AutoCAD Civil 3D 2010
Education Curriculum Instructor Guide, Unit Overview
Unit 3: Land Development

Autodesk

Unit 3 – Land Development

Unit 3 provides lessons that address the use of AutoCAD® Civil 3D® software for the land development industry. Land development, as far as this curriculum is concerned, includes projects under municipal (city or town) jurisdiction. These types of projects include, but are not limited to, capital infrastructure projects and private land development projects. Capital infrastructure projects involve the design and construction of municipal assets such as storm sewer, sanitary sewer, water main, and road networks. Private land development projects generally include subdivisions in which tracts of lands are cleared for the construction of new houses and all supporting services. Land development projects are distinguished from transportation projects usually undertaken by state, provincial, and federal-level organizations.

The lessons contained in Unit 3 include the following:

- Lesson 1 – Basic Grading
- Lesson 2 – Create Parcels
- Lesson 3 – Horizontal Alignments
- Lesson 4 – Profiles
- Lesson 5 – Assemblies and Corridors
- Lesson 6 – Cross Sections and Quantities
- Lesson 7 – Site Grading and Quantities
- Lesson 8 – Pipe Design

Lesson 1 introduces the student to basic grading concepts and includes exercises on how to grade a simple building pad. Lesson 2 addresses parcel creation and layout using a number of different methods. Lesson 3 addresses horizontal alignments, and in particular, how to create them for subdivisions and similar land development projects. Lesson 4 discusses existing and proposed road profiles. Lesson 5 covers assemblies and corridors, which are used to model roads. Lesson 6 addresses cross sections and quantity calculation for road designs. Lesson 7 offers a number of exercises, and addresses site grading concepts for a subdivision. Unit 3 ends with Lesson 8, which covers pipe layout and design for a subdivision storm sewer. The following sections offer additional details of the lessons in Unit 3.

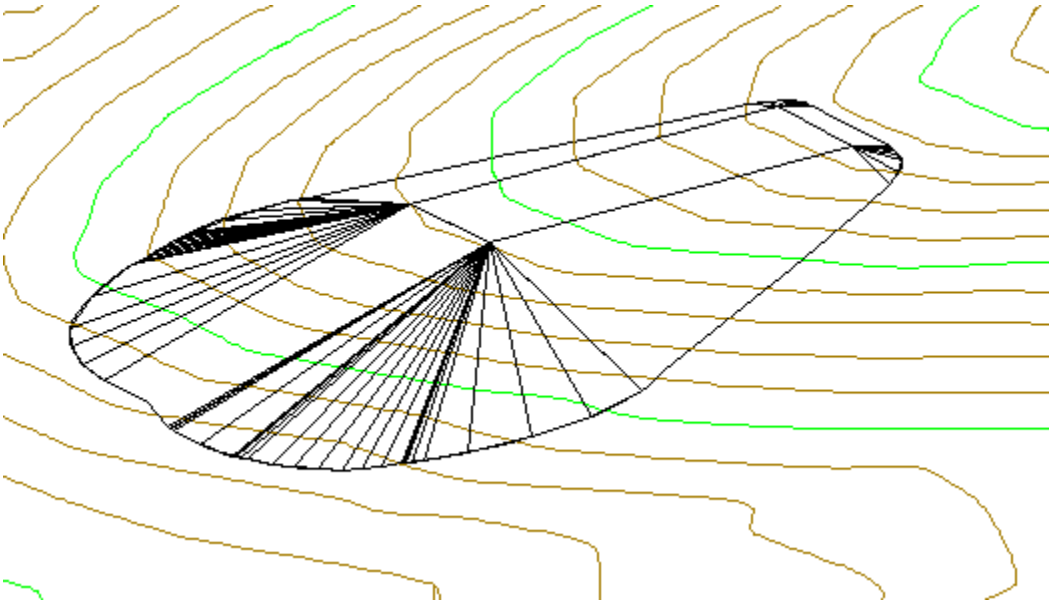
Lesson 1 – Basic Grading

In this lesson, students learn the basic concepts of grading a site. More advanced concepts and methods involving roadway corridors and bulk grading of entire blocks are covered in a subsequent lesson. From the previous unit, students now have the ability to collect and import survey data, create points and surfaces, and import images as background information. Using this knowledge, it is easy to comprehend the basic issues involved in manipulating the terrain using techniques such as spot elevations, feature lines, and a special feature of Civil 3D called *grading objects*, which are contained in grading groups. Feature lines and grading groups are contained within a site and these objects interact with one another when they are in the same site.

A fundamental aspect of projects that involve site grading is that a proposed surface representing design conditions must be created. The existing ground surface created from survey data and breaklines is the starting point; the design surface interacts with the existing ground surface. As the designer, you are responsible for developing one or more design alternatives that fits the needs of the client and the applicable regulations. There are many aspects of a project that are affected by grading decisions including stormwater drainage and low impact development methods, slope stability, sound barriers, applicable vegetation, visual impact of a site, and the cut and fill volume balance on the site.

