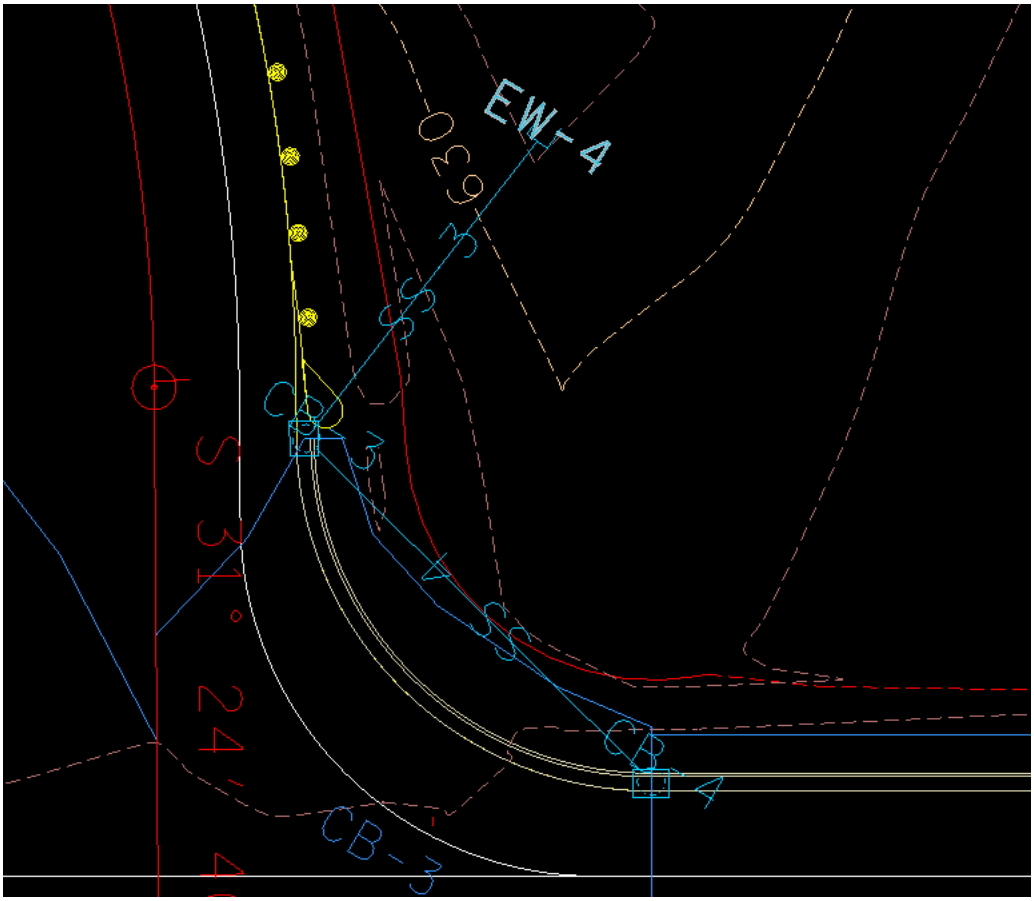
	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-2	CB-2	EW-3	629.488	626.869	2.294	23.695	4.398	0.214	8.067	0.327	7.949	0.330
SS-1	CB-1	CB-2	630.795	629.111	1.582	16.262	2.081	0.110	5.552	0.327	5.524	0.328

ASCII File: Edit Window Center Highlight Apply

5) CB-3 and CB-4 (899+75 Lt.)



Bottom CB elev. (min. depth)
CB-3 629.047
CB-4 630.065
The outlet can be located out from CB-3 toward Puckett Creek (EW-4)
Outlet el. < 627.00
Change CB-3 and CB-4 to CB#12 4' DIA, CB-4 Minimum Depth to 2.38
Link SS-4, CB-4 to CB-3
Link SS-4, CB-3 to EW-4



Network: 89950LT

Storm Drain Hydraulic Calculation Summary for Network 89950LT - Calculations Current

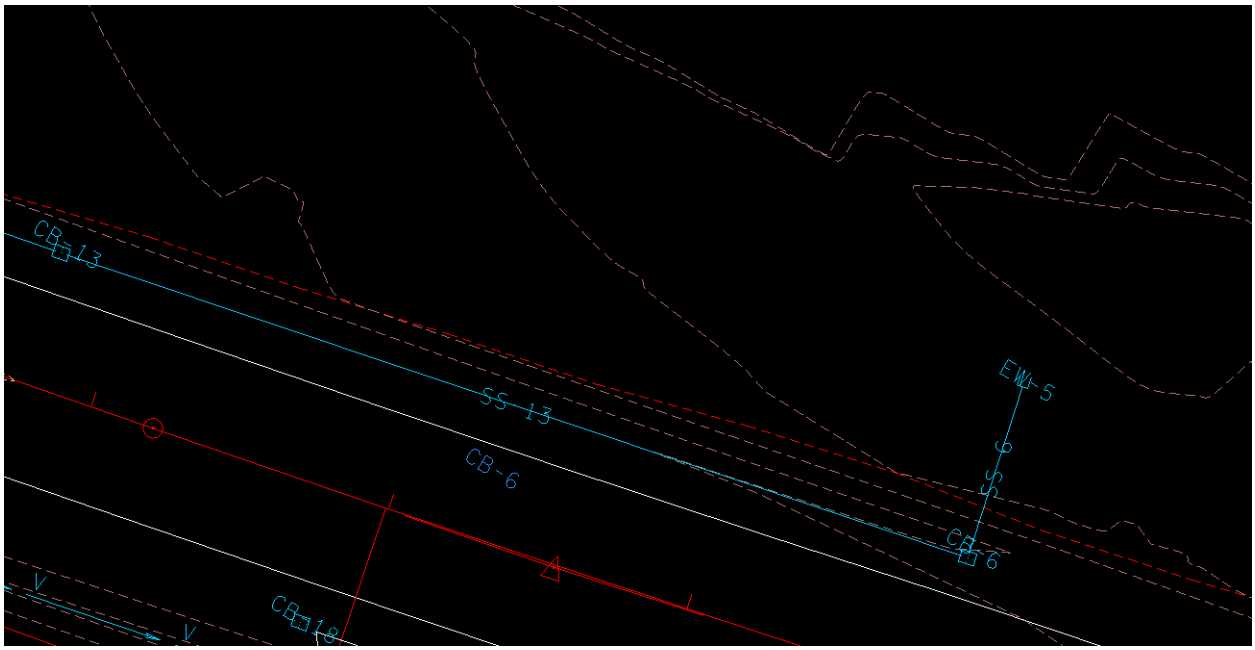
	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-3	CB-3	EW-4	629.991	626.692	2.657	25.963	5.271	0.220	8.977	0.336	8.857	0.339
SS-4	CB-4	CB-3	630.826	629.642	2.105	12.955	1.309	0.158	5.113	0.425	5.109	0.425

ASCII File: Edit Window Center Highlight Apply

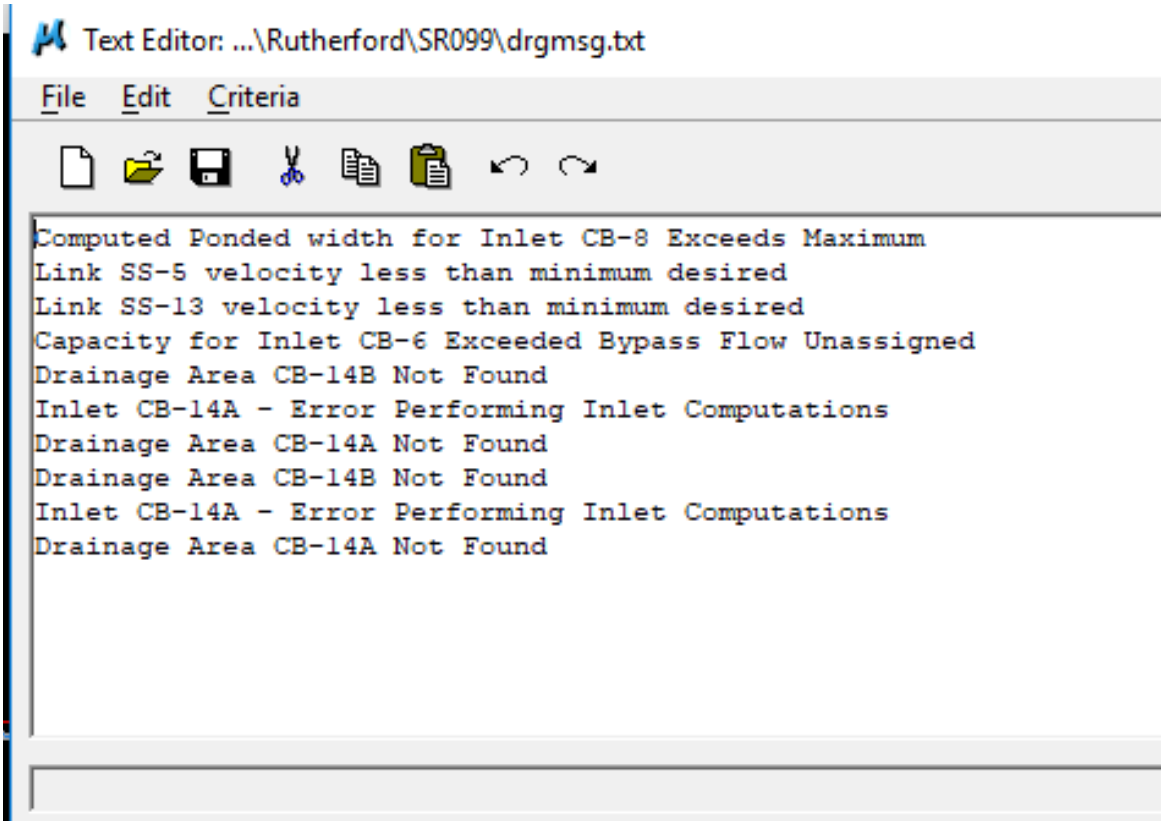
6) CB-8, CB-5, CB-13, and CB-6 (911+50 Lt. – 919+80 Lt.)
Bottom CB elev. (min. depth)

CB-8 635.512
CB-5 635.471
CB-13 634.878
CB-6 633.592

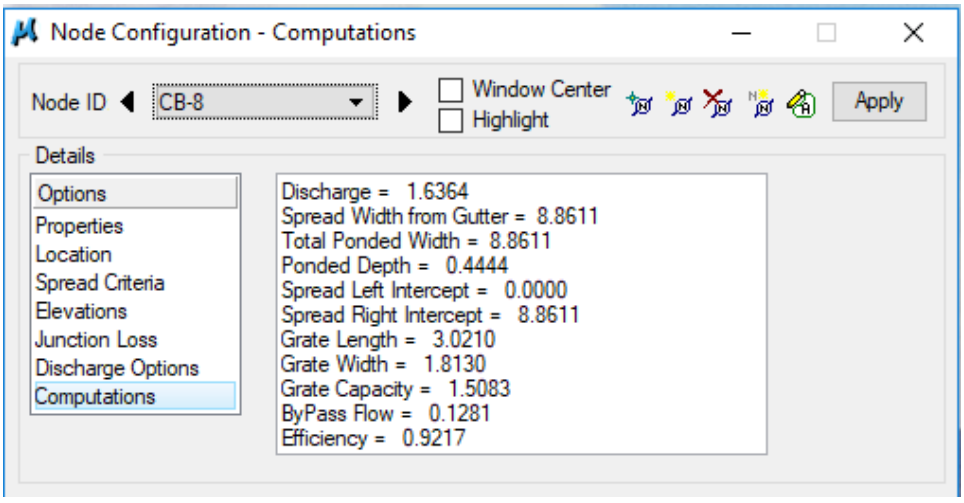
The outlet can be located out from CB-6 (EW-5)
Outlet el. < 633.00
Locate outlet EW-5 at toe of slope
Sta. 919+80, offset -100
CB-8 Minimum depth 2.38
Link SS-8, CB-8 to CB-5
Link SS-5, CB-5 to CB-13
Link SS-13, CB-13 to CB-6
Link SS-6, CB-6 to EW-5



Network: 91980LT



Check the ponding on CB-8:



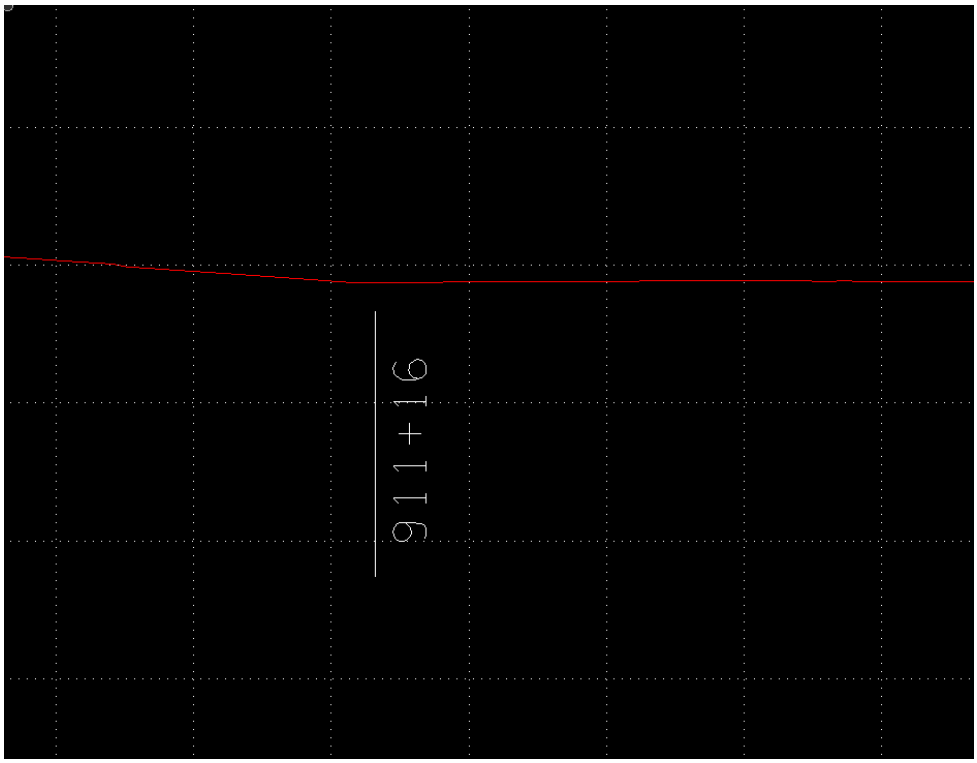
The velocities in SS-5 and SS-13:

Storm Drain Hydraulic Calculation Summary for Network 91980LT - Calculations Current

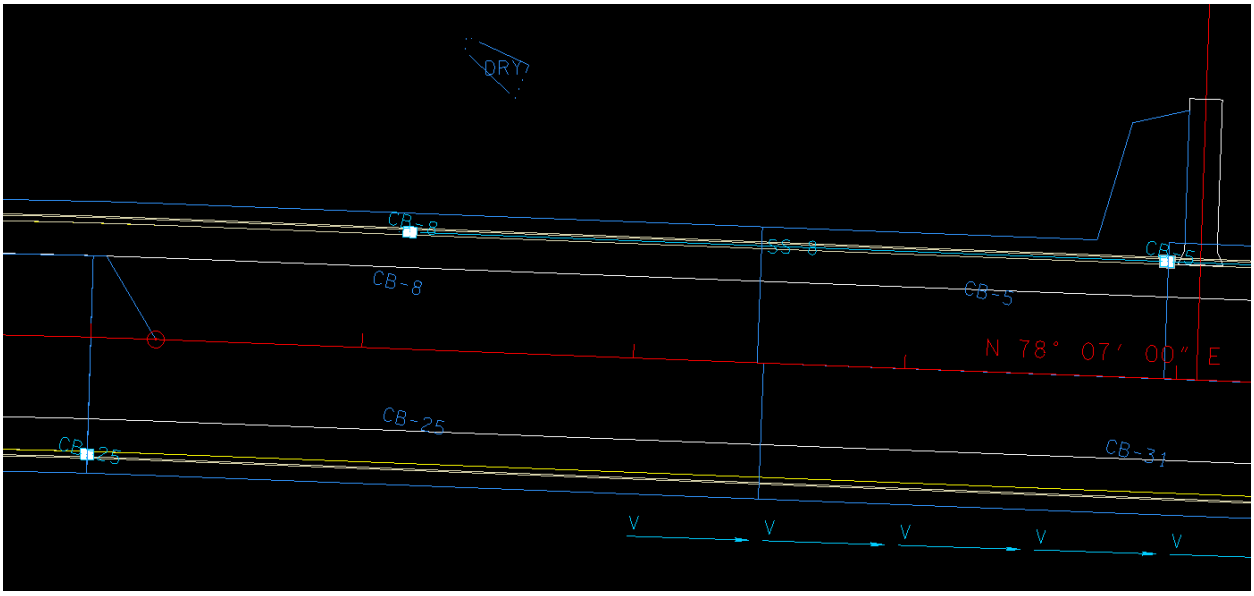
	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-6	CB-6	EW-5	633.165	631.905	5.381	11.583	1.059	0.521	6.111	0.748	6.058	0.753
SS-13	CB-13	CB-6	634.010	633.165	3.977	7.146	0.400	0.053	3.929	0.836	2.509	1.261
SS-5	CB-5	CB-13	635.064	634.010	2.526	7.146	0.407	0.032	3.526	0.638	2.931	0.735
SS-8	CB-8	CB-5	636.174	635.064	1.636	7.146	0.404	0.139	3.122	0.506	3.043	0.516

ASCII File: Edit Window Center Highlight Apply

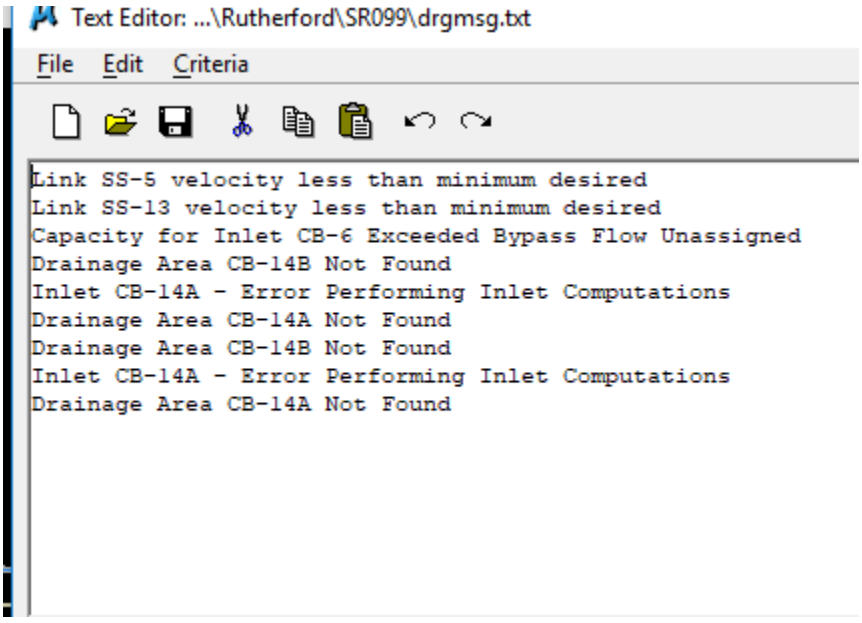
Upon closer inspection, it seems there is a dip in the left side gutter profile at the station 911+16.:



Change CB-8 to #14, relocate to 911+16, minimum depth will be 2.55 (2.22+0.33). Recalculate drainage areas:

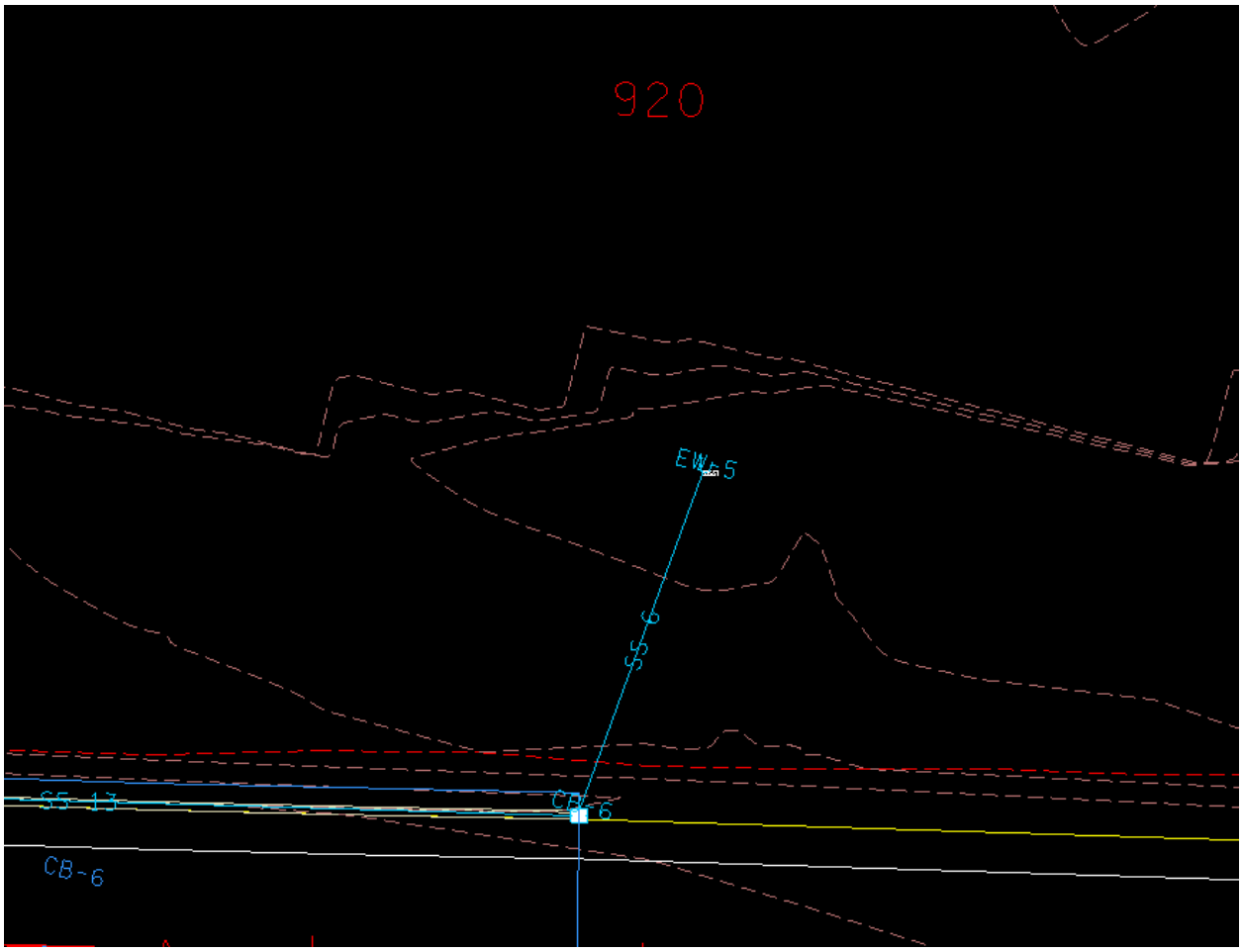


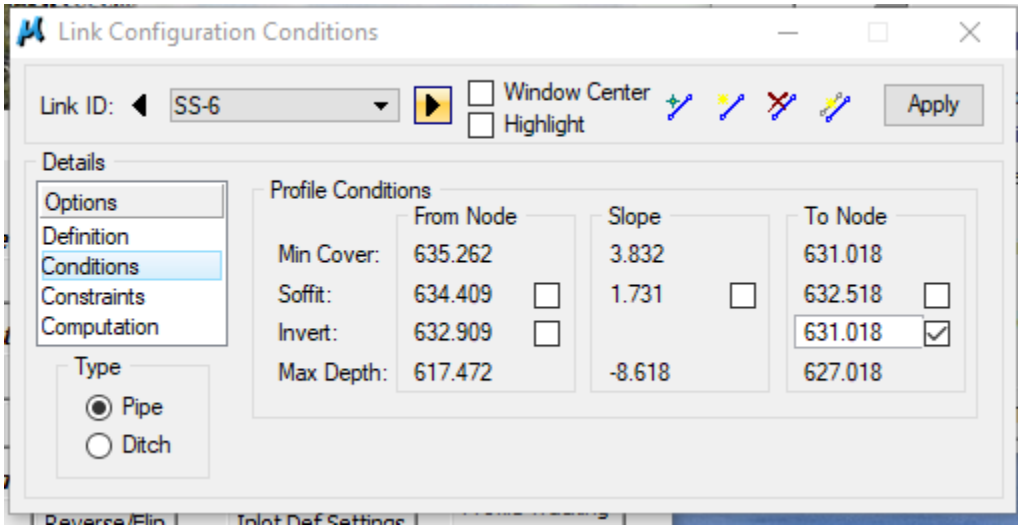
Re run Network 91980LT:



