



# MAPPING FUNDAMENTALS

## Members Guide: Book One, Version 2.0



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# GIS BASICS

## WORKING WITH ARCEXPLORER 9



PENNSTATE



Cooperative Extension  
Geospatial Technology Program

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## 2004 GIS MANUAL DESIGN / CURRICULUM DEVELOPMENT TEAM

### **Project Director**

Rick Day

### **Design & Development:**

Leah Wasser, Rick Day, Chihiro Mather

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# ABOUT

**GIS**  
SYSTEMS  
INFORMATION  
GEOGRAPHIC



# ABOUT GIS

## AN INTRODUCTION TO GIS

GIS stands for Geographic Information System. GIS allows you to combine and organize many layers of spatial information in a digital format — such as roads, streams and buildings (also known as GIS THEMES). These theme layers can be combined to create MAPS that illustrate information about a place. We can use these maps to gain a better understanding of a place. In addition to simply seeing what is there, these themes or layers can be used to ANALYZE where you live, which can help us make informed decisions about particular things. For instance, we can use GIS to find the best place to build a new house. Or we can use GIS to locate the best soils in an area for farming. In this chapter, we will look at why GIS is important and how it affects you in your everyday life!

## HOW IS GIS USEFUL?

Whether you realize it or not, GIS is used every day for many different things — things that even affect you! In the next few pages, we will take a look at what GIS is and why it is such a powerful tool!

**THE RED ARROW IN EACH PICTURE ON THIS PAGE REPRESENTS THE SAME VIEW.**

Looking at the city of Philadelphia from the steps of the Art



Looking at the city of Philadelphia from an airplane (PLAN)

### 1. GIS allows you to organize many layers of information

Maps contain different types of information. For instance, some maps show streams, roads, buildings and/or schools. Other maps show topographic data that indicate the ELEVATION CHANGE in an area.

GIS allows you to pick and choose what data you want to look at and what data you want to combine. For instance, imagine a map that shows streets, buildings, trees and parks. In a GIS, you can look at each individual layer by itself. You can turn on trees and turn off buildings. Or you can turn on buildings and turn off trees and streams. You can also organize these layers so that you can look at several layers at the same time. For example, if you want to see which parks are close to the river, you can look at those two layers together.

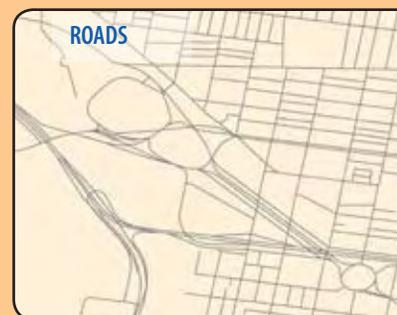
### 2. GIS allows you to create MAPS

Perhaps the most obvious use of GIS is to create CUSTOM, UNIQUE MAPS. The layers that we just discussed can be combined, in the order of your choosing, to create unique maps that focus on specific things. Not only does GIS allow you to organize specific data layers together, but also it allows you to change the colors and symbols used to represent those layers. To provide more clarity to your map, you can add labels, scale bars, legends and other objects. You can create extraordinary maps of any place for which you have digital data!

Different kinds of maps might show wetlands in an area, population distribution, or potential locations for a new school in your area!



## GIS CAN BE USED TO CREATE AND ANALYZE INFORMATION ABOUT AN AREA



GIS data can be used to make a map showing roads for part of Philadelphia.

OR



GIS can also be used to create a map of buildings and parks for an area.

## Map Of The National Mall, Washington, D.C.

### 3. GIS is a powerful ANALYSIS tool

One of the most powerful functions of GIS is its ability to store extra information about each layer in addition to simply showing the location, shape and size of elements. For instance, a ROADS layer can store the individual road names, road widths, and the number of people who drive on that road daily.

In turn, this extra data can be used for different kinds of ANALYSIS. For instance, imagine that you have a GIS theme that shows the location of all of the trees in your neighborhood. You could use that information to count, how many trees there were within 5 miles of your house!

Now let's imagine that you have that same TREE theme showing the location of all of the trees in your neighborhood. Also, imagine that this TREE theme has extra information about each of these trees — for instance, the tree species and height. Let's pretend now that you only want to know how many Red Oak trees are within 3 miles of your house. Using this GIS data, and the search function within the GIS software (also known as a QUERY), you could find out where all of the Red Oak trees are within three miles of your house!



### LOOK AT ALL OF THE TREES IN THIS MAP OF THE NATIONAL MALL IN WASHINGTON, D.C.!

The information on the map above (saved in a GIS) allows workers in Washington, D.C. to keep tabs on where trees are already planted in the area, and what species of tree they are. As they plant new trees or as trees die, workers can easily and quickly update the GIS database.

#### Map Legend

- Trees
- ★ Metro Stops
- Landmark Points
- ▬ Roads
- ▭ Buildings
- Ortho Photograph

## WHO USES GIS? GIS IS ALL AROUND YOU

You may not realize it, but GIS is an important part of your every day life! Let's look at a few examples of how GIS can be used to do many different things.

### GIS and Your Local Power Company

The companies that provide your home and your school with power often use GIS databases to tell them where power lines are in relationship to your house. When you call the power company to tell them that a power line is down by your house, the power company can use GIS to find your house and to figure out how to get there to fix the problem.

### The Police and 911

Did you know that when someone calls 911, the 911 operator on the phone finds your exact location using a GIS database? The 911 system, fire companies, and even the police all use GIS to help them with their jobs every day.

### How the Police Use GIS

If you've ever seen the television show "Cops," then you know that most police vehicles are equipped with computerized Global Positioning System (GPS) systems. These GPS systems use GIS mapping data to create base maps that track the exact location of the police car in an area at any given time.



GIS is all around you! Every day, it is used by many different people and companies for many different purposes.

