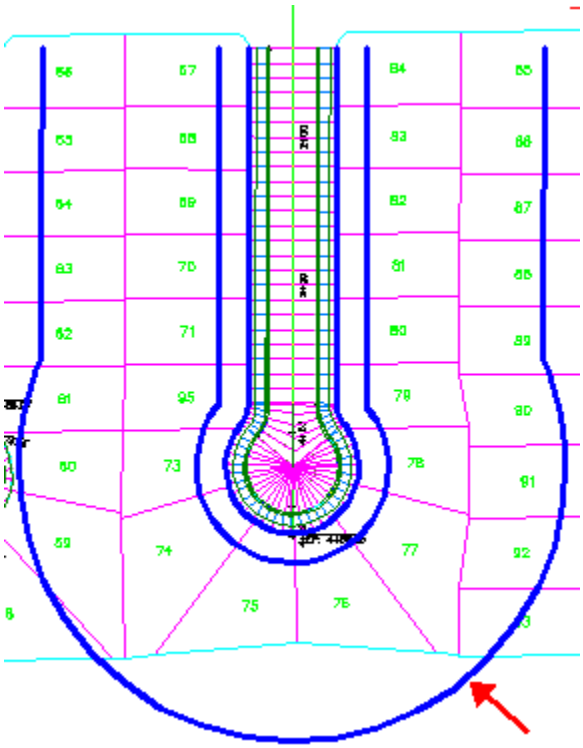
Site Grading and Quantities

Overview

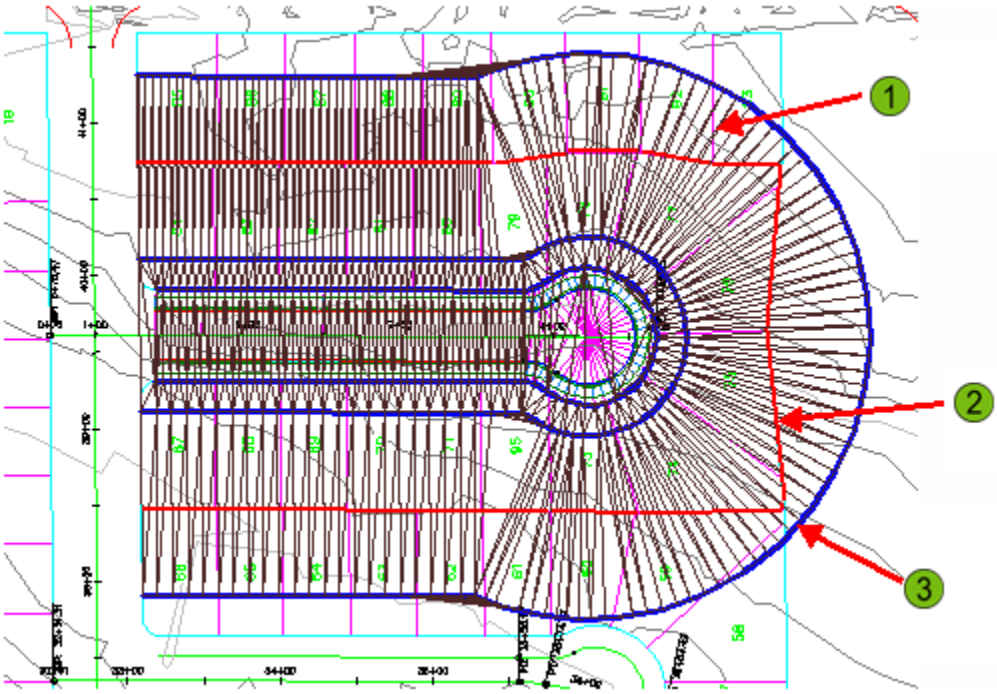
In this lesson, students work with feature lines and corridor surfaces to perform the site grading process for parcels adjacent to a subdivision road. Site grading, sometimes referred to as bulk grading, is the process of grading larger areas of land to general grade or slope specifications for design purposes. This process is typically followed by more detail grading of individual features such as building pads, driveways, or drainage paths on an individual lot. Some of the tools used in detail grading were discussed in an earlier lesson.

The process for creating an interim grading surface is necessary for solving grading for a subdivision design and usually follows the final development of the roadway corridor models. The creation of an interim grading surface helps you determine design elevations that would otherwise be difficult to calculate. This interim surface serves as the starting point for the detail grading process.

Feature lines can help you to effectively model proposed grading conditions. The following illustration shows feature lines created at the corridor right-of-way, at the building pad frontage, and beyond the back of parcels to model the overall flow characteristics of the site.



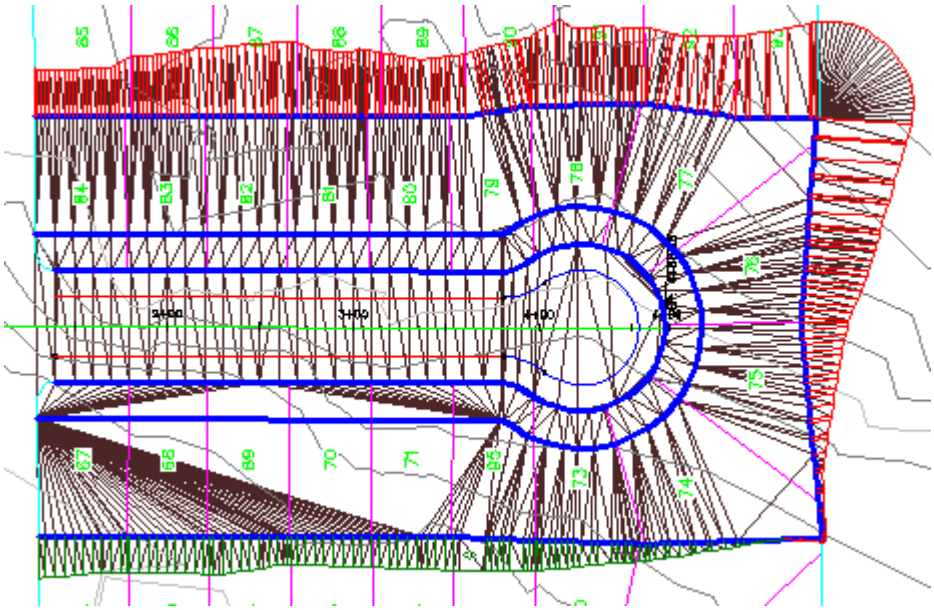
An interim grading surface that can be used to calculate a feature line along the back of parcels is shown in the following illustration. The feature line along the back of parcels is used for the grading footprint.