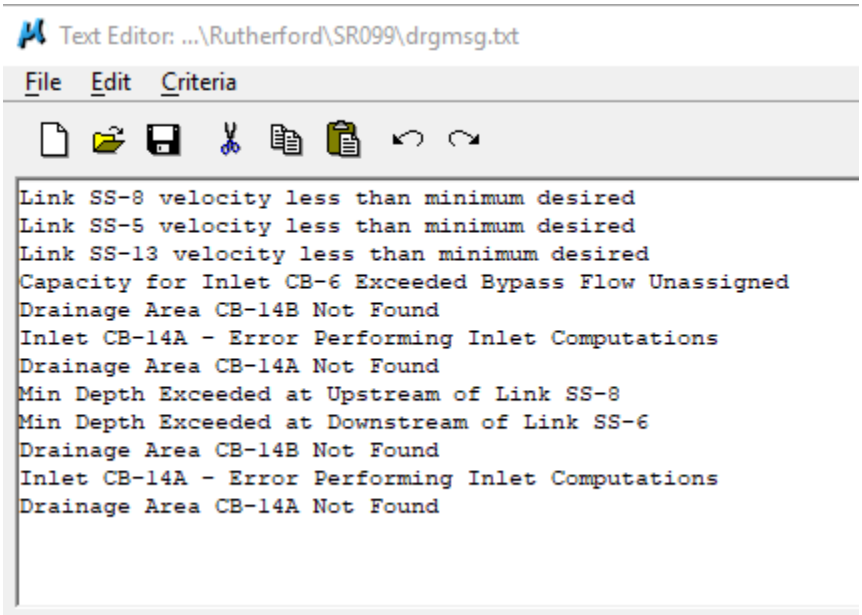
Ponding issue is solved, now to correct velocities in links SS-5 and SS-13

In addition EW-5 was moved to the low point according to the contours. This is elevation 631.02. The lower invert on link SS-2 was fixed at this elevation

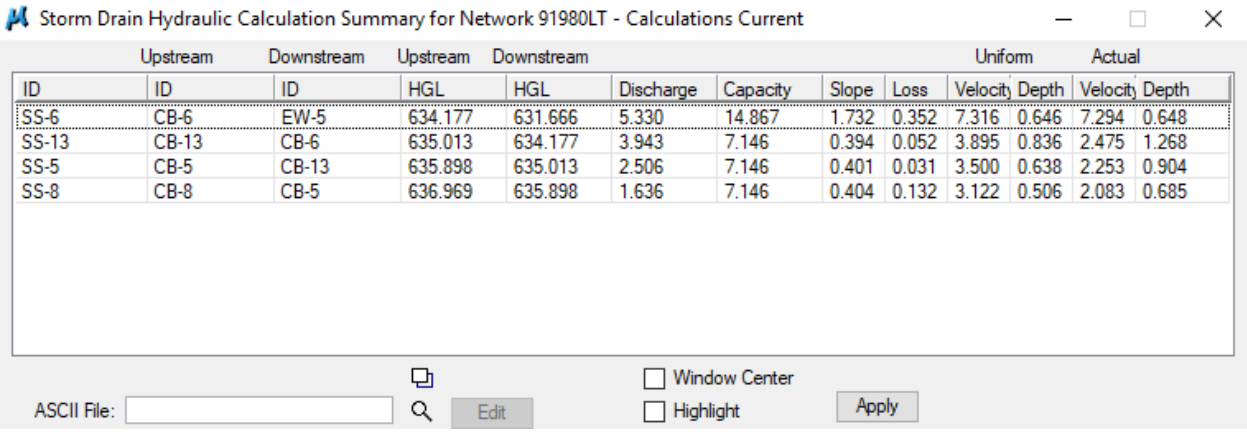




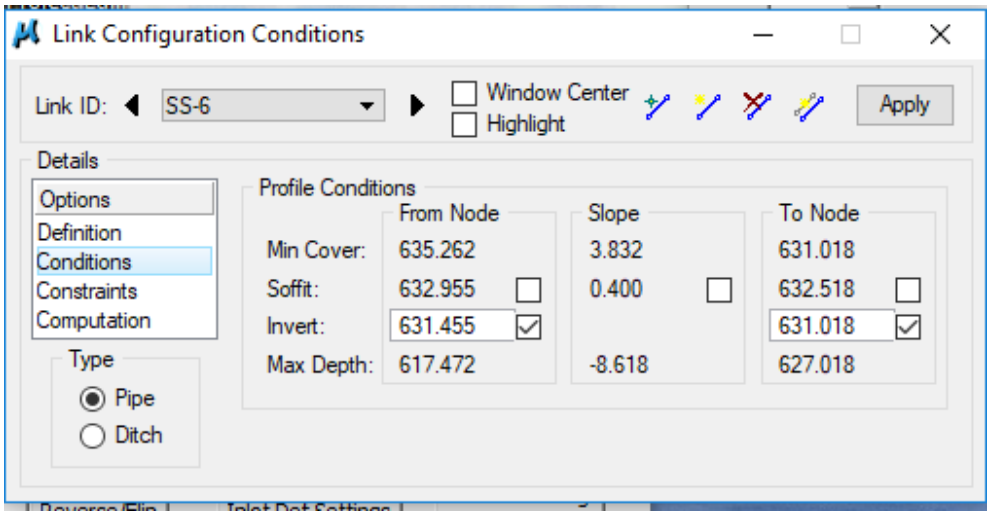
When the network is run again



Reports>Storm Drains/Links>Link Hydraulic Computations:

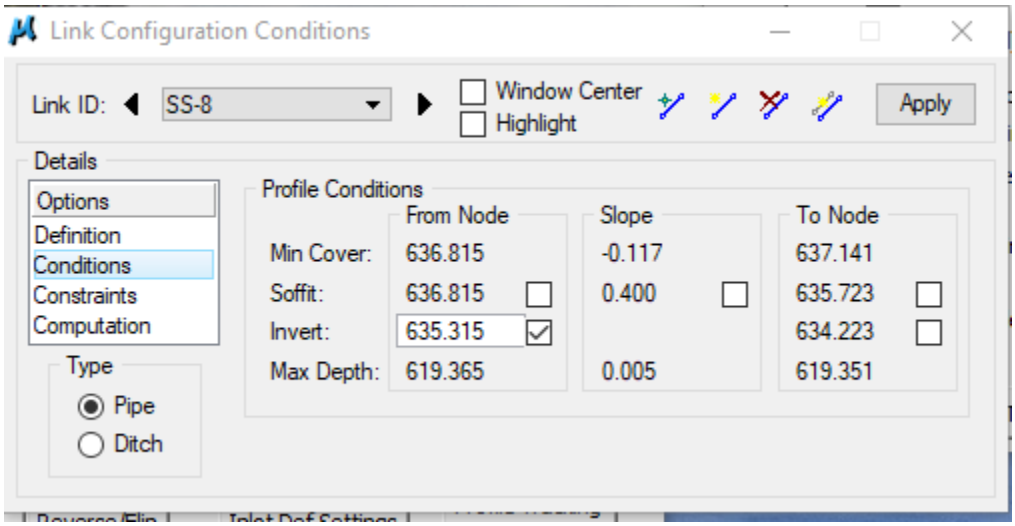


Reduce slope in SS-6 by lowering the upper invert



631.455 fixes the slope at 0.4%

On SS-8, fix the upper invert at 635.315. This is the minimum depth elevation and will eliminate the “Min Depth exceeded upstream of SS-8” error



Reports>Storm Drains/Links>Link Hydraulic Computations:

Storm Drain Hydraulic Calculation Summary for Network 91980LT - Calculations Current

	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-6	CB-6	EW-5	632.749	631.908	5.330	7.146	0.405	0.276	4.202	1.012	4.881	0.890
SS-13	CB-13	CB-6	633.683	632.749	3.943	7.146	0.394	0.052	3.895	0.836	2.666	1.170
SS-5	CB-5	CB-13	634.738	633.683	2.506	7.146	0.401	0.031	3.500	0.638	2.917	0.734
SS-8	CB-8	CB-5	635.978	634.738	1.636	7.146	0.404	0.133	3.122	0.506	3.050	0.515

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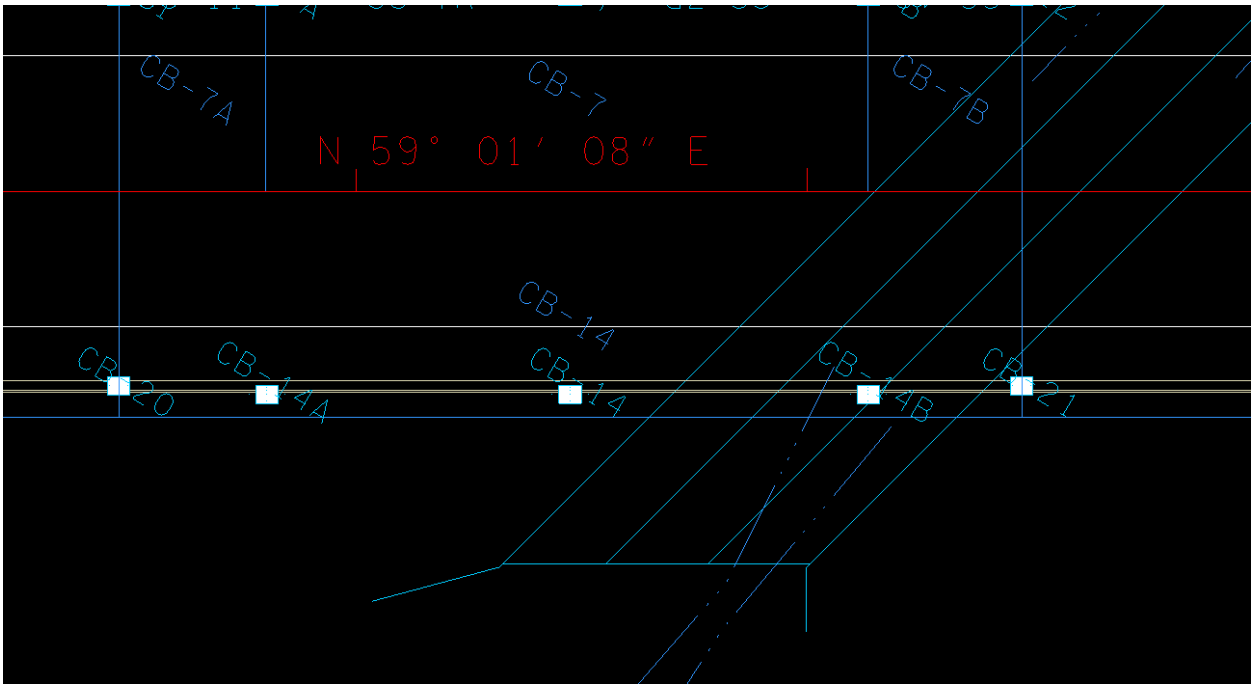
Velocities in SS-5 and SS-13 are still under the minimum allowable value, but noting that the slopes are all 0.4% there is not anything that can be done to increase the velocities.

7) CB-20, CB-14A, CB-14, CB-14-B, CB-21 (886+50 Rt. – 888+50 Rt.)



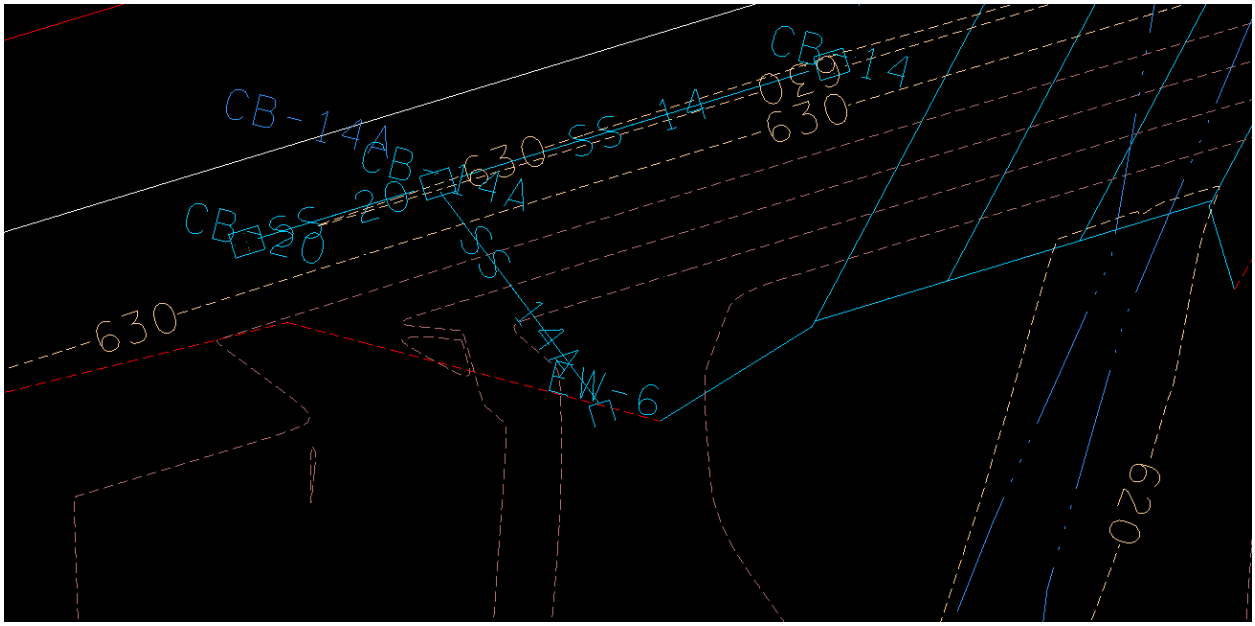
CB-14 is located on top of the propoed box bridge. There is not enough clearance elevation to allow for the minimum depth catch basin at that location, so CB-14B will have to be removed. For the same reason CB-21 will not be able to connect to the other catch basins. It can connect and form a network with the next catch basin CB-22.

Bottom CB elev. (min. depth)

CB-20	626.311
CB-14	626.099
CB-14A	626.190

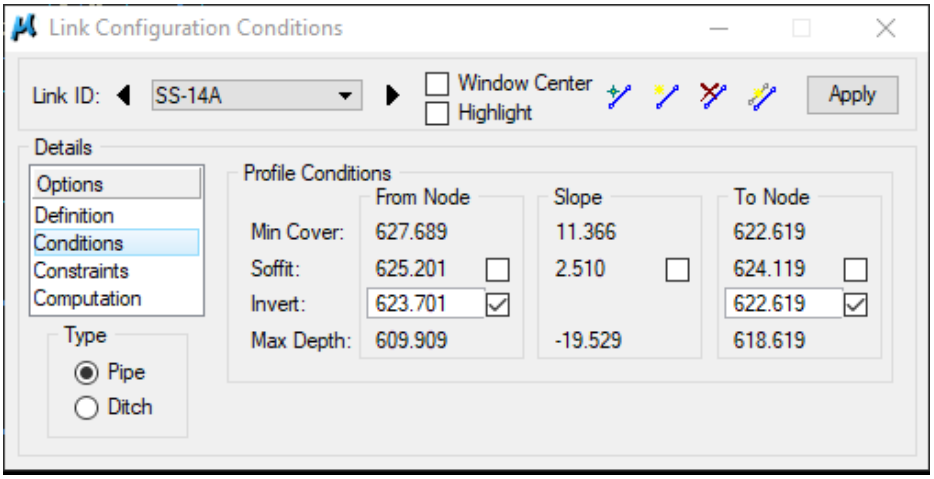
The outlet (EW-6) can be located out from CB-14A
Station 886+95
Offset 85, el. < 625.00

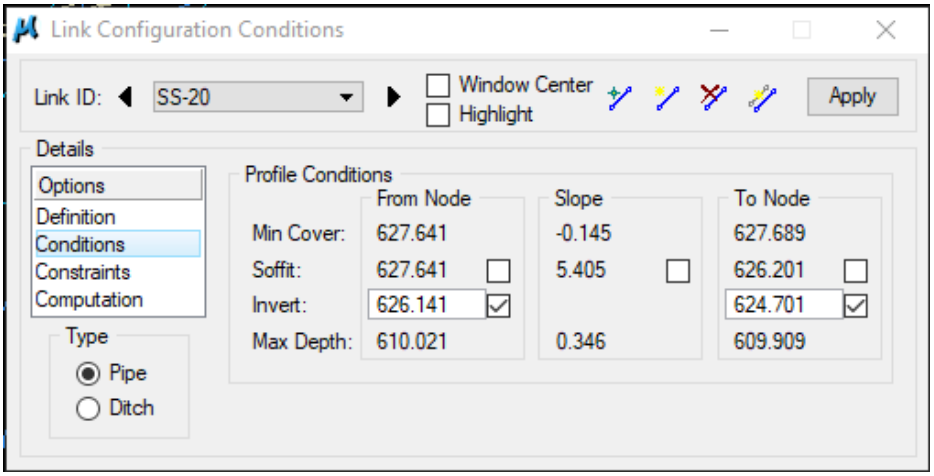
Link SS-20, CB-20 to CB-14A
Link SS-14, CB-14 to CB-14A
Link SS-14A, CB-14A to EW-6
CB-20 Min Depth, 2.38
CB-14 Min Depth, 2.55

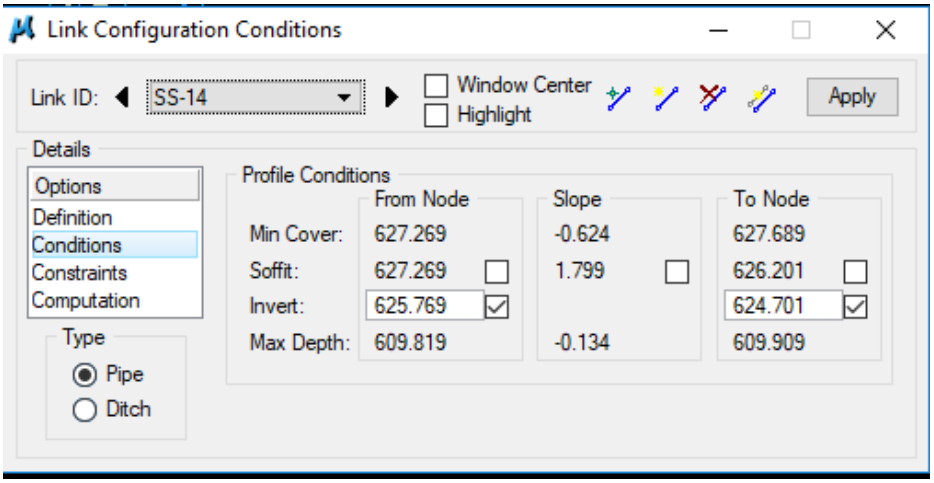


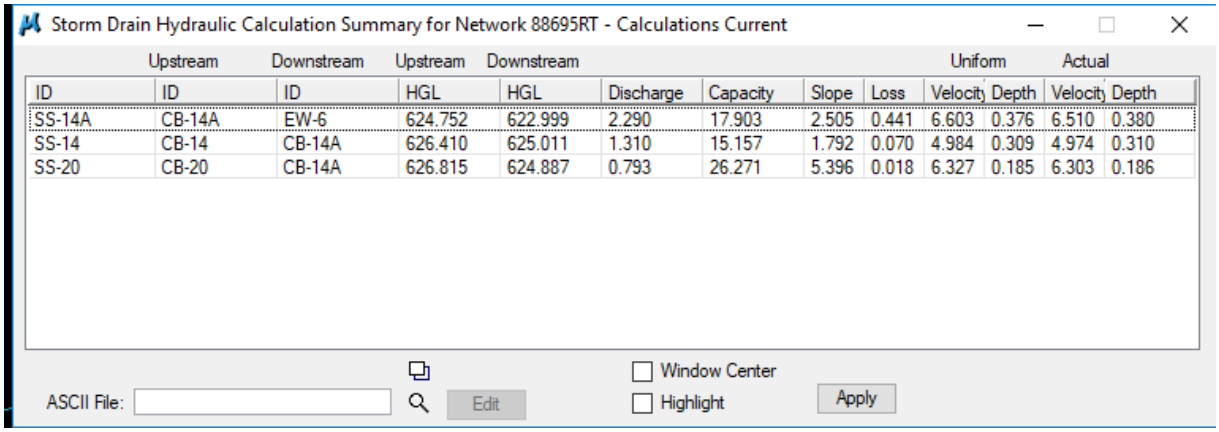
Network:88695RT

Upon running the network, the velocities in SS-20 and SS-14 were below the minimum value. This was fixed by increasing the slopes in those two links and decreasing the slope in SS-14A





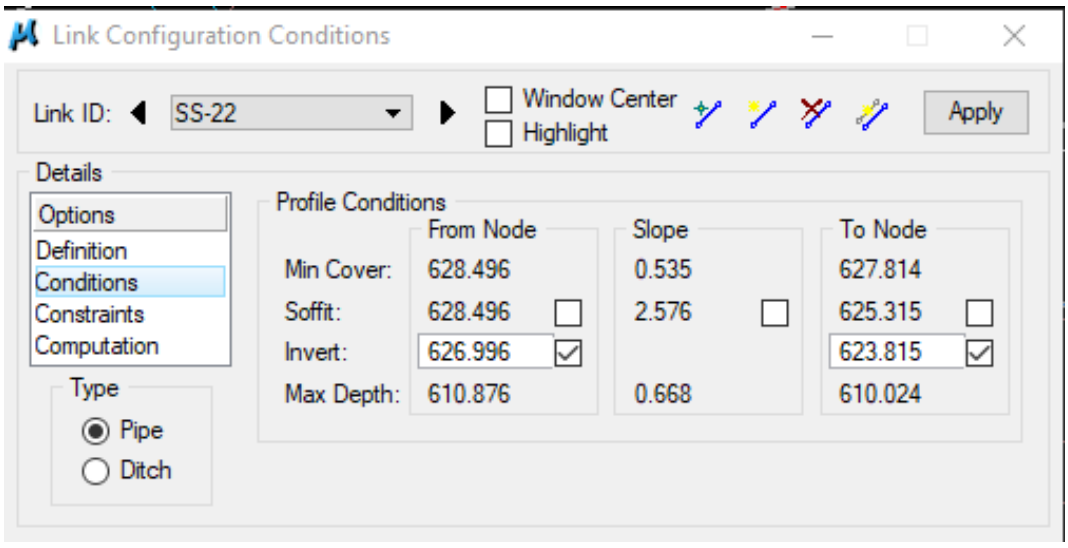


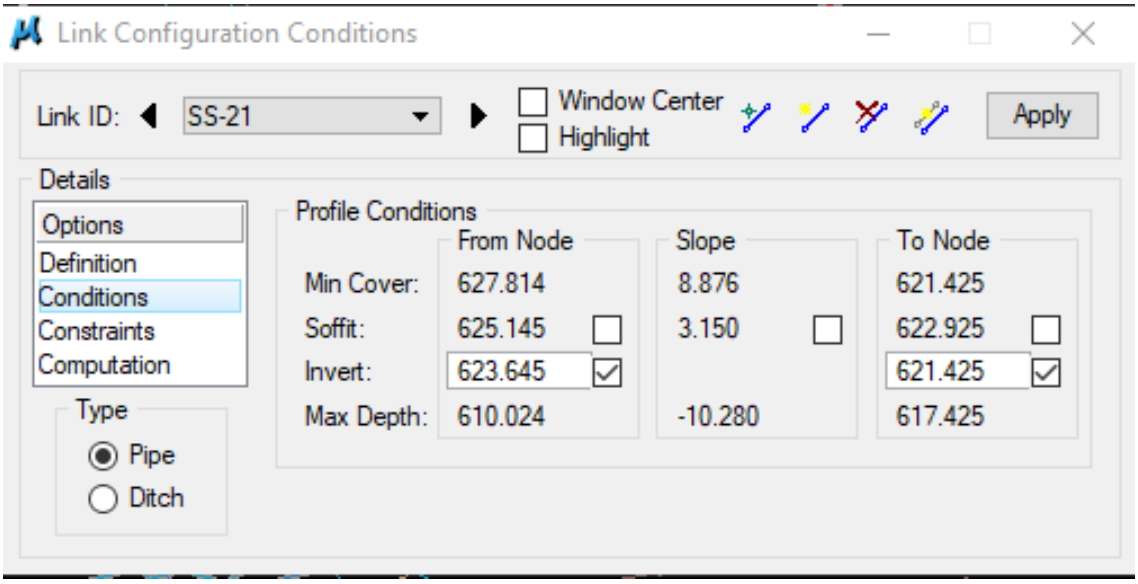


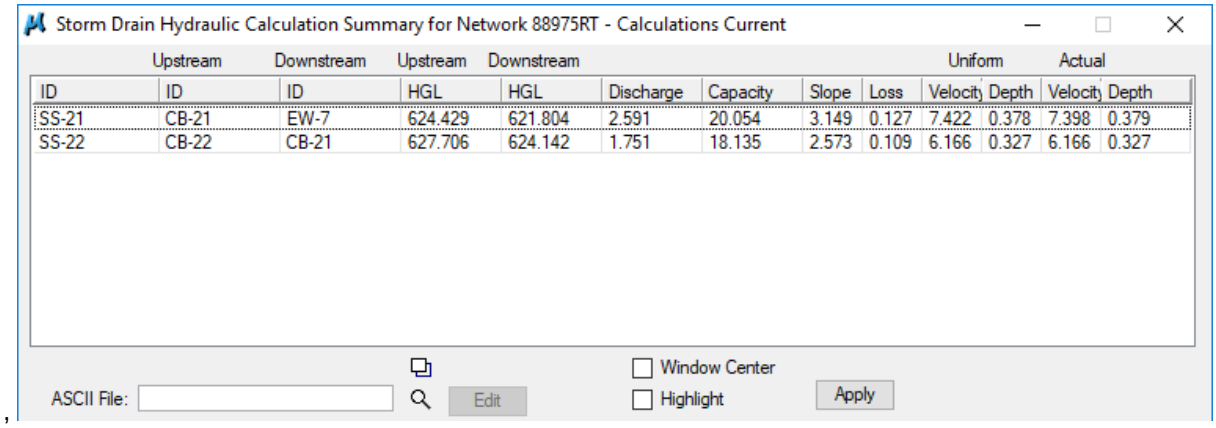
8) CB-22 and CB-22, outlet EW-7, 88975RT

Originally it was intended to stub into box, but elevations did not allow for minimum 0.4 slopes on the pipes which would not permit proper velocities .

