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Using AutoCAD® Civil 3D® for Stormwater Management Tasks: Part I, Hydrology

Dana Breig Probert, Engineered Efficiency

CV314-2 This class will show you how to harness the power of AutoCAD Civil 3D 2008 to assist in designing and performing a TR-55/TR-20 or Rational Method Stormwater Management Analysis, including techniques for annotating plans, creating tables and preparing for modeling in your favorite hydrology software package.

About the Speaker:
Dana received her Bachelor of Science in Civil Engineering from Georgia Tech in 1998. Since then she has worked on a variety of civil projects in the U.S. and Canada, using Land Desktop, Civil Design, Raster Design, Map 3D and Civil 3D. In addition, Dana works with several firms on their Civil 3D pilot projects and implementation plans, and has taught many Civil 3D classes. Dana has been an instructor at AU, worked on Autodesk courseware projects, and is coauthor of the book, "Mastering AutoCAD Civil 3D 2008," which can be purchased at www.masteringcivil3d.com. Dana is also a contributor to www.civil3d.com.
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Using AutoCAD® Civil 3D® for Stormwater Management Tasks: Part I, Hydrology

While Civil 3D does not include an true set of hydrology tools, there are many ways to get the data you need for your modeling software. This class will explore some of those techniques.

This class assumes:

1. You are frustrated with how you currently prepare data in CAD for input into TR20, TR55 or rational method analysis.
2. You know that Civil 3D is built on a full version of Map 3D and a full version of AutoCAD.
3. You understand that Civil 3D does not have any explicit hydrology tools, but there are lots of great Civil 3D and Map 3D tools that can be used to help you with your analysis.
4. You are familiar with Civil 3D objects especially surfaces and parcels.
5. You have a basic understanding of how to create Civil 3D labels.
6. You are willing to spend some time learning how to create expressions in Civil 3D labels.
7. You are willing to spend some time learning how to build Map Topologies, make Map Themes and create Map Annotation templates.
8. You are willing to spend some time learning how to use AutoCAD tables within drawings and possibly linking them to MS Excel.

✓ Since Map tools are a skill gap for many civil users, I will be showing quick steps on how to set up topologies, themes and annotation templates live demo portion of this class. Additional information can be found in tutorials under the Help menu, AU classes, AUONLINE, skill builders and AOTC. My shortlist of highly recommended skills for civil users includes: attaching a drawing, creating queries, importing GIS data through Map>Tools>Import as well as through the FDO.

Best Practices?

What is best practice for me could be completely wrong for you. Conventional wisdom on the use of Civil 3D is constantly evolving. Many people don't like sharing their best practices because any time you "stick your neck out" and show procedures you open yourself up for scrutiny and potential criticism. For me, I like to share information because it starts a dialog and encourages others to share their approach. The techniques in this presentation are intended to assist you in opening the Civil 3D bag of tricks and *launch you on your own journey to discovering your own Best Practices*.

Much of work that is ongoing is documented on blogs like www.civil3d.com and the Autodesk discussion groups, so become a regular reader, and when you feel ready, a contributor.

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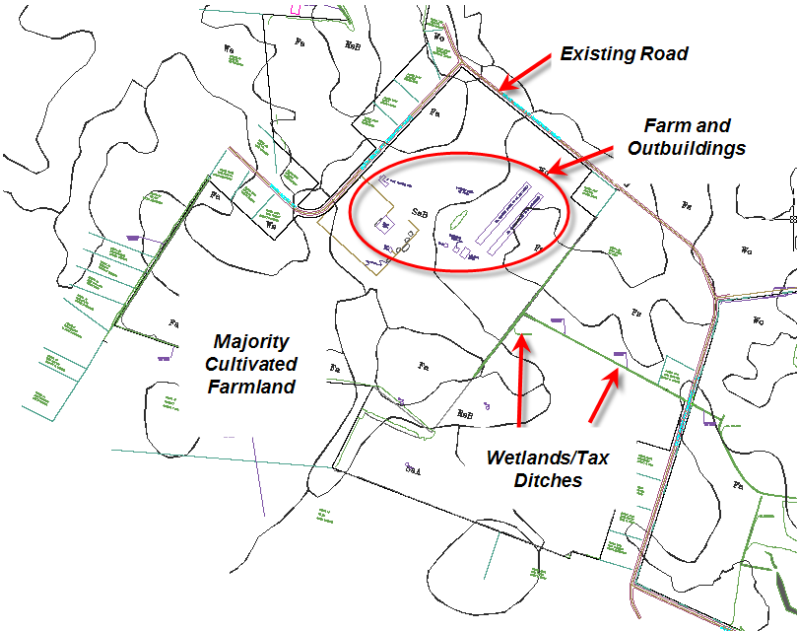
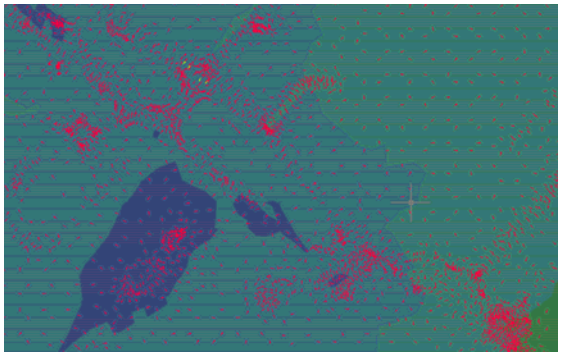
The Site

Our example site is approximately 170 acres located on the Delmarva Peninsula.



Analyzing Surface Elevations

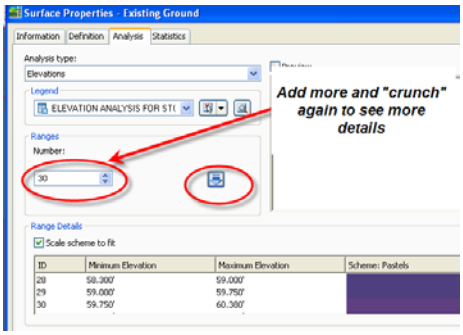
The Surface Elevation Analysis tool is useful for determining how water is moving across your site, where it is collecting and possible subcatchment delineations.



To create an elevation analysis:

1. Make sure you have an elevation analysis style that will show you what you need.
2. Build a surface.
3. Change the surface style to your elevation analysis style.
4. “Crunch” the surface and make customizations on the Analysis tab of the Surface Properties dialog box.

If the standard analysis ranges do not provide enough contrast, you can increase the number of elevation intervals.



A Surface Elevation table can be customized to provide the proper look and information for your plan.

