

Earthwork Design Guide



Roadway Design Division

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Introduction

An accurate and easily interpreted earthwork report is helpful to correctly estimate the cost of a project, both in terms of money and in terms of time and work. To accurately assess the earthwork for a project, a designer needs to have cut cross-sections, calculated topsoil needs and determined the rock content of the soil, if possible.

Part 1 of this document pulls together information from many sources and provides links for reference. The Designer should be able to find answers to most questions here.

Part 2 will go over how a designer will determine the earthwork quantities for a project and how to fill out the Earthwork Grading Quantities Table.

Part 3 provides a step-by step guide for calculating topsoil quantities.

Part 1 - Earthwork Quick Guide

Design Guidelines

Details on Earthwork design can be found in the [Roadway Design Guidelines, Chapter 2-700](#).

Specifications Manual

Earthwork is discussed in Part 2 of the [TDOT Specifications Manual](#)

Standard Drawings

Not applicable.

TDOT CADD Programs

Details of how to use MicroStation to calculate and record earthwork values can be found in Chapter 15 of the [GEOPAK Road Design class manual](#). Chapter 16 describes cross-sections, including how to incorporate the earthwork data.

Details of how to use the Open Roads Designer to calculate an record earthwork values can be found in Chapter 8 of the [ORD Roadway Design I Manual](#)

Roadway Design Plans

This list below describes where earthwork values can be found in a standard roadway plan set.

- Estimated Roadway Quantities Sheet: The totals of each earthwork type that was calculated will be shown here in cubic yards.
- Tabulated Quantities Sheet: On this sheet, an estimated grading quantities block, such as the one in Figure 1, will be shown. This table can be found in the Estimated Roadway Quantities excel file that will be used for your project. The example below is a balanced example, this one and an unbalanced example is shown in more details in [Roadway Design Guidelines, Chapter 2-706.00](#).
- Cross Section Sheets: For every cross section, a cut, fill, and rock area value will be listed in square feet.

ESTIMATED GRADING QUANTITIES						
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY		
	EXC.	EMB.	EXC.	SHRINK = 15 % SWELL = 15 %		
MAINLINE	219500	243000	190870			
SIDE ROADS	12500	5490	10870			
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES						
INDEPENDENT DITCHES						
TEMPORARY CONSTRUCTION EXITS						
OTHER						
PAVEMENT						
TOPSOIL (EMB.)	5000		4348			
TOPSOIL (EXC.)	13000		11305			
TOPSOIL (TO REPLACE STRIPPED TOPSOIL)		5000				
ROCK (C.Y.)	TOTALS (C.Y.)					
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)
45000		250000	253490	232000	201740	253490
				EXC.	EMB.	
				253490	VS.	-253490
				AVAILABLE	=	0
				WASTE MATERIAL	=	0

Figure 1. Estimated Grading Quantities block, balanced example.

Grading Reports

Grading reports are included in Construction Plan sets. These reports are used by construction contractors to estimate the amount of time, labor and equipment that will be needed. It is useful to separate the mainline estimates from those of side roads, driveways, ditches and culverts. An example of a grading report can be seen in Figure 2 below.

To create a grading report, start with the Grading Report Template file. Edit the header to include the correct information for your project, then paste the Estimated Grading Quantities block in the place the template indicates (removing the instructions). For each major feature of your project (mainline, sideroad, etc), paste the results of the earthwork log file generated by GEOPAK, or any calculations done manually. For readability, separate each log file with a copy of the text box provided in the template, and edit the description.

GRADING REPORT

COMPUTED BY: AMY LORENTZ
 CHECKED BY: DAWN PRUETT
 PIN: 124717.00
 ROUTE NO. OR STREET: SR 174

SHEET 1 OF 1
 STATE NO.:83027-3221-94
 FEDERAL PROJECT NO: BR-STP-174(27)
 COUNTY: SUMNER

ESTIMATED GRADING QUANTITIES						
DESCRIPTION	UNADJUSTED VOLUME \$ (CY)		ADJUSTED VOLUME \$ (CY)	BALANCE SUMMARY		
	EXC.	EMB.	EXC.	SHRINK =	20 % SWELL =	20 %
MAINLINE	4235	6578	3529			
SIDE ROADS	2341	654	1951			
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES				EXC.	EMB.	
PAVEMENT	542		452	16883	VS.	-7232
TOPSOIL (EMB)				AVAILABLE =		9651
TOPSOIL (EXC)				WASTE MATERIAL =		11581
TOPSOIL (TO REPLACE STRIPPED TOPSOIL)						
TOTALS (C.Y.)						
ROCK	EXC. (UNCL.)	EMB. (UNCL.)	EXC (COMMON)	EXC. (AVAIL)	EXC. (ADJ.)	
543	7118	7232	6576	5480	16883	

***** SR 174 *****

Material Name	End Areas	Unadjusted	Adjusted	Mult	Mass	Accum	Accum	Accum
Station		(sq. ft.)	Volumes (cu. yd.)	Volumes (cu. yd.)	Factor	Ordinate	Unadj Vol (cu. yd.)	Adj Vol (cu. yd.)
100+43.56	EARTH							
	Excavation	20	0	0	0.85		0	0
	Fill	0	0	0	1.00	0	0	0
100+50.00	EARTH							
	Excavation	22	5	4	0.85		5	4
	Fill	0	0	0	1.00	4	0	0
100+75.00	EARTH							
	Excavation	51	34	29	0.85		39	33
	Fill	0	0	0	1.00	33	0	0
101+00.00	EARTH							
	Excavation	117	78	66	0.85		117	99
	Fill	0	0	0	1.00	99	0	0
101+25.00	EARTH							
	Excavation	185	140	119	0.85		257	218
	Fill	0	0	0	1.00	218	0	0
101+50.00	EARTH							
	Excavation	251	202	172	0.85		459	390
	Fill	0	0	0	1.00	390	0	0

Figure 2 Example of Grading Report.

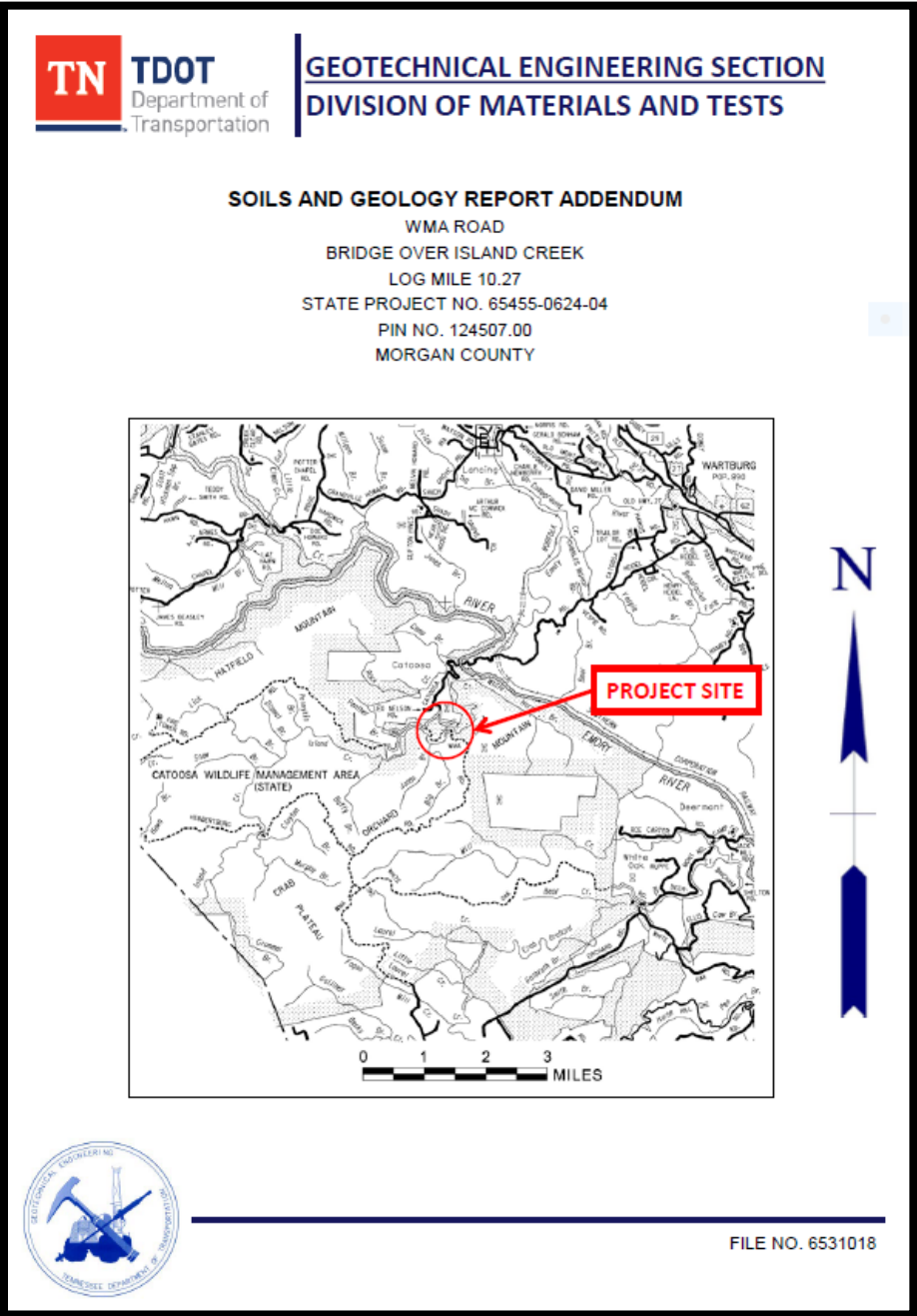
Other Helpful Material

[FHWA Earthwork Design](#)

Part 2 – Earthwork Grading Quantities Block Guide

2.01 Introduction

First, the designer should receive a Soils and Geology Report from the Geotechnical Engineering Division after the project has been submitted for Initial Studies. If the project changes during the R.O.W. stage, a Soils and Geology Report Addendum will be issued which is what is shown below and what will be used in this guide.