As with previous networks, adjustments to elevations had to be made to elevations to be able to obtain proper velocities

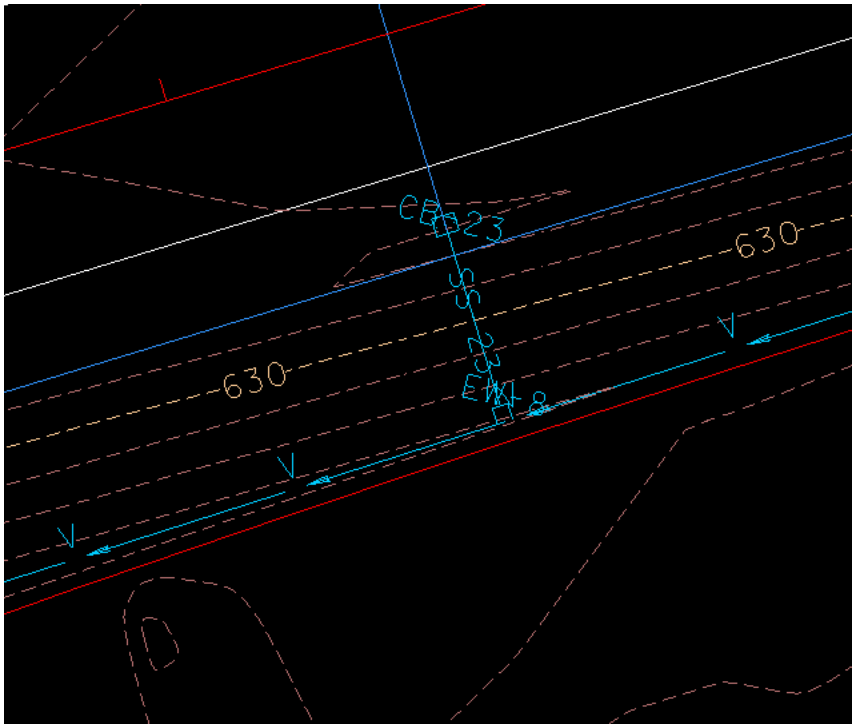


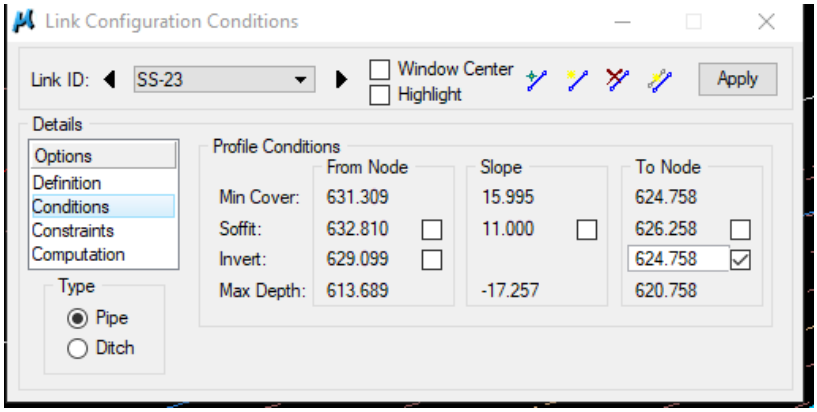

Link Configuration Conditions
Link ID:
SS-21
Window Center
Highlight
Apply
Details
Options
Definition
Conditions
Constraints
Computation
Type
Pipe
Ditch
Profile Conditions
From Node
Slope
To Node
Min Cover:
627.814
8.876
621.425
Soffit:
625.145
3.150
622.925
Invert:
623.645
621.425
Max Depth:
610.024
-10.280
617.425

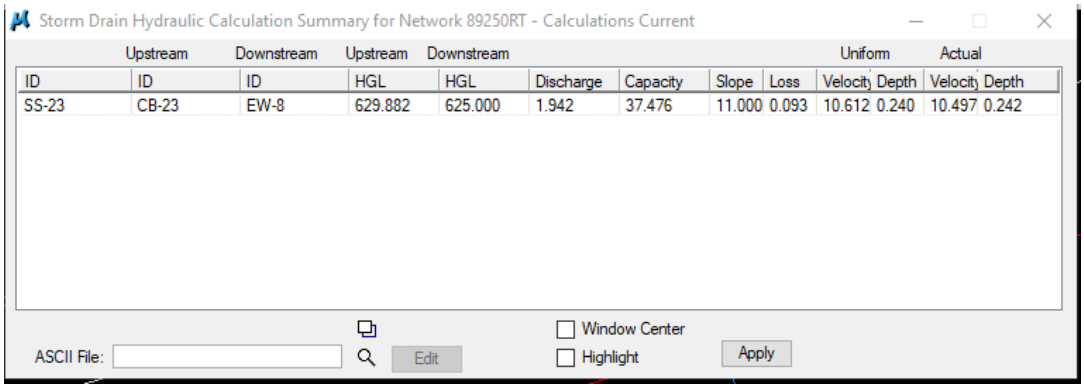

Storm Drain Hydraulic Calculation Summary for Network 88975RT - Calculations Current
Upstream
Downstream
Upstream
Downstream
Uniform
Actual
ID
ID
ID
HGL
HGL
Discharge
Capacity
Slope
Loss
Velocity
Depth
Velocity
Depth
SS-21
CB-21
EW-7
624.429
621.804
2.591
20.054
3.149
0.127
7.422
0.378
7.398
0.379
SS-22
CB-22
CB-21
627.706
624.142
1.751
18.135
2.573
0.109
6.166
0.327
6.166
0.327
ASCII File:
Edit
Window Center
Highlight
Apply

9) CB-23, outlet EW-8, 89250RT

This will be the last network before the high point at 895+50



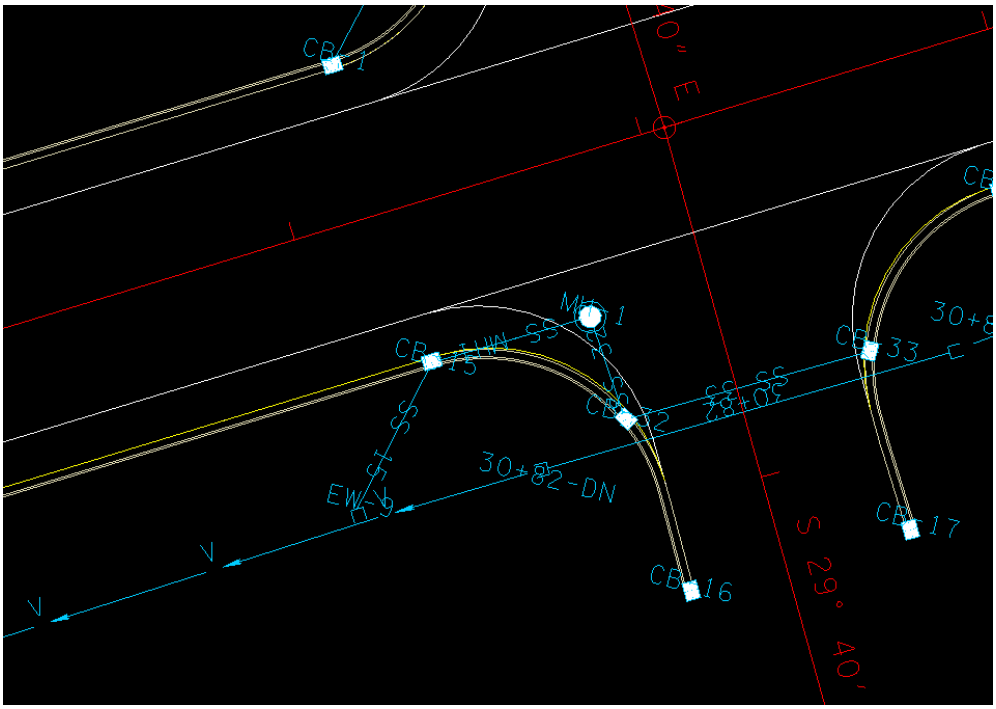




10) CB-15, CB-32,CB-33, outlet EW-9 (in proposed ditch), 89800RT

Change all to round catch basins (CB#12 4’ DIA) to accommodate link connections at an angle

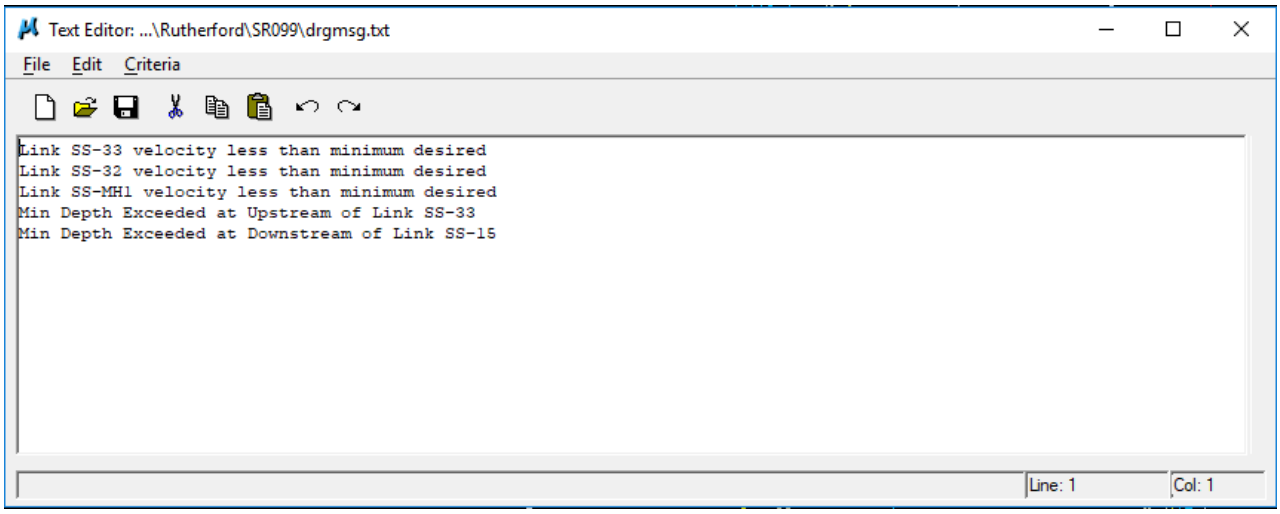
(Side Road and low point 899+00)

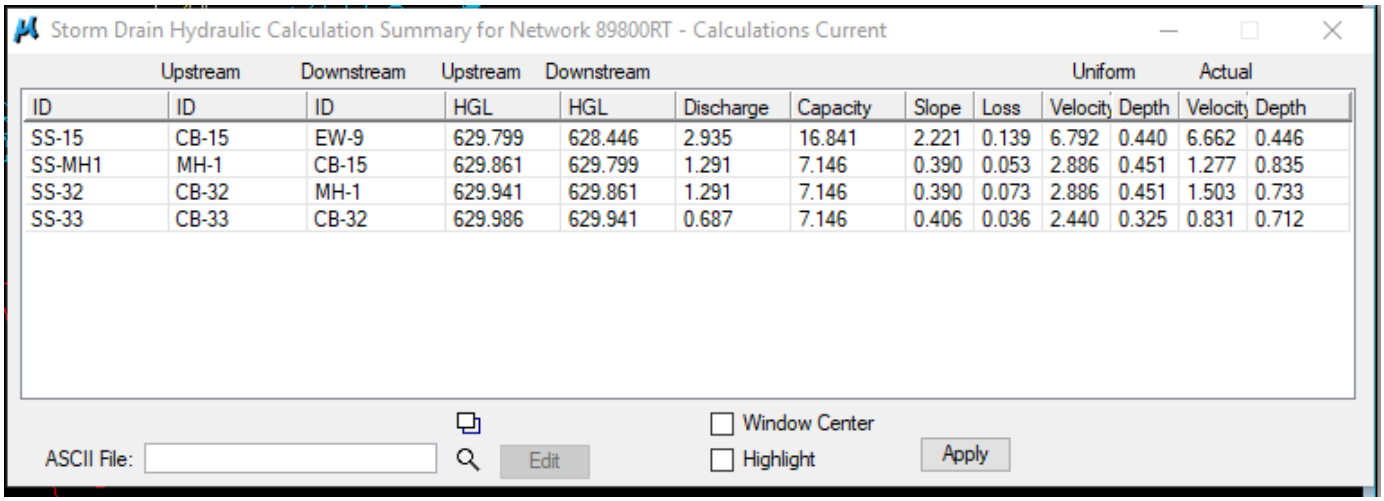


Note that a manhole has been added, MH-1

The outlet invert of link SS-MH-1 has been fixed at the ditch elevation at the endwall location (628.00)

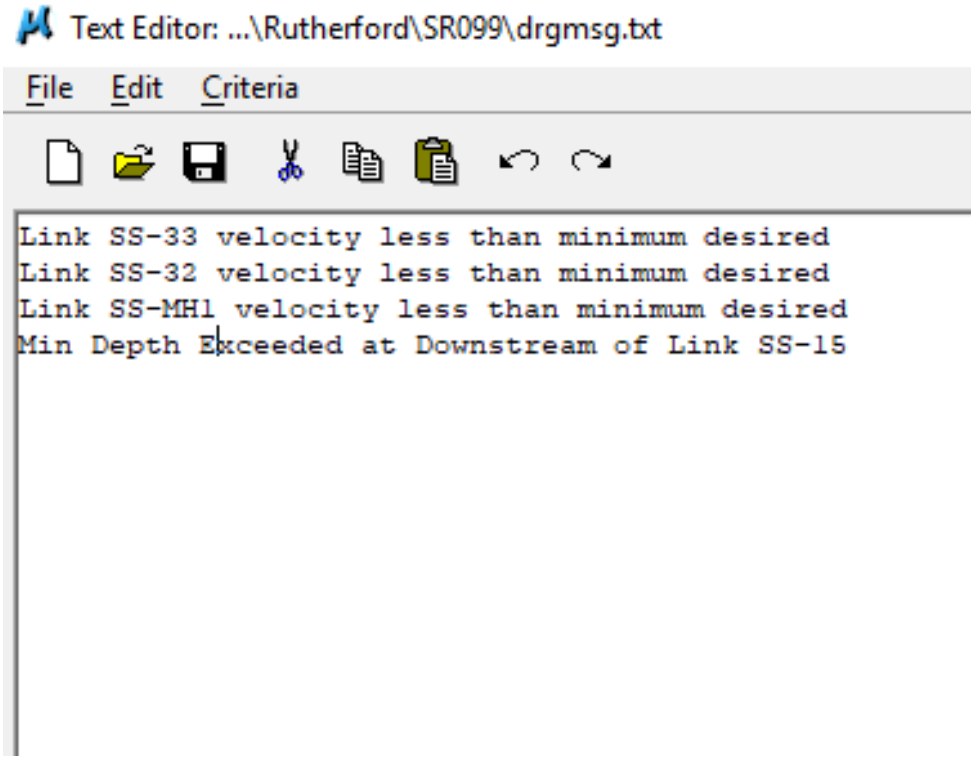
First run of the network :

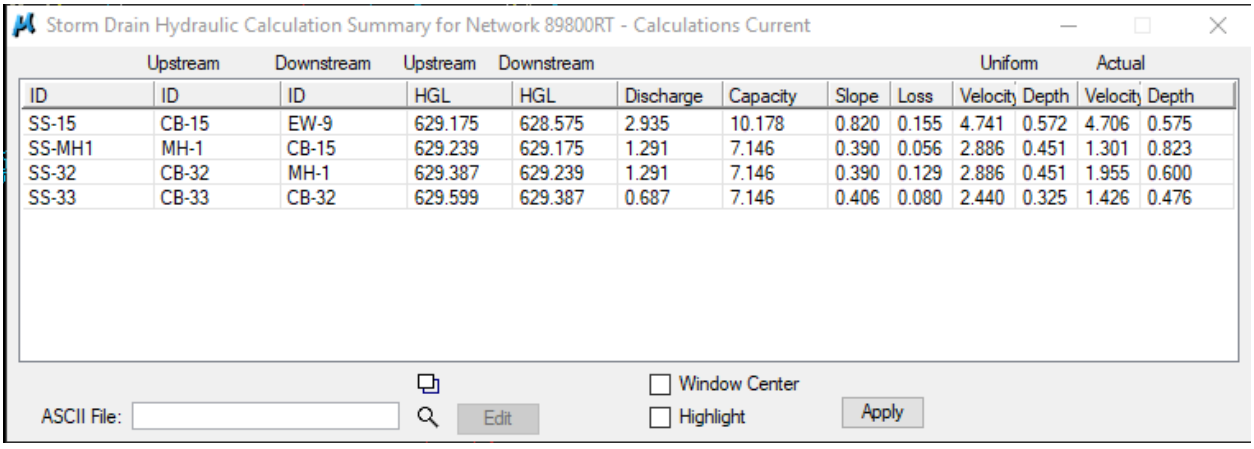




In SS-15, the outlet link, both the slope and velocity are acceptable. There is room to reduce the slope in this link so the slopes can be increased in the other links, resulting in increased velocities

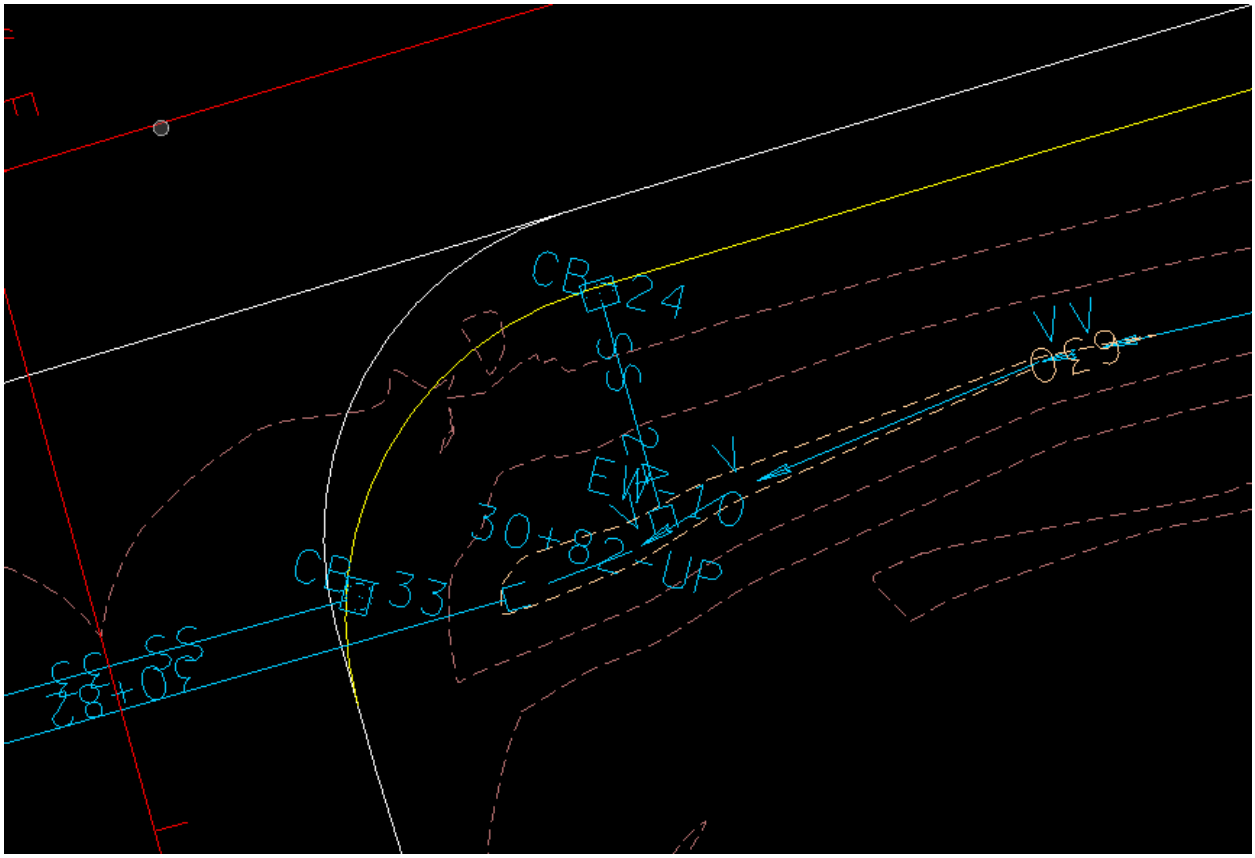
Second run of the network:





For this run, the upper invert of SS-33 was fixed at the minimum depth elevation for CB-33 and the upper invert of SS-15 was fixed so that the link has a slope of approx. 0.8. The velocities of three links are still below desired but we may have to live with it because of the terrain it is difficult to find any lower elevations to drain to.

Network 89990RT, outlet EW-10:



Storm Drain Hydraulic Calculation Summary for Network 89990RT - Calculations Current

	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-24	CB-24	EW-10	630.742	630.365	1.276	8.986	0.634	0.141	3.422	0.396	3.411	0.397

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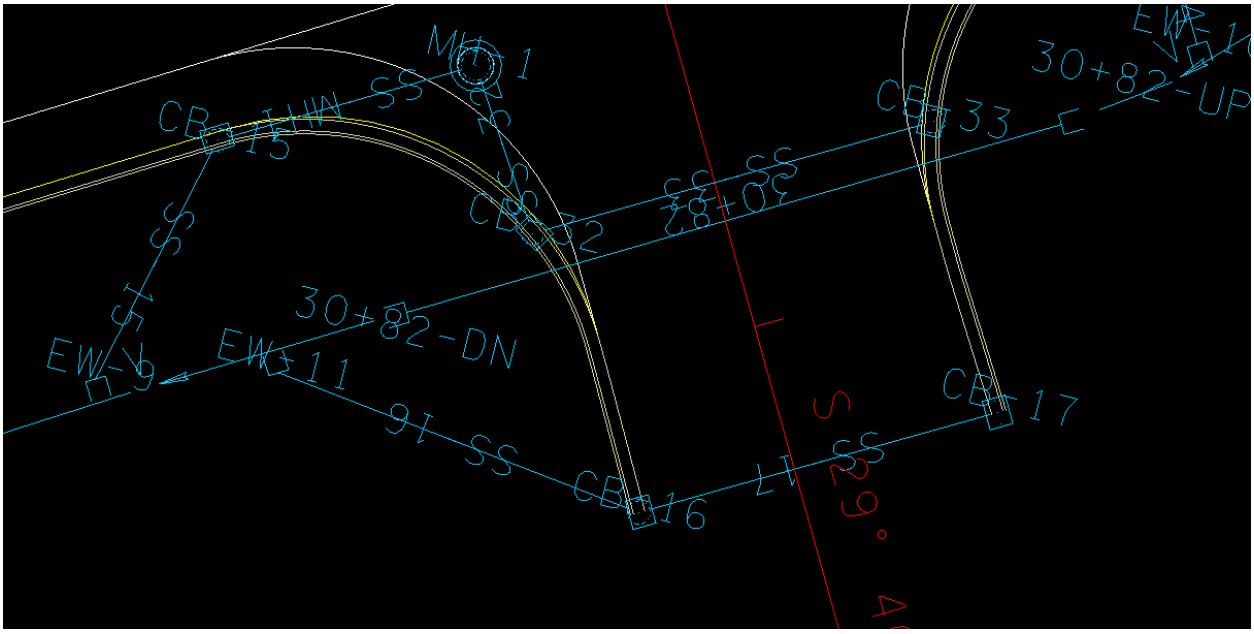
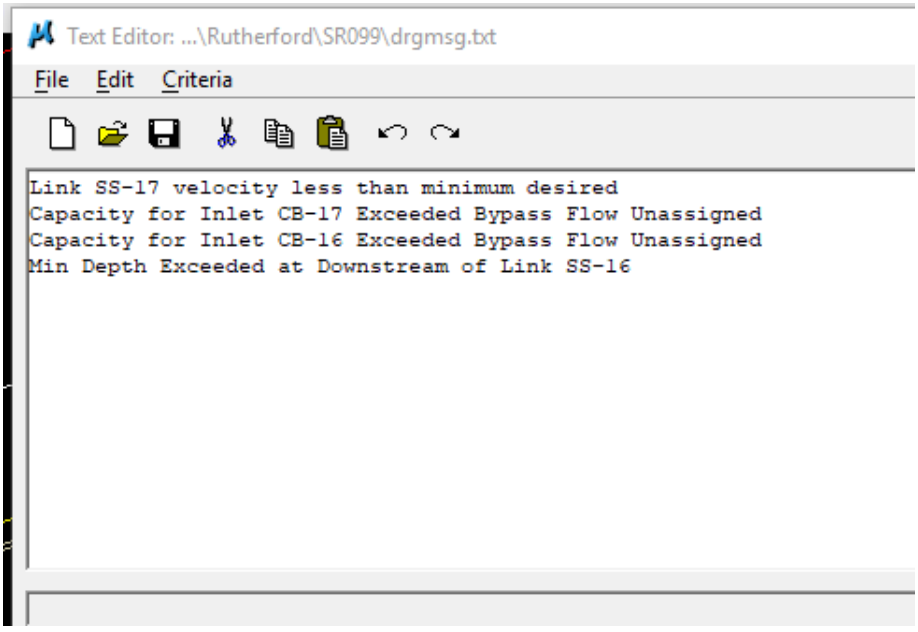
Calculations for network 89990RT