This lesson focuses on the use of feature lines, spot elevations, and grading objects. A feature line is similar to an AutoCAD 3D polyline, but offers powerful functionality for setting grades and vertex elevations. Spot elevations are simply design points inserted to control the position and elevation of a particular spot in the final design. Grading objects consist of a set of components that are most often used for projecting a feature line along a cut or fill slope to a surface. These objects are used to model the grading for the site, and are combined together to form the final grading surface. The final surface is important for a variety of reasons, including 1) quantity calculations, 2) generation of construction staking data, and 3) 3D modeling and visualization.

While this lesson covers basic grading concepts, many of these techniques are used in final, detail grading. The introduction of these techniques at this early stage reflects their relative simplicity, as well as their importance in visualizing the final product.



Objectives

After completing this lesson, students will be able to:

- Explain the function of sites.
- Explain the basic concepts of grading.
- Create spot elevations and feature lines.
- Edit grading criteria.
- Create grading objects and grading groups.
- Calculate cut and fill volumes for grading objects.
- Create a design surface.
- Use styles and labels to create a basic grading plan.

Exercises

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

1. Create Feature Lines and Spot Elevations
2. Create a Grading Object
3. Create a Design Surface

Lesson 2 – Create Parcels

In this lesson, students learn how to work with sites and parcels in AutoCAD® Civil 3D® software. A site contains design objects such as alignments, parcels, feature lines, and grading groups. Often the site is analogous to the initial parcel from which all subsequent parcel design is generated. A special parcel, known as the right-of-way parcel, represents the parcel of land for a road, also known as a road allowance. Building parcels are subdivided according to design criteria such as minimum area or road frontage. The conceptual design of parcel and road layout forms the fundamental idea of the development. Multiple design alternatives are normally created and evaluated based on many criteria.

Objectives

After completing this lesson, students will be able to:

- Create a site.
- Create a ROW parcel.
- Describe parcels and their properties.
- Create parcels using layout tools.
- Create parcels from objects that already exist in the drawing.
- Edit parcels.
- Renumber parcels.
- Label a parcel and create a table.

Exercises

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

1. Create a Site
2. Create a ROW Parcel
3. Create Parcels Using Layout Tools
4. Create Parcels from Objects
5. Edit Parcels
6. Renumber Parcels
7. Label Parcel Segments

Lesson 3 – Horizontal Alignments

In this lesson, students learn how to create subdivision road alignments from AutoCAD® entities such as lines, arcs, and polylines. Alignments are a critical component of all subdivision and roadway projects that have linear corridor design elements such as residential and collector roads. Alignments can also be used with creeks and rivers for floodplain analysis and channel design.

The following illustration shows two intersecting alignments:

Objectives

After completing this lesson, students will be able to:

- Describe alignments and their properties.
- Create alignments using objects.
- Describe alignment tag labels.
- Label alignments and create a table.

Exercises

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

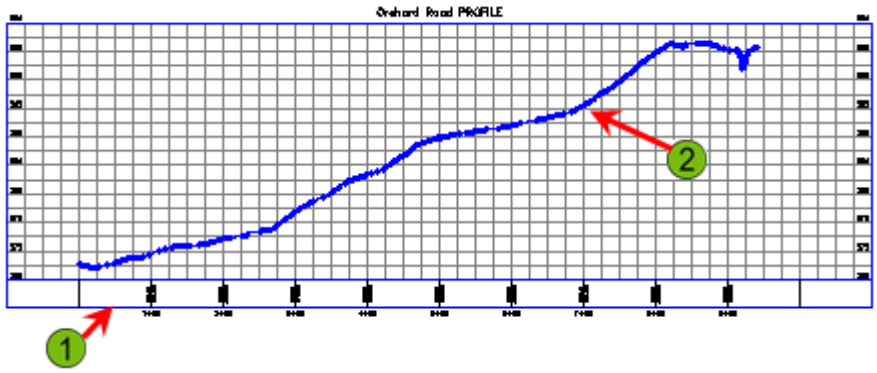
1. Create an Alignment
2. Label an Alignment

Lesson 4 – Profiles

In this lesson, students learn to create surface profiles and profile views. Surface profiles are created for alignments and typically show the nature of the existing terrain along the alignment. Profile views are the grid objects that show surface profile and other types of profile data.

Surface profiles are dynamic objects that automatically update if either the horizontal alignment geometry changes or the surface changes. This makes it very easy to adjust the horizontal alignment to best match the existing terrain.

A profile view with a surface profile is shown in the following illustration.



1. Profile view
2. Surface Profile

After the designer creates a surface profile, the next step in the road design process is to create a layout profile. The layout profile represents the design profiles and consists of tangents and vertical curves. You create layout profiles by using commands on the Profile Layout Tools toolbar. You can edit layout profiles graphically, using the table in Panorama, or by using profile creation tools on the Profile Layout Tools toolbar.

Objectives

After completing this lesson, students will be able to:

- Create a profile from a surface and create a profile view.
- Create a layout profile.
- Edit a layout profile using graphical and tabular methods.
- Label profiles and profile views.

