



***High Resolution  
Digital Shoreline***

*Creating Georeferenced T-Sheets  
for Shoreline Vectorization:*

*A Georeferencing Manual*

*Prepared by the  
NOAA Coastal Services Center*



# *Table of Contents*

Chapter 1: Overview.....	3
Chapter 2: Before Beginning.....	6
Chapter 3: Getting Started.....	8
Chapter 4: Adding Data and Using the Viewing Windows.....	13
Chapter 5: Adding Reference Points.....	18
Chapter 6: Error Checking.....	38
Chapter 7: Transforming the Image.....	46
Chapter 8: Tips and Tricks.....	60
Chapter 9: Technical Glossary.....	65

## *Chapter 1. Overview*

### *1A. Georeferencing Glossary*

Goal: To provide definitions for frequently used terms

### *1B. What is Georeferencing?*

Goal: To explain the process of georeferencing

## 1A. Georeferencing Glossary

You will be encountering terminology throughout this manual that you may not be familiar with. Here is a basic list of definitions to provide some background on the georeferencing process. Take a moment to familiarize yourself with them. A more complete listing, including definitions for other technical terms, can be found at the end of the manual.

- **Map:** An abstract representation of features on the surface of the Earth
- **Projection:** A mathematical model to convert the three-dimensional surface of the earth to a two-dimensional map
- **Datum:** A set of values to define the three-dimensional shape of the earth
- **Coordinate System:** A system used to locate positions and measure distances on a map
- **Scale:** A statement of a measure on the map and its equivalent measure on the surface of the earth. For example 1:20,000 means *one unit* of distance on the map equals *20,000 units* of the same distance on the earth
- **Latitude-Longitude:** A spherical reference system used to measure locations on the Earth's surface. Latitude measures locations running north and south, and Longitude measures locations running east and west
- **Degrees, Minutes, and Seconds:** Often used as units of measure for latitude and longitude. Each degree consists of sixty minutes, and each minute consists of sixty seconds
- **Georeferencing:** To establish the relationship between page coordinates on a planar map and known real-world coordinates
- **Source Coordinates:** The coordinates that will be changed into another format. In the examples in this manual, the source coordinates are referred to as *Image Coordinates* since their source is a scanned image
- **Destination Coordinates:** The values the source coordinates are changed into. In the examples in this manual, the destination coordinates are referred to as *Map Coordinates* since they will be converted to the latitude and longitude values of a map
- **Reference Points:** A set of points used to perform the georeferencing coordinate conversion. Also known as control points
- **Polynomial Transformations:** The process by which mathematical equations use the reference points to georeference data. In the examples in this manual, polynomial transformations are referred to as *Polynomial models* to prevent confusion with Geographic Transformer's process for creating a new image

## **1B. What is Georeferencing?**

This manual provides instruction on how to take a scanned image of a **topographic survey sheet** (t-sheet) and give it a sense of where it exists relative to the surface of the earth. This will be done using a software package called the **Geographic Transformer™** from **Blue Marble Geographics** company.

When image files are digitally scanned they are made up of a series of small squares. Arranged like a checkerboard, each square (referred to on the computer screen as a “pixel”) has a location assigned to it during the scanning process. These **image coordinates** are usually in the form of an (x,y) ordered pair. However these images are maps, so each image coordinate actually represents a location on the earth. These locations, referred to here as **map coordinates**, can be represented by many formats but this project will use **latitude** and **longitude** values. The process of taking the image coordinates (x,y pairs) and assigning them map coordinates (latitude/longitude) is called **georeferencing**.

Georeferencing involves a series of steps.

- First, select a series of image coordinates and assign them their corresponding map coordinates. These selected points are called **reference points**. The software will then use a mathematical model to convert all of the image coordinates to map coordinates based on the reference points. This process is an attempt to create the best fit possible, but invariably error is introduced.
- Next, the reference points are edited to ensure the error values fall into acceptable ranges. The ranges are dependent on the scale of the original image you are working with.
- Once the error is within a certain tolerance, the image can be **transformed**. The transformation process creates a new image in a specified destination coordinate system from the geographically referenced source image.

The rest of the manual will explain these steps in greater detail. However, each map is different, so some of the intermediate steps along the way may need to be altered. As you become more familiar with the georeferencing process and the Geographic Transformer software, these alterations will become easier. Nonetheless, the overall process will remain the same.

## *Chapter 2. Before Beginning*

### *2. Important Issues*

Goal: To explain grouping file types and naming conventions

## **2. Important Issues**

Before opening Geographic Transformer and beginning the georeferencing process, some issues need to be addressed.

### **I. File Location:**

The georeferencing process will use and create several files.

- **\*.tif** files: Image files
- **\*.rsf** files: Reference setting files
- **\*.txt** files: A list of reference points, map coordinates, and associated error values for each
- **\*.tsf** files: Transformation setting files
- **\*.log** files: Log files
- **\*.RSF, \*.TAB, \*.TFW** files: Reference type files

**Note: Make sure all of these files are contained within the same directory containing the original image file.**

When the time comes to work with these files, be sure to double check their location. Geographic Transformer will display the location of the last directory used for a particular event. For example, if you saved the reference setting file for t-sheet t9876 in its directory, and then went on to work on t-sheet t3456, when you save t3456's reference settings file, the default location would be given as t9876. Because you do not want to put any files for t3456 in the t9876 directory, you will need to change the location before you perform the save.

### **II. Naming Conventions:**

The original images you will be working with will most likely have a "t" or "tp" prefix along with a series of numbers. Any of the files listed above should also contain the same characters so they can be easily associated with a particular t-sheet. If it is beneficial to add information to these existing formats, just make sure you retain the original t-sheet designation. (e.g., if you save two reference setting files, you may choose to name one **tp1234\_1.rsf** and the other **tp1234\_2.rsf**)

In addition, the final transformed image should contain a "g" at the end to signify that it has been georeferenced (e.g., **tp1234g.tif**).

END

## *Chapter 3. Getting Started*

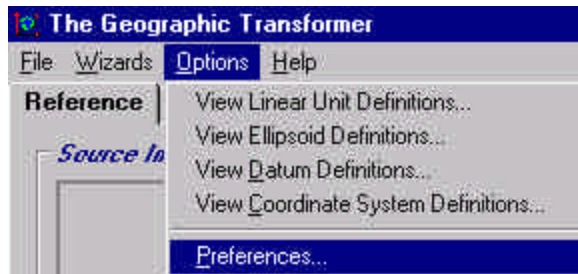
### *3. Opening and Setting Up Geographic Transformer*

Goal: To prepare Geographic Transformer for use





When you are finished examining the GUI, locate the **Options** choice from the **menu bar**. Click on **Options** and from the drop-down list, select **Preferences**. These options should be automatically retained each time you use the software, but it is a good idea to check them each time you open Geographic Transformer.



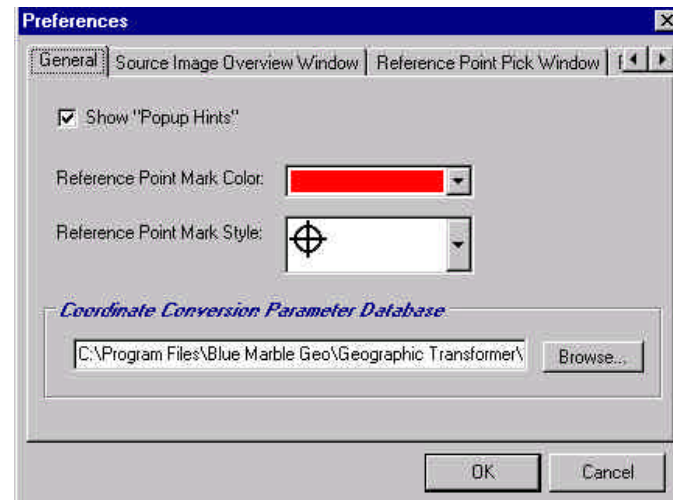
Clicking on **Preferences** will open a window allowing you to set a variety of options for your operations. If it is not already active, click on the tab labeled **General**. (You may need to use the arrow keys on the right to scroll back and forth.)

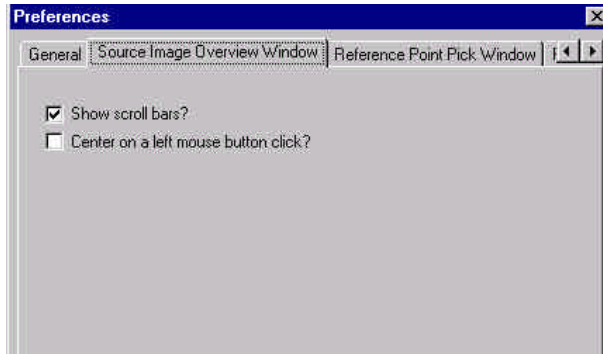
Leave the box labeled **Show Popup Hints** checked on.

You may set the color and marker styles to your individual preferences by clicking on the down arrows for each box and choosing from the resulting lists. You can come back and change these at any point during the exercises if you wish.

**Caution: Do not change the path giving the location of the Coordinate Conversion Parameter Database.**

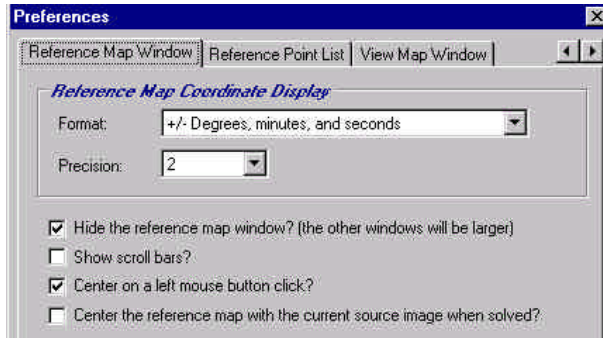
When your **General** settings are done, click on the tab to the right labeled **Source Image Overview Window**.



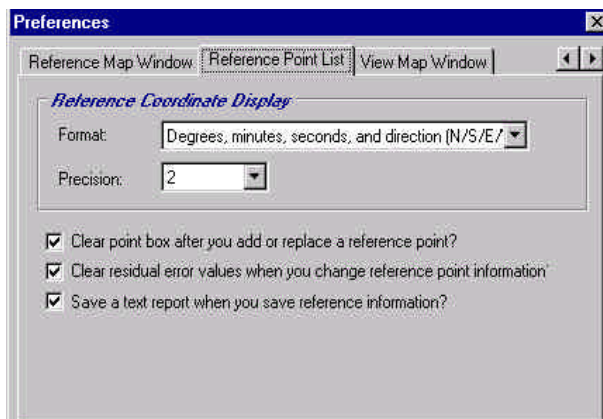


From the **Source Image Overview Window**, place a check in the box labeled **Show scroll bars**. Remove the check from the box labeled **Center on a left mouse button click**.

Click on the tab to the right marked **Reference Point Pick Window** and make these settings the same as the ones above.



Use the right arrow button to scroll the tabs to reveal several more. Click on the tab labeled **Reference Map Window**. From here, make sure there is a check in the box marked **Hide the reference map window**. This option will not be used, and hiding it will provide more room on the GUI. After this option is set click on the tab labeled **Reference Point List**.

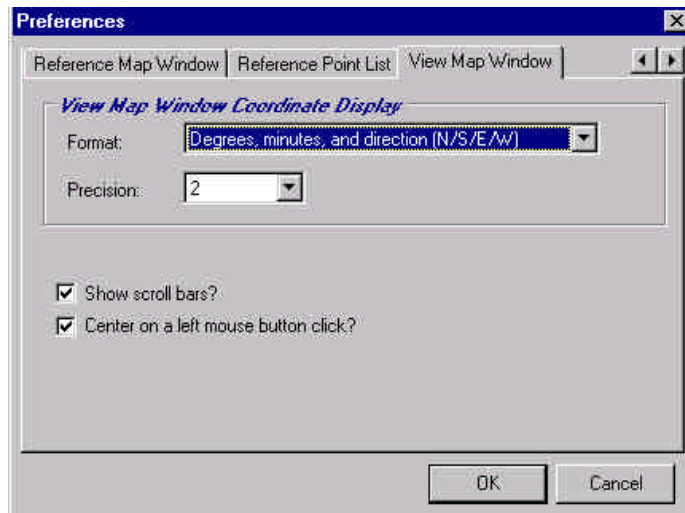


In the **Reference Point List** menu, click on the down arrow for the **Format** box. From the resulting list, highlight the following option:

**Degrees, minutes, seconds, and direction (N/S/E/W)**

This is the format used to enter map coordinates.

Leave the **Precision** set to **2**, and make sure all three remaining boxes are checked on.



For the final setting, select the tab labeled **View Map Window**.

Set the **Format** to

**Degrees, minutes, seconds, and direction (N/S/E/W)**

Leave the **Precision** equal to **2** and place check marks in the remaining two boxes.

After all the settings have been established, click on the **OK** button to apply you options.

END

## ***Chapter 4. Adding Data and Using the Viewing Windows***

### ***4A. Adding Source Data***

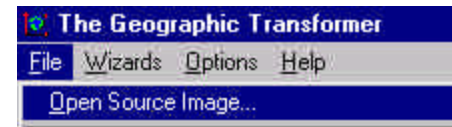
Goal: To add \*.tif image files

### ***4B. Using the Viewing Windows***

Goal: To become familiar with the View environment

## 4A. Adding Data Sources

To add the image to be georeferenced, click on the **File** option from the **Menu Bar**. From the drop-down list, select **Open Source Image**.



This will open a window labeled **Select a Source Image**. Navigate to a directory containing an unreferenced t-sheet and add it to the Geographic Transformer GUI. (There is no way to close an image when you are finished georeferencing it. Simply add another image, or exit the program.)

The selected image will automatically be displayed in the **Source Image Overview Window**. At the same time, the **Reference Point Pick Window** will show a zoomed-in region of the same image.

## 4B. Using the Viewing Windows

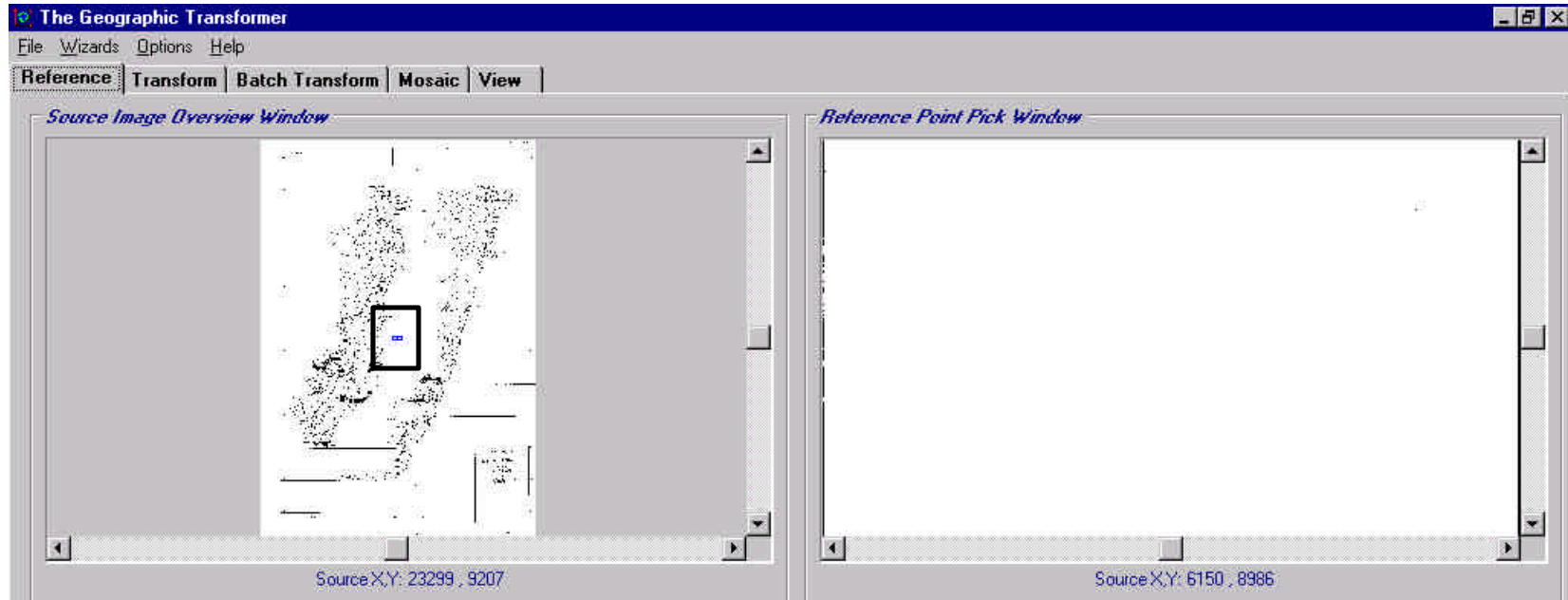
The **Source Image Overview Window** provides an overview of the entire t-sheet. During the course of selecting reference points, you will need to move to different areas to pick points. This window will provide a shaded blue box to indicate where you are.

**Caution: Do not zoom into any areas of the Source Image Overview Window. It is difficult to reset it to its original orientation.**

The **Reference Point Pick Window** is the window where you will do all of the zooming and selecting. The area seen in this window is represented by the blue box in the **Source Image Overview Window**.

Sometimes using the vertical and horizontal scroll bars located on the bottom and right sides of these windows can be tricky. They tend to be slow, so be patient. Additionally, avoid trying to grab the slider and drag it along. Very often this will lock the view in the upper or right hand corners, making it difficult to see what is in your windows.

At this point the view should look similar to the following graphic:



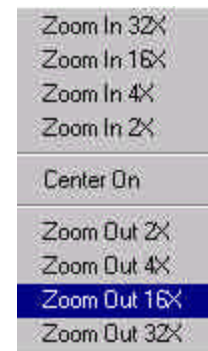
Notice the image coordinates are given underneath the windows. If you place your cursor in either window and move it around, these values will change.

