

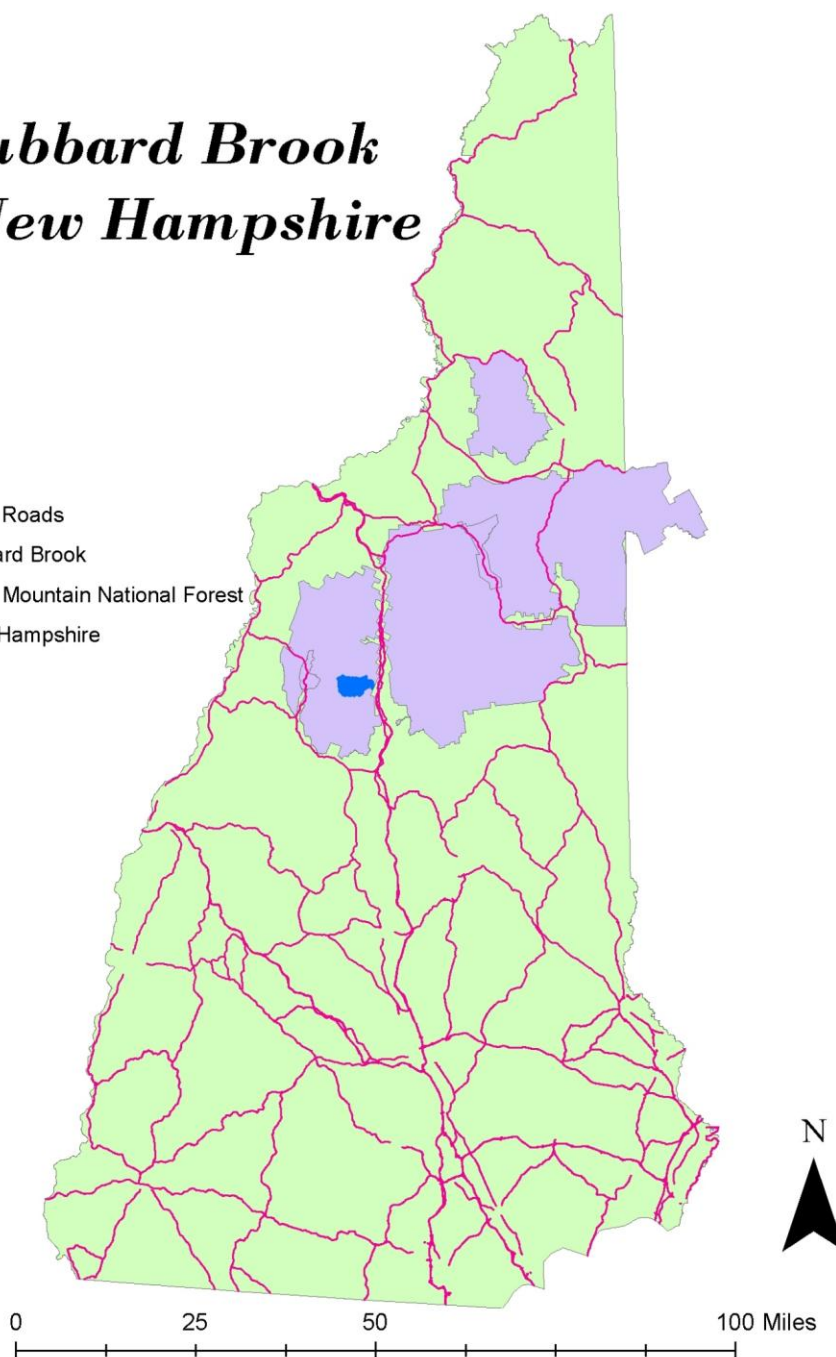
# GIS Mapping for Hubbard Brook Experimental Forest

*A Service Learning Project for Plymouth Regional High School Environmental Science*

## *Hubbard Brook in New Hampshire*

### Legend

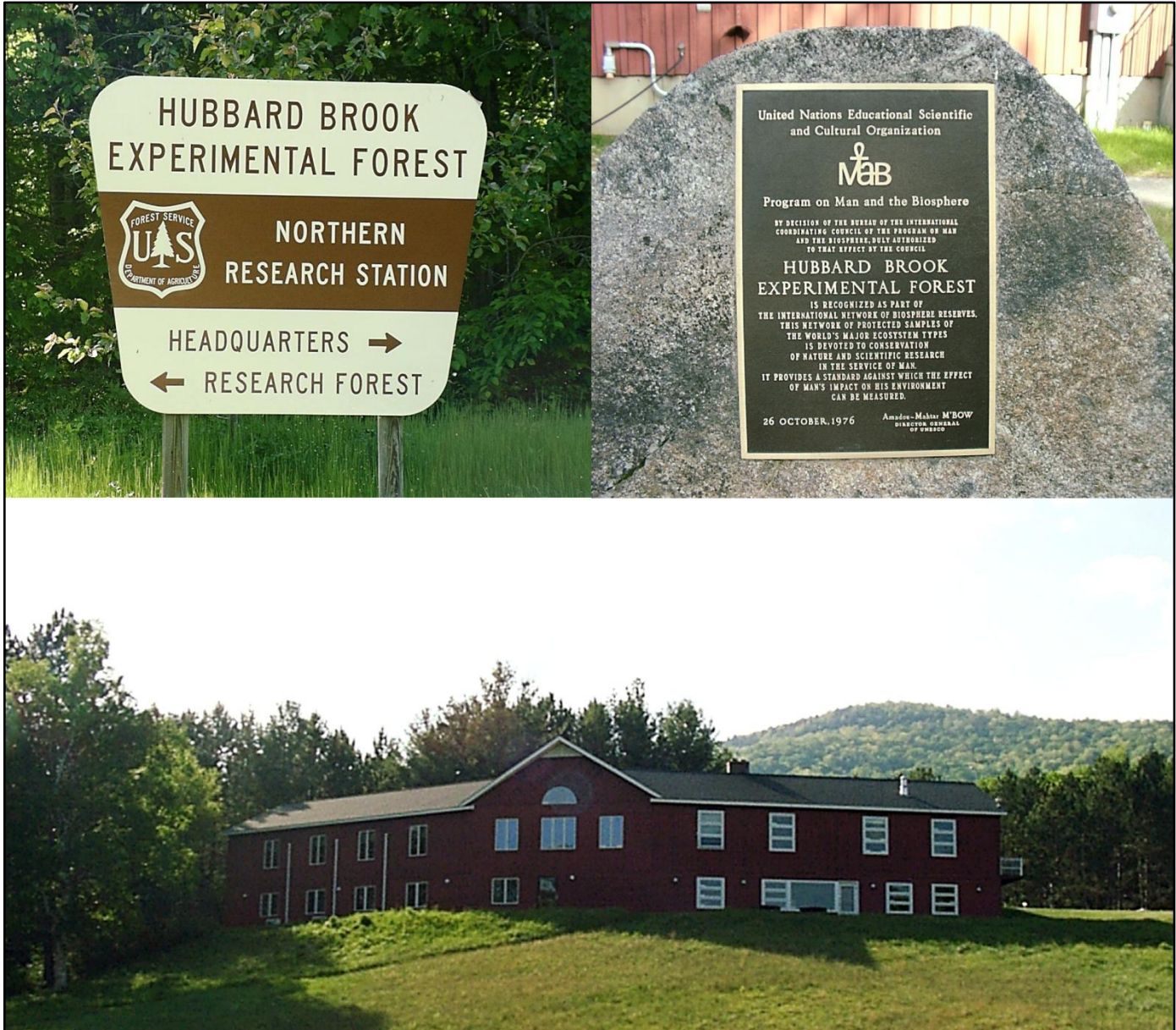
- Major Roads
- Hubbard Brook
- White Mountain National Forest
- New Hampshire



Hubbard Brook Experimental Forest [[External Link](#)], established in 1955 in Thornton, NH, is recognized worldwide as a premier ecological research site. It was here that the small watershed approach to studying the environmental impact of various activities was first pursued and that acid rain was first recognized as a major environmental problem in North America. Hubbard Brook is also a member of the Long Term Ecological Research network [[External Link](#)].

