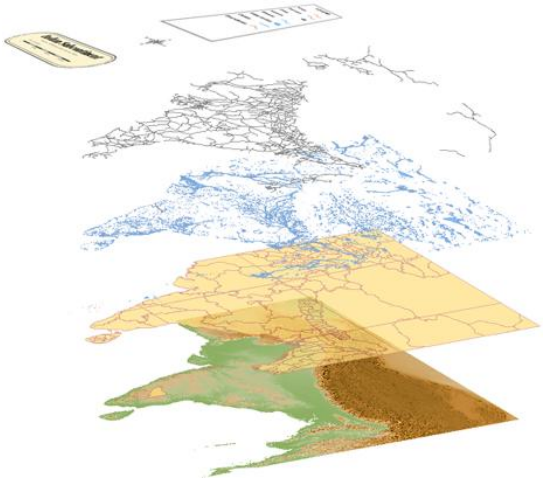
# Cartographic Basics

## Overview

Cartography is the art and science of making maps. Mapmaking involves many considerations, including the function of the map, data required for display, scale, colors, symbology, classification, generalization, and distortion. Maps are communication tools that provide a way to visualize data for specific locations. With GIS, maps can also present information in an analytical paradigm, presenting data or even results of models or calculations overlaid on a location.

In digital cartography, a map is made up of layers that overlay one another. You need to arrange these layers in the correct order, so that every feature in the map is in its proper place in the vertical arrangement. Features should be overlain so that they do not obscure each other. Typically images, such as satellite photographs, are located on the lower layers, that is, at the bottom of the *draw order*. Polygon layers, such as state and city boundaries, are typically placed above the images, followed by the layers of line features and point features. Finally, elements such as the map legend, scales, and North arrows provide the finishing touch.



# Objectives

After completing this lesson, students will be able to:

- Describe the basic elements of cartography.
- Stylize features based on attribute data.
- Label feature objects.

# Exercises

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

1. Create a Population Map
2. Create a Site Map
3. Create a Zoning Map
4. Create a Slope Analysis Map

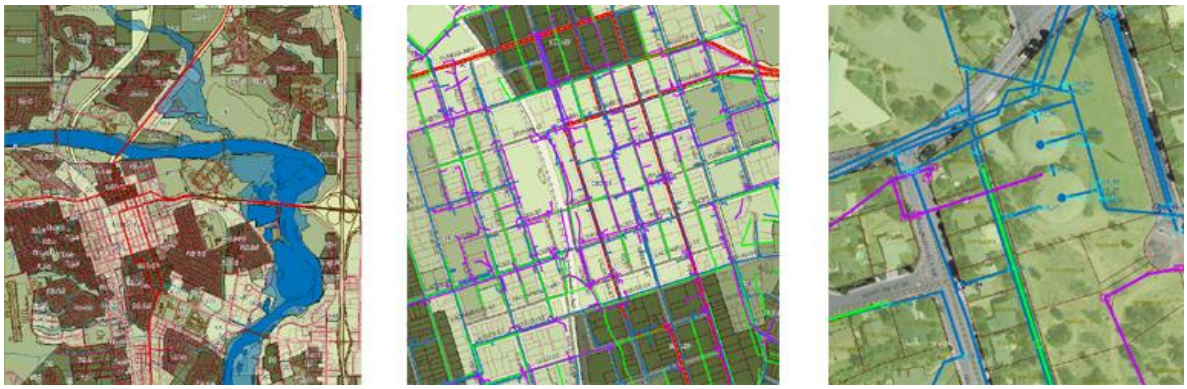
# Cartography Overview

When maps are created, a number of decisions must be made. The most important question to answer is, “What is the purpose of the map?” Deciding the function of the map is paramount to other questions, such as:

- Will a hard copy be the final product?
- What scale will show the extent of the area necessary and the level of detail desired?
- What data layers should be included?
- What symbology (style) should be used for each data layer?
- Do data need to be grouped by an attribute value (classified), then symbolized?
- If classification is used, which method is appropriate?
- Are there lines or polygons that need to be generalized?

These are only a few of the many issues that must be addressed when creating a map. If the map will be printed, decisions become final and care must be taken to examine the options. For digital maps that will be viewed on a computer screen, some options are dynamic. For example, text size and point symbol size may be set to be an absolute size or set to be relative to the screen size. Some data layers may be shown only at certain scale (zoom) levels. The following images illustrate this concept. A small-scale map is one that shows a large area (1:100,000 or 1”=10,000’, for instance). A large-scale map is one that shows a small area (1:500, or 1” = 40’, for instance).

- View on the left, showing most of the city: No water pipes, storm drains, or sewer pipes are visible (scale = 1:20,000).
- View in the center, showing a neighborhood in the city: Pipes appear as blue, purple, and green lines (scale = 1:5,000).
- View on the right, showing just a few parcels: Symbols appear for hydrants, manholes, tanks, and valves. Aerial photo background appears (scale = 1:1,500).



Features can change their appearance as the scale changes, as shown in the following illustration.