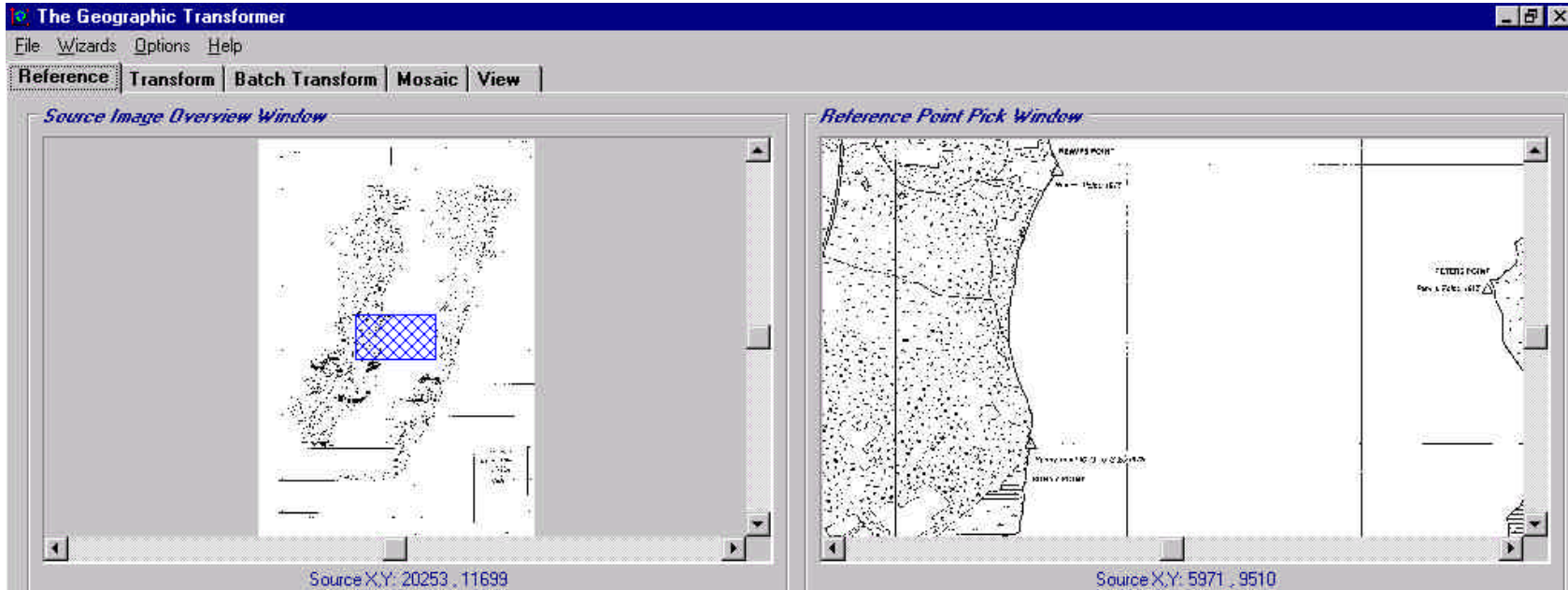
In addition, in the very center of the source image, you should be able to see a small blue box. (It is outlined in black in the graphic above to make it easier to see.) This corresponds to the area seen in the **Reference Point Pick Window** on the right. Here it looks blank because it is zoomed in quite far to a location that contains no shoreline.

To zoom out to get a better view, place your cursor in the **Reference Point Pick Window**. It should appear as a cross.

Click on your **right** mouse button. This will open a window with several zoom settings, shown to the right.

In this **Zoom Setting Window**, use the **left** mouse button to select the option **Zoom Out 16X**.





You should see that you have now zoomed out in the **Reference Point Pick Window**. The blue box is also more visible in the **Source Image Overview Window**.

You will find that when zooming in, your blue box becomes smaller, and when zooming out, it becomes larger.

**Note: Only zoom in and out from within the Reference Point Pick Window.**

To move the blue box around to see different areas of the image, you need to be in the **Source Image Overview Window**. Take the cursor and move it into the **Source Image Overview Window**. Position it somewhere in the **upper left** corner of the source image indicated by the black box in the graphic to the right.

Use the **left** mouse button to click when the cursor is in position.





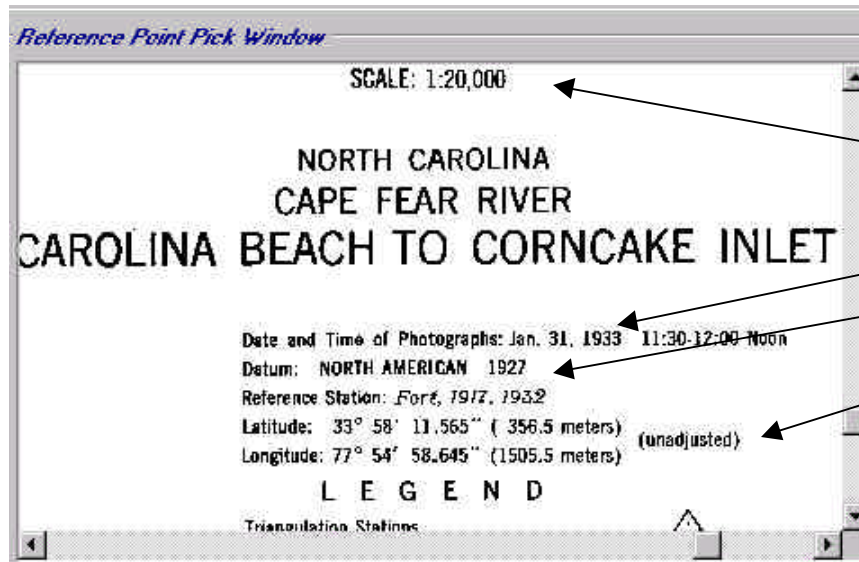
At this point the blue box should be in the upper left hand corner where you clicked, and you should be looking at a zoomed-in version of the same area in the **Reference Point Pick Window**.

## A Warm Up Exercise:

Spend a few moments familiarizing yourself with moving around and zooming in and out. In doing so, you should observe that very often, the latitude and longitude lines are only visible when you are zoomed in past a certain point. Not all of them show up clearly when you look at the entire image in the **Source Image Overview Window**.

Remember, move the blue box by **left clicking** on a location in the **Source Image Overview Window**. Adjust the zoom factor by **right clicking** in the **Reference Point Pick Window**, then **left clicking** on an appropriate zoom factor.

While you are doing this, find the following information (shown in the graphic below) contained on every t-sheet.



This image to the left shows data important to later steps in the georeferencing process. When you find it, zoom in and record the following:

- Scale
- Photography date(s)
- Datum
- Coordinate system (most t-sheets will be in Latitude / Longitude format, although some may have another system as well.)

Once you have written down this information, you are ready to begin adding your reference points.

END

## ***Chapter 5. Adding Reference Points***

### ***5A. How to Choose Reference Points***

Goal: To provide an overview of what points to select

### ***5B. Selecting Initial Points for the Automatic Reference Point Selection Wizard***

Goal: To place points in the four corners

### ***5C. Using the Automatic Reference Point Selection Wizard***

Goal: To use the wizard to select the remaining points

### ***5D. Removing Unwanted Points***

Goal: To remove points that contain no shoreline data

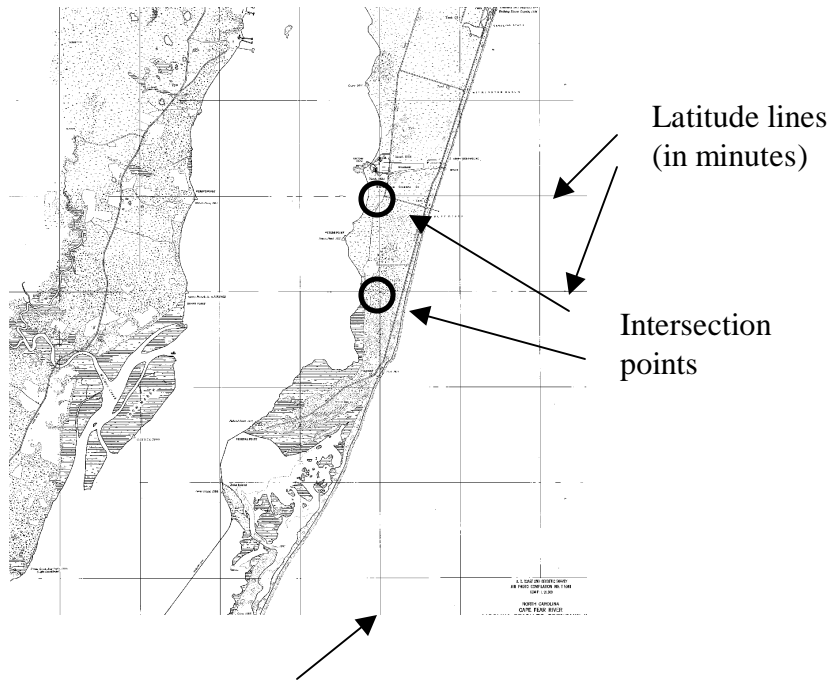
## **5A. How to Choose Reference Points**

Choosing the proper reference points is important. As mentioned in Chapter 1B, when applying the polynomial models there is always some degree of error. You can minimize this error from the outset by selecting points wisely. Before using the computer any further, get a hard copy of the t-sheet you will be using. This will aid in the selection process.

As a general rule for georeferencing these t-sheets, place reference points only on the following locations:

- ***Intersections of latitude and longitude lines for each minute interval.***

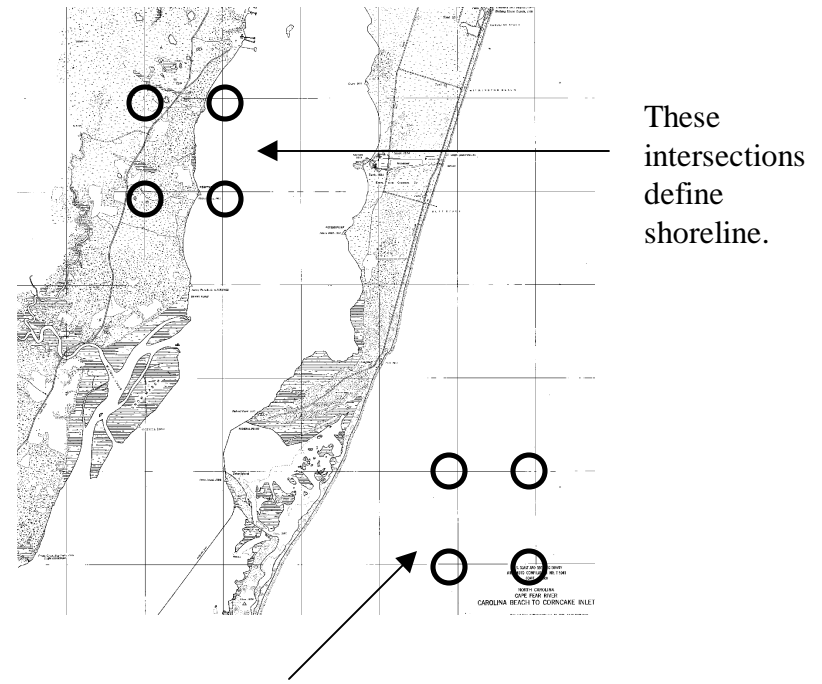
This will make it easy to match image coordinates to map coordinates.



Longitude lines (in minutes)

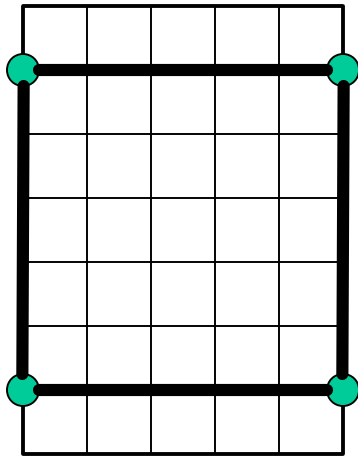
- ***Those intersections that define an area that contains shoreline data.***

Some t-sheets have extra space that doesn't contain shoreline. Putting reference points at these intersections can adversely affect the transformation process.

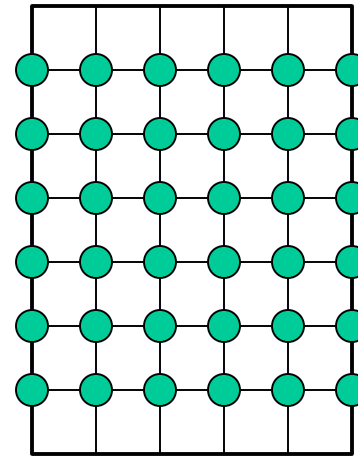


These intersections do not.

When following these guidelines, you will find some t-sheets will require the placement of many reference points. Rather than place them all by hand, Geographic Transformer's **Automatic Reference Point Selection Wizard** provides a convenient alternative. To use the wizard, you will need to manually place four reference points that create a box containing the area you want to place the points. Once the corners are defined, the Wizard will fill in the remaining points inside the box as illustrated below.



Four initial reference points define a box.



The wizard adds the rest.

On some maps, the first four reference points might be the corners of the entire t-sheet. On other maps, you may need to use an area smaller than this. In any event, the maximum number of reference points the Wizard can place is 100. Because you want reference points on grid intersections for each minute interval, the largest region permitted by placing points one after the other is 10 minutes across and 10 minutes down.

Sometimes the area you want may exceed this 10-minute by 10-minute region. In these cases, it is often possible to limit the number of reference points placed by not using consecutive minutes. For example, if the box were 10 minutes horizontally and 11 vertically you could take every other minute going down. So instead of 11, there would now be 6. This would create 60 points, well within the constraints of the software.

A good question to ask at this point is “How many reference points are needed?”.

The number of reference points required to transform an image is directly related to the type of polynomial model that is being used. Recall that these models are mathematical equations that use the reference points to georeference data. More information concerning what these models do will be addressed in Chapter 5C.

For the **Affine** and **First Order Polynomial Models** that Geographic Transformer provides, the *minimum* number of reference points needed is **four**. For the **Second Order Polynomial Model**, the *minimum* number of reference points needed is **six**.

**Note: The Second Order Polynomial Model is the only one you will be using to transform these images, so any t-sheet you georeference will require at least 6 points.**

Even though you only need six reference points, the more you have, the better the outcome of the transformation. Typically, having more will allow greater flexibility when going through the error checking procedures that will be explained later. Because of the need to use many reference points, using the wizard can save considerable time and effort in placing points. Remember to use good judgement when selecting your points. Having many poor reference points can be just as bad as having too few as this will generally result in a greater effort to remove them or correct their error values.

Unfortunately, you will not be able to use the **Automatic Reference Point Selection Wizard** for every t-sheet. It is best used to place reference points on maps with large areas of shoreline. With t-sheets that have small areas of shoreline separated by large areas of non-shoreline, it may be more beneficial to place the reference points in their proper locations manually. For many maps, however, the wizard will be a handy tool.

On the following pages, an example is provided to illustrate the process of choosing reference points for the example t-sheet.



The image seen here is the t-sheet used as an example in this manual. The four points defining the entire map (indicated by the circles) have the following coordinates:

	<u>Longitude</u>	<u>Latitude</u>
<b>Top Left:</b>	<b>78° 01' w</b>	<b>34° 05' n</b>
<b>Top Right:</b>	<b>77° 52' w</b>	<b>34° 05' n</b>
<b>Bottom Left:</b>	<b>78° 01' w</b>	<b>33° 54' n</b>
<b>Bottom Right:</b>	<b>77° 52' w</b>	<b>34° 54' n</b>

If you were to choose these as the initial four reference points, you would create a box 10 minutes across and 12 minutes down totaling 120 points — too many for the Wizard to place.

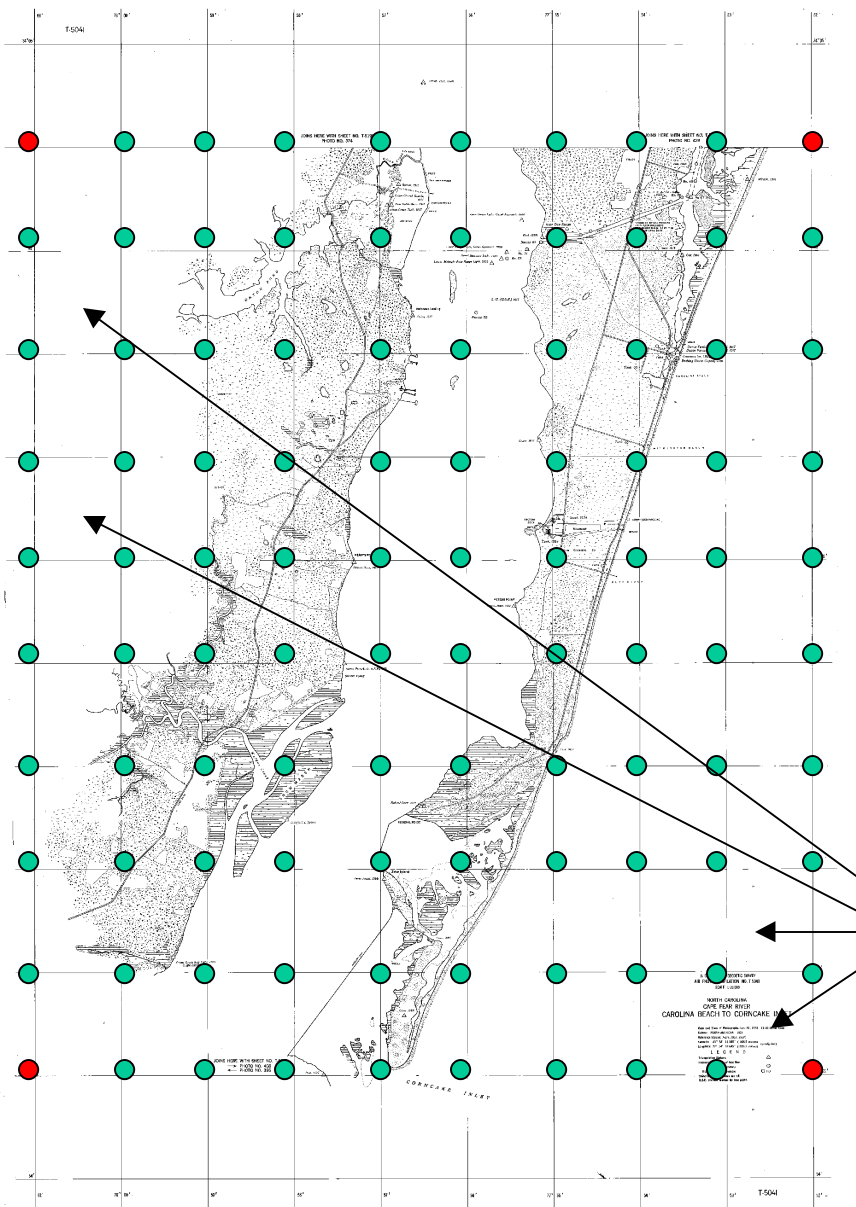
Notice, however, that the land area is only included between the following latitudes (indicated by the arrows):

**34° 04' n (top)** and **33° 55' n (bottom)**

By omitting the extra space at the top and bottom of the t-sheet, there are now an acceptable number of reference points that the Geographic Transformer can automatically place. The new area is 10 minutes across and 10 minutes down, totaling 100 points.