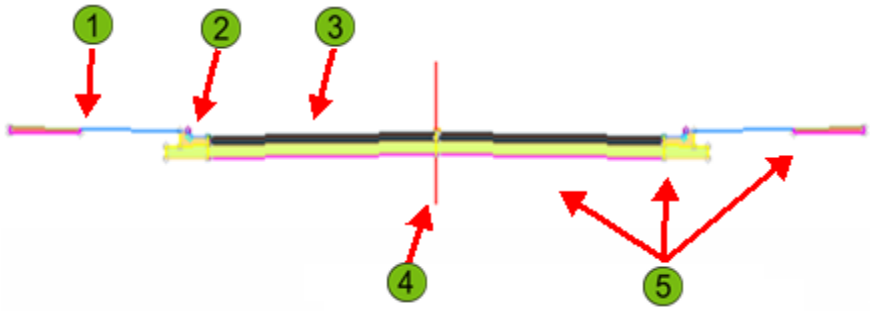
Exercises

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

1. Create a Surface Profile and a Profile View
2. Create a Layout Profile
3. Edit Profile Geometry
4. Label Profiles and Profile Views

Lesson 5 – Assemblies and Corridors

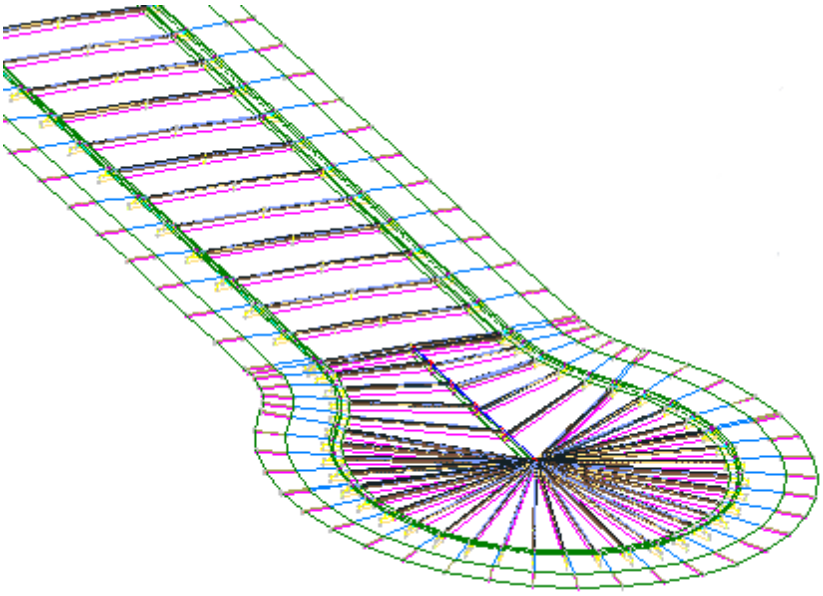
In this lesson, students learn how to create assemblies and use them to create corridor models. Once a corridor model is created, students learn how to create corridor surfaces from the model. Subassemblies are individual objects that are pieced together as a design cross section, or an assembly object. The assembly object, along with the horizontal and vertical alignment, is used to build the corridor model for a road, highway, railway, embankment, channel, or any cross section-based features. The subassemblies are logically designed, and respond dynamically in the design environment, making it easy to generate and evaluate design alternatives.



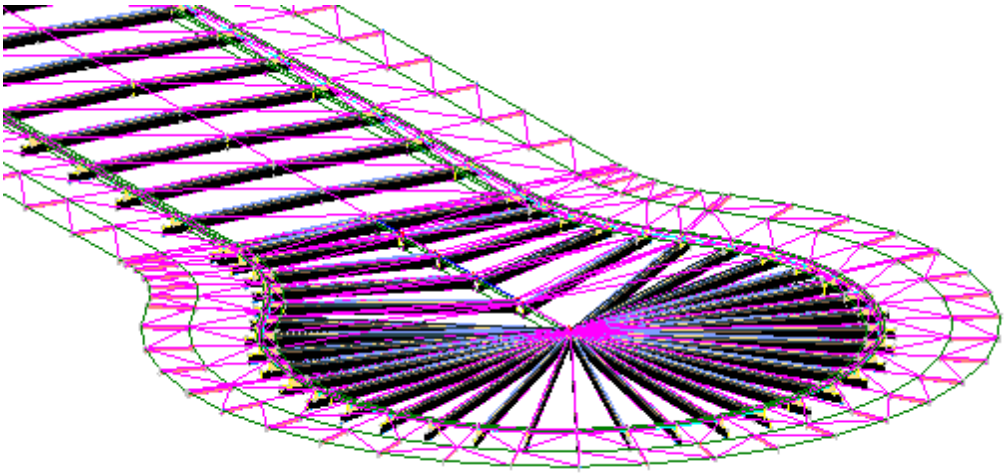
1. Sidewalk
2. Curb
3. Lane
4. Assembly
5. Subassemblies

You can use corridor models to represent any road, rail, channel, or berm design that has typical cross-section features. When you create a corridor model, you create a single object that includes all the design components and input parameters for a road or other type of feature created from a typical cross section.

