1-1-2002

A GIS Approach for the Abandoned Mine Inventory with Haul Roads of the Monongahela National Forest to Provide a Comparative Analysis of USFS/USACE Collection Procedures and Image Basemap Selection for Cartographic Representation

John R. Ferguson II
jrferguson77@yahoo.com

A GIS APPROACH FOR THE ABANDONED MINE INVENTORY WITH HAUL ROADS OF THE MONONGAHELA NATIONAL FOREST TO PROVIDE A COMPARATIVE ANALYSIS OF USFS/USACE GPS COLLECTION PROCEDURES AND IMAGE BASEMAP SELECTION FOR CARTOGRAPHIC REPRESENTATION

Thesis submitted in partial fulfillment of the
Requirements for the degree of
Master of Science in the Physical Science of
Geobiophysical Modeling

By

John R. Ferguson II
Marshall University

12 July 2002

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ACKNOWLEDMENTS

The author would like to thank the U.S. Army Corps of Engineers for the use of their mapping software, Arcview 3.2a (ESRI, 1996) and providing data for completing the GIS database. Individually the author would like to thank H. Steve Brewster and Steve S. Spagna from the U.S. Army Corps of Engineers, for their contributions and support. Additionally, the author would like to acknowledge Dr. James Brumfield and Marshall University for providing insight and education for the completion of this thesis. And finally, thanks to committee members, Dr. Ralph Oberly and Dr. Dewey Sanderson, without whose support, the completion of these degree requirements would not have been possible.

ABSTRACT

The Monongahela National Forest spans 10 counties in eastern central West Virginia. It has been an area of high mining and timbering activities throughout much of the early to mid twentieth century. As a result, the United States Forest Service (USFS) has focused reclamation and remediation efforts on the abandoned mine land areas. Much of the area has been subjected to mining after effects such as acid mine drainage, structural remains, gob/spoil piles, garbage piles, mine portals, and highwalls. In 1998 the USFS contracted with the U.S. Army Corps of Engineers (USACE) to locate these mining remains and provide a detailed georeferenced inventory with a Global Positioning System (GPS) as the primary means of data collection. This included Universal Transverse Mercator (UTM) coordinate locations for each feature along with such descriptors as the pH level, oxygen content, temperature, and size of each pond, as well as 3-dimensional descriptions of the additional encountered features. A geobiophysical model containing the abandoned mine land features will provide the information necessary for appropriate steps toward reclamation and restoration of the area.

In order to provide a more comprehensive and detailed summary of all the located features, the completion of this research implemented current inventory practices of importing all collected data into a Geographical Information System (GIS) which was Arcview 3.2a (Environmental Systems Research Institute, Inc., 1996). These current procedures, which were not used on the Monongahela National Forest data prior to this research, require the use of scanned, georeferenced, Digital Raster Graphic (DRG) United States Geological Survey (USGS) topographic maps, at a scale of 1:24,000, as requested by the USFS. These maps, however, contain outdated information and, in addition, digital revisions cannot be made without recreating the entire paper map. The primary objective of this research creates a GIS database infrastructure for the Monongahela National Forest inventory using USGS Digital Orthophoto Quarter Quadrangles (DOQQ's) as an image base map to allow for more current geobiophysical modeling and an easily updated data management tool. The completion of the research objectives will provide insight for the collection procedures of future inventories and related products, as well as demonstrate the technologies available through the implementation of a GIS.

CHAPTER 1 INTRODUCTION

Background

The abandoned mine inventory conducted in the Monongahela National Forest in 1998 by the USACE encompassed an estimated 24,000 acres, as determined by the two-man survey team of Steve Spagna, P.G. and Paul Dean, P.S. This crew used Trimble GeoExplorer II (Trimble, 1996b) Global Positioning System to collect the feature locations in the North American Datum of 1927. In association with this, descriptions of the features were recorded and water quality data was collected where applicable (see Appendix II). The inventory data was collected and stored in spreadsheet format for distribution to the USFS. A second inventory of abandoned mine lands, conducted in the Wayne National Forest, southern Ohio, has been completed as of the time this thesis was written. This second inventory used Geographic Information System (GIS) technology to overlay inventory feature data on to digital USGS topographic maps (see Appendix I). A discussion and demonstration in a Geographic Information System of the use of these USGS Digital Raster Graphic versions versus Digital Orthophoto Quarter Quadrangle maps for this type of work as it relates to the Monongahela National Forest, along with current inventory collection procedures and GIS encoding, is the focus of this research. The research foundations for development are discussed in the following sections.

Global Positioning System

A Global Positioning System is a world-wide, 24-hour, all weather satellite based positioning system that is operated by the U.S. Department of Defense (DOD). These systems can collect exact coordinates for any position on earth by a series of calculations involving measurements from a group of satellites to the desired position (Trimble 1996a). The location of one satellite puts the location of the position along a sphere surrounding the satellite. The addition of a second satellite increases the point location accuracy and narrows the location to an area within the intersection of two spheres, each surrounding their own satellite, respectively. In accordance, a third satellite continues to increase the point location accuracy by narrowing the position to two points of which one is out in space and is an unrealistic location. The intersection of the area within the first two spheres with a third sphere forms the two possible point locations as seen in Figure 1 below. Four satellites are needed to find an unknown X, Y, Z point location; this narrows the desired location to 1 point (Trimble 1996a).

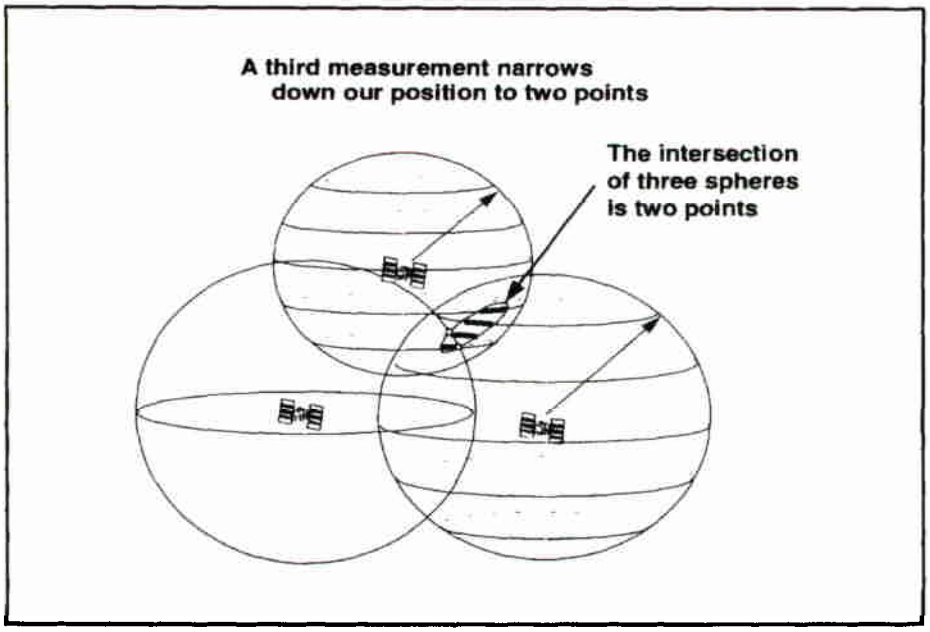


Figure 1 A representation of 3 Satellites from Trimble, 1996a.

An accurate representation of 3-dimensional positions requires a 3-dimensional surface to represent the earth. The most common surface used to represent the earth is a geoid (DOD, 2000; Higgins 1999). The best-fit model that accurately portrays this surface is an ellipsoid (Figure 2) (Trimble 1996a), which is a geometric or mathematical reference shape (DOD, 2000). The reason for an ellipsoidal representation versus a spherical one is that the actual shape of the earth is an ellipsoid due to distortion along the earth's axis caused by rotation. The difference was 21.5 km between the equatorial and polar radii (USGS, 1999). GPS receivers use the ellipsoidal shape to accurately depict positions on the earth. The location of a point on this ellipsoid changes from place to place based on the relative center of the Earth's mass. As a result, many ellipsoid models have been created; however, the WGS 84 Ellipsoid and the Geodetic Reference System of 1980 (GRS-80) ellipsoid has been chosen for GPS collections (DOD, 2000; Trimble, 1996a). A datum is a mathematical model that describes the shape of the earth (USGS, 1999). It has been created to incorporate the GRS-80 ellipsoid and is called the World

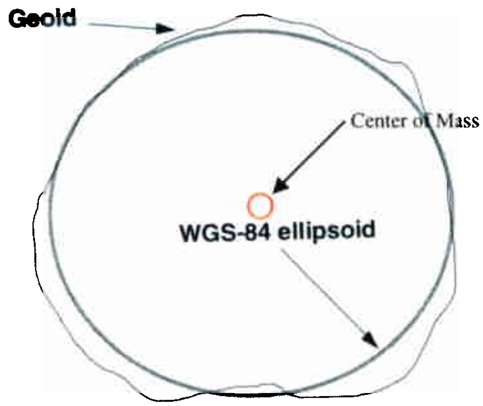


Figure 2 The WGS84 ellipsoidal model, based on satellites, with the geoid based on a mathematical representation of the earth, i.e. Clark 1886 Ellipsoid (NAD27 based) from Trimble, 1996a.

Geodetic System 1984 (WGS-84) (Trimble, 1996a). Calculations involved in the development of the North American Datum of 1983 (NAD83) are essentially the same as those used on the WGS-84 measurements and for all practical purposes are the same (Trimble, 1996a). Within the United States, these newer datums have replaced the widely used North American Datum of 1927, which was based on the Clarke Ellipsoid of 1866 (USGS, 1999). USGS topographic maps were created using this older datum of 1927. Subsequently, the USGS DRG's were scanned and georeferenced using NAD27. More recently, this USGS mapping product has been digitally reprojected to the more accurate NAD83 to make it more compatible with DOQQ's and satellite imagery.

USGS Digital Maps: DRG's

The USGS created its first topographic map in 1879 and has since created more than 54,000 maps (USGS, 1998a). The topographic maps have since become the most widely used maps and are most distinguished from other map types through the use of contour maps which show elevation and add a 3-dimensional effect to the paper maps (USGS, 1998a). These maps were created at a scale of 1:24,000 and represent 7.5

minutes of latitude by 7.5 minutes of longitude and are thus referred to as 7.5-minute quadrangle maps (USGS, 1998a). Along with the contour lines, the maps include such details as schools, churches, cemeteries, campgrounds, ski lifts, and fence lines (USGS, 1998a), along with houses, pipelines, and government boundaries, such as forest land. The USGS DRG's meet U.S. National Map Accuracy standards, at the 1:24,000 scale, of 90% of the tested points falling within 12.19 meters (1/50 inch) (USGS, 2002). Revisions made to these must be at least equal to the previous version and all features should match within 22.25 meters/73 feet of those on a DOQQ (Moore, 2000). In 1995 the USGS, in association with the Land Information Technology Company, Ltd., initiated a program to scan all USGS standard maps, including the 7.5-minute topographic maps. From 1995 to 1998 these Digital Raster Graphic (DRG) maps were produced at a scan resolution of 250 dots per inch (dpi) (USGS, 2002). As of October, 2001, all DRG revisions will have scan resolutions of 500 dpi (USGS, 2002). The DRG coverage does not cover the entire conterminous United States, as areas in California and Tennessee were created by separate agencies, California Spatial Information Library and Tennessee Valley Authority, respectively (USGS, 2002).

The DRG's have been projected, in a consistent manner with other USGS data, on Universal Transverse Mercator (UTM) projection. The UTM was developed in 1947 and was used by the military to project data on large-scale maps. Although most USGS 7.5-minute paper maps are projected on the Lambert and Transverse Mercator projections of the State Plane Coordinate System, the reason for the conversion for DRG maps to UTM was to create a universal projection system for all digital data (Moore, 1997). A projection is a device used to convey a map or geospatial database, which is flat, onto a curved surface, which often causes some distortion (USGS, 1999).

USGS Digital Maps: DOQQ's

A Digital Orthophoto [Quarter] Quadrangle (DOQQ) is a computerized image of an aerial photograph which combines the characteristics and quality of an image with the geometric qualities of a map (USGS, 1998b) using color infrared (CIR) photography as a source (Moore, 1997). It refers to a 1-meter ground resolution quarter quadrangle representing 3.75 x 3.75 minute area (USGS, 1996a), although most DOQQ's have overlapping edges to allow for edge matching and mosaicking, the amount of which differs between DOQQ (USGS, 1996b), from 50 to 300 meters (USGS, 1995). The DOQQ is created by scanning an aerial photograph transparency, taken at an altitude of approximately 20,000 feet above the mean terrain through the use of a 152-millimeter focal-length camera (USGS, 1996a and Moore, 1997) during the leaf off period, usually in April for West Virginia, for deciduous trees (USGS, 1995). The aerial transparency (diapositive) is scanned using a precision image scanner and the scanned file is digitally rectified to an orthographic projection through the image processing of each pixel using photogrammetric space resection equations (USGS, 1996a). In order to produce the image, inputs such as ground control points from ground surveys or aero triangulation, conjugate photo-coordinates of these points, the parameters for camera orientation, and a digital elevation model (DEM) are required (USGS, 1996a). DOQQ's meet National Map Accuracy Standards, at a scale of 1:12,000, requiring that 90% of the well-defined points tested must fall within 33.3 feet/10.2 meters (1/30 inch/1/11.8 centimeters) (USGS, 1998b).

The USGS began production of the DOQQ's in 1991 and the program now totals more than 50,000 maps (USGS, 1998b). The program is expected to reach completeness by 2004 and will then be updated every 10 years, except in high land change areas where there will be a 5 year cycle (USGS, 1998b). The DOQQ's are projected using the UTM system on NAD83, and are being updated to WGS84, which is displayed in the accompanying header file (Figure 3) that also includes the date of the photograph, coordinates, primary and secondary datum, resolution and additional information (USGS, 1995). Primary uses for the DOQQ imagery include a common base map in geographical information systems to help locate, coordinate, and manage data, a tool for revising digital line graphs (DLG), as well as a basis for DRG revisions, and image processing applications, to name a few.

QUADRANGLE_NAME: SNYDER KNOB QUADRANT: NE
WEST_LONGITUDE: -79 56 15.000
EAST_LONGITUDE: -79 52 30.000
NORTH_LATITUDE: 38 37 30.000
SOUTH_LATITUDE: 38 33 45.000
PRODUCTION_DATE: 1999 11 30
RASTER_ORDER: left_right/top_bottom
BAND_ORGANIZATION: BIP
BAND_CONTENT: RED
BAND_CONTENT: GREEN
BAND_CONTENT: BLUE
BITS_PER_PIXEL: 8
SAMPLES_AND_LINES: 6155 7624
HORIZONTAL_DATUM: NAD83
HORIZONTAL_COORDINATE_SYSTEM: **UTM**
COORDINATE_ZONE: 17
HORIZONTAL_UNITS: meters
HORIZONTAL_RESOLUTION: **1.00**
SECONDARY_HORIZONTAL_DATUM: NAD27
XY_ORIGIN: 592183.000 4276082.000
SECONDARY_XY_ORIGIN: 592167.066 4275862.228
NATION: US
STATE: WV
NW_QUAD_CORNER_XY: 592488.585 4275699.111
NE_QUAD_CORNER_XY: 597929.241 4275763.950
SE_QUAD_CORNER_XY: 598014.200 4268828.442
SW_QUAD_CORNER_XY: 592568.821 4268763.635
SECONDARY_NW_QUAD_XY: 592490.933 4275491.994
SECONDARY_NE_QUAD_XY: 597931.728 4275556.835
SECONDARY_SE_QUAD_XY: 598016.684 4268621.468
SECONDARY_SW_QUAD_XY: 592571.168 4268556.660
RMSE_XY: 2.50
IMAGE_SOURCE: COLOR INFRA-RED FILM
SOURCE_IMAGE_ID: NAPP 10269-010
SOURCE_IMAGE_DATE: 1997 4 8
SOURCE_DEM_DATE: 1997 0 0
AGENCY: WESTERN MAPPING CENTER (WMC)
PRODUCER: WOOLPERT LLP
PRODUCTION_SYSTEM: INTERGRAPH ISPM, ISIR
STANDARD_VERSION: 1996 12
METADATA_DATE: 1999 12 1
DATA_FILE_SIZE: 140795625
BYTE_COUNT: 18465

Figure 3 Example header file that accompanies DOQQ (Snyder Knob NE.sid). Relative information has been highlighted

Geographical Information Systems

A Geographic Information System (GIS) is a powerful computer mapping system used as a tool for managing georeferenced information (ESRI 1998). The implementation of a quality GIS presents many advantages with regard to data management and the spatial distribution of information. One such advantage of this computerized mapping system is that the maps can be updated and maintained repeatedly, by anyone, with minimal effort (ESRI 1998). The use of a desktop GIS acts as a combination of standard mapping features such as "display-only, thematic, and street-based mapping" (ESRI 1998). A digital GIS creates presentation quality maps with relative ease and allows paper form data to be manipulated and displayed spatially. The power and flexibility of the desktop GIS allows data to be displayed as with paper maps, but with a more graphic, visual, and detailed representation of the real world.