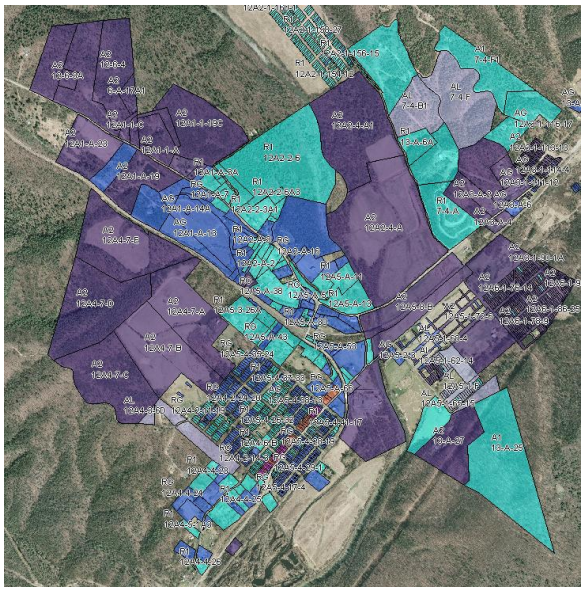
- View on the left, showing the entire country: No roads are visible (scale = 1:10,000,000).
- View in the center, showing a district: Roads appear as red lines (scale = 1:1,000,000).
- View on the right, showing a city: Roads appear as thick yellow lines with red edges (scale = 1:100,000).

Information on digital maps can also be quickly changed to display the features based on the specific requirements. The map in the following illustration has the point symbol size based on the population of the city.

## About Symbology

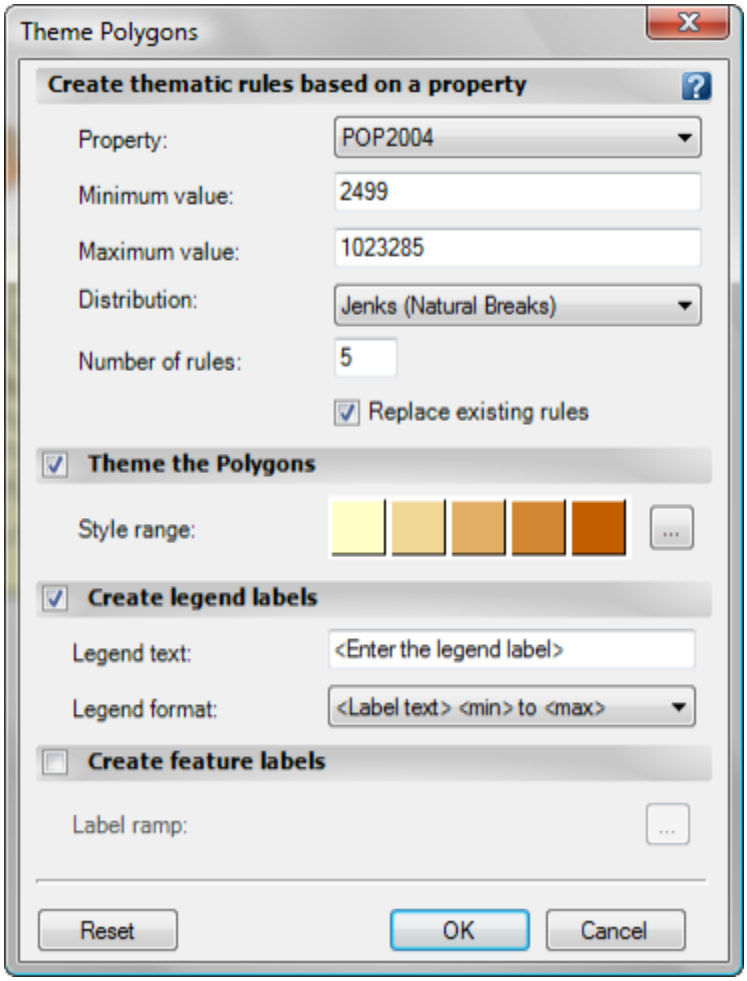
Symbology refers to the practice of using symbols for points, lines, and polygons to make the features easy to recognize, or to convey information based on the symbol itself. In Map 3D, symbology is referred to as style, and a style controls the display of features on a map. When point, line, and polygon features are added to a map, they appear with default symbols, line types, and fill styles.

A thematic map represents features according to values of a particular property, which can be either alphanumeric or numeric. A theme displays data in varying styles to indicate different values such as a zoning map shown below, which symbolized the polygons based on the alphanumeric property of a zoning code.