## GIS Is Used to Manage Forests



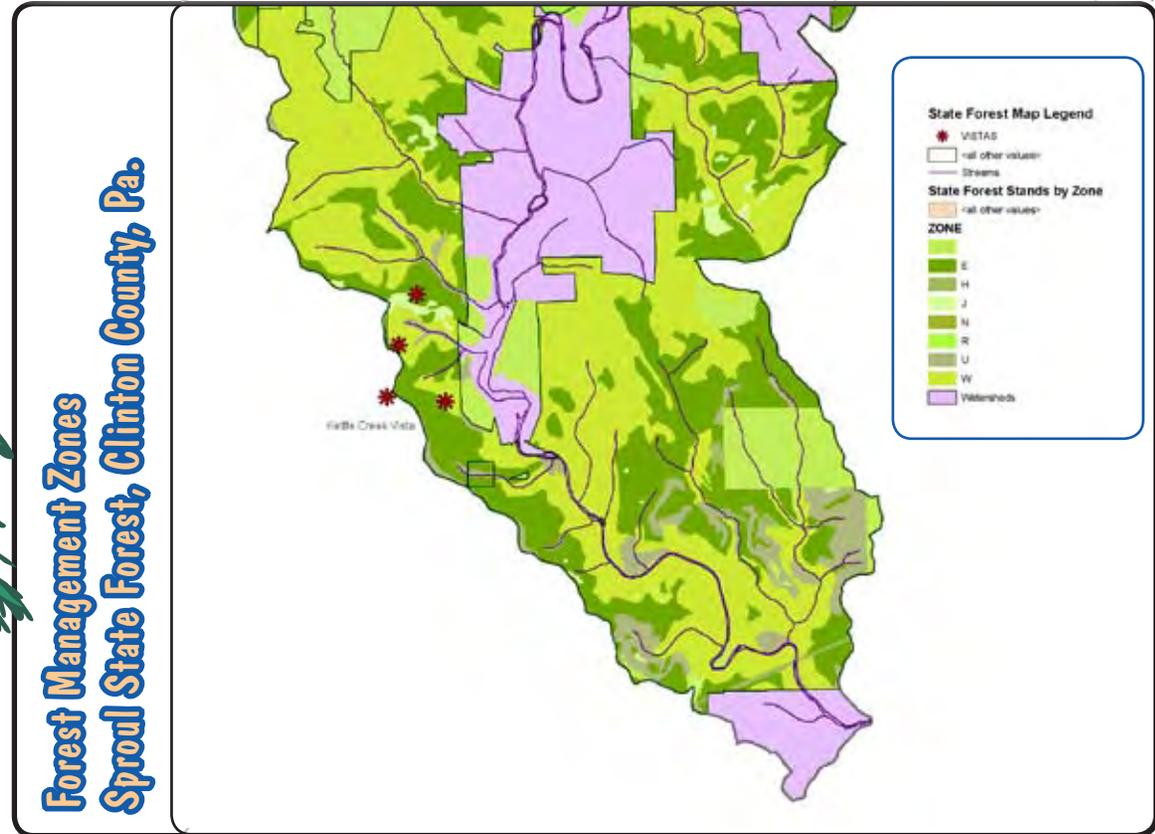
How can GIS be used to manage forests? Foresters can use GIS to find the best soils for a specific tree species that they want to grow, to analyze the types of vegetation growing in a particular forest and to keep track of areas that have been cut, burned, or otherwise managed at some point. Foresters also use GIS to look at property values and to anticipate the types of development that might occur next to the forest.

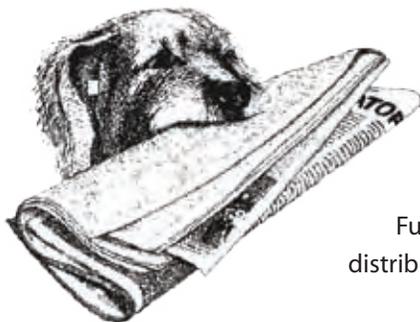


Each colored area on the map below represents a different forest stand area. Forest STANDS are categorized according to the types of tree species that grow in each area. This information helps the forester make decisions about the management and care



### Forest Management Zones Spruce Knob State Forest, Clinton County, Pa.





### The Local Newspaper

How could a local newspaper possibly use GIS in their everyday operations?

The newspaper keeps track of subscriptions in their delivery area in a GIS database, as shown in the example below. Furthermore, marketing staff who work for the newspaper, can use GIS to IDENTIFY the locations that have the highest distribution of newspapers and in turn focus on increased marketing in the other areas to gain more subscriptions.