1. Interim grading surface
2. Back of lots
3. Offset feature line

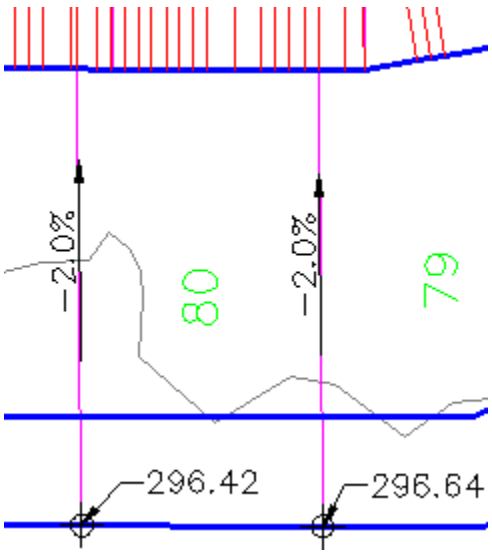
You use grading objects to create a surface to generate volume calculations that estimate the required materials for your design. As with any drawing object, the grading design and any related objects are automatically updated whenever you make a change to the grading.

A final grading surface is as shown.



Surface labels can help you with the design process because they automatically update when the surface changes. Additionally, it is a common practice to label finished grade surfaces to convey design information to contractors and other interested parties.

The following illustration shows surface labels on a finished grade surface.



Objectives

After completing this lesson, students will be able to:

- Create grading feature lines from a corridor.
- Describe the process for creating interim grading surfaces.
- Create an interim grading surface.
- Create a grading footprint.
- Describe grading objects.
- Describe the process for creating a final grading surface.
- Explain how you calculate earthwork volumes.
- Create a grading object to model the daylighting from the back of parcels feature lines to the existing ground surface.
- Create final grading surface and calculate the total earthworks volumes.
- Create spot elevation labels and grade labels for the design grading surface.

Exercises

The following exercises are provided in a step by step format in this lesson:

1. Create and Edit Feature Lines
2. Create an Interim Grading Surface
3. Create a Grading Footprint
4. Create Grading Objects
5. Create Final Grading Surface and Calculate Volumes
6. Label Final Grading Surface

About Feature Lines

A feature line is a Civil 3D object that represents a three-dimensional polylinear element. Feature lines connect a series of geometry and elevation points. You can draw feature lines, create them by converting existing objects, or create them from corridor feature lines. Feature lines are similar to 3D polylines and store both horizontal and elevation location data. Feature lines can be labeled with grades and elevations. Feature lines can help you to effectively model proposed grading conditions.

Many features of design surfaces are linear in nature. When developing a site, you often need to design sidewalks, curbs, lawns, parking lots, drainage paths, and driveways. Feature lines can be placed at specific locations, in a specific direction, and at specific grades. Using these feature lines as breaklines in a proposed surface will then control the location and slopes of your final design. For example, setting a feature line in a lawn or a parking lot in a specific direction, and at the desired elevation and grade, and then including it as a breakline in the proposed surface will constrain the design so that the surface follows that line.

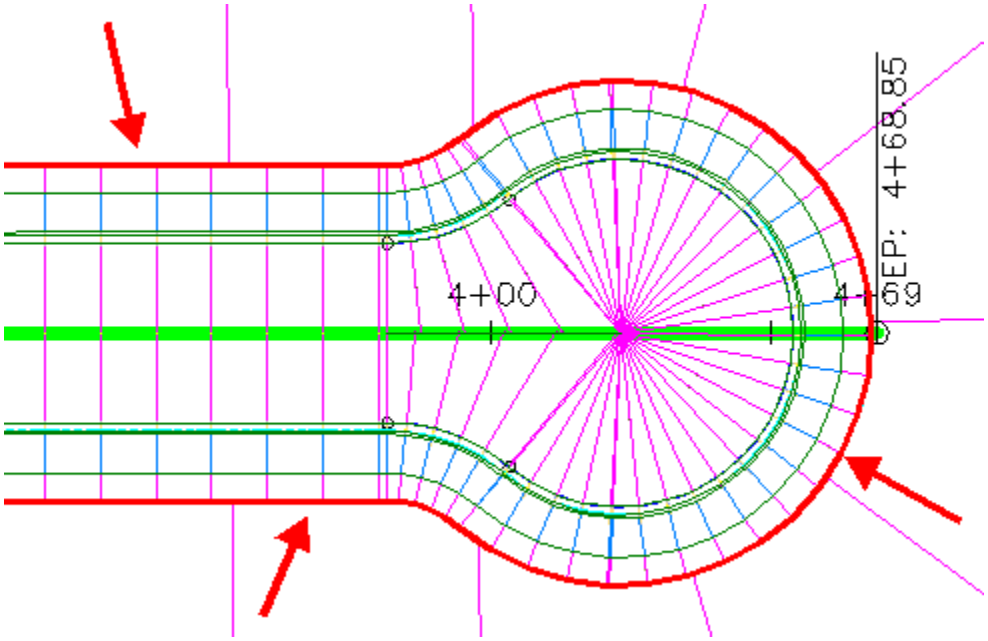
Feature lines are useful when transitioning from one surface to another. For example, when a road corridor surface is created and forms the boundary to a set of parcels that need to be bulk graded, a feature line can be extracted from the corridor model to form the boundary of the bulk grading for the parcels.

You can edit feature lines with ribbon commands. The Stepped Offset command offsets a feature line horizontally and vertically. There are also commands to join, fillet, and modify feature line elevations and grades. You can also label the elevations of feature line points and the grades of feature line segments. Feature lines can be used as breaklines for proposed surfaces.

Example: Grading Feature Line at Right-of-Way

Roads are typically the first part of a subdivision to be designed. Road profiles and elevations account for site topography, site drainage, and optimized cut and fill volumes. Roads, therefore, form the grading spine for subdivisions. Grading feature lines created from corridor feature lines are the starting point for subdivision grading. These are usually created at the right-of-way locations.

Residential subdivision road corridor models are typically calculated up to the right-of-way locations. After the corridor is calculated, you create a grading feature line from the right-of-way feature line. A grading feature line at the right-of-way location is shown in the following illustration.



Creating Feature Lines from Corridors

For residential subdivision roads, the corridor model is a three-dimensional representation of the road design up to the right-of-way lines. You grade the remainder of the subdivision by creating grading feature lines from the subdivision road corridors at the right-of-way. Other feature lines are created from corridor feature lines and can be used with grading commands to grade the land parcels adjacent to a corridor model.

Creating Grading Feature Lines Process

A grading feature line created from a corridor can be used as a starting point to perform grading tasks beyond the limits of the corridor. Grading feature lines created from a corridor are dynamic and automatically update when the corridor model changes. To edit grading feature lines created from corridors, you can remove the dynamic link.

You create grading feature lines from corridor feature lines using the Feature Line > Create Grading Feature Lines from Corridor command on the ribbon, Home tab, Create Design panel. When a corridor contains multiple baselines, you must individually select the feature lines for each baseline to create grading feature lines.