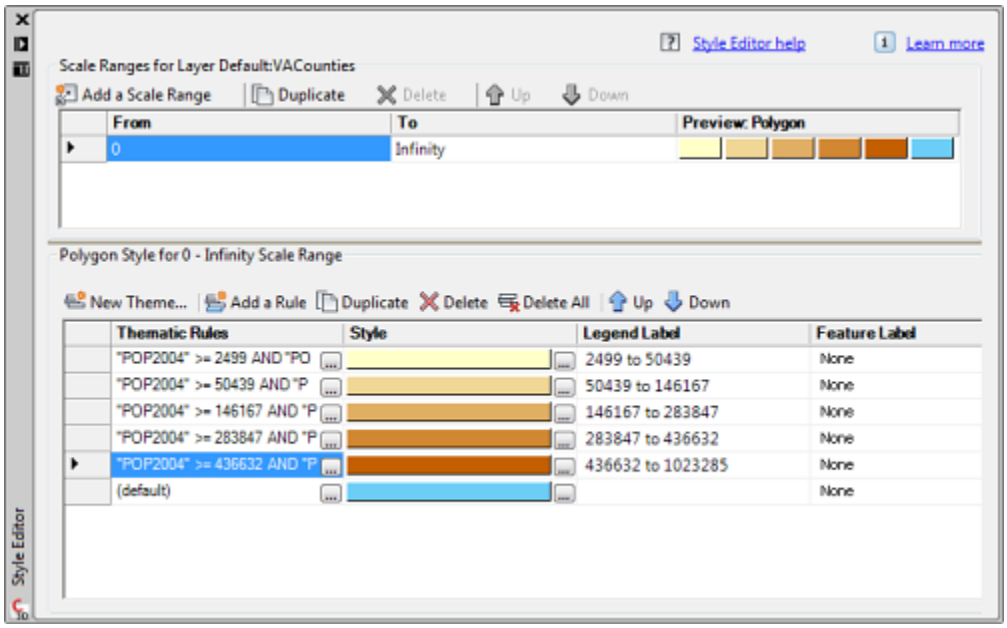


## Classification

It is often desirable to display features based on numeric data in the GIS database. Each feature may have a different numeric value, and to represent the theme, the values need to be classified, or assigned to a range (bin). There are several different methods of classifying numeric data, otherwise known as assigning the data to a distribution. Map 3D can use the Quantile, Standard Deviation, Equal Number, or Jenks methods of distributing data into ranges. The number of ranges can also be specified. Often a color ramp is used to indicate the progressive change from one range to the next, which enables the map reader to see spatial relationships easily.




The Style Editor is accessed by double-clicking the Feature Layer in the Task Pane, or by right-clicking the layer and selecting Edit Style.

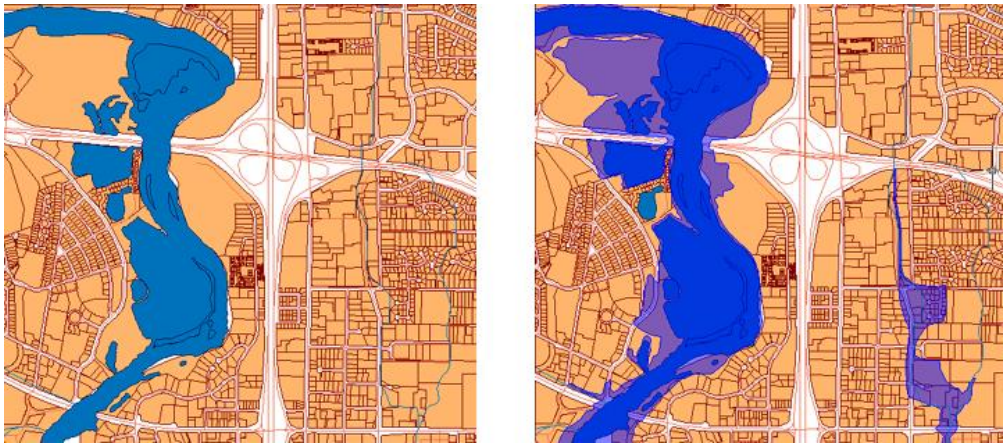



## Transparency

Using aerial photographs or satellite photographs as a background is a good way to provide a context for the map. For example, if the map is to show the installation area for new services such as pipes or cables, an aerial photograph clarifies building locations and potential obstacles, such as trees. If a parcel layer is added on top of the aerial photograph, more information about the existing conditions becomes visible. It is especially useful to be able to make the parcels layer partially transparent, in order to view both the parcel boundaries and the aerial photograph background, as in the following illustration.

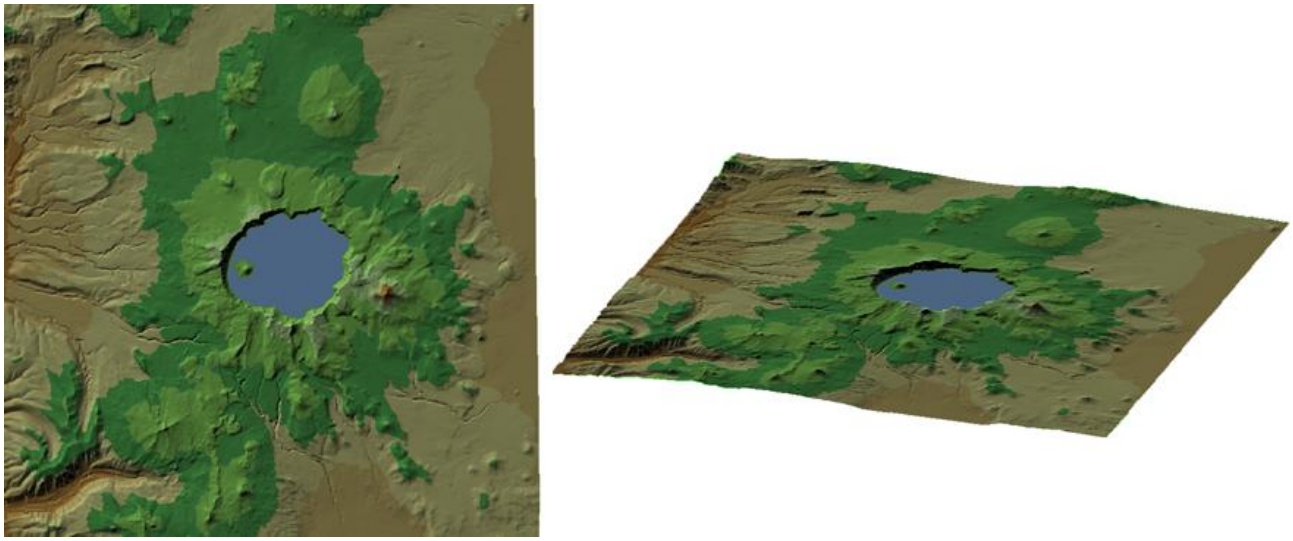
Another useful application of transparency is to create an overlay of one feature layer on top of another, for example, to show the parcels that fall within a flood zone. In the following illustration , the river is shown without its flood zone on the left and with the flood zone on

the right. The layer showing the extent of the flooded area has been made partially transparent to show which parcels are affected.