By looking at a hard copy of the t-sheet prior to using the computer, you can quickly and easily decide which points to choose as the four initial points.

After you have established the bounds of your area, you will add the four corners and tell the wizard how many points across and down to add. The result will be similar to the graphic on the next page.



This graphic represents what your output would look like after you defined the corner points and used the **Automatic Reference Point Selection Wizard**.

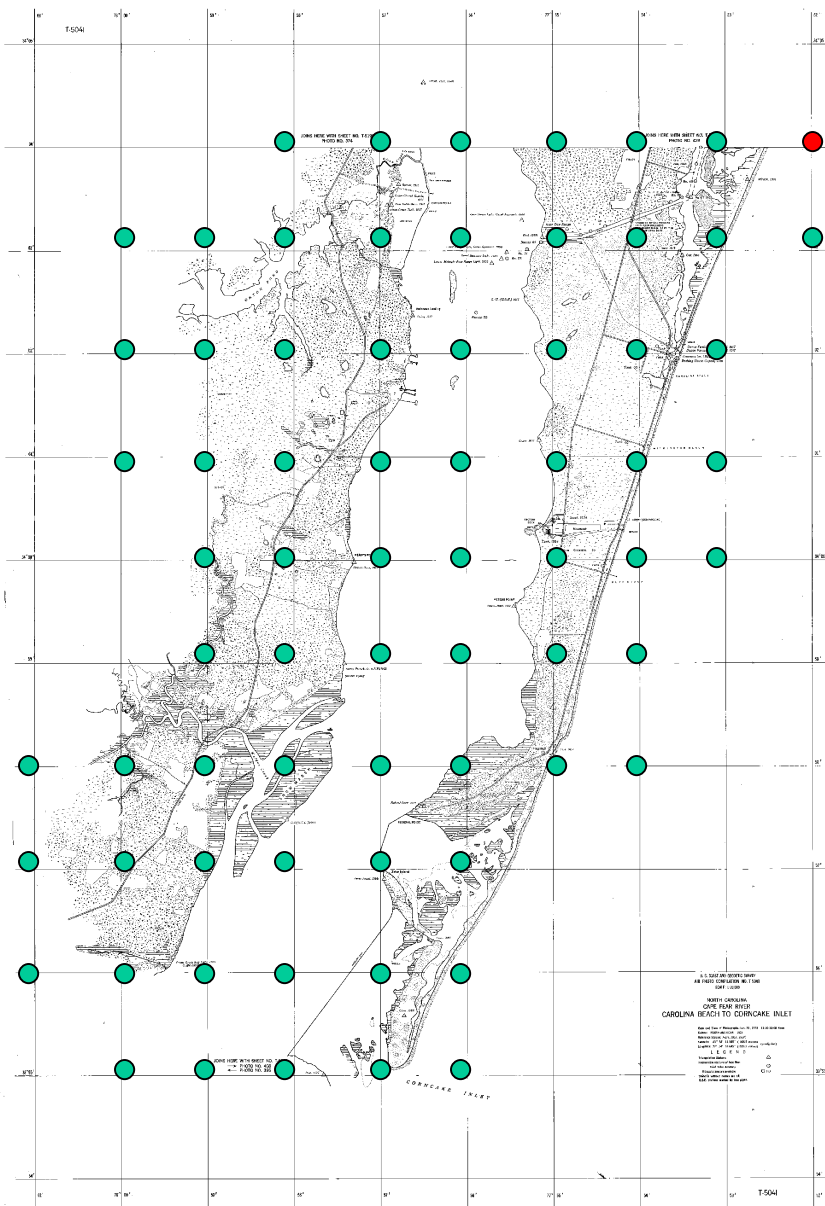
In this example, the black reference points represent the four corner points you will have to manually enter. These define the box within which the wizard will operate.

The remaining gray reference points represent the ones the wizard will automatically add based on your input of how many rows across and down your box covers.

Notice that after this process, there are some reference points that enclose grid squares that contain no shoreline data. Many of these are located in the lower right and upper left corners.

Before performing any error checking, you will need to edit out these unnecessary reference points. Remember, the reference points should contain shoreline data whenever possible. The illustration on the next page indicates good choices of points to keep.

**Examples of several reference points defining grid squares with no shoreline data**



After editing out the unwanted reference points, those shown in the graphic to the left are the ones you should keep during the error checking and transformation processes. Note that each grid square encloses some form of shoreline data.

Chapter 5A was intended to provide a general overview on how to select suitable reference points. Again, each t-sheet will be different, so you may have to adjust some of these steps to suit your needs.

It is recommended that for the first few t-sheets you georeference, you should preview a printout before adding the points on the computer. This will enable you to plan where reference points should be located to give the best coverage, as well as help you to quickly determine their map coordinates.

As you become more familiar with the process, you may decide to skip this step, but planning ahead can often prevent many problems from occurring in later steps.

The next chapters will guide you through using the software to add and edit reference points based on this example map. Follow along using the information on your t-sheets.



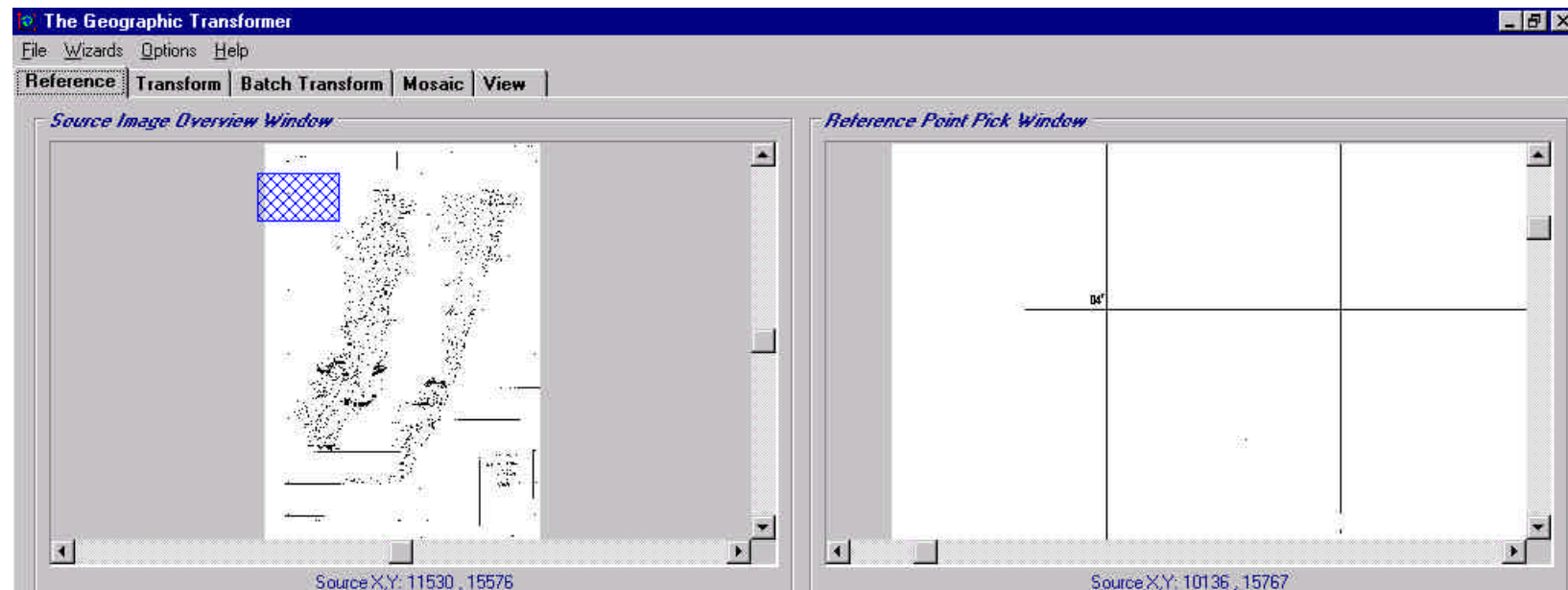
## **5B. Selecting Initial Points for the Automatic Reference Point Selection Wizard**

After you have become accustomed to moving around in the windows, you are ready to select your first points. To review, the goals are to:

- Locate appropriate reference points on the map where the latitude and longitude lines intersect.
- At these points, tell the computer that the (x,y) image pairs have map coordinates defined by the latitude and longitude values.

The majority of the maps you will be georeferencing will have a grid system in which the lines run vertically and horizontally. Some maps may have the latitude and longitude grid tilted at an angle. Maps of this type will need to have points added in a slightly different manner, which is explained in Chapter 8. This chapter will concentrate on the first type.

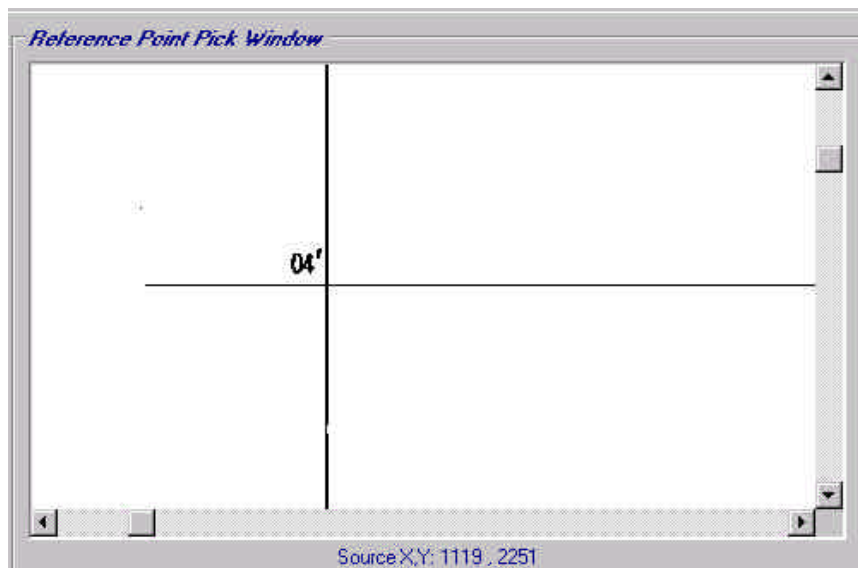
By now you should have examined a print-out of your t-sheet and located the four initial corner points. To begin the process of adding points, in the **Reference Point Pick Window**, zoom out to an area where you can begin to see grid lines and labels. Then in the **Source Image Overview Window**, move the blue box to the location of your first corner point in the upper left-hand corner. Your display should look similar to this:



When the blue box is positioned accordingly, you should be able to make out the intersection of the lines. If you can't make out the lines, you may need to zoom in further.

Once you can see the grid lines, zoom in on the intersection. Position your cursor in the **Reference Point Pick Window** near the intersection. (The point on the screen where your cursor is when you click with your mouse button defines the center of where you will zoom in, so try to get as close to the intersection as possible.)

When you have your cursor in place, **right** click with your mouse to open the **Zoom Selection Window**. How far you are currently zoomed in will determine how much closer you need to get. You may have to try several zoom factors to reach a setting where you can clearly see the grid lines and their labels. Use the graphic below as a guide for how far to zoom in:



Here you can clearly see the intersection and label. Remember, the lines running **horizontally** are the **latitude** lines, and the **vertical** ones are **longitude** lines.

Because this intersection was identified by examining the printout in Chapter 5A, you already know this intersection marking the upper left corner has the following coordinates:

**Latitude: 34° 04' n**

**Longitude: 78° 01' w**

After you have identified the latitude and longitude values for the point on your t-sheet you can define them as your first **map coordinate**.

When entering coordinate values, enter each as a two digit number. For instance, enter 05 instead of 5. Place a space in between groups of two. Also, even if there are no seconds associated with your coordinates, enter 00 as a place holder. It will not matter whether the “n” or “w” defining the direction is in uppercase or lowercase.

If at any time during the input process you make a mistake, simply delete it and enter the correct value. None of the values will be compiled until the **Add** button is clicked at the end of the process.

Locate the **Reference Point Information** panel in the middle of your GUI underneath the viewing windows. With your mouse, left click in the box labeled **Point Name** and type **Point 1**. This will label the first reference point as Point 1.



Reference Point Information  
Point Name:

Next, **left click** in the box labeled **Reference East**. Now enter the **longitude** because longitude is a measure of east/west direction. Recall that earlier we set one of the preferences to permit input values of **degrees, minutes, seconds, and direction**. This setting will allow us to read the information for the points directly from the t-sheet and enter it.

Type in the **longitude** value for your intersection as follows:



Reference East:

(The **78** is a measure of **degrees**, the **01** indicates **minutes**, the **00** indicates **seconds**, and the **w** means it is **west** of 0° longitude.)

Now, **left click** in the box labeled **Reference North** to enter the **latitude** coordinate because latitude is a measure of north/south direction.

Type in the **latitude** value for your intersection as follows:



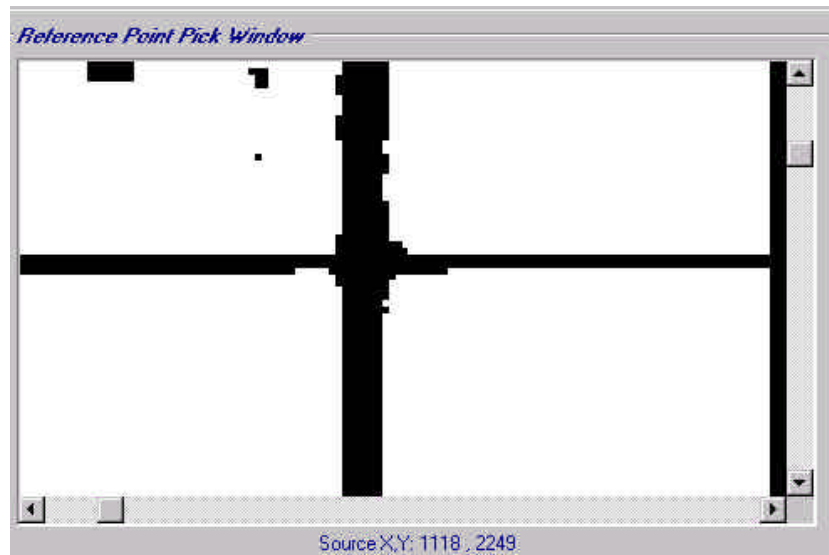
Reference North:

(Similarly, the **34** is a measure of **degrees**, the **04** indicates **minutes**, the **00** indicates **seconds**, and the **n** means it is **north** of 0° latitude.)

After this information is in place for the east and north values, all that remains is to add the **image coordinates**.

To add the **image coordinate** associated with the **map coordinate** just defined, zoom into the intersection in the **Reference Point Pick Window**.

Place your cursor over the intersection, and **right** click to activate the **Zoom Selection Window**. Select a setting that will make your **Reference Point Pick Window** look approximately like the following (this may take some adjusting):



When your window is roughly at this setting, place your cursor as close as possible to the middle of the intersection and **left** click with your mouse.

Once you have clicked, you should notice that the remaining two boxes in the **Reference Point Information** area were automatically filled with the image coordinate's **Source X** and **Source Y** values for the point you selected.

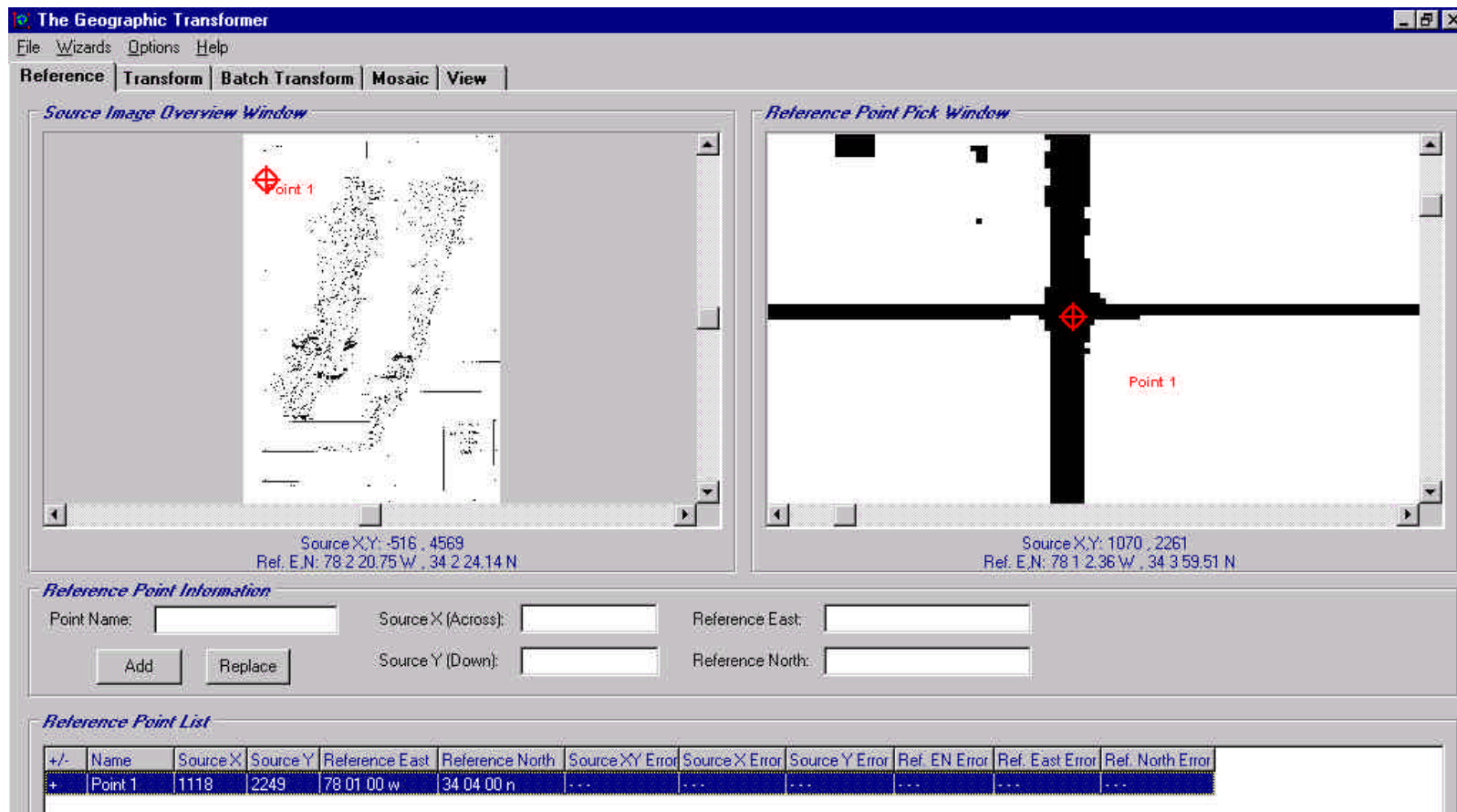
At this point, your **Reference Point Information** area should have all the fields filled in.