Inventory Location

Monongahela National Forest

The Monongahela National Forest was established as a result of the 1911 Weeks Act, allowing for the purchase of land for protection of the watershed as well as the natural resources for the long-term. This Act was a result of the major timbering and clearing of the forests in the eastern United States during the late 1800's to the beginning of the 20th century. The initial purchase in 1915 was for 7,200 acres and was called the Monongahela Purchase until 1920 when it was decreed the Monongahela National Forest. Today the forest has grown to an impressive 909,000 acres throughout 10 counties in West Virginia (USFS, 2000). Primary focus, for this project, of the Monongahela Forest is within Greenbrier, Nicholas, Pocahontas, Randolph, Tucker, and Webster counties in eastern central West Virginia, (Figure 4), which is where the greatest concentration of mining activity has taken place. The watersheds within these counties detail the drainage system and basins responsible for the flow throughout this area. The Blackwater River, Dry Fork, Shaver's Fork, Upper Tygart Valley River, Upper Elk River, Williams River, Gauley River, Upper Gauley River, Cranberry River, Cherry River and Spring Creek are all watersheds containing the mining area features of interest. Throughout the forest, areas of rugged terrain, thickets of blueberries, highland bogs, and exposed surficial rocks dominate. Due to such a wide range in elevations from 900 feet at Petersburg (Grant County) to the state's highest elevation, 4,861 feet at Spruce Knob, the forest is home to a variety of plant life. The growth of these is dependent on geographic location, as seen in the abundance of rhododendron and laurel, which occur on the west side of the Allegheny Front, and cactus and endemic shale barren species occurring on the eastern side. An explanation for such random species habitat is due to the presence of the rain shadow, responsible for nearly 60 inches of annual precipitation on the west side of slopes as compared to nearly half of that on the eastern side (USFS, 2000; Strausbaugh and Core, 1964). The vast range of mineral and natural resources within the Monongahela National Forest have resulted in a depleted and damaged environment containing mining related problems and nearly all of the trees being of second growth.

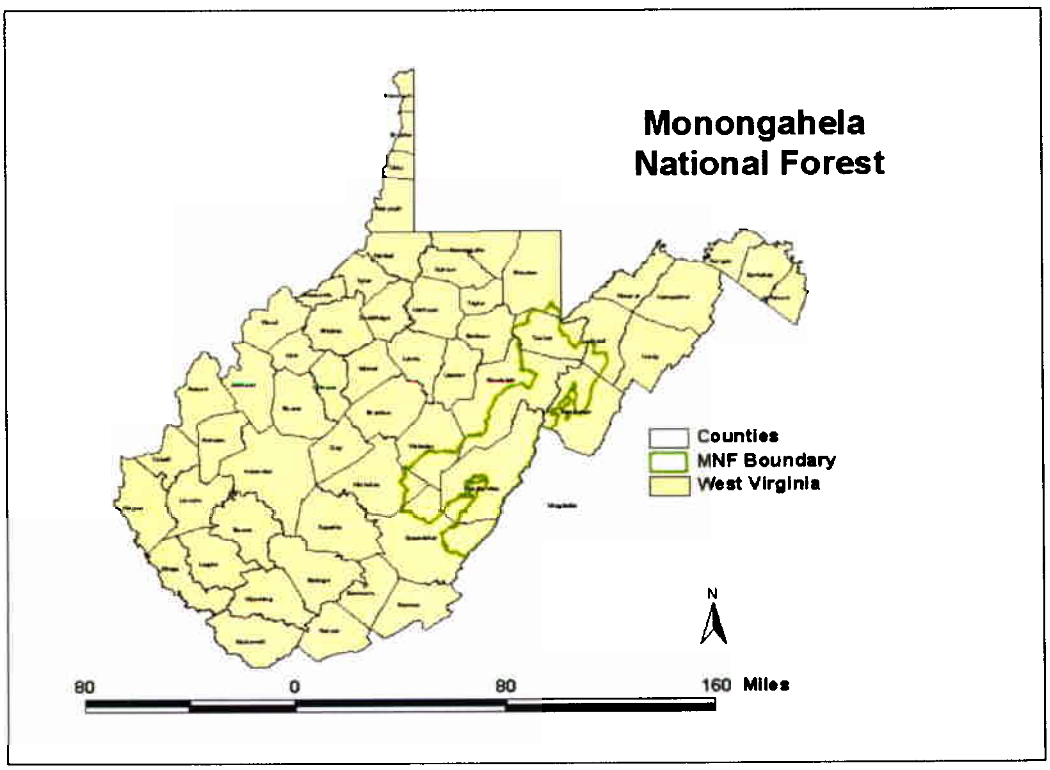


Figure 4 Monongahela National Forest within West Virginia.

Greenbrier County

Greenbrier County is the second largest county in the state and is located in the southeastern portion of West Virginia. Total area for the county as, determined by the West Virginia Geological Survey, is 1022.8 square miles. Elevations for Greenbrier county range from its highest point of 4,372 feet at Grassy Knob to its lowest of 1,520 feet along the Greenbrier River (Price and Heck, 1939). The northeastern and northwestern portions of Greenbrier County are home to the Monongahela National Forest, which extends east to the state line, south from the county line to the intersect of the state line and White Sulphur-Anthony Creek District line. As of 1939 (Monongahela National Forest purchase of 1911), the forest extended through 96,571 acres in the county (Price and Heck, 1939). The eastern forest area is predominantly white pine, while the northwestern section contains spruce, hemlock, yellow birch, and other high altitude species (Price and Heck, 1939). Greenbrier County is home to one of the most extensive, commercially minable coals throughout much of the Monongahela National Forest, the Sewell Coal seam. It has a mappable thickness of 2 to 9 feet and is found throughout much of the northern and northwestern sections of the county (Price and Heck, 1939). Additional coals of minable thickness such as the Little Raleigh, Beckley, Fire Creek, and the No. 3 and 6 Pocahontas coals are all present, but are significant on a local scale only (see Appendix IV).

Nicholas County

Located in the south central part of West Virginia, Nicholas County comprises nearly 657 square miles. The Monongahela National Forest comprises more than 23,000 acres of the county (Reger, 1921). Figure 4 indicates the extent of the forest and shows that nearly the entire eastern edge of Nicholas County is engulfed by the forested area. The range in elevation is vast from 675 feet at Belva to 3850 feet at the Webster County line (Reger, 1921). The stratigraphy of the county ranges from the Quaternary strata to the primary coal producing members of the Pennsylvanian and Mississippian Periods. (Reger, 1921). Coal on a minable scale is present extensively throughout the entire county. Of the 44 coal seams found in Nicholas County, 17 are of a minable thickness (Reger, 1921). Of these, several are found throughout the Monongahela Forest and are of the greatest thickness. The Lower Kittanning, Eagle, and Sewell Coals have the most extensive distribution throughout the county (Reger, 1921). The Lower Kittanning varies from 4 to 10 feet thick and produces a large amount of commercial quality coal throughout the northwestern section of Nicholas County (Reger, 1921). The Eagle Coal has a slightly broader extent than the overlying Lower Kittanning and varies from 2 to 5 feet thick. The Sewell Coal of the New River Group (see Appendix IV), is the primary minable seam throughout the county. It extends across more than half of the southern portion of the county and has a minable thickness from 2 to 6 feet (Reger, 1921).

Pocahontas County

The largest portion of the Monongahela National Forest is contained within Pocahontas County as nearly the entire county is forest with the exception of a small portion extending from the lower, middle of the county nearly midway to the center of the county. This area totals more than 243,000 acres as of 1939 (Price, 1939). The rugged, mountainous terrain of the county ranges in elevation from 1,952 feet to 4,842 feet at Bald Knob, which is 18 feet below the highest point in the state, Spruce Knob in Pendleton County (Price, 1929). There are mainly three minable coal seams in Pocahontas County and these occur within the Pottsville Series (Price, 1929). All three of the coals, Gilbert, Hughes Ferry and Sewell Coals (see Appendix IV), occur in the southwestern portion of the county with the latter being the most extensive and valuable coal within the county. The Sewell has a minable thickness from 3 to 6 feet (Price, 1929).

Randolph County

Randolph County is located in the eastern part of the state with its closest point nearly 5 miles from the Virginia border. More than 164,000 acres of the Monongahela National Forest cross through the 1,046 square miles of the county (Reger, 1929). The majority of the county's timber is of second growth, while much of the original timber was clear cut by the numerous lumber companies which operated throughout the county in the early 1900's. Elkins, WV, is home to the United States Forest Service headquarters and has overseen operations there for more than seventy years.

Economically minable coal is extensive throughout Randolph County and includes such seams as the Middle and Lower Kittanning, of the Allegheny Series (see Appendix IV) and the Sewell Coal seam of the New River Group (Reger, 1923). The Middle and Lower Kittanning coal occur extensively in the western portion of the county, specifically in the Roaring Creek District. The two coals are often separated by no more than 25 to 50 feet and range in a combined thickness from 7 to 12 feet. The Sewell Coal covers the entire western edge along with the entire southeastern edge of the county and has a thickness ranging from 2 to 8 feet (Reger, 1923).

Tucker County

The Monongahela National Forest throughout Tucker County, WV, is located primarily in the area surrounding the Dry Fork of the Cheat River. The approximate area for Tucker County is 421.67 square miles (Price, 1939), of which 46,146 acres comprise the Monongahela Forest (Reger, 1923). The virgin forests in this area were mostly spruce and hemlock, but these have since been destroyed by either timbering or forest fires and have given way to large growth of blackberries, wild cherries, and birch (Reger, 1923). Prominent throughout Tucker County are the numerous surficial exposures of hard rocks from the Allegheny and Pottsville Series (see Appendix IV), responsible for the distinguished mountain ridges. Examples of these as well as those rocks from the Conemaugh can be seen with relative frequency on the closely outcropping rocks. Tucker County lies in the midst of the Cumberland Plateau in the Western Division of the Appalachian Mountains. Severe folding has a strong influence and is responsible for much of the rock exposures at the surface. The vast ridge and valley networks throughout the area are the result of the development of an ancient, early Cretaceous, peneplain (Reger, 1923), or an area of low relief formed by long-continued erosion (Easterbrook, 1999). Throughout time this peneplain has risen by the formation of the mountains leaving behind the deep valleys of today. Coal of minable thickness in Tucker County appears to be limited to the Pittsburgh Coal, Little Pittsburgh Coal, Bakerstown Coal, Upper Freeport Coal, and Sewell Coal (Reger, 1923). The Pittsburgh and Little Pittsburgh Coal are not significant throughout Tucker County; however, they do have extensive thicknesses of up to 12 feet in some instances. The Bakerstown Coal, of the

Conemaugh Series, and the Upper Freeport Coal, of the Allegheny Series, are extensive in the eastern part of the county with thicknesses of 3 to 8 feet and 5 to 8 feet, respectively. The Sewell Coal, of the Pottsville Series, is extensive through the central and southeastern portion of Tucker County, but minable thicknesses are rare (Reger, 1923).

Webster County

Webster County was created from subtractions made to Nicholas, Braxton, and Randolph counties. The southeastern portion of Webster County is covered by the Monongahela Forest and it accounts for more than 65,000 acres. The total land area of Webster County is 558.6 square miles, as determined by the U.S. Geological Survey in 1920 (Reger, 1920). Elevation varies from 940 feet above sea level near the Webster County/Braxton County line intersect with the Elk River, to about 4200 feet at the intersection of Webster, Greenbrier, and Pocahontas counties (Reger, 1920). The Eagle Coal, of the Kanawha Group (see Appendix IV), is a key-rock identifier in the northwestern portion of the county. This coal member is the most widely persistent coal within the Kanawha Group in the county. The Eagle Coal ranges in thickness from 2 to 4 feet and has been mined and prospected on both the local and small commercial scale (Reger, 1920). The most recognizable and identifiable coal in the southeastern section of the county is the Sewell Coal, from the New River Group (Reger, 1920). Its thickness ranges from 2 to 5 feet and it is a relatively clean coal with a minable thickness and commercial value.

Statement of the Problem

Primary methods of data collection for the USACE/USFS GPS surveys, as they apply to the Monongahela National Forest Abandoned Mine Lands inventory, require that the projection and coordinates be UTM in NAD27. This datum, as previously mentioned, is based on the 1866 Clarke Ellipsoid (USGS, 1999). Its development stemmed from ground surveys that took place in Europe and North America in the late 1800's (USGS, 1999). The North American Datum of 1983 represents a much more accurate depiction of the location of features on the earth's surface. The geodetic datum used in GPS data collection is the WGS84, which has essentially the same calculations as NAD83, because the satellites send the positions to the GPS units based on this datum (Higgins, 1999). As a result of this, data collection in NAD27 will not correlate correctly with the more accurate NAD83 datum and more detailed imagery of the NAD83 datum, such as the DOQQ's, without coordinate conversions using appropriate programs such as NADCON (USACE, 1997) or GEOTRANS (USACE, 1997). In addition, the accuracy of a NAD27 dataset over a large area after coordinate conversions may be limited.

In association with the problem of the use of NAD27 data collection is the use of NAD27, or the recently reprojected NAD83, USGS 7.5-minute DRG topographic maps versus NAD83 USGS DOQQ's for GIS base maps. Rationale for this outdated method of data reference is based upon usage of the 7.5-minute topographic quadrangle as a required digital base map by the USFS. The recent updated publications by the USGS have reprojected these DRG maps to NAD83, leaving no viable use for NAD27 (Moore, 2001). Consequently, the use of the USGS 7.5-minute, 1:24,000 scale, topographic map for a GIS base map creates an additional problem that is addressed in this thesis involving this archaic quadrangle map which lacks picture-like detail, current land usage and changes, and the ability to be digitally updated.

Data collection and assumptions concerning the actual shape of the earth have obviously changed since this time and require that a more current datum system be adopted. For this reason the World Geodetic System of 1984 was developed and should be the primary datum used in all current data collections. Original production of USGS 7.5-minute quadrangle maps began in the 1930's and reached peak publishing around 1970. Production of these maps continued until the early 1990's with the average currency date for the 7.5-minute quadrangles being 1967. Since the early stages of the USGS map production, revisions have taken place. The average date of currency for these revisions is 1979 (Moore, 2000). This information indicates that the majority of these 7.5-minute quadrangles, and subsequent DRG's, are more than 20 years old. Not only has the land surface changed throughout this time, but also other information shown on these maps including demographics, land use, and land classification, to name a few, have changed as well. For this reason a more accurate, current base map for the development of a GIS database should be the USGS NAD83 DOQQ's.

Proposed Statement of Solution

Satisfactory completion of the stated solution by the objectives of this thesis provided a comprehensive GIS database using the USGS DOQQ's as a base map for overlaying the data collected during the inventorying of the Monongahela National Forest. The improved access to the abandoned coal mine data, through the use of the GIS database, will provide information as detailed in Eaton and Zlotin, 2001, for the evaluation of mining sites and abandoned mine lands, mine planning and subsidence risk assessment, and erosion control projects, to answer the numerous requests by the public, industries, government agencies, and research institutions for such data (Eaton and Zlotin, 2001). In order to remain consistent with the data collected in NAD27, and the base map of DOQQ's, without converting inventory data to NAD83, it was necessary to use converted NAD27 DOQQ's from the West Virginia Department of Environmental Protection's website http://129.71.240.42/data/doqq.html. This ensured that data placement was accurate and error minimized, according to NAD27, which would have been unavoidable with conversion to DOQQ's of NAD83. The issue of NAD83 versus NAD27 has been addressed in this thesis and will provide evidence to establish precedence for upgrading GPS data collection to the newer datum, NAD83 or NAD84 (WGS84), when future work is performed. The implementation of DOQQ's for this thesis will show their image capabilities, resolution, and detailed features to both the USFS and the USACE, which are not available with the use of DRG's.

Defense of Solution

To facilitate the objective of creating an accurate and comprehensive GIS, it was necessary to mention the complications and location inaccuracies associated with collecting GPS data using NAD27. The geoid shape of the earth is changed with WGS84. Newer calculations are compensating more and more for these changes across the earth (USGS, 1999). As a result of these changes that are taking place, older datums used to represent the shape of the earth are becoming increasingly less accurate and outdated. For this reason a global best fit datum was developed by the National Imagery and Mapping Agency of the US Department of Defense (Higgins, 1999). This datum, known today as the World Geodetic System of 1984 (WGS84), has been revised since its inception to a level of accuracy better than 2 cm (Higgins, 1999). Based on these measurements, local datums have been developed to increase the level of accuracy even further. One such datum, which can be applicable anywhere, is the North American Datum of 1983 (USGS, 1999). Differences in NAD27 and NAD83 GPS collection data can be up to 200 meters apart in the north-south direction (USGS, 1999) and nearly 16 meters in the east-west direction (Chapter V). These differences in datums, data collections with them and GIS database creation with base maps from different datums were the primary focus of this thesis.