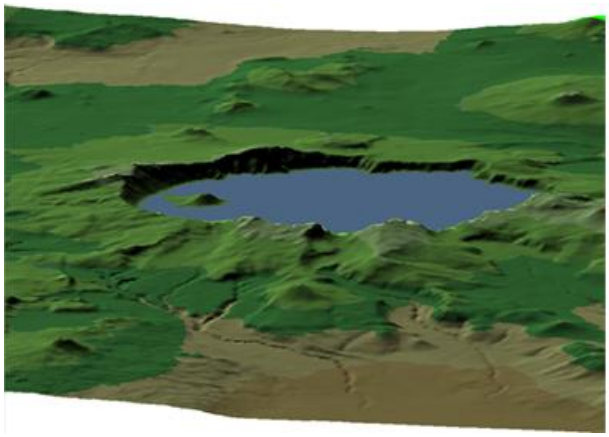


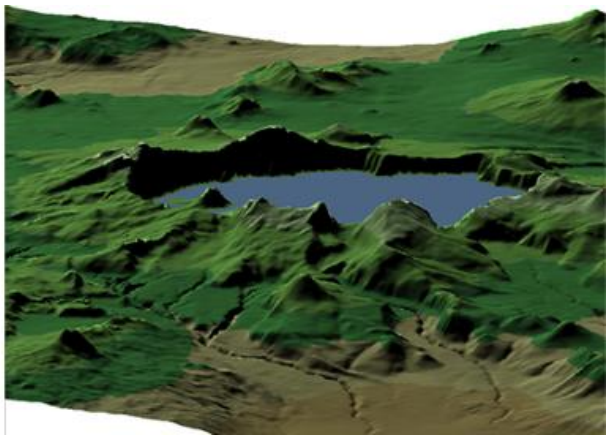
## 3D Visualization

3D surfaces can also be used to display topographical information on a map. 3D models can illustrate aspects of a site or landscape that can't be visualized from an ordinary map. This is especially useful for the site analysis phases of engineering projects. The following illustration displays a model of Crater Lake, in the state of Oregon, USA.



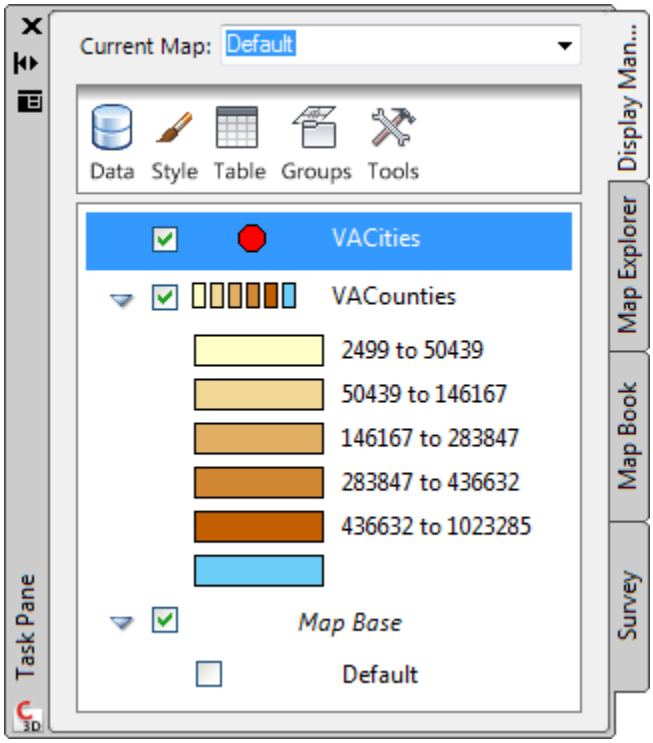
It can be useful to enhance the view of a surface by exaggerating the vertical dimension, especially for terrain that is mostly flat, or which varies only slightly in elevation. The following illustration shows a view of Crater Lake with the normal horizontal-vertical ratio of 1:1 on the left. The view on the right exaggerates the vertical dimension to 2; that is, a vertical distance is equal to twice the horizontal distance. This exaggeration emphasizes the differences between elevation values and gives a more dramatic visual effect.





## Managing Layers

The Display Manager lists the feature layers from top to bottom. Layers can be dragged above other layers to modify the draw order.




The following illustration shows a map with an incorrect draw order (on the left). The center view shows the result of moving the flood zone layer on top of the river layer. The view on the right shows the final map with the parcels layer also moved to a higher position in the draw order.

Folders are another means to manage feature layers. Related layers can be stored in the same folder. Because folders have their own visibility control, all the layers in a folder can be turned on and off at the same time.