11) CB-16, CB-17, outlet EW-11 (in proposed ditch), 89825RT





Storm Drain Hydraulic Calculation Summary for Network 89825RT - Calculations Current

	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-16	CB-16	EW-11	629.261	628.452	0.475	11.953	1.112	0.033	3.121	0.212	3.121	0.212
SS-17	CB-17	CB-16	629.472	629.261	0.275	7.146	0.393	0.044	1.840	0.209	1.124	0.294

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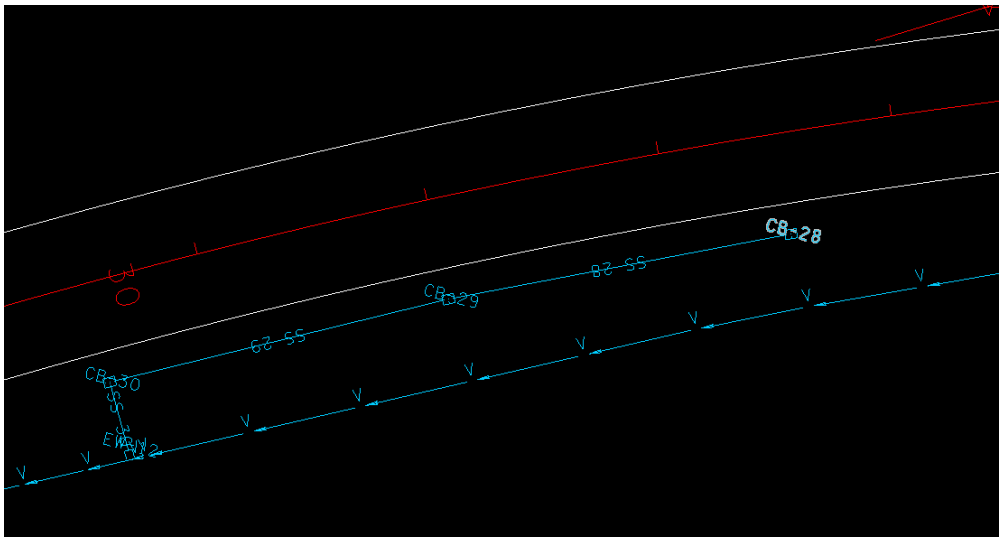
12) CB-30, CB-29, CB-28, outlet to EW-12 (in proposed ditch),90150RT



Storm Drain Hydraulic Calculation Summary for Network 90150RT - Calculations Current

	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-30	CB-30	EW-12	632.412	631.233	4.735	14.751	1.707	0.465	7.051	0.608	6.681	0.633
SS-29	CB-29	CB-30	632.866	631.932	3.321	8.582	0.571	0.065	4.293	0.677	4.293	0.677
SS-28	CB-28	CB-29	633.739	632.755	1.857	8.336	0.542	0.168	3.596	0.501	3.596	0.501

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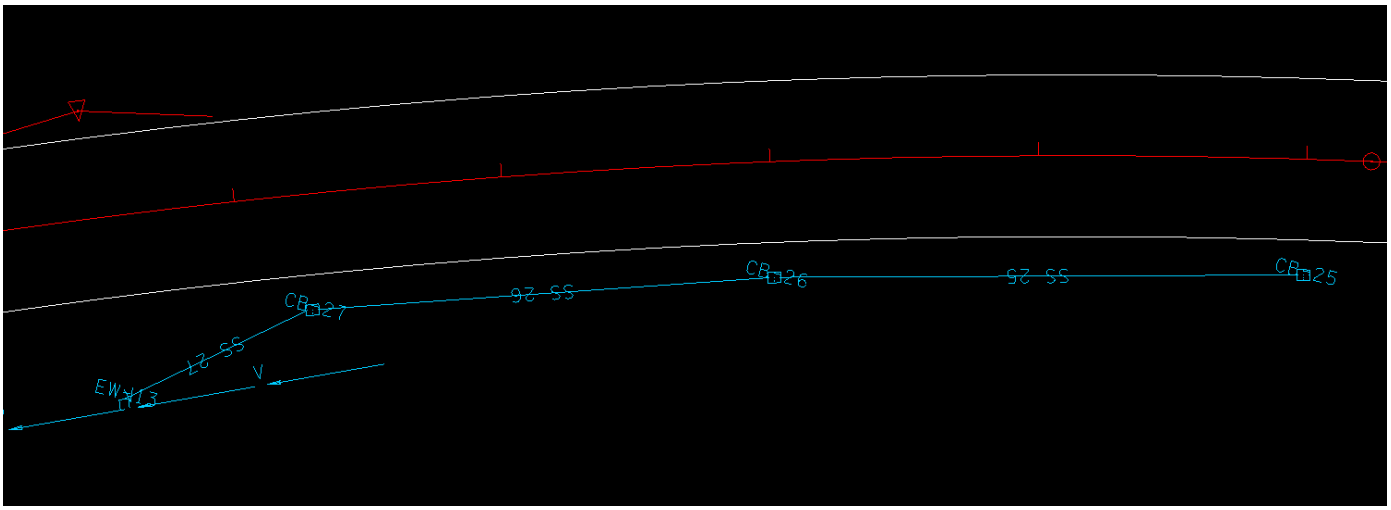
12) CB-27, CB-26, CB-25, outlet to EW-13 (in proposed ditch),90550RT



Storm Drain Hydraulic Calculation Summary for Network 90550RT - Calculations Current

	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-27	CB-27	EW-13	634.946	634.416	5.173	8.158	0.514	0.087	4.593	0.913	4.827	0.876
SS-26	CB-26	CB-27	635.650	634.946	3.602	7.146	0.392	0.063	3.805	0.792	3.533	0.841
SS-25	CB-25	CB-26	636.016	635.650	1.665	6.042	0.284	0.111	2.761	0.561	1.564	0.871

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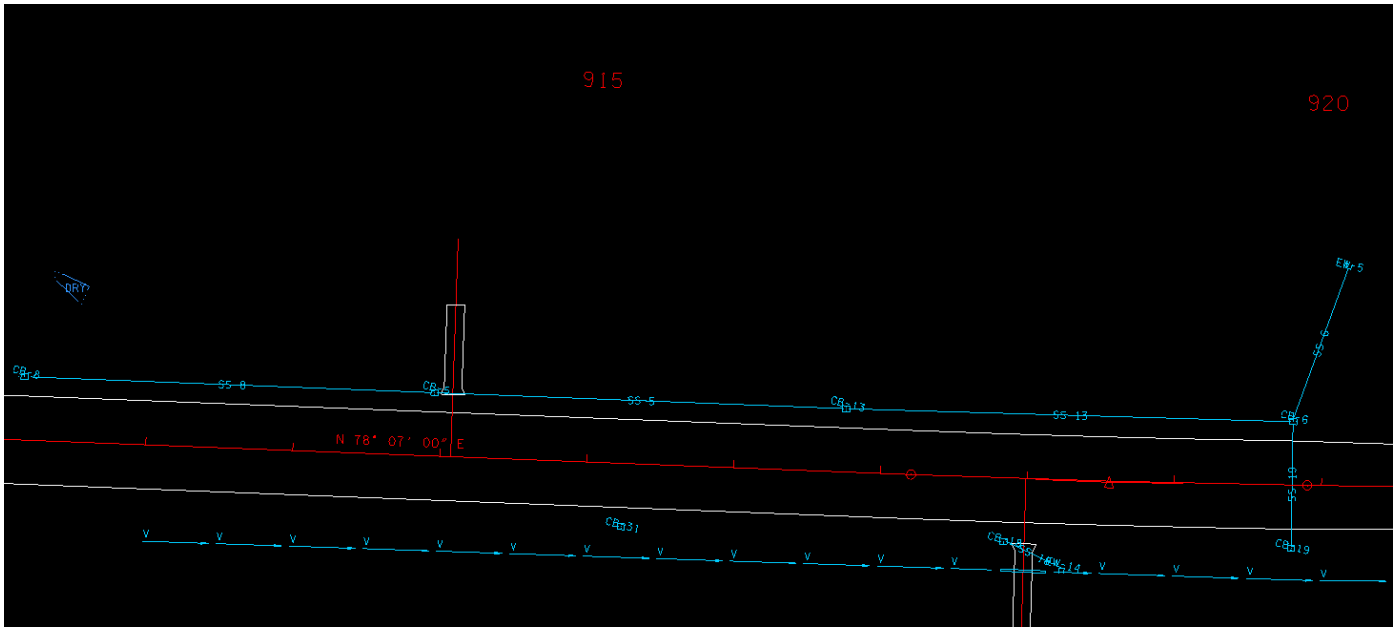
14) CB-8, CB-5, CB-13, CB-6, CB-19,outlet to EW-5, 91980LT



Storm Drain Hydraulic Calculation Summary for Network 91980LT - Calculations Current

	Upstream	Downstream	Upstream	Downstream					Uniform		Actual	
ID	ID	ID	HGL	HGL	Discharge	Capacity	Slope	Loss	Velocity	Depth	Velocity	Depth
SS-6	CB-6	EW-5	633.363	631.987	6.282	7.146	0.397	0.755	4.262	1.166	5.202	0.969
SS-13	CB-13	CB-6	633.775	633.363	3.943	7.146	0.394	0.039	3.895	0.836	2.232	1.500
SS-19	CB-19	CB-6	634.136	633.657	1.139	7.146	0.409	0.115	2.832	0.418	3.026	0.399
SS-5	CB-5	CB-13	634.739	633.775	2.506	7.146	0.401	0.031	3.500	0.638	2.513	0.826
SS-8	CB-8	CB-5	635.978	634.739	1.636	7.146	0.404	0.133	3.122	0.506	3.043	0.516

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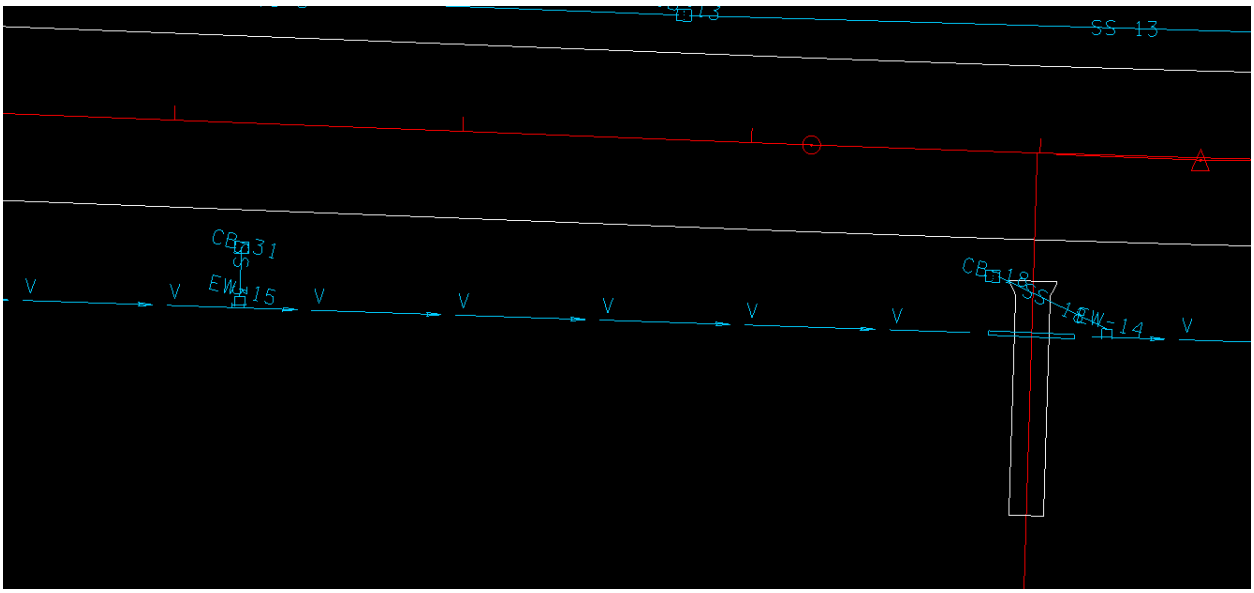
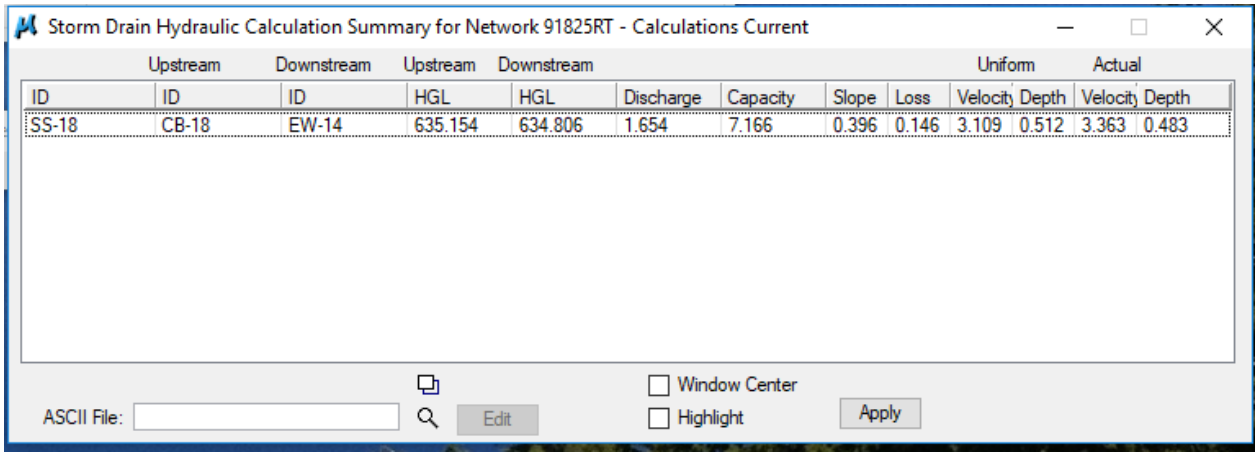
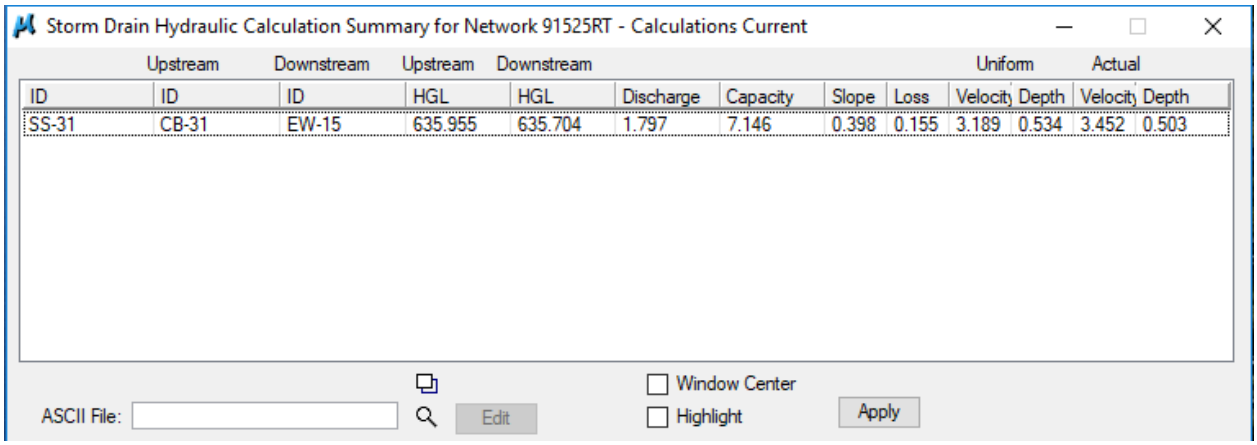
14) CB-31, outlet to EW-15, 91525RT
CB-18, outlet to EW-14, 91825RT







Taking into account the minimum depths for the catch basins, the ditch profile did not allow for the outlets to have the proper elevations and minimum slope for the links. The outlet elevations were fixed so that the links had a 0.4% slope. This will require the ditch profile to be modified.

Station	CB min.depth elev.	old ditch elev. (outlet)	new elevation
915+25	635.26	636.22	635.20
918+25	634.49	635.16	634.32

Appendix A

TN TDOT Department of Transportation **Roadway Design Division**

Website www.tn.gov/tdot/roadway-design/training.html

Email TDOT.RoadwayDesignDivisionTraining@tn.gov

TRANSPORTATION PLANNING REPORT

STATE ROUTE 99

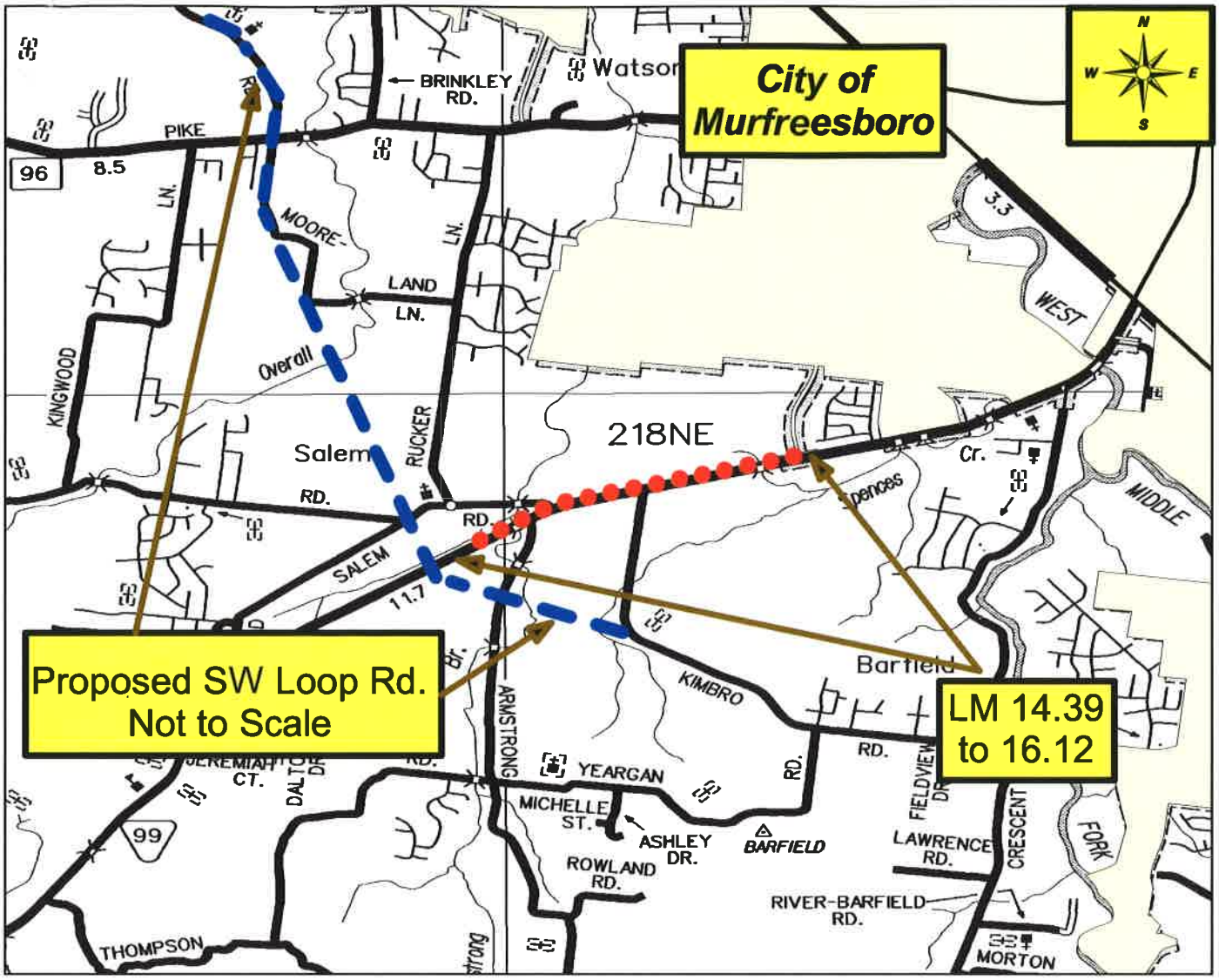
FROM PROPOSED SOUTHWEST LOOP ROAD TO CASON LANE IN MURFREESBORO, RUTHERFORD COUNTY

PIN# 106982.00

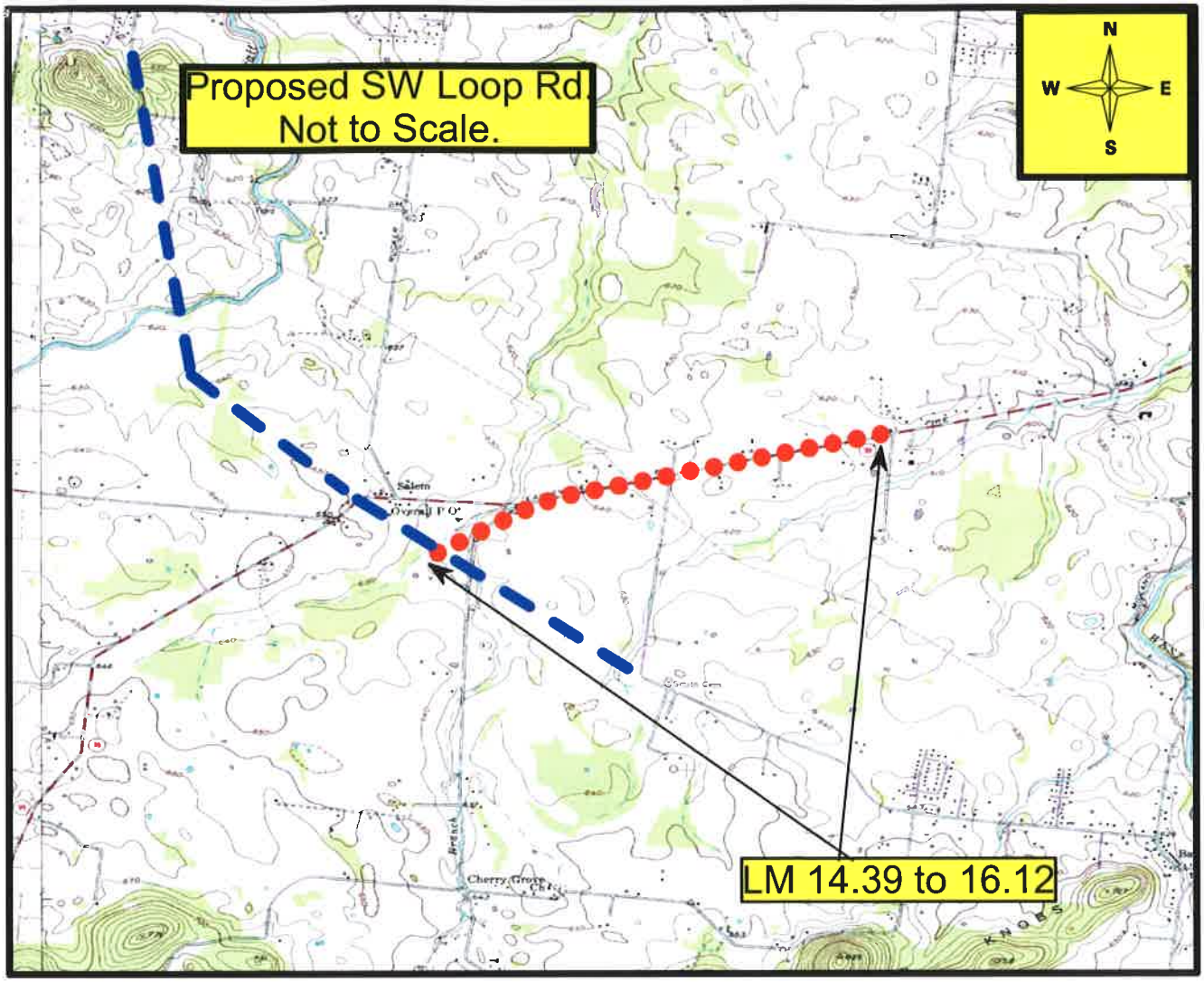
PREPARED BY
TENNESSEE DEPARTMENT OF TRANSPORTATION
PROJECT PLANNING DIVISION

Recommended by:	Signature	DATE
CHIEF OF ENVIRONMENT AND PLANNING	Ed Cole	12/12/06
TRANSPORTATION DIRECTOR PROJECT PLANNING DIVISION	Stan Pelt	12-12-06
TRANSPORTATION MANAGER 2 PROJECT PLANNING DIVISION	Bill Hunt	12/08/06

This document is covered by 23 USC § 409 and its production pursuant to fulfilling public planning requirements does not waive the provisions of § 409.

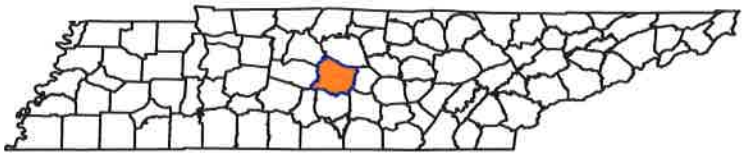


Legend	
SR-99 Ext.: Proposed SW Loop Rd. to Cason Ln.	Rutherford County State Route 99 From proposed SW Loop Road to Cason Lane
City of Murfreesboro	



0.0 0.6 1.2 1.8 2.4 3.0

Miles



Legend

SR-99 Extension: SW Loop Rd. to Cason Ln.