Objective Statement of Thesis Research

The completion of this thesis required the adherence to three primary objectives. The first objective was to establish the difference, through discussion, between the datums of the World Geodetic System of 1984, which is essentially the same as the North American Datum of 1983 (Trimble, 1996a) as used in this thesis, and the North American Datum of 1927, as they pertain to data collection of Global Positioning Systems. This objective details the benefits in changing collection procedures to the more current datum and why this is an appropriate decision. The second objective was to discuss the advantages and disadvantages between the use of DRG's and DOQQ's as a base map within a GIS. A comparison of the two was established through the completion of the third objective. This third objective was to create a GIS database for Geobiophysical Modeling using data previously collected from the Monongahela National Forest Abandoned Mine Lands Inventory as performed by the USACE for the USFS. The GIS database included all collected features such as ponds, highwalls, spoil/gob piles, rubbish piles, structures, portals and haul roads with drainage. In addition to creating a spatial display of the georeferenced points using USGS DOQQ's, sample views were also created using Arcview's Spatial and 3D Analyst (ESRI, 1996) containing Digital Elevation Models to perform hillshading, 3-dimensional views, and slope within a selected DOQQ, Snyder Knob NE.

CHAPTER 2 METHODS

Field Work

In order to execute the objectives of this research it was first necessary to review the procedures and criteria for conducting abandoned mine inventories to ensure that collection procedures were accurate and performed at a high level of competence. The first process in the formation of these procedures was to create an abandoned mines data dictionary (see Appendix III) that summarized all encountered features in the field. The Trimble Geoexplorer II (Trimble, 1996b) GPS units are equipped with the ability to develop and maintain a data dictionary. This allowed the data to be collected in a format that was easily imported into an Excel (Dodge, et. al., 1997) spreadsheet and then more readily exported into a Geographic Information System. The data dictionary was divided into two parts, the first of which included general mine site information and numbers, the names of search area and historical sites, and the forest, county, and hydrologic codes. The second part included actual feature identification such as highwalls, portals, ponds, gob piles, subsidence features, structures and rubbish deposits (Appendix III; Tracy, 1998). In order to conduct the field survey with the greatest likelihood of accuracy, it was necessary to perform the inventory during leaf-off period. This limited the likelihood of the vegetative canopy acting as a shield and preventing the GPS units from providing an efficient signal to the satellites (Trimble, 1996a). The leaf off period for the Monongahela National Forest search area ranges from mid-November to early April dependent upon significant weather changes (Spagna, 1999).

The selection of field equipment for this project was crucial to conducting the inventory due to limited accessibility with vehicles and lack of additional resources. A Trimble Pathfinder Geoexplorer II (Trimble, 1996b) handheld receiver was the GPS used for all data collection based on compactness and accuracy. The horizontal and vertical accuracy for these units are 1-2 meters and 3-5 meters, respectively (Trimble, 1996a). The units were configured based on pre-determined parameters established by the

Trimble manual (Trimble, 1996a) as well as the USACE (Spagna, 1999) and as detailed in Chapter 3 of this thesis. All collected GPS data was differentially corrected to ensure the greatest possible level of accuracy using the GPS accompanying software Trimble Pathfinder Office (Trimble, 1997).

The second piece of field equipment necessary for the inventory relates to the water quality sampling for all ponds and relevant streams encountered throughout the search area. The Hydrolab Surveyor 4 (Hydrolab Corp., 1998) with mini sonde was chosen to perform the collection of water quality and included such outputs as pH, specific conductivity, temperature, oxygen reduction potential, turbidity, and dissolved oxygen. Of these displayed, parameters required for this project include pH, specific conductivity, temperature, and estimated discharge volume.

Data Collection

Consistency was important when establishing the criteria for determining the location, description and features associated with the mining sites (Spagna, 1999; Appendix II). Area streams that were encountered were identified and established as pH checkpoints. These were important in identifying underground mines, which are typically located on benches, flat areas, and near haul roads, as well as areas of acid mine drainage away from the highwall area (Spagna, 1999). Additional features which existed away from the observed highwall area included portals which essentially are the remains of a mine opening. Some portals are open with evidence of such features as discharge and gob piles, while others are collapsed and buried beneath forest vegetation litter (Spagna, 1999). Any seeps encountered as flow from portals or other mining activities required water quality collection data, which was helpful in identifying the mining related problems, such as acid mine drainage.

Surface mines influence the topography of a location presence due to their large areas and are typically easily recognized by their association with vast highwalls, related depressions, and ponds. Only non-vegetated highwalls were inventoried and many of the highwalls are located on the topographic quadrangles. As previously mentioned, these mining sites have related features that need to be described by attributes as well as being identified (Spagna, 1999). All features need to have an identification number correlating the different features of a like area along with GPS coordinates. A portal or opening needs to additionally have descriptions of the portal access, portal opening size, evidence of visitation, distance from improvements, and discharge volume and color (Spagna, 1999). Highwalls should have a length, height, slope, distance from improvements, and evidence of visitation (Spagna, 1999). Ponds should be classified by type, size, pH, specific conductivity, temperature, water color, discharge, and volume (Spagna, 1999). Coal gobs and spoil piles, referring to the waste removed from a mine, are identified by lack of vegetation and require attributes such as area, height, burning evidence, discharge volume, color, and water chemistry, to be recorded (Spagna, 1999). Subsidence features are the result of collapses associated with underground mine voids. Classification terms for these are slumps, for those occurring on slopes or ridges, and subsidence for those found in a stream. They were classified by attributes including open/closed, opening size, and distance from improvements (Tracy, 1998). Rubbish deposits were defined by any type of industrial or residential waste and by the presence or absence of hazardous waste, area, height, and a description of contents (Tracy, 1998). Finally, structures, including equipment, and foundations of structures associated with the mining industry, were identified on the basis of the presence/absence of hazardous materials, distance from improvements, approximate size, and a general description (Tracy, 1998). Additional features were encountered such as mining related discharges and were all identified using descriptors associated with pond features. A photograph of each feature along with a general sketch of the search area accompanied all data (Spagna, 1999).

The data was collected using the Trimble Geoexplorer II (Trimble, 1996b) handheld GPS units. Each feature was selected using the data dictionary that was created using Trimble Pathfinder Office (Trimble, 1997). This software allowed for a numbering system to be established for each feature, which was helpful when post-processing the collected GPS data.

GPS Post Processing

Upon completion of the inventorying for each day, the GPS data was transferred to a laptop computer to avoid memory failures to the GPS. It was necessary to install the Trimble Pathfinder Office (Trimble, 1997) software on the laptop to allow for the post-processing procedure. This software allowed the GPS to connect, through a provided key, to the laptop for data transfer. The software then displayed the collected feature location points using the predefined coordinates, UTM, on a blank display screen. After all points were checked for numbering accuracy, the locations were differentially corrected using the Morgantown, WV, base station maintained by the West Virginia Department of Environmental Protection (WVDEP). This data was collected from their website http://129.71.240.42/gps/cal.html. The base station provides differential correction of rover files which can improve GPS data position accuracy up to 10 meters. At this point the datum was selected from the native WGS-84 GPS collected datum to the NAD27 datum, prior to differential correction. After correction, the file was exported from Trimble Pathfinder Office (Trimble, 1997) into a readable format known as the American Standard Code for Information Interchange (ASCII). This file format was a means of allowing the data to be imported into an Excel spreadsheet (Dodge, ET. Al., 1997).

GIS Development

Once the inventory data was collected, post-processed, and imported into spreadsheet format it was integrated into GIS software. ArcView version 3.2a (ESRI, 1996) was chosen to compile and process all collected data for this project. The first step in creating the GIS database was to select appropriate base maps. For this thesis a comparative analysis was made between a representative DOQQ and DRG for purposes of depicting advantages of upgrading to the more detailed DOQQ. The remainder of the inventory was created using DOQQ's. In addition, an overview of the project area was created using an outline of the state and counties provided in ESRI's dataset (ESRI, 1996). Since consistency was a factor in displaying data accurately, the DOQQ's were chosen from the West Virginia Department of Environmental Protection's website http://129.71.240.42/data/doqq.html. These DOQQ's are in NAD27 datum, which corresponds with the collected inventory data on USGS 7.5-minute Quadrangle base maps. For this reason, it was possible to show a comparison between the information available from a DOQQ versus a DRG, which is also in the NAD27 datum. NAD83 DRG's and NAD83 DOQQ's could have been selected as base maps if the inventory data had been converted to NAD83. This researcher chose to leave the data in its original collected datum and used base maps which met National Map Accuracy standards. Due to the amount of data in the inventory and the vast coverage area of the Monongahela National Forest, it was necessary to create more than one view and subsequently additional printed copies to accommodate this.

The initial step in beginning the GIS development was to create an overview layout to show the inventory/Monongahela National Forest location. This was accomplished by importing a boundary line of West Virginia and all 55 counties. This data is available from the datasets that accompanied the Arcview 3.2a (ESRI, 1996) software. The imported files must then be reprojected in Arcview 3.2a (ESRI, 1996) to allow all related data to be overlain on the overview map. Once the map was set to the correct projection of UTM zone 17, then a quadrangle index was imported to determine which quadrangles were necessary for this database compilation. This index was made available through data compiled by the USACE Hydrology and Hydraulics Branch. Additional overview data included watershed boundaries, streams, and areas of coal mining influence which were assembled from the West Virginia GIS Technical Center's website http://wvgis.wvu.edu/data/data.php which are NAD83 corrected, but made available in NAD27. This data showed the drainage patterns of streams from the various watersheds and will provide helpful information for determining stream orders affected from acid mine drainage.

The next developmental step was to import additional digital data into a separate view in the GIS project, using a NAD27 National Elevation Dataset (NED) compiled by the USGS covering the state of West Virginia. This dataset was acquired from the COE

Hydrology and Hydraulics Branch; however, a dataset is available for public use, in NAD83, from the West Virginia GIS Technical Center's website, http://wvgis.wvu.edu/data/dataset.php?action=search&ID=29. The NED is a compilation of 30-meter Digital Elevation Models (DEM). The addition of the 30-m DEM files provided elevation information for the area and allowed Arcview 3.2a (ESRI, 1996) software package to create a 3-dimensional view of the region, as well as additional Arcview Spatial Analyst 1.1 and 3-D Analyst 1.0 (ESRI 1996) features.

CHAPTER 3 TECHNIQUES

GPS Configuration

Prior to the inventory process, the Trimble Geoexplorer II (Trimble, 1996b) needed to be configured to appropriate settings to maximize collection accuracy. These parameters were outlined in the scope of work provided to the COE from the USFS and are included in the Trimble handbook (Trimble 1996b). The following are the primary configurations that were made to the GPS units:

SNR mask – 5
PDOP mask – 8
PDOP switch – 8
Antenna Ht. – 2.0 m
Log DOP's – Off
Velocity – Off
Minimum Positions – 100

Likewise, the Hydrolab (Hydrolab Corp., 1998) element on the mini sonde needed to be cleaned and the attached cover filled with water to maintain it during transportation. The connections between the Hydrolab (Hydrolab Corp., 1998) unit and the mini sonde had to be clean and the cover caps had to be in place to avoid debris from collecting inside.

Field Work

The reconnaissance phase of the project began by locating the mining areas on the 1:24,000 scale USGS topographic maps. Several of the more important quadrangles that were necessary for this project were Beverly East, Bowden, Camden on Glady, Durbin, Fork Mountain, Glady, Lead Mine, Lobelia, Mill Creek, Mozark Mountain, Samp, Sharp Knob, Snyder Knob, Webster Springs SW and SE, Wildell and Woodrow. Familiarization with each map and an outline of the inventory area was crucial to expedite the location of the majority of the mining features. A basic sight map of a mining influenced area can be seen in the Snyder Knob topographic map (Figure 5). The mining areas are depicted by the purple color and are usually labeled. Large areas like these and the many others in the Monongahela National Forest required a two-man team of surveyors in order to effectively cover the area, maintain and transport equipment, and provide a factor of safety (Spagna, 1999). Along with the GPS unit and Hydrolab (Hydrolab Corp., 1998) with mini sonde, a digital camera, field log books, sketch pad, maps, GPS antenna, water bottles, cleaning solutions for the Hydrolab (Hydrolab Corp., 1998), and water sampling kits (when necessary), replacement batteries for the GPS and rechargeable batteries for the Hydrolab (Hydrolab Corp., 1998), all needed to be backpacked in and out of the forest.

GPS Data Collection

When a feature was first located, the GPS was connected to the external antenna and is elevated approximately 2 meters to help reduce any impedance of the signal and the satellites. The appropriate name of the encountered feature was then selected and numbered based on mine site and feature, within the abandoned mine data dictionary (Appendix III). The GPS was allowed to collect data for a minimum of 100 positions, where available. On some rare occasions due to tree limb canopy cover or satellite positioning it was not feasible to allow the GPS to reach this many positions, due to the amount of time it often takes (Spagna, 1999). The position collection of the hand-held units is an average; therefore, accuracy was not adversely compromised when less than 100 positions are collected (Trimble, 1996a). Each point was collected and stored in the GPS unit and any additional information from the sites, i.e. Hydrolab (Hydrolab Corp., 1998) data, pictures, etc. was all referenced using the same number system. Field notes were recorded as well, to act as a backup in case of equipment error, file loss, memory failure, or human error. The satellites give positioning on the earth based on WGS84 datum coordinate system. The GPS units collect data from the satellites in this coordinate system and then internally convert the data to a selected datum, such as NAD27 for this inventory, through internal calculations (Trimble, 1996b). For example,

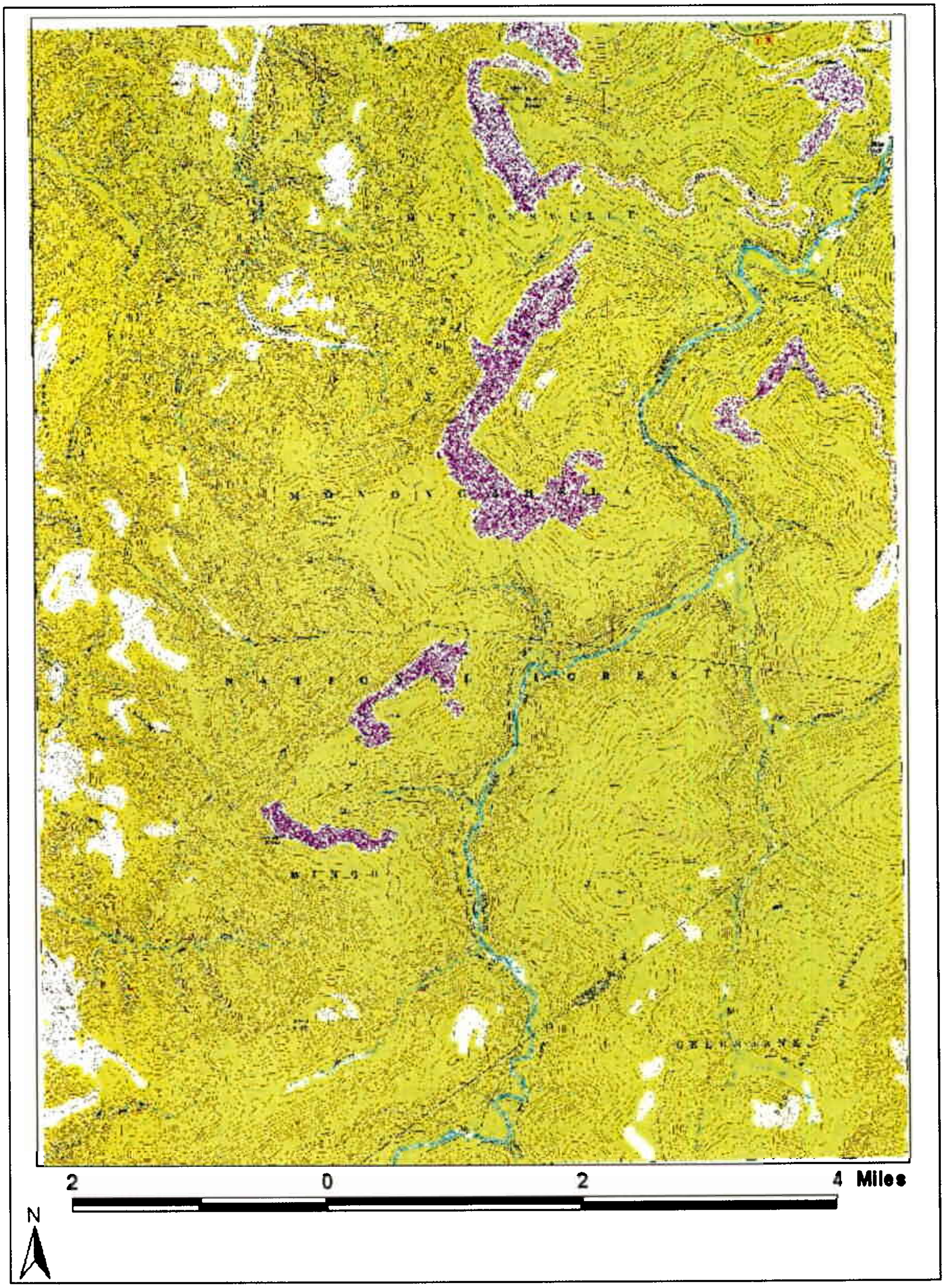


Figure 5. USGS 7.5-Minute Topographic Quadrangle of Snyder Knob. Areas of mining influence are shown in purple.

the WGS84 datum has the values 0,0,0 for the X,Y,Z axes, respectively, and all other coordinates are based on this (Trimble, 1996b). The same axis measurements for NAD27 differ from WGS84 by -8,160,176 for the X,Y,Z, respectively (Trimble, 1996b). Conversely, the more current NAD83 coordinate system is identical to the WGS84 (Schwarz, 1989) and has no difference in the X,Y,Z axes, 0,0,0 (Trimble, 1996b). The only difference in the datums of NAD83 and WGS84 exists with respect to the ellipsoids used for the coordinate system calculations (Schwarz, 1989). The reason for these differences came about because the Defense Mapping Agency used normalized form in their calculations with the WGS84 ellipsoid, while the GRS 80 ellipsoid (NAD83's ellipsoid) used the unnormalized form (Schwarz, 1989). Essentially, these differences arise due to rounding to eight significant Figures and result in no significant differences when used in practice (Schwarz, 1989).