ELEVATION ANALYSIS FOR STORMWATER

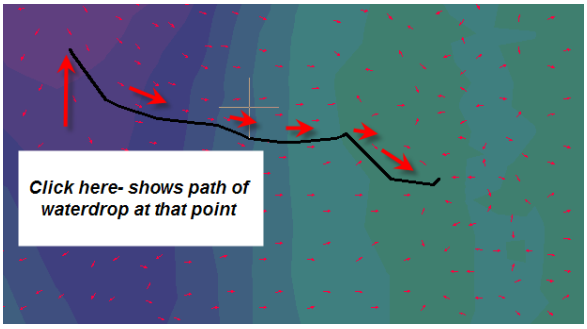
Number	Minimum Elevation	Maximum Elevation	Color
1	38.674	40.850	
2	40.850	43.040	
3	43.040	45.220	
4	45.220	47.400	
5	47.400	49.580	
6	49.580	51.760	
7	51.760	53.940	
8	53.940	56.110	
9	56.110	58.300	
10	58.300	60.380	
11	60.380	60.480	

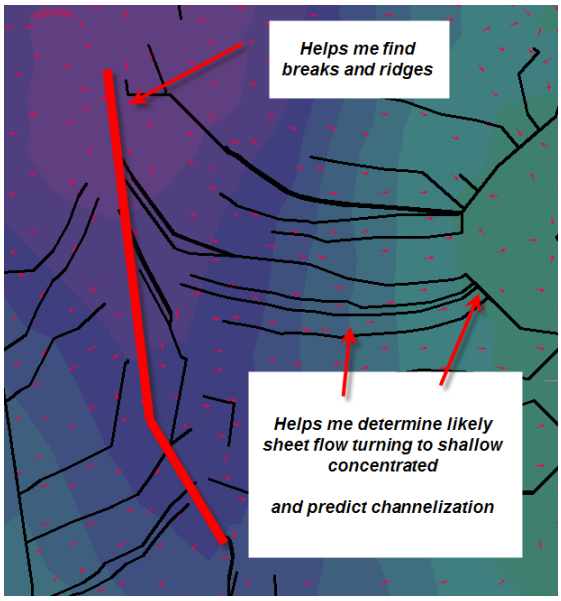
Red to Blue

Low to High

Using Water Drop

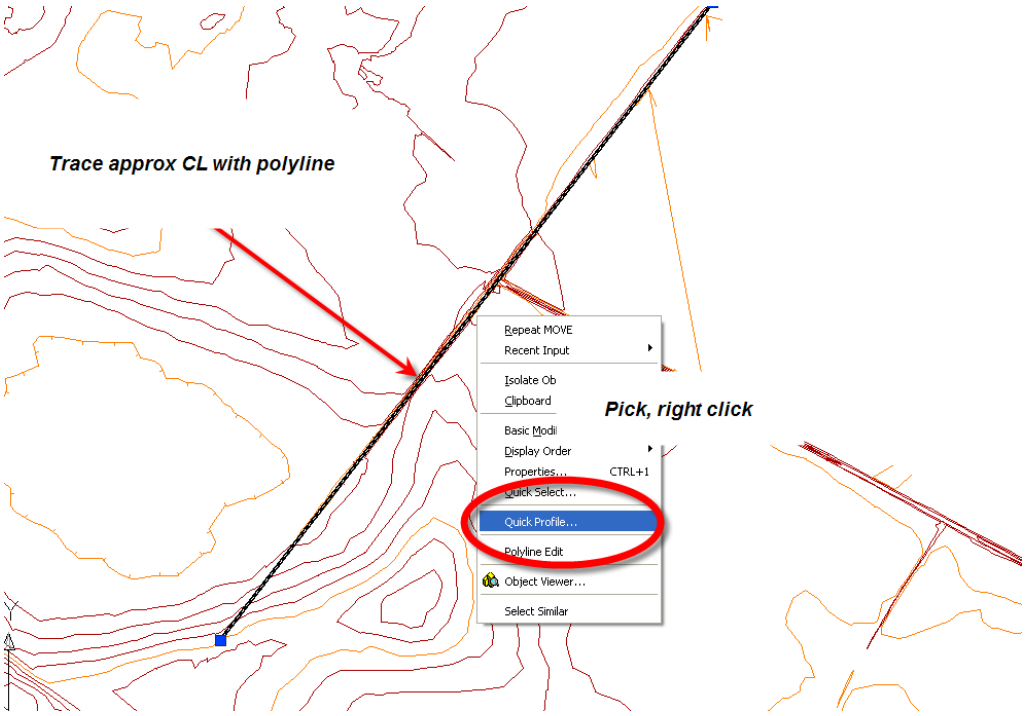
Surfaces>Utilities>Water Drop can help you determine how water will flow across your site and assist you in making judgments about time of concentration.