Double-check all of your entries. If anything is incorrect you can delete it and change it. When everything is correct, click on the **Add** button.

Reference Point Information					
Point Name:	Point 1	Source X (Across):	1118	Reference East:	78 01 00 w
		Source Y (Down):	2249	Reference North:	34 04 00 n
<input type="button" value="Add"/> <input type="button" value="Replace"/>					

Once you clicked the **Add** button, **Point 1** and its associated information were added to the **Reference Point List**, and symbol graphics were added to both windows indicating the point's location as shown below.

If at this stage you made a mistake, simply double click on the entry in the **Reference Point List**. This will display the current data for the point in question in the **Reference Point Information** area. You can now adjust the values, and then click the **Replace** button. The new values will then appear on the screen.



If you wish to change the color or type of symbol, you can click on the **Preferences** choice from the **Options** pull-down menu and follow the instructions from Chapter 3.

After each point is added, you will need to resize the zoom factor to make the blue box appear larger in the **Source Image Overview Window**. This will make it easier to move to the area of the next point. (It doesn't matter in what order you select the other corners.)

To resize your window, place the cursor in the **Reference Point Pick Window**, **right** click on the mouse, and select a **Zoom Out** setting. Again, the setting will depend on how far you are zoomed in on the intersection, but for this level, a setting of **Zoom Out 16X** would be a good choice.

Now you are ready to add the remaining three corner points. Use the following steps a guide to place these or any other reference points that need to be manually input:

- **Source Image Overview Window:** Use the **left** mouse button to move the blue box to the proper place on the t-sheet.
- **Reference Point Pick Window:** Use the **right** mouse button to zoom in so you can clearly see the grid intersection and the latitude and longitude labels. If you are not completely centered, you can use the **Center On** option in the **Zoom Settings** window.
- **Reference Point Information:** Enter the name of the point (the second point will be Point 2, the third Point 3, the fourth will be Point 4, and so on as needed).
- **Reference Point Information:** Enter the **longitude** value in the box labeled **Reference East**.
- **Reference Point Information:** Enter the **latitude** value in the box labeled **Reference North**.
- **Reference Point Pick Window:** Zoom in very close to the grid intersection and **left** click on the mouse to select the x,y source coordinates.
- Double check your values then click on the **Add** button. Make sure your point information appears in the **Reference Point List** and view windows.
- **Reference Point Pick Window:** Zoom out to make the blue box large enough to move to the next point.

After the four corners are selected, you should notice two things. First, in the **Reference Point List**, error values have been filled in. These are explained in detail in the next chapter. Second, in the view windows, along with the (x,y) coordinates there is now another set of coordinates giving latitude and longitude values.

The reason for these changes is that after four points are added, the Geographic Transformer automatically applies an **Affine Polynomial model** to convert image coordinates to map coordinates. Observe that below the **Reference Point List** there is a menu box in which you can specify the model type.



Eventually you will apply a **Second Order Polynomial model**, but with only four points, the only type allowed is the **Affine** form. To be able to apply the **Second Order Polynomial model**, it is necessary to add more points.

**Note: Before adding additional points, save your four initial reference points by clicking on the Save button. Be sure you are saving the \*.rsf file in the appropriate directory. You may need to navigate to the directory of the current t-sheet.**

## 5C. Using the Automatic Reference Point Selection Wizard

This function allows you to easily add many reference points automatically, rather than by hand. It is set up as a **wizard**, which is a series of windows that will prompt you to do certain things, then move you to the next step.

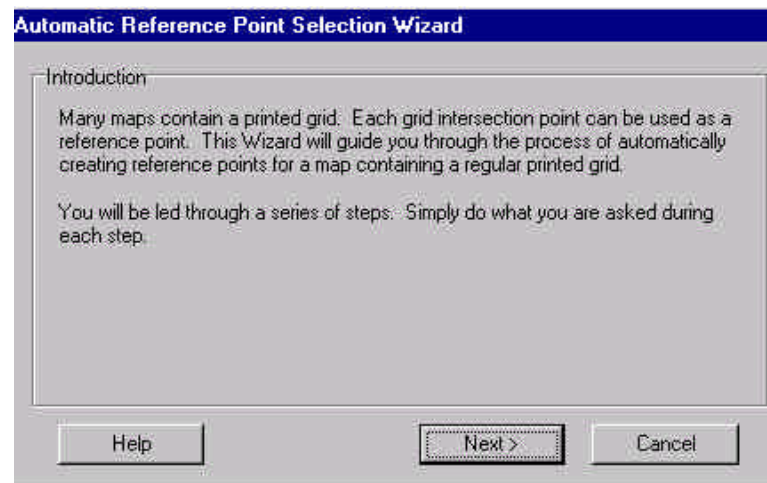
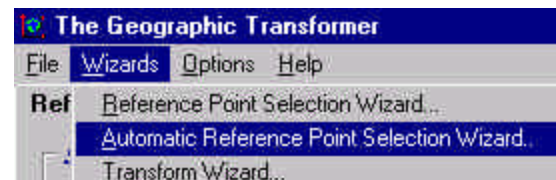
Recall that the maximum number of points the wizard can place is 100. The example outline for this t-sheet was set in Chapter 5A and contains an appropriate number reference points. By now you should have consulted a printout to define the extent of where the wizard will place the points for your t-sheet. If you have determined it is appropriate to use the wizard, go ahead and open it.

Remember, the wizard is best used for t-sheets containing large areas of shoreline. If your t-sheet contains very little shoreline, or shoreline that is separated by large areas of non-shoreline, it may be better for you to place the appropriate reference points by hand. If you were to use the Wizard in these situations, you would need to go back and eliminate large numbers of unwanted reference points. For these types of maps, refer back to the outline on page 29 on how to manually add reference points, and then skip ahead to Chapter 6.

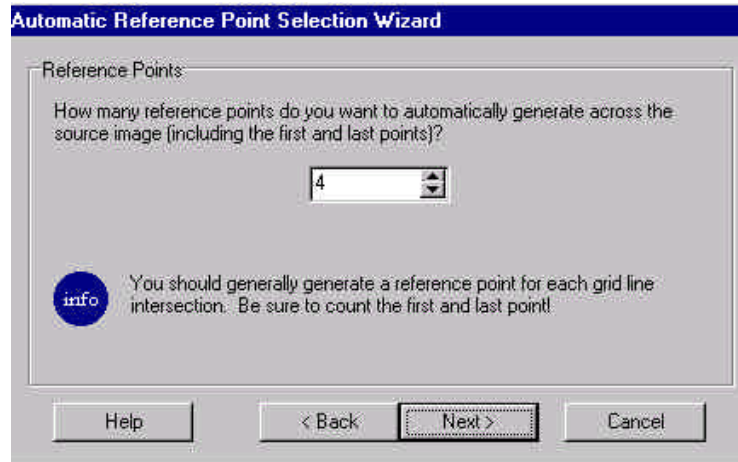
Access the **Automatic Reference Point Selection Wizard** by clicking the **Wizards** option on the **menu bar**. Select the option labeled **Automatic Reference Point Selection Wizard**.

The wizard will open with a window giving a short introduction. You may read this, or click **Next** to move to the next step.

The following two windows will tell you that you need to have a **source image** open, and four corner points selected. Because you will have met these criteria, click **Next** until you reach the window illustrated on the following page:



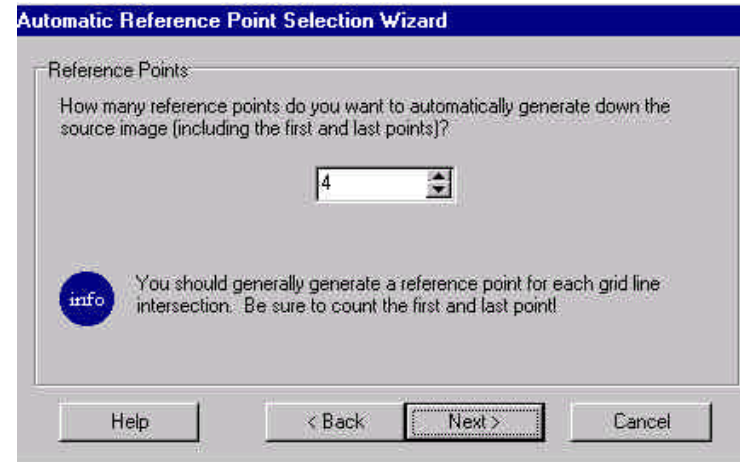




This window prompts you to define the number of points to place **across** your image, including the two corner points already there. Refer back to the instructions in Chapter 5A if you are unsure how to get this value.

You may use the arrow buttons to scroll to the appropriate number, or place your cursor in the box and type it in. (This example will use 10 points across.)

After you have entered your value, click **Next**.



This window prompts you to define the number of points you want to place **down** your image, including the two corner points already there. (Again, this example will use 10 points down.)

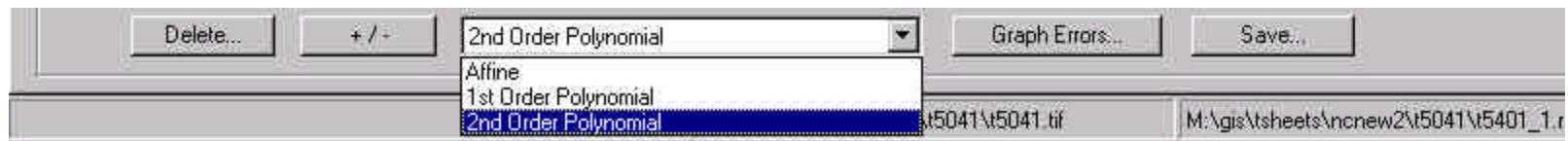
After you have entered your value, click **Next**.

After entering the values, Geographic Transformer will add the points. Click on the **Finish** button in the wizard to dismiss it and move on to the next step.

The wizard will then add the reference points as well as error values for each one. However, these error values still correspond to the **Affine model**.

Before moving on, you must apply a **Second Order Polynomial model**. This type of model is used when taking an image and assigning it latitude and longitude values, which is exactly what is happening here. Additionally, this model takes into account how map areas can be affected by the curvature of the earth.

Since there are now more than four points, you can apply this by model by selecting **Second Order Polynomial** from the box located just beneath the **Reference Point Information** area.



Once this is applied, the **Reference Point Information** area should now show this change by displaying the following. Note that it indicates the model type and number of reference points it is applied to. Additionally, the errors have automatically been re-calculated to reflect the new model.

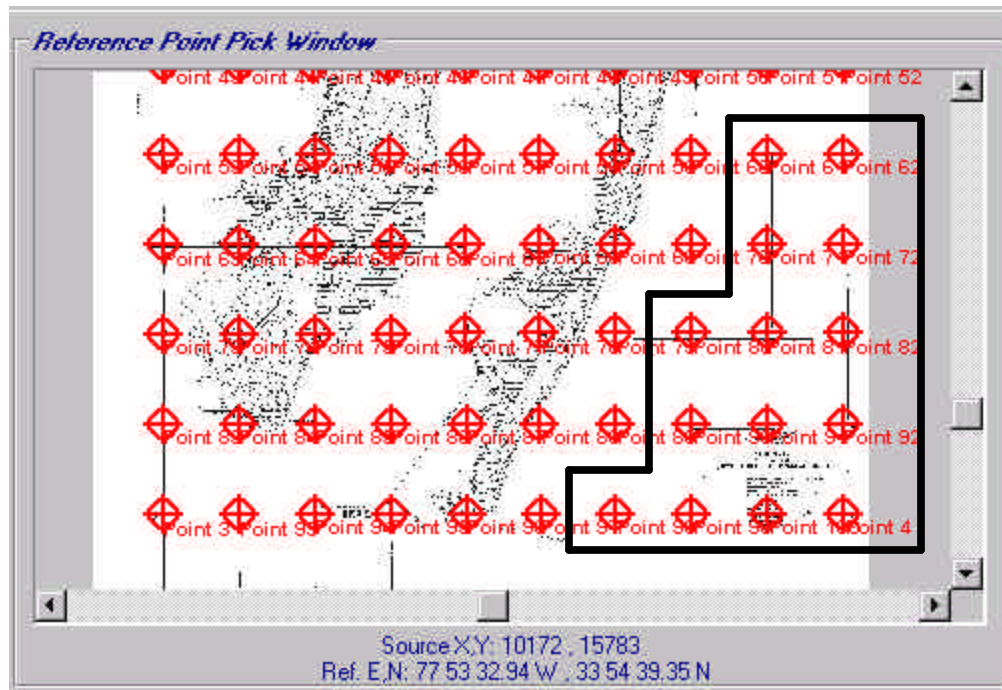
*Reference Point List - 2nd Order Polynomial model applied with 100 points included out of 100 total points.*

+/-	Name	Source X	Source Y	Reference East	Reference North	Source XY Error	Source X Error	Source Y Error	Ref. EN Error	Ref. East Error	Ref. North Error
+	Point 1	1117	2248	78 1 0.00 W	34 4 0.00 N	4.8	3.9	-2.9	0.0	0.0	0.0
+	Point 2	12028	2242	77 52 0.00 W	34 4 0.00 N	4.7	-3.8	2.7	0.0	0.0	0.0
+	Point 3	1124	15300	78 1 0.00 W	33 55 0.00 N	4.7	-3.7	2.9	0.0	0.0	0.0
+	Point 4	12055	15279	77 52 0.00 W	33 55 0.00 N	4.7	3.8	-2.8	0.0	0.0	0.0
+	Point 5	2325	2250	78 0 0.00 W	34 4 0.00 N	1.4	-1.3	0.4	0.0	0.0	0.0
+	Point 6	3539	2249	77 59 0.00 W	34 4 0.00 N	0.9	-0.6	0.7	0.0	0.0	0.0
+	Point 7	4752	2247	77 58 0.00 W	34 4 0.00 N	0.8	-0.8	0.0	0.0	0.0	0.0
+	Point 8	5966	2246	77 57 0.00 W	34 4 0.00 N	0.3	0.1	0.3	0.0	0.0	0.0

Buttons: Delete... + / - 2nd Order Polynomial Graph Errors... Save...

## 5D. Removing Unwanted Points

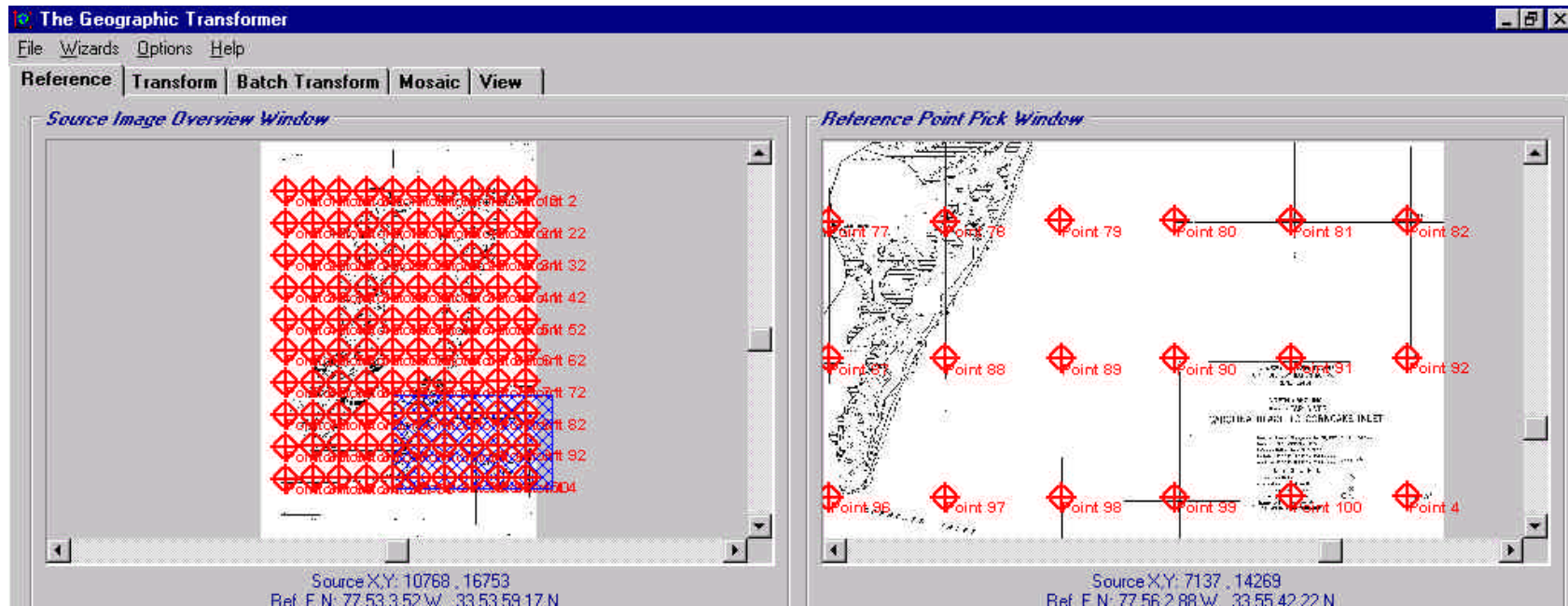
Some of the points the wizard places may need to be discarded as they may ultimately introduce unacceptable errors. Zoom out several factors to provide a larger view of the reference points.