Water Quality Data Collection

The Hydrolab required calibration throughout the inventory process, on at least a weekly basis, to ensure accuracy and involved cleaning with distilled water, pH solutions (4 and 7), and conductivity solutions. When transporting the Hydrolab, it was necessary to keep the probe on the mini sonde submerged in water. The cover for the probe is filled approximately halfway to allow for this. When a necessary structure was encountered the Hydrolab was connected to the mini sonde, ensuring that both the female and male connectors were clean of debris. The Hydrolab mini sonde was placed into the water sample area so that the probe was immersed completely, or near so, in water. After initiating the unit, it needed to remain in the water several minutes or until the readings had stabilized. Typically, the measurements are recorded in the field logbook as a precautionary measure to ensure that the memory is not filled to capacity and in case of batteries failure (see Appendix V, Tables 1-6).

Laboratory Work

GPS Post-Processing

The Trimble GeoExplorer II (Trimble, 1996b) handheld GPS units are rated for a horizontal accuracy of sub 10 meters; this improves to 2-5 meters after differential correction (Figure 6). However, this inventory and the Trimble General Reference guide were both completed prior to the stoppage of GPS accuracy degradation by President Clinton (Clinton, 2000). Before May 1, 2000 the U.S. Department of Defense used a process known as Selective Availability to purposely degrade the accuracy of GPS units used by the public (Clinton, 2000). This process reduced the accuracy to 100 meters horizontal and 160 meters vertical (Wood, 2000). These accuracies represent a two standard deviation error, 95% probability that the accuracy will be within 100 meters of the actual point. The root mean square error (RMS) is the value of one standard deviation (68%), typically the error published by GPS manufacturers (Wood, 2000). used by the public (Clinton, 2000. The process of differential correction, as used in this inventory collection, overcomes the error associated with selective availability by using a static base station and a roving survey station. These differential corrections subtract the measured error at the base station from the error associated with the roving unit (Wood, 2000). The accuracy error is greatly improved from 100 meters to about 2-5 meters for these GPS units and sub-meter (0.4 – 1meter) for more advanced GPS' (Trimble, 1996b). The discontinued usage of selective availability, as of 1 May 2000, improves the predicted accuracy from 100 meters to within 20 meters prior to differential correction (Office of Press Secretary, 2000) and submeter (0.02 meters) accuracy with real time differential correction GPS units.

As defined by the West Virginia Department of Environmental Protection website http://129.71.240.42/gps/diffcor.html, differential correction errors include: ephemeris error, satellite clock error, orbital errors, and atmospheric delay, (WVDEP, 2000). The process involves correcting collected field points versus a base station with known positions. In West Virginia these base stations are located in Nitro and

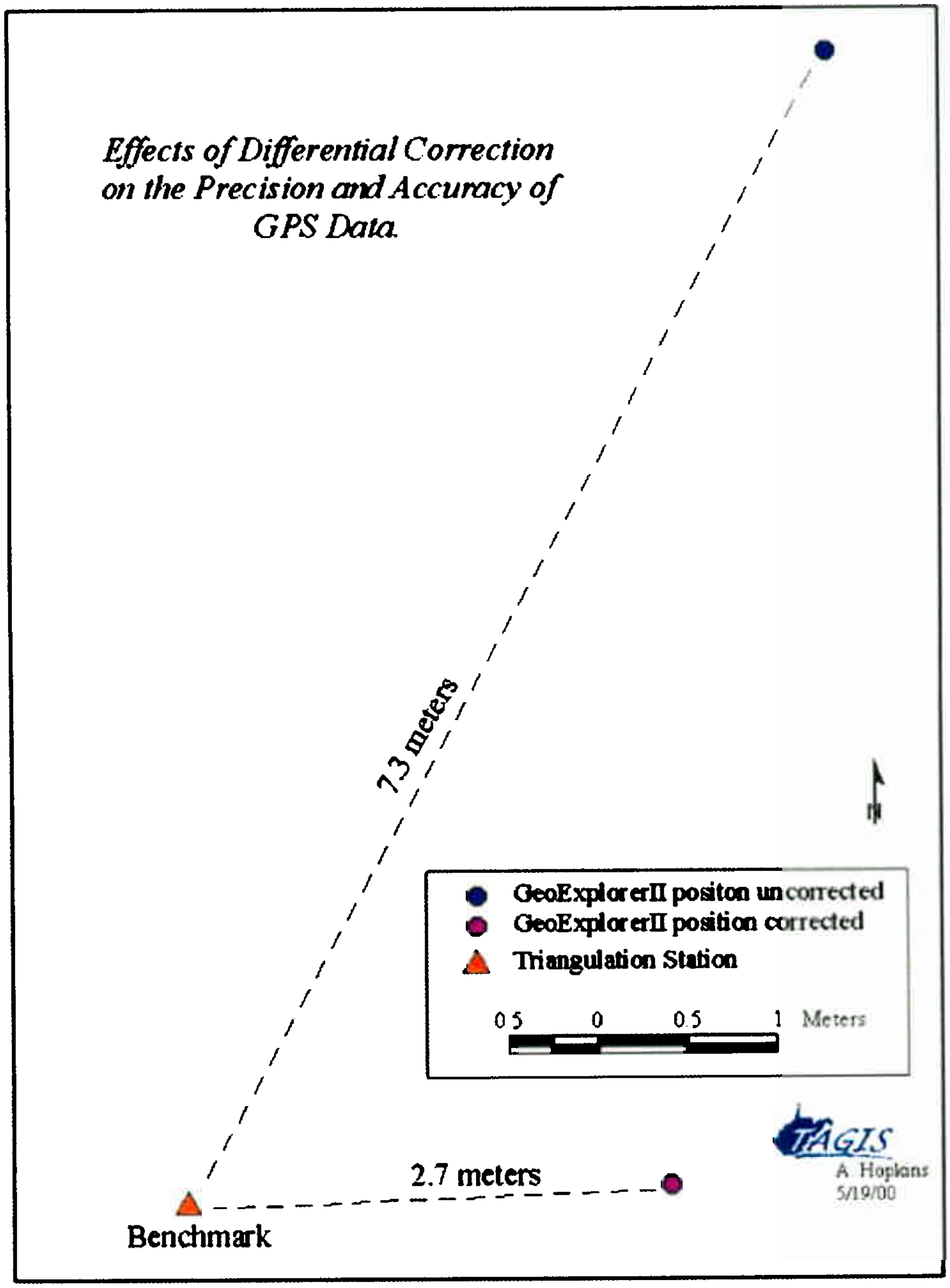


Figure 6. An example of the improvements made to GPS position accuracy through differential correction. (from WVDEP website http://129.71.240.42/gps/diffcor.html

Morgantown. The farther the roving station are away from the base station, the less accurate the positions are.

The post processing procedure was to first connect the GPS receiver to the computer via serial port. In order to read the data, Trimble Pathfinder Office (Trimble, 1997) software needed to be opened (this software is included with the purchase of the Trimble GPS units). The points were then transferred and displayed with an X as a point locator based on their coordinates. Next, the WVDEP website was accessed for the differential correction process. Once the site was opened, navigation to the GPS base station site, Nitro location, was executed. Next, file retrieval for the approximate day/time of data collection was performed and the appropriate files were downloaded. These files were then imported into the Pathfinder Office program and the collected points were corrected based on these values. This new data was then exported in ASCII file format for importation into Microsoft Excel (Dodge, ET. Al., 1997).

GIS Development

GPS Point Import

After the collected data was exported into ASCII format it was imported into an Excel spreadsheet and saved as a database file with .dbf (database) extension. This allows for the table to be easily imported into Arcview. The GIS creation process began by opening the Arcview 3.2a (ESRI, 1996) software. When the prompt appeared to start with a new view, a blank project or an existing project, the new view option was selected. 'No' was selected at the next prompt to add data to the view now. On the main menu, Tables was selected then, 'New' button to add a new table. Next, the newly created database with .dbf extension was navigated to within its folder (see Figure 7). The table was now available in the project to be added as an event theme. In order to do this, a new view was opened and the table was added as an event theme under the view drop down menu, displaying a screen that resembled Figure 8. When this screen was displayed the table was added based on its representative coordinate system, in this case UTM.

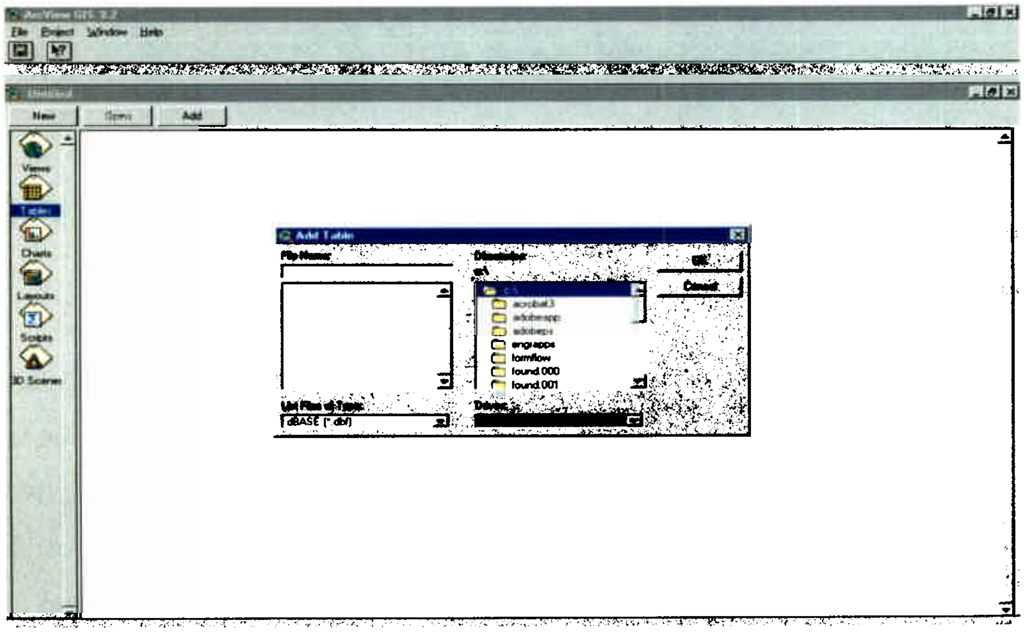


Figure 7. Excel database (.dbf) added to project as a table.

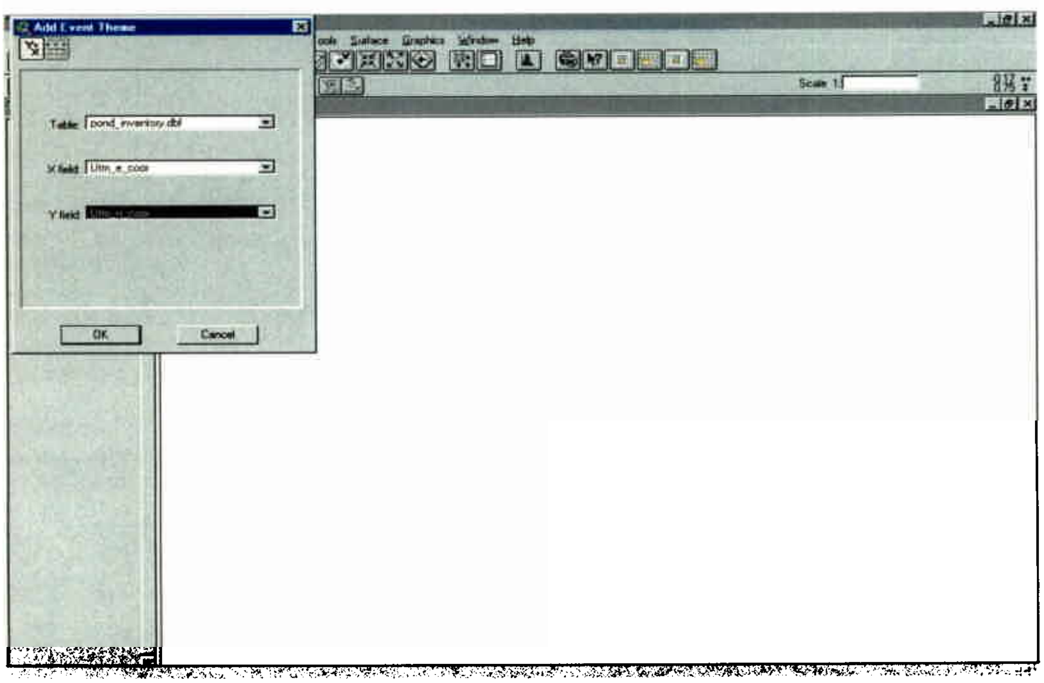


Figure 8. The newly added table was then added to the view as an event theme.

The appropriate column that represented the coordinate system for the X and Y fields was then selected. For example, the UTM Easting was selected for the X field and the UTM Northing for the Y field. After the table had been added to the view, it was activated by clicking on the box beside the file name, adding a checkmark to the box. The inventory location points were placed on the basis of their collected coordinate plane that was selected for each X and Y field, UTM zone 17. Each separate database with different features was added to the view following the same procedures.

Base map: ESRI Digital Data

The overview area was represented by selecting various digital datasets to outline the inventoried area. The first two datasets were chosen from the ESRI data included with the Arcview 3.2a software (ESRI, 1996). This data was found following the path C:ESRI\ESRIDATA\USA. The first data set selected was the States.shp file. It was added to a separate view due to its Latitude/Longitude coordinate system. The second dataset added was the Counties.shp. Each dataset was added to the view as a theme under the view drop-down menu, with the file type of feature data source. The view needed to be reprojected to a coordinate system that coincided with the feature data and additional base map imagery, which was UTM 1927, Zone 17. The View drop-down menu was selected, then properties. Next, the projection option was selected and the category changed to UTM-1927 with the type changed to Zone 17. In order to focus only on West Virginia, the files needed to be clipped. To do this, the states theme was activated and the theme table displayed as seen in the Figure below. From here the West Virginia feature was found and highlighted and the theme table closed. Next, the states theme, with West Virginia highlighted, needed to be converted to a shape file from the theme drop-down menu. An appropriate name and location was selected and then the shapefile was saved in the new projection. The theme could not be added to the view because of this. The counties shapefile was created in the same manner, with the exception of selecting each county within the state at the opened theme table. The newly created shapefiles were then added to their own view along with a boundary of the Monongahela National Forest, obtained from the USFS in shapefile format. Additionally, stream and watershed shapefiles were added to the view.