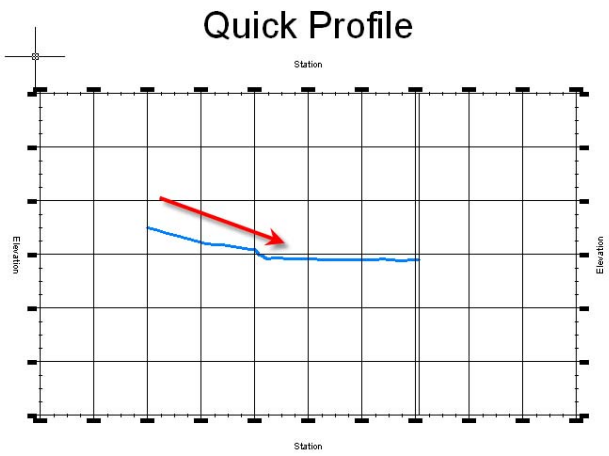




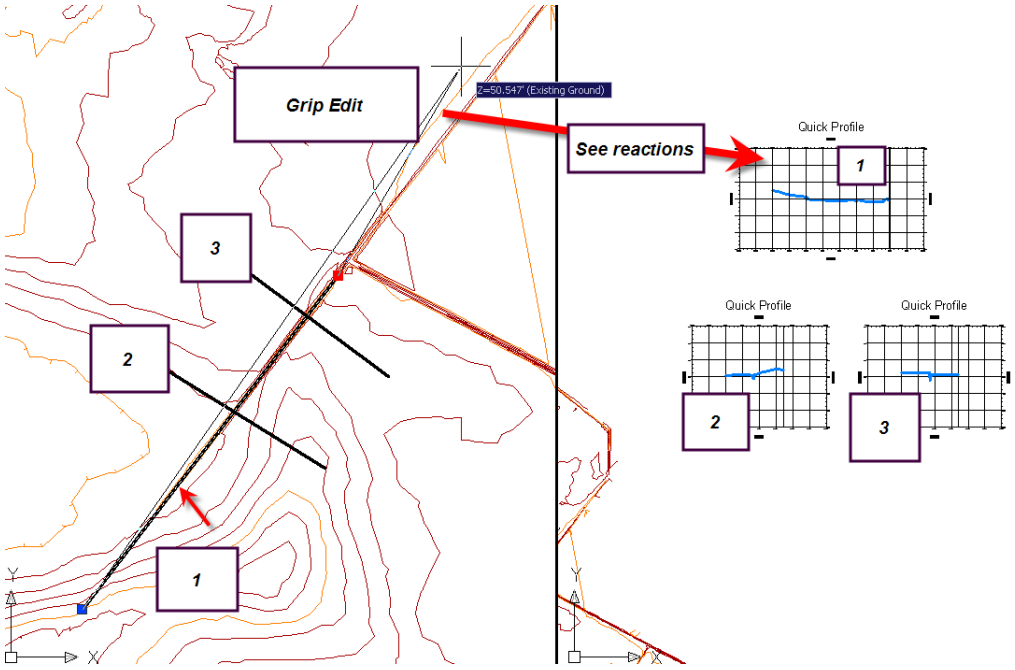
Making Quick Profiles

Quick profiles can help you learn more about the drainage nuances of your site. Right click on an object, or choose Profiles>Quick Profile.





Multiple Quick Profiles can be used to asses your surface, and learn about channel flow.

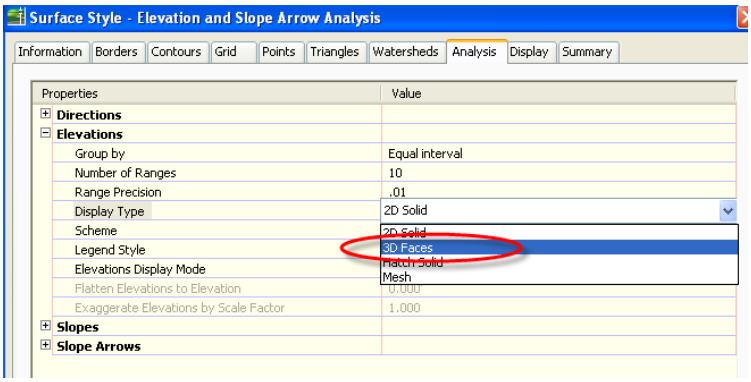


✓ You might find it useful to split your model space into multiple viewports so that you can see what is happening in plan and profile at the same time. To split your viewport use View>Viewports>2 Viewports.

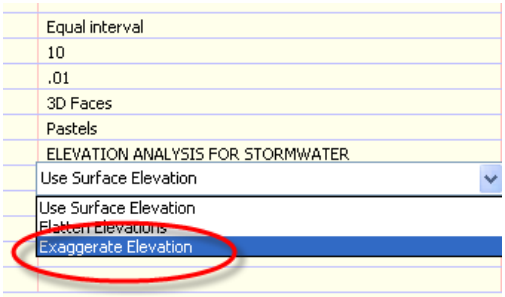
Simple Surface Visualization

Surface visualization can assist the designer, the review agency and the client in understanding site drainage patterns for both existing and proposed ground.

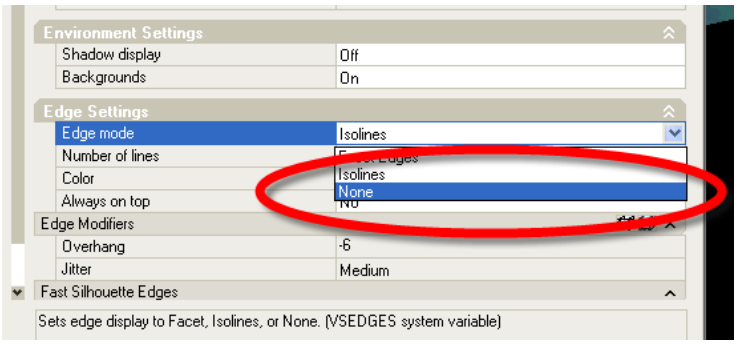
You can visualize the elevation analysis of the surface by changing the elevation analysis style to 3D faces.



It often helps to exaggerate the triangle elevations when your site is relatively flat.

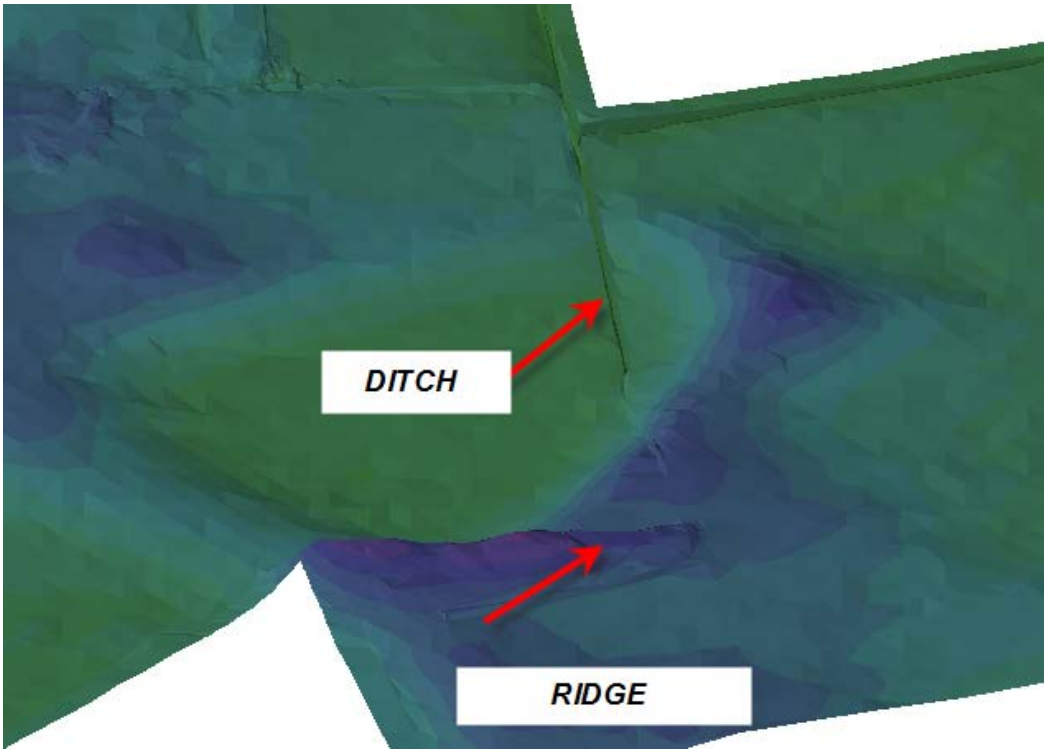


Another thing you can do is to remove the isolines from the visual style. This will make the surface easier to see in 3D.