As noted earlier, areas that should be removed are those that have no shoreline within the region formed by any four reference points. Therefore, many of the reference points in the lower right of this image enclosed in the box will need to be deleted.

Also, reference points that rest on areas where the intersection of grid lines are missing or are obscured by other lines should be eliminated, as it becomes difficult to determine the exact center of the intersection. These types of points are best found when going through the steps outlined in Chapter 6C, but they bear mentioning here.

Zoom in slightly to better see the reference point names.



At this stage, you can see that the following reference points have no shoreline inside them: **91, 92, 100, and 4**. Similarly, there is no shoreline inside the box defined by reference points: **80, 81, 90, and 91**. These should be deleted.

On the other hand, the box enclosed by reference points **78, 79, 88, and 89** does have shoreline in it and these reference points should be kept.

Use your zooming techniques to move through the windows and record points that need to be removed.

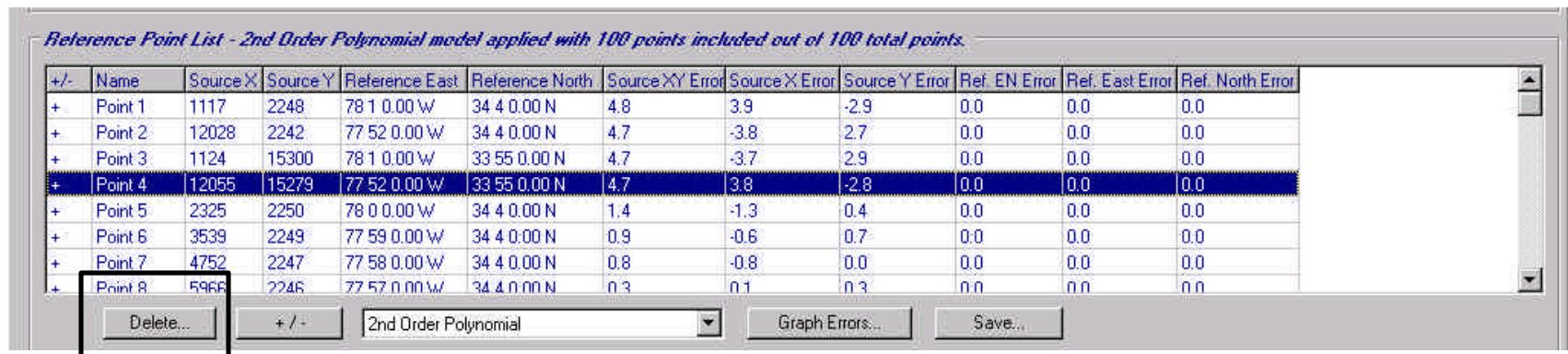
**Note:** After you have identified the points, save your reference setting file, again making sure it is in the appropriate directory.

In the event that you make a mistake when deleting the points, you can go back and re-load this file rather than going through the selection wizard process again.

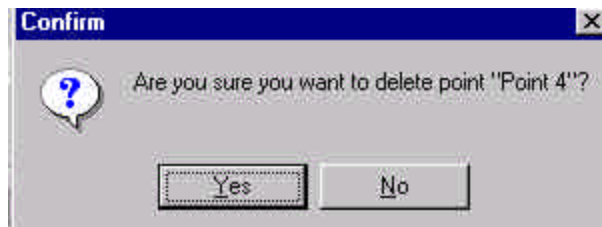
**Note: Use caution when deleting reference points, as there is no Undo button to erase mistakes. Make sure you have saved the points placed by the wizard before proceeding.**

After recording the points to be deleted, they can be removed in the following way:

- Scroll through the list and locate the point to be deleted.
- Click on it once to highlight it as seen below.



- Click on the **Delete** button and respond **Yes** if this is really a point you want to delete.



**Note: When you are done removing points, save your reference setting file again. Be sure it is in the proper location.**

END

## ***Chapter 6. Error Checking***

### ***6A. What is Root Mean Square Error?***

Goal: To provide an explanation of error values

### ***6B. How to View Errors for Automatically Selected Points***

Goal: To provide an overview of using the Residual Error Graphs

### ***6C. Adjusting the Reference Points***

Goal: To place all the points within the appropriate tolerances

## **6A. What is Root Mean Square Error?**

**Root Mean Square (RMS)** error is a measure of how many units the **map coordinates** differ from the **image coordinates** after applying a polynomial model. Ideally, RMS errors of 0 are desired, but often this is impossible. Therefore depending on the **scale** of the map, certain **error tolerances** have been established in accordance with National Map Accuracy Standards:

For maps of scale 1:5,000: RMS error must be **less than 15.6 units**

For maps of scale 1:10,000: RMS error must be **less than 7.8 units**

For maps of scale 1:20,000: RMS error must be **less than 4.0 units**

For maps of scale 1:40,000: RMS error must be **less than 2.0 units**

After all of the reference points are finalized and you have removed the ones that do not belong, you will need to go back and inspect the error values for each of the remaining points to be sure each falls into the acceptable range defined by the map scale.

**Note: This is a very important step. Each reference point must be within the appropriate range, otherwise it can invalidate the remainder of the georeferencing process.**

If there are points that exceed the given range, there are options described in the following sections to correct them. It may seem at first to be very difficult to check and alter a large list of points. However, the steps involved are relatively simple and easy to perform.

In the case of the example map in this manual, the tolerance will be less than 4.0 source units (pixels) since it is a 1:20,000 scale map. The scale of your map should have been recorded in the **Warm Up Exercise** in Chapter 4. If you do not know the scale of your t-sheet, you will need to locate it. Refer to Chapter 4 if you have difficulty finding the map scale.

## **6B. How to View Errors for Automatically Selected Points**

Geographic Transformer provides several different measures of RMS error in the **Reference Point List**. The type most applicable for this project is the **Source XY Error**. This takes into account the error in both the x and y directions for each point in the source units (in this case, pixels.)

Other values in the list give just the amount of source error in the x or y direction, or various errors in map units (meters). Again, the checking you will be doing will focus only on the **Source XY Error** column, indicated by the black box in the graphic below.

*Reference Point List - 2nd Order Polynomial model applied with 76 points included out of 76 total points.*

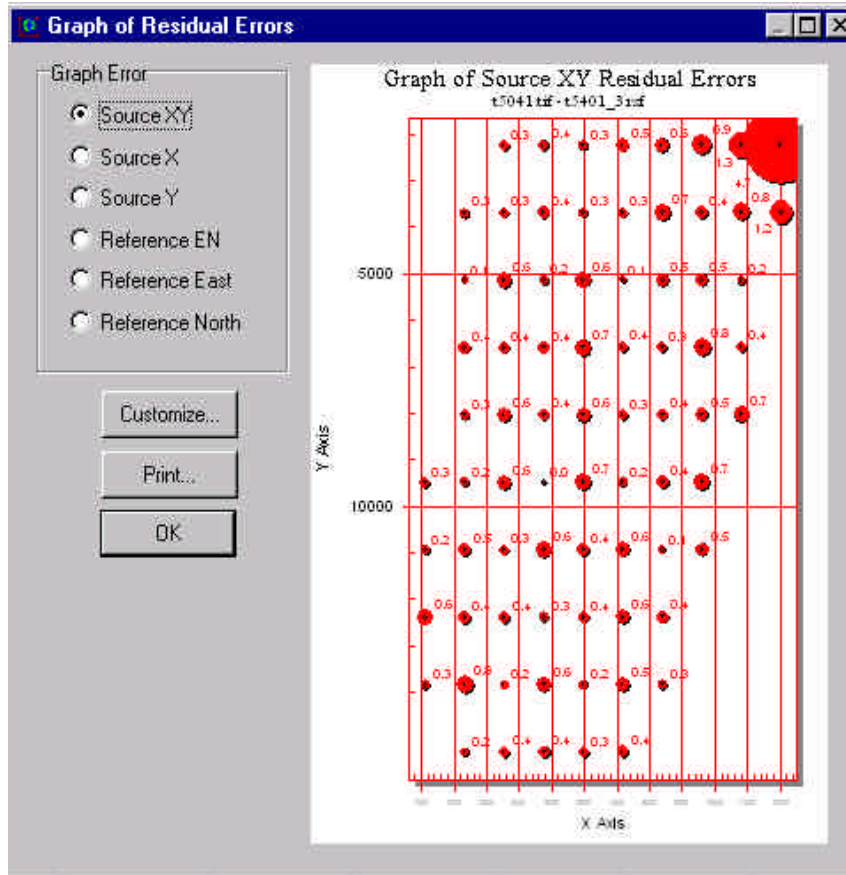
+/-	Name	Source X	Source Y	Reference East	Reference North	Source XY Error	Source X Error	Source Y Error	Ref. EN Error	Ref. East Error	Ref. North Error
+	Point 2	12028	2242	77 52 0.00 W	34 4 0.00 N	4.7	-3.8	2.8	0.0	0.0	0.0
+	Point 6	3539	2249	77 59 0.00 W	34 4 0.00 N	0.3	0.3	0.2	0.0	0.0	0.0
+	Point 7	4752	2247	77 58 0.00 W	34 4 0.00 N	0.4	-0.2	-0.4	0.0	0.0	0.0
+	Point 8	5966	2246	77 57 0.00 W	34 4 0.00 N	0.3	0.3	0.1	0.0	0.0	0.0
+	Point 9	7179	2244	77 56 0.00 W	34 4 0.00 N	0.5	-0.1	-0.5	0.0	0.0	0.0
+	Point 10	8393	2243	77 55 0.00 W	34 4 0.00 N	0.6	0.6	-0.1	0.0	0.0	0.0
+	Point 11	9606	2241	77 54 0.00 W	34 4 0.00 N	0.9	0.4	-0.8	0.0	0.0	0.0
+	Point 12	10820	2240	77 53 0.00 W	34 4 0.00 N	1.3	1.2	-0.5	0.0	0.0	0.0

You can view these errors in several ways. You can manually scroll down the list and look at the **Source XY Error** values, or you can visualize all of them by clicking on the **Graph Errors** button located to the right of the polynomial model selection box.



Using the **Graph Errors** option provides the following output:





Selecting the radio buttons on the left side allows you to view various error types. Make sure it is set to **Source XY**.

If you used the Automatic Selection Point Wizard to place the reference points, most of the error values should be very low.

Unfortunately, this can be deceiving.

**Note: After the reference points are placed, you will need to go back to each one and see how well it really matches up with the intersection it is supposed to represent. In most cases, there will not be an exact overlay**

This is because the mathematical models being used are not perfect. They attempt to give the best fit possible but many times, minor adjustments need to be made.

In the next section you will see that it is quite easy to adjust the reference points and more accurately position them. Each time you adjust one, you will see the error values for others change. Sometimes, these can change by large amounts – even exceeding the acceptable ranges. This is normal, because each point has a direct effect on all the others.

Do not worry about the error as you adjust the points. After this process is complete, you should find that the majority of the RMS values fall within tolerances.

To adjust the points, click on **OK** to dismiss the **Graph of Residual Errors**.

## 6C. Adjusting the Reference Points

Since you will need to check each reference point, begin by scrolling to the first entry in the list and double clicking on it. You will note that the view windows automatically adjust to center on the point, and its attributes are displayed in the **Reference Point Information** area. You may need to alter the zoom setting to get a good view of the actual intersection. If necessary, zoom into the **Reference Point Pick Window** to roughly the following scale:

**Reference Point Information**

Point Name:       Source X (Across):       Reference East:

         Source Y (Down):       Reference North:

**Reference Point List - 2nd Order Polynomial model applied with 76 points included out of 76 total points.**

+/-	Name	Source X	Source Y	Reference East	Reference North	Source X/Y Error	Source X Error	Source Y Error	Ref. EN Error	Ref. East Error	Ref. North Error
+	Point 2	12028	2243	77 52 0.00 W	34 4 0.00 N	5.2	-3.8	-3.5	0.0	0.0	0.0
+	Point 6	3539	2249	77 59 0.00 W	34 4 0.00 N	0.3	0.3	0.2	0.0	0.0	0.0
+	Point 7	4752	2247	77 58 0.00 W	34 4 0.00 N	0.4	-0.2	-0.4	0.0	0.0	0.0

The graphic illustrates the concept made on the previous page. The RMS error for this point is very low (0.3), but the model hasn't done the best job of placing the point where it should be. In this case, there is no question that this point needs to be re-aligned to position it in the center of the intersection.

When going through the entire list, not every point will need to be altered. Use your best judgement as to whether a point looks close enough to the center of the intersection.

Although checking every point may sound difficult, adjusting the misplaced points is quite easy. After you have zoomed in close enough, position the cross-hair cursor to the place that the point should be located and **left** click with your mouse.

This will reset the **Source X** and **Source Y** entries. Then, simply click on the **Replace** button just below the **Point Name** input box. You should note that the **Reference Point List** has immediately updated to reflect this change:

**Source Image Overview Window**

Source X,Y: 9107 , 16961  
Ref. E,N: 77 54 25.61 W , 33 53 50.70 N

**Reference Point Pick Window**

Source X,Y: 3512 , 2263  
Ref. E,N: 77 59 1.31 W , 34 3 59.44 N

**Reference Point Information**

Point Name:  Source X (Across):  Reference East:   
 Add  Source Y (Down):  Reference North:

**Reference Point List - 2nd Order Polynomial model applied with 76 points included out of 76 total points.**

+/-	Name	Source X	Source Y	Reference East	Reference North	Source XY Error	Source X Error	Source Y Error	Ref. EN Error	Ref. East Error	Ref. North Error
+	Point 2	12028	2243	77 52 0.00 W	34 4 0.00 N	5.4	-4.0	3.6	0.0	0.0	0.0
+	Point 6	3544	2248	77 59 0.00 W	34 4 0.00 N	4.4	4.4	-0.7	0.0	0.0	0.0
+	Point 7	4752	2247	77 58 0.00 W	34 4 0.00 N	1.0	-0.9	-0.2	0.0	0.0	0.0

Observe the changes to the marker position in the **Reference Point Pick Window**, as well the **source coordinates** and **RMS values** in the **Reference Point List**.

**Note: Again, be sure to examine each reference point in the list and make any adjustments that appear necessary. Don't worry about the RMS values as you progress through this step. They will be addressed when all the points have been re-aligned.**

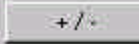
After all the points are aligned to the best of your ability, you must examine the resulting RMS errors to be sure they fall within the acceptable range. When you find a point with too large an error, you have two options:

- First, you can double click on it in the list to center it in your view windows. At this point, you can further adjust it if it appears necessary by following the procedure on the previous pages.
- Alternatively, you can “turn it off.” In other words, you can remove it from the error calculations without having to actually delete it. Often, removing one or two points that have RMS errors that are too high can make any other bad points fall into acceptable ranges.

If you have gone through the list and adjusted the reference points once, turning the points off is generally the best option. Continually re-adjusting involves zooming further in to better locate the actual center of intersection, which many times can be obscured by other lines, smudges, or sometimes not there due to the way the line was drawn. Recall from Chapter 5D that points falling in these areas are best deleted from the list anyway. If you find any reference points over these obscured areas, go ahead and turn them off as they will typically contain high RMS error values.

Scroll through the list and identify the point with the largest unacceptable RMS error. To turn it off, make sure it is highlighted by using a single **left** click on it in the **Reference Point List**.

+/-	Name	Source X	Source Y	Reference East	Reference North	Source XY Error	Source X Error	Source Y Error
+	Point 65	3545	10950	77 59 0.00 W	33 58 0.00 N	2.0	-1.7	1.1
+	Point 66	4764	10951	77 58 0.00 W	33 58 0.00 N	4.7	3.5	3.2
+	Point 67	5972	10948	77 57 0.00 W	33 58 0.00 N	2.8	-2.4	1.4
+	Point 68	7190	10948	77 56 0.00 W	33 58 0.00 N	3.2	1.7	2.8
+	Point 69	8399	10944	77 55 0.00 W	33 58 0.00 N	3.3	-3.3	0.2

Then click on the button marked  located underneath the list. Notice this removes this point from the RMS calculations, and then re-calculates the values for the remaining points. Also note that clicking on this button will turn any point that was turned off back on again.

+/-	Name	Source X	Source Y	Reference East	Reference North	Source XY Error	Source X Error	Source Y Error
+	Point 65	3545	10950	77 59 0.00 W	33 58 0.00 N	1.9	-1.6	1.1
-	Point 66	4764	10951	77 58 0.00 W	33 58 0.00 N	---	---	---
+	Point 67	5972	10948	77 57 0.00 W	33 58 0.00 N	2.7	-2.3	1.6
+	Point 68	7190	10948	77 56 0.00 W	33 58 0.00 N	3.4	1.8	2.9
+	Point 69	8399	10944	77 55 0.00 W	33 58 0.00 N	3.2	-3.2	0.3

Continue scrolling through the list for the next largest RMS value and turn it off.

Each time you turn one off, be sure to look through the entire list to find the next highest value. The idea is to remove the worst points (those with the highest RMS values) first, as this typically forces the others to fall into place. Continue this process until all RMS values are acceptable.

After you have turned off all the bad points, note that the **Reference Point List** has kept track of how many points you began with, and how many of these are good.



*Reference Point List - 2nd Order Polynomial model applied with 69 points included out of 76 total points.*

If you find that you have turned off quite a few points, you may want to have a supervisor inspect your work. There may be something else affecting your RMS values. Recall that you need a minimum of six acceptable reference points to continue, and preferably more. Also keep in mind that if you are turning many points off, it may be possible to turn some back on without exceeding the error tolerances.

When the error values for all of the points are acceptable, go through the list and **delete** the points you have turned off. Double check your values to be sure they all fall under the tolerance level for your map. This will represent the final edits for the reference points.

**Note: When you have done this, save your reference setting file in the correct directory. This is the file you will use for the next step.**

END

## ***Chapter 7. Transforming the Image***

### ***7A. What Does Transforming Do?***

Goal: To provide an explanation of the process

### ***7B. Setting the Parameters***

Goal: To correctly set the options

### ***7C. Finishing Up***

Goal: To check the image and delete unwanted files

## **7A. What Does Transforming Do?**

So far, the steps you have performed were:

- Obtain a digital image of a t-sheet.
- Select suitable reference points.
- Apply a polynomial model to convert the image coordinates to map coordinates.
- Check and correct the RMS error.