### Newspaper Subscription Areas - Somewhere in America

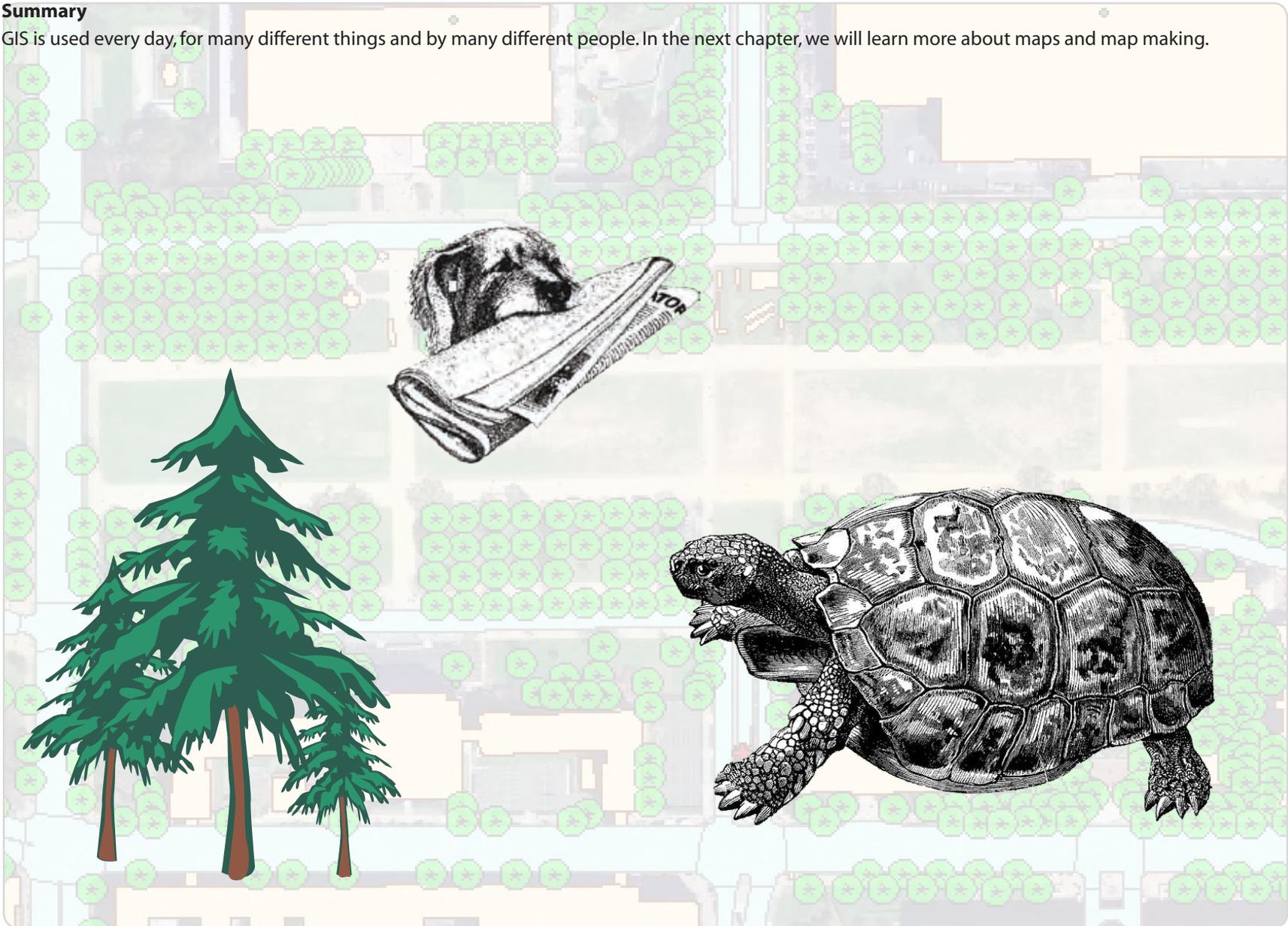


**Subscription Area Legend**  
Newspaper Subscription Area  
Subscription Type

- Full Subscription
- No Subscription
- Sunday Only
- Weekend Only

## Summary

GIS is used every day, for many different things and by many different people. In the next chapter, we will learn more about maps and map making.





ABOUT

MAPPING



# ABOUT MAPPING

## ACTIVITY 2A - WHAT IS A MAP?

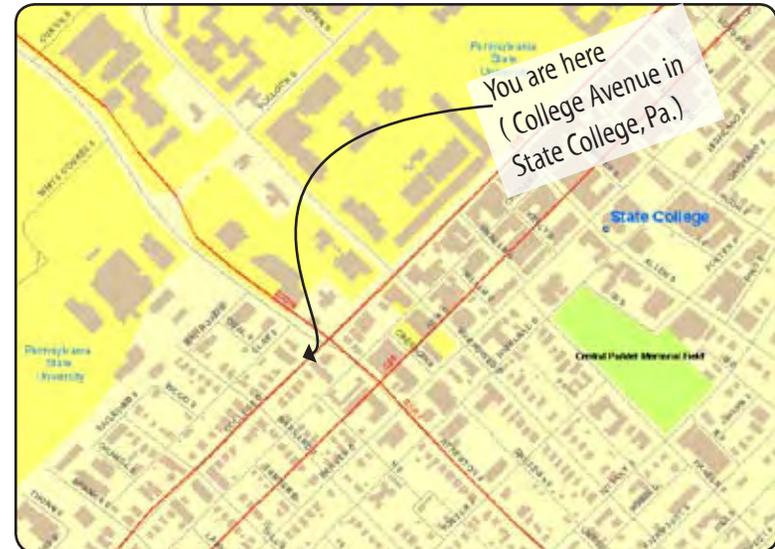
Before we discuss GIS and the computer in more detail, we must gain a good understanding of the development of maps. Break out into groups of 2 to 4 people. Use the images to the right as references. In your groups, discuss the questions on the following page. In a few minutes, we will discuss the answers to these questions. When you are answering the questions, think about which of the two maps located on the right hand side of this page, would be MORE USEFUL to give to a friend to provide directions to your house.

### What Is a Map? What Do We Use Maps For?

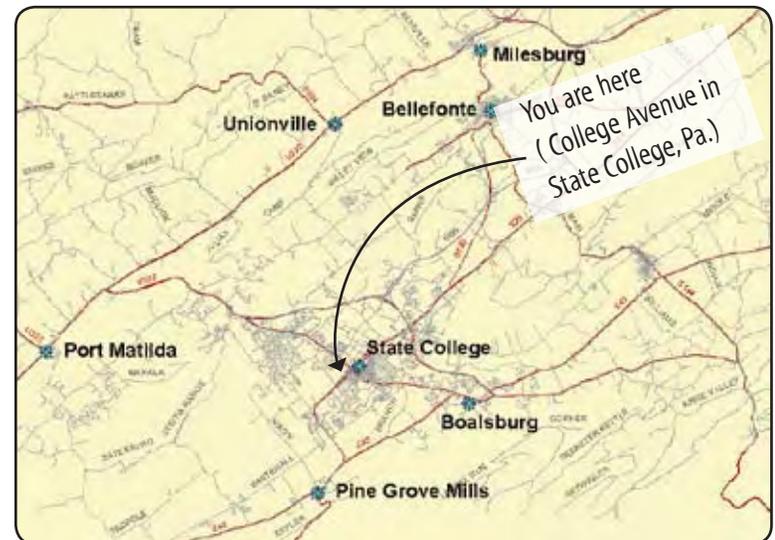
A map is a drawing (or a graphic representation) of an area. A map might include different types of information.