A completed corridor model for a residential subdivision road with a cul-de-sac is shown in the following illustration.



Corridor surfaces are useful for design and construction tasks. You can use corridor surfaces to calculate earth cut and fill quantities, label spot elevations and slopes, and generate construction staking data.



Objectives

After completing this lesson, students will be able to:

- Describe assemblies and subassemblies.
- Describe the subassembly input and target parameters.
- Create assemblies.
- Describe a corridor model and list its components.
- Create a corridor model for a subdivision road with a cul-de-sac.
- Create a corridor surface.

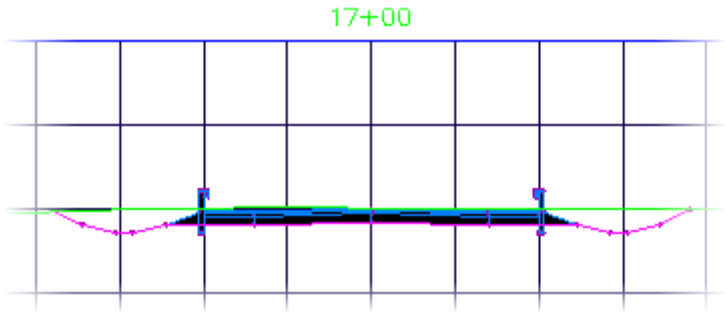
Exercises

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

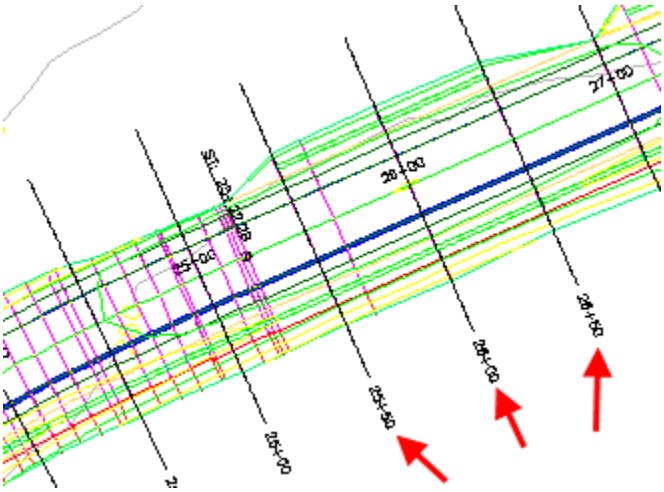
1. Create Assemblies
2. Create a Corridor Model
3. Create a Corridor Surface

Lesson 6 – Cross Sections and Quantities

In this lesson, students work with cross sections, sample lines, corridor quantities, and quantity reports. Cross-section views are inserted at sample line locations along the alignment and illustrate the materials to be used at that particular location. Section views display surface, corridor surface, corridor, pipe network, and material section data at the sample line locations. Section data in the section views is automatically updated when the corridor recalculates or section data changes. A section view is shown in the following illustration.

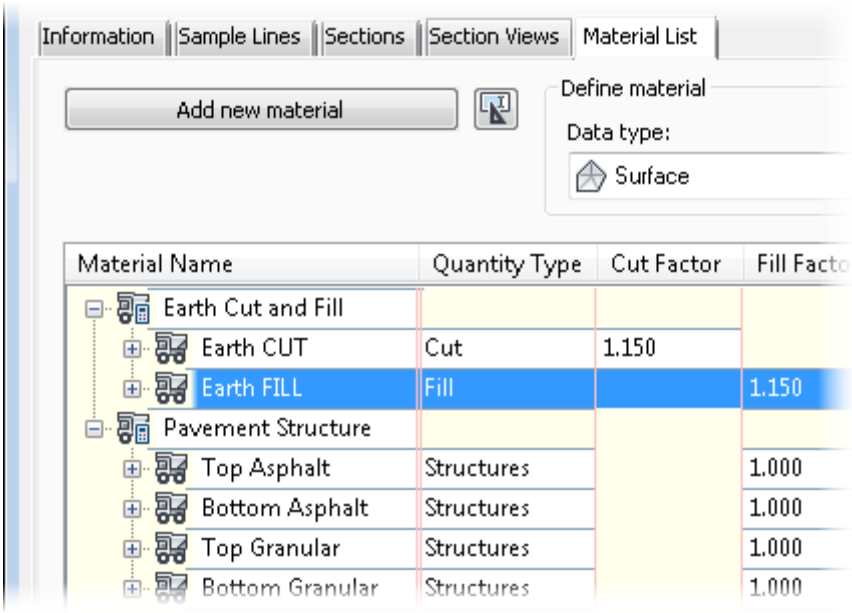


Sample lines are required to calculate quantities and to create section views that display section data. Sample lines are attached to an alignment, as shown in the following illustration.



Earth cut and fill and pavement structure quantities are calculated from data associated with cross sections at the sample lines in order to estimate the amount of earth to be moved and the required materials for construction. Earth cut and fill volumes are calculated by comparing the corridor datum surface section data with the existing ground surface section data. Pavement and base material volumes necessary to construct the roadway are calculated directly from the corridor section data.