2.02 Estimated Grading Quantities Block Set-Up

First, obtain the Estimated Grading Quantities Block and Topsoil Quantities Table from the Estimated Roadway Quantities File located on the [Roadway Design Documents](#) webpage. An example of the Estimated Grading Quantities Block is shown below.

ESTIMATED GRADING QUANTITIES						
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY		
	EXC.	EMB.	EXC.	SHRINK = 0 %	SWELL = 0 %	
MAINLINE	0	0				
SIDE ROADS	0	0				
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0		EXC.		EMB.
INDEPENDENT DITCHES	0	0				
TEMPORARY CONSTRUCTION EXITS	0	0		0	VS.	0
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	0	0				
TOPSOIL (EMB.)	0			AVAILABLE	=	0
TOPSOIL (EXC.)	0					
TOPSOIL TOTALS (SEE TOPSOIL TAB)				WASTE MATERIAL	=	0
ROCK (C.Y.)		TOTALS (C.Y.)				
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)
0	0	0	0	0	0	0

2.02.01 Shrink and Swell

The shrink and swell factors are an important thing to pull from the Soils and Geology Report. For this project, both the **shrink and swell factors** are **20%**.

ESTIMATED GRADING QUANTITIES						
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY		
	EXC.	EMB.	EXC.	SHRINK = 20 %	SWELL = 20 %	
MAINLINE	0	0				
SIDE ROADS	0	0				
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0		EXC.		EMB.
INDEPENDENT DITCHES	0	0				
TEMPORARY CONSTRUCTION EXITS	0	0		0	VS.	0
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	0	0				
TOPSOIL (EMB.)	0			AVAILABLE	=	0
TOPSOIL (EXC.)	0					
TOPSOIL TOTALS (SEE TOPSOIL TAB)				WASTE MATERIAL	=	0
ROCK (C.Y.)		TOTALS (C.Y.)				
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)
0	0	0	0	0	0	0

2.02.02 Graded Solid Rock

The report recommended that graded solid rock (GSR) and geotextile fabric are to be used in the fill sections along the project. These two items were given in the report and shown below. These quantities should be added to the Estimated Roadway Quantities sheet.

ESTIMATED SOIL QUANTITIES			
ITEM NO.	DESCRIPTION	UNIT	QUANTITY
① 203-02.01	BORROW EXCAVATION (GRADED SOLID ROCK)	TON	229
① 740-10.04	GEOTEXTLE FABRIC (TYPE IV)	SY	379

FOOTNOTES:

① THIS ITEM TO BE USED BETWEEN STATION 101+70 TO 103+28 RIGHT OF CENTERLINE AND STATION 104+68 TO 105+08 LEFT OF CENTERLINE OTHERWISE AS DIRECTED BY ENGINEER FOR THE STABILIZATION OF SUBGRADE.

For this project, from the Soils and Geology Report, it would require 229 tons of GSR or **130 C.Y.** This quantity should be added to the **ROCK EMB.** cell in the Estimated Grading Quantities block.

ESTIMATED GRADING QUANTITIES						
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY		
	EXC.	EMB.	EXC.	SHRINK = 20 %	SWELL = 20 %	
MAINLINE	0	0				
SIDE ROADS	0	0				
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0				
INDEPENDENT DITCHES	0	0				
TEMPORARY CONSTRUCTION EXITS	0	0				
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	0	0				
TOPSOIL (EMB.)	0					
TOPSOIL (EXC.)	0					
TOPSOIL TOTALS (SEE TOPSOIL TAB)						
ROCK (C.Y.)		TOTALS (C.Y.)				
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)
0	130	0	-130	0	0	0

EXC. EMB.
0 vs. 130

AVAILABLE = 130

WASTE MATERIAL = 156

BORROW ROCK = 156

2.03 Mainline Cut/Fill Calculations

The next quantities to determine will be the project's mainline cut and fill volumes. To calculate these, follow the steps in Chapter 8 of the [ORD Road I Manual](#) or in Exercise 15 of the [GEOPAK Road Course Guide](#). The following is the result from running the earthwork in GEOPAK. The unadjusted volumes (C.Y.) can be added to the Estimated Grading Quantities block. This would be **230 C.Y.** for **MAINLINE EXC.** and **250 C.Y.** for **MAINLINE EMB.**

Material Name	Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	Mult Factor

EARTH			
Excavation	230	230	1.00
Fill	250	250	1.00

ESTIMATED GRADING QUANTITIES					
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY	
	EXC.	EMB.	EXC.	SHRINK = 20 %	SWELL = 20 %
MAINLINE	230	250	184		
SIDE ROADS	0	0			
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0			
INDEPENDENT DITCHES	0	0			
TEMPORARY CONSTRUCTION EXITS	0	0			
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	0	0			
TOPSOIL (EMB.)	0				
TOPSOIL (EXC.)	0				
TOPSOIL TOTALS (SEE TOPSOIL TAB)					
ROCK (C.Y.)		TOTALS (C.Y.)			
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)
0	130	230	120	230	184

EXC.	184	VS.	EMB.	-120
AVAILABLE	=			64
WASTE MATERIAL	=			77
BORROW ROCK	=			156

2.04 Additional Cut/Fill Project Amounts

2.04.01 Side Roads

The side road earthwork quantities can be calculated using a similar method as the mainline quantities in the manuals mentioned above. For this project, it was determined that the **SIDE ROADS EXC.** quantity is **309 C.Y.** and the **SIDE ROADS EMB** quantity is **67 C.Y.**, as shown below.

Material Name	Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	Mult Factor
EARTH			
Excavation	309	309	1.00
Fill	67	67	1.00

ESTIMATED GRADING QUANTITIES							
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY			
	EXC.	EMB.	EXC.	SHRINK = 20 % SWELL = 20 %			
MAINLINE	230	250	184				
SIDE ROADS	309	67	248				
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0		EXC.		EMB.	
INDEPENDENT DITCHES	0	0					
TEMPORARY CONSTRUCTION EXITS	0	0		432	VS.	-187	
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	0	0					
TOPSOIL (EMB.)	0			AVAILABLE	=	245	
TOPSOIL (EXC.)	0						
TOPSOIL TOTALS (SEE TOPSOIL TAB)				WASTE MATERIAL	=	294	
ROCK (C.Y.)		TOTALS (C.Y.)			BORROW ROCK	=	156
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)	
0	130	539	187	539	539	432	

If a project has pavement, independent ditch, private drive, business, or field entrances earthwork, those quantities can also be calculated and then added to the Estimated Grading Quantities block. Steps on how to calculate each of these can be found in either the [ORD Road I Manual](#) or the [GEOPAK Road Course Guide](#). For driveways, see the [Driveway Quick Guide](#) for guidance on driveway earthwork calculations.

2.04.02 Temporary Construction Exits

This project requires two temporary construction exits in the project limits. From the [Drainage Manual Chapter 10](#), each exit requires earthwork to take place. Section 10.08.1.3 discusses the pay items that are required for temporary construction exits. Each exit requires a minimum of 7.15 C.Y. of excavation. Since this project has two and using the minimum required excavation, double 7.15 C.Y. to make 14.3 C.Y. This number can be rounded up to **15 C.Y.** and added to the Estimated Grading Quantities Block under Temporary Construction Exits. Each project may require more excavation for the temporary construction exits.