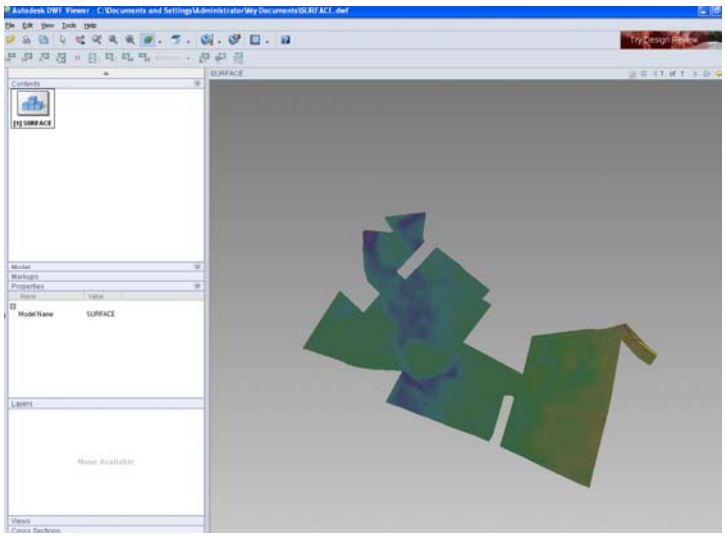


✓ Visual styles are an AutoCAD feature. Read up on the AutoCAD visualization tools under help, or check out other AU classes on the subject.

Rotate the surface into an isometric view and apply your visual style.



Create a 3D DWF by typing 3DDWFPUBLISH in the command line and saving the resulting file. A DWF can be shared with non CAD users and provides an easy way to navigate your simple visualization.



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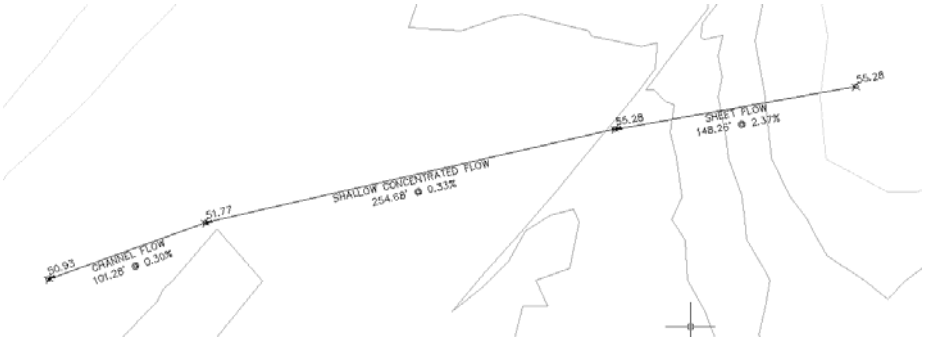
Labeling your Surface Slopes and Spot Elevations

Surface slope and spot elevation labels can be customized to assist in labeling TC paths. Alternatively, you can use a set of alignment and profile labels for more powerful TC path analysis.



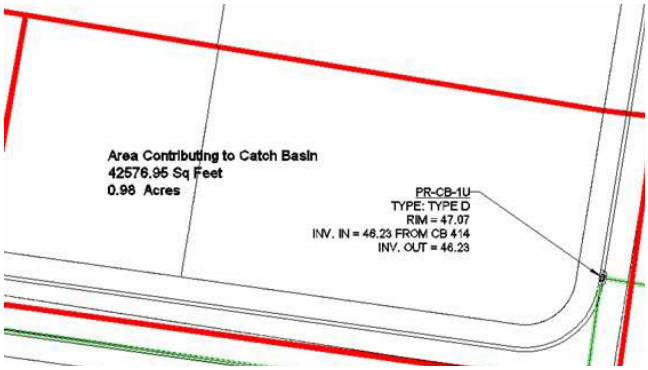
Subcatchment Analysis and Curve Number Determination

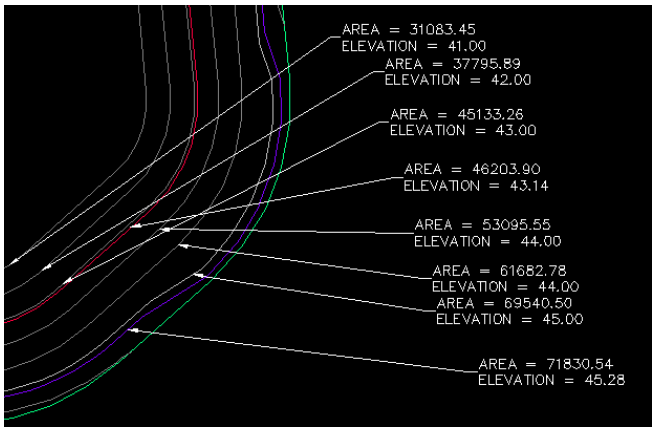
TR-55, TR-20, Rational Methods and other accepted forms of hydrologic analysis typically require the breakdown of our site into a series of areas that combine Drainage Area (Subcatchment), Soil Hydrologic Group, Cover Type and Cover Quality. The delineation of these areas is time consuming by hand or with traditional AutoCAD tools.