The following illustration shows a material list for corridor quantities. The material list is assigned to a sample line group.



Quantity reports are created from a sample line group and can be inserted in a drawing as a table, or extracted to an external file. After a quantity report is created, if the corridor model changes, the section data attached to the sample lines also updates. When the section data attached to the sample lines updates, the quantity table in the drawing also updates. This makes it very easy to quickly analyze quantities and adjust corridor models to balance earth cut and fill volumes.

The following illustration shows a portion of a quantity report in a table in a drawing area.

Total Volume Table						
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
22+00.00	22.49	132.73	31.34	325.98	125.78	3360.02
22+50.00	44.54	84.68	74.13	219.93	199.91	3579.96
23+00.00	89.36	54.86	147.60	140.70	347.50	3720.66
23+50.00	173.73	11.25	288.62	66.40	636.13	3787.06
24+00.00	196.97	0.00	402.83	11.36	1038.96	3798.41
24+50.00	190.12	0.00	416.84	0.00	1455.80	3798.41
25+00.00	100.86	17.09	311.71	17.90	1767.51	3816.31
25+50.00	46.68	38.46	157.09	59.15	1924.61	3875.46
26+00.00	14.99	60.49	65.66	105.36	1990.27	3980.83
26+50.00	1.18	95.42	17.22	166.02	2007.49	4146.85

Objectives

After completing this lesson, students will be able to:

- Describe sample lines and how they are used in cross sections.
- Create and edit sample lines.
- Modify the sample line group properties and add additional section data.
- Describe criteria used in quantity takeoff calculations.
- Calculate the earth cut and fill and pavement structure quantities for a corridor model.
- Create quantity reports that display quantity calculations.
- Create a quantity report in a table and a quantity report in a web browser.
- Create section views from sample lines.
- Create multiple section views.

Exercises

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

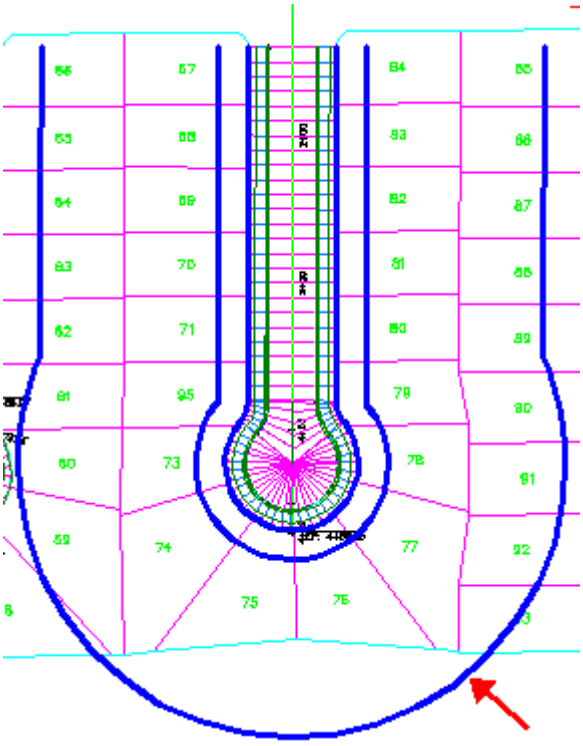
1. Create and Edit Sample Lines
2. Modify Sample Line Group Properties
3. Calculate Corridor Quantities
4. Create Quantity Reports
5. Create Multiple Section Views

Lesson 7 – Site Grading and Quantities

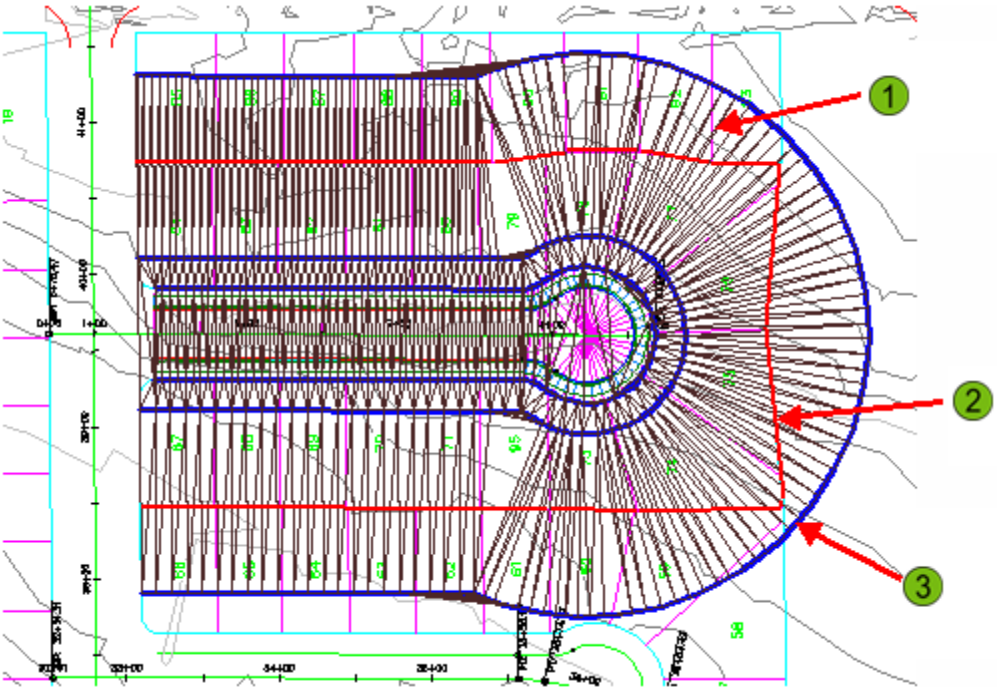
In this lesson, students work with feature lines and corridor surfaces to perform the site grading process for parcels adjacent to a subdivision road. Site grading, sometimes referred to as bulk grading, is the process of grading larger areas of land to general grade or slope specifications for design 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.