### How Much Information is Generally Included on Maps (Map Extent)?

As you probably noticed in the last activity, every map has a particular SCALE. One map might show more DETAIL - things such as road names and buildings. Another map could show more area and LESS DETAIL. We will be discussing map SCALE in greater detail in the advanced manual.



Maps can be created at different scales and with different information. The map above shows a neighborhood in State College, Pennsylvania. It includes buildings and roads.



This map is printed at a different SCALE than the map above. Notice how you can't see any buildings on this map — they would be too small to see at this scale.

**THINK!**

1. Which map shows a **GREATER AREA** (shows more land)?

- a.) Map #1 shows a greater area.
- b.) Map #2 shows a greater area.

Explain Your Answer: \_\_\_\_\_

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2. Which map does a better job of showing individual **ROADS**?

- a.) Map #1 shows individual roads better.
- b.) Map #2 shows individual roads better.
- c.) Both maps do a good job of showing individual roads.

Explain Your Answer: \_\_\_\_\_

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3. Which map does a better job of showing your location relative to other cities in the area?

- a.) Map #1 does a better job of showing my location relative to other cities.
- b.) Map #2 does a better job of showing my location relative to other cities.

Explain Your Answer: \_\_\_\_\_

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4. Which map would be more useful in finding a specific **BUILDING** on a particular street?

- a.) Map #1 is more useful for finding buildings.
- b.) Map #2 is more useful for finding buildings.

Explain Your Answer: \_\_\_\_\_

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## LARGE-SCALE VS... SMALL-SCALE MAPS

Maps can be created at different scales depending upon what area we want to look at, what kind of information we want to show, and how we want to use the map. For instance, if you wanted to make a map of the neighborhood where you live, you zoom in close to your neighborhood so that the roads and buildings are large enough to see and name. However, if you wanted to show someone where your town is located within your state, you zoom out to show the boundaries of your state RELATIVE to your neighborhood.

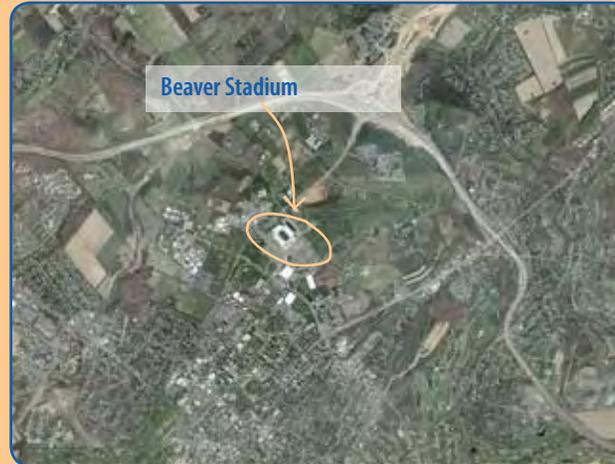
### About Scale

Simply defined, scale is the relationship between measuring distance on a map and the actual distance, in real life, on the ground. When you refer to map scale you can describe it as being either at a SMALL SCALE or a LARGE SCALE.

### Small Scale

A small-scale map is one in which you are FURTHER AWAY from objects on the ground. A smaller scale map shows MORE LAND AREA, but the objects are SMALLER. Picture yourself in an airplane, looking down at the Earth. As you take off or go up higher in the sky, objects on the ground will begin to appear smaller. You will also be able to see a larger area on the ground.

From the airplane, it seems that the interstate highway is only about one eighth of an inch wide. Of course, in reality, we know that the inter-

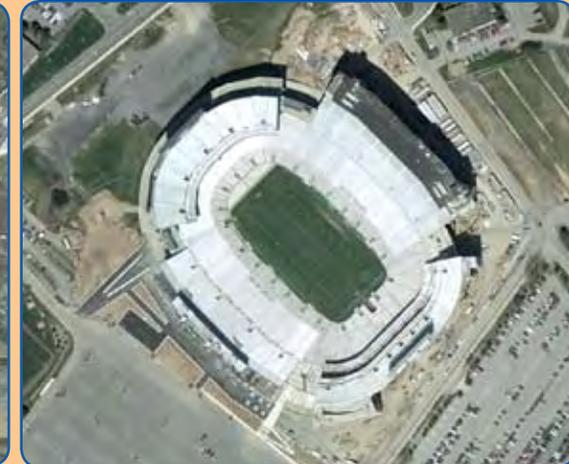


SMALL Scale Map — Beaver Stadium from far away!

state is really much wider than one eighth of an inch! It is probably more like one-hundred feet wide! From the airplane, you see things at a different scale than you would on the ground because you are FURTHER AWAY from them.

### An Even Smaller Scale!

Now, imagine that you are an astronaut on a space shuttle flying through space. You can see the entire Earth from space and everything on the Earth looks tiny. From the space shuttle, things appear even smaller than from the airplane. From the space shuttle, you are looking at the earth at an even SMALLER SCALE.

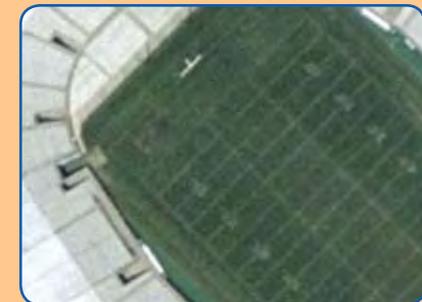


LARGE Scale Map — Beaver Stadium close up

### LARGE SCALE

A large scale map is one in which you are zoomed in CLOSE to your objects. It shows LESS LAND AREA, and the objects on it appear LARGER.

Let's go back to that airplane that we just discussed. Imagine that you are now landing. While you descend (move downwards towards the Earth), the things that you see on the ground will appear to be larger than they were when you were higher up. For instance, that Highway that appears to be  $1/8''$  from 30,000 up in the sky, might now appear to be  $1/2''$ .