The final stage of the process is to **transform** the image. The transformation process takes the original image you started with and creates a brand new one based on the steps outlined above as well as additional input you will have to provide. This input is described in the following section. The new image will have all of its coordinates in latitude and longitude values, making it suitable to be used in the vectorization stage.

When transforming an image, you have two options. First, there is a **Transformation Wizard**, located under the **Wizards** option on the **menu bar**. This is similar to the **Automatic Reference Point Selection Wizard** used in Chapter 5 in that it will prompt you for information through a series of windows.

This manual will illustrate the second option, selecting the **Transform** option from the **operation tabs**. This is the preferred choice because it permits all the settings to be displayed together on one screen, making it easier to see and check all of the input.

The information you will have to provide is identical in either case. As you become more familiar with the process, you may find one more suited to you than the other. Either way is fine, but for starters, begin with the second option.

## 7B. Setting the Parameters

The Geographic Transformer needs to know several things about the image you have and the image you want to produce before it can proceed. Basically it requires information on: the reference image, the destination image, and the extent of the area to be transformed. To add this data, click on the **Transform** option from the **operation tabs**.

The screenshot shows the 'Transform' tab of the Geographic Transformer GUI. It is divided into four main sections, each with a blue heading:

- Reference Parameters:** Contains fields for 'Source Image' (with a file path and a 'Browse...' button) and 'Reference File' (with a file path and a 'Browse...' button). Below these is a 'Reference Coordinate System Definition' section showing 'US State Plane 1927, Texas South Central 4204, NAD 1927 (NADCON CONUS) [NADCON method], US Survey Feet' and a 'Reference Coordinate System...' button.
- Destination Parameters:** Contains fields for 'Destination File' (with a 'Browse...' button), 'Referencing Type' (a dropdown menu set to 'All Formats (RSF, MapInfo TAB, and ESRI World)'), 'Border Color' (a dropdown menu set to 'White'), 'Destination Resolution [METERS]' (a text input field), and 'Central Latitude' (a text input field). Below these is a 'Destination Coordinate System Definition' section showing 'Geodetic Latitude / Longitude, North American Datum 1983 [Molodensky method]' and a 'Destination Coordinate System...' button.
- Transformed Area Parameters:** Contains a 'Geodetic Latitude / Longitude, North American Datum 1983 [Molodensky method]' label, an 'Output Area Coordinate System...' button, and four text input fields for 'Northwest Corner East', 'Northwest Corner North', 'Southeast Corner East', and 'Southeast Corner North'. Below these are two buttons: 'Default to Source File Extents' and 'Default to Reference Point Extents'.
- Tiling Parameters:** Contains a 'Scheme' dropdown menu set to '(none)'.

When you open the **Transform** GUI, you will see the screen displayed in the graphic above. Note there are four sections (those with blue headings) that need input. A few may already have information in them. Some of these automatically default to the project you are currently working on, and others retain data from previous transformations.

**Note:** Before beginning any new transformation, you will need to make sure each section reflects the proper settings.



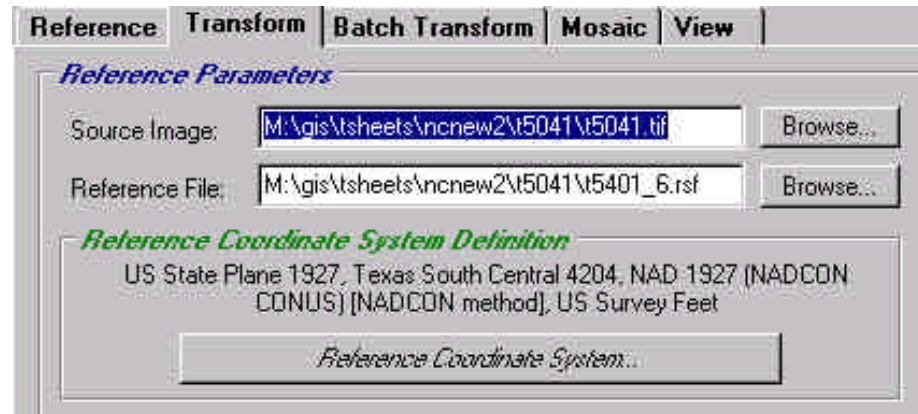
## I. Reference Parameters:

This is the first section to address. Typically, the fields for the **Source Image** and **Reference File** will default to the image and reference settings file that are currently open.

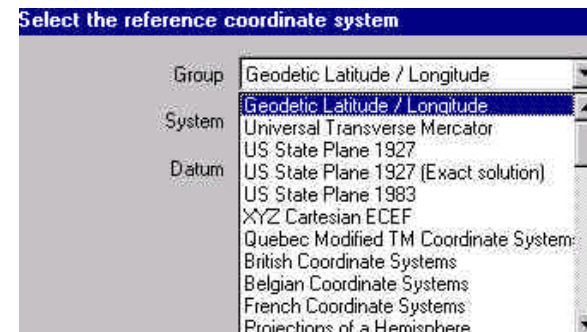
Make sure these are set to the correct files. Pay particular attention to the **Reference File** if you have created several reference settings files.

**Note: You must use the one that has been adjusted and error checked.**

Use the **Browse** buttons to search for the correct files if they do not appear by default.



The **Reference Coordinate System Definition** is asking what coordinate system the original image is in. This information should have been obtained in the **Warm Up Exercise** you performed at the end of Chapter 4. If you haven't done so, go back to the source image and locate this. Once you have it, click on the **Reference Coordinate System** button to enter the coordinate system. This will prompt you to select several options.



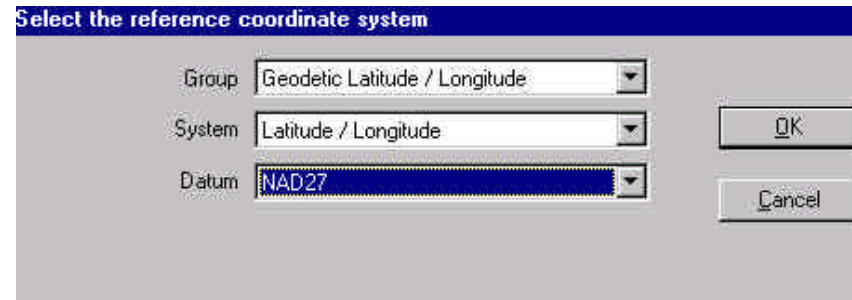
The **Group** field will allow you to choose several settings from the pull-down menu accessed by the down arrow on the right side of the input box. A partial list is illustrated in graphic above and to the right.

Many of these choices you will not need. As a general rule of thumb, if your map has lines of latitude and longitude, select **Geodetic Latitude / Longitude**.

Once the **Group** is set, select the **System**. When using **Geodetic Latitude / Longitude** as the group, the only system available to use is **Latitude / Longitude**.

The last step is to set the **Datum**. (The datum is part of the information obtained from the **Warm Up Exercise**.) From the pull-down list locate the proper setting for your t-sheet and select it.

Click **OK** when done.



## II. Destination Parameters:

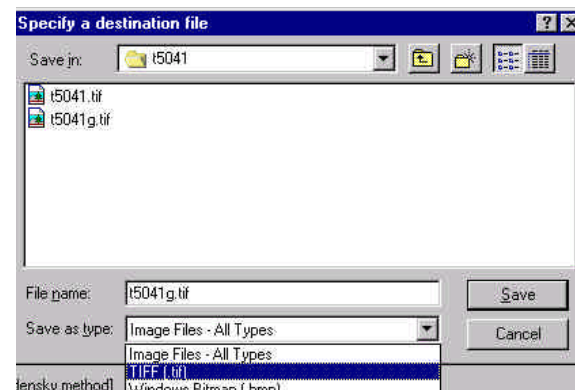
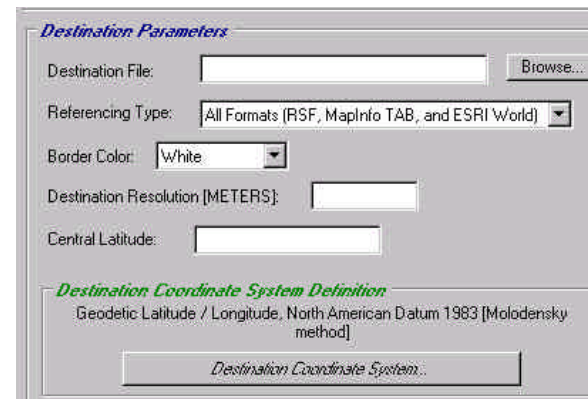
This section defines certain output image specifications.

For the **Destination File** field, click the **Browse** button.

In the **Specify a destination file** window that appears ensure the following:

- The destination file is in the folder containing the other files for this image.
- Add a “g” at the end of the **File name** to indicate it has been georeferenced.
- Set the **type** to a .TIF image.
- Click **Save** when done.

Leave the **Referencing Type** and **Border Color** fields as they appear labeled here.



The **Destination Resolution** field is a measure of ground units of the destination image map, and determines the size of the pixels in the transformed image. The coordinate system you set will determine what units this value takes. The program will tell you which units to use by displaying them inside the parentheses. For **Geodetic latitude /longitude**, it is meters.

In this example, a 1:20,000 scale map scanned at 400 dots per inch (dpi) is being transformed. The new image map should have an equivalent resolution. Calculate the required destination resolution as follows:

Source Scale = **1:20,000**. This means **1 inch (in) = 1,666.667 feet (ft)** (because  $20,000 \text{ in} / [12 \text{ in/ft}] = 1,666.667 \text{ ft}$ )

Scanning Resolution = **400 dpi**

Source Image Resolution =  $(1,666.667 \text{ ft}) / (400 \text{ dpi}) = 4.167 \text{ ft per pixel}$

Destination Resolution =  $(4.167 \text{ ft per pixel}) * (0.3048 \text{ meters per ft}) = 1.27 \text{ meters per pixel}$

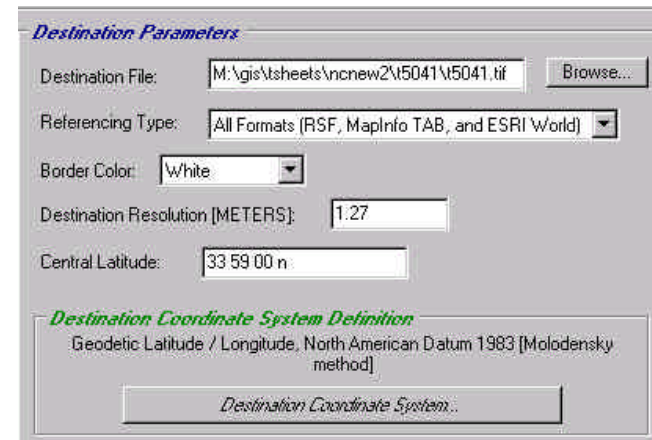
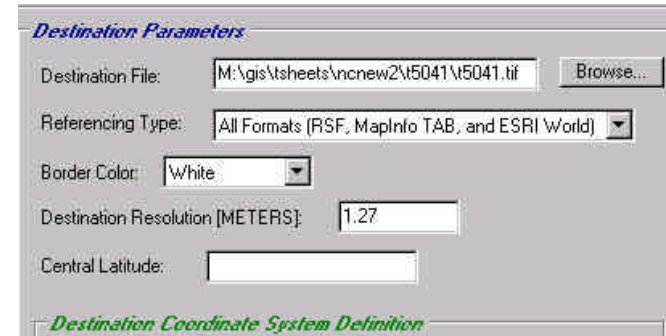
**Note: You will have to obtain the scale and dpi your map was scanned at to perform this calculation for your t-sheets. The scale should have been recorded as part of the Warm Up Exercise. The dpi value will be provided for you.**

The **Central Latitude** field defines the aspect ratio of latitude to longitude for the transformed image. The **Central Latitude** is the mid-point of the northern and southernmost latitudes. It can be found by looking at the t-sheet and finding the line that divides the map into two equal north and south pieces. In other words, if your map has 11 lines of latitude, the central latitude would be the sixth one.

For this example, the value turns out to be 33° 59' 30" n.

Observe that this doesn't necessarily have to be an **actual** line on the map as this t-sheet has no latitude marked that splits the image into equal areas to the north and south. Refer to the map in Chapter 5A to see this. Finding the **Central Latitude** is often made easier when looking at a printout of the map.

Enter the values in the same manner as when defining the reference points (degrees, minutes, seconds, direction.)



In all cases, make sure to set the **destination coordinate system** in the following manner:

- Group: **Geodetic Latitude / Longitude**
- System: **Latitude / Longitude**
- Datum: **NAD83**

Click **OK** when done.

Select the destination coordinate system

Group: Geodetic Latitude / Longitude

System: Latitude / Longitude

Datum: NAD83

OK

Cancel

### III. Transformed Area Parameters:

These parameters control the extent of the output image. Set the **Output Area Coordinate System** to be the same as defined in the last step:

- Group: **Geodetic Latitude / Longitude**
- System: **Latitude / Longitude**
- Datum: **NAD83**

When selecting the corners' parameters, click on **Default to Source File Extents**. This will set the extent of the new image to be the same as the original.

Transformed Area Parameters

Geodetic Latitude / Longitude, North American Datum 1983 [Molodensky method]

Output Area Coordinate System...

Northwest Corner East: 78 1 54.55 W

Northwest Corner North: 34 5 33.75 N

Southeast Corner East: 77 51 40.40 W

Southeast Corner North: 33 53 8.16 N

Default to Source File Extents

Default to Reference Point Extents

### IV. Tiling Parameters:

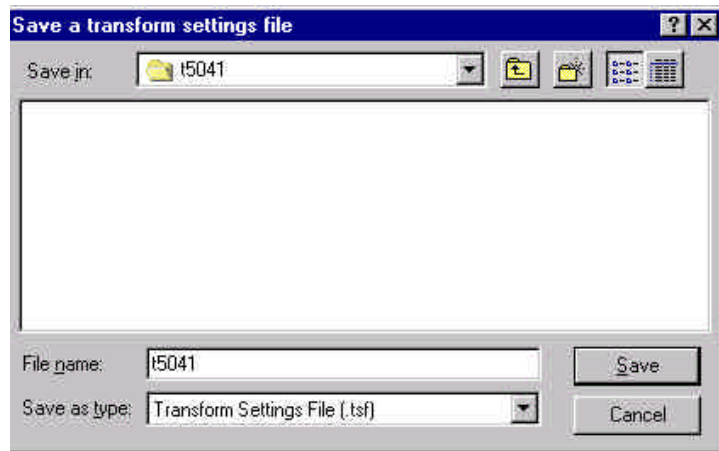
Tiling allows you to split a large image into smaller pieces. You will not be applying any tiling parameters to the images you make, so set the **Scheme** field to **none**.

Tiling Parameters

Scheme: (none)

After you have entered all of the information for your map, take a moment and review all the settings. When everything is properly defined, the image is ready to be transformed. Click on the button labeled **Transform** to begin the process.

A window will appear asking you to **Save a transform settings file**. Navigate to the appropriate directory and save the **.tsf** file.



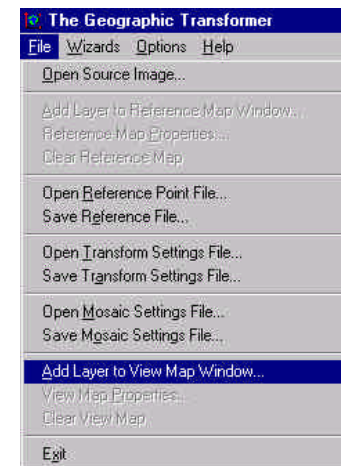
After you click the **Save** button, a window will appear giving the status of the transformation. When it is done, a second window will appear indicating whether or not the process was successful.

When transforming, each job is broken up into smaller sections. Typically, a t-sheet will have no more than about 50 to 55 sections, and usually much less. If a larger number appears (for instance one in the hundreds) this may indicate an error in your settings. Should this happen, you might consider canceling the process and re-examining the transformation settings.

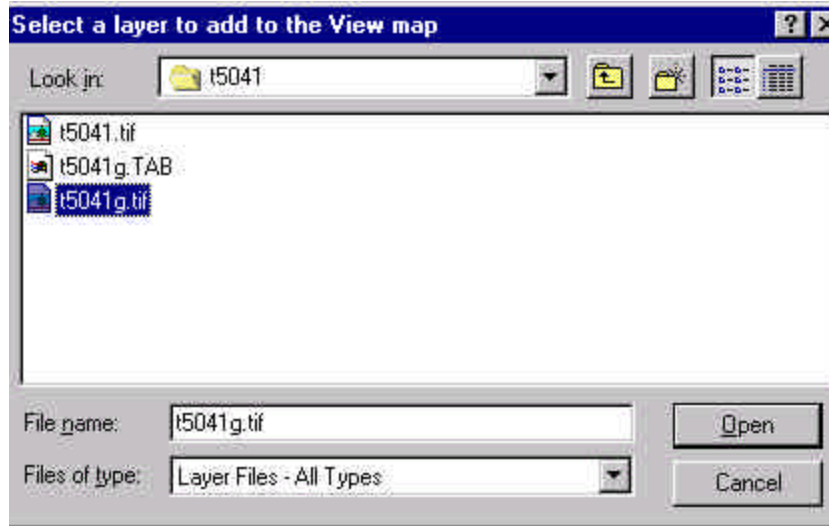
## 7C. Finishing Up

After a successful transformation, the image needs to be visually inspected. From the **operation tabs**, select the one labeled **View**. A new GUI will appear. From here the image can be inspected and compared to existing shoreline data.

Next, click on the **File** option from the **menu bar**. Select **Add Layer to View Map Window** to add the transformed image.