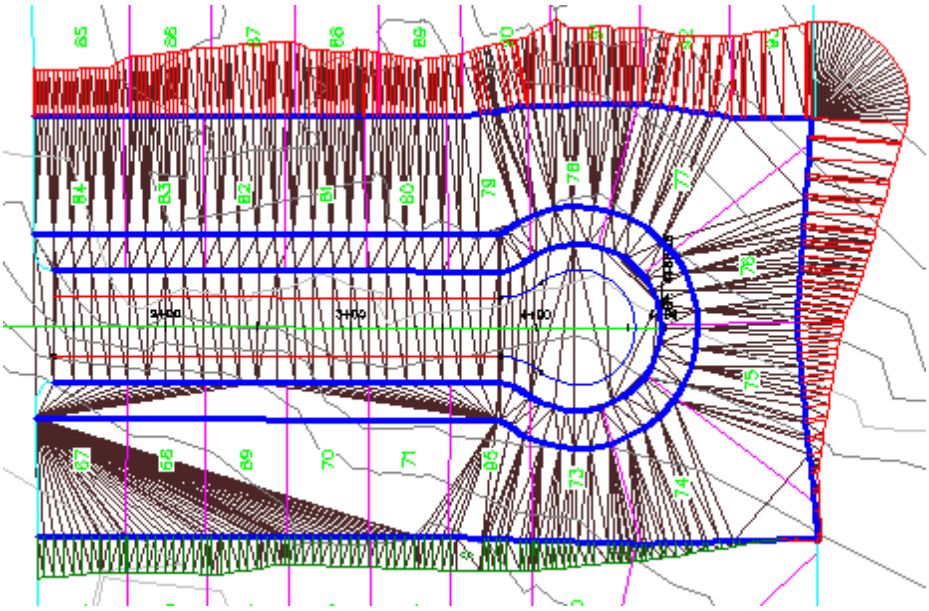
An interim grading surface that can be used to calculate a feature line along the back of parcels is shown in the following illustration. The feature line along the back of parcels is used for the grading footprint.



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

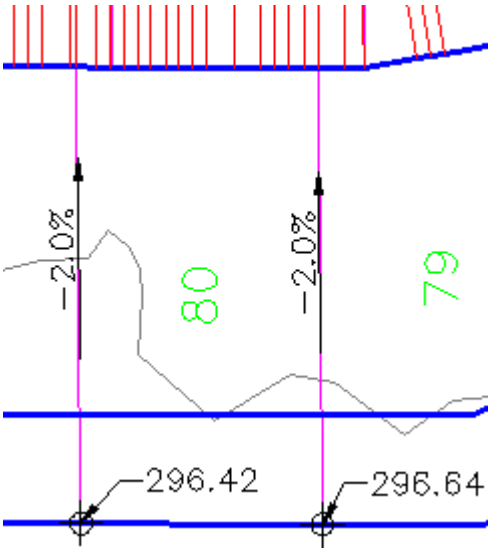
You use grading objects to create a surface to generate volume calculations that estimate the required materials for your design. As with any drawing object, the grading design and any related objects are automatically updated whenever you make a change to the grading.