ESTIMATED GRADING QUANTITIES							
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY			
	EXC.	EMB.	EXC.	SHRINK = 20 % SWELL = 20 %			
MAINLINE	230	250	184				
SIDE ROADS	309	67	248				
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0		EXC.		EMB.	
INDEPENDENT DITCHES	0	0					
TEMPORARY CONSTRUCTION EXITS	15	0	12	444	VS.	-187	
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	0	0					
TOPSOIL (EMB.)	0			AVAILABLE	=	257	
TOPSOIL (EXC.)	0						
TOPSOIL TOTALS (SEE TOPSOIL TAB)				WASTE MATERIAL	=	309	
ROCK (C.Y.)		TOTALS (C.Y.)			BORROW ROCK	=	156
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)	
0	130	554	187	554	554	444	

2.04.03 Bridge Excavation

This project includes a proposed bridge, which means that bridge excavation is required. The process on how to calculate how much bridge excavation is needed, follow Part 4 of the [Structures Calculation Guide](#). The following shows the excavation volumes required for the proposed bridge. Add the **122 C.Y.** to the **OTHER (BRIDGE EXCAVATION, ETC.)** tab on the Estimated Grading Quantities block.

GRAND SUMMARY TOTALS				
Material Name	Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	Mult Factor	

EARTH				
Excavation	122	122	1.00	
Fill	0	0	1.00	

ESTIMATED GRADING QUANTITIES							
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY			
	EXC.	EMB.	EXC.	SHRINK = 20 % SWELL = 20 %			
MAINLINE	230	250	184				
SIDE ROADS	309	67	248				
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0		EXC.		EMB.	
INDEPENDENT DITCHES	0	0					
TEMPORARY CONSTRUCTION EXITS	15	0	12	541	VS.	-187	
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	122	0	98				
TOPSOIL (EMB.)	0			AVAILABLE	=	354	
TOPSOIL (EXC.)	0						
TOPSOIL TOTALS (SEE TOPSOIL TAB)				WASTE MATERIAL	=	425	
ROCK (C.Y.)		TOTALS (C.Y.)			BORROW ROCK	=	156
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)	
0	130	676	187	676	676	541	

2.04.04 Topsoil

Topsoil is another earthwork quantity that needs to be added to this estimated grading quantities block. Topsoil can either be furnished to the project or used from the existing soil on

the project site. Geotech will assist with the determination of whether or not your on-site soil is approved. Additionally, the project needs to have adequate on-site storage area for the topsoil. The steps to calculate the required topsoil can be found in Part 3 – Computing Topsoil Quantities. For this project, it was determined that there will be 32 C.Y. of fill topsoil required to replace the stripped topsoil. This quantity can then be added to the Topsoil Quantities Table under the subcategory Existing Topsoil is Not Suitable for Reuse. Chapter 7 of the RDG contains all relevant item numbers and payment options used for Topsoil.

TOPSOIL								
IF EXISTING TOPSOIL IS SUITABLE FOR REUSE								
PROPOSED SLOPE AREA S.F.	EXISTING TOPSOIL (EXC.)	EXISTING TOPSOIL (EMB.)	EXISTING TOPSOIL (TOTAL) C.Y.	REQUIRED TOPSOIL C.Y.	PLACING TOPSOIL 203-04 C.Y.	FURNISHED TOPSOIL 203-07 C.Y.	EXCESS TOPSOIL C.Y.	WASTE TOTAL (C.Y.)
1728	0	0	0	32	0	32	0	425
IF EXISTING TOPSOIL IS NOT SUITABLE FOR REUSE								
PROPOSED SLOPE AREA S.F.	EXISTING TOPSOIL (EXC.)	EXISTING TOPSOIL (EMB.)	EXISTING TOPSOIL (TOTAL) C.Y.	REQUIRED TOPSOIL C.Y.	PLACING TOPSOIL 203-04 C.Y.	FURNISHED TOPSOIL 203-07 C.Y.	EXCESS TOPSOIL C.Y.	WASTE TOTAL (C.Y.)
1728	N/A	N/A	N/A	32	N/A	32	N/A	N/A

2.05 Item Numbers

With all the quantities calculated above filled in, the final Estimated Grading Quantities block item numbers can be filled out. Below is the Estimated Grading Quantities block with the quantities that need to be added to the estimated Roadway Quantities Block highlighted.

ESTIMATED GRADING QUANTITIES						
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY		
	EXC.	EMB.	EXC.	SHRINK = 20 % SWELL = 20 %		
MAINLINE	230	250	184			
SIDE ROADS	309	67	248			
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0				
INDEPENDENT DITCHES	0	0				
TEMPORARY CONSTRUCTION EXITS	15	0	12			
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	122	0	98			
TOPSOIL (EMB.)	0					
TOPSOIL (EXC.)	0					
TOPSOIL TOTALS (SEE TOPSOIL TAB)				AVAILABLE = 354		
ROCK (C.Y.)				WASTE MATERIAL = 425		
TOTALS (C.Y.)				BORROW ROCK = 156		
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)
0	130	676	187	676	676	541

TOPSOIL								
IF EXISTING TOPSOIL IS SUITABLE FOR REUSE								
PROPOSED SLOPE AREA S.F.	EXISTING TOPSOIL (EXC.)	EXISTING TOPSOIL (EMB.)	EXISTING TOPSOIL (TOTAL) C.Y.	REQUIRED TOPSOIL C.Y.	PLACING TOPSOIL 203-04 C.Y.	FURNISHED TOPSOIL 203-07 C.Y.	EXCESS TOPSOIL C.Y.	WASTE TOTAL (C.Y.)
1728	0	0	0	32	0	32	0	425
IF EXISTING TOPSOIL IS NOT SUITABLE FOR REUSE								
PROPOSED SLOPE AREA S.F.	EXISTING TOPSOIL (EXC.)	EXISTING TOPSOIL (EMB.)	EXISTING TOPSOIL (TOTAL) C.Y.	REQUIRED TOPSOIL C.Y.	PLACING TOPSOIL 203-04 C.Y.	FURNISHED TOPSOIL 203-07 C.Y.	EXCESS TOPSOIL C.Y.	WASTE TOTAL (C.Y.)
1728	N/A	N/A	N/A	32	N/A	32	N/A	N/A

Below, is the Estimated Grading Quantities block with the earthwork quantities for this project filled out.

ESTIMATED ROADWAY QUANTITIES			
ITEM NO.	DESCRIPTION	UNIT	QUANTITY EXAMPLE
203-01	ROAD & DRAINAGE EXCAVATION (UNCLASSIFIED)	C.Y.	676
203-02.01	BORROW EXCAVATION (GRADED SOLID ROCK)	TON	229
203-07	FURNISHING & SPREADING TOPSOIL	C.Y.	32

NOTE: 156 C.Y. of graded solid rock is the same quantity as 229 tons of graded solid rock.

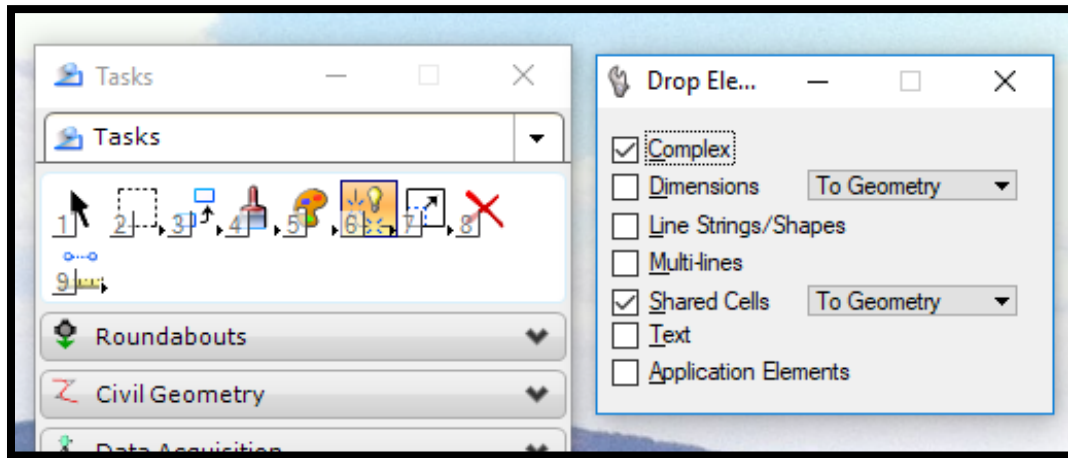
For additional Item Numbers that may be needed for the completion of the Estimated Quantities block, see [Chapter 7 Item Numbers](#).