Rutherford County
State Route 99
From Proposed SW Loop Road to Cason Lane

DATA TABLE
State Route 99
Rutherford County

No Build
From: 0.1± west of Proposed SW Loop RD **EXISTING CONDITIONS**
To: Near Cason Lane

Item		
Functional Class		Urban Minor Arterial
System Class		STP
Length - Miles		2.0 ±
Cross Section Feet		24 / 40-44 / 120-140
Present ADT (2011)		12,150
Projected Future ADT (2031)		17,000
Percent Trucks		6 %
Estimated Right-of-Way Acquisition (Acres)		N/A
Estimated Right-of-Way Tracts Affected		N/A
Estimated Business Displacements	$	N/A
Estimated Right-of-Way Cost	$	N/A
Estimated Utility Cost Reimbursable	$	N/A
Estimated Utility Cost Non-Reimbursable	$	N/A
Estimated Construction Cost	$	N/A
Estimated Preliminary Engineering Cost	$	N/A
Total Estimated Cost	$	N/A

DATA TABLE
State Route 99
Rutherford County

OPTION 1
From: 0.1± west of Proposed SW Loop RD **PROPOSED**
To: Near Cason Lane

Item		
Functional Class		Urban Minor Arterial
System Class		STP
Length - Miles		2.0 ±
Cross Section Feet		88 / 120
Present ADT (2011)		12,150
Projected Future ADT (2031)		17,000
Percent Trucks		6 %
Estimated Right-of-Way Acquisition (Acres)		6.0±
Estimated Right-of-Way Tracts Affected		10
Estimated Business Displacements	$	N/A
Estimated Right-of-Way Cost	$	395,000
Estimated Utility Cost Reimbursable	$	N/A
Estimated Utility Cost Non-Reimbursable	$	950,000
Estimated Construction Cost	$	7,955,000
Estimated Preliminary Engineering Cost	$	600,000
Total Estimated Cost	$	8,555,000

PROJECT DATA TABLE

STATE ROUTE 99

	APPROXIMATE LENGTH	PROPOSED IMPROVEMENT	2011 AVERAGE DAILY TRAFFIC	2031 AVERAGE DAILY TRAFFIC	PERCENT TRUCKS	2031 LEVEL OF SERVICE	R.O.W COST	UTILITY RELOCATION COST	CONSTRUCTION COST	PRELIMINARY ENGINEERING COST	TOTAL COST
SECTION 1											
OPTION 1	2.0±	5 LANE	12,150	17,000	6	B	$395,000	$950,000	$7,955,000	$600,000	$8,555,000
NO-BUILD	2.0±	EXISTING TWO-LANE	12,150	17,000	6	E	N/A	N/A	N/A	N/A	N/A
TOTAL											
OPTION 1	2.0±						$395,000	$950,000	$7,955,500	$600,000	$8,555,000

EXISTING CONDTIONS

State Route 99 in Rutherford County was added to the state road system on June 25, 1931. It extends from the Marshall County line to the Cannon County line, a total distance of approximately 33.23 miles. The proposed project length is approximately two miles from Cason Lane to the proposed Southwest Loop Road. The existing route consists of a standard two-lane with twelve foot traffic lanes and eight to ten foot shoulders and ditches in the project area. Option 1 does not include the proposed Southwest Loop Road that is a priority project for the city of Murfreesboro, or the widening of State Route 99 from Cason Lane to State Route 96 project; they are separate projects.

The base year (2011) average daily traffic (ADT) along this route ranges from a low of 10,890 to a high of 15,640. This traffic is based on 2005 cycle counts and a previous project prepared for design dated December 12, 2005. The design year (2031) traffic is based on the growth rate from the Nashville Metropolitan Planning Organization (MPO) computer model and long range plan. CSX Railway currently provides freight service for area industry. Trucking is the dominant means for moving goods to and from local businesses and industry.

Using the base years 2003 through 2005 crash data, a crash rate of 1.83 (crashes per one million vehicle miles) was calculated for the existing route. This can be compared to the statewide average rate for these years of 2.51.

COMMUNITY PROFILE

The sixth largest city in Tennessee, Murfreesboro is an urban community of 86,793 residents according to a 2005 estimate. The unemployment rate in Murfreesboro is 3.9%, which is lower than the statewide average of 5.2% for Tennessee. The city is located in the exact geographical center of Tennessee, located approximately thirty miles from Nashville on the major interstate (I-24) corridor between Nashville and Chattanooga. State Route 840 provides Murfreesboro with quick and efficient access to Interstate 40 to the north and Interstate 65 to the west, aiding in the economic development of the area.

Murfreesboro has over 150 industries that comprise distribution, warehousing, and manufacturing involving a wide range of products. Some of the larger companies are Nissan Motor Corp., Bridgestone/Firestone, Ingram Book Group, General Mills/Pillsbury, Whirlpool Corporation, State Farm, Borders Group, and Verizon Wireless.

The City of Murfreesboro is experiencing an increase in residential and commercial development along State Route 99 that has increased traffic demand along the route. The traffic generators can be separated into four land use categories: 1) industrial and manufacturing, 2) retail, 3) educational or institutional, 4) residential.

PURPOSE AND NEED OF THE PROJECT

The purpose of this study is to analyze existing and projected conditions to determine the purpose and need of improving State Route 99 east from the proposed Southwest Loop Road to Cason Lane. The proposed widening of State Route 99 from Cason Lane to the proposed Southwest Loop Road was initiated through the Tennessee Department of Transportation (TDOT) Program Development and Project Management Office and the City of Murfreesboro requesting the extension of an on-going project that runs from State Route 96 to Cason Lane. The proposed Southwest Loop Road project is a priority for local officials. The Proposed Southwest Loop Road and the proposed widening of State Route 99 from Southwest Loop Road to State Route 96 are included in the Nashville Municipal Planning Organization's (MPO) Long Range Plan. The Advance Planning Report (APR) for the widening project of State Route 99 from State Route 96 to Cason Lane was approved in April of 2000.

Intersection of SR-99 & Old Salem Road heading east at LM 14.71

The objective of this report is to define the purpose and need of the proposed improvement and estimate the cost of project implementation. This study was initiated due to the growth of residential and commercial developments, the inherent increase of truck and

employee traffic in and around Murfreesboro's downtown and industrial park areas, and the construction of new access roads connecting to the existing route.

The primary purpose of this project is to fill in the gap of an arterial traffic network caused by the development by the City of Murfreesboro plans to construct a new Southwest Loop Corridor. The project is needed to eliminate the potential for hazardous traffic conditions caused by a chokepoint between two high volume corridor routes.

Intersection of SR-99 & Belle River RD (new subdivision) heading east at LM 14.77

Other options were considered initially, but were not studied further because the no build option, a three lane option, or a four lane option would not fulfill the purpose and need of the project. These options would not (1) serve future demand for regional accessibility to the interstate highway system; (2) would not provide economic growth potential of the City of Murfreesboro and Rutherford County by improving the highway system; (3) the no build and three lane options would not increase the capacity on existing State Route 99 in order to meet future traffic demands; (4) the four lane option would handle the increased traffic demands, but would cause access issues and require more right-of-way to be acquired increasing the cost of the project. The four lane option would also have a greater impact on environmental and historic resources.

Currently, trucks account for 6% of the traffic on State Route 99 in the project area. This proposed project will reduce travel time and vehicle emissions to residential and commercial areas, the interstate, and the downtown area.

The primary need on State Route 99 in Rutherford County is for improved local and regional mobility. Several specific needs are encompassed in this broad goal:

1. Allow additional economic growth in the City of Murfreesboro and Rutherford County by providing improvement to the transportation system.

2. Provide an east/west route to serve demand for regional accessibility to the interstate highway system and protect that provision in the future.

3. Increase the capacity on existing State Route 99 in order to improve safety and mobility.

4. Widening needed to handle increased traffic demand spurred by commercial/ residential development, and construction of new access roads connecting to the existing route.

5. With the construction of the proposed Southwest Loop Road and the widening of State Route 99 from State Route 96 to Cason Lane, this two mile section of State Route 99 connecting Cason Lane to the proposed Southwest Loop Road will need to be widened to prevent a choke point being created. The creation of a choke point at the intersection of State Route 99 and Cason Lane would introduce adverse capacity and safety conditions.

Approaching intersection with Cason Lane heading east at LM 16.04

Addressing transportation needs through corridor planning offers many benefits and represents a new way of identifying transportation improvements throughout the state. Rather than planning on a project-by-project basis and in a piecemeal fashion, corridor planning allows TDOT to look at a larger area and develop creative, collaborative and long-term solutions to problems. Projects developed through corridor planning offer more transportation choices and are more financially responsible in a time of limited resources at all levels of government. The 10-year Strategic Investment Plan is intended to jumpstart key pieces of the 25-year vision plan which is discussed in detail in the Long Range Transportation Plan (LRTP).

The LRTP looks at multimodal approaches to meet the increasing transportation needs in Tennessee for the next 25-years. It describes what type of transportation system we will have in the future and provides policy direction for investments and operating decisions. Each of the six primary modes of transportation (aviation, bicycle/pedestrian, highway, public transportation, rail and waterways) was examined for current use, future travel and freight demands and the condition of the system.

LEVEL OF SERVICE

The character of operating conditions can be quantified by a "Level of Service" (LOS) analysis. The proficiency of roads is described by their LOS. The criteria are defined as shown in the "Level of Service" section of this report and reflect the ability of roads to accommodate motor vehicle traffic and subsequent physical and psychological comfort levels of drivers. The LOS analysis incorporates several factors including traffic volumes, number of lanes, terrain, percent of no passing zones, directional split, heavy vehicles, and shoulder widths. The projected traffic volumes for the base and design years are depicted in the Project Data Table and on the traffic schematic included in this report.

LOS is a qualitative measure that describes the character of traffic conditions related to speed and travel time, freedom to maneuver, traffic interruptions, etc. There are six levels ranging from "A" to "F" with "F" being the worst. Each level represents a range of operating conditions. General descriptions of operating conditions for each of the levels of service are as follows:

LOS	Traffic Flow Conditions
A	Free flow operations. Vehicles are almost completely unimpeded in their ability to maneuver within the traffic stream. The general level of physical and psychological comfort provided to the driver is high.
B	Reasonably free flow operations. The ability to maneuver within the traffic stream is only slightly restricted and the general level of physical and psychological comfort provided to the driver is still high.
C	Flow with speeds at or near free flow speeds. Freedom to maneuver within the traffic stream is noticeably restricted and lane changes require more vigilance on the part of the driver. The driver notices an increase in tension because of the additional vigilance required for safe operation.

D Speeds decline with increasing traffic. Freedom to maneuver within the traffic stream is more noticeably limited. The driver experiences reduced physical and psychological comfort levels.

E At lower boundary, the facility is at capacity. Operations are volatile because there are virtually no gaps in the traffic stream. There is little room to maneuver. The driver experiences poor levels of physical and psychological comfort.

F Breakdowns in traffic flow. The number of vehicles entering the highway section exceed the capacity or ability of the highway to accommodate that number of vehicles. There is little or no room to maneuver. The driver experiences poor levels of physical and psychological comfort.

The LOS analysis completed for this route utilized the projected design year (2031) traffic on the existing route as well as on the proposed improvement. The "no-build" operating conditions deteriorate to a LOS of "E" by the design year 2031. The proposed widening indicates a LOS of "B" for the same design year.

PROPOSED IMPROVEMENT

Description

This report will focus on an option to improve State Route 99 from Cason Lane to the proposed Southwest Loop Road along existing State Route 99, a total distance of approximately 2.0 miles.

Intersection of SR-99 & Armstrong Valley Road heading east at LM 14.52

The typical section will consist of four 12' traffic lanes with a 12' continuous turn lane, two 14' shoulders (includes curbs and gutters), two 5' sidewalks and utility strips. Most of the work will be within the existing 120' ± right-of-way. This proposed typical section is the same as the existing project running from State Route 96 to Cason Lane along existing State Route 99. Because of this, only one option was prepared for this report. There may be some areas where slope or construction easements will be necessary and some right-of-way will be required. Other options were considered initially, but were not studied further because of the impact they would have on historic sites and environmental factors if the alignment of State Route 99 were shifted to the north or south of its existing location. The option studied for this report will minimize adverse effects on historic sites or environmental factors by maintaining the existing alignment of State Route 99.

It is proposed to widen the existing roadway symmetrically about the centerline. The exception will be where a branch of Puckett Creek parallels the route on the north side through the area where the proposed Southwest Loop Road crosses State Route 99. Through this area, the roadway alignment will either be shifted to the south to avoid the creek or a retaining wall will be constructed to avoid the creek. The plans and cost estimates were developed with the idea of relocating the centerline to the south, which will require the purchase of 40'± of new right-of-way for about 3000'±. The necessary right-of-way to build the project will vary depending on construction slope requirements.

A no-build option was also analyzed for this report. The no-build option, as the name implies, denotes that only minor improvements (such as safety improvements and normal maintenance) would be made to the existing road and/or intersection areas. The no-build option does not meet the purpose and need of the project, and it will not provide the needed capacity to handle future traffic demands.

Intersection of SR-99 & Kimbro Road heading east at LM 15.29

ASSESSMENT OF OPTIONS

The TDOT has adopted seven guiding principles against which all transportation projects are to be evaluated. These guiding principles address concerns for system management, mobility, economic growth, safety, community, environmental stewardship, and fiscal responsibility. These guiding principles are discussed in the following paragraphs as they relate to the option for improving State Route 99 in Rutherford County.

Guiding Principle 1: Preserve and Manage the Existing Transportation System

When construction was completed on June 25, 1931, State Route 99 provided a facility for regional mobility through Rutherford County. That function has degraded in recent decades due to the lack of access control combined with increased commercial and residential development along the route.

The widening of existing State Route 99 is consistent with TDOT's goal of preserving the existing transportation system. The widening of existing State Route 99 through this section of Rutherford County would not necessitate acquisition of developed right-of-way as it would in a commercial and residential area that would involve significant property and environmental impacts. This improvement does not add additional mileage to the State Highway System.

Guiding Principle 2: Move a Growing, Diverse, and Active Population

The option considered in this report will provide needed capacity to address Murfreesboro's and Tennessee's regional travel demands. Residential and commercial

development and access along existing State Route 99 has made it less conducive to accommodating regional trip making, particularly to commuter movement.

Guiding Principle 3: Support the State's Economy

State Route 99 provides direct and indirect access to all of the major population centers in Rutherford County. The population in Murfreesboro has increased approximately 21% since the 2000 census. The unemployment rate in Murfreesboro is 3.9%. The areas economic growth and jobs created in Rutherford County and in Murfreesboro have not only benefited the local economy, but the state's as well.

The development of the proposed State Route 99 project will create better and safer access to residential and commercial areas along the route, as well as new residential and commercial developments in the future.

Guiding Principle 4: Maximize Safety and Security

Traffic crash rates on existing State Route 99 were 1.83, calculated from crash data for the years 2003 through 2005. A total of 39 traffic crashes were reported during that period, of which 18 (46%) involved an injury. There were no fatalities during this time period. The statewide average crash rate for an urban minor arterial two-lane road is 2.51.

Guiding Principle 5: Build Partnerships for Livable Communities

Nashville MPO staff coordinated with local officials to identify their concerns and objectives. In keeping with the goals of TDOT's current Public Involvement Process, the Nashville MPO conducted meetings with the local officials and the public to coordinate the transportation needs envisioned by the citizens of the local community and those of TDOT. This public involvement process will continue as mandated by the provisions of the National Environmental Policy Act (NEPA).

Guiding Principle 6: Promote Stewardship of the Environment

A detailed environmental study is needed to fully address the impact of the considered option within the Area of Potential Effects (APE). The APE is the geographic area in which an undertaking may directly or indirectly impact the environment. A more comprehensive analysis of the impacts will be completed at a later date to comply with the National Environmental Policy Act (NEPA). This analysis will require the consideration of

environmental values in the decision making processes by taking into account the environmental impacts of proposed actions and reasonable alternatives to those actions. Additional environmental disciplines such as social, economic, farmland, displacements, and land use impacts will be evaluated in the NEPA document.

Guiding Principle 7: Promote Financial Responsibility

Preliminary construction cost estimates were prepared for each considered option. Table 1 summarizes the construction cost estimates for Option 1 and the no-build option.

Table 1

Comparison of Construction Cost Estimates

OPTION	NUMBER OF NEW LANES	CONSTRUCTION COST	LENGTH	COST PER MILE
No Build	n/a	$0	n/a	n/a
Option 1	4	$8,555,000	2.0	$4,277,500

PRELIMINARY HISTORIC ANALYSIS

TDOT historians have conducted a records search at the Tennessee State Historic Preservation Office (TN-SHPO) and a reconnaissance level field survey of this project in Rutherford County. Currently there is one property listed on the National Register of Historic Places (NRHP) within the existing State Route 99 corridor: Boxwood, a historic house on the south side of State Route 99 nearly one half mile west of Cason Lane. The reconnaissance survey identified several properties that will require additional survey and research.

1. Harrison Farms—TDOT historians surveyed a part of the area of potential effect for this project for the State Route 99 from Cason Lane to State Route 96 project. At the time Harrison Farms was not determined eligible for listing on the NRHP. However due to the passage of time, this property will need to be reassessed.

2. Salem—The town of Salem has several older properties that would need to be assessed if the project has the potential to impact it.

3. RD-2013-Free Classic Farmhouse with outbuildings—This farm on the south side of State Route 99 will require additional survey and research in order to determine NRHP eligibility.

4. Two farms, not previously surveyed by the TN-SHPO, will require documenting but are unlikely to be NRHP eligible.

Further research may indicate that some or none of the properties mentioned above are NRHP eligible. Measures should be taken in the planning process to avoid the National Register properties and minimize adverse effects. If properties are identified later as being eligible for the National Register, they will also need to be avoided to prevent adverse effects. Maintaining the existing alignment of State Route 99 will minimize adverse effects to the properties listed.

Summary

This project is an extension of an existing project widening State Route 99 from State Route 96 to Cason Lane. The proposed typical section will be the same as what was developed for the previously mentioned project.

Improvements of State Route 99 are needed to address the following needs:

1. Provides an east/west route to serve demand for regional accessibility to the interstate highway system and protect that provision in the future.
2. Provides economic growth potential for the City of Murfreesboro and Rutherford County by improving the highway system.
3. Increase the capacity on existing State Route 99 in order to meet future traffic demands.
4. Provides a higher LOS for motorist comfort levels.

Option 1 is based solely within the existing corridor and will be further evaluated under future studies for horizontal and vertical alignment, right-of-way, utility adjustments, environmental mitigations and structures. The proposed project area is approximately two miles in length.

The option will improve deficiencies throughout the route. The improved roadway will also enhance access to both commercial and residential sites along the route. Other primary beneficial effects include: (1) improved local and regional accessibility; (2) improved operating conditions along the project corridor; (3) increased traffic capacity; and (4) enhancement of

future planned growth by local and/or regional land use planning agencies; 5) Reduced fuel emissions as a result of eliminating slow moving or standing vehicles passing through the chokepoint.

The primary adverse effects of the proposed build option include: (1) the loss of land for right-of-way; (2) temporary construction impacts (dust, siltation, equipment noise, etc.) during the construction period; (3) traffic noise.

As depicted on the Project Data Table, the design year 2031 LOS for the option is "B" throughout the entire proposed route. The comparable LOS for the no-build option is a deficient LOS of "E". In addition, the disadvantages of the no-build option include continued inadequate operating conditions inherent with increased traffic volumes. Some advantages of the no-build option include no disruption of the area due to construction and measures to mitigate environmental impacts would not be necessary.

Other options were considered initially, but were not studied further because the no build option, a three lane option, or a four lane option would not fulfill the purpose and need of the project. These options would not (1) serve future demand for regional accessibility to the interstate highway system; (2) would not provide economic growth potential of the City of Murfreesboro and Rutherford County by improving the highway system; (3) the no build and three lane options would not increase the capacity on existing State Route 99 in order to meet future traffic demands; (4) the four lane option would handle the increased traffic demands, but would cause access issues and require more right-of-way to be acquired increasing the cost of the project. The four lane option would also have a greater impact on environmental and historic resources.

In conclusion, this report identifies the option to address the purpose and need. Option 1 does meet the purpose and need; while the no build option does not. Therefore, the widening option should be advanced as a solution for further development under the NEPA planning process.

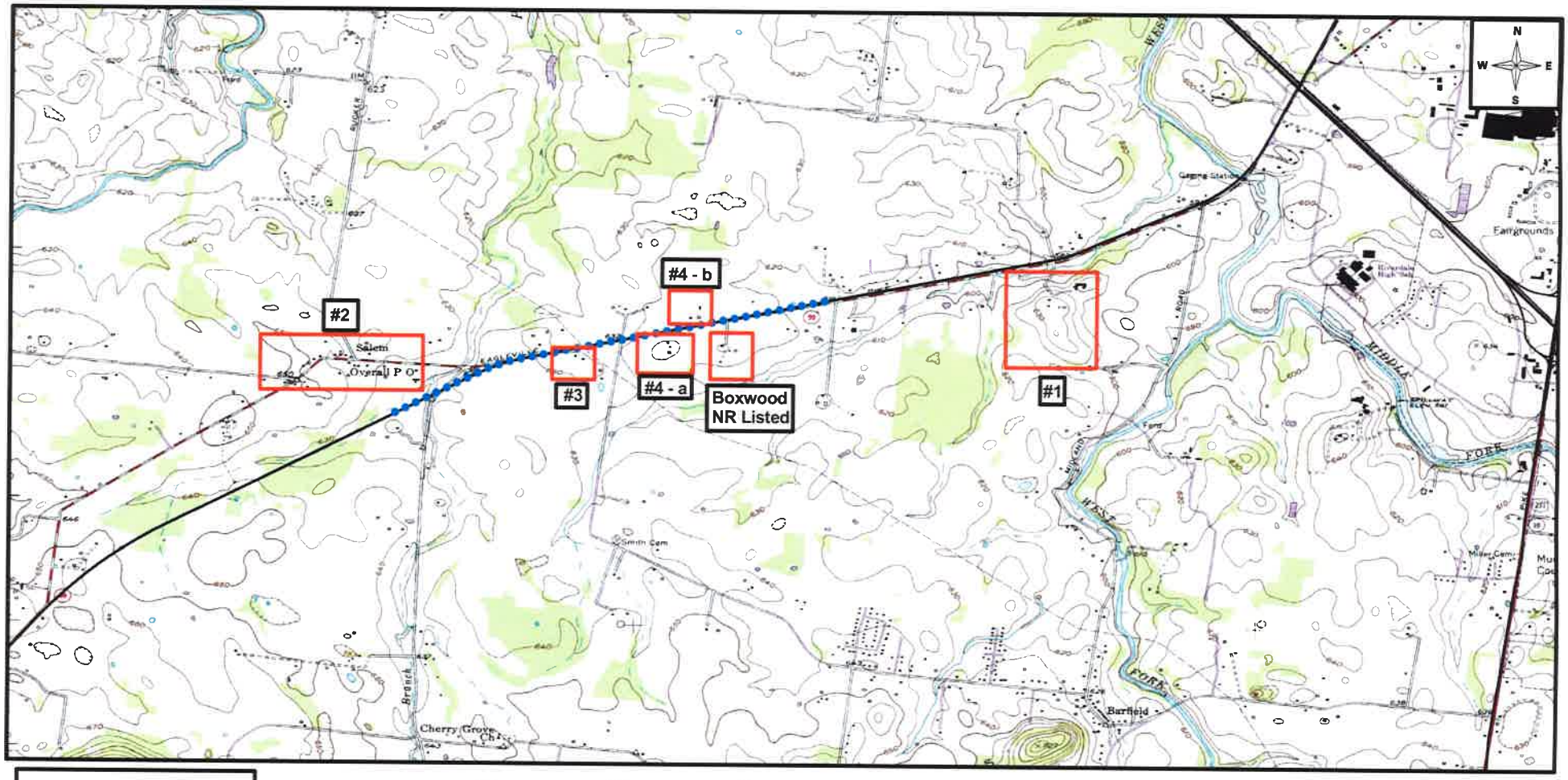
No Build

- Does not provide the needed capacity to address mobility concerns.

Option 1

- Increases system capacity
- Improved local and regional mobility
- Promotes economic development
- Reduces fuel emissions
- Provides better route connectivity with Interstate 24
- Helps to preserve State Route 99 by improving along the existing section from the proposed Southwest Loop Road to Cason Lane. Improvements along this section are needed to meet future traffic demands.

Historic Preservation Scoping Map
State Route 99 from Proposed SW Loop Road to Cason Lane
Rutherford County



Legend

Study Area

0.0 0.6 1.2 1.8 2.4 3.0 Miles

Preliminary Environmental Evaluation

If preliminary field reviews indicate the presence of any of the following facilities or Economic, Social and Environmental categories (ESE), place the number of facilities in the blank opposite the item. Where more than one location option is to be considered, place its letter designation in the blank.