Hubbard Brook is located within the White Mountain National Forest [[External Link](#)], and primary and ultimate responsibility for site administration lies with the USDA Forest Service through the Northeastern Research Station [[External Link](#)]. However, the Forest Service works cooperatively with researchers from a

variety of institutions to promote and manage research activities at the site. The Hubbard Brook Research Foundation [[External Link](#)] also works to promote and sustain the Hubbard Brook Ecosystem Study.



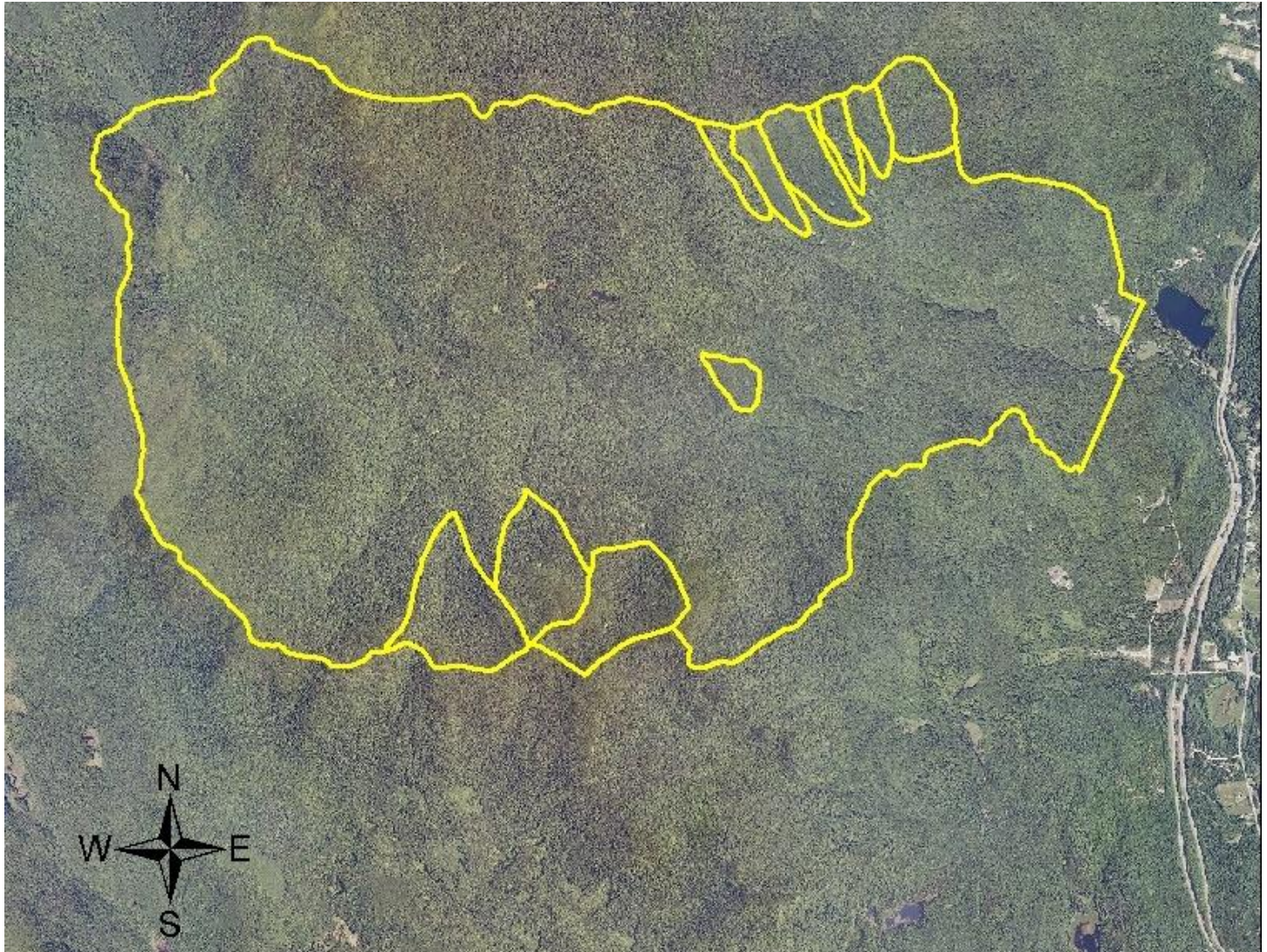
*Top Left: Sign at the Entry to Hubbard Brook Experimental Forest; Top Right: Plaque from the United Nations recognizing Hubbard Brook Experimental Forest as part of an International network of biosphere reserves; Bottom: Robert S. Pierce Ecosystem Laboratory.*

Science classes at Plymouth Regional High School [[External Link](#)], which serves the town of Thornton, have a long history of visiting Hubbard Brook Experimental Forest (HBEF) to tour the forest and learn about the ecological research and long term monitoring activities that occur there. This past year, it was discovered that although many of the institutions that conduct research at Hubbard Brook use GIS software, the Forest Service employees on site did not have access to GIS or even basic maps of the forest and monitoring stations that could be provided to researchers who wished to submit research proposals, or to the press who wished to utilize them when publicizing the results of the research at Hubbard Brook. As Plymouth Regional High School has a school site license for ESRI's ArcGIS software and the Environmental Science class each year completes a culminating project utilizing GIS, this seemed a golden opportunity to provide a small service to Hubbard Brook while giving our students the opportunity to work on a real world project that would have lasting impact.



Hubbard Brook Experimental Forest was established in 1955 primarily for hydrological research and consists of a 3,037-hectare valley and surrounding hills with elevations ranging from 222 meters to 1,015 meters. Forest cover consists largely of northern hardwoods, with spruce-fir at high elevations as is typical for the region. The last commercial logging operations occurred prior to 1920 when it became part of the White Mountain National Forest. Some of the special features of the area that make it ideal for ecological studies are clusters of similar-sized small watersheds with well defined boundaries, relatively impermeable bedrock, and fairly homogeneous geologic features, soil types, and climate.