Keep the following guidelines in mind when you create feature lines:

- Grading feature line geometry should be simplified when possible. The goal is to minimize the number of elevation and geometry points, without disrupting the integrity of the design.
- Feature lines in the same site interact with each other. If two feature lines overlap, an elevation point is automatically created at the intersection point of the feature lines.
- You can use feature line style to control the appearance of the feature lines.
- You can use the Stepped Offset feature line command to create a new feature line by specifying a horizontal and vertical offset. You can use elevation difference or grade to calculate the elevations of the new feature line.

About Interim Grading Surfaces

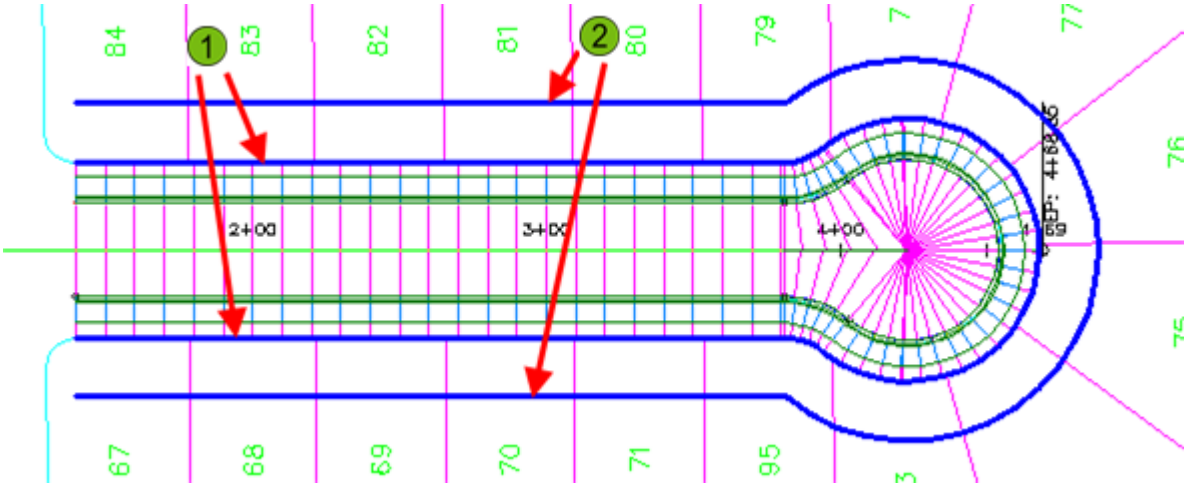
An interim grading surface models the overall flow characteristics of the site, and is used to establish the design elevations at the back of parcels. The interim grading surface is an intermediate surface that is created to help you grade elevations at the back of lots.

To create the interim grading surface, you use the corridor feature lines and the feature lines created with the Stepped Offset command. The surface can be deleted after the elevations at the back of lots are calculated.

The interim grading surface is created from the grading feature lines created from the corridor, and the offset feature lines are created with the Stepped Offset feature line command.

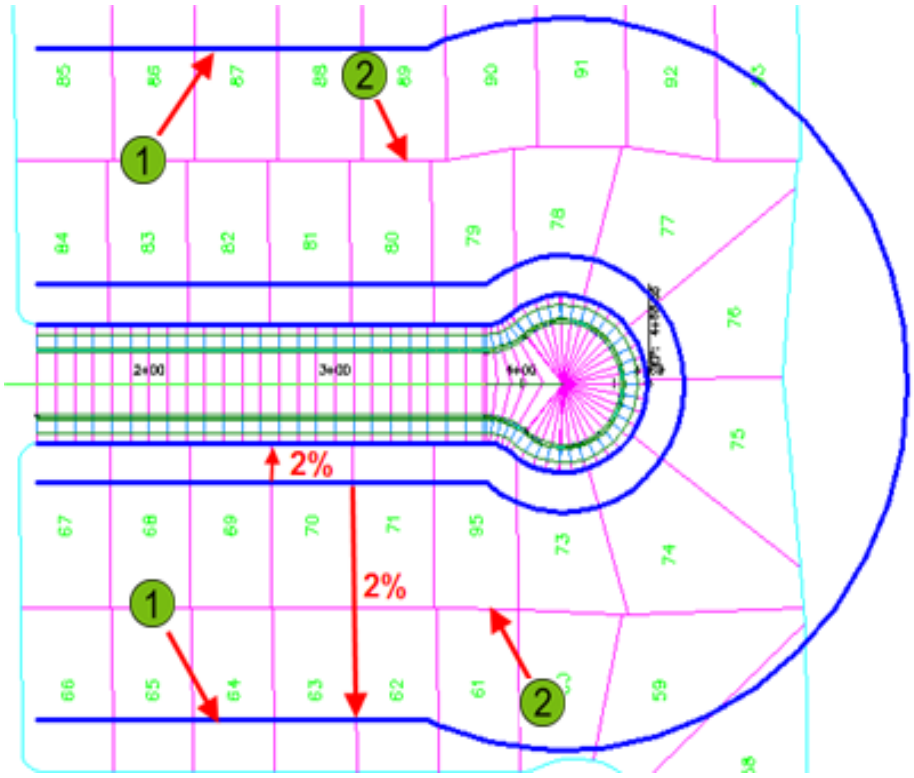
Creating Interim Grading Surfaces

Prior to creating the interim grading surface, feature lines exist at the corridor right-of-way and at the setback locations. These feature lines are shown in the following illustration.



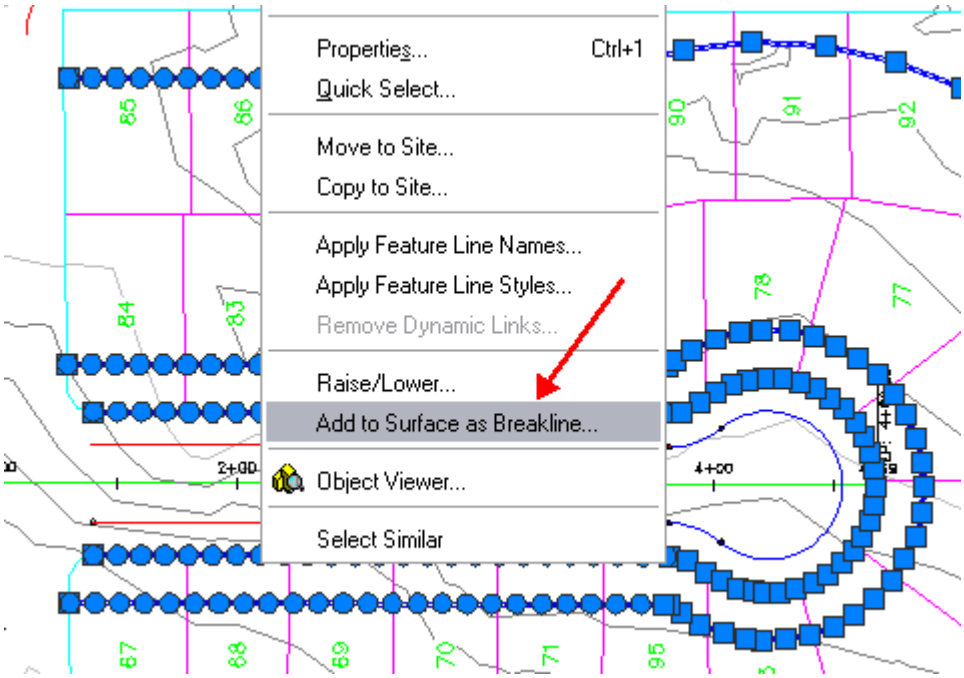
1. Right-of-Way feature lines
2. Setback feature lines