Base map: DOQQ and DRG

The most informative image base map that will be used in this project will be the digital aerial photographs (DOQQ). These are accessed from a collected database already compiled or from various GIS data collections such as the website, http://www.dep.state.wv.us/metadata/. These file types, known as MrSID files, required an additional extension in order for them to be imported into the project. MrSID is an acronym for Multi-Resolution Seamless Image Database. A file of this type represents a compressed version of the actual aerial photograph (WVDEP). The extension needed to view such file in Arcview 3.2a (ESRI, 1996) was attained from www.esri.com and was then placed in the extensions folder within the Arcview 3.2a (ESRI, 1996) program file folder, C:ESRI\AV_GIS30\ARCVIEW\EXT32. Once the extension was added to the folder, it needed to be activated in the project by selecting the 'File' drop-down menu and the extensions option. The screen menu now resembled Figure 9.

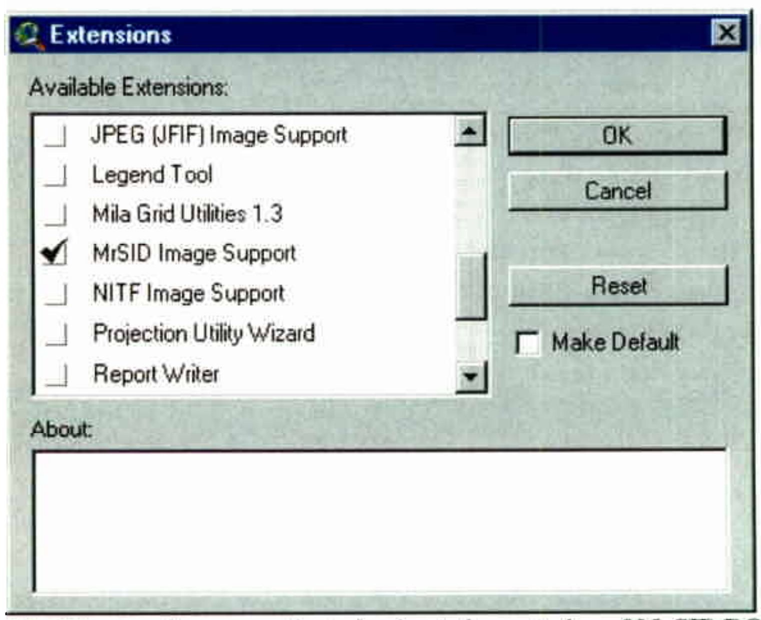


Figure 9. MrSID extension was activated prior to importation of MrSID DOQQ files.

Next, the DOQQ's were added to the view through the drop down View menu. At this prompt the file type was selected to Image Data Source and the selected DOQQ's were added to the project view. Again, this image was activated in the view by checking the box to the left of the image name. In order to view the previously added feature data, each inventory event theme was shifted above the newly added DOQQ images theme by using the mouse and dragging the theme above. For this thesis only the DOQQ's that contained the inventoried feature points were imported into the project. The DOQQ's provide a digital representation of the search area.

The comparison between the information supplied by the DOQQ's versus the DRG's began with the importation of the Snyder Knob USGS 7.5-minute digital quadrangle. These are the standard maps requested by the USFS because of the amount of text data that they supply. The Digital Raster Graphic (DRG) maps are United States Geological Survey (USGS) digital topographic maps that have been scanned and georeferenced, or placed in their exact location in space based on a standard coordinate system. Typically, the referenced datum is North American Datum (NAD) 1927 coinciding with the inventory data and the DOQQ's. Unfortunately, when scanned, the maps include not only the map data, but the white border with text as well. In order to remedy this, the DRG needed to be clipped. The first step in doing this was to add the DRG to the view with image data source as the file type, following the same procedure as the DOQQ import with the exception of the MrSID extension. Next, two extensions needed to be added to the ARCVIEW extensions folder, the same path as mentioned previously. The first is DRG clipper 2.0/3.0 that clipped the borders from the DRG. The second extension is the DRG Tools extension which allowed some added manipulation to be performed on the DRG in conjunction with the clipped border. These extensions were obtained from the ESRI website, www.esri.com and appear in the extension window as seen in Figure 10. The first step in this procedure is to make the desired DRG themes active, then click on the DRG clipper icon (see Figure 11) that should be displayed once the DRG Clipper 2.0/3.0 extension has been turned on.

Next, Arcview prompted for the selection of the DRG datum, which was NAD 1927. Once selected, the next window asked whether to recode the cells outside the map area to 255. The 255 number is a color designation which represents black (ESRI, 1998).

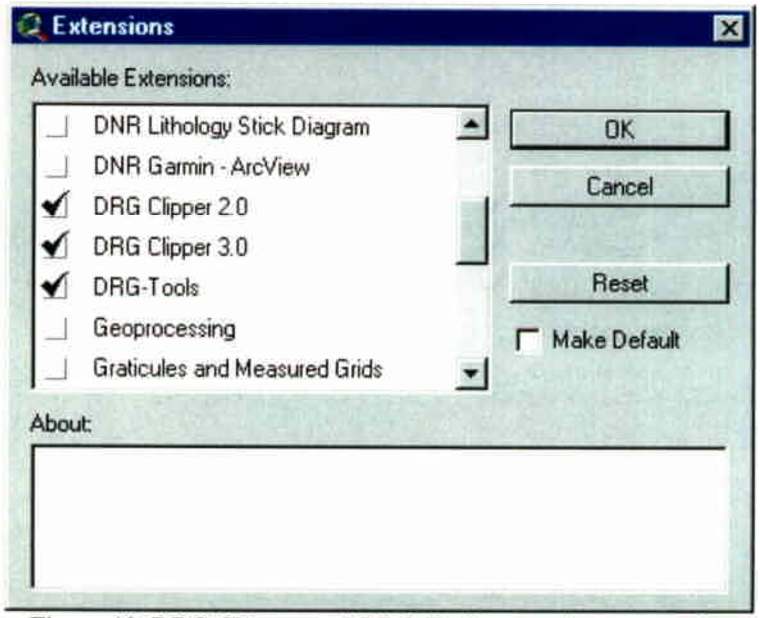


Figure 10. DRG Clipper and DRG Tools extensions are activated.

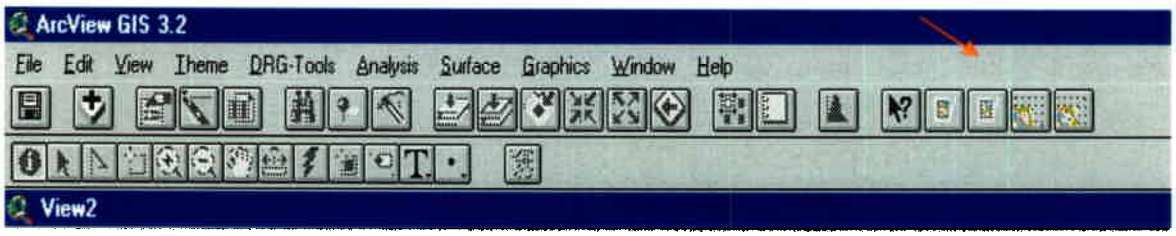


Figure 11. DRG Clipper icon was added to the view window when activated.

Next, the newly clipped DRG needs to be located and added to the view as an image data source. The themes were located in the folder from which the DRG was selected. However, the names were changed to the USGS standard designation of a numbering system. The images were imported with the border clipped and were bounded by the recoded black cells which represent the actual rectangle shape of the map; however, the map was slightly rotated to compensate for the flatness of the map projected on the roundness of the earth. The other icon associated with the DRG clipper extension allowed additional DRG's to be mosaiced with the Snyder Knob digital quadrangle and other related DRG's.

The current USGS revision program has reprojected the DRG's to fit the datum of NAD83. However, this transformation does not come without confusion when adding the DRG's to a GIS. Depending upon what the source for the DRG is, it may come with the white border or collar attached. This usually provides data such as the year revised, year published, ant the projection and datum. In accordance with this are the graticules, or the network of neatlines defining the latitude and longitude of the map (Moore, 2001). Since the actual paper copies of the maps were projected in UTM NAD27 (USGS, 1999) the coordinates provided by a GIS system and those reflected by the graticules will not match up (Moore, 2001). A remedy for this was to remove the collar and the graticules from the DRG. This provides a topographic basemap available in NAD83 with one noticeable flaw. The removal of the border leaves a black 2"-3" margin around the DRG. This is easily removed using the DRG 2.0/3.0 Clipper extension found on the website www.esri.com . The removal of this black strip by recoding the outside margin area to a value of 255, or clear, leaves a remaining slight black edge as a result of the displacement that occurs when projecting a flat map on to a curved surface. Again this can be removed using the DRG 2.0/3.0 Clipper extension that creates a transparent overlay. The DRG appears now in a satisfactory NAD83 placement with no glaring problems. The exception to this occurs when attempting to place an adjoining DRG into the GIS view. The same procedure is followed to clip the collar and make the overlay transparent; however, the margin between the two DRG's is not compensated for by any type of overlap, such as in the DOQQ's, resulting in an approximate 20 meter absence of data. This 'no data' area requires the use of more advanced and complicated GIS techniques in order to provide a satisfactory mosaic.

Geobiophysical Modeling of Selected Images

The primary GIS database has been completed to this point of the research; however, geobiophysical modeling of datasets provided additional information that may be useful to both the USFS and the COE in future projects. This process began with the importation of the National Elevation Dataset (NED) DEM data set for the entire state of West Virginia. The first step was to locate and import the downloaded dataset and clip it to the search area. This allowed the NED DEM dataset to be more manageable and take less time to load into the view. Before importing the grid, Spatial Analyst 1.1 and 3-D

Analyst (ESRI, 1992) extensions must be activated. The NED DEM dataset was added to a separate view as a grid data source. Once activated in the view, the NED DEM dataset was clipped to a more manageable area. The first step in doing this was to import the Monongahela National Forest boundary shapefile. Next, the Analysis Properties for the DEM was selected from the Analysis drop-down menu. Next, the analysis extent drop-down menu was selected to establish the extent of the clipped region, by selecting Same As Forest Boundary. Finally, with the NED DEM dataset active Convert to Grid from the theme menu was selected and an appropriate name and location were defined. The grid was then added as a grid data source. The output grid was clipped to the boundary of the Monongahela National Forest.

The newly added grid of the clipped area around the Monongahela National Forest allowed for various image analysis processes. The first step was to change the color ramp of the new grid to a pre-established elevation color. This was done by "double-clicking" on the grid theme and selecting Elevation #1 from the color ramp drop-down menu. For analysis purposes the Snyder Knob SE.sid DOQQ was used; it was added to the view. A 3-D scene was then made with the DOQQ draped on the DEM grid. To accomplish this, both themes were activated and turned on in the view. Then, 3-D scene was selected from the view menu, followed by selecting themes at the Add View to 3D Scene as 'prompt'. With the 3-D scene legend open, all the themes were turned off, except for the DOQQ. Next, under Theme, 3-D Theme Properties, a base height was assigned to the image to display it in 3-D. Surface was the assigned base height and the newly formed grid file was selected. A Z-factor of 1.5 was applied to the image to allow the features to be more distinguished. The pond inventory features were then displayed on the 3-D DOQQ by the same procedure. The Z-factor was set at 1.55 to place the points slightly above the DOQQ.

Using the Monongahela National Forest grid that was previously created a slope and aspect analysis was created to help determine areas of steepness and, subsequently, water flow. This was performed by activating the grid theme and selecting derive slope from the surface menu. The newly formed slope grid is automatically displayed in the view. The aspect grid is formed in the same manner by selecting derive aspect from the surface menu. Another spatial analyst feature performed on this data set was the hillshade grid. This was created using the surface menu and selecting compute hillshade to create a relief type map of the gridded area.

CHAPTER IV RESULTS AND DISCUSSION

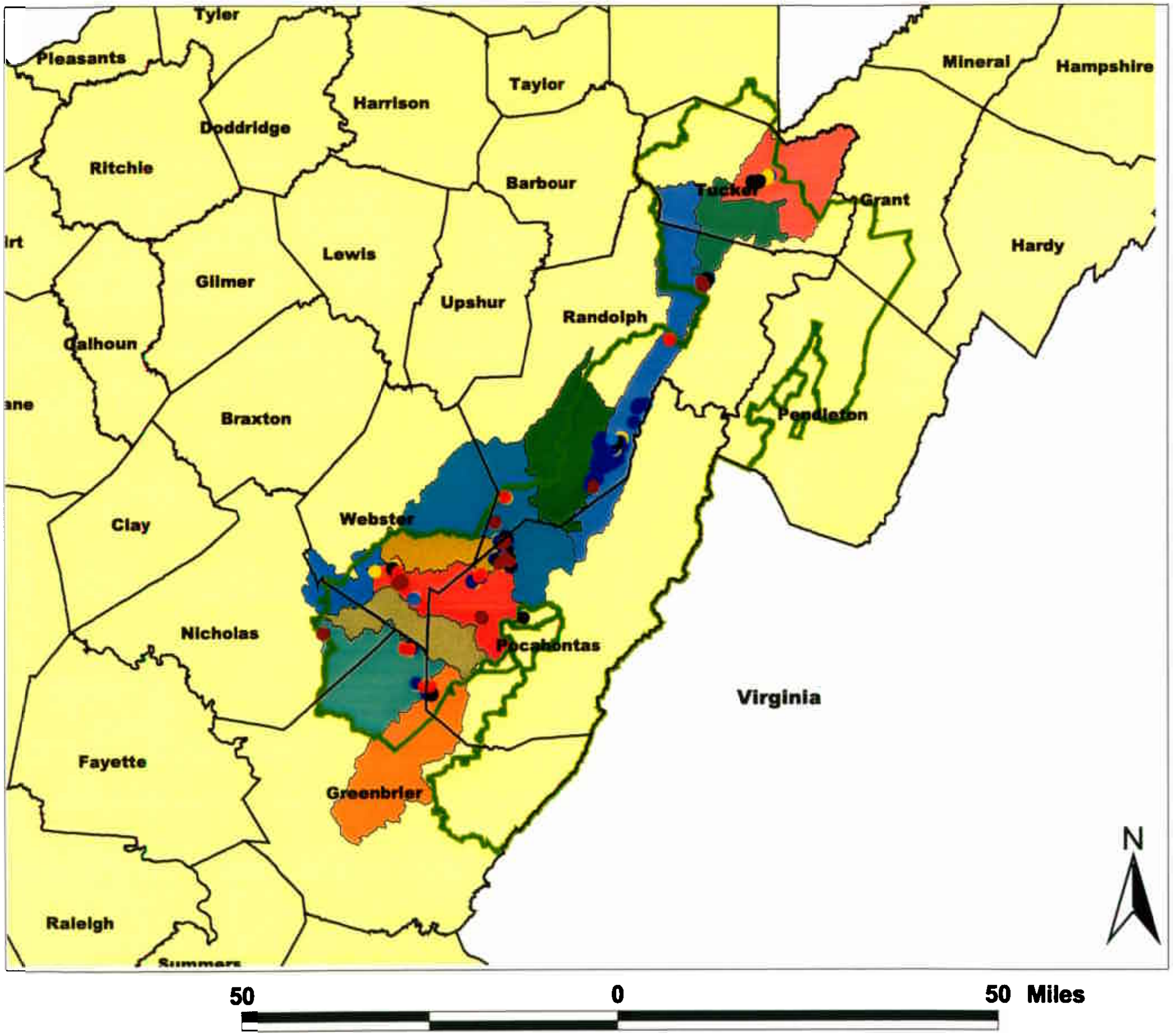
Inventory

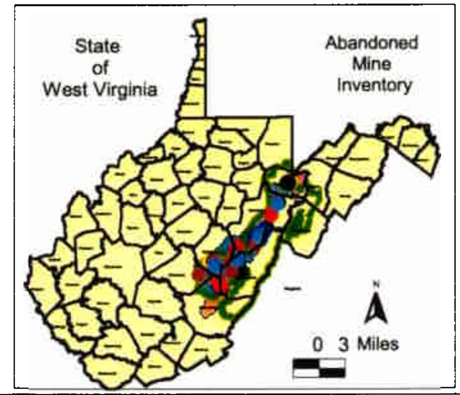
The inventory data collection process was completed by the United States Army Corps of Engineers field team, which consisted of Steve Spagna and Paul Dean, on November 9, 1998 (Appendix IV). A total of 54 mine sites were documented consisting of 5 underground, 38 surfaces, and 11 underground/surface combination. This total number of mine sites yielded 79 ponds, of which the lowest pH was 3.4 and the highest was 8.3. The average pH for the ponds was 5.9. Highwalls totaled 89, with the average length and height being 1439' x 31', respectively. The inventory resulted in 32 structures, 5 rubbish deposits, 58 coal spoil sites (with an average of 14,565 ft^2), and 58 mine portals (see Appendix V tables 1-6 for complete inventory results). The completion of the GIS database allows for these results to be queried based on established parameters and then for these results to be displayed spatially by their georeferenced location.