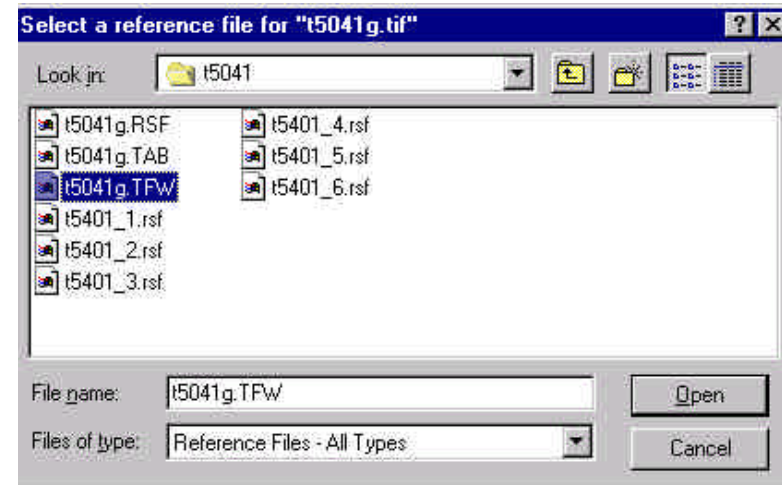
Navigate to the directory containing the georeferenced t-sheet and highlight the appropriate file. Click **Open**.



To add this to the **View Map Window**, you will also be prompted to select a **reference file** associated with the given image. The transformation process will create three types of reference files:

- Blue Marble's Reference Setting File (\*.RSF)
- MapInfo's TAB file (\*.TAB)
- ESRI's TIFF World File (\*.TFW).

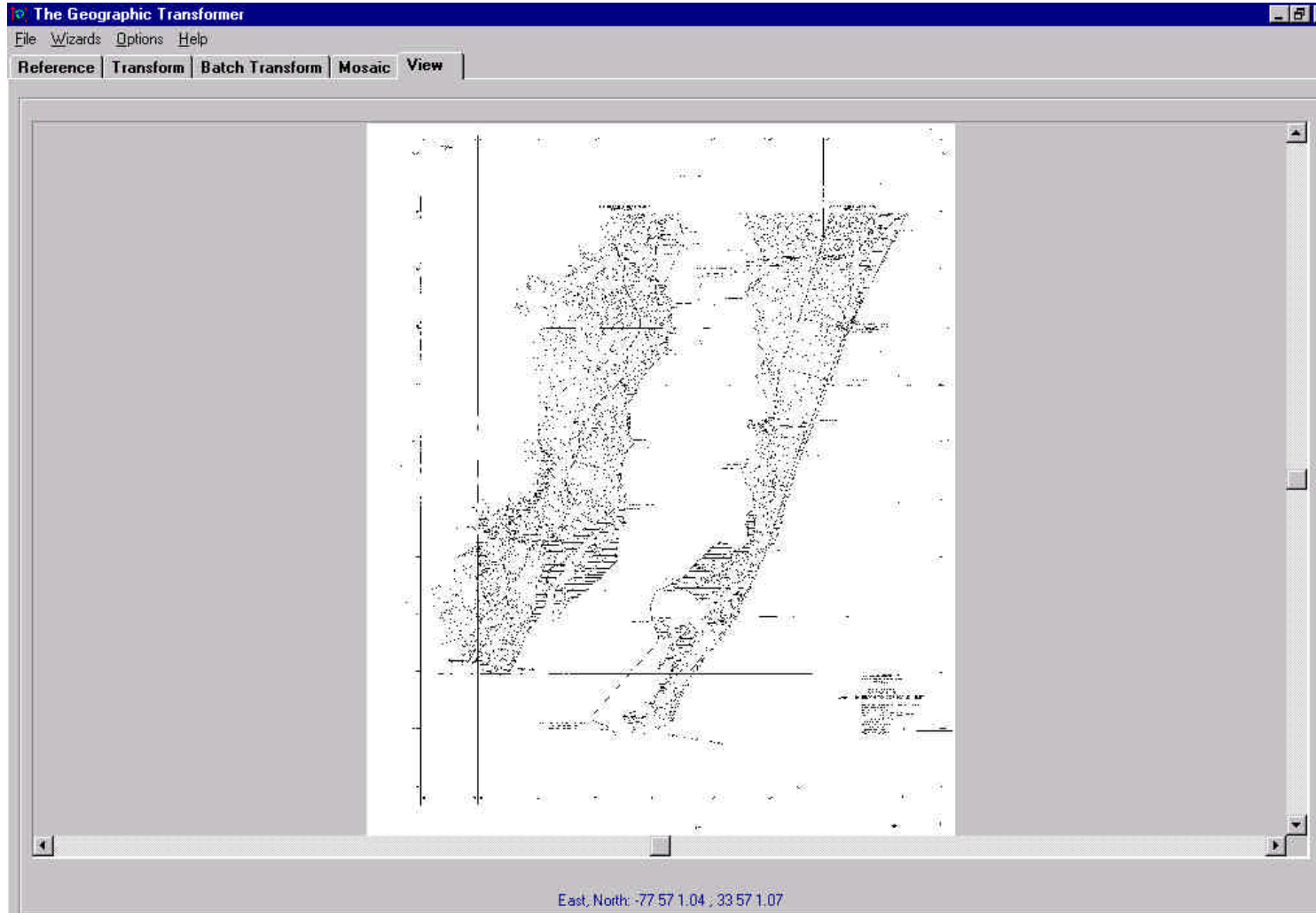
Choose the ESRI TIFF World File reference file (\*.TFW) and click on the **Open** button. Wait while your image is displayed.



**Note:** Be sure to select the reference file associated with the proper image. If you have previously viewed an image, the window listing the reference files will be associated with those of the previous t-sheet.

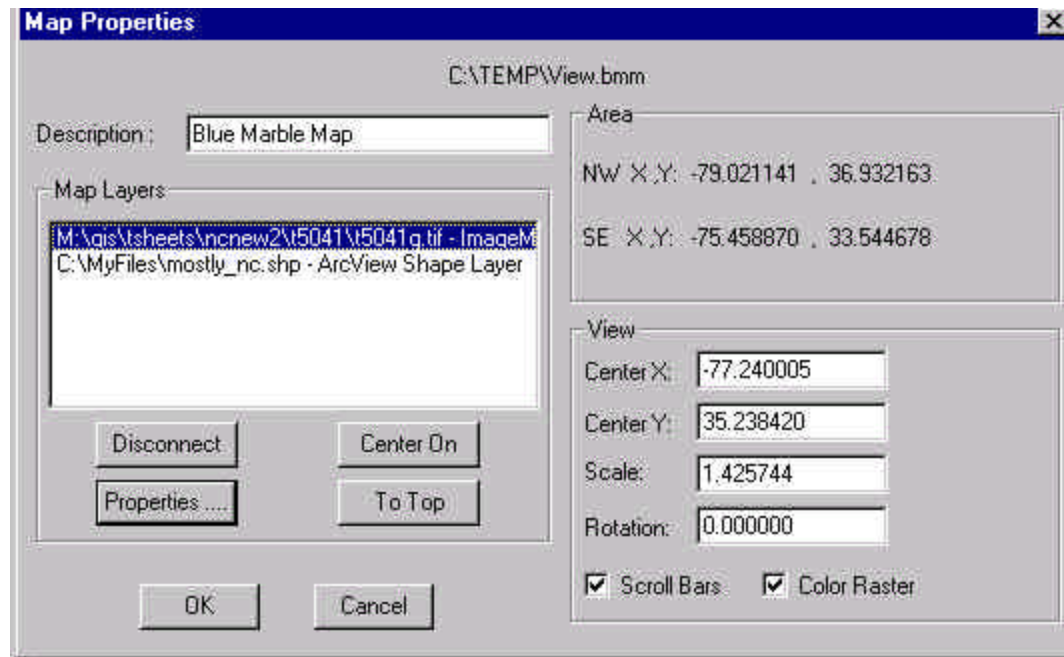
The image should display in the window. As a primary check, locate a prominent feature on the map, position your cursor on it, and record its coordinate value displayed below. Match this value against the same feature on your printout. If these two correlate, continue on.

If this primary check doesn't match, try another. If the second points still do not correlate, something may have been incorrectly set prior to transforming. Contact a supervisor before proceeding.

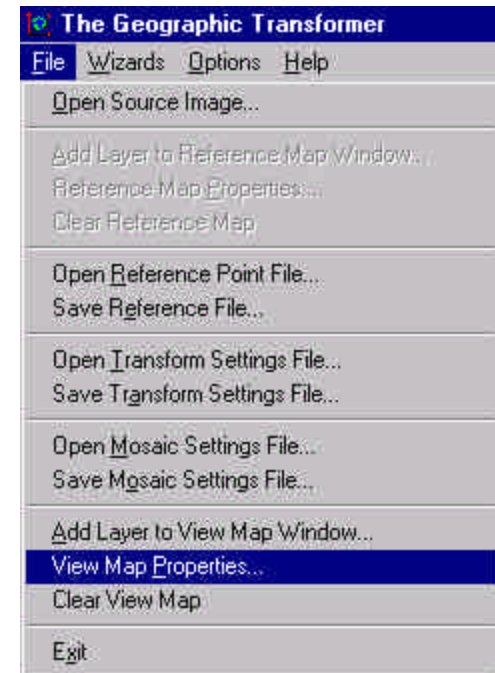


A second method of checking the transformation compares the new image against a shapefile (\*.shp) containing shoreline data for the state your t-sheet is taken from. Click on the **File** option from the menu bar and add the necessary shapefile using the **Add Layer to View Map Window** option.

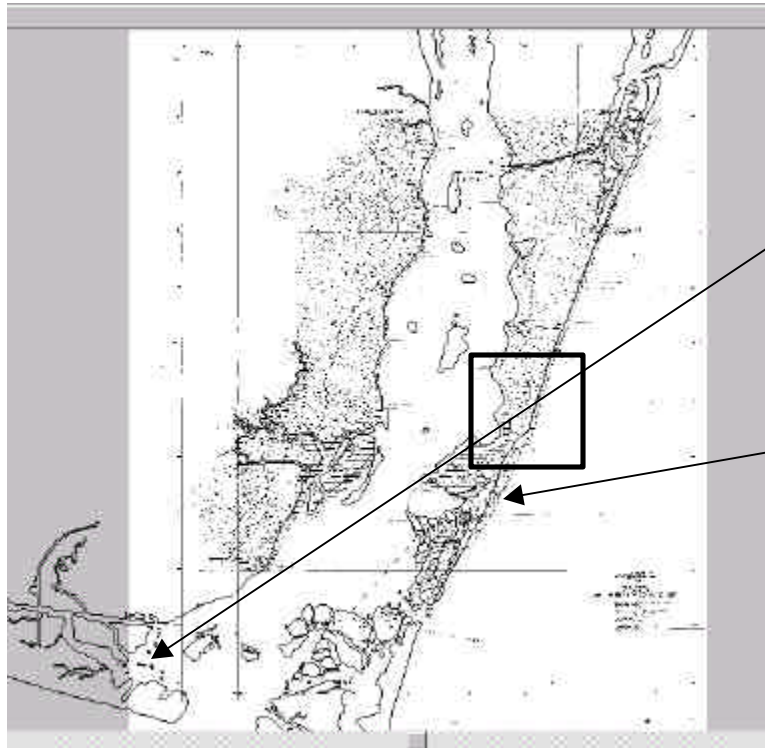
After the shoreline shapefile is added, you may need to adjust your **View Map Window** to see both layers. To do this, select the **File** menu option and choose **View Map Properties**.



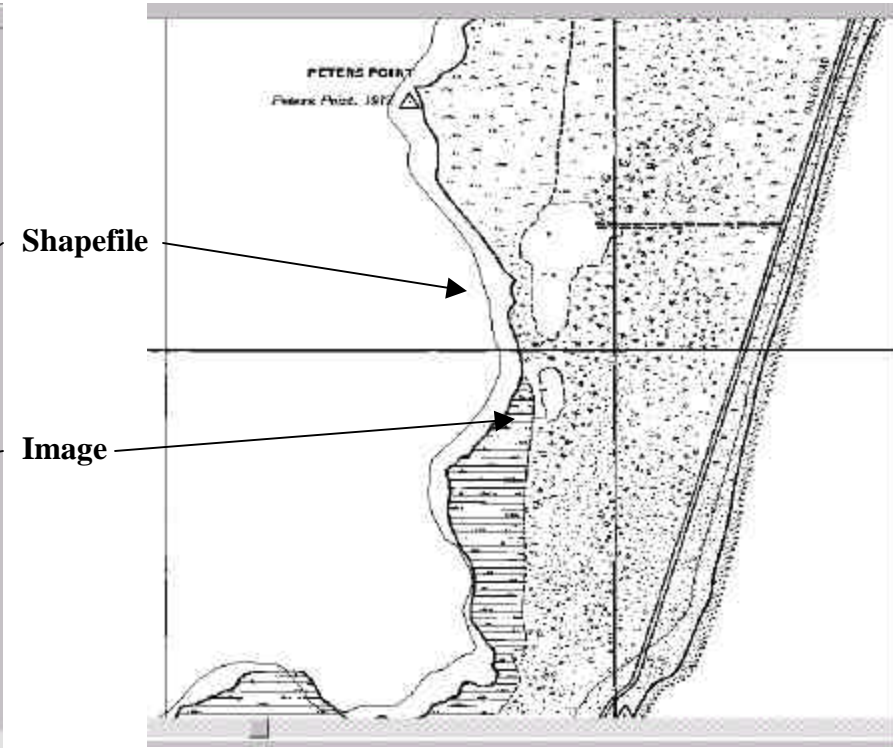
In the **Map Properties** window shown above, make sure that the \*.tif image is first on the list. (If it is not, select it and click the **To Top** button.) Once the image is on top, make sure it is highlighted and click on the button labeled **Center On**. This will center the **View Map Window** on the selected layer. Click **OK**.







The transformed image and shapefile overlay.



A zoomed in view of the area in the black box.

The graphic on the left illustrates the window after centering on the image. Although this evaluation is somewhat difficult because both layers appear in the same color, it is possible to see that the image appears to follow the general pattern of the shoreline shapefile. To get a better look, place your cursor near some shoreline and **right** click to zoom in.

The graphic on the right depicts the region enclosed by the dark box. Here, the thin line representing the shoreline shapefile matches up fairly well with the transformed image. As long as these two layers are in roughly the same orientation, the transformation was successful. If there were major discrepancies between these two layers, this would indicate something went wrong during the georeferencing or transformation processes.

If the transformed image matches fairly well with the shapefile, the only remaining step is to clean up the directory of unnecessary files. When you are finished checking the image, select the **Clear View Map** option from the **File** pull-down menu.

During the course of the georeferencing process, there may be several files created that do not need to be saved. These should be deleted to save space and remove clutter. Using the **Windows Explorer** or **File Manager** program, open the folder for the t-sheet you georeferenced, and observe the files in it.

**Because each session will create different numbers of certain types of files (usually \*.rsf or \*.tsf files), the following is a list of the files types that should remain:**

- any log (\*.log) files
- the original image (\*.tif) file
- the georeferenced image (\*.g.tif) file
- all three reference type (\*.RSF, \*.TAB, \*.TFW) files associated with the georeferenced (\*.g.tif) file
- the final transformation settings (\*.tsf) file
- the **final** reference setting file (\*.rsf) and **text** (\*.TXT) file that correspond to the settings used to transform the original image. (Following the convention of numbering them, these should be the ones with the highest number.)

After identifying those files that should remain, delete the rest. Your directory should now look similar to graphic shown to the right. Note the type of files shown in the graphic to the right coincide with those listed above.

Contents of 'M:\gis\tsheets\ncnew2\t5041'

Name	Size	Type	Modified
t5041.log	66KB	Text Docum...	3/24/1999 10:21 AM
t5041.tif	27,264KB	TIF Image D...	3/16/1999 3:15 PM
t5041.tsf	1KB	TSF File	3/23/1999 3:56 PM
t5041g.RSF	1KB	RSF File	3/24/1999 10:21 AM
t5041g.TAB	1KB	MapInfo TA...	3/24/1999 10:21 AM
t5041g.TFW	1KB	TFW File	3/24/1999 10:21 AM
t5041g.tif	27,433KB	TIF Image D...	3/24/1999 10:21 AM
t5401_1.rsf	1KB	RSF File	3/22/1999 9:03 AM
t5401_1.TXT	3KB	Text Docum...	3/22/1999 9:03 AM
t5401_2.rsf	6KB	RSF File	3/22/1999 1:15 PM
t5401_2.TXT	23KB	Text Docum...	3/22/1999 1:15 PM
t5401_3.rsf	5KB	RSF File	3/22/1999 1:21 PM
t5401_3.TXT	18KB	Text Docum...	3/22/1999 1:21 PM
t5401_4.rsf	5KB	RSF File	3/22/1999 2:47 PM
t5401_4.TXT	18KB	Text Docum...	3/22/1999 2:47 PM
t5401_5.rsf	5KB	RSF File	3/22/1999 3:49 PM
t5401_5.TXT	18KB	Text Docum...	3/22/1999 3:49 PM
t5401_6.rsf	5KB	RSF File	3/22/1999 4:00 PM
t5401_6.TXT	16KB	Text Docum...	3/22/1999 4:00 PM

Contents of 'M:\gis\tsheets\ncnew2\t5041'

Name	Size	Type	Modified
t5041.log	66KB	Text Docum...	3/24/1999 10:21 AM
t5041.tif	27,264KB	TIF Image D...	3/16/1999 3:15 PM
t5041.tsf	1KB	TSF File	3/23/1999 3:56 PM
t5041g.RSF	1KB	RSF File	3/24/1999 10:21 AM
t5041g.TAB	1KB	MapInfo TA...	3/24/1999 10:21 AM
t5041g.TFW	1KB	TFW File	3/24/1999 10:21 AM
t5041g.tif	27,433KB	TIF Image D...	3/24/1999 10:21 AM
t5401_6.rsf	5KB	RSF File	3/22/1999 4:00 PM
t5401_6.TXT	16KB	Text Docum...	3/22/1999 4:00 PM

After these files are georeferenced and transformed, they are ready to be used in the vectorization stage of the project.

This completes the formal instruction on how to use Geographic Transformer to georeference and transform raw image files into images that contain and display real-world locations.

The next chapter provides several time saving tips to assist users who have familiarized themselves with the fundamentals of the software and the georeferencing process.