Even LARGER scale - the football field at Beaver Stadium

## ACTIVITY 2B: SCALE

Draw a map at different scales. In the spaces below draw two pictures (maps). In the first box, draw a picture of your house as it might appear looking down from an airplane in the sky. In the other box, draw a picture of your house, but this time imagine that you are sitting in a tree, just a little bit above your house. When you are done, you will break up into groups and discuss the differences between the two drawings.



Drawing from an airplane high the sky.

A large, empty, rounded rectangular box with a thin brown border, intended for drawing a house as seen from a high altitude.

Drawing from a tree just a few feet above your house.

A large, empty, rounded rectangular box with a thin brown border, intended for drawing a house as seen from a low altitude, just above the roof.

### ACTIVITY 2b: Map Scale

**Objective:** To visualize map scale

**Life Skill:** Visualizing information, Processing information

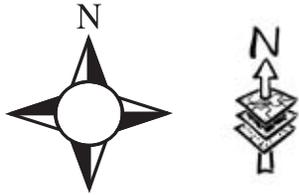
### Estimated Time

15 Minutes

### Materials Needed

Pen / Pencil

## A QUICK EXERCISE: DIRECTION AND THE NORTH ARROW



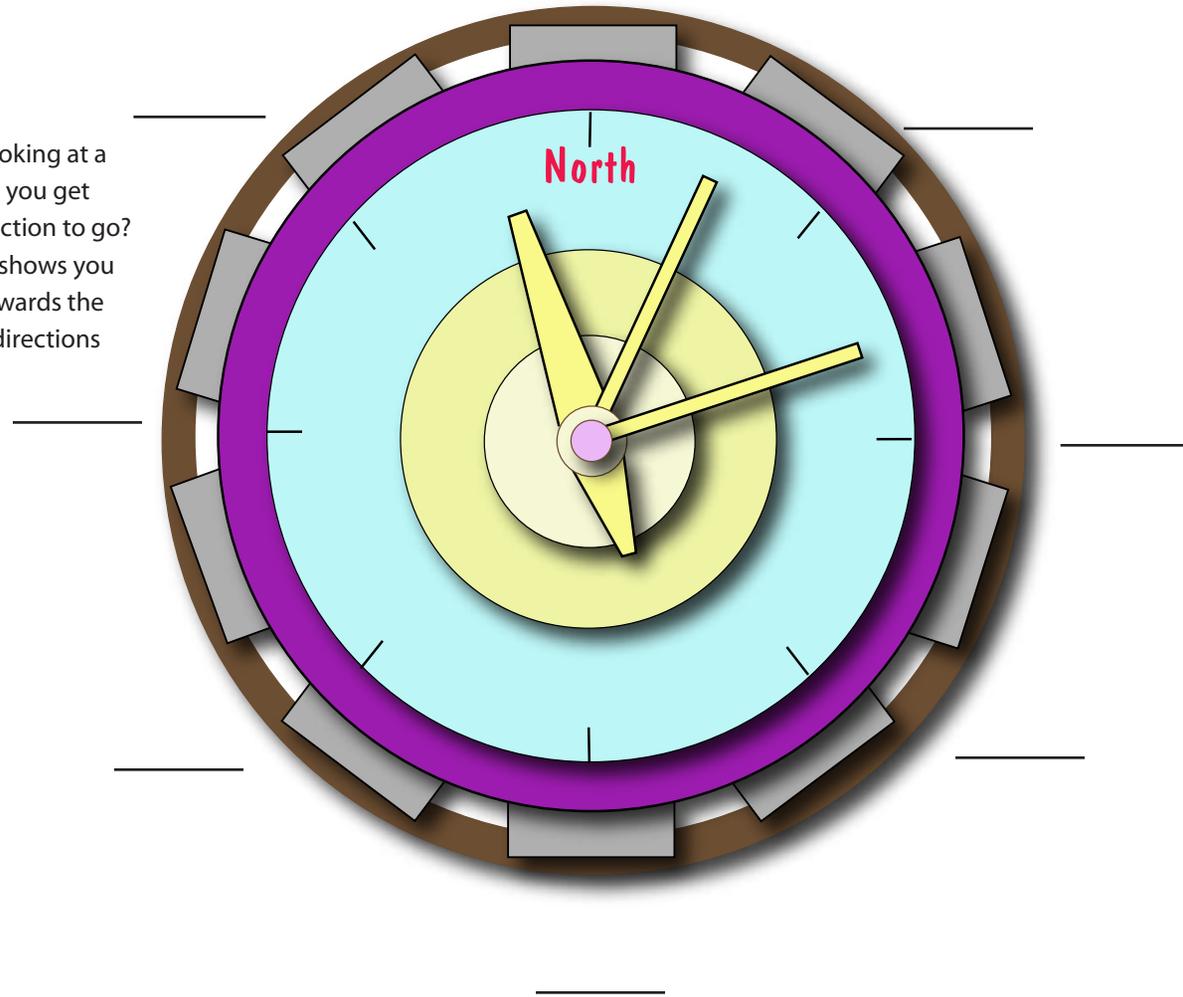
### Where is North?

How do you know what direction is 'up' or north when you are looking at a map? The most common use for maps is for directions — to help you get from one place to another. However, how do you know what direction to go? A good map always contains a NORTH ARROW. The north arrow shows you where north is on the map. On most maps, north is facing 'up' (towards the top of the page); however, sometimes north is oriented in other directions on the page.



### Fill in the missing directions on the compass below.

North has already been filled in for you. Missing is East, West, South, North East, South East, North West, South West.



## ACTIVITY 2C-1: CREATE YOUR OWN MAP - MAPPING WHERE YOU LIVE

In the space below, draw a map of your home and neighborhood. On your map, be sure to include ROADS and BUILDINGS and then anything else that you think is important. There is NO RIGHT OR WRONG WAY to draw this map; simply do the best that you can! You might want to think about what information you are going to include on your map before you start. At the end of this activity, you will share your map with your group, so try to make it neat!