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

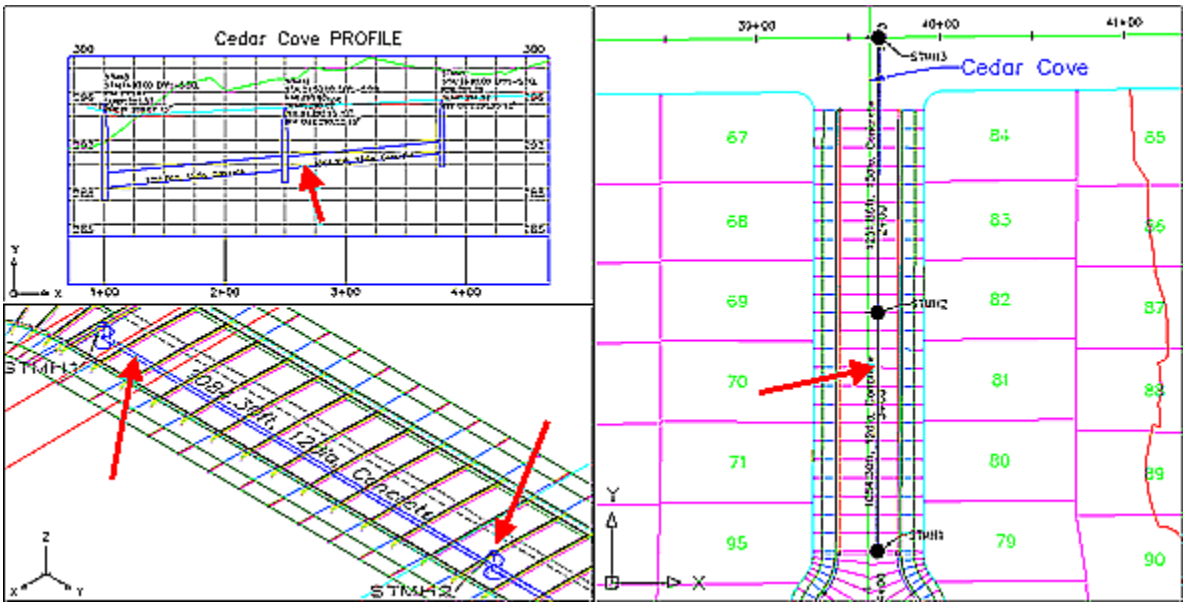
The following exercises are provided in a step by step format in this lesson:

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

Lesson 8 – Pipe Design

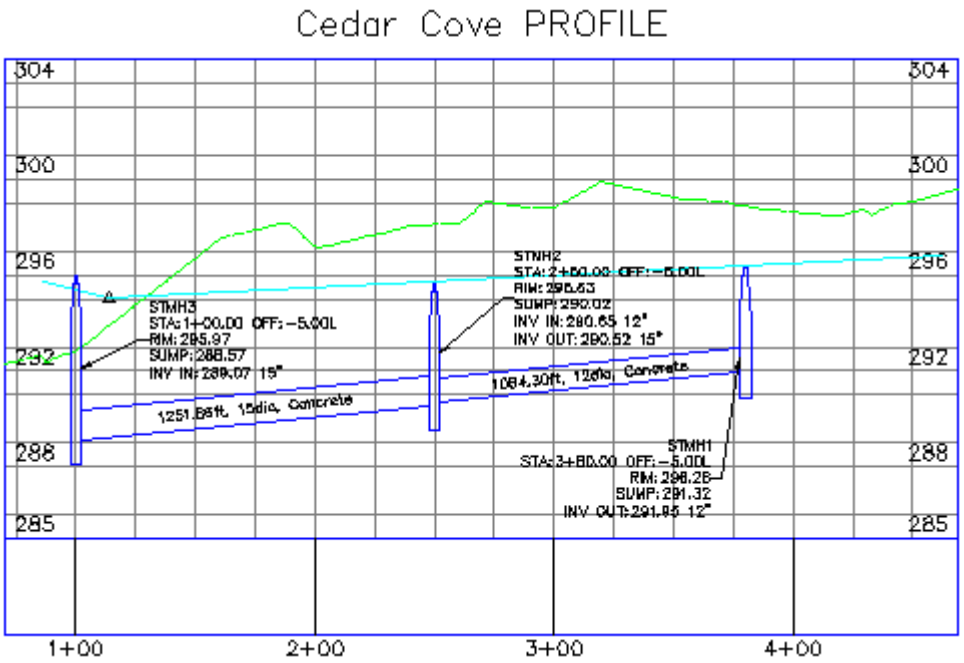
In this lesson, students learn how to add pipes and structures to a pipe network in plan view and in profile view. Students also learn how to label the pipes and structures in both views. The Hydraflow Storm Sewers Extension is used to calculate pipe sizes and invert elevations for a storm sewer pipe network. Students create a pipe network to model storm sewer, sanitary sewer, and water main systems. By creating a 3D model of a pipe network, you can quickly explore different design alternatives and check for interferences with other subsurface features.

The following illustration shows a pipe network in plan, profile, and 3D views. The arrows indicate the pipe network.