Polylines for Area Delineation

Benefits of Using Polylines for Area Delineation

- Familiar, easy to create and edit AutoCAD objects
- Can be labeled with Civil 3D General Line labels (length, area, elevation, etc)
- Can be labeled and added to tables using AutoCAD fields
- Can be created, queried and manipulated through Map tools
- Can be converted to topologies and Civil 3D parcels with some cleanup





Limits of Using Polylines for Area Delineation

- Not reactive to neighboring polylines
- Keeps you in AutoCAD mindset
- Not controlled by Civil 3D object styles

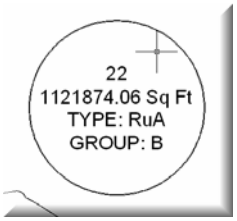
Recommendations for Use:

- When you aren't ready to use Civil 3D parcels to study areas
- Rational Method Calculations where you want to use an AutoCAD table
- "Contours" for ponds if you cannot met your design intent with Civil 3D corridors/grading objects/surfaces

Civil 3D Parcels for Area Delineation

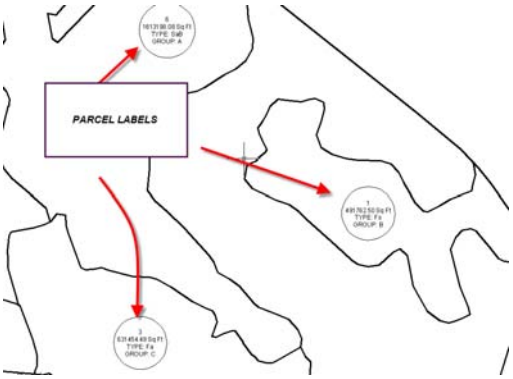
Benefits of Using Parcels for Area Delineation

- Dynamic with other parcels
- Easy to make dynamic tables
- Some custom properties available– like description, Tax ID and address, as well as User Defined Properties
- Area, TaxID, and User Defined Properties can be used in expressions for many calculations as part of labels or tables.
- Flexible, dynamic, autosizing, plan readable labels
- CAD Standards maintained by Civil 3D Parcel Object Styles
- Prospector aids in controlling appearance and labeling quickly
- Prospector information can be copied and pasted into excel for further study



SOIL AREA TABLE

PARCEL	SOIL TYPE	AREA
1	RuA	11.29
2	Wo	56.25
3	SaB	14.50
4	RuA	10.98



Limits of Using Parcels for Area Delineation

- Must have good understanding of Civil 3D Site Geometry
- User defined properties are difficult to use and manage
- Expressions can only calculate based on the current parcel– cannot sum or do "percent of the whole" calculations in tables or labels.
- No intersect topology intelligence (ie cannot blend subcatchments and soils)
- Cannot be queried or take advantage of other Map tools

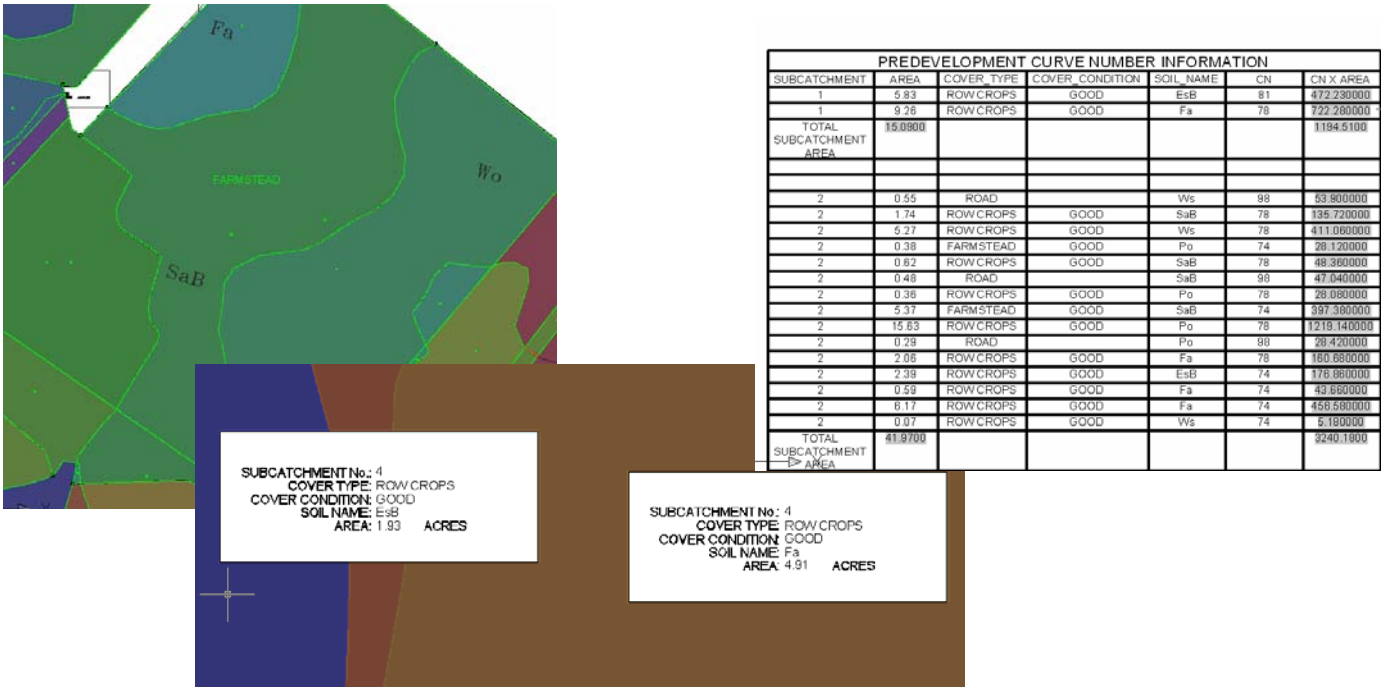
Recommendations for Use:

- For subcatchments, soils areas and similar on small sites or when you have already done most of the “overlay” breakdown by hand
- When you want to do the rational method calculations right in your parcel table or area labels
- When the truly dynamic nature of parcels outweighs any negatives

Map Polygon Topology

Benefits of Using Topologies for Area Delineation

- Robust analysis tools for intersection of topologies– ie breakdown of subcatchments overlaid with soil group overlaid with cover type
- Semi-dynamic labeling that “reads” the topology data similar to Civil 3D labels
- Thematic mapping capabilities for presentation drawings and analysis
- Can be queried, modified and analyzed using Map tools
- Works with attribute extraction for semi-dynamic tables with can be used to many different types of calculations
- Information can be reported and exported to drawing tables or external files