GIS Database

The GIS database was created by this researcher to satisfy the objectives of this thesis. MAP 1 was created using the Monongahela National Forest inventory database as an overview using shapefiles (.shp) of an outline of the state of West Virginia, with county boundaries, forest boundary, and watersheds (see Map 1). This display allowed for the concentration of mining influenced lands to be analyzed. The addition of watershed locations on the map provides information on which area streams were most affected from the mining remains. From MAP 1, the area of greatest post-mining activity was along the border of Shaver's Fork watershed with the Upper Tygart Valley River, within Randolph County. A second area of high concentration of post-mining influence lands was near the intersection of the Williams River, Upper Elk River, and Upper

MAP 1
Monongahela National Forest by Watershed with Abandoned Mine Land Inventory





LEGEND

Counties

Features
- Structures
- Rubbish
- Portals
- Coal Spoil
- Ponds
- Highwalls
- Mine Sites

MNF Boundary

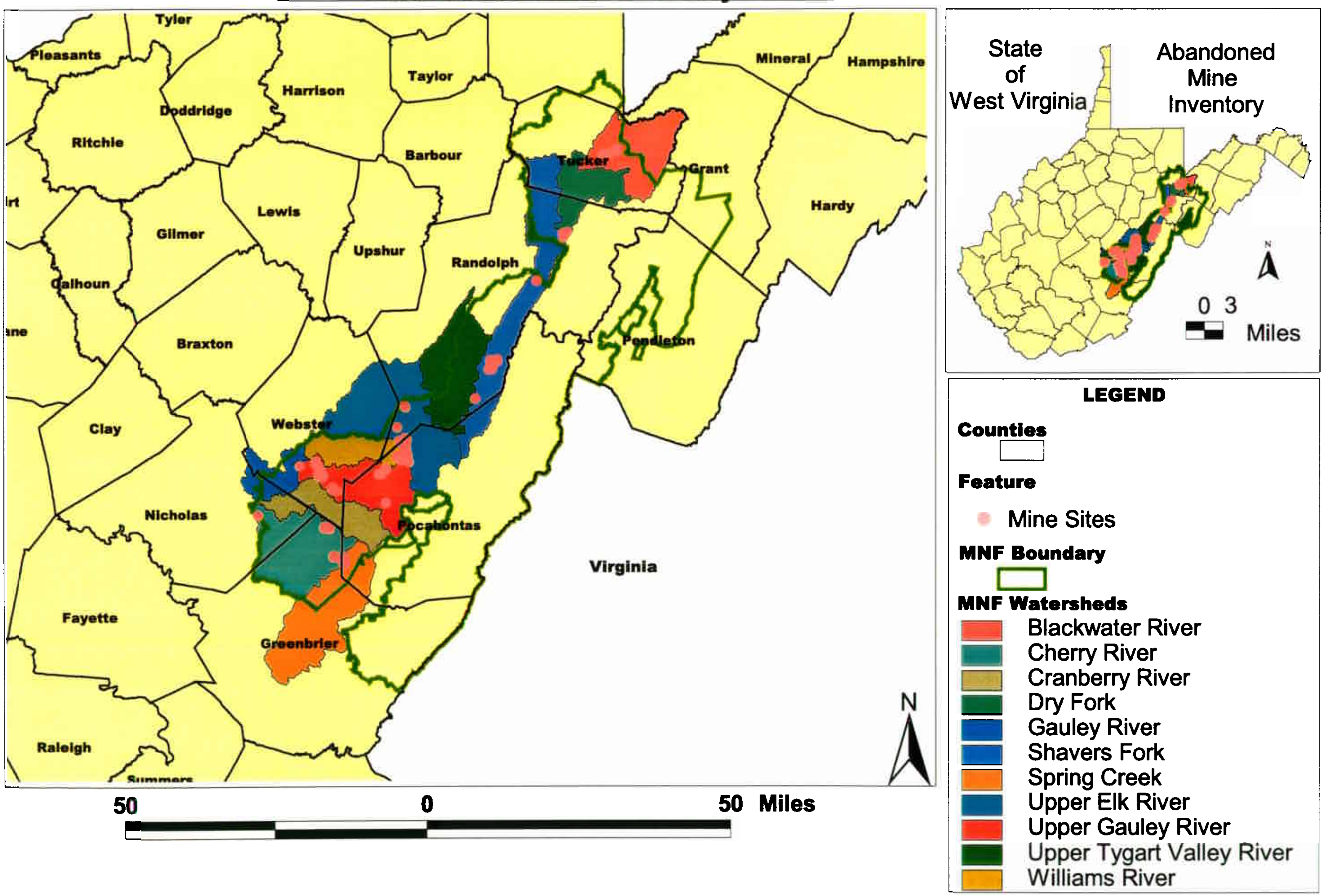
MNF Watersheds
- Blackwater River
- Cherry River
- Cranberry River
- Dry Fork
- Gauley River
- Shavers Fork
- Spring Creek
- Upper Elk River
- Upper Gauley River
- Upper Tygart Valley River
- Williams River

Gauley River watersheds at the Southeastern border of Randolph County with Pocahontas County.

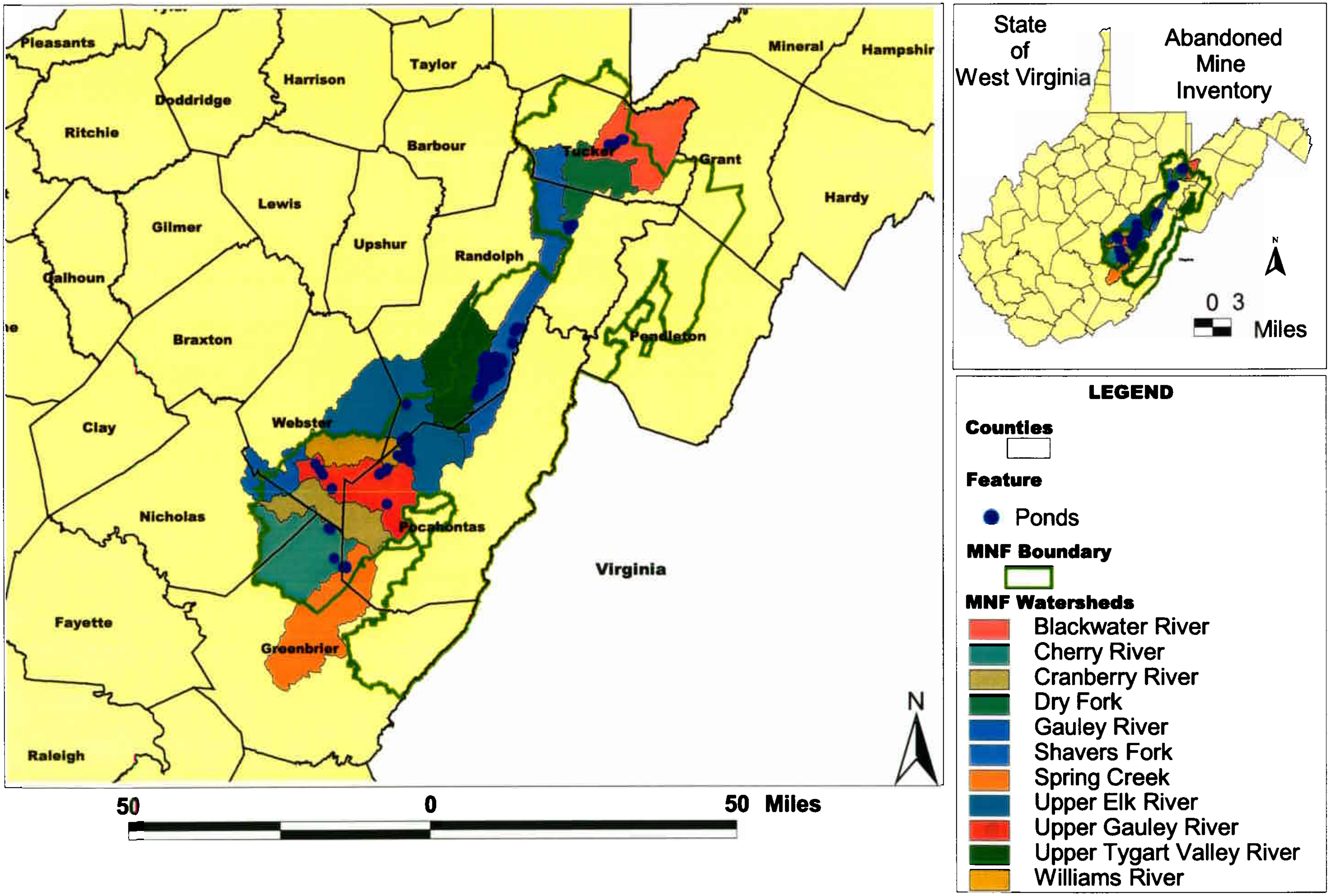
An individual examination of each inventory feature was made in MAPS 2-6. MAP 2 contained the mine site locations, the majority of which seem concentrated in southwestern Pocahontas County and southeastern Webster County. The majority of these mine sites were contained in the Upper Elk River and Upper Gauley River watersheds. MAP 3 detailed the locations of ponds throughout the inventory area. High concentrations of these ponds occurred in Randolph County, particularly in Upper Tygart Valley River and Shavers Fork watersheds. MAP 4 shows that highwalls in the Monongahela National Forest occurred mostly in the same regions as the mine sites. This included Upper Gauley River and Upper Elk River watersheds within Pocahontas and Webster Counties. MAP 5 was a combination of coal spoil sites and mine portals. Examination of this map revealed that the majority of these features occurred in the same regions as the highwalls and mine sites. MAP 6 of the inventory contained the smallest number of features, rubbish piles and structures. Only one area of concentration existed, at the junction of the Williams River, Upper Gauley River, and Upper Elk River watersheds, within Pocahontas County.

The importation of NAD27 USGS DOQQ's, from the Department of Environmental Protection website, in MrSID format can be seen in MAP 7. Only the DOQQ's that contained portions of the inventory were used in the creation of this database to minimize database size. The database placement on a DOQQ base map revealed images of the actual strip mine sites, ponds, and related features viewable from the air. A more detailed summary of the DOQQ inventory placement can be seen in MAP 8 of the Snyder Knob NE quarter quadrangle. The accuracy of the GPS survey was evident in this map, as the view on the left showed feature locations, such as the ponds, and the view on the right showed pond locations viewable from the air. Cleared off areas within each view are the mine strip benches. The majority of the ponds were located at the base of the highwalls. The improvement in the information provided by the DOQQ base map versus the DRG base map can be seen in MAP 9.

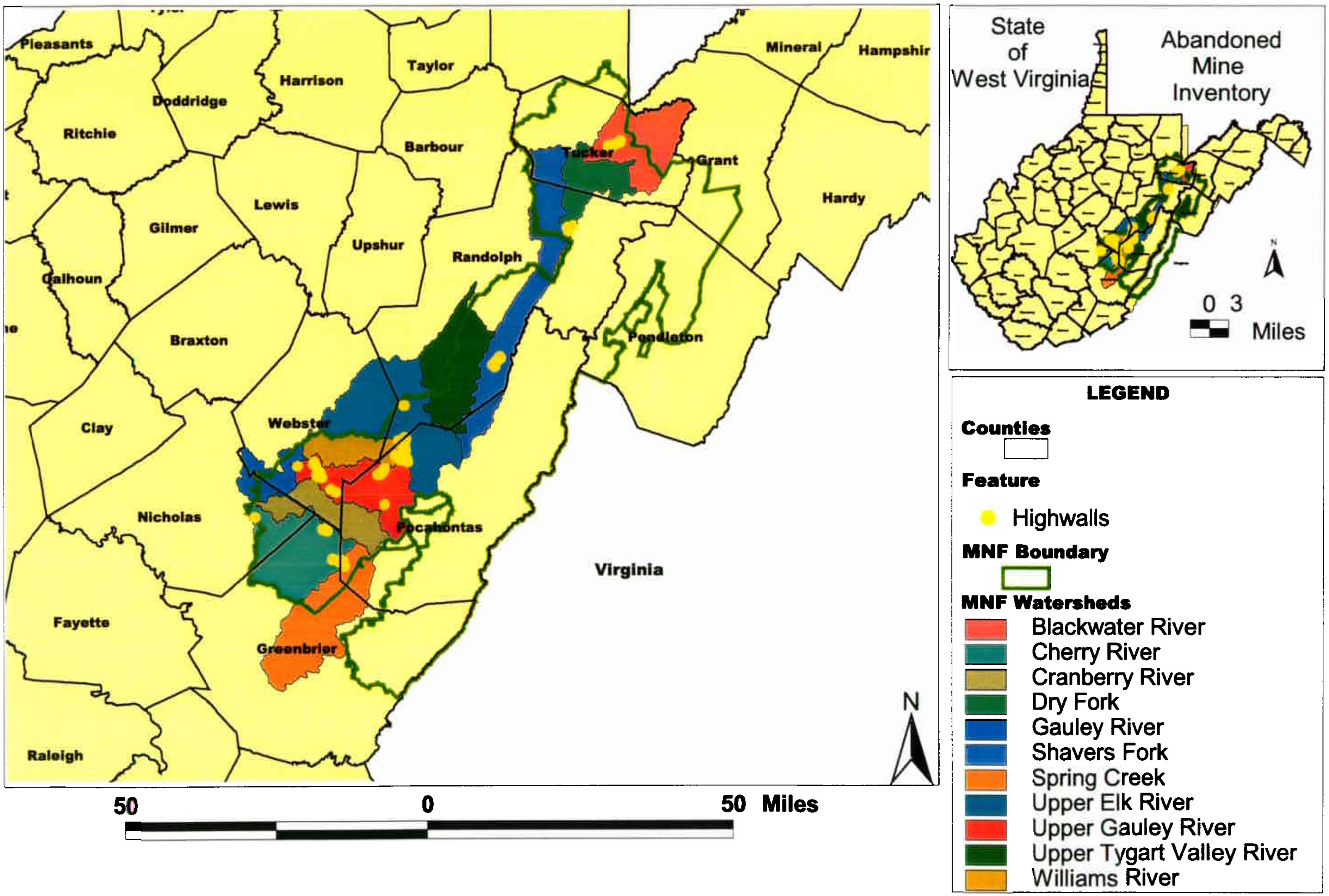
MAP 2
Monongahela National Forest
by Watershed
Abandoned Mine Inventory - Mine Sites



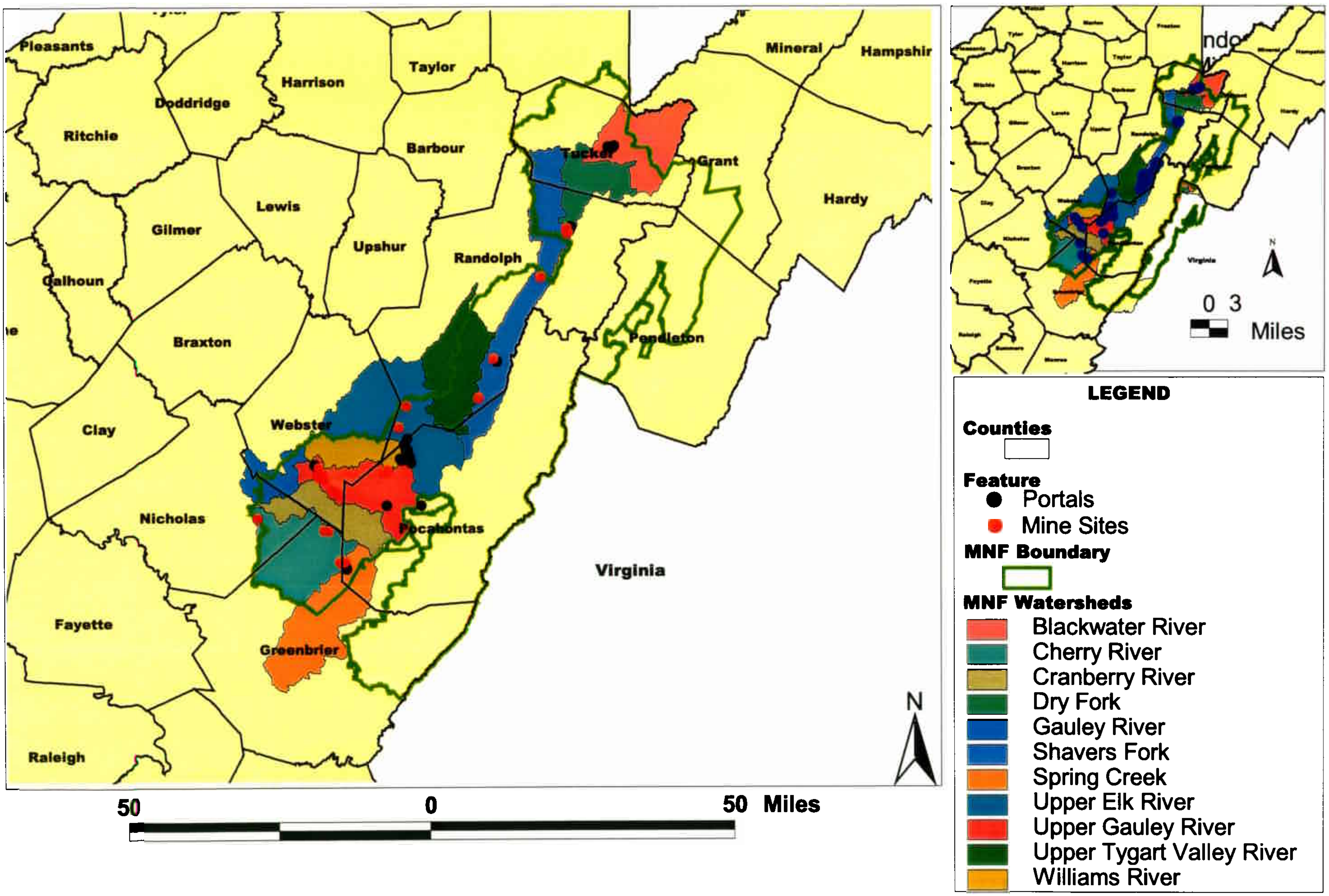
MAP 3
Monongahela National Forest by Watershed
Abandoned Mine Inventory - Ponds