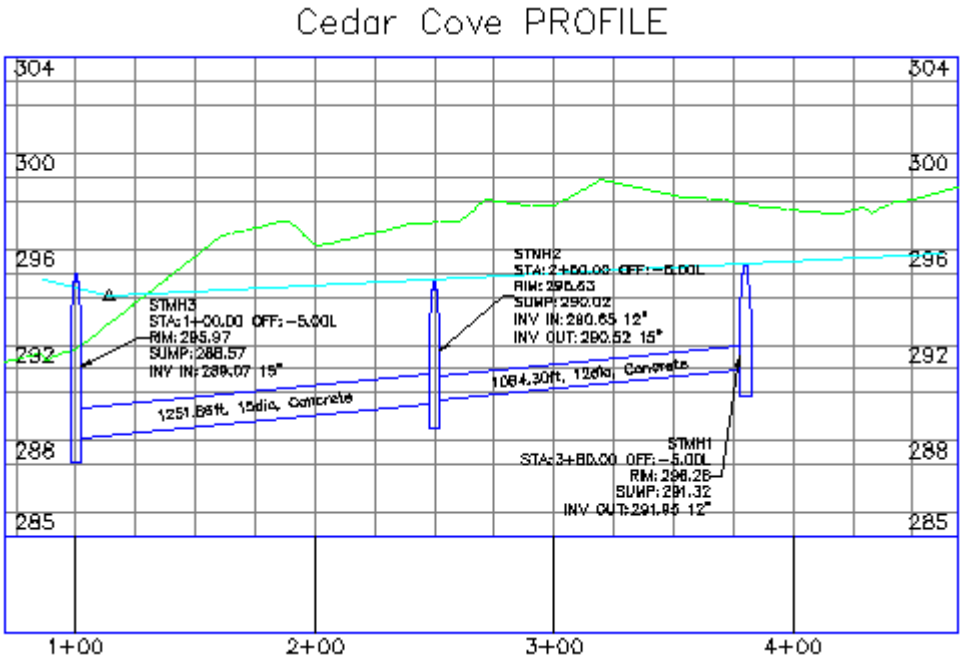
When you draw pipe network parts in profile view, you can evaluate the engineering attributes of your design. You can also customize the appearance of labels to help you design, or meet internal or client CAD standards requirements. When you edit pipe network data, the pipe network objects and labels in plan and profile view automatically update to reflect your revisions. This makes it very easy to generate and evaluate alternatives during the planning and detailed design processes. Furthermore, when you edit the plan view location of pipe network parts, the pipe network parts in the profile view automatically update.

The following illustration shows a pipe network in a profile view.

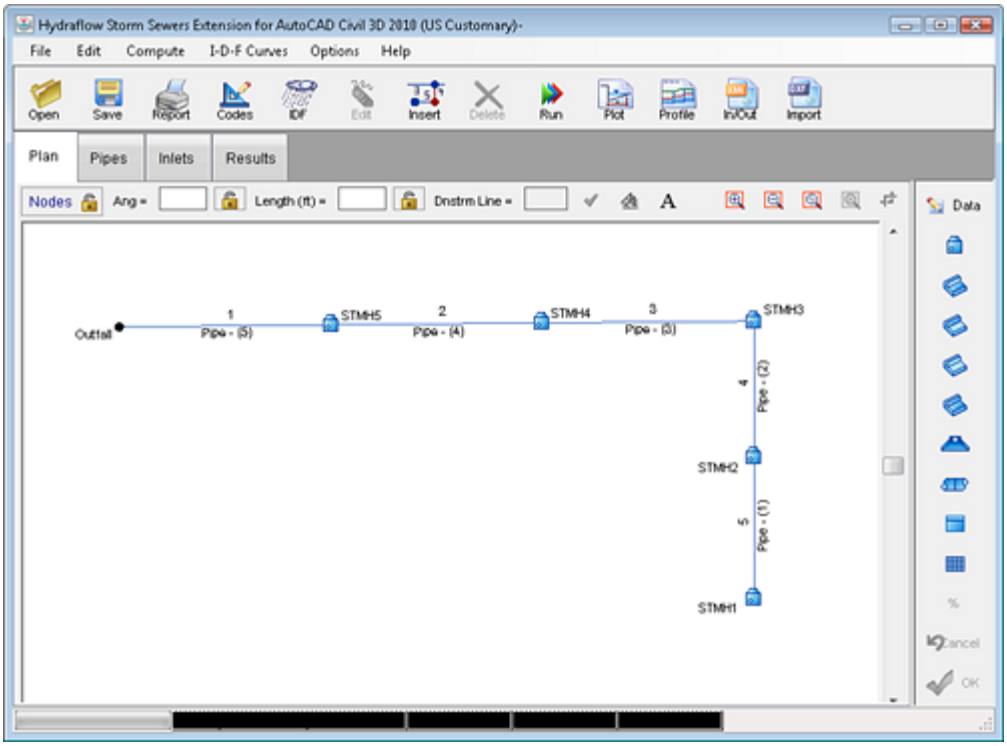


When you label a pipe network, you display the engineering data that you need to complete and evaluate the design and to construct the pipe network. Pipe labels can be created when you create the pipe network or after you create the pipe network. Pipe labels automatically update when you make changes to the pipe network.

The following illustration shows a labeled pipe network.



The Hydraflow Storm Sewers Extension is a powerful tool to calculate pipe sizes and invert elevations for a storm sewer pipe network.



Objectives

After completing this lesson, you will be able to:

- Describe the characteristics and function of pipe network objects.
- List the steps for creating pipe networks.
- Create a storm sewer pipe network for Cedar Cove.
- Draw a pipe network in profile view.
- Edit the pipe network.
- Label pipe networks.
- Design a storm sewer network that includes pipe sizes and invert elevations.

Exercises

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

1. Create a Pipe Network
2. Draw Pipes in Profile view
3. Edit a Pipe Network
4. Label Pipes
5. Design a Storm Sewer