PREDEVELOPMENT CURVE NUMBER INFORMATION

SUBCATCHMENT	AREA	COVER_TYPE	COVER_CONDITION	SOIL_NAME	CN	CN X AREA
1	5.83	ROW CROPS	GOOD	EsB	81	472.230000
1	9.26	ROW CROPS	GOOD	Fa	78	722.280000
TOTAL SUBCATCHMENT AREA	15.0900					1194.5100
2	0.55	ROAD		Ws	98	53.900000
2	1.74	ROW CROPS	GOOD	SaB	78	135.720000
2	5.27	ROW CROPS	GOOD	Ws	78	411.060000
2	0.38	FARMSTEAD	GOOD	Po	74	28.120000
2	0.62	ROW CROPS	GOOD	SaB	78	48.360000
2	0.48	ROAD		SaB	98	47.040000
2	0.36	ROW CROPS	GOOD	Po	78	28.080000
2	5.37	FARMSTEAD	GOOD	SaB	74	397.380000
2	15.63	ROW CROPS	GOOD	Po	78	1219.140000
2	0.29	ROAD		Po	98	28.420000
2	2.06	ROW CROPS	GOOD	Fa	78	160.680000
2	2.39	ROW CROPS	GOOD	EsB	74	176.860000
2	0.59	ROW CROPS	GOOD	Fa	74	43.660000
2	6.17	ROW CROPS	GOOD	Fa	74	456.580000
2	0.07	ROW CROPS	GOOD	Ws	74	5.180000
TOTAL SUBCATCHMENT AREA	41.9700					3240.1800

Limits of Using Topologies for Area Delineation

- Cannot be used as Civil 3D objects nor easily converted in an intelligent way
- Often challenging to prepare data property to create a sound topology
- Map tools are often unfamiliar to Civil 3D/Land Desktop users

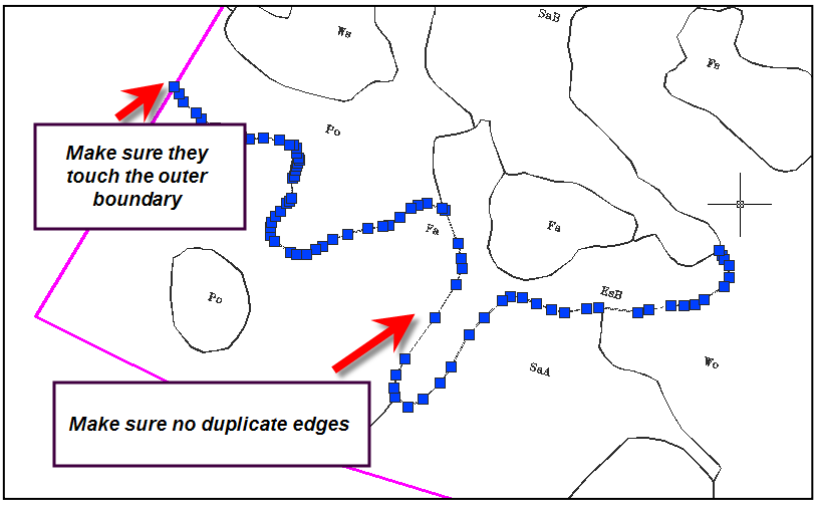
Recommendations for Use:

- Medium to large sites with several subcatchments, soil groups, cover types and other constraints for entering into Rational, TR-55 or TR-20 based modeling programs
- When you'd like to do TR-55 and composite CN calculations right in your drawing in a semi-dynamic way
- When you'd like to put together themed maps or presentation drawings based on the analysis

Using Civil 3D Parcels for Area Delineation

Civil 3D parcels can be used to delineation, labeling and analysis of subcatchment, soils boundaries and cover.

Civil 3D parcels interact as site geometry with other Civil 3D objects such as alignments and feature lines.



Always be sure to create parcels from lines that formed closed areas with no overlap. Make a new site for each parcel type.

If you were doing all of your SWM area study using Civil 3D Parcels, you should have a site for each different type of area such as:

- Soil Area Site
- Subcatchment Area Site
- Cover Type Site

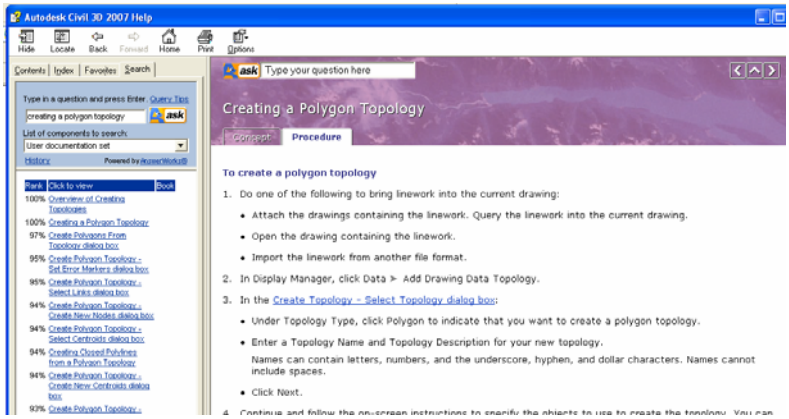
Take advantage of the extra fields available in Prospector for additional labeling and study capabilities, or add user defined properties. Also experiment with building custom parcel labels and tables to call out your additional information.

Using Map Topologies for Area Delineation

Civil 3D parcels can be used to delineation, labeling and analysis of subcatchment, soils boundaries and cover.

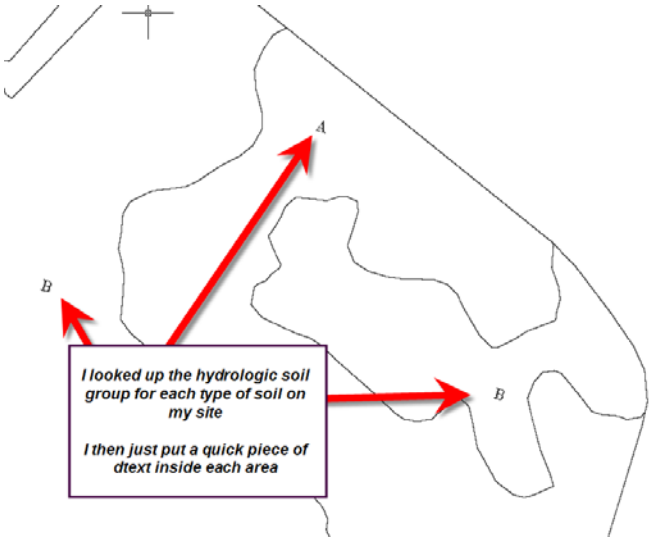
This is by far the most powerful analysis tool available to us in the Civil 3D environment. (Remember, Civil 3D is built on Map 3D). It will be important for you to read through the Map 3D Tutorials on Polygon Topologies, Drawing Cleanup, Object Data and other Map tools.

This will be difficult to repeat with your own data at first. Map topologies are rather picky about their geometry. Don't give up! Go through the tutorials a few times and look for ways you can leverage this in your work. There are many, many uses for topologies.