		Option
1.)	Hazardous Material Site or Underground Storage Tanks.....	
2.)	Floodplains.....	
3.)	Historical, archaeological, cultural, or natural landmark, or cemeteries.....	X
4.)	Airport.....	
5.)	Residential establishment.....	X
6.)	Urban area, city, town, or community..... (Murfreesboro, Pop. 86,793)	X
7.)	Commercial area, shopping center.....	
8.)	Institutional usages:	
	a. School or other educational institution.....	
	b. Hospital or other medical facility.....	
	c. Church or other religious institution.....	X
	d. Public Building, e.g., fire station.....	
	e. Defense installation.....	
9.)	Agricultural land usage.....	X
10.)	Forested land.....	
11.)	Industrial park, factory.....	
12.)	Recreational usages:	
	a. Park or recreational area, State Natural Area.....	
	b. Wildlife refuge or wildlife management area.....	
13.)	Waterway:	
	a. Lake.....	
	b. Pond.....	
	c. River.....	
	d. Stream.....	X
	e. Spring.....	
14.)	Railroad Crossings.....	
15.)	Location coordinated with local officials.....	X
16.)	Other.....	

TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

Index Of Sheets

SHEET NO.	DESCRIPTION
1	TITLE SHEET
2	TYPICAL SECTION
3-8	PROPOSED LAYOUTS
9	GENERAL LOCATION MAP

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING

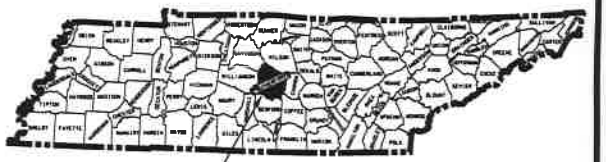
TENN.	YEAR	SHEET NO.
	2006	1
FED. AID PROJ. NO.		
STATE PROJ. NO.		

RUTHERFORD COUNTY

STATE ROUTE 99

FROM SOUTHWEST LOOP ROAD
TO CASON LANE

STATE HIGHWAY NO. 99 F.A.H.S. NO.



PROJECT LOCATION

BEGIN PROJECT

END PROJECT

SCALE: 1"= 1 MILE

APPROVED:
CHIEF ENGINEER

DATE:

APPROVED:
COMMISSIONER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED:
DIVISION ADMINISTRATOR DATE

SPECIAL NOTES

PROPOSALS MAY BE REJECTED BY THE COMMISSIONER IF ANY OF THE UNIT PRICES CONTAINED THEREIN ARE OBVIOUSLY UNBALANCED, EITHER EXCESSIVE OR BELOW THE REASONABLE COST ANALYSIS VALUE.

THIS PROJECT TO BE CONSTRUCTED UNDER THE STANDARD SPECIFICATIONS OF THE TENNESSEE DEPARTMENT OF TRANSPORTATION DATED MARCH 1, 1995 AND ADDITIONAL SPECIFICATIONS AND SPECIAL PROVISIONS CONTAINED IN THE PLANS AND IN THE PROPOSAL CONTRACT

TDOT ROAD SP. SV. 2 _____

DESIGNER FRANK FULGHAM DRAFTER FRANK FULGHAM

6/8/2006
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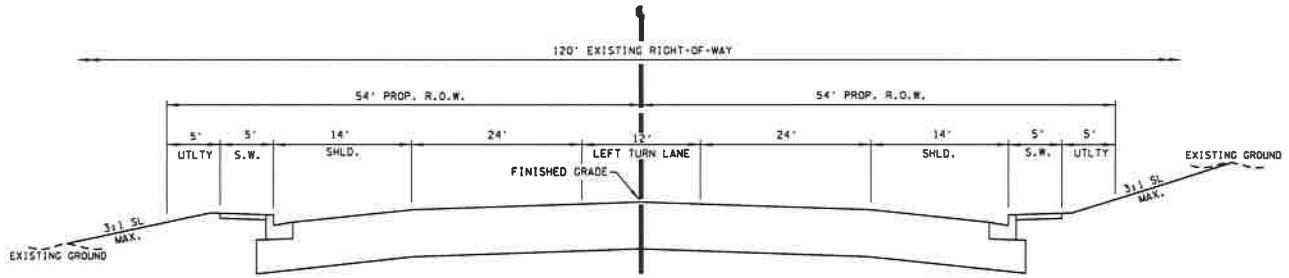
TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.
			2



PROPOSED TYPICAL SECTION

STATE ROUTE 99

FROM SOUTHWEST LOOP ROAD
TO CASON LANE

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RUTHERFORD CO.
S.R.99

NOT TO SCALE

6/6/2006
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TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.
			3

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STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RUTHERFORD CO.
S.R.99

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			4

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RUTHERFORD CO.
S.R.99

4/24/2006
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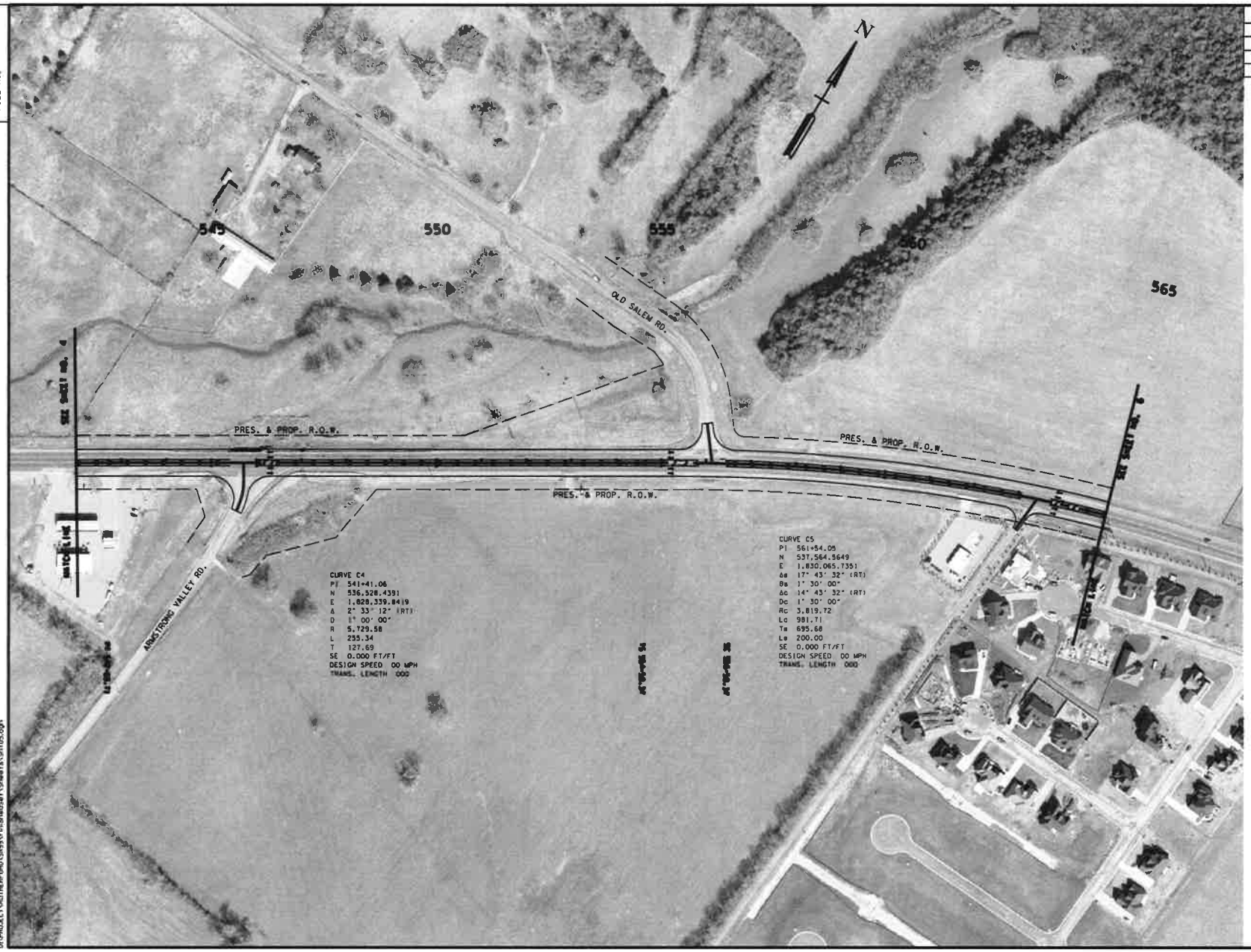
DESIGN DIVISION
FILE NO.



TYPE	YEAR	PROJECT NO.	SHEET NO.
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STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RUTHERFORD CO.
S.R.99

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DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.
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STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RUTHERFORD CO.
S.R.99

4/24/2006
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TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SECT NO.
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STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RUTHERFORD CO.
S.R. 99

4/24/2006
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TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.
			8

0 100 200 300

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RUTHERFORD CO.
S.R.99

4/24/2006
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Appendix D

TDOT Department of Transportation **Roadway Design Division**

Website www.tn.gov/tdot/roadway-design/training.html

Email TDOT.RoadwayDesignDivisionTraining@tn.gov

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
SUITE 1100, JAMES K. POLK BUILDING
NASHVILLE, TENNESSEE 37243-1402
(615) 741-0339

JOHN C. SCHROER
COMMISSIONER

BILL HASLAM
GOVERNOR

November 5, 2012

Mr. Shane Hester
Survey and Design Division
Suite 1200 James K Polk Bldg.
Nashville TN 37243

Subject: PE #75013-1242-54
STP-M-99(23)
State Route 99 from Proposed Southwest Loop Road to Cason Lane in Murfreesboro
Rutherford County

Dear Mr.: Hester

This office has completed the hydraulic analysis of the subject project and is forwarding the following hydraulic information for your use in completing plans. The proposed grade received April 30, 2008 is satisfactory for final design.

The existing structure 3 @ 15' x 9', 45° skew concrete box culvert at station 888+55 over Armstrong Branch will be extended 55 ft. from inlet and 45 ft. from outlet. By extending 3 @ 15' x 9' with a 3 @ 16' x 9', use transitioning on 1:1 slope. The following information must be included in the plans on the profile sheet.

Station 888+55----------	3 @ 15' x 9', 45° skew, RCB	
Drainage Area ----------	7.29	mi^2
Total Design Discharge (100 YR) ---	4270	cfs
Design Discharge (100 YR) ----------	3794	cfs
100 YR Backwater ----------	0.59	ft. at El. 629.28
100 YR Velocity ----------	9.76	fps
500 YR Discharge ----------	5420	cfs at El. 630.46
Inlet Invert Elevation ----------	619.40	
Outlet Invert Elevation ----------	619.00	
Approach Overtopping Elevation -----	630.35	
Standard Drawing Numbers ----------	STD-17-103 (3 @ 16' x 9' RCB)	

The existing structure 1 @ 8' x 8', 90° skew concrete box culvert at station 889+00 over Overflow to Armstrong Branch will be extended 28.50 ft. from inlet and 29.50 ft. from outlet. The following information must be included in the plans on the profile sheet.

Station 889+00	1 @ 8' x 8', 90° skew, RCB	
Drainage Area	7.29	mi^2
Total Design Discharge (100 YR)	4270	cfs
Design Discharge (100 YR)	476	cfs
100 YR Backwater	0.59	ft. at El. 629.28
100 YR Velocity	9.65	fps
500 YR Discharge	5420	cfs at El. 630.46
Inlet Invert Elevation	621.90	
Outlet Invert Elevation	621.50	
Approach Overtopping Elevation	630.35	
Standard Drawing Numbers	STD-17-53	

The existing structure 3 @ 15' x 9', 75° skew concrete box culvert at station 34+55.50 over Puckett Creek will be extended 18 ft. from inlet and 17 ft. from outlet. By extending 3 @ 15' x 9' with a 3 @ 16' x 9', use transitioning on 1:1 slope. The following information must be included in the plans on the profile sheet.

Station 34+55.50	3 @ 15' x 9', 75° skew, RCB	
Drainage Area	17.50	mi^2
Design Discharge (<2 YR)	1700	cfs
<2 YR Backwater	0.03	ft. at El. 624.13
<2 YR Velocity	5.53	fps
100 YR Discharge	8085	cfs at El. 628.37
Inlet Invert Elevation	617.15	
Outlet Invert Elevation	617.11	
Approach Overtopping Elevation	624.20	
Standard Drawing Numbers	STD-17-103 (3 @ 16' x 9' RCB)	

The existing structure 3 @ 10' x 5', 90° skew concrete box culvert at station 965+60 over Unnamed Drainage Swale will be extended 28 ft. from inlet and 33 ft. from outlet. The following information must be included in the plans on the profile sheet.

	3 @ 10' x 5', 90° skew, RCB	
Station 965+60		
Drainage Area	0.50	mi^2
Design Discharge (100 YR)	580	cfs
100 YR Backwater	0.62	ft. at El. 617.71
100 YR Velocity	14.37	fps
500 YR Discharge	749	cfs at El. 618.39
Inlet Invert Elevation	614.07	
Outlet Invert Elevation	612.12	
Approach Overtopping Elevation	619.80	
Standard Drawing Numbers	STD-17-94	

The existing structure at Veterans Parkway station 100+40.17 over Puckett Creek will remain a 3 @ 18' x 7', 90° skew concrete box culvert. The following information must be included in the plans on the profile sheet.

Station 100+40.17	3 @ 18' x 7', 90° skew, RCB	
Drainage Area	9.2	mi^2
Total Discharge (100 YR)	5,080	cfs
Design Discharge (100 YR)	3,124	cfs
100 YR Backwater	0.96	ft. at El. 632.95

100 YR Velocity	8.27	fps
500 YR Discharge	3,196	cfs at El. 633.79
Inlet Invert Elevation	624.50	
Outlet Invert Elevation	624.15	
Approach Overtopping Elevation	633.55	
Standard Drawing Numbers	STD-17-105	

The proposed overflow structure at Veterans Parkway station 101+45.00 will be a 1 @ 8' x 5', 90° skew concrete box culvert. The following information must be included in the plans on the profile sheet.

Station 101+45	1 @ 8' x 5', 90° skew, RCB	
Drainage Area	9.2	mi^2
Design Discharge (100 YR)	353	cfs
100 YR Backwater	0.96	ft. at El. 632.95
100 YR Velocity	8.83	fps
500 YR Discharge	362	cfs at El. 633.84
Inlet Invert Elevation	626.0	
Outlet Invert Elevation	625.8	
Approach Overtopping Elevation	632.09	
Standard Drawing Numbers	STD-17-52	

The proposed lateral structure at SR-99 station 864+96.53 will be a1 @ 18' x 7', 90° skew concrete box culvert. The following information must be included in the plans on the profile sheet.

Station 864+96.53	1 @ 18' x 7', 90° skew, RCB	
Drainage Area	9.2	mi^2
Design Discharge (100 YR)	1,031	cfs
100 YR Backwater	0.0	ft. at El. 633.40
100 YR Velocity	8.18	fps
500 YR Discharge	1,194	cfs at El. 634.18
Inlet Invert Elevation	625.80	
Outlet Invert Elevation	625.60	
Approach Overtopping Elevation	635.53	
Standard Drawing Numbers	STD-17-65	

The proposed lateral structure at SR-99 station 872+48.19 will be a 1 @ 8' x 5', 90° skew concrete box culvert. The following information must be included in the plans on the profile sheet.

Station 842+48.19	1 @ 8' x 5', 90° skew, RCB	
Drainage Area	9.2	mi^2
Design Discharge (100 YR)	259	cfs
100 YR Backwater	0.0	ft. at El. 629.83
100 YR Velocity	6.46	fps
500 YR Discharge	295	cfs at El. 630.31
Inlet Invert Elevation	624.60	
Outlet Invert Elevation	623.80	
Approach Overtopping Elevation	632.66	
Standard Drawing Numbers	STD-17-52	

Comments:

- Traffic is to be maintained on the existing structure.
- The proposed roadway grade between stations 856+49.00 and 883+35.00 is adequate to meet 100 yrs. flood design criteria
- Culverts exceeding 200 feet in length on all streams will require permit sketches including mitigation. Please coordinate with the Environmental Division to determine mitigation and ROW requirements.
- This project is located in Rutherford County Flood Insurance Study. We have issued a "No-Rise" certification stating that this project will not adversely impact the 100 year flood elevations, floodway elevations, and floodway widths.
- If 1 acre or more of land will be disturbed during construction, submission to Environmental Division, Permits Section of a NOI (Notice of Intent) form for a NPDES (National Pollutant Discharge Elimination System) permit is required. Please refer to the Roadway Design Guidelines and Instructional Bulletins for the information required by the Permits Section for permit processing.
- The Environmental Division, Permits Section will provide a comprehensive permit assessment when half size plans including erosion control at all stream crossings, a list of stations and impacts, and a copy of the USGS Quad map with impact locations indicated are provided.

If you have any questions or if we can be of any further assistance, you may contact this office at (615) 741-3351.

Sincerely,

(for)
Wayne J. Seger
Director, Structures Division

JKZ: DI: pc

Enclosures

cc: Ms. Carolyn Stonecipher
Mr. Rick Pack
Ms. Deedee Kathman
Mr. John Hewitt
Ms. Jennifer Lloyd
Mr. Houston Walker

Appendix E

TDOT Department of Transportation **Roadway Design Division**

Website www.tn.gov/tdot/roadway-design/training.html

Email TDOT.RoadwayDesignDivisionTraining@tn.gov

Appendix E

SIDE ROAD CROSS SECTIONS:

Roads on Left side of Mainline:

1. Beginning of alignment to beginning of radius run sections every 50 ft.
2. Beginning of radius to tie –in point on mainline (edge of pavement), sections every 5 ft.

Roads on Right side of Mainline:

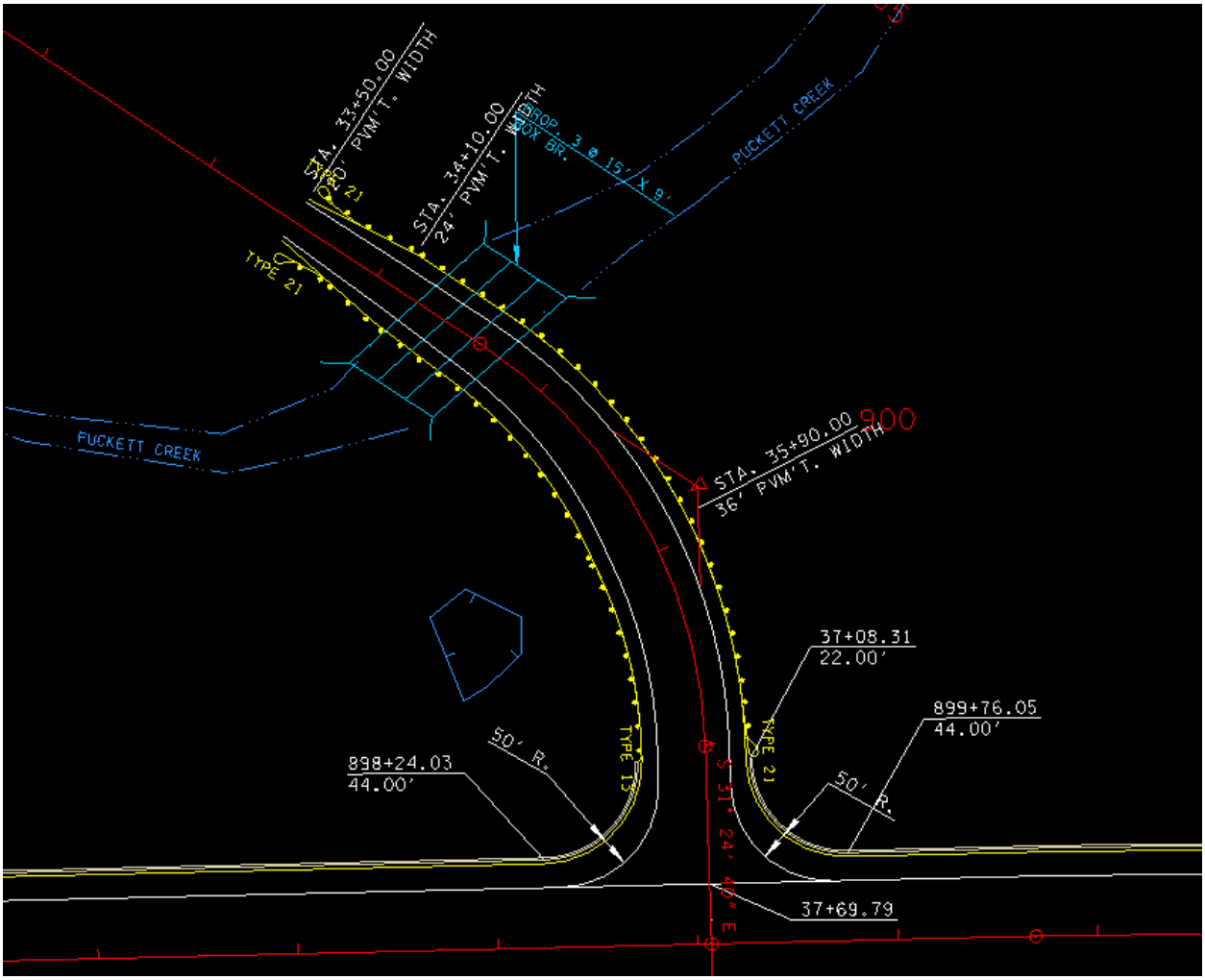
1. Tie-in point on mainline (edge of pavement) to end of radius, every 5 ft.
2. End of radius to end of alignment ,every 50 ft.

After the 5 ft interval cross sections are run in the radius area, check the cross sections against the plan view. Some manual modification may be necessary to ensure that pavement widths, offsets, etc. match what is drawn.

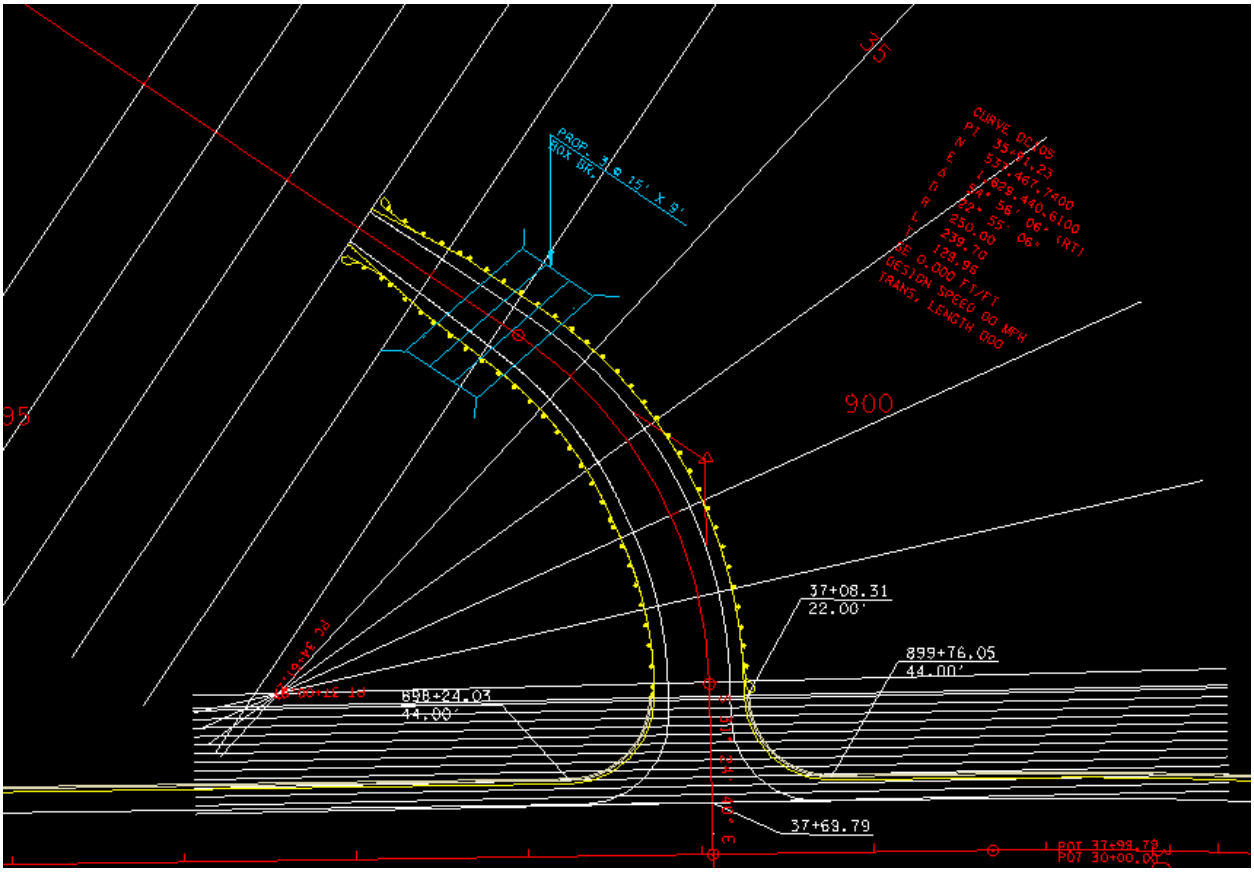
If the radius has curb and gutter, plot the elevations obtained from the cross section on a profile grid. It may be helpful , but not necessary to make an alignment of the radius. Make sure then that the curb and gutter radius has a smooth profile. Then go back to the cross sections and adjust the curb and gutter elevations match the profile. This is to insure that the radius transitions smoothly from the mainline to the side road.

After this is done then a dtm can be created of the side road and merged witn the mainline dtm created earlier to make a proposed surface.