### ACTIVITY 2b: Map Scale

**Objectives:** To visualize your neighborhood and then draw a map of it

**Life Skill:** Visualizing information, Processing information

#### Estimated Time

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45 Minutes

#### Materials Needed

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Pen / Pencil



## ACTIVITY 2C-2: COMPARING MAPS

Great work! Now that you have completed your map, we can move on. Trade maps with someone near you. In this activity, we are going to compare the different maps that everyone drew. Remember, like before, there is no “wrong” way to draw a map! We are going to compare the following things: Map Scale, Map Layers, and Map Perspective.

### Activity 2b - 1: Map Scale

While reading the following questions, think about the scale of the map that you are looking at. Think about how much area the map will show, how big the map is, how the map is drawn, and the scale of the map.

#### Map Scale Question 1

Can you accurately measure the distance or size of anything on the map and then relate to its REAL LIFE size on the ground (Is there a scale defined on the map)?

- a) Yes, I can figure out the real size of things on the map
- b) No

#### Map Scale Question 2

What is the map scale of the map? (Hint: if you do not see one, you can write that)

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### Map Perspective

What seems to be the most important element on the map (or does anything stand out as being more important?) Where is north on the map?

#### Map Perspective Question 1

Is there a north arrow anywhere on the map?

- a) Yes, there is a north arrow on the map.
- b) No, there is no north arrow on the map.

#### Map Perspective Question 2

In the space below, describe the things that you notice first about the map.

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### Map Layers

In the following pages, we will discuss map LAYERS, a very important part of GIS. Without knowing what layers are, answer the following questions below:

*In the space below, write down the GEOGRAPHIC elements (such as roads and buildings) that you see on the map:*

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_

### ALL MAPS ARE UNIQUE!

Notice that all of the maps drawn in Activity 2a are different in some way. They might be maps of different places, or the drawing style might be different. Can you think of a way that this may present a problem? For instance, if you give your friends directions to your house, could you use your map to direct them? Are there things that you could add to your map in order to make it BETTER in terms of providing directions?

When you choose a map to give your friends to help them find your house, could your friend figure out how far your house is from theirs by measuring distances on the map?

Variation of map scale, map content, and even the colors used to create the map can present a problem if it is not clearly explained. Let's look at some historical maps to see why.

**Map One**

What Area Is the Map Of: \_\_\_\_\_

\_\_\_\_\_

What Information Does the Map Show: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

How do you think this map is used? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Map Two**

What Area Is the Map Of: \_\_\_\_\_

\_\_\_\_\_

What Information Does the Map Show: \_\_\_\_\_

\_\_\_\_\_

**ACTIVITY 2D: MAPS AT HOME**

Go home tonight and find two to three maps in your house. On a piece of paper, write down:

1. The location of the map (what area does it show?)
2. The SCALE of the map (if you can find it — you can trace it if you want to)
3. Information shown on the map (does it show roads, streams, buildings, or other elements?)

If you can, bring the maps to the next 4-h meeting. Answer the questions about each map on this page. We will break out into groups and discuss the different maps that everyone brought in!

\_\_\_\_\_

\_\_\_\_\_

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\_\_\_\_\_

\_\_\_\_\_

How do you think this map is used? \_\_\_\_\_

\_\_\_\_\_

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**Map Three**

**What Area Is the Map Of:**

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**What Information Does the Map Show (describe the map):** \_\_\_\_\_

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**How do you think this map is used?** \_\_\_\_\_

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## Map: Geology in Pennsylvania

All of the maps on this page are of GEOLOGY. But notice how even maps that show the same information can look very different!

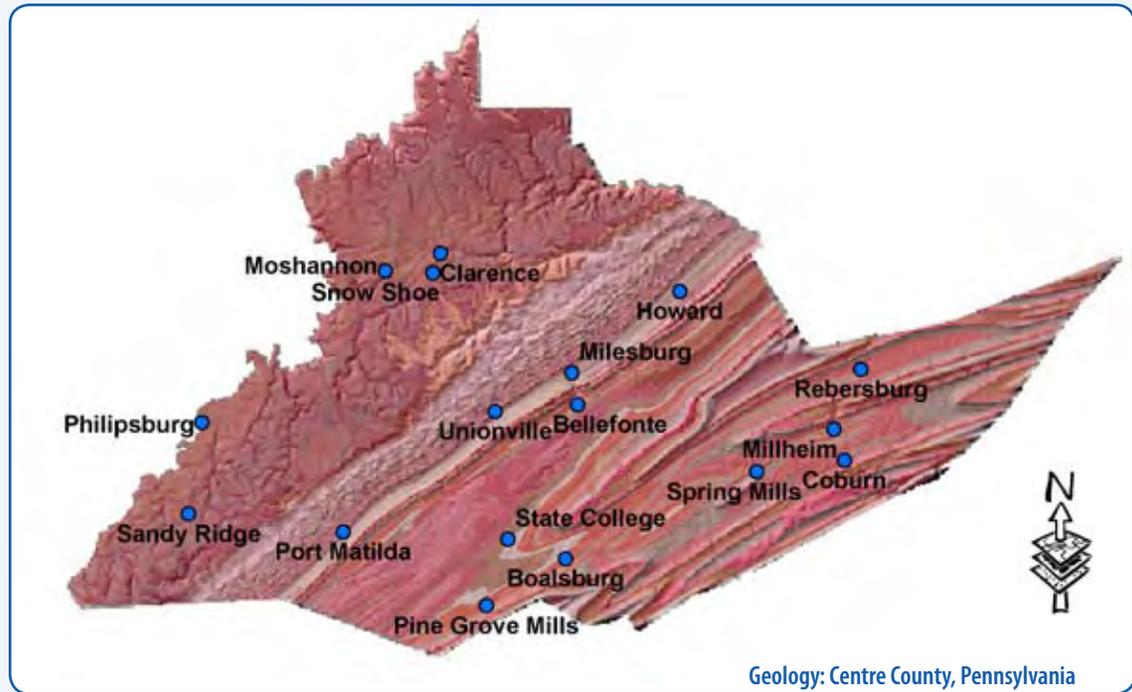
They can be different colors, show different areas, or have different data on them. The maps below all contain the SAME INFORMATION — they show geology. However, the maps are of different locations. The larger map shows Centre County, Pennsylvania. The smaller maps to the left show other areas in Pennsylvania.