END

## ***Chapter 8. Tips and Tricks***

### ***8A. Creative Use of the Automatic Reference Point Selection Wizard***

Goal: To show how to apply the wizard to unique situations

### ***8B. Moving from One T-sheet to the Next***

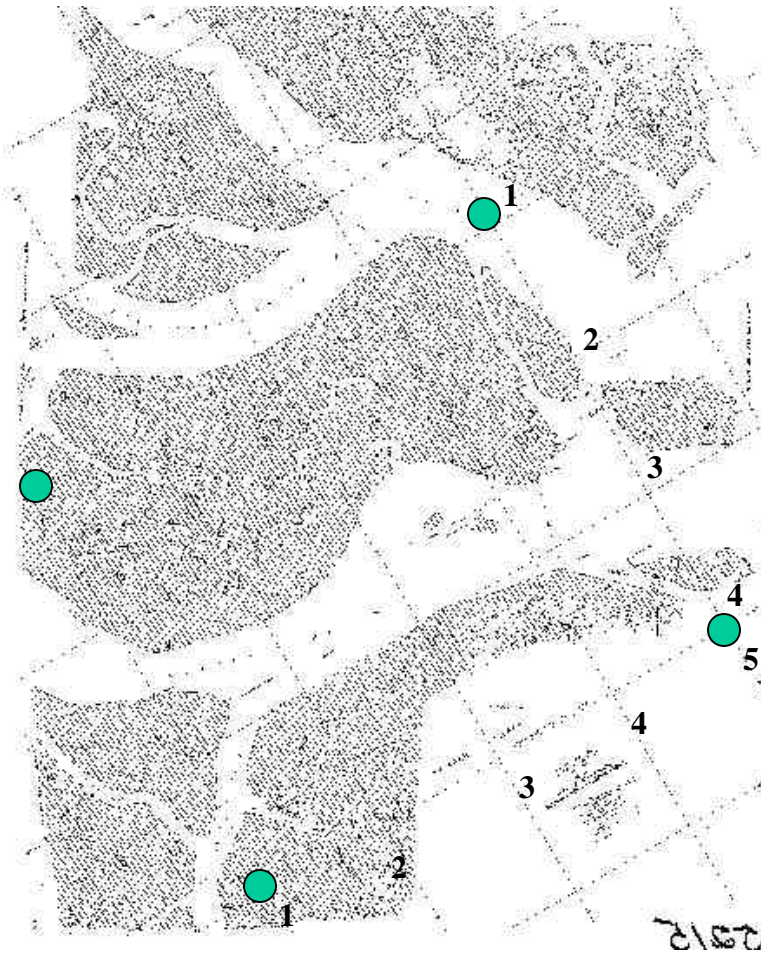
Goal: To show how to quickly move to the next image

### ***8C. Batch Transformation***

Goal: To show how to use the Batch Transformation option

## 8A. Creative Use of the Automatic Reference Point Selection Wizard

During the course of the georeferencing process, you may come across a t-sheet in which the grid lines are oriented in the diagonal fashion seen below.

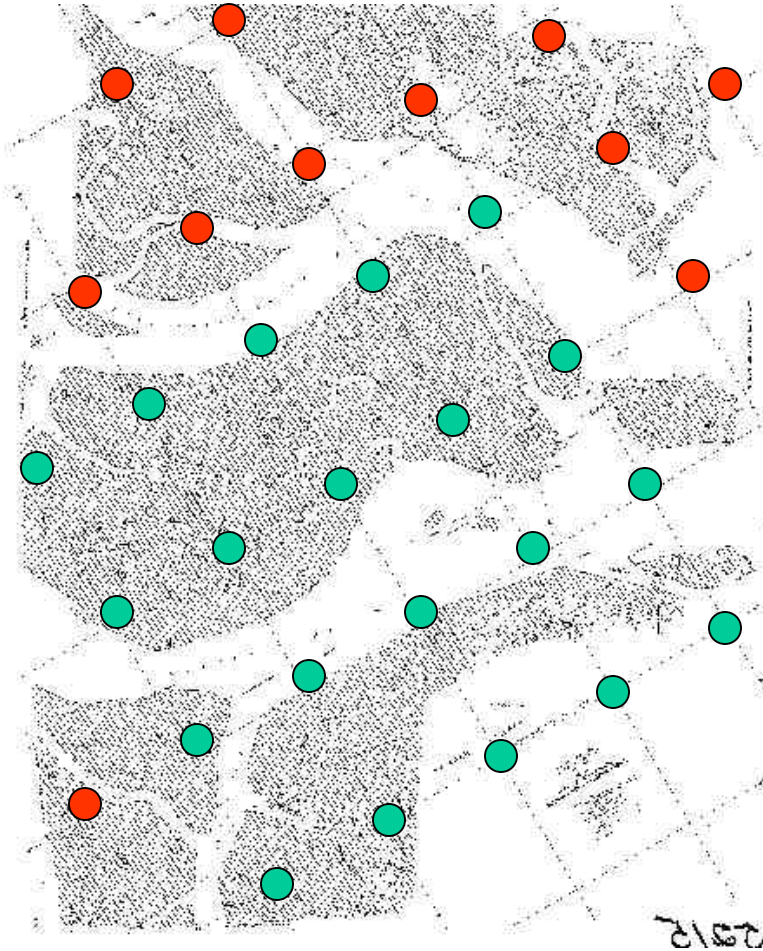


In a case like this, it will not be possible to use the wizard in the manner described earlier. However, it can still be applied to save the time of having to manually input all of the required points.

The process for a scenario such as this is to identify within the image the location at which four points will define *as large an area as possible*. After this is done, place the four initial points and apply the wizard to lay down the remainder using the steps described previously. (See Chapter 5C.)

To make things easier, adjust these points to correctly line up on the grid lines before adding any other points. This way, after you have manually input the remaining points you can go directly to the error checking steps. (See Chapter 6C.)

The graphic to the left provides a good example of an area to define for the **Automatic Reference Point Selection Wizard**. In this example, the parameters used for the wizard will be 5 rows across and 4 rows down (as labeled to the left.) This will place 20 points.



In the graphic to the left, the light points represent the ones the wizard has placed, and the dark ones are those that need to be input manually. Refer to Chapter 5B for instructions on how to manually add points.

As you can see, using the wizard in this fashion will help you save some time. By using this method, you will have to input only 11 of the 31 points by hand.

### **8B. Moving from One T-sheet to the Next**

When you have finished transforming one t-shirt and you are ready to begin another, Geographic Transformer doesn't provide an efficient means to clear out any old work that may remain in your **Source Image** and **Reference Point Pick** windows. Rather than exiting the program and beginning from scratch, here are some hints.

To clear out the reference points, highlight the first entry in the **Reference Point Information** area. Then use the mouse to click **once** on the **Delete** button.

From the window asking for confirmation, press the **Enter** key once. This will delete the selected record. At this point, the next record will become highlighted. You can now repeatedly use the **Enter** key to delete the remaining points in the list. For each record, pressing **Enter** once will bring up the confirmation window, and the second stroke will delete it.

**Note: Before deleting any points, make sure that all the reference point information has been saved in the directory folder associated with its t-sheet.**

After all of the reference points are deleted you can remove the existing **Source Image** by merely adding a new one. From the **File** pull-down menu, select **Open Source Image**. Navigate to the appropriate location and choose the next t-sheet. The program will automatically place the selected image into the **Source Image window** in place of the old one.

You may notice that although you are now ready to begin work on this t-sheet, the **map coordinates** giving the decimal degree measures from the previous image are still visible under both windows. This is normal, and will change to reflect the given image when enough points to define a polynomial model have been entered.

## 8C. Batch Transformation

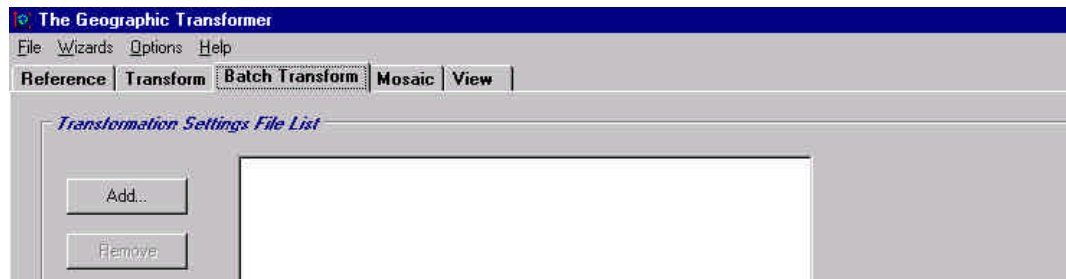
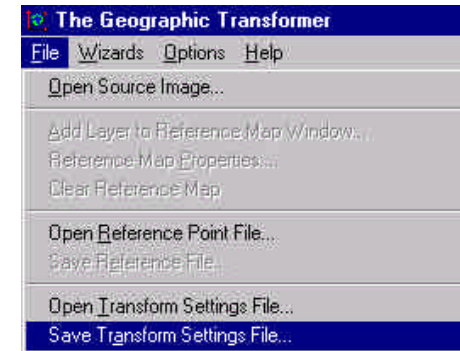
Rather than transform one image at a time, you may find it convenient to first georeference several t-sheets, then transform them as a group. Geographic Transformer allows this process by providing a **Batch Transformation** option.

To use this option, after you have georeferenced an image and set all of the transformation parameters, save the **transformation settings (\*.TSF) file**.

After it saves, **do not click on the Transform button**.

Instead, go through the steps to add another t-sheet and georeference it. Continue this process, remembering to save the **transformation settings files** for each one until you are ready to begin the transformation.

To use the batch transformation, select the **Batch Transformation** option from the **operation tabs**.



From the **Batch Transformation** window, click on the **Add** button.

From the **Select a Transform Settings File** window, navigate to the appropriate t-sheet directory and select the **transformation setting (\*.tsf) file**.

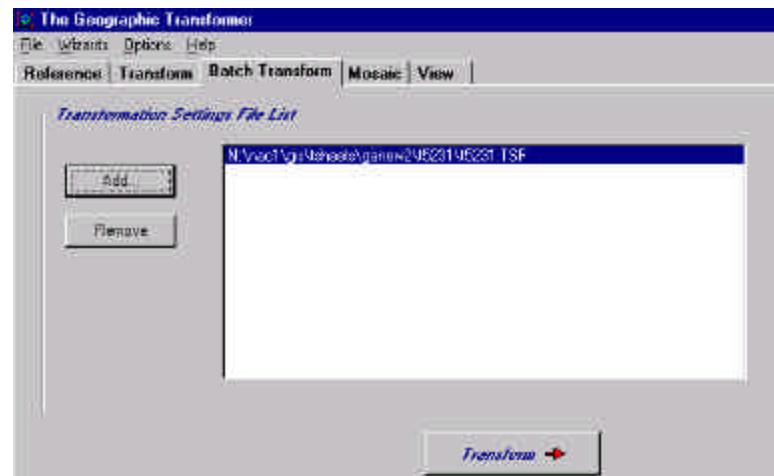
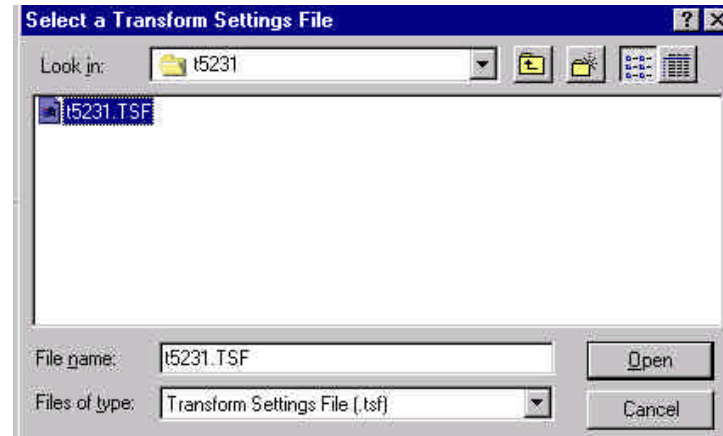
Click **Open**. This will add the **\*.TSF** file to the **Transformation Settings File** list.

Repeat this process to add all the transformation settings files for all the t-sheets you wish to transform. Use the **Remove** button if you need to take any off of the list.

After all the necessary files are present, click on the **Transform** button. This will start the process of transforming them in one group, one after the other. Because this will take some time if you have several files in the list, this is a good thing to do overnight or during a time when you are doing something else.

**However, use this option with caution.**

As with any automated process, if an error or problem occurs, it will stop and wait for input. In general, though, this is a very reliable option. Be sure to check all of the maps using the procedures outlined in Chapter 7C.



These three sections illustrated several ways to save time and effort during the georeferencing process. As you become more familiar with it, you may develop other methods. Feel free to experiment and use whatever works best for you.

END



## ***Chapter 9. Technical Glossary***

### ***9. Technical Glossary***

Goal: To define technical terms found in this manual

## Technical Glossary

- **\*.log files:** Provide a record of the georeferencing process.
- **\*.rsf files:** Store information pertaining to reference points.
- **\*.RSF, \*.TAB, \*.TFW files:** Store information needed to display transformed images.
- **\*.tif files:** Common format for many types of images. Other common types include JPEG (\*.jpg), GIF (\*.gif), and Bitmaps (\*.bmp).
- **\*.tsf files:** Store the parameters you set for a given transformation.
- **\*.txt files:** Accompany \*.rsf files and provide a list of each reference point and its associated error values.
- **Affine Polynomial:** Used to convert image coordinates to map coordinates by shrinking, rotating, and moving the coordinates.
- **Automatic Reference Point Selection Wizard:** Allows the user to automatically place up to 100 reference points on an image.
- **Batch Transformation:** Process of transforming multiple images at one time.
- **Border Color:** Used for the border of the transformed image.
- **Central Latitude:** Divides the map into equal parts north and south. Can be an actual line, or one that is not displayed. (e.g., The central latitude may occur at a value of X minutes and 30 seconds, even though the latitudes are only marked in increments of minutes.)
- **Coordinate System:** Used to locate positions and measure distances on a map.
- **Datum:** Set of values to define the three-dimensional shape of the Earth.
- **Degrees, Minutes, and Seconds:** Used as units of measure for latitude and longitude. Each degree consists of 60 minutes, and each minute consists of 60 seconds.
- **Destination Coordinates:** Values the source coordinates are changed into. In the examples in this manual, the destination coordinates are referred to as *map coordinates* since they will be converted to the Latitude and Longitude values of a map.
- **Destination Coordinate System:** Coordinate system defined for the transformed image.
- **Destination File:** Name and type of image format for the transformed file.
- **Destination Parameters:** Values pertaining to the Destination File, Referencing Type, Border Color, Destination Resolution, Central Latitude, and Destination Coordinate System that are required to transform an image.
- **Destination Resolution:** Determines the size of the pixels in the transformed image. Calculated based on the scale and dots per inch (dpi) value at which the map was scanned.
- **Extent:** Actual geographic area of the transformed image. Can be determined by the source image or by the reference points.

## *Technical Glossary: continued*

- **Georeferencing:** To establish the relationship between page coordinates on a planar map and known real-world coordinates.
- **Graphical User Interface (GUI):** A graphical method of controlling how a user interacts with a computer to perform various tasks, usually in the form of pictorial buttons (icons) and lists.
- **Latitude-Longitude:** A spherical reference system used to measure locations on the Earth's surface. Latitude measures locations running north and south, and longitude measures locations running east and west.
- **Map:** Abstract representation of features on the surface of the earth.
- **Menu Bar:** Feature on the Geographic Transformer GUI that allows the user access to File, Wizard, Option, and Help choices.
- **Operation Tabs:** Feature on the Geographic Transformer GUI that allows the user access to Reference, Transform, Batch Transform, Mosaic, and View functions.
- **Output Area Coordinate System:** Coordinate system used to define the extent of the transformed image.
- **Pixel:** A contraction of the words "picture element". The smallest unit of information in an image or raster map. Referred to as a cell in an image or grid.
- **Points, Lines, and Polygons:** The three basic forms of representing any geographic shape in a GIS.
- **Polynomial Transformations:** Process by which mathematical equations use the reference points to georeference data. In the examples in this manual, polynomial transformations are referred to as *polynomial models* to prevent confusion with Geographic Transformer's process for creating a new image.
- **Projection:** Mathematical model to convert the three-dimensional surface of the earth to a two-dimensional map.
- **Rasters:** A cellular data structure composed of rows and columns for storing images. Groups of cells with the same value represent features.
- **Reference Coordinate System:** Coordinate system of the un-referenced t-sheet.
- **Reference Parameters:** Values pertaining to the Source Image, Reference Setting File, and Reference Coordinate System that are required to transform an image.
- **Reference Points:** Set of points used to perform the georeferencing coordinate conversion.
- **Reference Point Information:** Area on the GUI where the user inputs reference point names and coordinate values.
- **Reference Point List:** Area on the GUI that displays reference points and error values.
- **Reference Point Pick Window:** Area on the GUI where the user selects reference points.
- **Referencing Type:** Provides the format of the file needed to display the transformed image (\*.RSF, \*.TAB, or \*.TFW).

## **Technical Glossary: continued**

- **RMS Error:** Root mean square error. A measure calculated when registering a map to a digitizer, indicating the discrepancy between known point locations and their digitized locations. The lower the RMS error, the more accurate the digitizing or transformation.
- **Scale:** Statement of a measure on the map and its equivalent measure on the surface of the earth. (e.g., 1:20,000 means one unit of distance on the map equals 20,000 units of the same distance on the earth. Large scale maps depict small areas, and small scale maps depict large areas.
- **Second Order Polynomial:** Used to convert image coordinates to map coordinates when the map coordinates are in Latitude/Longitude format or when the image areas can be affected by the curvature of the earth.
- **Shapefile:** Vector-based file format used by the Environmental Systems Research Institute's (ESRI) ArcView GIS software to display features of points, lines, and polygons.
- **Source Coordinates:** Coordinates that will be changed into another format. In the examples in this manual, the source coordinates are referred to as image coordinates because their source is a scanned image.
- **Source XY Error:** Type of RMS error that takes into account errors in both the horizontal and vertical directions.
- **Source Image Overview Window:** Area on the GUI that displays the source image.
- **Transformed Area Parameters:** Values for the output area coordinate system and extent of the transformed image.
- **Topographic Survey Sheet (T-sheet):** Type of map derived from a coastal survey.
- **Transformation Wizard:** Feature that steps the user through the transformation process.
- **Transforming:** Process by which Geographic Transformer creates a new image based on georeferencing information the user provides.
- **Vector File Format:** Type of geographic file where locations defining points, lines, and polygons are stored as specific coordinate values.
- **View Map Window:** Display window used to view the transformed image and ancillary data.
- **Zoom Setting Window:** Displays zoom factors for use in the Reference Point Pick Window.

END