## Hubbard Brook Experimental Forest Watersheds

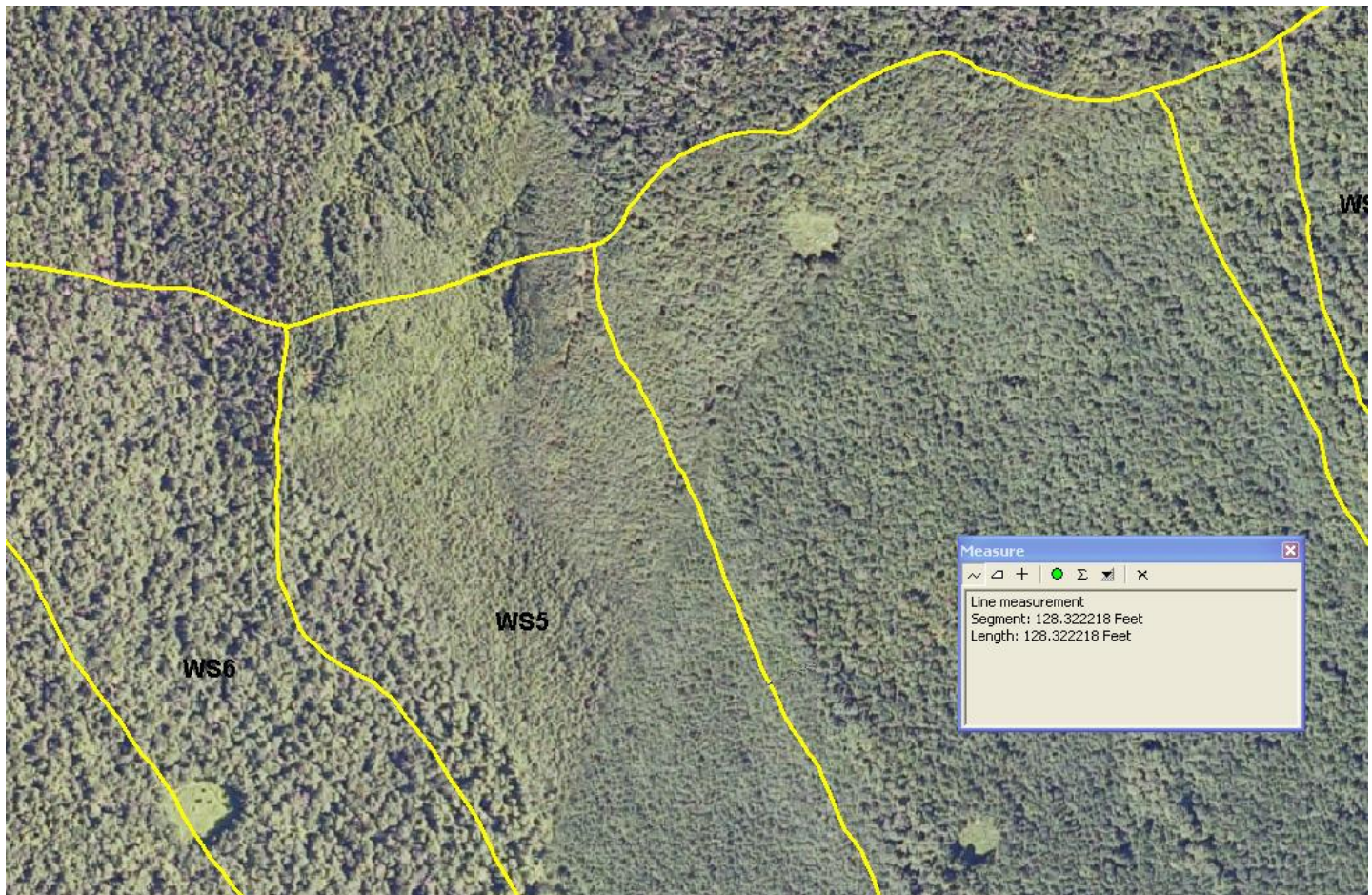


*This map shows the outline of Hubbard Brook Experimental Forest and the sub-watersheds used as experimental and reference watersheds.*

A variety of Hubbard Brook data has been digitized and is available as GIS files [[External Link](#)]. One of the GIS layers available is the watershed boundaries file shown above. The abstract from the metadata for this layer, indicates: "Diazo copy of Hubbard Brook Watershed Map generated stereophoto-grammetrically based on May, 1956 aerial photography. Shows New Hampshire state plane coordinate system reference points which were projected into UTM Zone 19 and used as reference tics. The watersheds boundaries were delineated on a paper diazo copy of the Hubbard Brook Watershed Map supplied by Wayne Martin and manually digitized." Although at the scale shown in this picture, the watershed boundaries look fine, when zoomed in to the experimental watersheds shown in the northeast corner, some discrepancies can be observed. Several of these watersheds have been cut at various times as part of the experimental studies, and



as noted in the image below the boundary lines fail to match up with the change in vegetation that can be observed in the aerial photograph. There are a number of possible causes for this discrepancy. It could be that the original watershed boundaries drawn on the paper map did not exactly match decisions made in the field as to the boundaries when the watershed were cut. A second possible cause could be an improper transformation from NH state plane coordinate system to UTM Zone 19. As a result of this, it is recommended that the watershed boundaries file be updated. This could be accomplished either through the use of the new data gathered via LIDAR or by fieldwork with the Trimble GPS unit that Hubbard Brook has available, or a combination of both.



*Close up of watershed delineation over the aerial photograph. In the GIS file, Watershed 5's eastern boundary is approximately 128 feet off from the actual boundary as can be observed from the change in vegetation. Also, the clearing in watershed 6 at the lower left, appears to penetrate into watershed 7, when it is actually totally contained in watershed 6.*

Another GIS file that could use updating is the Buildings layer. This file consists of point data for each building in the area, which was generated from the same 1956 aerial photograph as the watersheds. The points also lack any attribute information, and no distinction is made between buildings associated with Hubbard Brook Experimental Forest, Hubbard Brook Research Foundation or those privately held by citizens who live adjacent to the forest. As part of this Community Atlas project, the buildings layer was partially updated. A separate file was created for those buildings associated with Hubbard Brook, and information on the identity and ownership of each building was added. Newer buildings that were visible in the 2009 NAIP imagery, such as some of the Mirror Lake Hamlets, were also added to the file. As some of the buildings are not visible under the forest cover, it is recommended that a GPS unit be used to obtain precise positional locations on those buildings, and then they be added to the file.

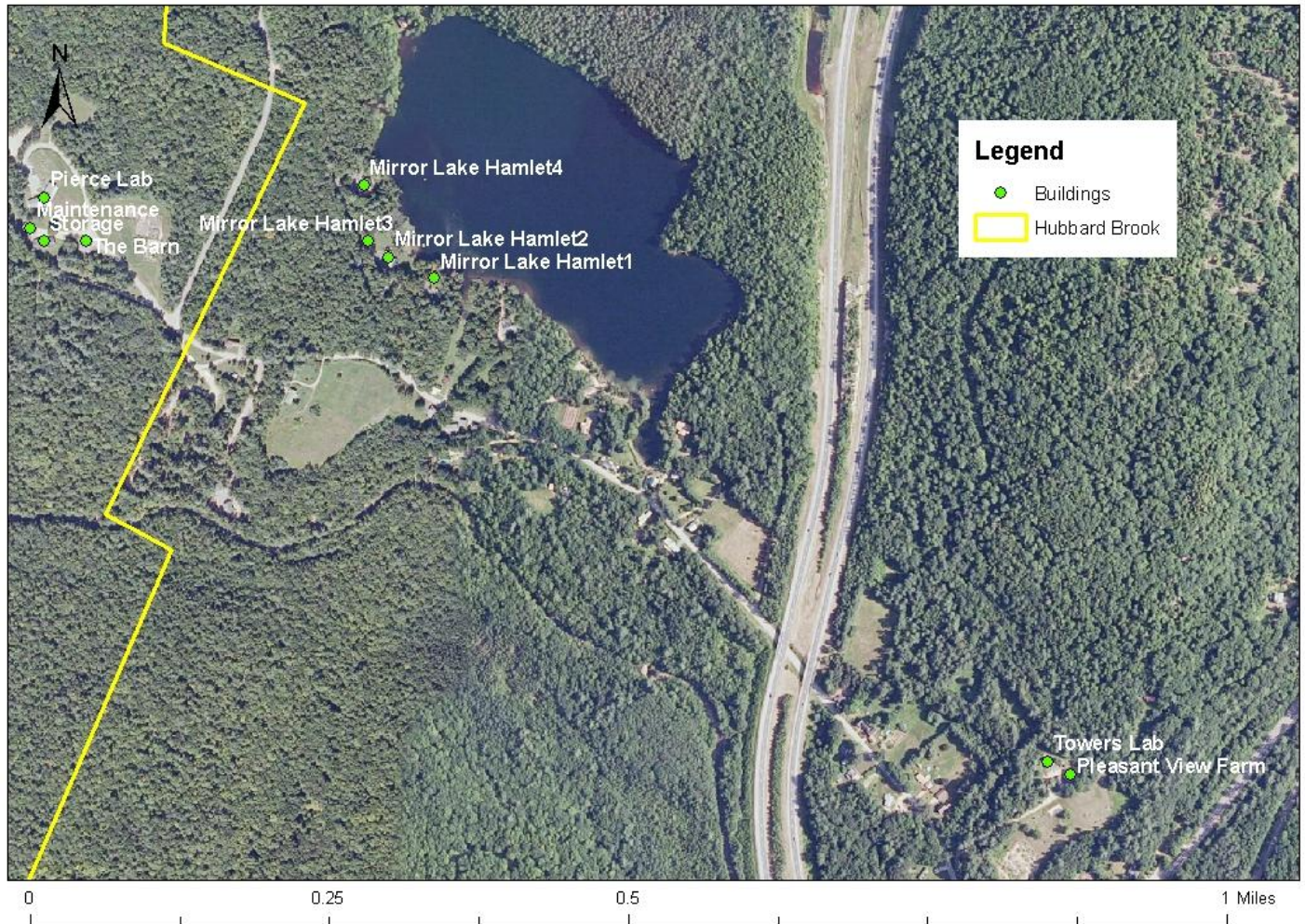




*Buildings GIS Layer imposed over the aerial photograph. Although generally the buildings are showing in the correct locations, there are many new buildings that are not shown (such as the maintenance and storage sheds at the southwest corner of the field, below Pierce Lab). In addition, certain buildings no longer exist (such as the old farmhouse which would be located in the field below Pierce lab).*