The Stepped Offset command is used to offset the setback feature lines to a location beyond the back of the lots. The elevation of the second offset feature lines (beyond the back of lots) is calculated by a negative elevation differential between the setback feature lines and the second offset feature line. This is shown in the following illustration.



1. Second Offset feature line
2. Back of lots

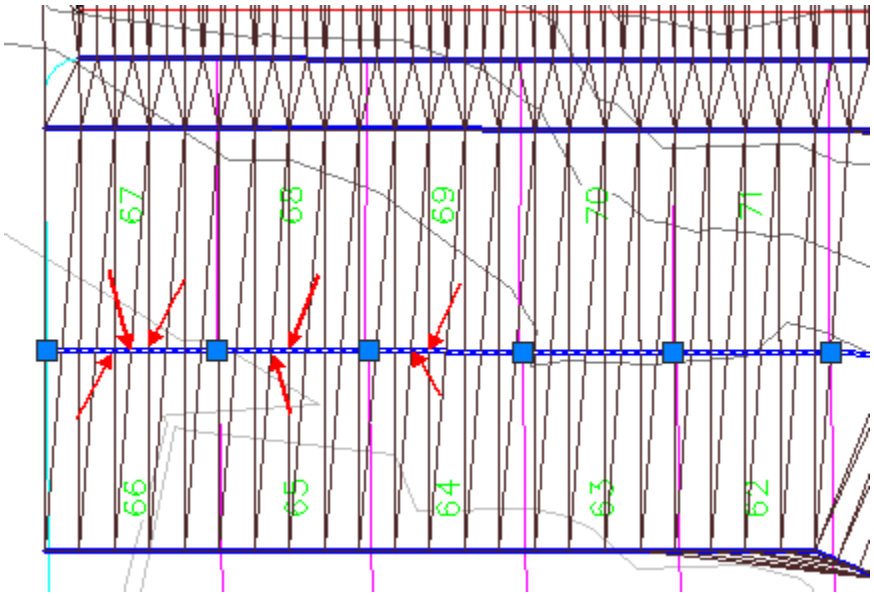
After you create the second offset feature line beyond the back of lots, you then use the feature lines to create the interim grading surface. You create the interim grading surface and then add the feature lines as breakline surface data. This is shown in the following illustration.



Creating Feature Lines from Surfaces

You create a feature line at the back of parcels that will be used for the grading footprint. The elevations are assigned to the feature line points from the interim grading surface. This process essentially drapes the feature line onto the surface and assigns elevations at the feature line vertices, or elevation points.

When you assign elevations to a feature line from a surface, you can either assign the elevations at the feature line vertex elevations, or you can add the intermediate grade break points. The intermediate grade break points are calculated at the locations where the feature lines intersect the surface triangulation lines. When you use intermediate grade break points, more elevation vertices are created on the feature line. This is shown in the following illustration.



The feature line created at the back of parcels is used as a grading footprint for daylighting to the existing ground surface.

About Final Grading Surfaces

A final grading surface is made from the interim grading surface and serves as the basis for detail grading. Grading Objects are very powerful to help you grade to existing surfaces, interim surfaces, and feature lines.

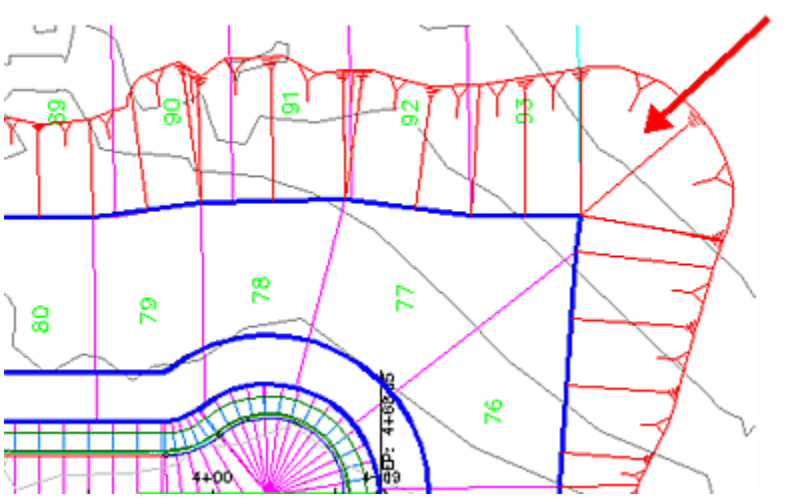
Grading Objects

Grading objects and grading groups are integral to grading a surface. Criteria and styles can be assigned to a grading object or group, and surfaces are created from grading objects or groups. A grading object represents an existing or proposed design feature. It represents a projected slope to either a surface, elevation, or an offset. A grading object typically consists of:

- The *baseline*, which can be a feature line or a lot line.
- The *target*, which can be a surface, a distance, an elevation, or a relative elevation.
- *Projection lines* that define the direction of the grading.
- The *face*, which is the area enclosed by the baseline, the target line, and the projection lines.

After it is created, you apply grading criteria and styles to the grading object. A grading object must be assigned to a grading group.

A grading object is shown in the following illustration.



Grading Groups

Grading groups are part of Civil 3D sites. Grading groups organize grading objects, contain volume data for the grading objects, and contain the configuration that combines grading objects into a surface. You create a surface from multiple grading objects within a grading group.