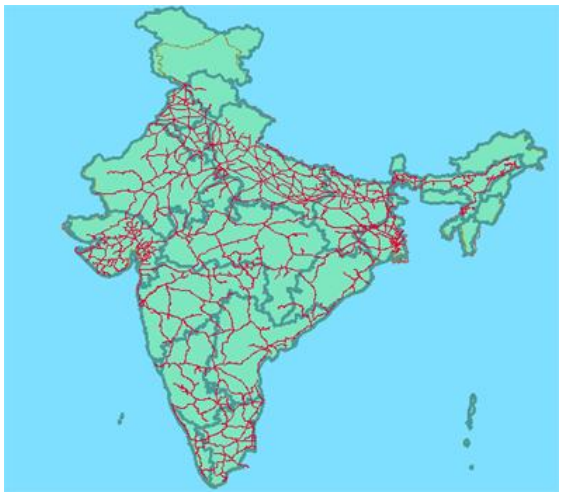
## GIS Data Layers versus AutoCAD Layers

The term “layers” in AutoCAD® Map 3D can be confusing. GIS data layers (feature layers) are shown and can be manipulated in the Display Manager Task Pane. The terms “AutoCAD layers” or “drawing layers” refer to the classic layers of DWG objects (lines, polylines, arcs, blocks, text, Etc.), which appear in the Layer Properties Manager dialog box. The GIS data layers do not have any connection to the AutoCAD layers. However, a feature layer can be created from an AutoCAD layer and can be displayed in the Display Manager. Layers that you create from DWG objects participate in the draw order in the same way that layers made from features do.

There are several good reasons to create feature layers from DWG layers. You can:

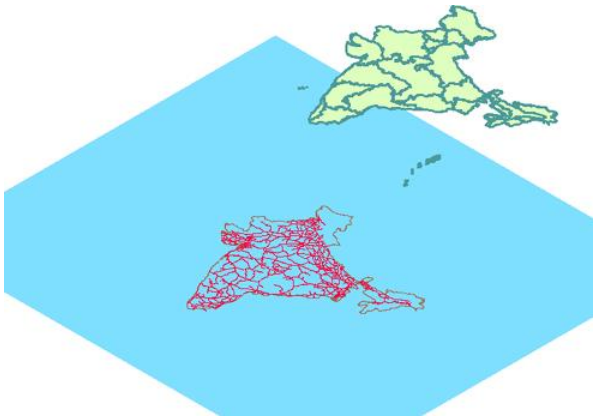
- Control all layers in the map directly from the Display Manager.
- Style the DWG objects using the Display Manager.
- Set scale ranges for the DWG objects so that they are visible only when you zoom in.
- Create themes from the DWG objects.

The map in the following illustration is composed of layers made from features and from AutoCAD layers.

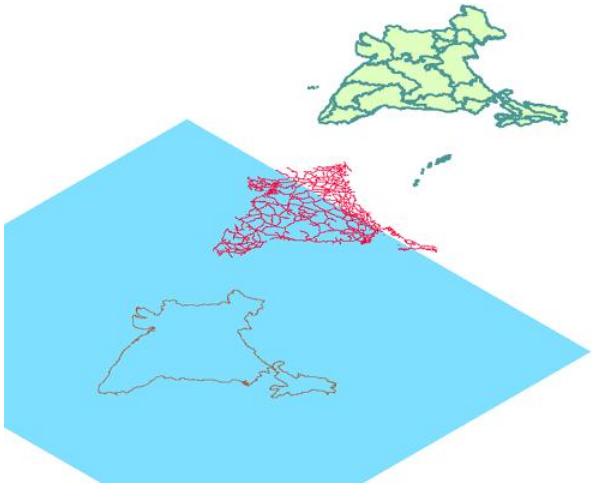


At the bottom of the Display Manager is a default layer named “Map Base.” The purpose of this layer is to serve as a container for all the visible AutoCAD layers. Therefore, if it is turned off, none of the AutoCAD layers are displayed. This does not affect the AutoCAD layers in any way; that is, it does not freeze the layers. It simply means that they are not displayed in the map. However, if a feature layer is created from one of the AutoCAD layers, the feature layer is displayed in the Display Manager and is no longer included in the Map Base layer.

In the following illustration, the Map Base layer displays three AutoCAD layers: the blue rectangle, the coastline (brown polyline), and the railway network (red polylines). The green state boundaries are in a feature layer.



If a feature layer is created for the railway network, the structure of the map looks like this:



The railway lines have been placed on their own layer and are no longer under the control of the Map Base layer. The visibility and styling of these polylines can now be handled separately in the Display Manager