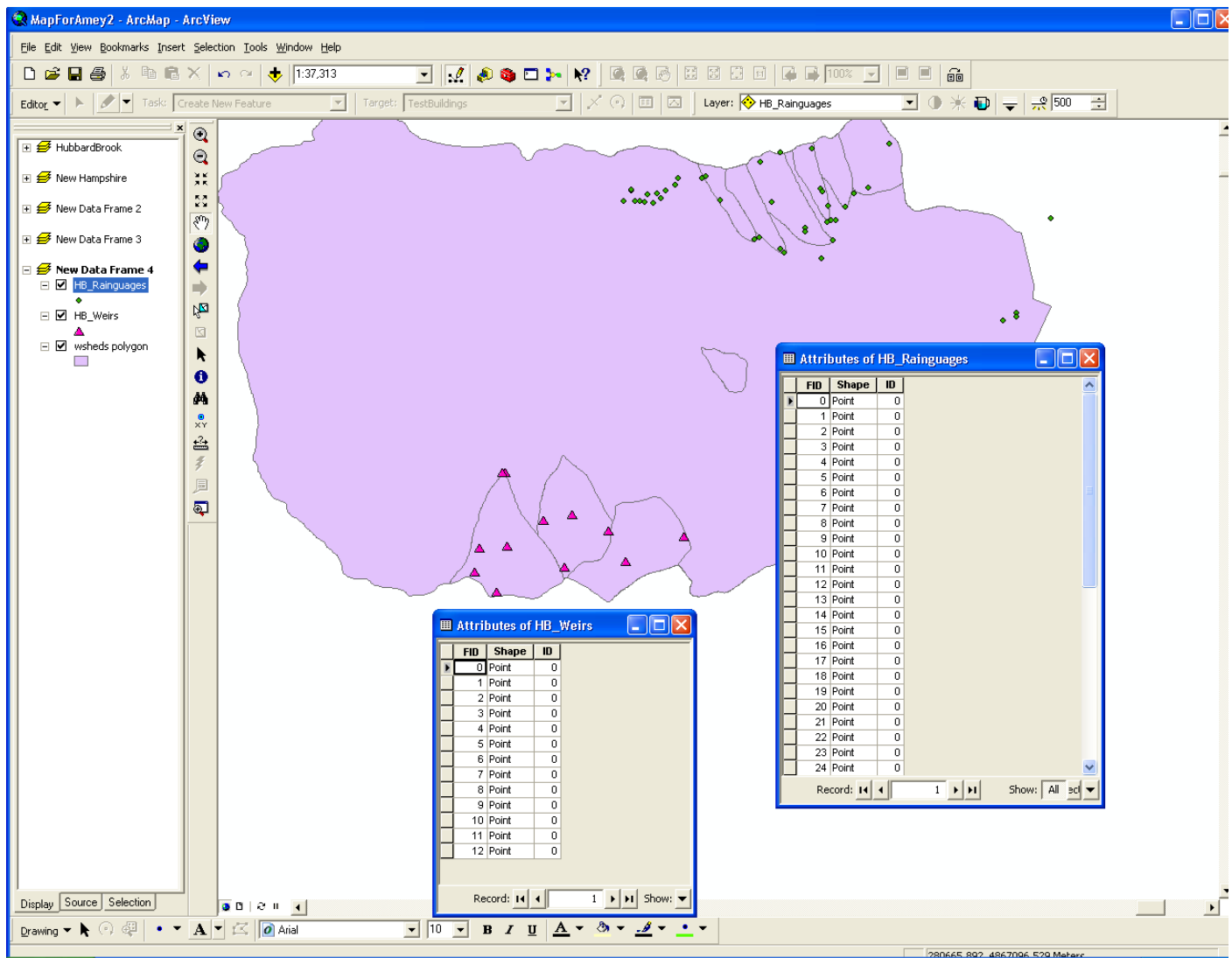


## Hubbard Brook Site Facilities



*This map shows a revised building layer containing only facilities associated with Hubbard Brook. In addition, the file has had appropriate attribute information added to identify both the building and its ownership.*

As in the case of the watershed and buildings layers, the locations of the rain gages and weirs on the watersheds had also been manually digitized based on the 1956 aerial photograph. At some point during the last few years an attempt was made to collect updated and improved data on the locations of these features through the use of the Trimble mapping quality GPS unit available at Hubbard Brook. The files created as a result of this work are shown in the image below. Unfortunately, no attribute information is associated with each point. Either the information was not collected, or somehow was not transferred into the GIS file when the GPS points were downloaded from the Trimble unit. One of the files is identified as HB\_Raingauges, but actually contains points for all features for the south facing watersheds shown near the top of the image. The second file is identified as HB\_Weirs, but actually contains points for all features for the north facing watersheds shown near the bottom of the image. The two different files actually just represent two different days of data collection at two different sites.