Geology: This map shows the same geologic information as the map of Centre County. However, the scale and location are different. This is an area within North Western Pennsylvania.



This map shows the same geologic information as the map of Centre County. However the scale and location are different. This is an area in Port Matilda, Pennsylvania.



Geology: Centre County, Pennsylvania



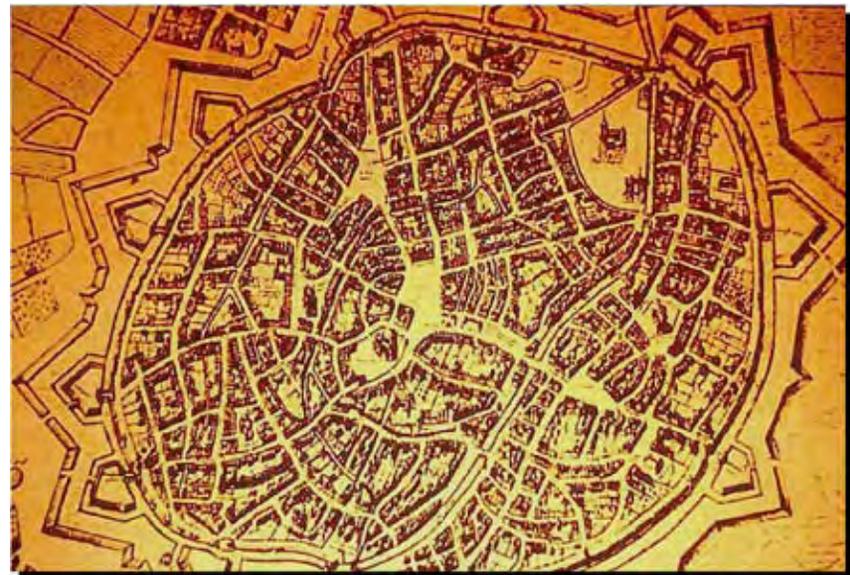
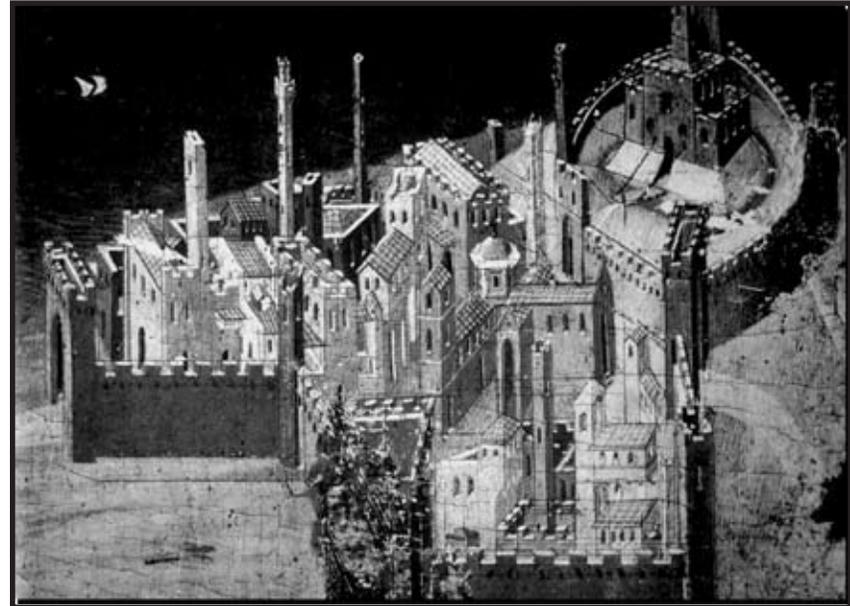
## MAPPING THROUGH HISTORY

What do you think early maps looked like? Early maps were often an interpretation of how a place LOOKED. They were not accurate, to-scale drawings that could be used to measure distances between places, or used for detailed directions. Early maps were also all very different. While some were more accurate (figure 2.1), others were more abstract (figure 2.2).

**Let's discuss early maps in more detail. Look at the images to the right. How wide do you think that town is?**

If your answer to the question posed above is "I don't know," then you are exactly right! Early maps lacked true SCALE. That means the elements drawn on the map were not in PROPORTION to the elements found in the landscape. Therefore, there was no real way of measuring how big things actually were, or how far apart they were.

Take another look at the images to the right. How tall are the buildings? How far apart are the buildings? Can you measure anything on the map and relate that to its size in an actual BUILT LANDSCAPE?





## HISTORIC MAPS, MAP EXTENT AND PERSPECTIVE

Maps have changed dramatically through time. In early times, when horses were the main transportation option, people did not have the ability to travel as far. For instance, a trip that takes you four hours in a car today took a few days or perhaps a week in the early days.

Because of this, the MAP EXTENT (how large an area the map shows) was much smaller. You do not need to see a map of the next state over if you can not travel there! As transportation networks developed and evolved, there was a slowly realized need for maps that showed a greater area. There was also a need for maps that were more accurate.

### Problems with Early Maps (that computers can solve)

We can learn a tremendous amount from studying maps — especially early hand-drawn ones. When we take a closer look and try to use early maps, we see that they present many problems. A few of these problems are listed below and the list continues on page 2-14.

#### 1.) You Can't Measure Things Accurately (Lack of True Scale)

Hand-drawn maps, particularly early ones, lack an accurate and uniform scale system. This means that when you look at these maps, you are never sure how big things were in real life, or how far apart they were in the landscape.