Example for Old Salem Road:



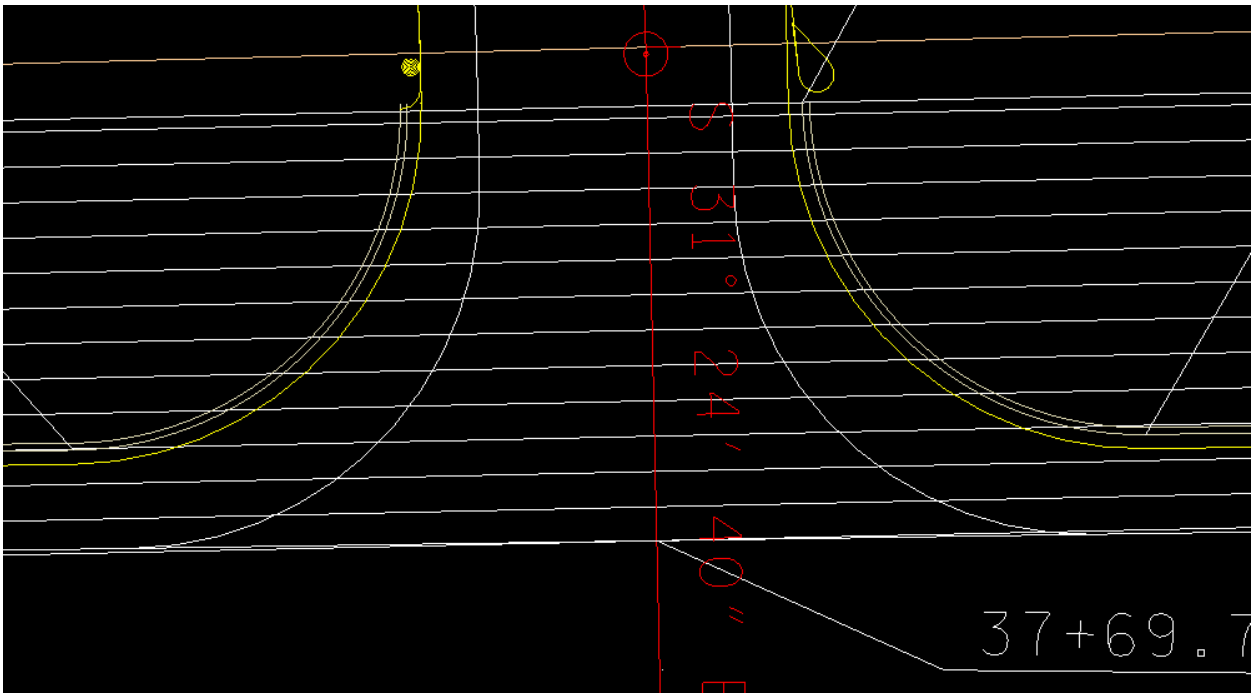
The alignment begins at 33+50 and ends at 37+69.79. The radius begins at 37+08.31. The end points of the radius on the mainline are 898+24.03 and 899+76.05.



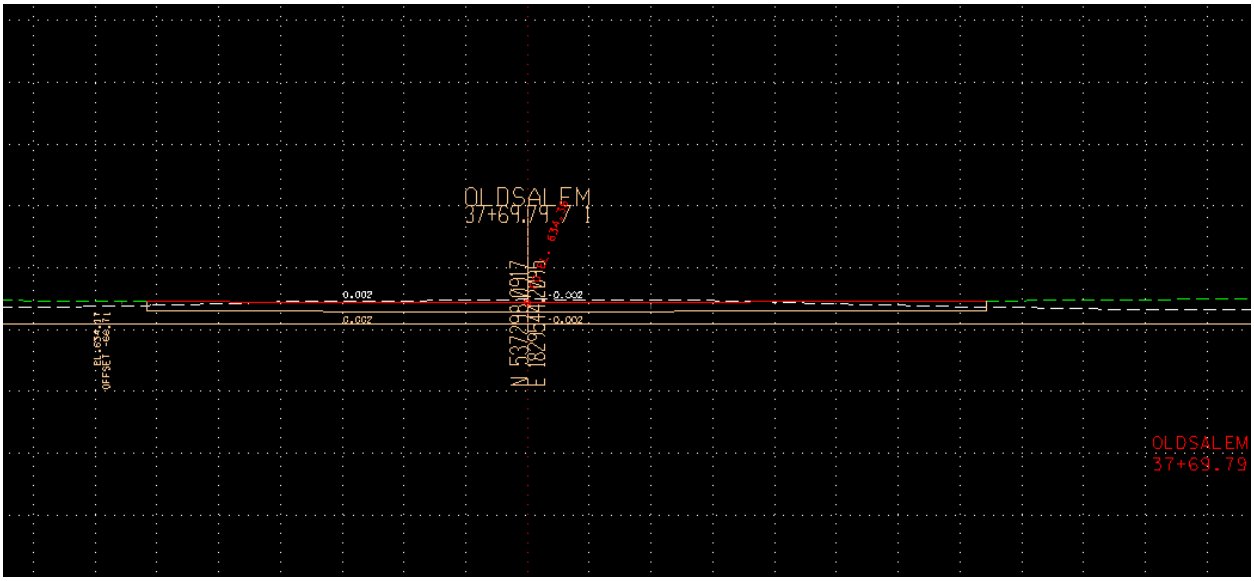
Pattern lines every 50 feet until beginning of intersection radius, then every 5 ft.

Cut existing and proposed cross sections for 50 ft spaced sections and 5 ft spaced sections in separate files.

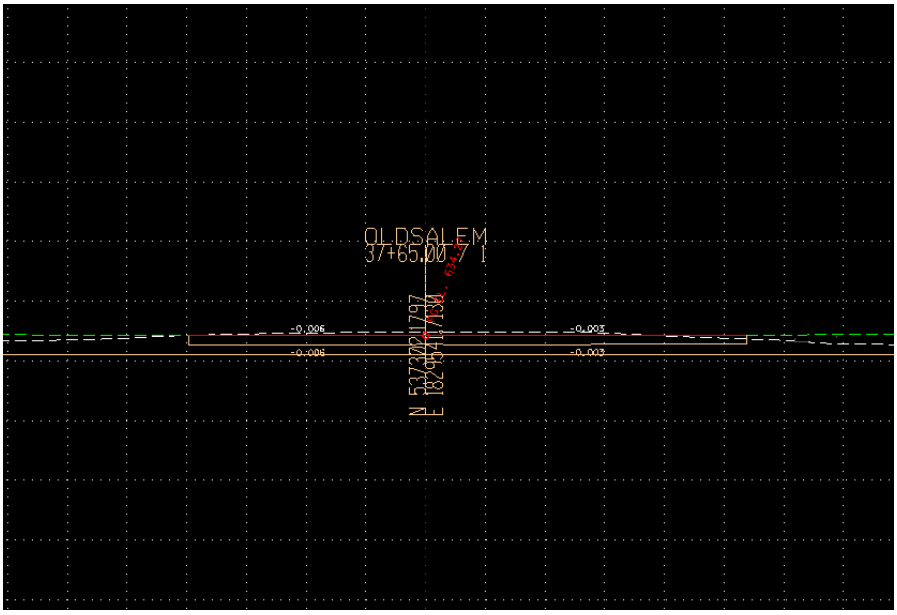
When cross sections are run for the radius area, modify the last three sections to remove the curb and gutter and shoulder as evidenced by the pattern lines:



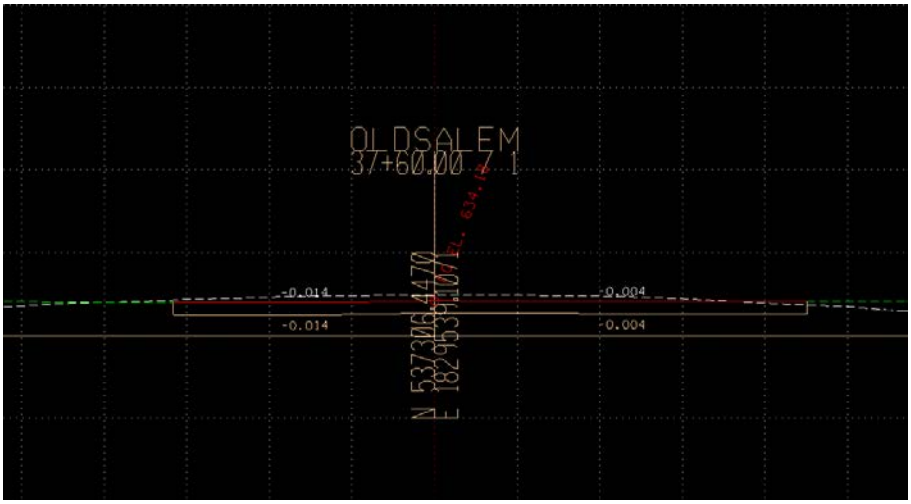
It may be necessary to modify the pavement widths to match the edge of pavement lines drawn in the proposed file.



The last section corresponding with the pattern line drawn at the mainline edge of pavement. The Mainline EOP is the green dashed line. The red proposed side road finished grade surface was modified to match the green line.

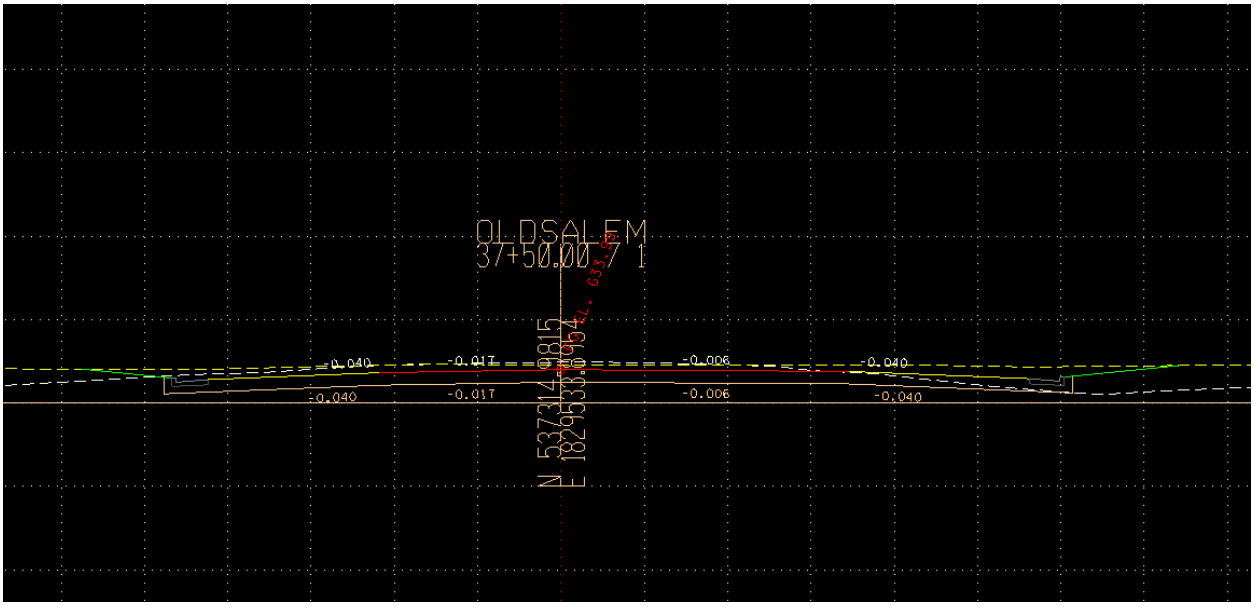


Modified section at 37+65. Section is modified to match green dash line, which is mainline tin surface.

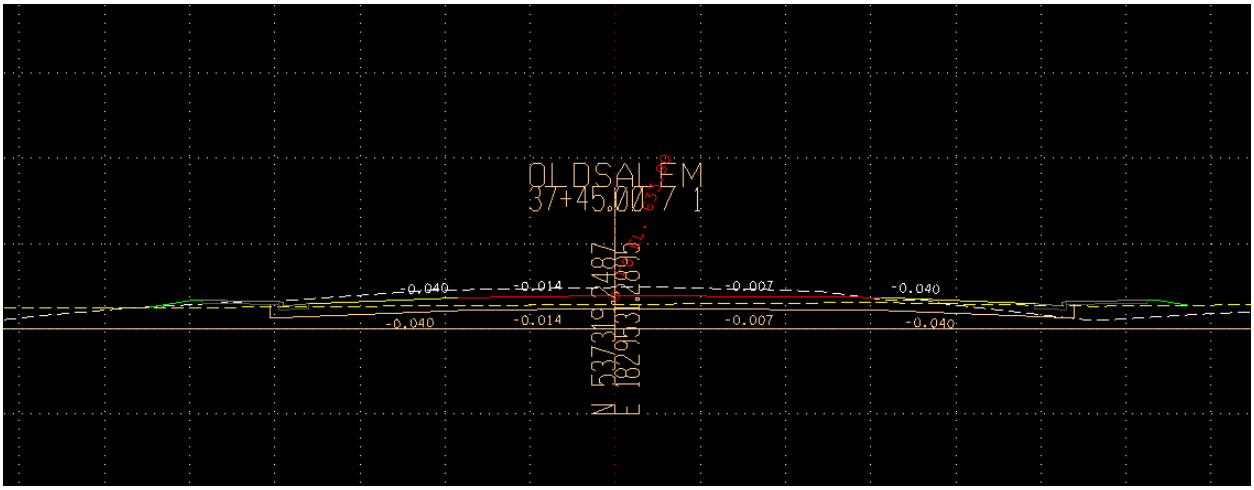


Modified section at 37+60.

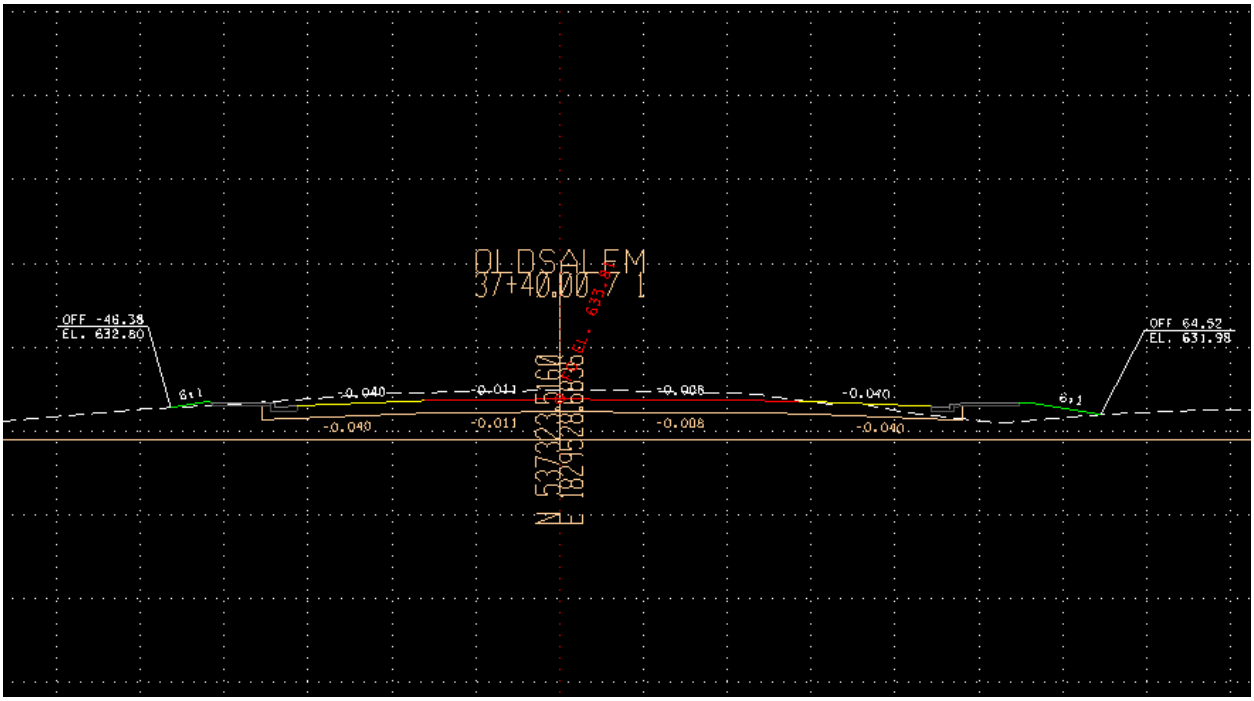
Modified section at 37+55. Now includes shoulder



Modified section at 37+50. Now includes curb and gutter. The mainline surface is the yellow dash line.



Modified section at 37+45. Now includes sidewalk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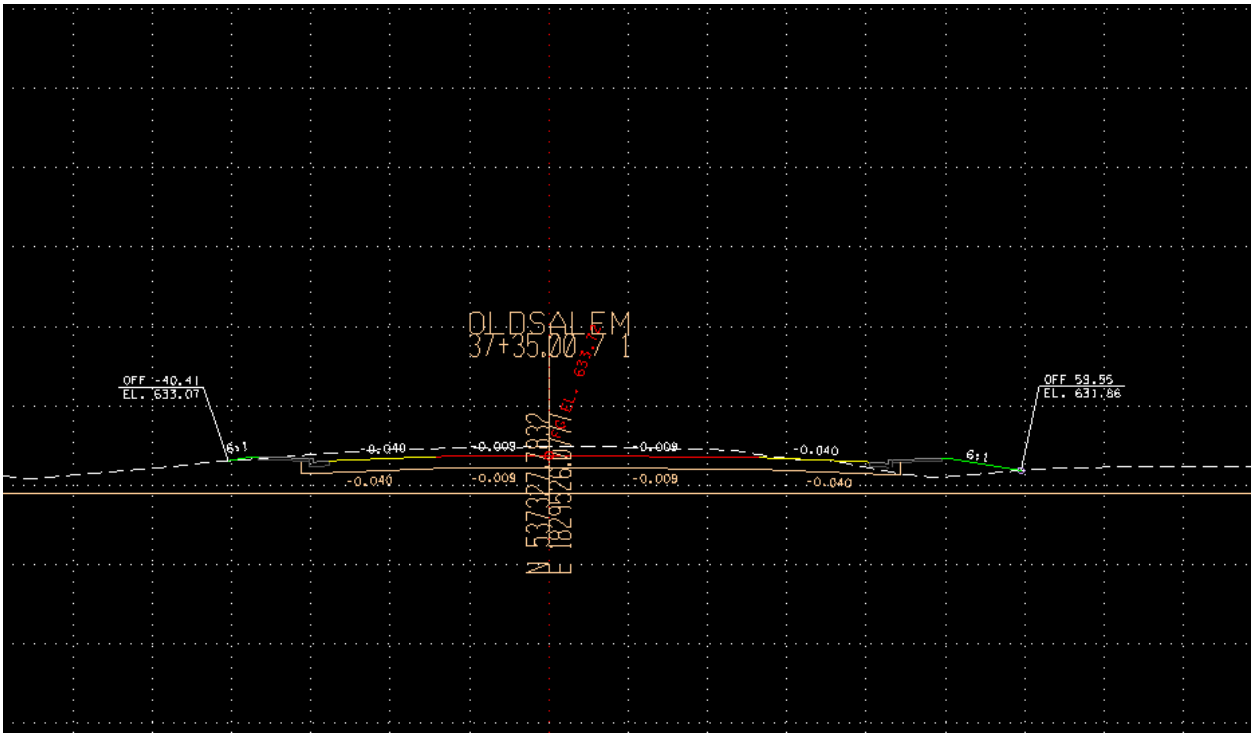
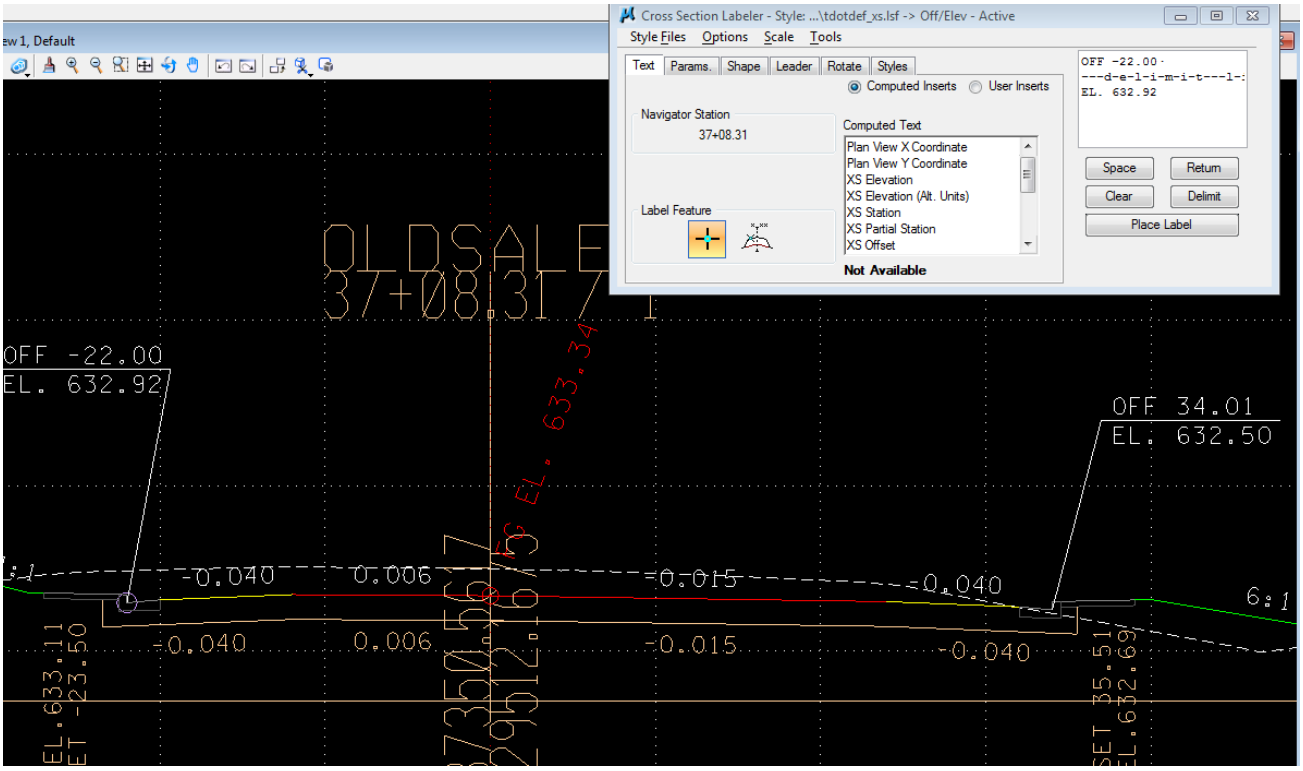
37+40.00
OFF -46.38
EL. 632.80
OFF 64.52
EL. 631.98
6:1
6:1
-0.040
-0.011
-0.008
-0.040
-0.040
-0.011
-0.008
-0.040


OLDSALEM
37+35.00
OFF -40.41
EL. 633.07
OFF 53.55
EL. 631.86
6:1
6:1
-0.040
-0.009
-0.009
-0.040
-0.040
-0.009
-0.009
-0.040

For the sections from 37+08 to 37+25, offsets are close enough they do not need to be modified.