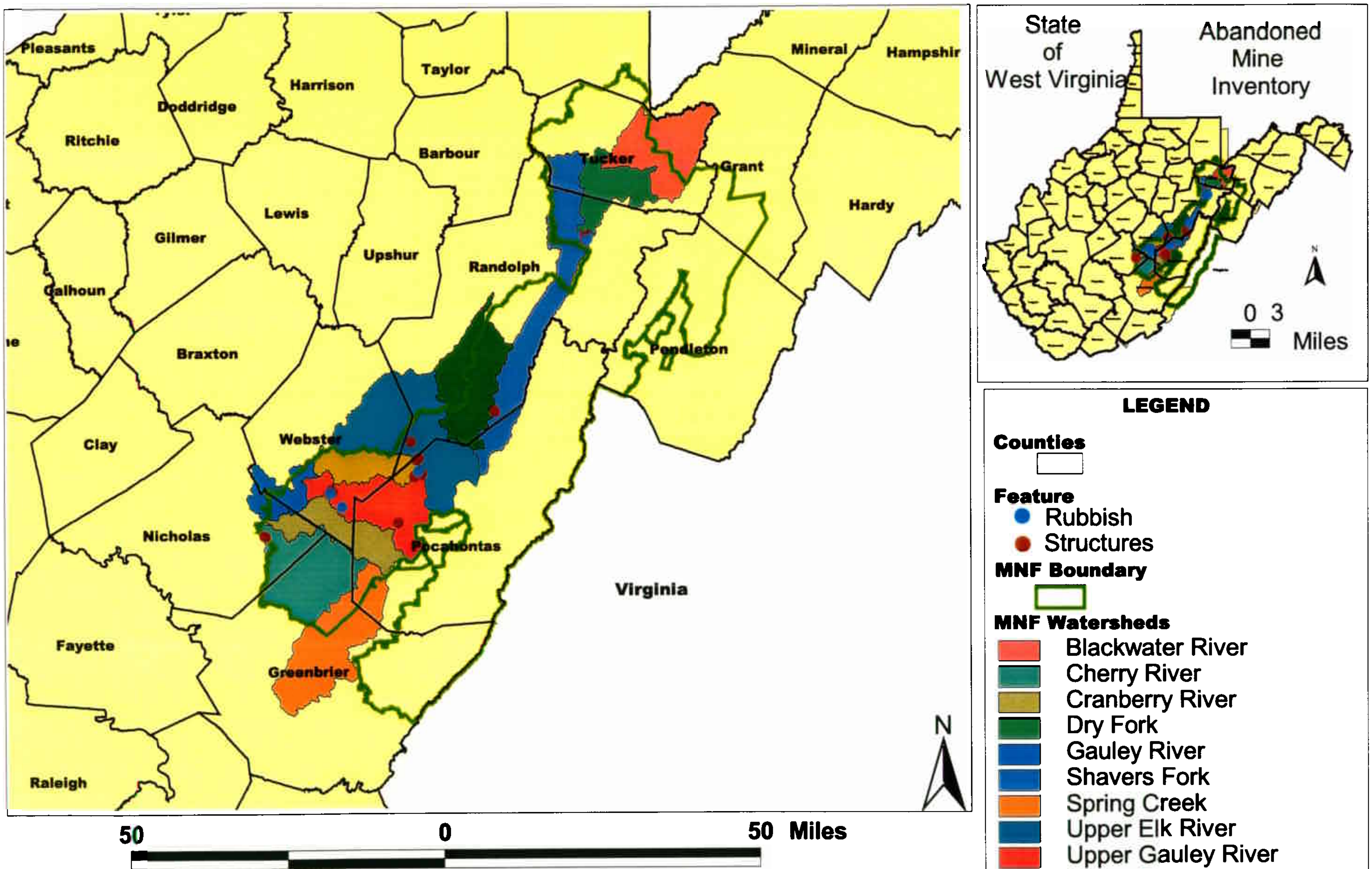
MAP 4
Monongahela National Forest by Watershed Abandoned Mine Inventory - Highwalls



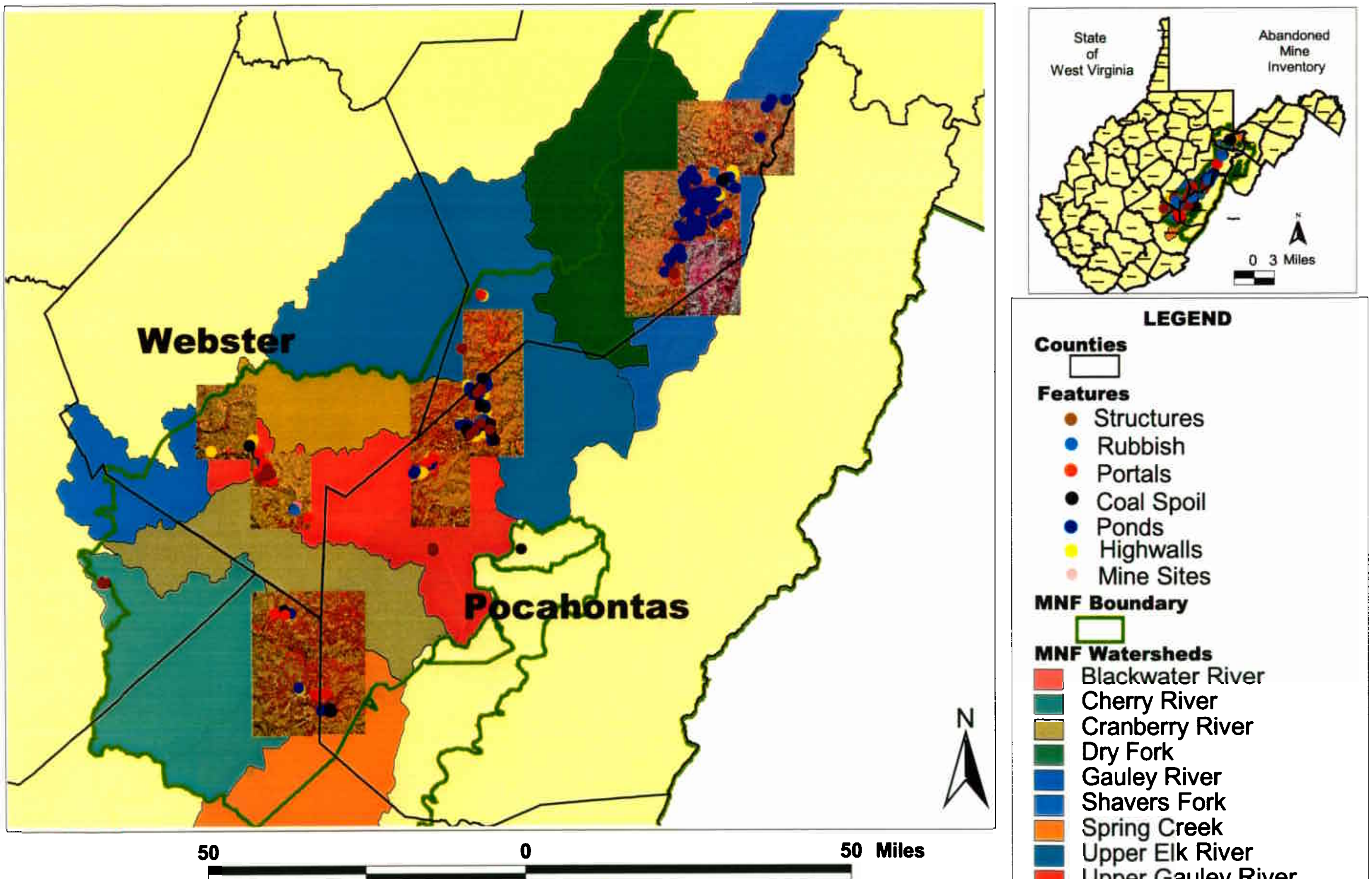
MAP 5
Monongahela National Forest
by Watershed
Abandoned Mine Inventory - Mine Portals/Coal Spoil



MAP 6
Monongahela National Forest by Watershed
Abandoned Mine Inventory - Rubbish/Structures



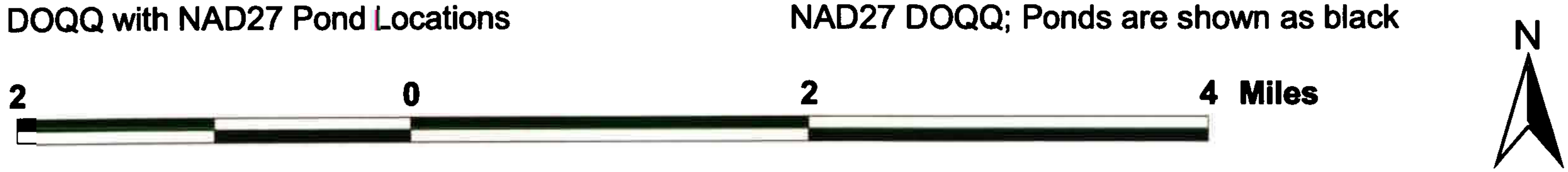
MAP 7
Mononhahela National Forest by Watershed with Abandoned Mine Land Inventory
Overlain on Selected DOQQs



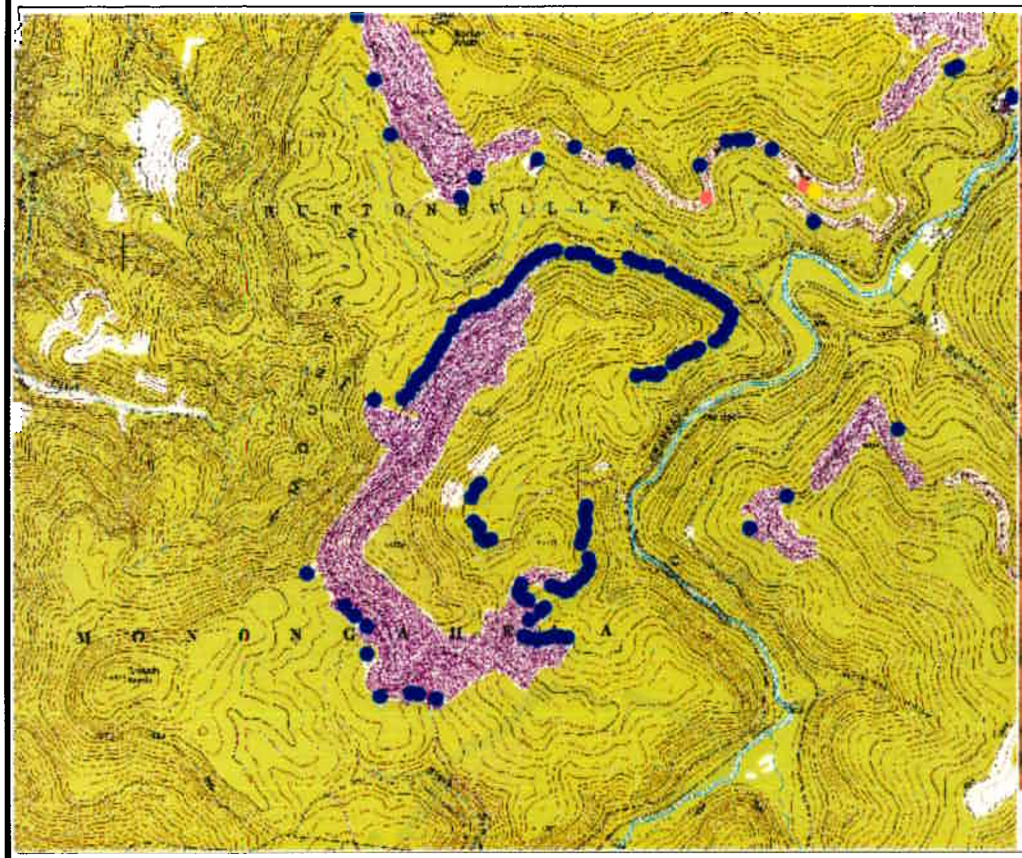
MAP 8
Snyder Knob NE NAD27 DOQQ
Comparing Pond Inventory to Actual Pond Location

A
NAD27 DOQQ with NAD27 Pond Locations

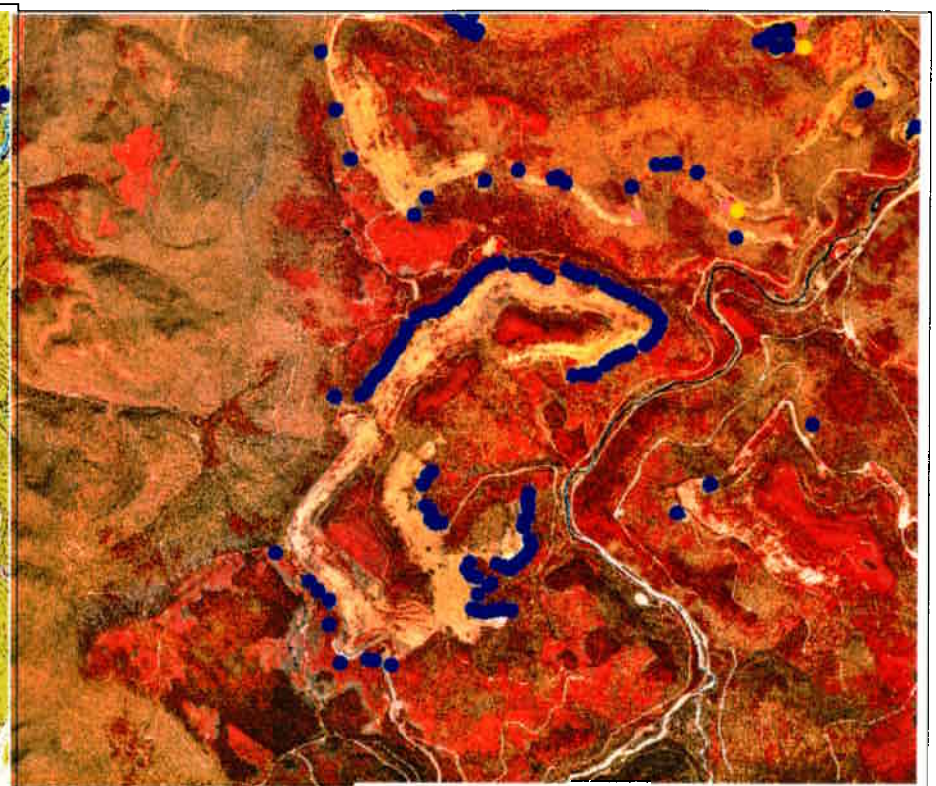
B
NAD27 DOQQ; Ponds are shown as black



MAP 9
Comparison of Evident Features Between Snyder Knob NE DOQQ and Snyder Knob DRG



A
Snyder Knob NAD27 DRG
Last field check date 1974



B
Snyder Knob NE NAD27 DOQQ from 1997
Mine Bench is more continuous than on DRG

This detailed a side by side view of the USGS 7.5-minute Snyder Knob digital topographic quadrangle and the USGS DOQQ's of Snyder Knob NE/NW. This map provided detailed evidence that the DRG's are outdated and contains less accurate and detailed information. The pond inventory follows the strip mine bench in its entirety as seen in the DOQQ; however, the view of the DRG revealed that the strip bench stopped midway through the pond series. The source date for the DOQQ, as revealed by the header data, shows that the photograph was taken on April 8, 1997. Information provided on the collar of the DRG revealed that the map was first created in 1973, field checked in 1974. The map was revised from aerial photographs in 1982, not field checked, and then edited in 1989. The twenty-three year difference from the first field checked date and the DOQQ photograph date showed dramatic changes in the land cover of the mining areas. MAP 10 is a comparison of DOQQ images from Snyder Knob NE; the one on the left is NAD27, while the one on the right is NAD83. The inventory data is displayed on each view for a comparison of the difference between the two datums prior to data conversion.