Build Your Geometry: Polylines and Centroids

Start with AutoCAD polylines, and then break at intersection points per topology requirements (see Help). Make sure each enclosure has a centroid. Centroids can be blocks, nodes, or text. You can manually place centroids, or if you are importing GIS data (such as a shapefile) you can use **Map>Tools>Create Centroids.**



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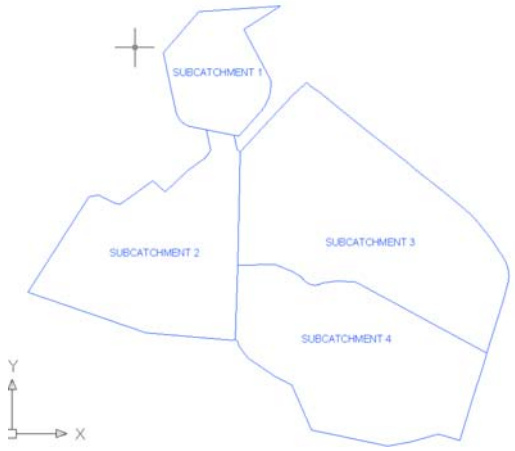
Create Three Topologies

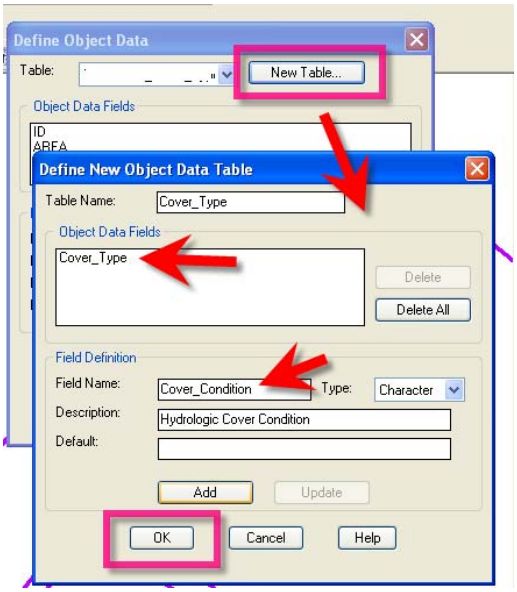
Use Map>Topologies>Create to define your topology. Work through the Wizard picking the appropriate geometry to each topology:

1. Subcatchments
2. Soil Groups
3. Cover Types



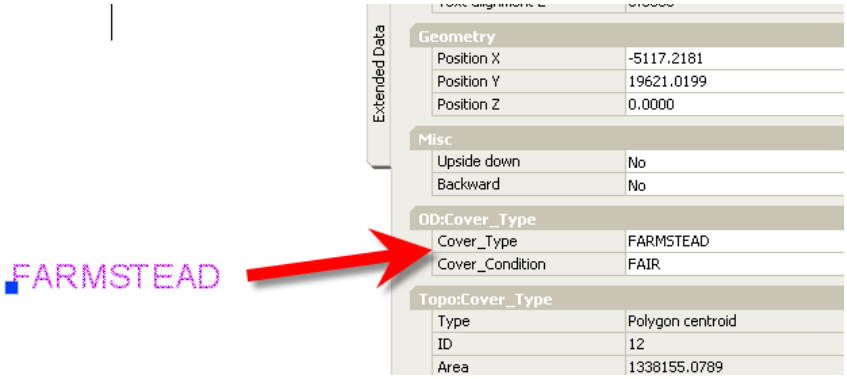
Define Object Data for Your Topologies

Create the object data tables under **Map>Object Data>Define Object Data** that will house the information to give each polygon intelligence such as soil group, subcatchment number, cover type and any other important information.



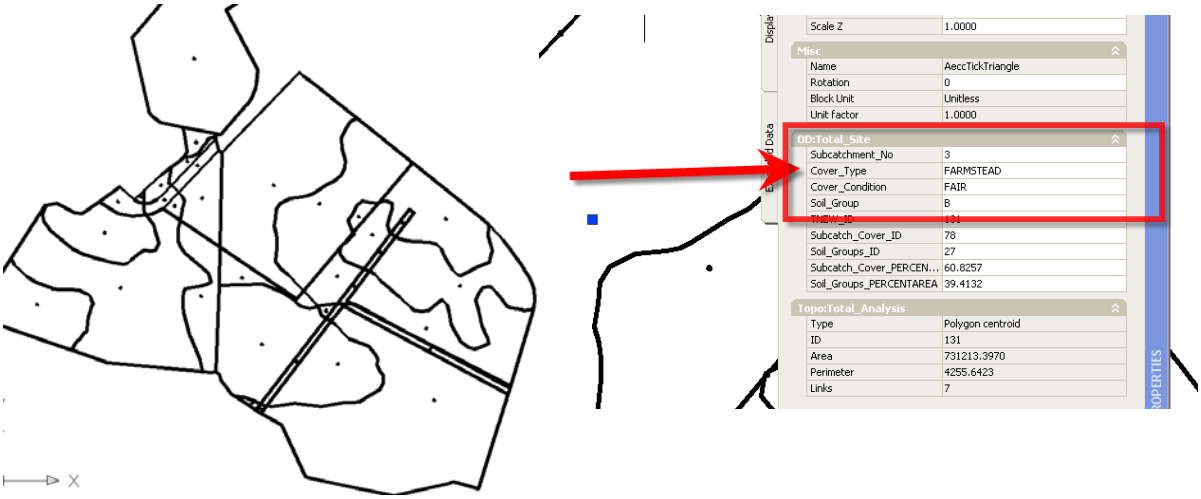
Attach Appropriate Object Data to Each Polygon Centroid

After you define the object data, use **Map>Object Data>Attach/Detach Object Data** to attach the appropriate data table to each centroid. Use the AutoCAD Properties box to go through and assign the correct values to each centroid.



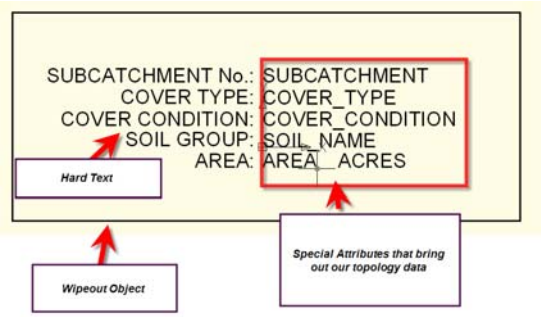
Create Two Overlay Topologies

Unfortunately, Map won't let us to a "three way stack" of our topologies. Make an overlay topology that combines Subcatchments with Soil Groups called "Sub_Soil", then make a second overlay topology that combines "Sub_Soil" with Cover Types.