### TRIP TO THE LIBRARY! (ACTIVITY 2E)

Find a friend or family member and go to your local library. You are going to find two historic (older) maps. Your librarian can help you find the maps.

Once you have found the maps, record each map using one of the following methods:

1. If you have a digital camera, your librarian can help you take a PICTURE of the map.
2. If the library has a SCANNER, you can SCAN the map.
3. Or, you might be able to make a COPY of the map using a copy machine.

If you are unable to record the map using any of the above suggestions, simply write down as much information about the map as possible. Include in your description what the map shows, the date of the map, the location of the map, the scale, and any other information that you think is important.

In our next meeting, we will break out into groups and discuss everyone's maps.

# PLANIMETRIC VS. PERSPECTIVE DRAWINGS

Just like there are different types of maps, there are there different ways to draw the things that we see around us. Let's look at two different drawing types: planimetric and perspective.

## PLANIMETRIC

A planimetric drawing is one that is drawn at a SPECIFIC SCALE. This means that each element on the drawing is drawn IN PROPORTION to that same element in the landscape. For instance, we might set a scale of 1" = 200'. This means that 1" on the map is equal to 200' on the ground. We will be discussing scale in greater detail in the advanced section of this manual. Architects, engineers, and ;landscape architects often use planimetric drawings as a design tool to represent their building or landscape design.

## PLANIMETRIC — TOP VIEW

There are different types of planimetric VIEWS. The TOP VIEW (also called the plan view) is the most common view used in map making. A TOP VIEW is the view that you would see if you were in an airplane looking directly down at the place you are mapping.

## PLANIMETRIC — SIDE VIEW

On the other hand, a SIDE VIEW is the view that you would see if you are looking, from the side, at a building or a landscape.

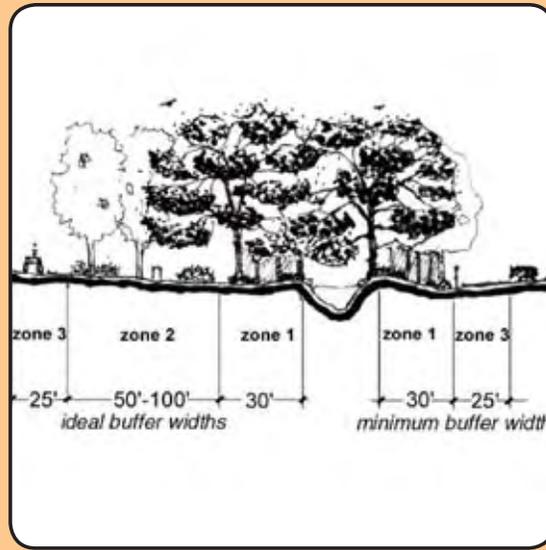
## PERSPECTIVE

Another type of drawing is the perspective. While the planimetric drawing is drawn in proportion to the object, the perspective is

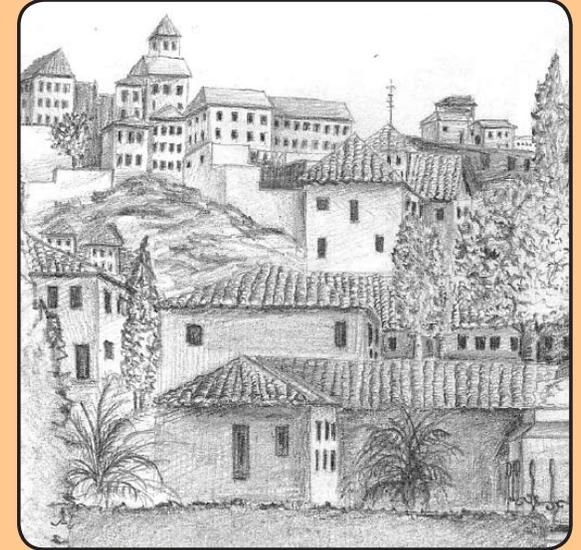
drawn according to the object's DISTANCE from the viewer (that's you). Therefore, a perspective drawing appears to be closer to what you would ACTUALLY SEE when you are walking around. Objects close by are drawn larger than objects in the distance because that is how they appear to your eye.



Planimetric: Top View (PLAN)



Planimetric: Side View (SECTION)



Perspective

## 2.) You Cannot Easily

### Change the Scale of a Paper Map.

If a map is hand-drawn and to scale, it is difficult to quickly change the scale of the map. In the early days, you would have to completely redraw the map in order to change the scale. Today, you can use a copy machine to reproduce a drawing at a different scale using the 'enlarge' or 'reduce' functions. However, you risk losing accuracy and quality when you do so.

## 3.) Everything Is Different!

### Nothing Is Standard.

As we saw in Activity 2a, hand-drawn maps are always unique. There will always be different drawing styles and maps will always be drawn with different types of pens, markers, pencils, colors, and so on). These different styles can make comparing maps a challenge. Furthermore, a hand-drawn map is more likely to have mistakes!

## 4.) How Can You Make Copies?

### (Challenges with Map Reproduction and Distribution)

The earliest maps were etched onto stone walls before we had paper and pencil. Can you imagine sharing a map that is etched in stone on a wall? In later years, with the development of paper and then the printing press, we were able to create, share and reproduce maps. However, these maps could still not be easily and quickly copied, changed, or shared. Also, if the maps could be reproduced on a printing press, the reproductions lost quality or accuracy during production.

## 5.) If You Lose the Original, the Map Is Gone Forever

### (Problems With Backing Up the Map)

What happens when you lose your original, hand-drawn map that you spent hours creating? Well, maybe you have made a back-up copy of that map. However, the original is gone forever. You can easily share a digital, computer-made map. You can back it up and make as many copies as you wish without losing any quality or accuracy.

## MOVING TOWARD STANDARDIZATION IN MAP MAKING

We have discussed many potential problems with paper maps.

Computerized mapping and drafting programs were developed to solve many of these problems. The computer allows you to quickly and easily share and backup data. You can also, at the touch of a button, print or create accurate, to-scale copies of your maps.



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