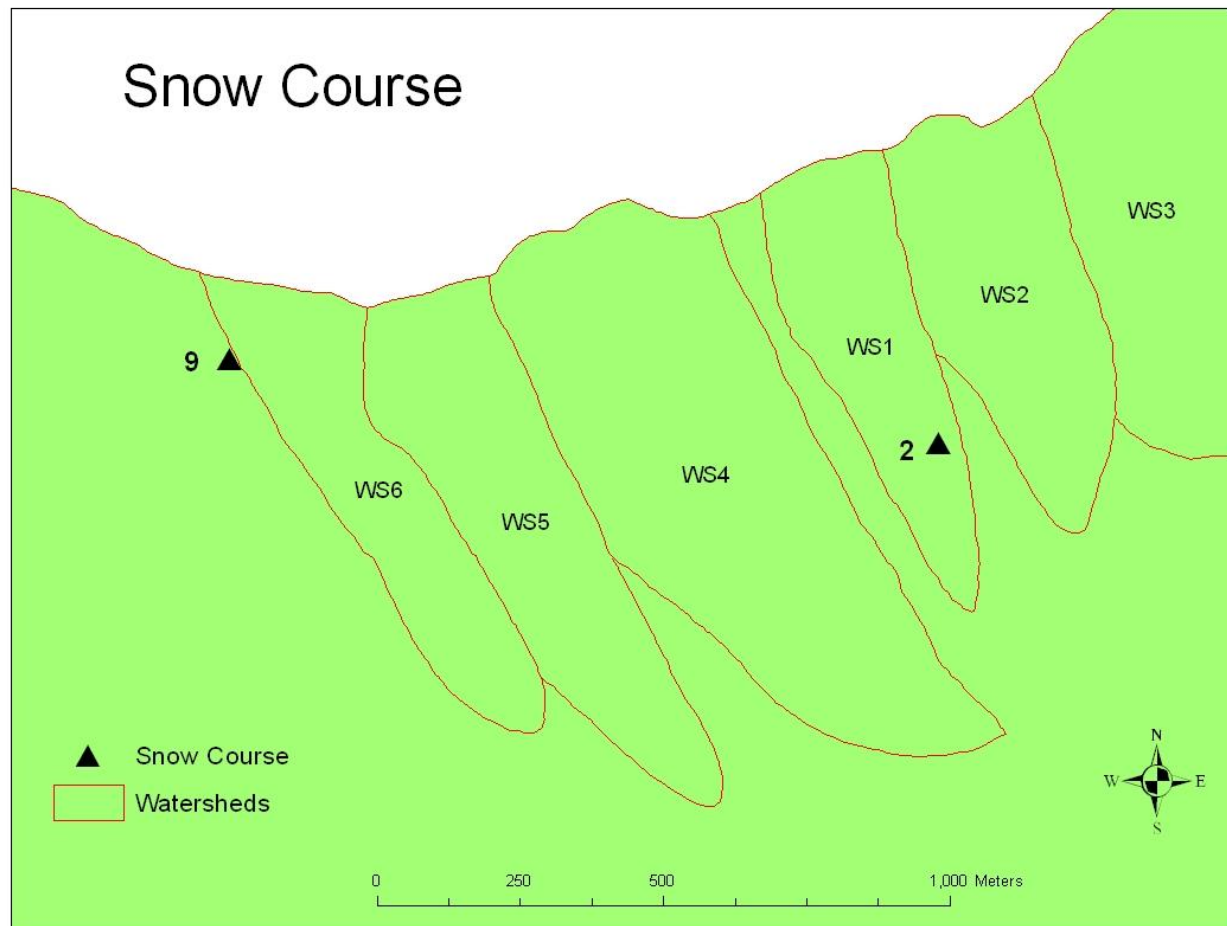


Screen Grab showing the Hubbard Brook Experimental Forest and the new GPS points collected with the Trimble GPS unit. Although one of the files is called HB\_Weirs and the other HB\_Raingauges, they actually represent two different days of fieldwork, and each file contains points for a variety of feature types. Unfortunately, the attribute information on the points was either not collected, or not transferred from the GPS file to the GIS file.

Fortunately, all was not lost as Amey Bailey, US Forest Service Technician, visits each of these sites at least weekly to collect data and samples. Being intimately familiar with the site locations, she was able to identify the features present at each point. Working with the students, a code sheet was created to identify each point (see table below). For many of the points, more than one measurement is made at the site, so duplicate points were created to allow for this. Once the data was properly attributed, the basic maps that were one of the primary project goals could be created. Unfortunately, the discrepancy between the new data and old watershed boundaries made it appear that the Weirs were often located outside the watersheds! As this would not be useful for the purposes of making the basic maps that the USFS desired, it was decided to use the old weirs and rain gages for this project for the south facing watersheds. However, the new attributed files are available for use once the watershed boundary files have been updated. Two of the basic maps are shown below, and more can be seen in *Hubbard Brook: An Overview of a World Renowned Ecological Research Site*, the second Community Atlas project submitted this year.

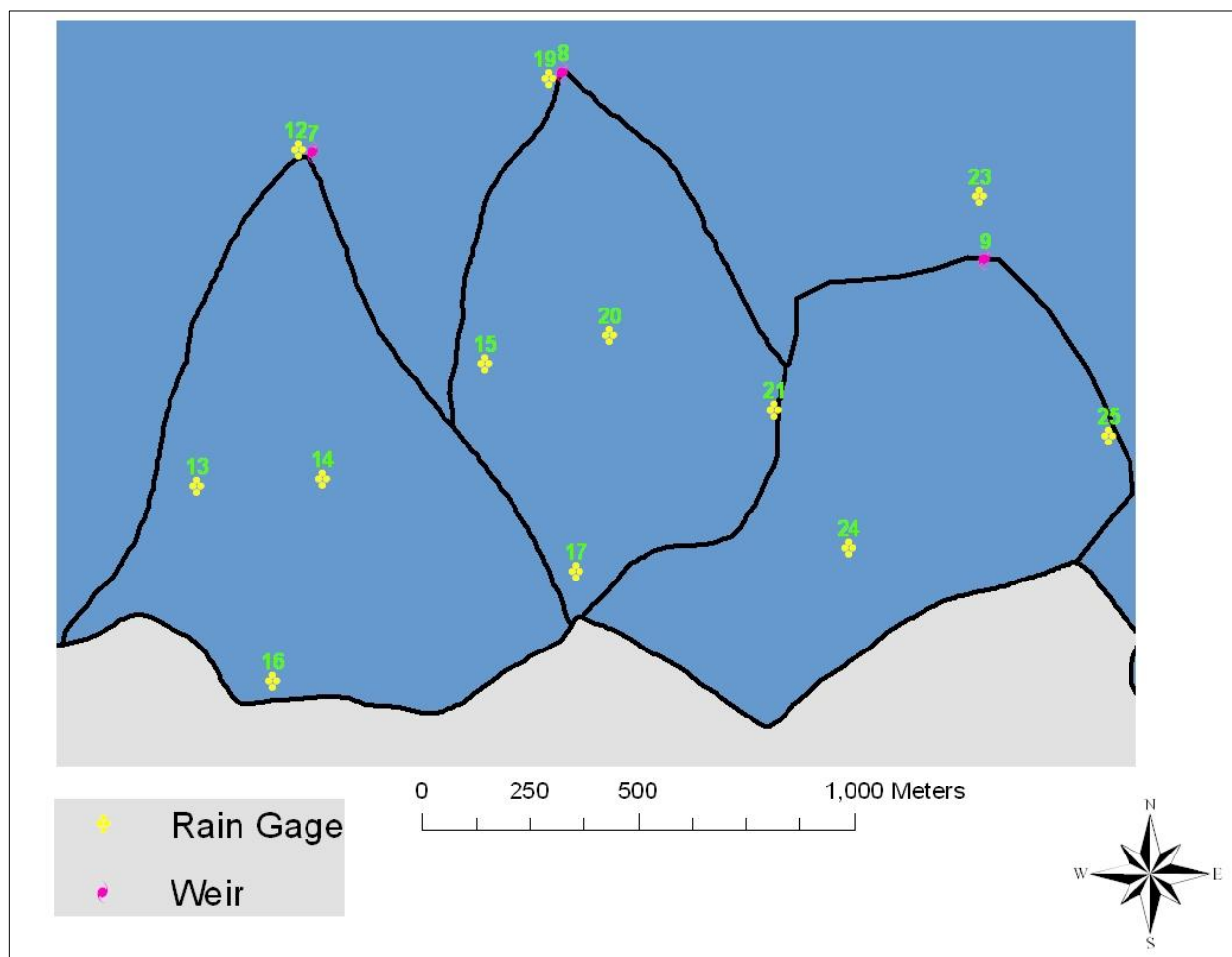
### Code Sheet

Rain Gauge	RG
Snow Course	SNO
Phenology	PN
Soil Frost	SF
Weirs	WRS
SCANS	SCN
Air Temp	AT
Precipitation	PRC
Hourly Met Data	HMD
NADP	
Standard Can	SC
Cast Net	CASTNT
Old tower site	OLDTWRSITE
SOIL TRENCH	ST