Make an Annotation Template For Labeling Each Polygon

An annotation, not unlike a Civil 3D label, harvests the resulting object data from the final overlay topology.



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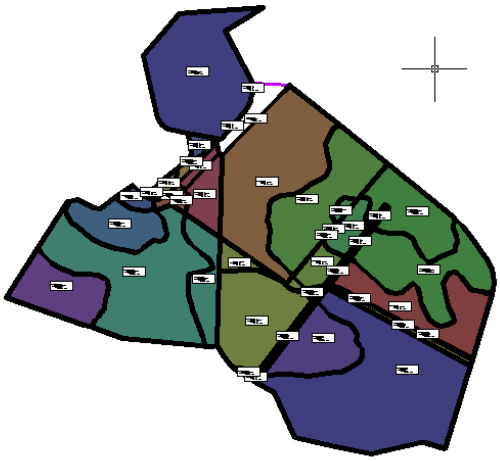
Apply a Theme to Your Topology Including Annotation

Create a theme that separates the topology into its smallest parts. Apply hatch color and annotation.



Create a Data Extraction Table

Annotations are really just attributed blocks. That attribute information can be extracted as a .csv, exported to Excel, or made into an AutoCAD table. Additional columns can be added for formulas, user data, fields and more. Also, you can explore the possibilities of creating a dynamic link to Excel using the new AutoCAD 2008 tools.

CURVE NUMBER CALCULATIONS						
SUBCATCHMENT	COVER_TYPE	COVER_CONDITION	SOIL_NAME	AREA	CN	CN X Area
1	ROW CROPS	GOOD	A	15.08	67	
2	ROAD	N/A	B	0.66	97	64.0200
2	ROW CROPS	POOR	B	6.17	81	499.7700
2	ROW CROPS	GOOD	B	0.50	78	39.0000
2	ROW CROPS	GOOD	A	0.54	67	36.1800
2	ROAD	N/A	B	0.81	97	78.5700
2	FARMSTEAD	FAIR	B	2.79	74	206.4600
2	FARMSTEAD	FAIR	A	0.33	57	18.8100
2	ROW CROPS	POOR	B	5.01	81	405.8100
2	ROAD	N/A	A	0.44	97	42.6800
2	ROW CROPS	POOR	A	17.59	72	1266.4800
2	ROW CROPS	POOR	B	4.05	81	328.0500
2	ROW CROPS	GOOD	B	0.07	78	5.4600
2	ROW CROPS	GOOD	A	0.59	67	39.5300
			TOTAL	39.5500		3030.8200
			WEIGHTED CN	76.6326		

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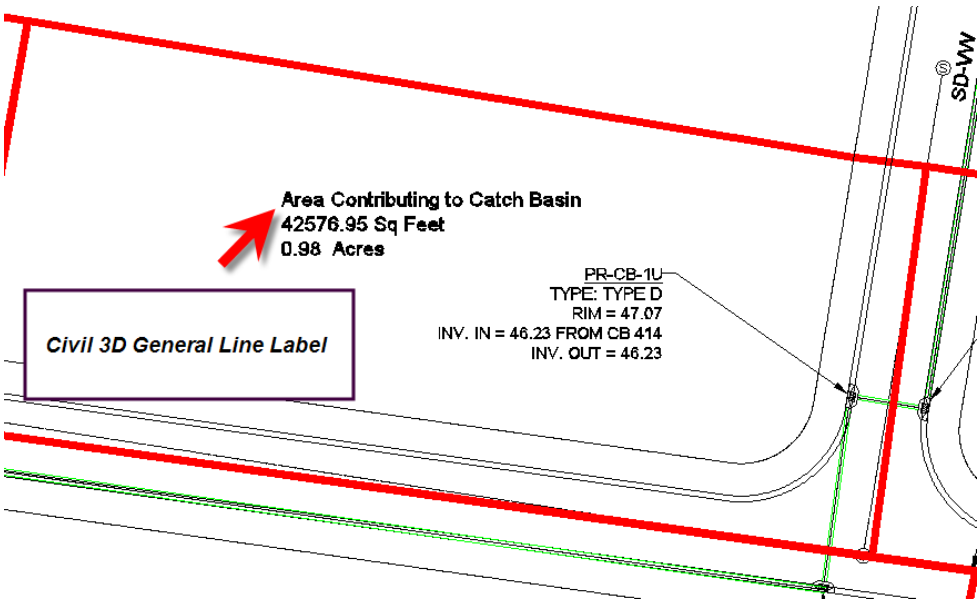
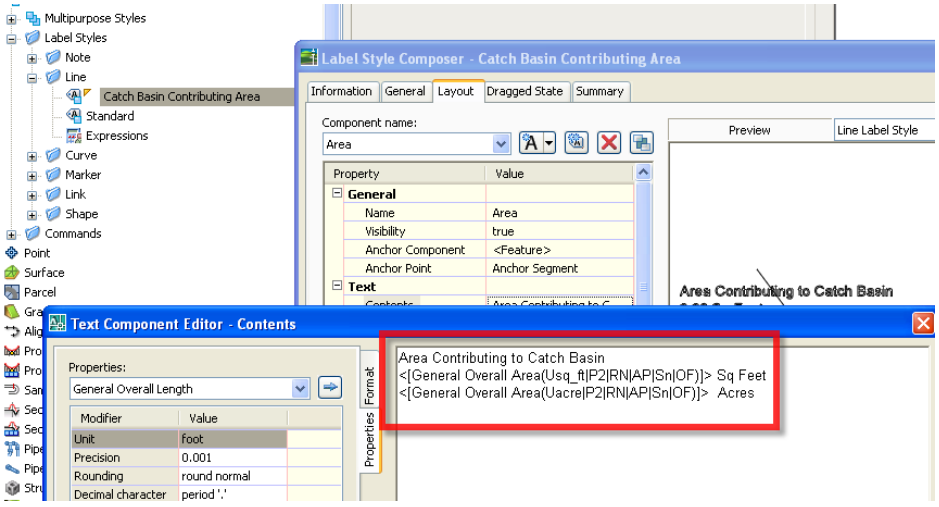
Using Polylines for Area Delineation

Regular polylines can be used for area delineation, and can be labeled with Civil 3D General line labels.





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A Few Ideas for Obtaining Pond Information

Surfaces>Utilities>Extract Objects from Surface is useful for obtaining polylines that represent contours. These contours can then be labeled with a general line label which can make it easier to obtain contour areas. This information can now be quickly typed into your stormwater modeling software.