Part 3 – Computing Topsoil Quantities

The following is a step-by-step tutorial on using MicroStation to calculate topsoil quantities

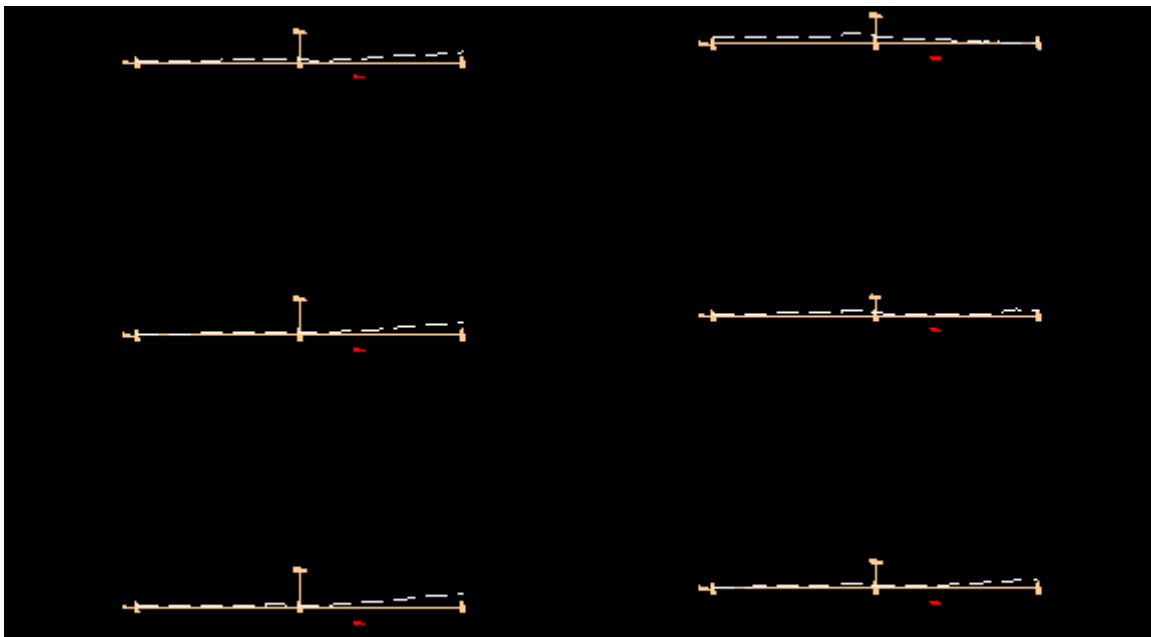
1. Drop Complex Elements

Before running the cross sections, the first step is to go into your Survey DGN file and drop the status on the edge of pavement lines. The program will not run for complex elements.



2. Run Existing Ground Cross Sections on Project

This example is SR 95 from Station 287+00 to Station 289+50 (6 sections):



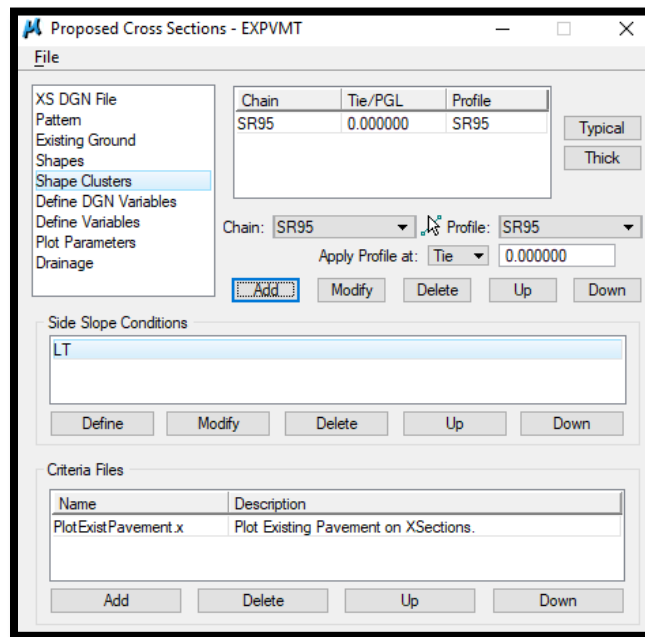
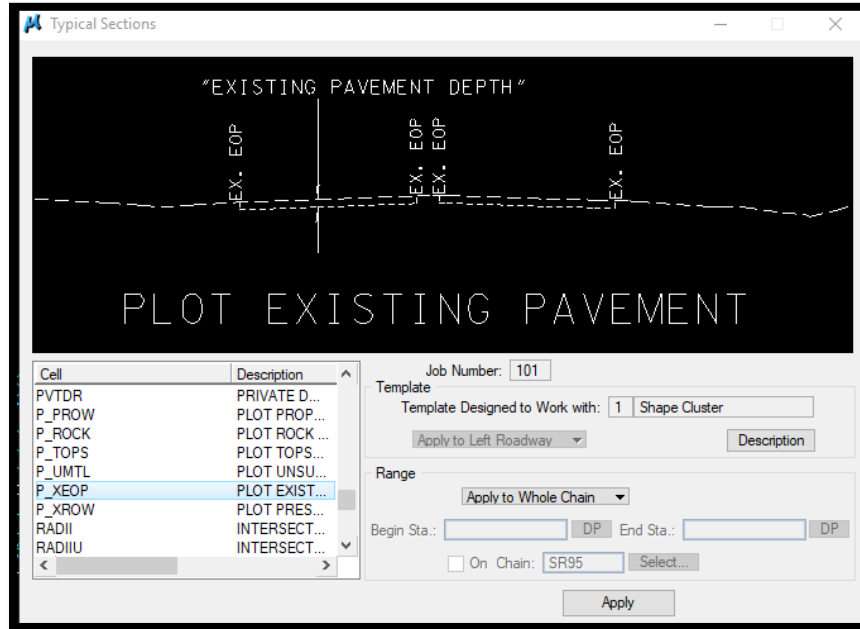
3. Plot existing pavement on cross sections

GEOPAK Project Manager>Proposed Cross Sections

Create Run "EXPVMT"

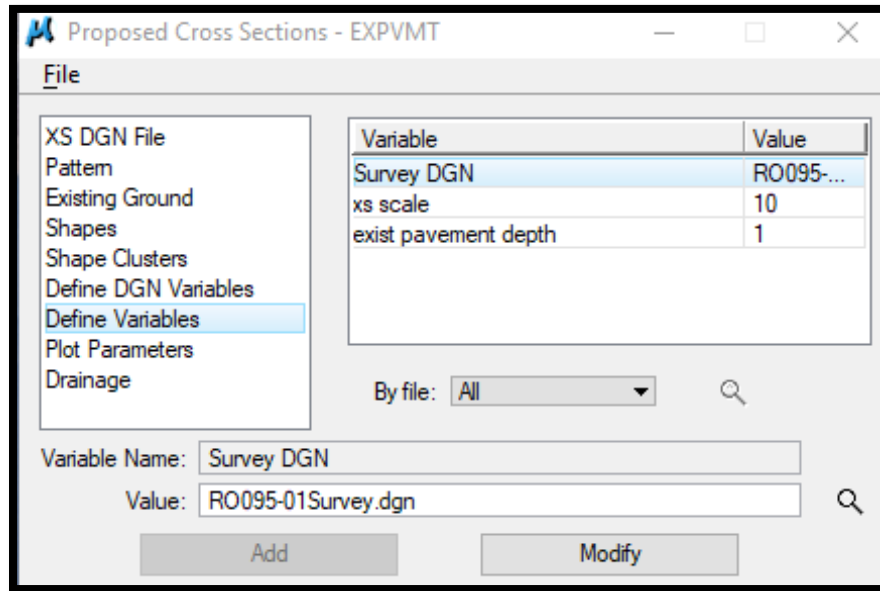
Shape Clusters:

Select template "P_XEOP"



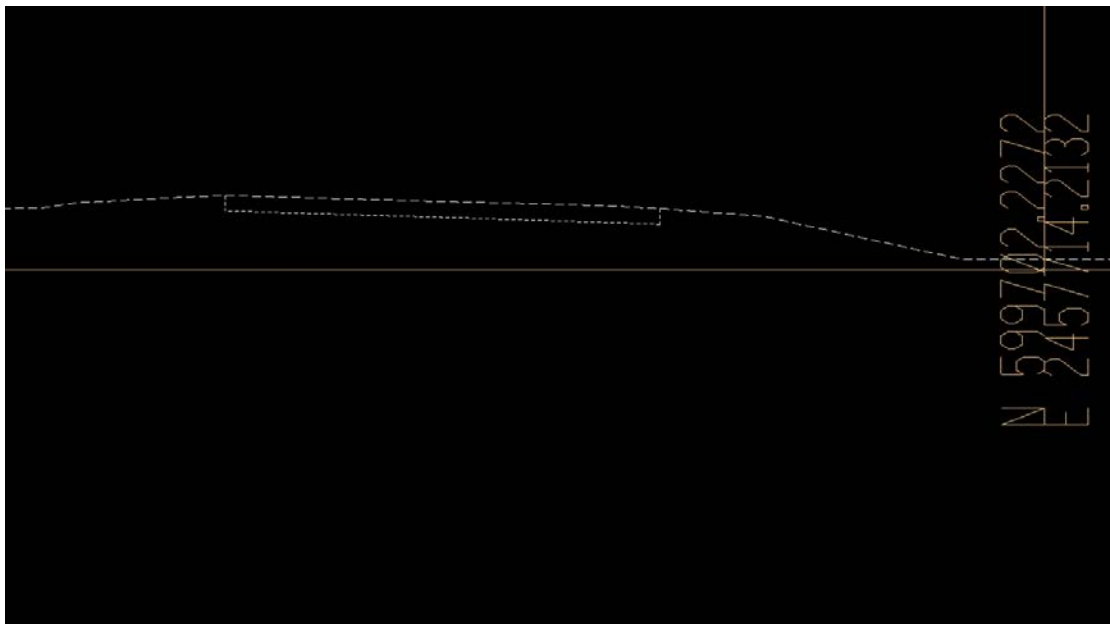
Define Variables:

Change the Survey DGN name to the file for your project



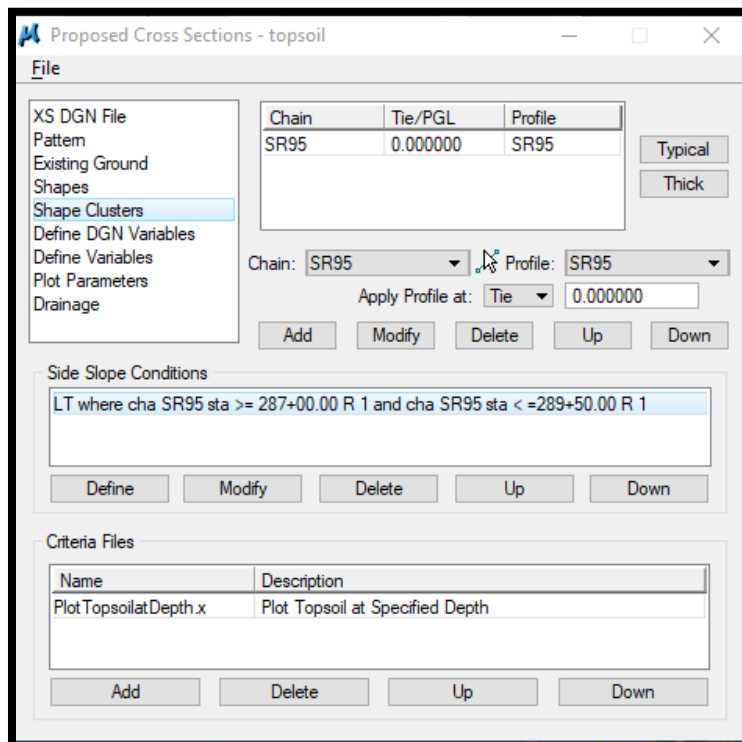
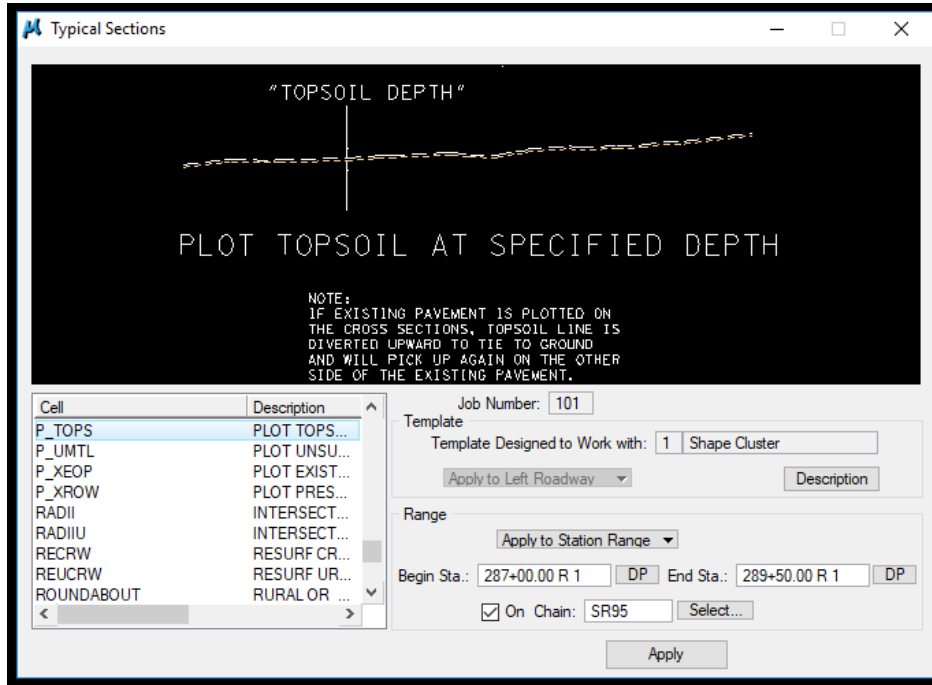
All other settings can stay the same as for other cross section runs

Then run cross sections:

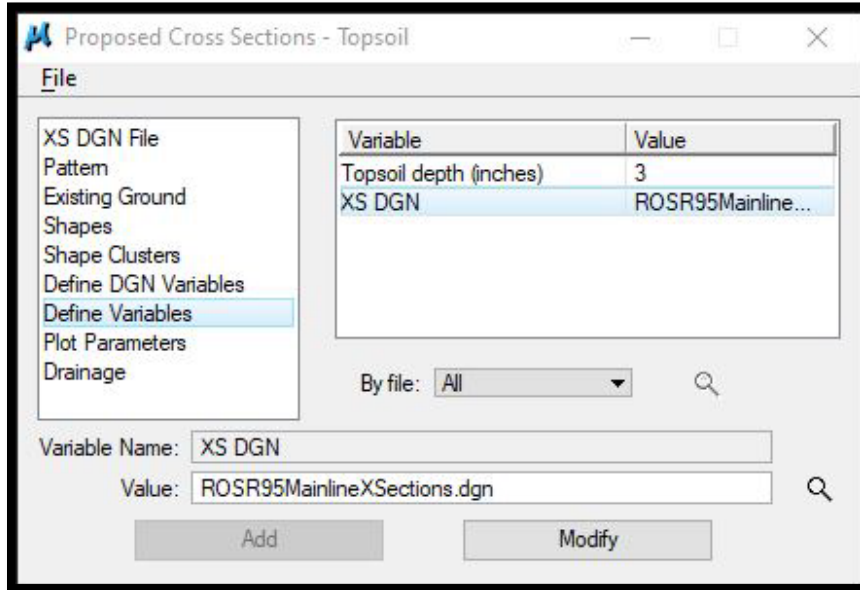


4. Plot Existing Topsoil Layer

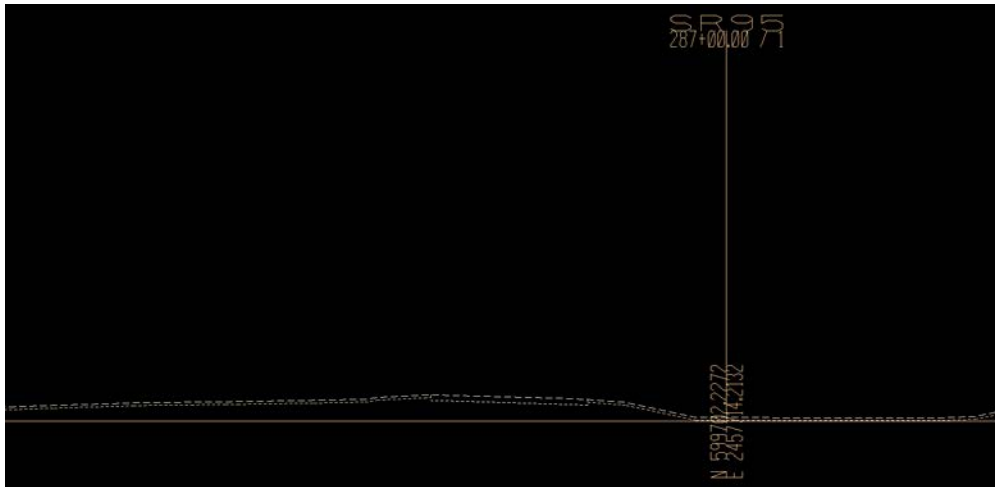
Open GEOPAK Project Manager. Go to Proposed Cross Sections. Create a new run “topsoil”, or copy the Proposed cross section run, and use the same settings with the exception of “Shape Clusters”. Delete the previous clusters, add new cluster using the template P_TOPS



In "Define Variables" edit the "XS DGN" file:



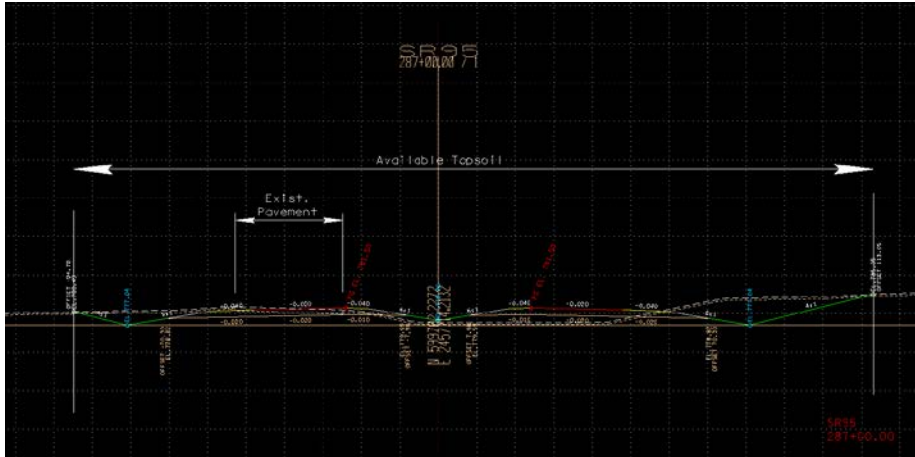
Next - select "Run"



The topsoil layer is plotted on the cross sections at a default depth of 3 inches. This is to allow for 100% Shrinkage. See Roadway Design Guidelines [Chapter 2-706.00](#) Topsoil Requirements for Earthwork Balances for more information regarding the shrinkage guidelines for topsoil. Notice it excludes the existing pavement but plots along the entire ground line of the cross sections.

The available topsoil is the ground line (dashed) between the excavation limit lines, excluding the existing pavement area.

5. Run Proposed Cross Sections

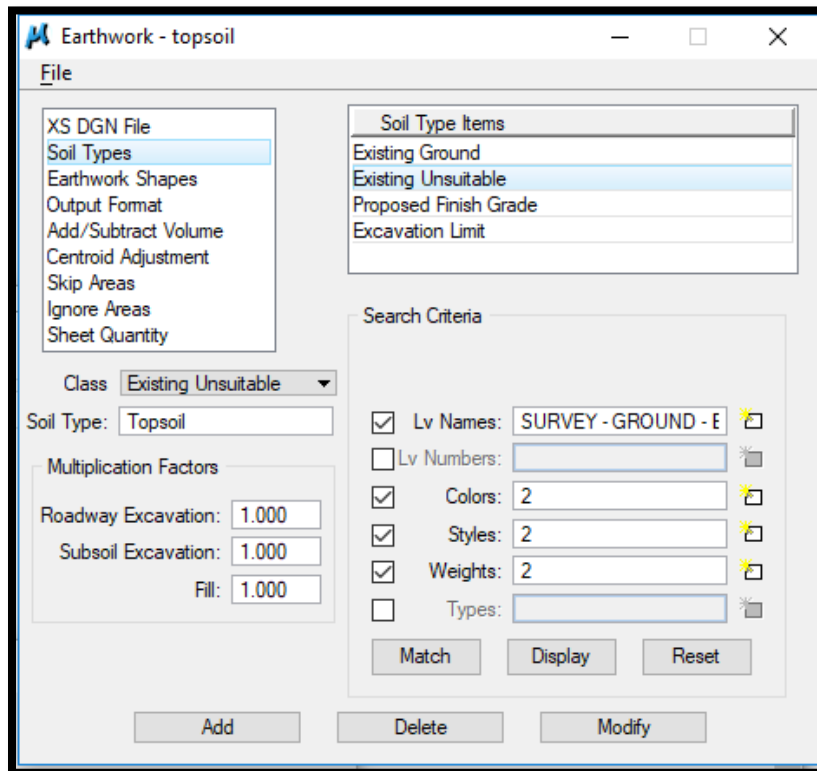


6. Run Earthwork

Create run "Topsoil"

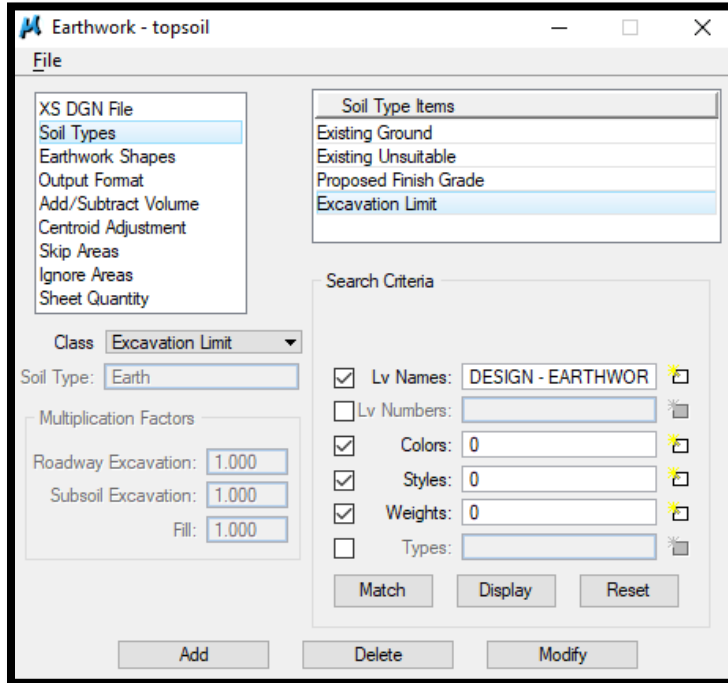
Make settings as shown in [GEOPAK Road Manual](#) Exercise 15. In Soil Types, add settings for Topsoil and Excavation Limit as shown-

Topsoil Settings:



Level Name - SURVEY-GROUND- Bottom of Topsoil Layer

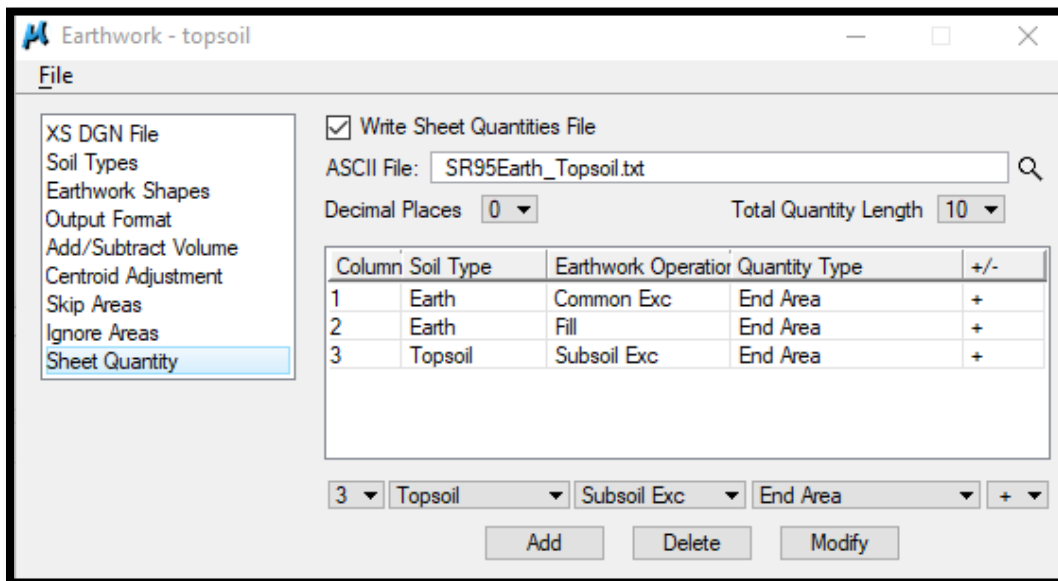
Excavation Limit:



Level Name - DESIGN-EARTHWORK- Excavation Limit Lines

Sheet Quantity

Add column for Topsoil and change the ASCII File Name to *Project_Topsoil.txt*



When all settings are made, then select File>Run

Output file SR95Earth_Topsoil.txt:

SR95Earth_Topsoil - Notepad						
File Edit Format View Help						
Station		Volumes (sq. ft.)	Volumes (cu. yd.)	Volumes (cu. yd.)	Factor	Ordinate