## Labels

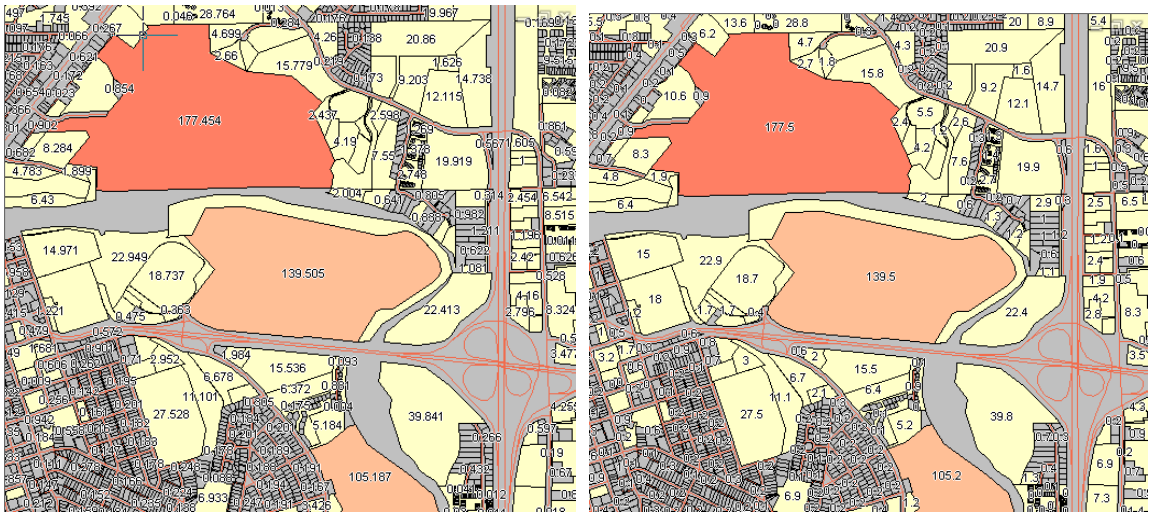
Labels are the textual annotations that show information relating to the map features, such as the parcel numbers or the street names on a city map. All feature classes, such as parcels or roads, have a data table that contains attributes, stored as columns in the table. Typical properties are the ID and the number in the case of parcels, or size and material in the case of water pipes. Many other attributes can also appear in the label. Generating labels for features is simply a matter of selecting which attributes to use as annotation.


AutoCAD Map 3D centers the label on the feature. It uses a method called *dynamic labeling*, which means that the placement of the labels is optimized so that labels on the same layer do not overlay one another. One major issue is deciding the proper size of the labels relative to the features. In general, there are two ways to manage this. The first is to create a series of scale ranges with larger labels for closer zoom levels (larger scales). The second is to have the

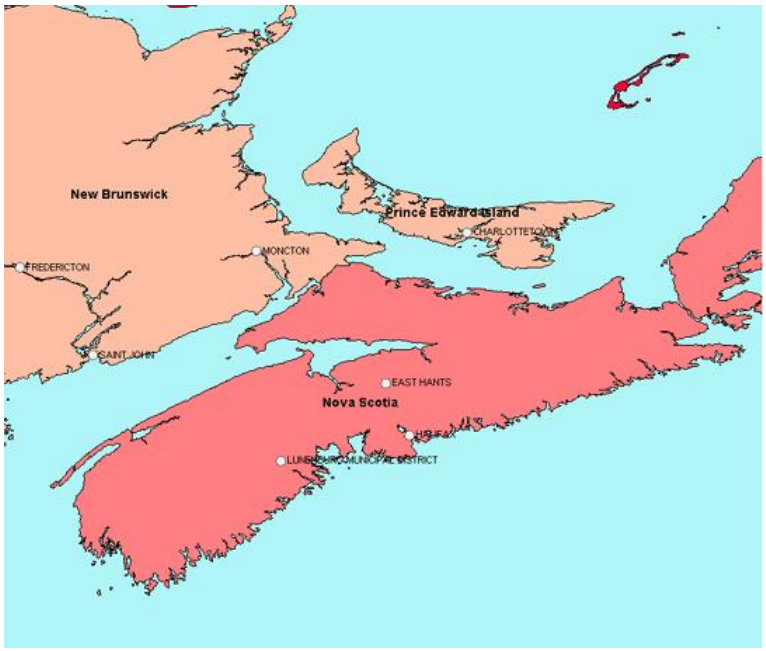
labels change size automatically as the zoom level changes. The first method takes a little time and experimentation to set up, but offers greater control over the size and placement of the labels. The second method can be convenient because it takes almost no time to set up and gives good results.

By default, AutoCAD Map 3D labels features with the attribute selected without changing the values. For example, if the value for the AREA attribute is set to 0, the label shows 0 for AREA. This may mean that the value is not known or has not been specified. This type of nonsensical value can be filtered out and prevented from appearing on the map by using an *expression*.

One example of the use of an expression to change the appearance of labels is shown in the following illustration. The labels on the left image show the area of the parcels to an accuracy of three decimal places. It is good to have this kind of accuracy in the data. However, it is not necessary to display all three decimal places on the map because it will look cluttered. An expression has been used to edit the labels to one decimal place for the image on the right.