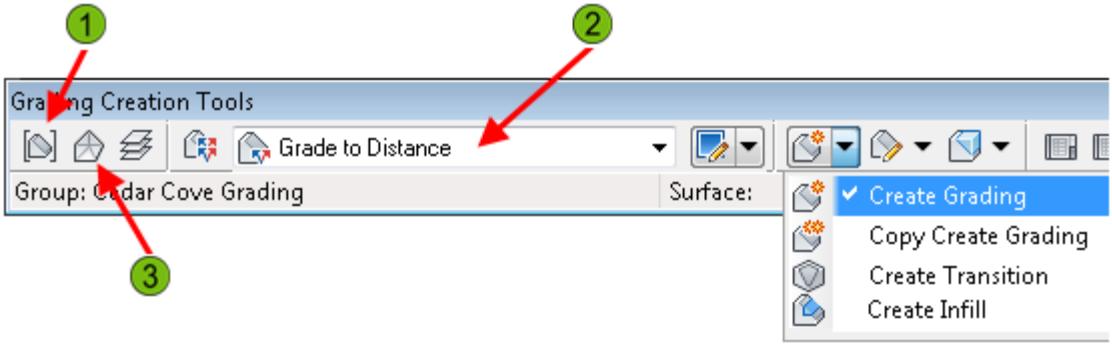
If you create grading objects that represent a runoff and a drainage ditch, you can create the two grading objects as part of the same grading group. If the group is configured to create a surface, the two objects combine to create the surface in the drawing.

Creating Grading Objects

To create grading objects, you do the following:

- Select or create a grading group.
- Select a grading footprint feature line.
- Select grading criteria.
- Select a target surface (if criteria targets a surface).
- Specify grading parameters.

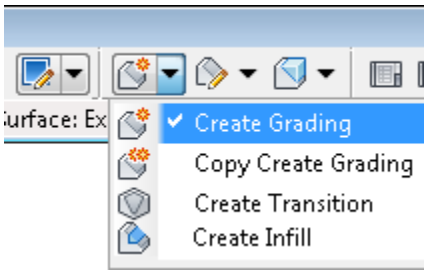
You create grading with the Create Grading command on the Creation Tools toolbar, which is shown in the following illustration.



1. Set Grading Group
2. Grading Criteria
3. Target Surface

When you create the grading group, you have the option to automatically create a grading surface and a comparison surface for volumes as part of the grading group. If you choose to bypass this option, you can perform these steps later.

After you create the grading group, you specify the target surface, which is the Existing Ground surface. You finally select the grading criteria, which is Grade to Surface and create the grading and specify the slopes. This is shown in the following illustration.



About TIN Volume Surfaces

Earthwork volume quantities are vital to calculate, as this is one of the most expensive elements of a design. Therefore, it is desirable to "balance" the earthwork. Balance is achieved when the material to be cut equals the material to be placed as fill. Civil 3D combines two surfaces to create a TIN volume surface, which includes as part of its properties the cut and fill quantities.

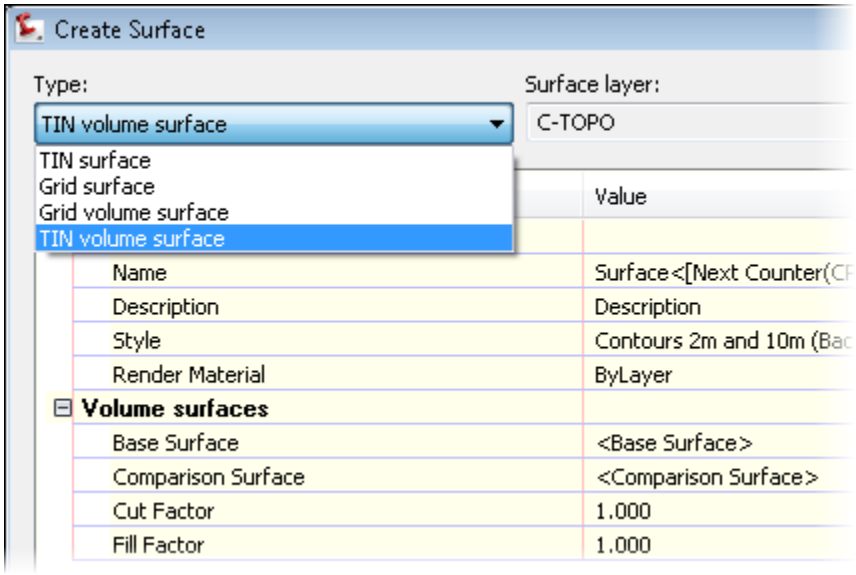
A triangulated irregular network, or TIN, is a surface model consisting of data points (vertices) connected by 3D lines (TIN lines) to form three-dimensional irregularly shaped triangular

faces. These triangular faces are collectively called a TIN. TINs are used to model existing ground surfaces, proposed surfaces, subsurfaces (like bedrock), and water surfaces. A volume TIN surface is a TIN resulting from the comparison of two different TINs, such as an existing ground and a proposed ground surface.

TIN volume surfaces are used to compare and calculate:

- Volumes between proposed and existing surfaces.
- Detention basin storage volumes.
- Detention basin earthwork cut volumes.
- Berm and stockpile volumes.

The Create Surface dialog box, with the TIN Volume Surface type selected is shown in the following illustration. Note the base and comparison surfaces, and the cut and fill factors.



Calculating Earthwork Volumes

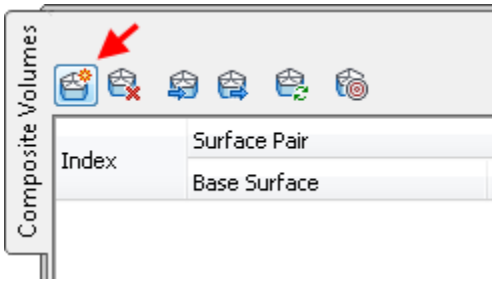
You can calculate earthwork volumes in several ways, two of which are introduced here. The first method employs a simple calculation and displays the results in the Panorama window. The second method is more complex and uses the existing ground surface and the prefinal top surface to create a composite surface for calculating volume. The advantage to the second method is that the volume surface is similar to a standard TIN surface and is an object in your drawing. Therefore, its styles can be modified, analyzed, and used for exhibits, such as cut and fill maps. Both methods give you the same cut, fill, and net volume results.

Process: Calculating Earthwork Volumes (Method 1)

The following steps outline the process for calculating earthwork volumes using the simple calculation method.

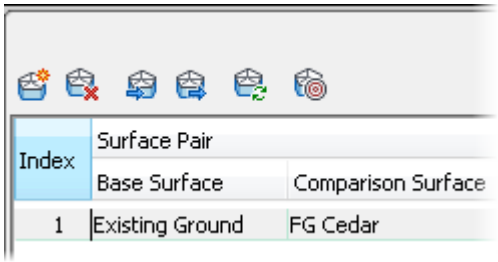
1. Create a new volume:

- Use the Surfaces menu or Panorama window.



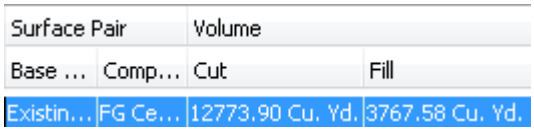
2. Select the base and comparison surfaces.

- Select the base surface (EG).
- Select the top surface (Prefinal Top).



3. Calculate the volumes (done automatically by AutoCAD® Civil 3D® software):

- Examine the calculated cut, fill, and net volumes.