287+00.00	EARTH					
	Common Exc	319.2	0	0	1.00	
	Subgrade Exc	0.0	0	0	1.00	
	Subsoil Exc	0.0	0	0	1.00	
	Fill	132.6	0	0	1.00	0
	TOPSOIL					
	Common Exc	55.0	0	0	1.00	
	Subgrade Exc	0.0	0	0	1.00	
	Subsoil Exc	34.9	0	0	1.00	
	Fill	0.0	0	0	1.00	0
	Mass ordinate for TOPSOIL = 0					
287+50.00	EARTH					
	Common Exc	244.9	522	522	1.00	
	Subgrade Exc	0.0	0	0	1.00	
	Subsoil Exc	0.0	0	0	1.00	
	Fill	82.8	199	199	1.00	323
	TOPSOIL					
	Common Exc	61.4	108	108	1.00	
	Subgrade Exc	0.0	0	0	1.00	
	Subsoil Exc	26.6	57	57	1.00	
	Fill	0.0	0	0	1.00	323
	Mass ordinate for TOPSOIL = 165					
288+00.00	EARTH					
	Common Exc	125.6	343	343	1.00	
	Subgrade Exc	0.0	0	0	1.00	
	Subsoil Exc	0.0	0	0	1.00	
	Fill	139.4	206	206	1.00	460
	TOPSOIL					
	Common Exc	42.2	96	96	1.00	
	Subgrade Exc	0.0	0	0	1.00	
	Subsoil Exc	39.9	62	62	1.00	
	Fill	0.0	0	0	1.00	460
	Mass ordinate for TOPSOIL = 323					

Continued:

SR95Earth_Topsoil - Notepad						
File Edit Format View Help						
288+50.00 EARTH						
Common Exc	55.7	168	168	1.00		
Subgrade Exc	0.0	0	0	1.00		
Subsoil Exc	0.0	0	0	1.00		
Fill	309.8	416	416	1.00		212
TOPSOIL						
Common Exc	22.8	60	60	1.00		
Subgrade Exc	0.0	0	0	1.00		
Subsoil Exc	52.6	86	86	1.00		
Fill	0.0	0	0	1.00		212
Mass ordinate for TOPSOIL = 469						
289+00.00 EARTH						
Common Exc	40.6	89	89	1.00		
Subgrade Exc	0.0	0	0	1.00		
Subsoil Exc	0.0	0	0	1.00		
Fill	429.7	685	685	1.00		-384
TOPSOIL						
Common Exc	12.4	33	33	1.00		
Subgrade Exc	0.0	0	0	1.00		
Subsoil Exc	57.8	102	102	1.00		
Fill	0.0	0	0	1.00		-384
Mass ordinate for TOPSOIL = 604						
289+50.00 EARTH						
Common Exc	35.6	71	71	1.00		
Subgrade Exc	0.0	0	0	1.00		
Subsoil Exc	0.0	0	0	1.00		
Fill	669.0	1017	1017	1.00		-1330
TOPSOIL						
Common Exc	9.5	20	20	1.00		
Subgrade Exc	0.0	0	0	1.00		
Subsoil Exc	66.3	115	115	1.00		
Fill	0.0	0	0	1.00		-1330
Mass ordinate for TOPSOIL = 739						
290+00.00 EARTH						
Common Exc	0.0	33	33	1.00		
Subgrade Exc	0.0	0	0	1.00		
Subsoil Exc	0.0	0	0	1.00		
Fill	0.0	619	619	1.00		-1916
TOPSOIL						
Common Exc	0.0	9	9	1.00		
Subgrade Exc	0.0	0	0	1.00		
Subsoil Exc	0.0	61	61	1.00		
Fill	0.0	0	0	1.00		-1916
Mass ordinate for TOPSOIL = 809						
XS-NOELEM No cross-section elements found at						

Continued:

SR95Earth_Topsoil - Notepad

File Edit Format View Help

Material Name	Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	Mult Factor		

EARTH					
Common Exc	1226	1226	1.00		
Subgrade Exc	0	0	1.00		
Subsoil Exc	0	0	1.00		
Fill	3142	3142	1.00		
TOPSOIL					
Common Exc	326	326	1.00		
Subgrade Exc	0	0	1.00		
Subsoil Exc	483	483	1.00		
Fill	0	0	1.00		
S P L I T S U M M A R Y T O T A L S					
Material Name	XS Quant Unadjusted Volume (cu. yd.)	XS Quant Adjusted Volume (cu. yd.)	Add/Sub Quant Unadjusted Volume (cu. yd.)	Add/Sub Quant Adjusted Volume (cu. yd.)	Mult Factor

EARTH					
Common Exc	1226	1226	0	0	1.00
Subgrade Exc	0	0	0	0	1.00
Subsoil Exc	0	0	0	0	1.00
Fill	3142	3142	0	0	1.00
TOPSOIL					
Common Exc	326	326	0	0	1.00
Subgrade Exc	0	0	0	0	1.00
Subsoil Exc	483	483	0	0	1.00
Fill	0	0	0	0	1.00
B A L A N C E P O I N T S U M M A R Y					
Material Name	Cumulative		Incremental		Mult Factor
	Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	

Earth (Common Exc.) = 1226 C.Y.

Emb. = 3142 C.Y.

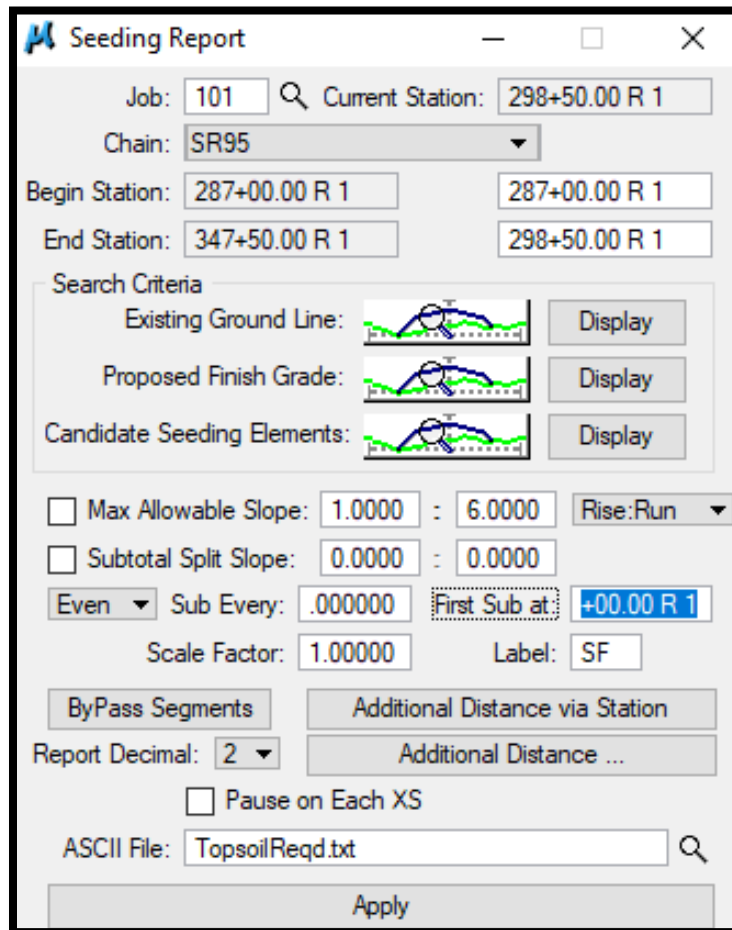
Exc. Topsoil Volume = 326 C.Y. + 483 C.Y. = 809 C.Y.

7. Required Topsoil

Since topsoil will be required on all slopes, calculate the surface area of the proposed fill and cut slopes and multiply by the thickness of the required topsoil (6").

In the [GEOPAK Road Couese Guide](#), reference Exercise 17 (Cross Section Reports) to calculate the surface area (seeding and sodding). In step 5 of Exercise 17, use the setting **Even at 50** for the Subtotal option. For the ASCII File name, use TopsoilReqd.txt.

* 6" is used for quantities calculations to allow for 100% shrinkage down to the required 3" (See Roadway Design Guidelines Chapter 2-707.00 Roadway Design Guidelines)



The screenshot shows the 'Seeding Report' dialog box with the following settings:

- Job: 101
- Current Station: 298+50.00 R 1
- Chain: SR95
- Begin Station: 287+00.00 R 1
- End Station: 347+50.00 R 1
- Search Criteria:
 - Existing Ground Line: [Display]
 - Proposed Finish Grade: [Display]
 - Candidate Seeding Elements: [Display]
- Max Allowable Slope: 1.0000 : 6.0000 (Rise:Run)
- Subtotal Split Slope: 0.0000 : 0.0000
- Even [Selected] Sub Every: .000000 First Sub at: +00.00 R 1
- Scale Factor: 1.00000 Label: SF
- Buttons: ByPass Segments, Additional Distance via Station, Additional Distance ...
- Report Decimal: 2
- Pause on Each XS: [Unselected]
- ASCII File: TopsoilReqd.txt
- Apply button

Output file TopsoilReqd.txt:

SUBTOTALS EVERY		50.0000 Ft		BEGINNING AT STATION		287+00.00 R 1 METHOD INCR				[SF]	
SCALING FACTOR		=		1.00000		WITH LABEL					
STATION	SLOPE DISTANCE	AVERAGE SLOPE	DIST	A R E A		SF	SUBTOTAL	A R E A		SF	
	LT RT	LT RT		LT	RT	BOTH	LT	RT	BOTH		
	(TOTAL)										
287+00.00 R 1	33.15 51.98						0	0	0		
	(85.13)	32.54	51.16	1627	2558	4185					
287+50.00 R 1	31.93 50.33						1627	2558	4185		
	(82.26)	30.70	44.03	1535	2202	3737					
288+00.00 R 1	29.46 37.72						1535	2202	3736		
	(67.18)	28.26	31.16	1413	1558	2971					
288+50.00 R 1	27.06 24.60						1413	1558	2971		
	(51.66)	20.27	26.39	1014	1320	2334					
289+00.00 R 1	13.48 28.17						1014	1320	2333		
	(41.65)	14.83	34.30	741	1715	2456					
289+50.00 R 1	16.18 40.43						741	1715	2456		
	(56.61)										
TOTAL	LEFT	RIGHT		BOTH							
SF=	6330.0000	9353.0000		15681.0000							
ACRES=	0.1453	0.2147		0.3600							

Multiply the proposed slope area by the required thickness:

$$15681 \text{ S.F.} \times 6 \text{ in} \times 1\text{ft}/12 \text{ in} = \underline{7841 \text{ C.F.}}$$

$$7841 \text{ C.F.} \times 1 \text{ C.Y.}/27 \text{ C.F.} = \underline{290.4 \text{ C.Y.}}$$
 (This is the required topsoil)

Refer to [Chapter 2-707.00](#) Topsoil Requirements for Earthwork Balances in Roadway Design Guidelines for the relationship of topsoil to total earthwork.

Earthwork Balances:

30% Shrinkage

Road & Drainage Exc (Uncl.) (Item 203-01) = Common Exc (calculated in Step 5) =

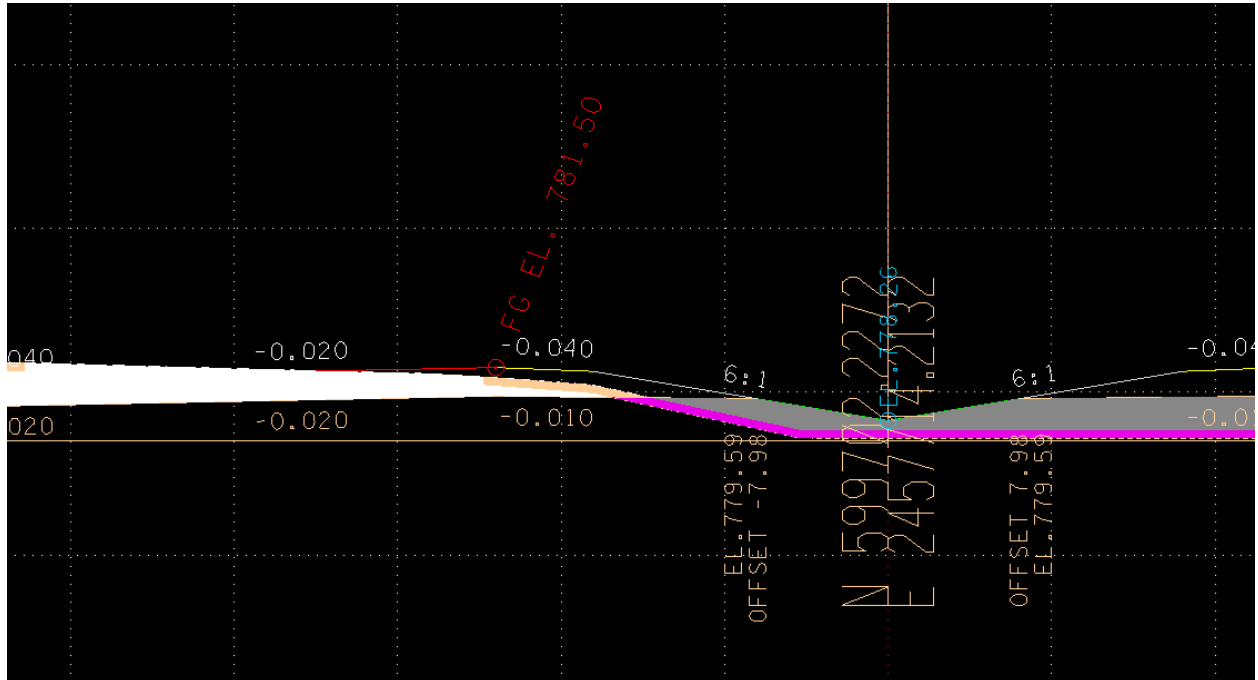
$$(1226 \text{ C.Y.}) \times (1 - 0.30) = \underline{859 \text{ C.Y.}}$$

$$\text{Borrow Exc (Uncl.) (Item 203-03) = Fill (calculated in Step 5) - Road \& Drainage Exc} = (3142^* - 858) \times 1.30 = \underline{2969 \text{ C.Y.}}$$

8. Grading Quantity Block

The figure below is the earthwork summary from the *Earthwork Design Guide*, Section 6 which includes the topsoil excavation volumes.

When the earthwork is ran in GEOPAK shapes are placed on the cross section corresponding to the excavation and embankment areas as shown in the figure below.



Earth common Exc. = White (CO=0)

Earth Fill = Gray (CO=1) + Purple (CO = 10)

Topsoil Common Exc. = Tan (CO=2)

Topsoil Subsoil Exc. = Purple (CO=10)

In the figure below is the Estimated Grading Quantities Block and Topsoil Quantities Table with numbers filled in as calculated in the earthwork report.

ESTIMATED GRADING QUANTITIES						
DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)	BALANCE SUMMARY		
	EXC.	EMB.	EXC.	SHRINK = 30 % SWELL = 30 %		
MAINLINE	1226	3142	859			
SIDE ROADS	0	0				
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES	0	0		EMB.		EXC.
INDEPENDENT DITCHES	0	0				
TEMPORARY CONSTRUCTION EXITS	0	0		3142	VS.	-859
OTHER (BRIDGE EXCAVATION, PAVEMENT, ETC...)	0	0				
TOPSOIL (EMB.)	326			AVAILABLE	=	2283
TOPSOIL (EXC.)	483					
TOPSOIL TOTALS (SEE TOPSOIL TAB)				BORROW MATERIAL	=	2968
ROCK (C.Y.)		TOTALS (C.Y.)				
EXC.	EMB.	EXC. (UNCL.)	EMB. (UNCL.)	EXC. (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)
0	0	2035	3142	2035	1226	859

TOPSOIL								
IF EXISTING TOPSOIL IS SUITABLE FOR REUSE								
PROPOSED SLOPE AREA S.F.	EXISTING TOPSOIL (EXC.)	EXISTING TOPSOIL (EMB.)	EXISTING TOPSOIL (TOTAL) C.Y.	REQUIRED TOPSOIL C.Y.	PLACING TOPSOIL 203-04 C.Y.	FURNISHED TOPSOIL 203-07 C.Y.	EXCESS TOPSOIL C.Y.	ADJUSTED WASTE TOTAL (C.Y.)
15681	809	0	809	290	290	0	519	3487
IF EXISTING TOPSOIL IS NOT SUITABLE FOR REUSE								
PROPOSED SLOPE AREA S.F.	EXISTING TOPSOIL (EXC.)	EXISTING TOPSOIL (EMB.)	EXISTING TOPSOIL (TOTAL) C.Y.	REQUIRED TOPSOIL C.Y.	PLACING TOPSOIL 203-04 C.Y.	FURNISHED TOPSOIL 203-07 C.Y.	EXCESS TOPSOIL C.Y.	ADJUSTED WASTE TOTAL (C.Y.)
	N/A	N/A	N/A	0	N/A	0	N/A	N/A

Unadjusted Volumes:

Mainline Exc. = Earth Common Exc. = 1226 C.Y.

Mainline Emb. = Earth Fill - Topsoil Subsoil Exc. = 3142 C.Y. - 483 C.Y. = 2659 C.Y.

Existing Topsoil (Exc.) = Topsoil Common Exc. + Topsoil Subsoil Exc. = 483 C.Y. + 326 C.Y. = 809 C.Y.

Totals:

Exc. (UNCL.) = 1226 C.Y.

Emb. (UNCL.) = 2659 C.Y.

Exc. (Common) = 1226 C.Y. – Exc. (Rock) = 1226 C.Y.

Exc. (Avail.) = 1226 C.Y. x (1-0.30) = 859 C.Y.

If value of Rock is known, then the Exc. (Adj.) can be calculated as follows:

Exc. (Adj.) = 859 + Exc. (Rock) x (1 + 0.30)

NOTE: If there are Side Roads and Private Drives, etc. add the corresponding exc. and emb. values in the appropriate spaces.