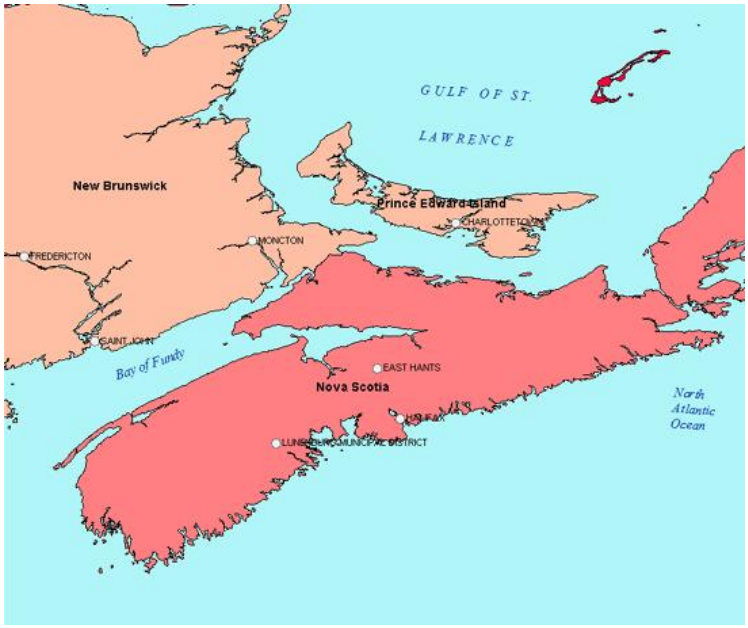



Controlling the precise placement and appearance of a label can be difficult. The labels that are generated automatically for features on the map may not always appear exactly where desired. For example, in the following illustration, the labels for the provinces and cities are placed dynamically and will shift position as you zoom in and out. This is the desired outcome for maps that will be viewed on the Internet, with different zoom scales. However, for plotted or printed map sheets, more control over the position of the labels is required.




Standard AutoCAD Mtext can be used to place text anywhere on the map, but this text cannot be saved to the database with the rest of the feature data. For both precise control over the text and the ability to store the text in a database, add a special kind of layer called an *annotation layer*.

This type of layer is displayed in the following illustration. The blue text showing the main bodies of water has been added on its own annotation layer. The text is stored in the database, in this case an SDF file, but it retains the styling applied to the individual text strings.



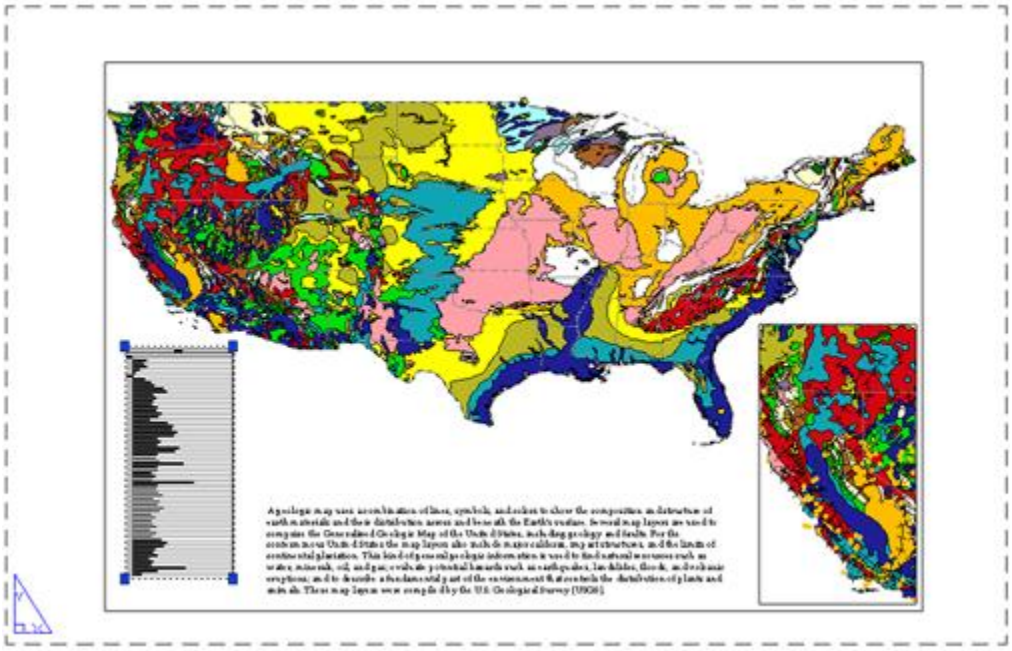
## About Legends

When creating engineering or planning drawings, plans are typically produced in a standard format with a title bar and various other layout elements. When creating a map, a *legend* is a required element. The legend is the key that explains the symbols, theme ranges, linework, and other conventions of the map.

The following illustration shows two legends that contain themes. The map on the left shows land values for the parcels in a city. The map on the right shows elevation values for a surface.


In AutoCAD Map 3D, the legend is a direct reflection of what is visible in the Display Manager. When creating the legend, the default is a table that includes all the layers in the Display Manager that are currently on. In order to show the ranges for a theme, ensure that the layer with the theme is expanded so that the ranges are visible.

The legend is always placed in the model view. In order to include the legend in a layout view for plotting or publishing, create a viewport for the legend and place it at the appropriate location in the layout, as shown.



## Key Terms

| | |
|---|---|
| Cartography | The art and science of mapmaking. |
| Scale | The ratio of distance on a map to distance on the ground. |
| Symbology | Symbology refers to the practice of using symbols for points, lines, and polygons to make the features more recognizable, or to convey information based on the symbol itself. |
| Thematic Map | A thematic map represents features according to values of a particular property, alphanumeric or numeric. A theme displays data in varying styles to indicate different values. |
| Classification | Numeric property data (attributes) are frequently classified into ranges (bins) in order to display the ranges by color. There are several methods for classifying the numeric data. |
| Color Ramp | A sequence of colors showing a progression of numeric ranges of values. |
| AutoCAD Layers | The classic layers of DWG objects that appear in the Layer Properties Manager dialog box. |
| GIS Data Layers | GIS data layers (feature layers) are shown and can be manipulated in the Display Manager Task Pane. |
| Map Base Layer | The purpose of the Map Base Layer is to serve as a container for all the visible AutoCAD layers. |
| Annotation Layer | A layer specifically for annotation that is stored in the GIS database. |

## Exercise 1: Create a Population Map

In this exercise, students create a map of population for the counties in Virginia.