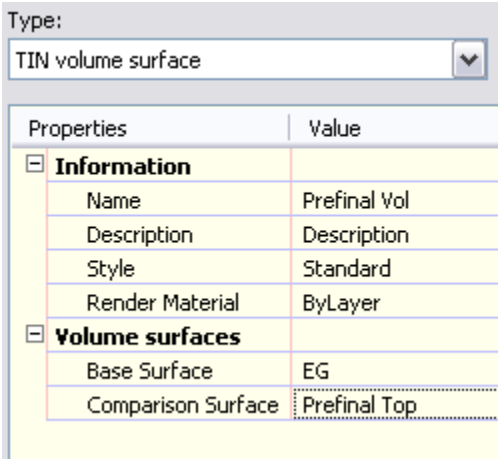


Process: Calculating Earthwork Volumes (Method 2)

The following steps outline the process for calculating earthwork volumes using the composite surface method.

1. Create a new surface. Set base and top surfaces.

- Create the TIN volume surface.
- Select the base surface.
- Select the comparison surface.



2. Calculate volumes.

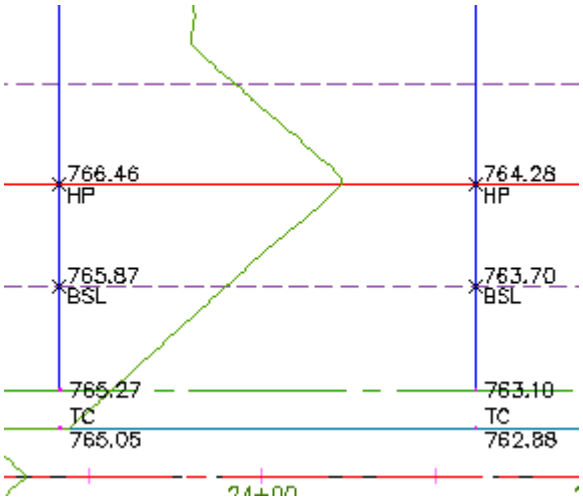
- Examine calculated cut, fill, and net volumes.

Statistics	Value
General	
TIN	
Volume	
Base Surface	EG
Comparison Surface	Prefinal Top
Cut volume (unadjusted)	24640.79 Cu. Yd.
Fill volume (unadjusted)	33803.99 Cu. Yd.
Net volume (unadjusted)	9163.20 Cu. Yd. <Fill>

Surface Annotation

In order to convey the engineering grading design intent, surfaces that are to be constructed in the field must be properly labeled or annotated. Elevations at key locations on the surface must be clearly identified. Additionally, the process of annotation itself must be both an accurate and relatively simple process. AutoCAD Civil 3D provides several methods for annotating a surface.

The following illustration shows elevations for the high point (HP), building setback line (BSL), and top of curb (TC).



Surface annotation can be accomplished in many ways. A common method is to create dynamic surface labels that automatically update when the underlying surface model changes. A second method is to create a point object that can receive its elevation from an underlying surface. While points can be used as part of a surface definition, they do not automatically update if the surface, from which their elevation was derived, changes.

Surface annotation is useful for labeling the following:

- Top of curb elevations
- High/low point elevations
- Lot corner elevations
- Swale centerlines
- Detention basin outfall elevations

Creating Spot Elevation Surface Labels

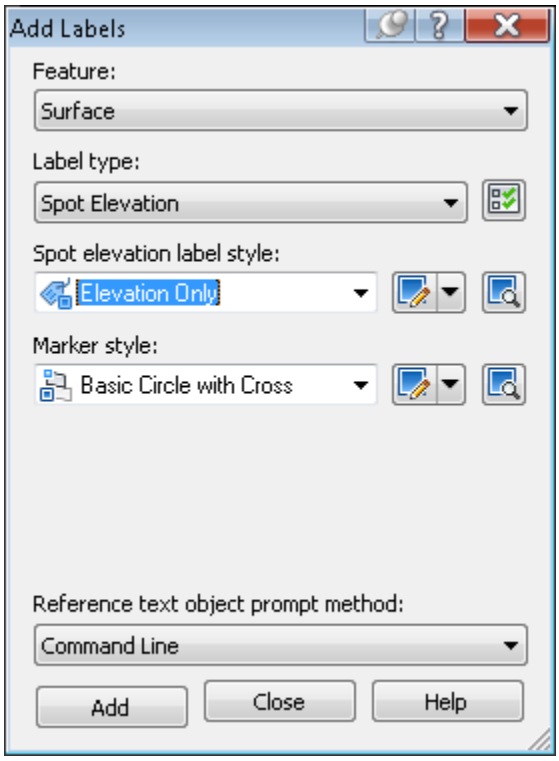
You refine the grading of the individual lots by setting spot elevations at points of interest on the lot lines. You use surface labels to annotate spot elevations at various locations. You create points at the lot line intersections with the building setback line, and at high points on the side yard lot lines. The labels assist in relaying design intent to the review agencies and contractors, while the points add detail to the grading design, moving the process toward a more complete final design.

Process: Creating Spot Elevation Surface Labels

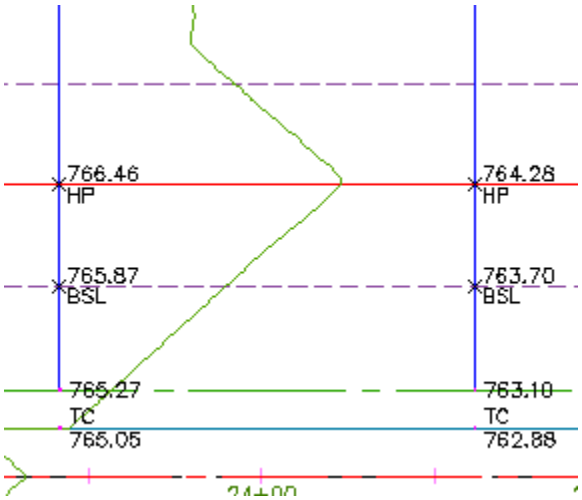
The following steps outline the process for creating spot elevation surface labels.

1. Add labels:

- Set default point descriptions.
- Set running object snaps to endpoint and intersection.
- Run the Create Random Points (on Surface) command.



2. Set points at the building setback lines and high points.



Keep the following guidelines in mind for creating spot elevation and grade labels:

- You can use the Apparent Intersection running object snap to select the location to be labeled. However, doing this may require two clicks for each lot line. On a project of this size, this action might not be overly time-consuming, but on larger projects it is.
- You can set points on a surface where the elevation of the points automatically sets to the underlying surface elevation. However, when the underlying surface is modified, the point elevations remain static. Therefore, you should use spot elevation surface labels because they are updated when the surface changes, making it that much easier to keep the annotation and the design elements synchronized. In anticipation of future revisions to the road profile and, thus, the lot grading, use a combination of both points and spot elevation surface labels.
- You can label grades and elevations on feature lines using line labels. This is helpful when you are grading a site using feature lines and need to visualize elevation and grade data for the design.