*A sample map showing the snow courses for the south facing watersheds.*

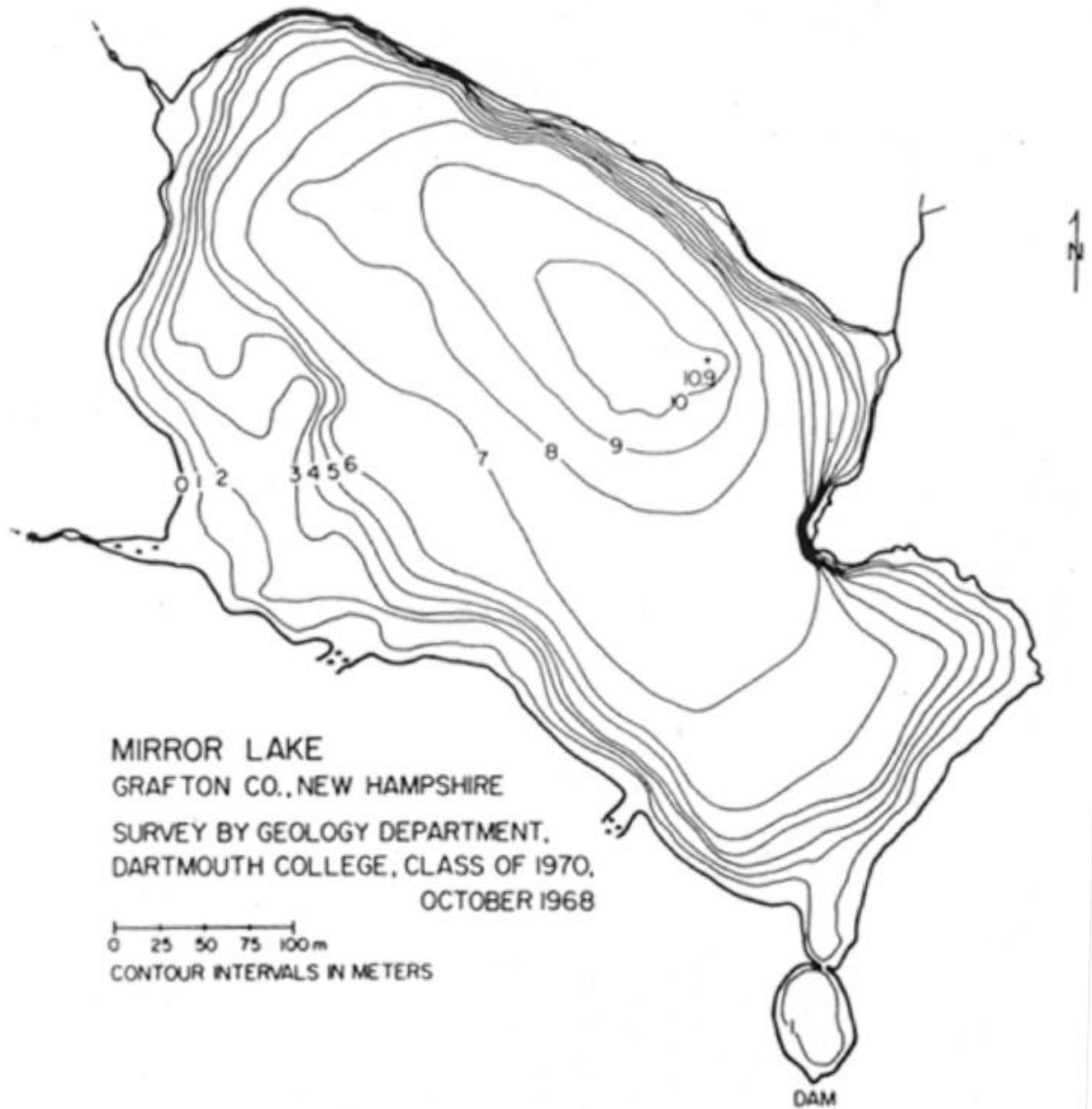




*A sample map showing the rain gages and weirs of the north facing watersheds.*

Although the available GIS files for Hubbard Brook could use some updating, additional data on Mirror Lake, located right outside the Hubbard Brook Experimental Forest and also used for research by the staff of Hubbard Brook, has not been digitized at all. Two examples of this are the bathymetry data for Mirror Lake, and the Mirror Lake watershed boundaries. In order to remedy this situation, paper copies of the maps were scanned and then georeferenced to the aerial photographs. Then the bathymetric contours and watershed boundaries were digitized from the scanned map.