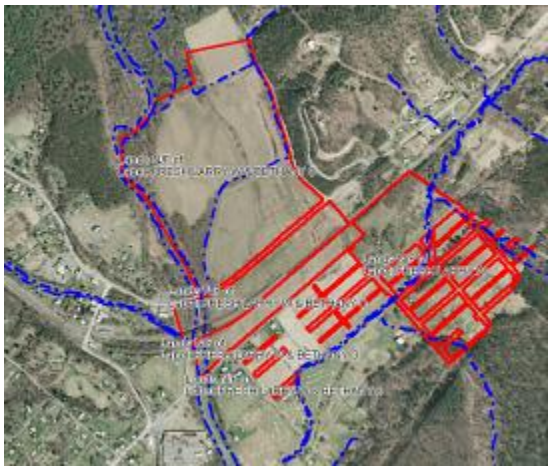
At the end of this exercise, the drawing displays as shown.

For this exercise, open …*I_Cartography-EX1.dwg (M_Cartography-EX1.dwg).*

## Exercise 2: Create a Site Map

In this exercise, students create a site map to identify the proposed project area using aerial images, parcel, and hydrographic data.

At the end of this exercise, the drawing displays as shown.

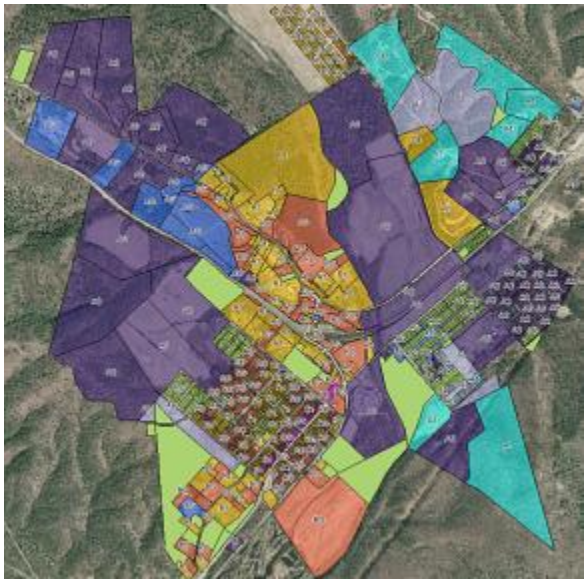


For this exercise, open …*I_Cartography-EX2.dwg (M_Cartography-EX2.dwg).*

## Exercise 3: Create a Zoning Map

In this exercise, students create a zoning map to identify the existing property zoning conditions surrounding the project area.

At the end of this exercise, the drawing displays as shown.

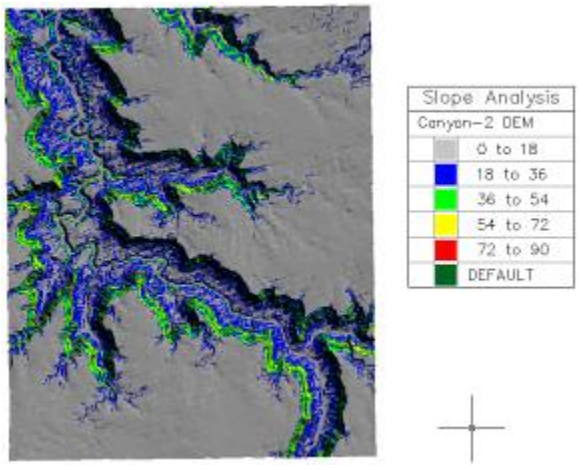


For this exercise, open *…\I_Cartography-EX3.dwg (M_Cartography_EX3.dwg).*

## Exercise 4: Create a Slope Analysis Map

In this exercise, students use the Data Connect feature to connect to Raster DEM Data to show slope data.

At the end of this exercise, the drawing displays as shown.




For this exercise, open *…\I_Cartography-EX4.dwg (M_ Cartography-EX4.dwg).*

If students have changed to the Tool-based Geospatial workspace and opened the Task Pane, skip to step 3.

# Assessment

## Challenge Exercise

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

## Questions

1. What is a theme?
2. What data is used to stylize (symbolize) features?
3. What is the function of scale ranges?
4. Why would you use AutoCAD text instead of feature labels?
5. What is the purpose of a legend?

## Answers

1. A theme is a special style used to vary the stylization based on some property of the objects. For example, instead of just coloring the lakes blue, you could vary the shade of blue based on the depth of the lake. Instead of just altering the line width of the roads, you could vary the line width based on traffic flow.
2. Any attribute data can be used to stylize a feature, or to set up a particular "theme."
3. Scale ranges enable features to appear and disappear as you zoom in and out. Details that would clutter the map when it is zoomed out to its full extent can be hidden and displayed only when the map is zoomed in.
4. AutoCAD text enables more control on the exact placement and appearance of the text.
5. A legend is the key that explains the symbols, theme ranges, symbology, and other conventions of the map.

# Lesson Summary

In this lesson, students learned how to create maps by displaying the data using different styles and themes, as well as by creating labels to annotate the map. Students learned about styles, labels, legends, expressions, and classification of numeric data. Using the Style Editor and Display Manager, students created typical maps that are commonly required in engineering projects.

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