In the side road cross section file, document the curb and gutter elevations for each section in the radius:

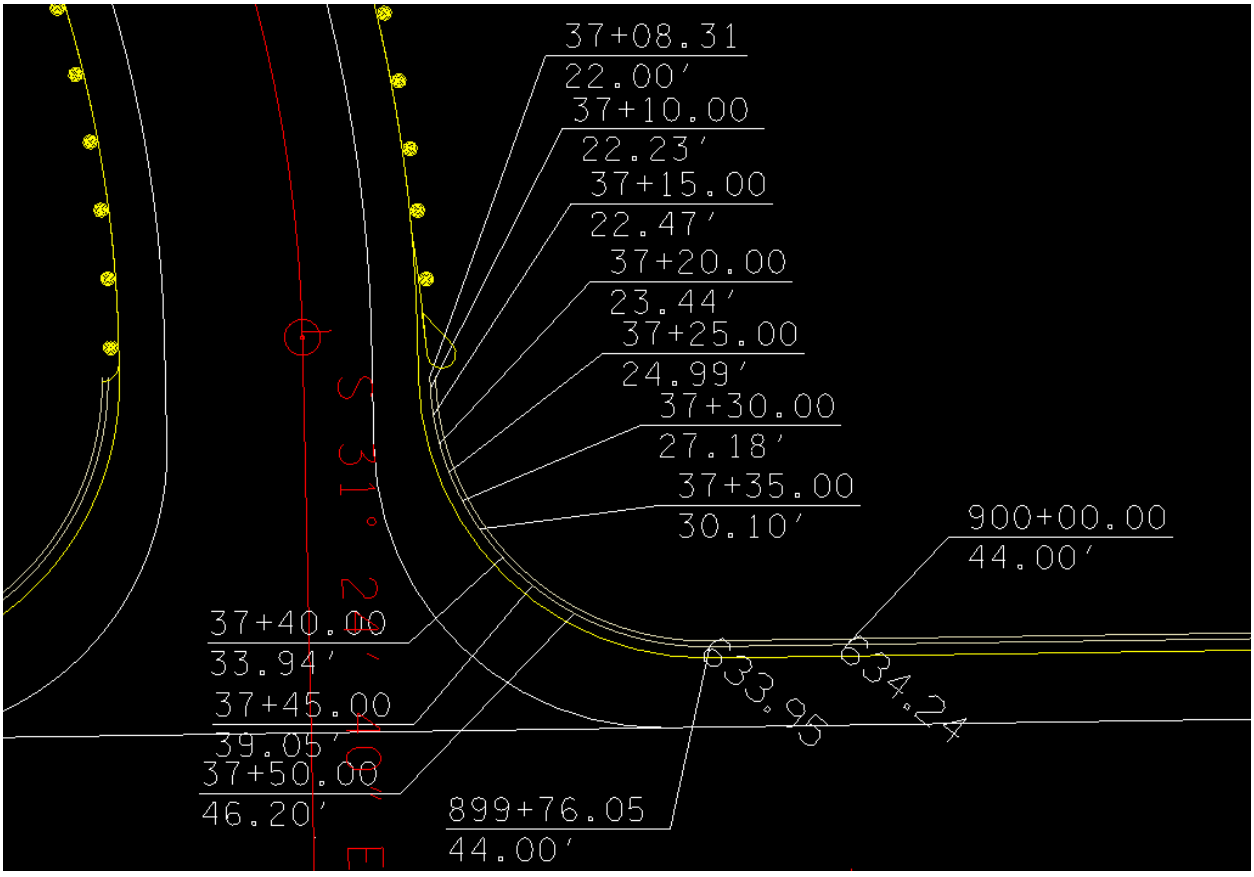


Section at 37+08.31 (beginning radius) showing left and right curb and gutter elevations

Curb and Gutter elevations at each station:

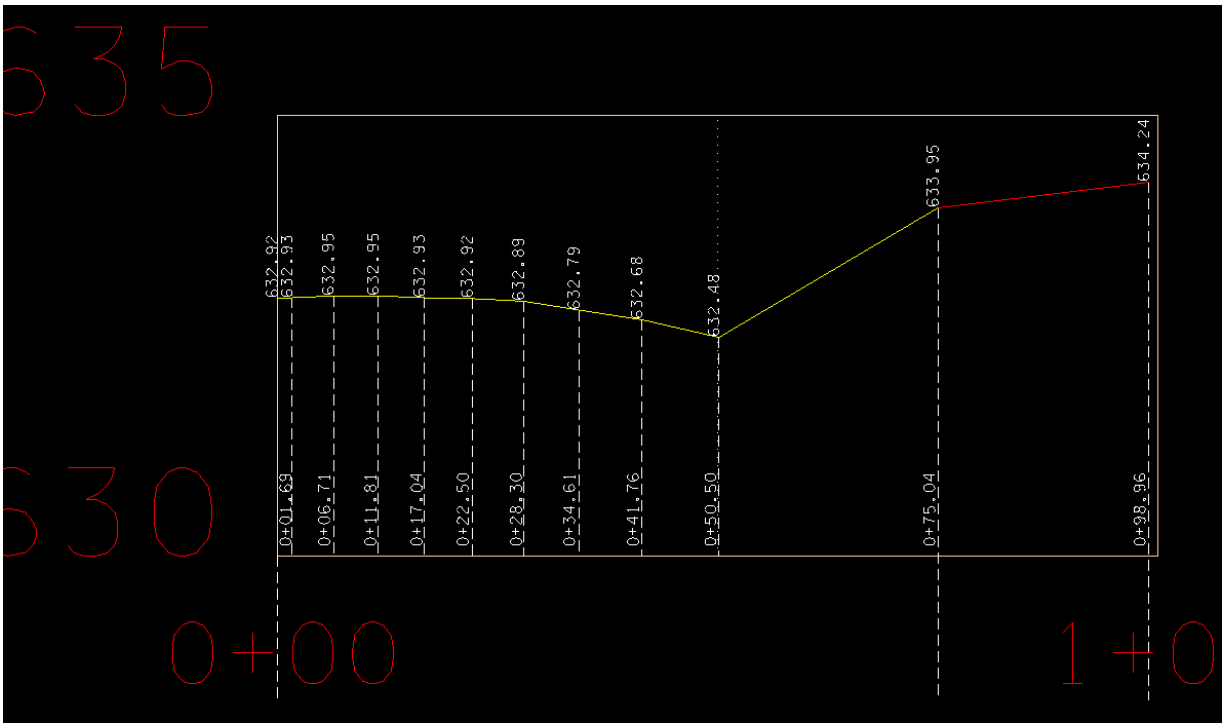
Old Salem Road						
Left side radius				Right side radius		
	*elev.	station on radius			*elev.	station on radius
37+08.31	632.92	0+00		37+08.31	632.50	0+00
37+10	632.93	0+01.69		37+10	632.53	0+01.69
37+15	632.95	0+06.71		37+15	632.59	0+06.73
37+20	632.95	0+11.81		37+20	632.52	0+11.85
37+25	632.93	0+17.04		37+25	632.69	0+17.13
37+30	632.92	0+22.50		37+30	632.72	0+22.65
37+35	632.89	0+28.30		37+35	632.72	0+28.55
37+40	632.79	0+34.61		37+40	632.75	0+34.60
37+45	632.68	0+41.76		37+45	632.68	0+41.77
37+50	632.48	0+50.50		37+50	632.60	0+51.71
899+76.05 SR99	633.95	0+75.04		898+24.04 SR99	634.04	0+74.62
900+00	634.24	0+98.96		898+00	634.23	0+98.65
* elevation after first cross section run						

Left radius:

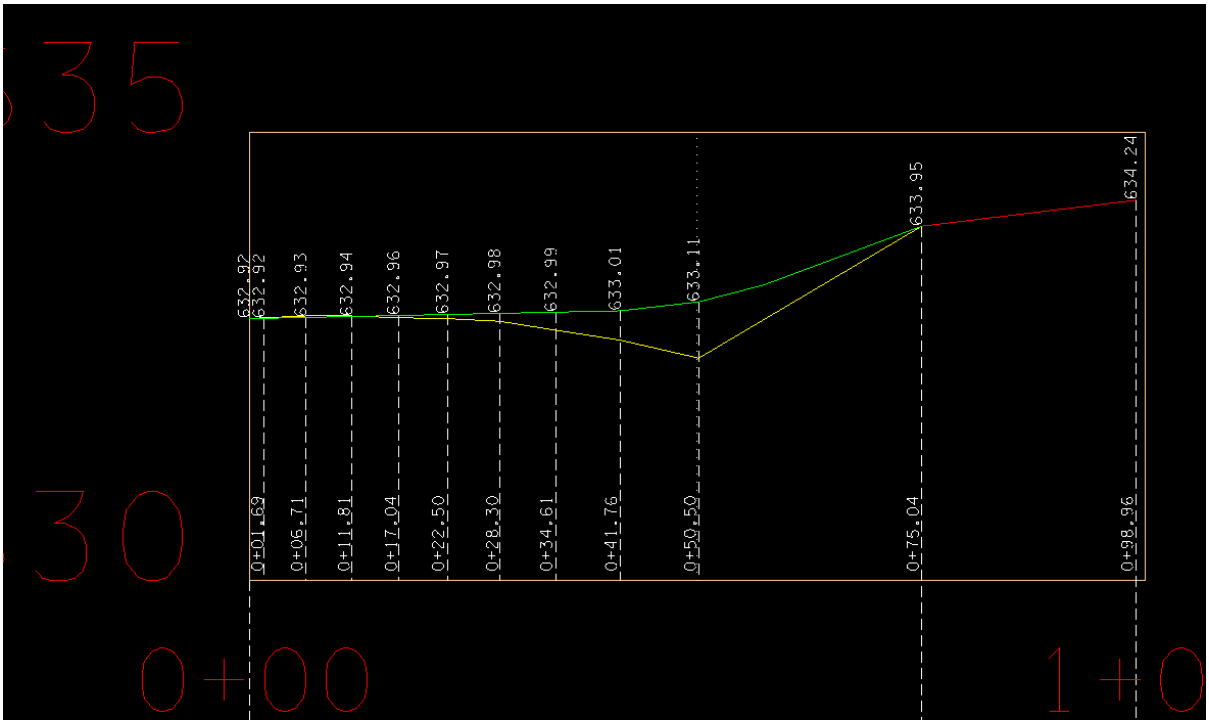


The left side radius showing the station points at which there were curb and gutter elevations. The length along the radius from 37+08.31 to SR99 899+76.05 is 75.04 ft. From 899+76.05 to 900+00 the length is 23.95. the

gutter elevations were read from the mainline dtm using DTM Tools. Using this information the curb and gutter profile can be drawn.



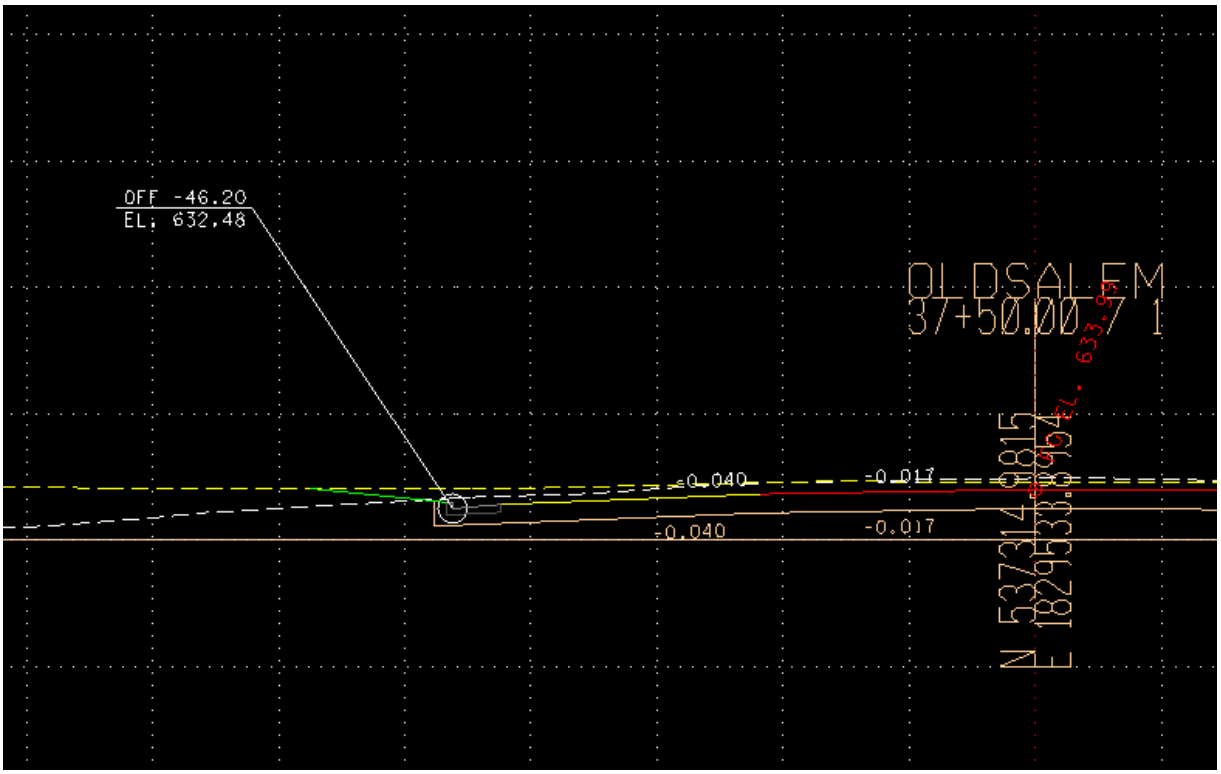
Profile of left side radius showing elevations at each cross section of Old Salem Road. The red line is the curb and gutter profile of the mainline from 899+76 to 900+00. That part will not change.



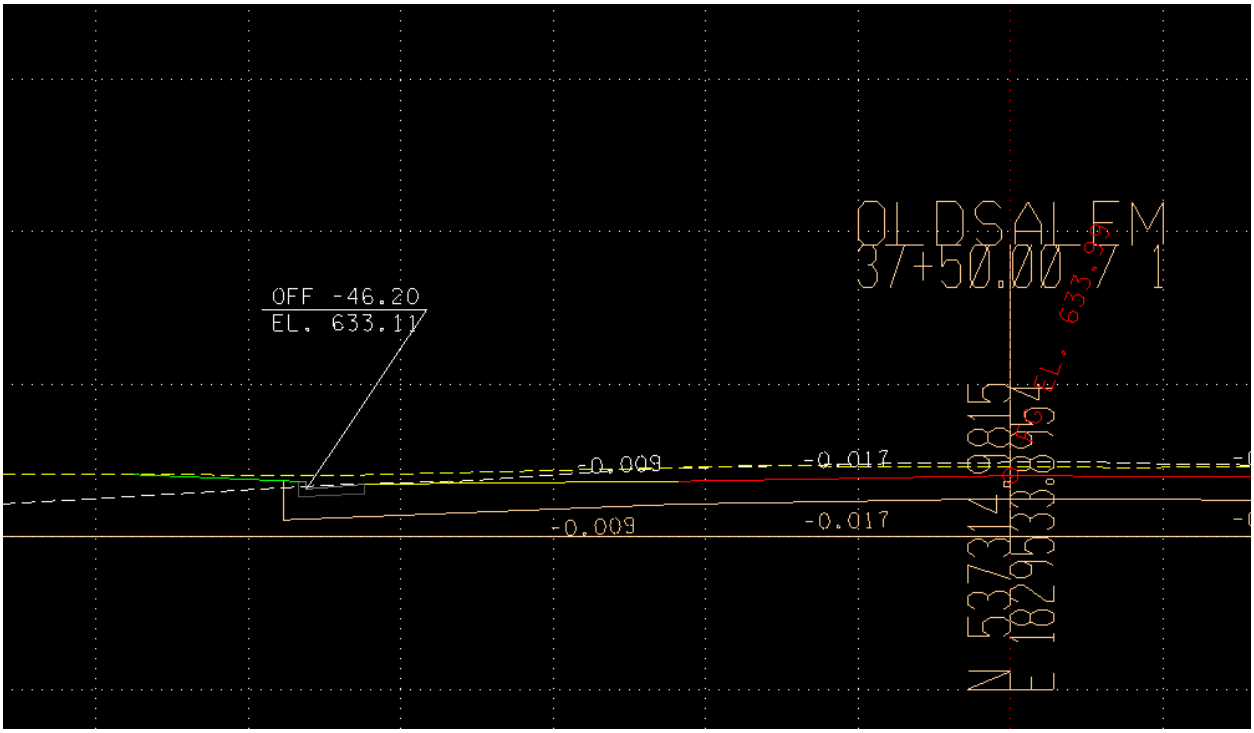
The adjusted curb and gutter profile in green, with new elevations.

New Elevations at each station for left side:

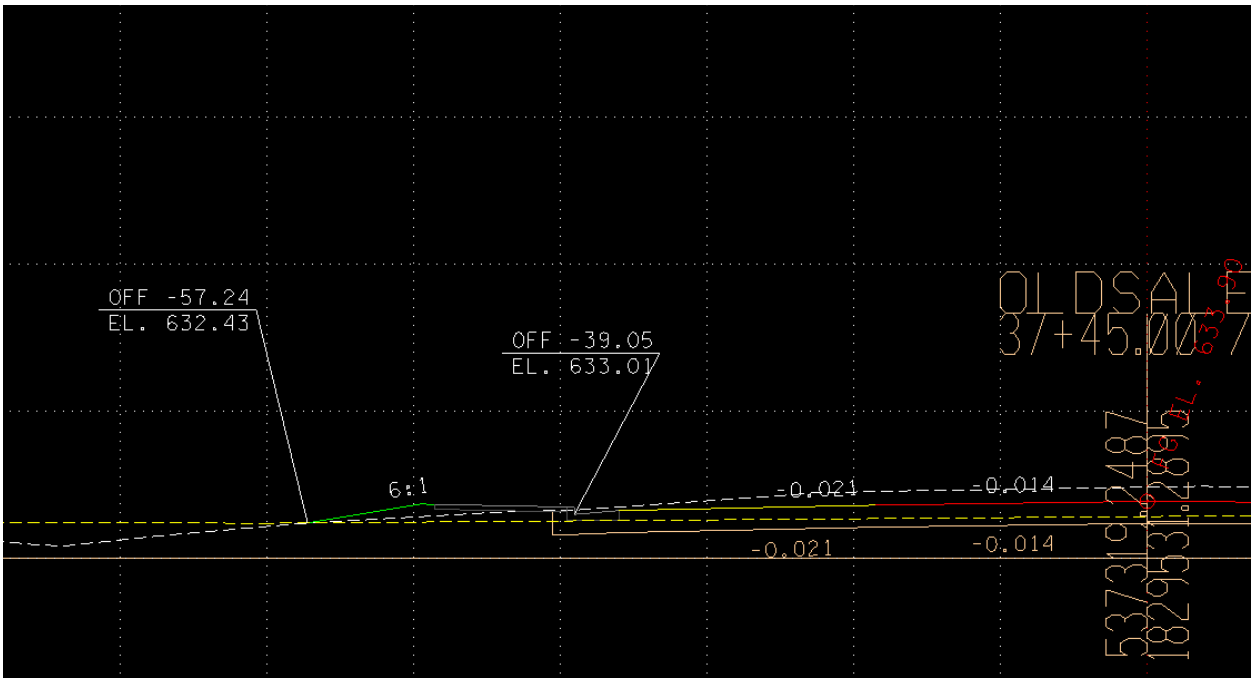
Old Salem Road			
Left side radius			
	* elev.	station on radius	adj. elev.
37+08.31	632.92	0+00	
37+10	632.93	0+01.69	632.92
37+15	632.95	0+06.71	632.93
37+20	632.95	0+11.81	632.94
37+25	632.93	0+17.04	632.96
37+30	632.92	0+22.50	632.97
37+35	632.89	0+28.30	632.98
37+40	632.79	0+34.61	632.99
37+45	632.68	0+41.76	633.01
37+50	632.48	0+50.50	633.11
899+76.05 SR99	633.95	0+75.04	
900+00	634.24	0+98.96	
* elevation after first cross section run			



Station 37+50 as originally drawn



Station 37+50 with curb and gutter elevation adjusted.



Station 37+45 with curb and gutter elevation adjusted.

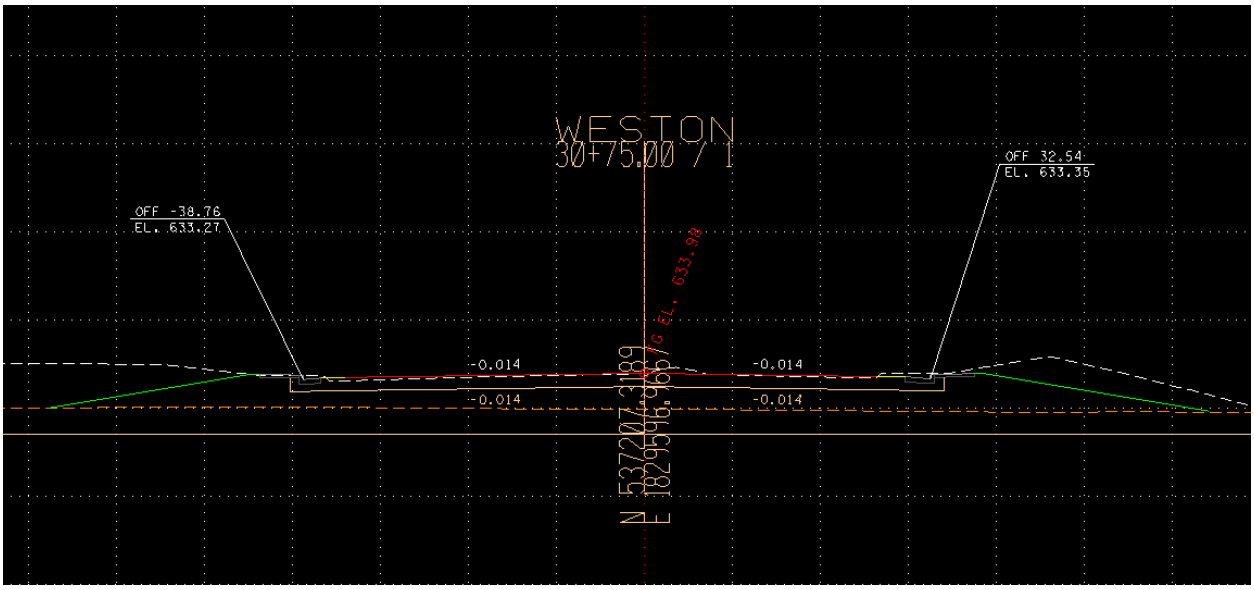
When all curb and gutter elevations for the left radius have been adjusted, take similar steps to adjust the curb and gutter elevations for the right radius.

Right side radius			
	* elev.	station on radius	adj. elev.
37+08.31	632.50	0+00	
37+10	632.53	0+01.69	632.53
37+15	632.59	0+06.73	632.58
37+20	632.52	0+11.85	632.64
37+25	632.69	0+17.13	632.70
37+30	632.72	0+22.65	632.77
37+35	632.72	0+28.55	632.84
37+40	632.75	0+34.60	632.91
37+45	632.68	0+41.77	632.99
37+50	632.60	0+51.71	633.18
898+24.04 SR99	634.04	0+74.62	
898+00	634.23	0+98.65	

Since the radius section was in curb and gutter, two separate runs were made, so create a dtm for the section running from the beginning station of the alignment to the beginning or the radius. Then create a dtm for the radius section, and then merge the two dtms to create a single dtm for the road. For example, for Old Salem Road, the section from the beginning of the vertical alignment (33+50) ti the beginning of the intersection radius (37+08.31) would be oldsalem1.tin. From 37+08.31 to the mainline edge of pavement (37+69.79) would be oldsalem2.tin. Merge the two to create oldsalem.tin.

If the radius section is not in curb and gutter, or if the entire side road is curb and gutter, it would not be necessary to make two separate dtms.

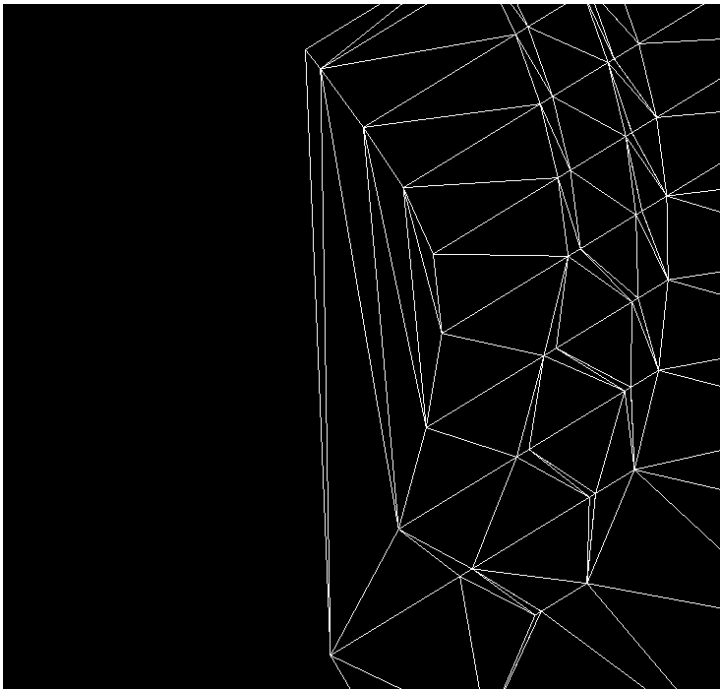
Weston Blvd. has curb and gutter for its entire length, so it will not be necessary to cut two sets of cross sections. Cut cross sections every 5 feet from the beginning at the mainline edge of pavement (30+00) to the end of the intersection radius (30+95.81), then every 50 feet to the ending station of the vertical alignment (31+25).



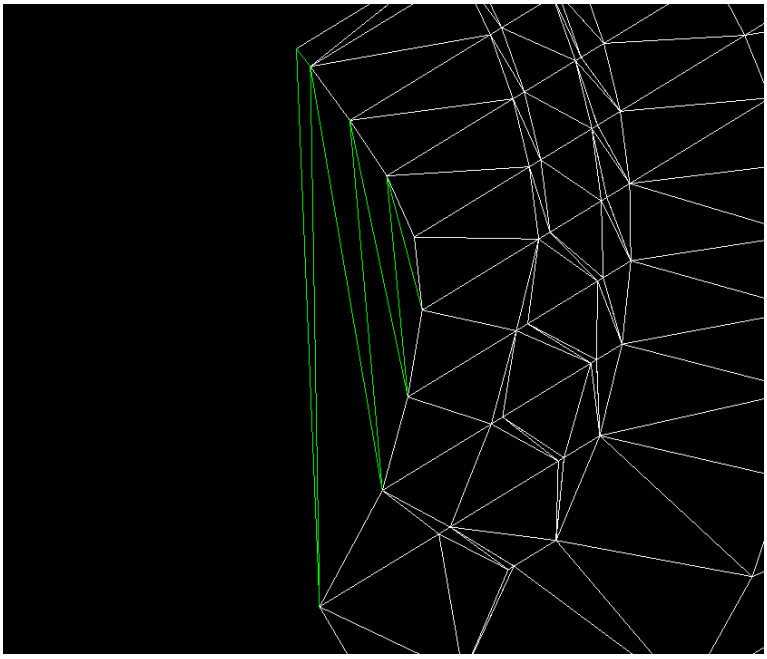
Modified cross section at 30+75 Weston Blvd. Orange dash line is mainline dtm surface. Curb and gutter elevations and off sets shown.

Once tin files are made of each side road, merge them with the mainline tin file to create a proposed tin file.

It may be necessary to edit the surfaces before merging, using the “edit triangles” option under DTM Tools.



Example of triangle display



Delete triangles highlighted in green