# MIRROR LAKE

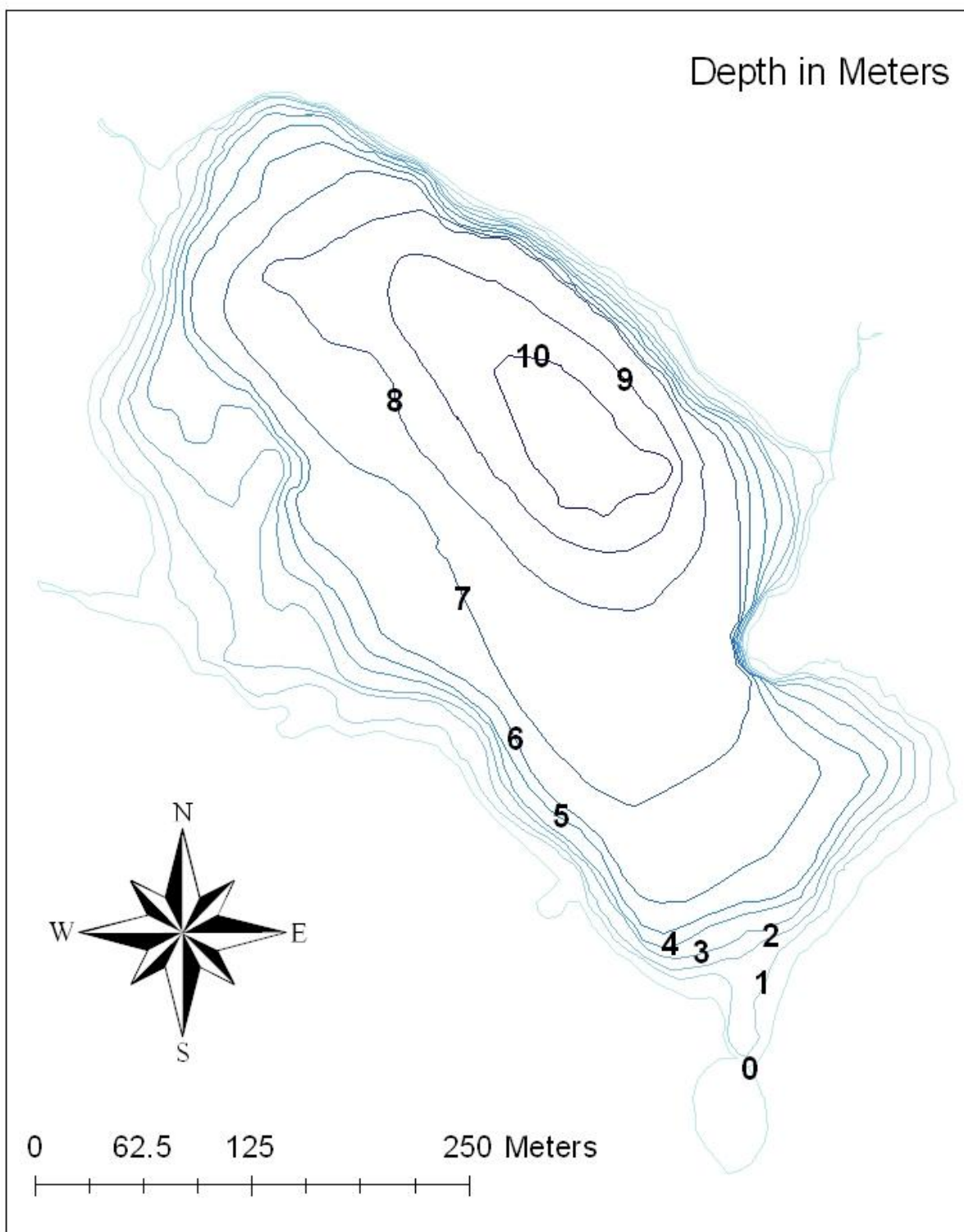


**Hydrographic map of Mirror Lake, New Hampshire.**

*Scanned image of bathymetric contours of Mirror Lake.*

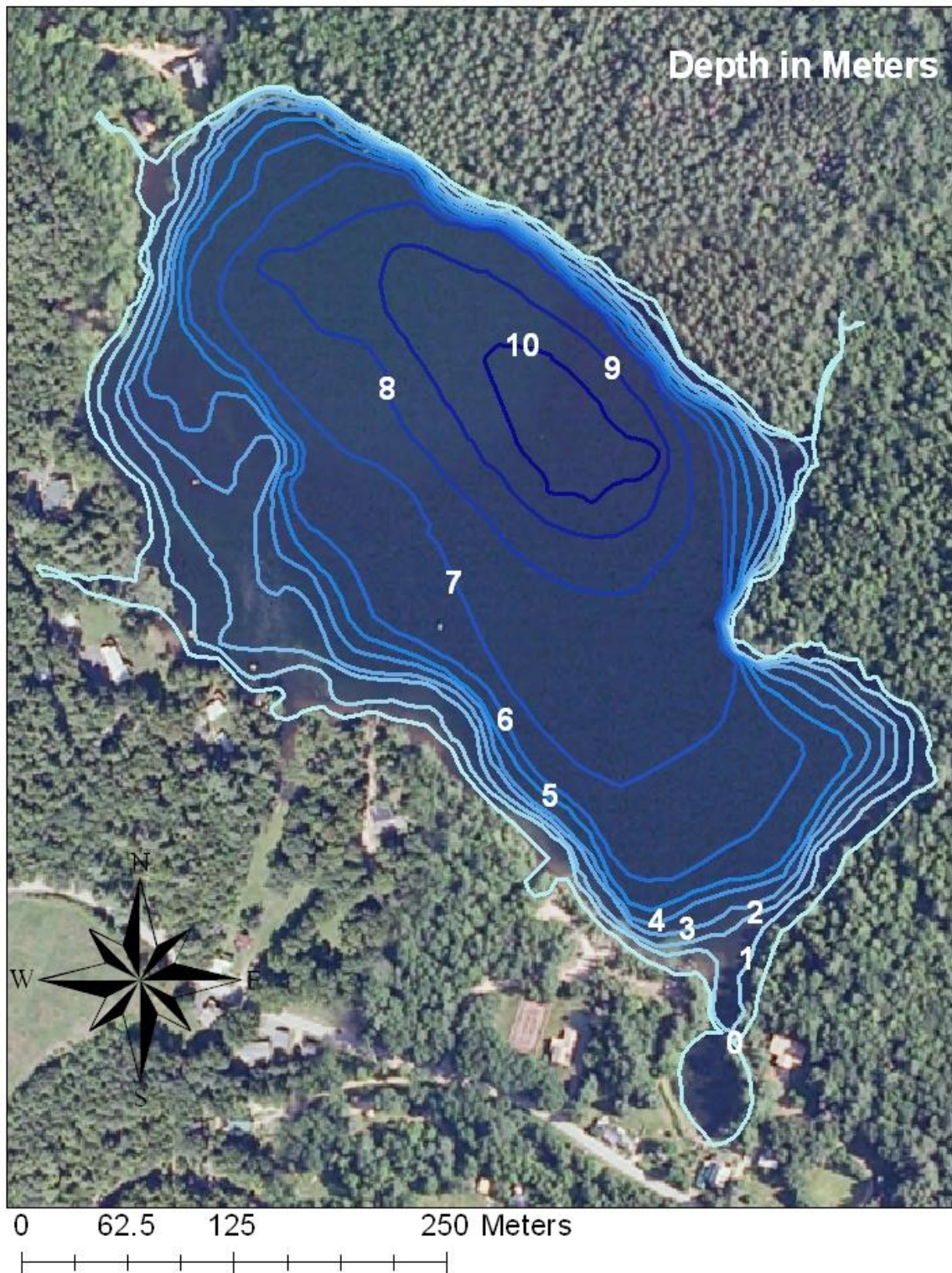


# Mirror Lake Bathymetry



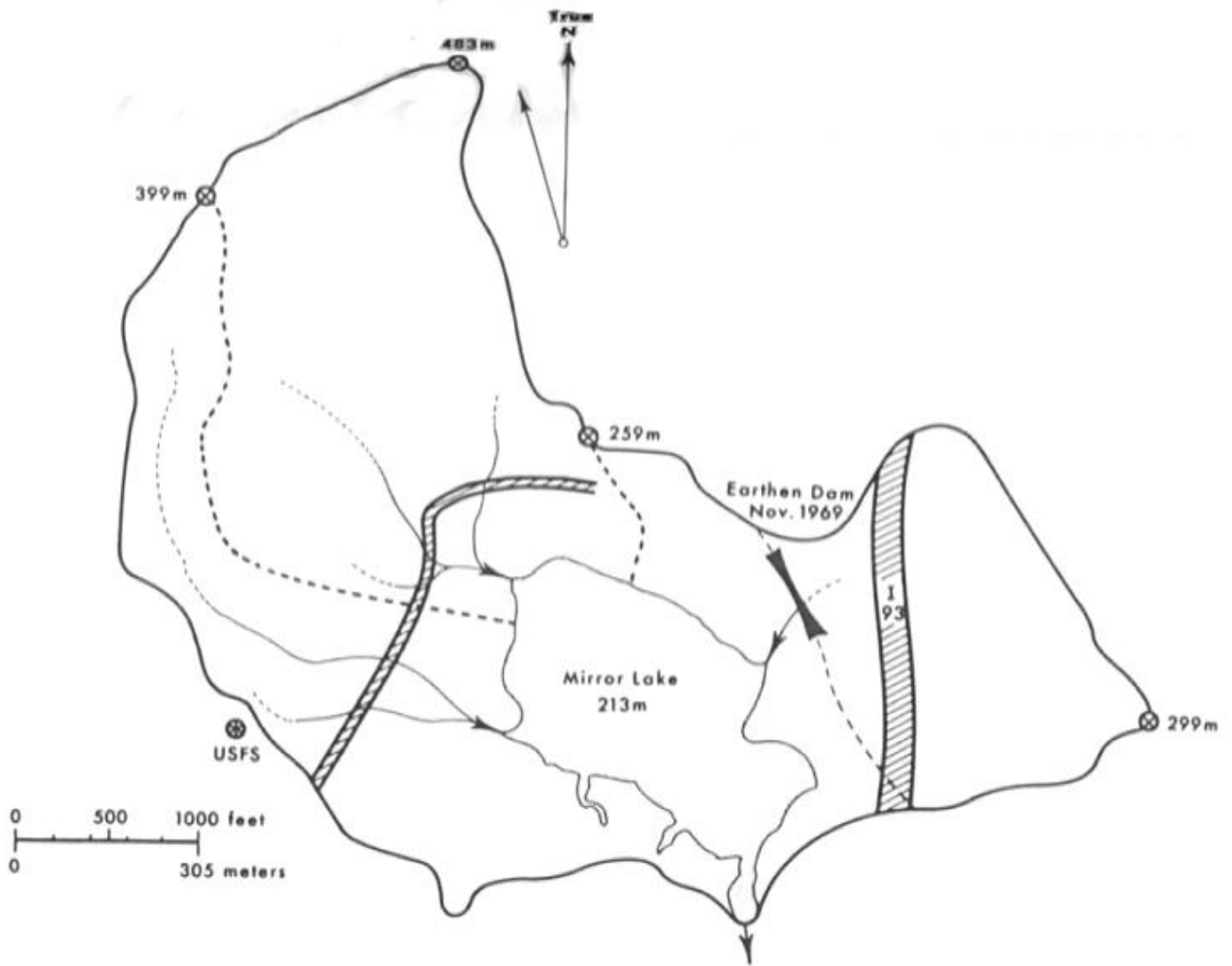
*Digitized bathymetric contours.*

# Mirror Lake Bathymetry



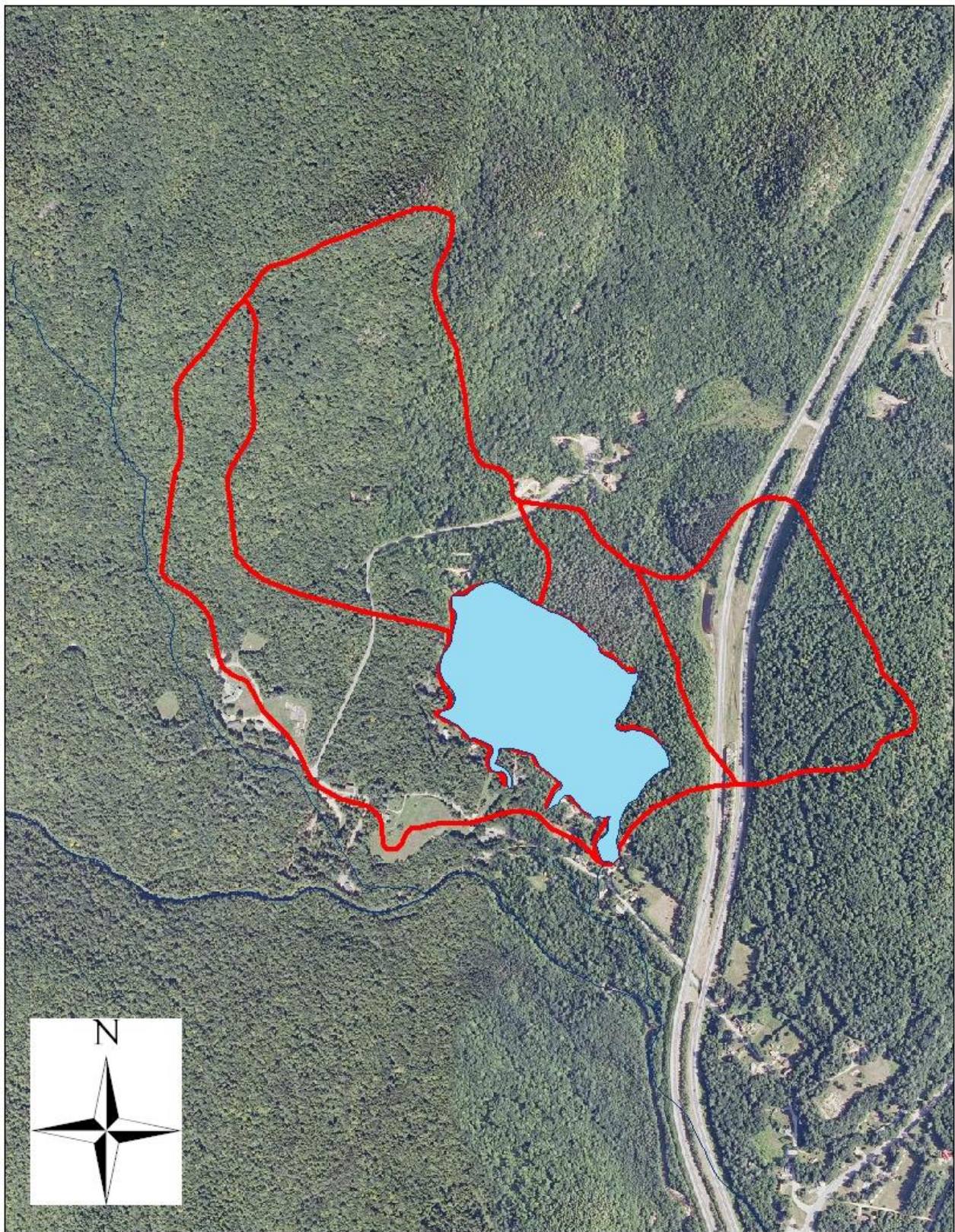
*Digitized bathymetric contours displayed over the 2009 NAIP imagery.*





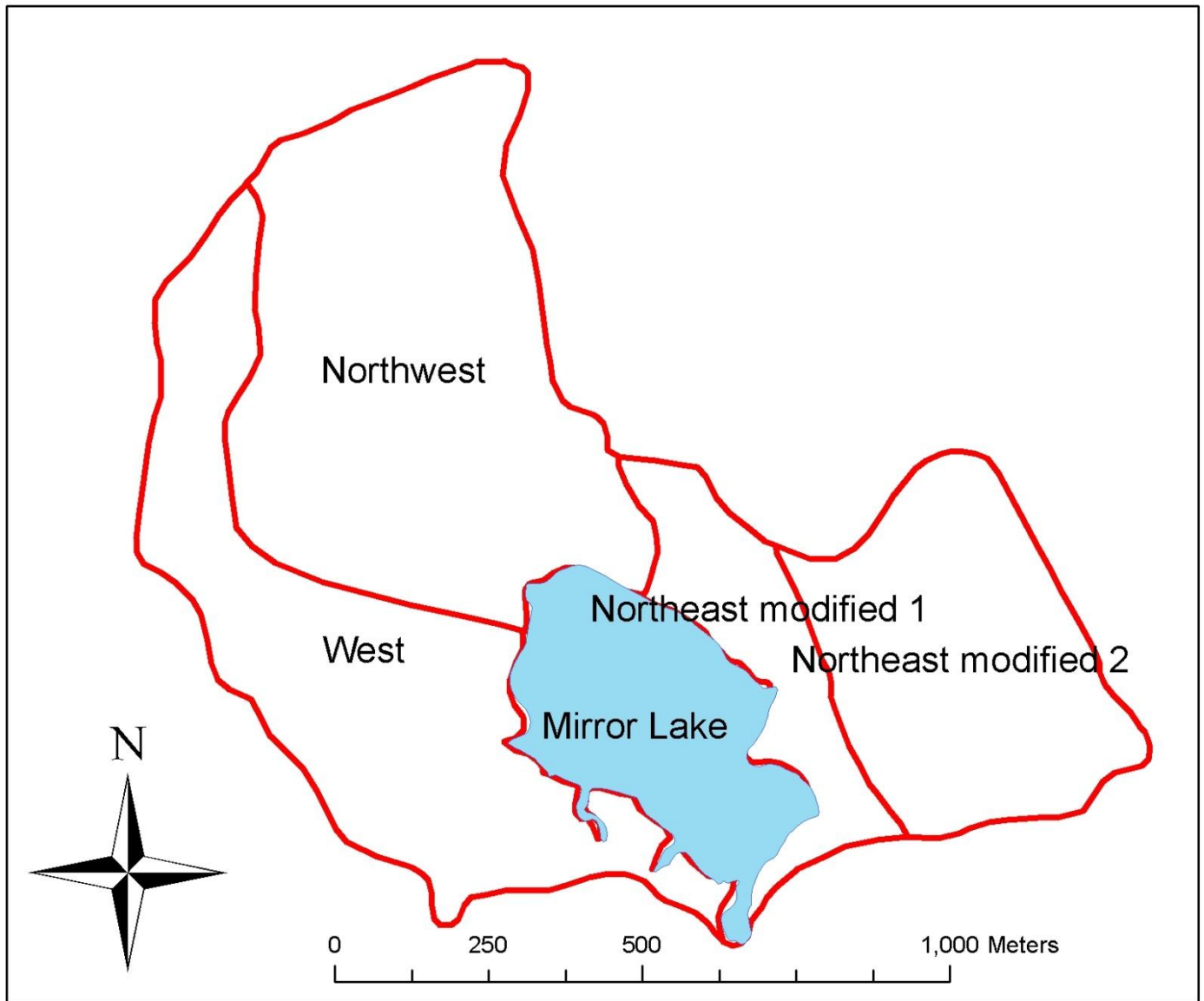
Scanned image of Mirror Lake watershed boundaries.





*Mirror Lake sub-watersheds over the 2009 NAIP imagery.*





*Labeled Mirror Lake sub-watersheds.*

#### **Data Sources:**

Hubbard Brook GIS data files (Hubbard Brook Watershed boundaries and Hubbard Brook Buildings) are used courtesy of the USDA Forest Service, Northeastern Research Station, Durham, NH

GPS points from the HB\_Raingauges and HB\_Weirs file are used courtesy of Chris Eager, Hubbard Brook Project Leader, USDA Forest Service, Northeastern Research Station, Durham, NH

2009 NAIP Imagery courtesy of US Department of Agriculture's Farm Service Agency.

**Project Assistance:**

- Amey Bailey, forest service technician at Hubbard Brook, devoted a great deal of time to working with our students to prepare maps and GIS files for the project.
- Geoff Wilson, Hubbard Brook Research Foundation technician, provided the students with a tour of Hubbard Brook as well as critiques of their maps.
- Don Buso, Institute of Ecosystem Studies Technician; Chris Eager, Project Leader for the US Forest Service; and Adam Finkleman, graduate student at Plymouth State University's Center for the Environment all provided information utilized in the project.
- Rebecca Lilja, GIS specialist for the US Forest Service and Shane Bradt, Geospatial Extension Specialist at UNH Cooperative Extension also provided assistance and answered questions.

A special thank you to all for your assistance, time, and patience!