Key Terms

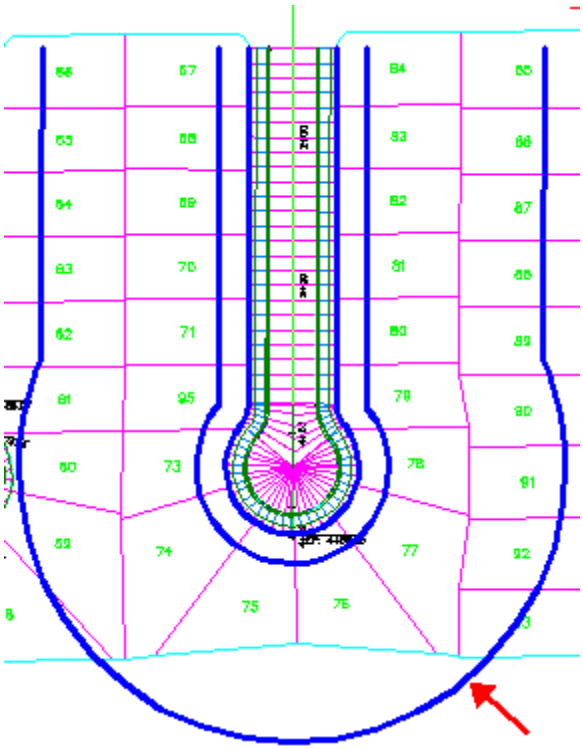
Feature Line	A feature line is a special line type that grading commands recognize and use as a footprint, and surfaces can use as a breakline. You can draw feature lines, create them by converting existing objects, or export feature lines from corridors. Feature lines are similar to AutoCAD 3D polylines and store both horizontal and elevation location data. Feature lines can be labeled with grades and elevations.
Feature Line Style	The feature line style controls the appearance of a feature line.
Grading Feature Line from Corridor	You can create feature lines from corridors. Oftentimes, a designer creates a grading feature line at the corridor right-of-way locations. These feature lines are used to begin the grading for the subdivision parcels. Grading feature lines created from a corridor can either be dynamic, and automatically react with changes to the corridor, or they can be static, and therefore editable.
Elevation Editor	The Elevation Editor is displayed in the Panorama window and is used to modify the elevations of feature lines. You can modify individual elevation points or raise and lower the feature line by a specified

	distance. When you click an elevation point in the Elevation Editor, Civil 3D displays a graphic marker in the drawing area to show the location of the selected elevation point.
Interim Grading Surface	An interim grading surface is created to model the overall drainage characteristics for the site. Feature lines can then be created at any location on the site and assigned elevations from the interim grading surface.
Daylighting	Daylighting refers to the action of projecting a slope from a feature line to a surface. The location where the projected slope intersects the surface is called the *daylight line*.
Stepped Offset	Stepped Offset is a feature line tool that offsets a feature line by a horizontal and vertical distance. You can also specify the offset parameters with a horizontal distance and a grade.
Corridor Datum Surface	The corridor datum surface represents the subgrade level of a corridor. It is included as data in the design site grading surface for earthwork volume calculations.
Elevation Point	An elevation point is a location on a feature line with an assigned elevation.
Grading Object	A grading object is a Civil 3D object that represents a projected slope to either a surface, elevation, or an offset. Grading objects are most often used to daylight to an existing surface. Grading objects intersect each other if they are in the same Civil 3D specified site.
Grading Group	Grading groups are part of Civil 3D sites and are used to organize grading objects.
Grading Style	A grading style controls the appearance of grading object slopes. You assign different grading styles for cut and fill conditions.
Composite Volume	A composite volume is a method for calculating the volume between two surfaces.

Exercise 1: Create and Edit Feature Lines

In this exercise, students create grading feature lines to begin the grading process for parcels adjacent to a subdivision road. Students first create a grading feature line from the corridor model at the right-of-way location. The next grading feature line is created at the building frontage location. The final grading feature line models the overall flow characteristics of the site.

The completed exercise is as shown.



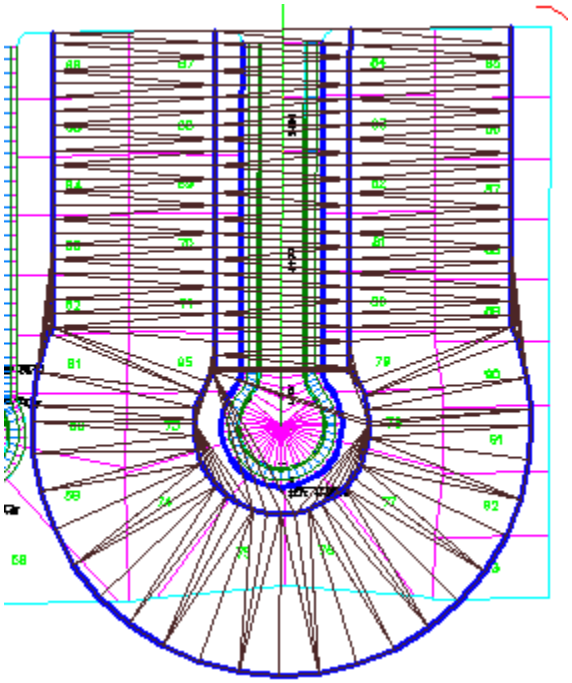
For this exercise, open *…\I_SiteGrading-EX1.dwg (M_SiteGrading-EX1.dwg).*

For this scenario, the builder grades the parcels adjacent to Cedar Cove first.

Exercise 2: Create an Interim Grading Surface

In this exercise, students create an interim grading surface. The creation of an interim grading surface is an intermediate step that enables students to calculate the elevations at the back of the parcels adjacent to Cedar Cove.

The completed drawing is as shown.



For this exercise, open *…\I_SiteGrading-EX2.dwg (M_SiteGrading-EX2.dwg).*

Extend Offset Feature Lines

Students begin by extending the offset feature lines to property lines to the north. To do this, students use the AutoCAD Extend command.

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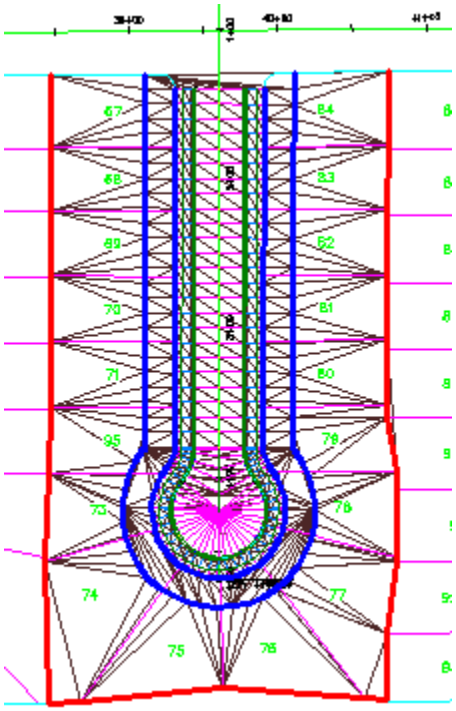
Exercise 3: Create a Grading Footprint

In this exercise, students create a feature line along the back of the Cedar Cove parcels that will be used as a grading footprint. The elevations of the feature line points are calculated from the interim grading surface. Students also combine the corridor datum surface data to begin the creation of the final grading surface.

The completed drawing is as shown.



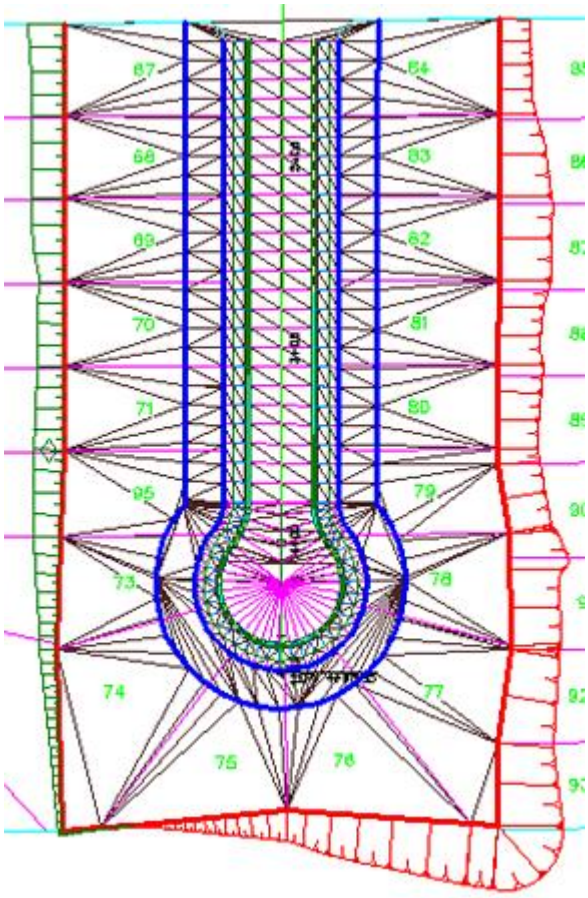
For this exercise, open *…\I_SiteGrading-EX3.dwg (M_SiteGrading-EX3.dwg).*

Students begin by suppressing the display of the interim grading surface.

Exercise 4: Create Grading Objects

In this exercise, students create a grading object to model the daylighting from the back of parcels feature lines to the existing ground surface.

The completed exercise is as shown.



For this exercise, open …*I_SiteGrading-EX4.dwg (M_SiteGrading-EX4.dwg).*

Exercise 5: Create a Final Grading Surface

In this exercise, students calculate the total earthworks volumes.

The completed drawing is as shown.

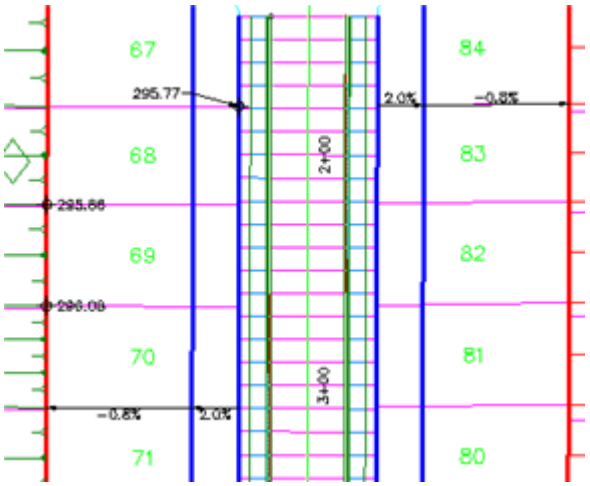
Surface Pair		Volume	
Base ...	Comp...	Cut	Fill
Existin...	FG Ce...	12773.90 Cu. Yd.	3767.58 Cu. Yd.

For this exercise, open *…\I_SiteGrading-EX5.dwg (M_SiteGrading-EX5.dwg).*

Exercise 6: Label the Final Grading Surface

In this exercise, students create spot elevation labels and grade labels for the design grading surface.

The completed drawing is as shown.



For this exercise, open *…\I_SiteGrading-EX6.dwg (M_SiteGrading-EX6.dwg).*

Students begin by suppressing the display of the FG Cedar surface.

Assessment

Challenge Exercise

Instructors provide a master or challenge exercise for students to do based on this lesson.

Questions

1. What is the process for offsetting a feature line horizontally and vertically?
2. What controls the display of a feature line?
3. What is the easiest way to edit the elevations and grades on a feature line?
4. Why would a designer create an interim grading surface?
5. What is the procedure called for projecting a slope from a feature line to a surface?
6. What is a grading object?
7. What is a grading group?
8. What controls the display of a grading object? What display components can be controlled?
9. What type of volume calculation does Civil 3D use to calculate the volume between two surfaces?

Answers

1. Use the Create Feature Line from Stepped Offset command. This is on the Home tab, Create Design panel, click Feature Line > Create Feature Line from Stepped Offset.
2. The Feature Line Style controls the display of a feature line.
3. There are several easy ways to edit feature line elevations and grades. One of the easiest ways is to click the feature line and select Edit Elevations. Civil 3D shows the Grading Elevation Editor in the Panorama window. You can interactively modify the elevations and grades on the feature line. Another easy method is the Quick Elevation Edit button on the Edit Elevations panel of the Modify tab.
4. The interim grading surface models the overall drainage characteristics of the site. Elevations at various points are often assigned from the interim grading surface.
5. This procedure is called *daylighting*.
6. A grading object is a Civil 3D object created by projecting a slope from a feature line to a surface.
7. Grading objects are organized in a grading group. Grading objects within the same grading group interact with each other.
8. The Grading Style controls the display of a grading object. You can control the display of slope patterns, the projection lines, and the daylight lines.
9. Civil 3D uses the composite volume calculation method.

Lesson Summary

In this lesson, students learned how to design the grading for a subdivision. Students began with grading feature lines created from the corridor surface at the right-of-way locations. These feature lines were then offset horizontally and vertically using the Stepped Offset command. The offset feature lines were further offset beyond the back of parcels and limits of proposed grading.

An interim grading surface was then created from all the feature lines. New feature lines were created at the back of parcel locations and assigned elevations from the interim grading surface. These feature lines were then used to create grading objects, which projected daylight slopes to the existing ground surface.

A final site grading surface was then created. The final site grading surface was compared with the existing ground surface to calculate earthworks volumes. Students then labeled grades and spot elevations.