Calculations to determine the actual displacement of the inventory after conversion to NAD83 from NAD27 can be seen in the following table.

NAD27			NAD83		
	Northing	Easting		Northing	Easting
Point 1	4331082	628224		4331302.48448	628239.82217
Point 2	4224166	553671		4224385.16665	553687.02733
Displacement	106916	74553		106917.31783	74552.79484
	Displacement value between NAD27—NAD83	Northing 1.31783 m	Easting 0.20516 m		

Table 1 Showing displacement of northern most point (1) and southern most point (2) before and after conversion with Corpscon from NAD27 to NAD83.

By using the Pythagorean Theorem to calculate the sides of a triangle the actual displacement distance can be calculated through the formula $A^2 + B^2 = C^2$, where A is equal to the Northing distance, B is equal to the Easting distance and C is the actual displacement between the two points. Substituting the values from the table into the formula gives the following:

$$(1.31783)^2 + (0.20516)^2 = C^2$$

When this equation is simplified to solve for C, the following equation is derived:

$$C = \sqrt{(1.31783)^2 + (0.20516)^2}$$

Solving this equation results in C = 1.3337 meters of displacement when performing the conversion from UTM NAD27 to UTM NAD83 of an upper point from the inventory and lower point from the inventory using Corpscon software developed by the Army Topographic Engineering Center, as modified from the NADCON conversion program developed by the National Geodetic Survey (USACE, 1997). The average distance between the two points in the Northing direction from NAD27 to NAD83 was 219.83 meters, while the Easting direction was 15.92 meters.

Additional error is introduced when discussing the location of the WVDEP differential correction base station in Morgantown, which was used as a control reference for the GPS data collection. As previously mentioned the farther away the roving unit is from the basestation, the less accurate the differentially corrected positions become, typically 10 ppm, or 10 mm of accuracy degradation for every kilometer between the base station and the rover (Trimble, 1996a). The distance from the Monongahela National Forest inventory areas to the Morgantown base station ranged from about 90 km to more than 150 km, which could equal an accuracy degradation of more than 1.5 meters.

Geobiophysical Modeling

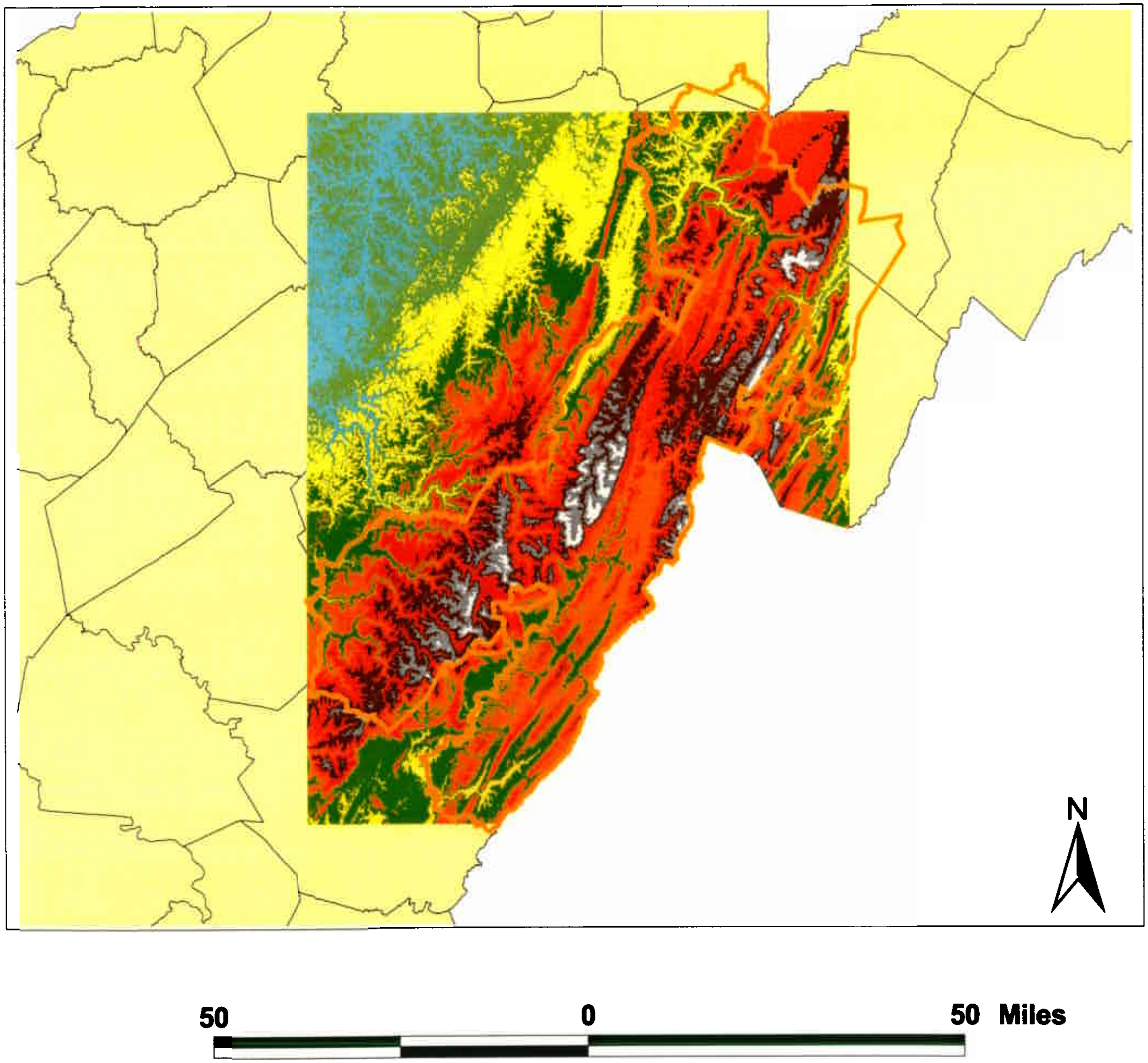
A Digital Elevation Model (DEM) of the Monongahela National Forest area was created in MAP 11. This dataset was projected in NAD83 datum. MAP 11 depicts the location of the inventory features with respect to their elevation. Based on this map, the majority of the features occur within the gray and black sections of the map which represent elevations of 1203-1241 and 1064-1202 meters, respectively. From this DEM, a NAD83 Snyder Knob DOQQ was draped on top to provide a 3-dimensional view to help capture the actual surface topography of the area, as seen in MAP 12. Additionally, the DEM allowed for the calculation of a slope grid as seen in MAP 13. This slope map shows the ratio of the vertical rise in the mountains versus the horizontal run and represents this value in degrees. GRAPH 1 is included to show the distribution of slope through the use of a histogram. This graph shows that the greatest percentage of slope lies within the 6.9 to 13.8 degree range. Associated with the slope map calculation is the aspect map calculation, as seen in MAP 14. This map shows the azimuth direction of slope in percentages. The aspect map also shows the path of least resistance of flow, or the direction water may flow down the slope. GRAPH 2 represents the aspect map calculation and shows the most common direction of slope is to the Northwest (292.5-337.5 degrees). The final map created from the DEM is the hillshade MAP 15. This map creates a relief map effect, which is depicted by various shades of gray created by a simulated sun angle of 315 degrees.

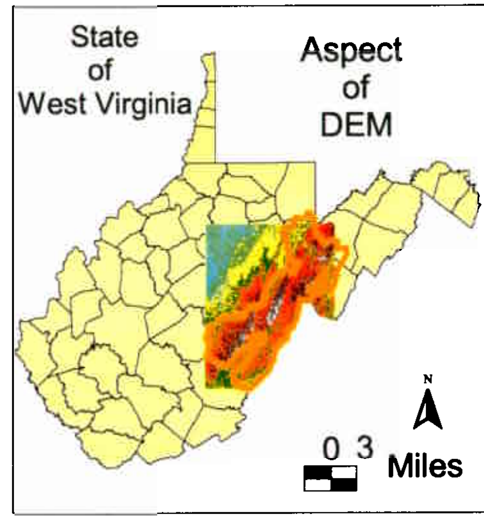
MAP 10
Comparison of Snyder Knob NE
NAD27 DOQQ to NAD83 DOQQ

A
Converted NAD83 DOQQ to NAD27 UTM 17
with USGS 7.5-Minute Quadrangle based data

B
NAD27 UTM 17 Data on NAD83 DOQQ
with approximate 200 meter North-South displacement

MAP 11
Digital Elevation Model (NAD83) in Meters of Monongahela National Forest





LEGEND

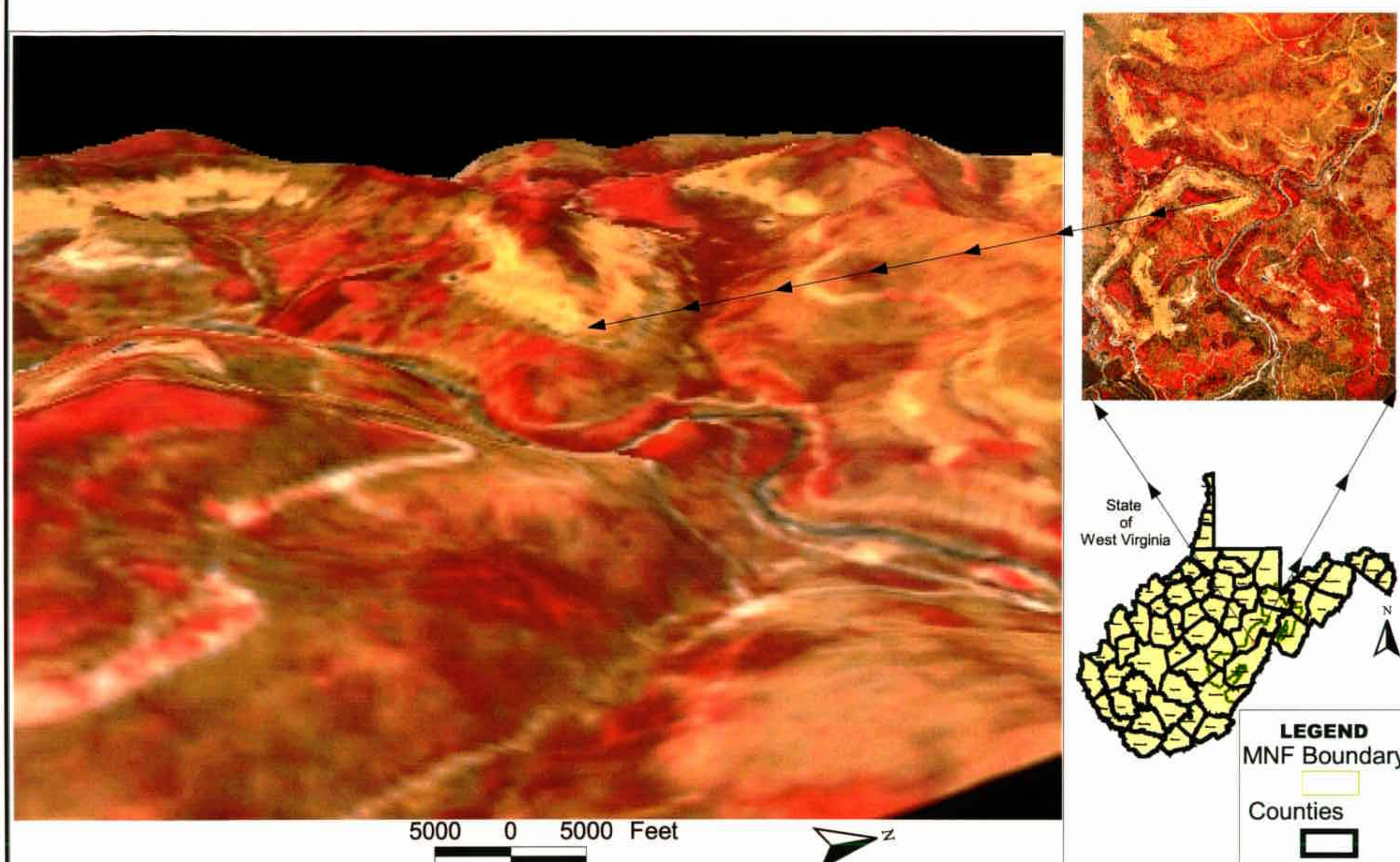
Counties

MNF Boundary

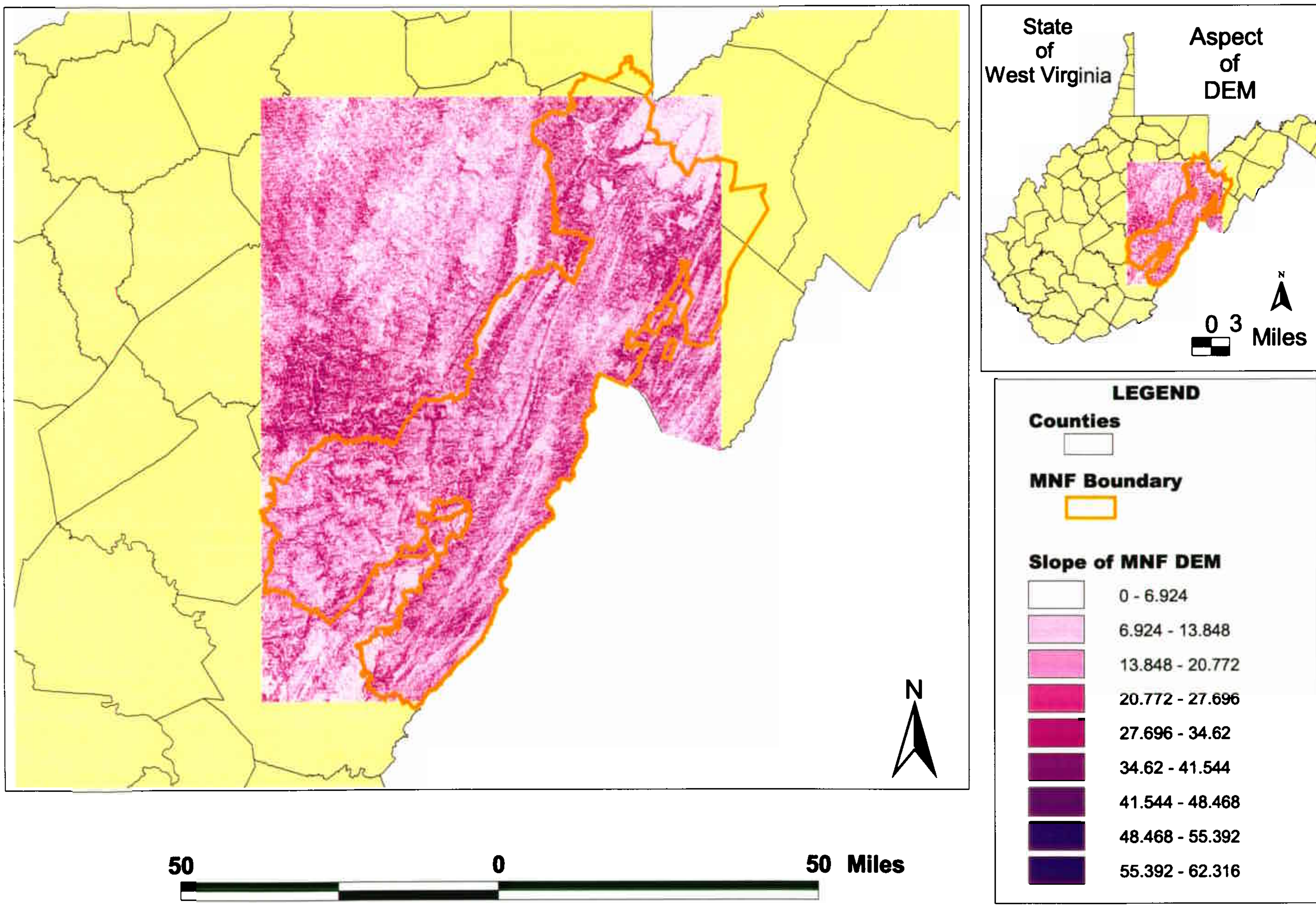
MNF Elevation Data in Meters

228 - 367
368 - 506
507 - 645
646 - 784
785 - 924
925 - 1063
1064 - 1202
1203 - 1341
1342 - 1481

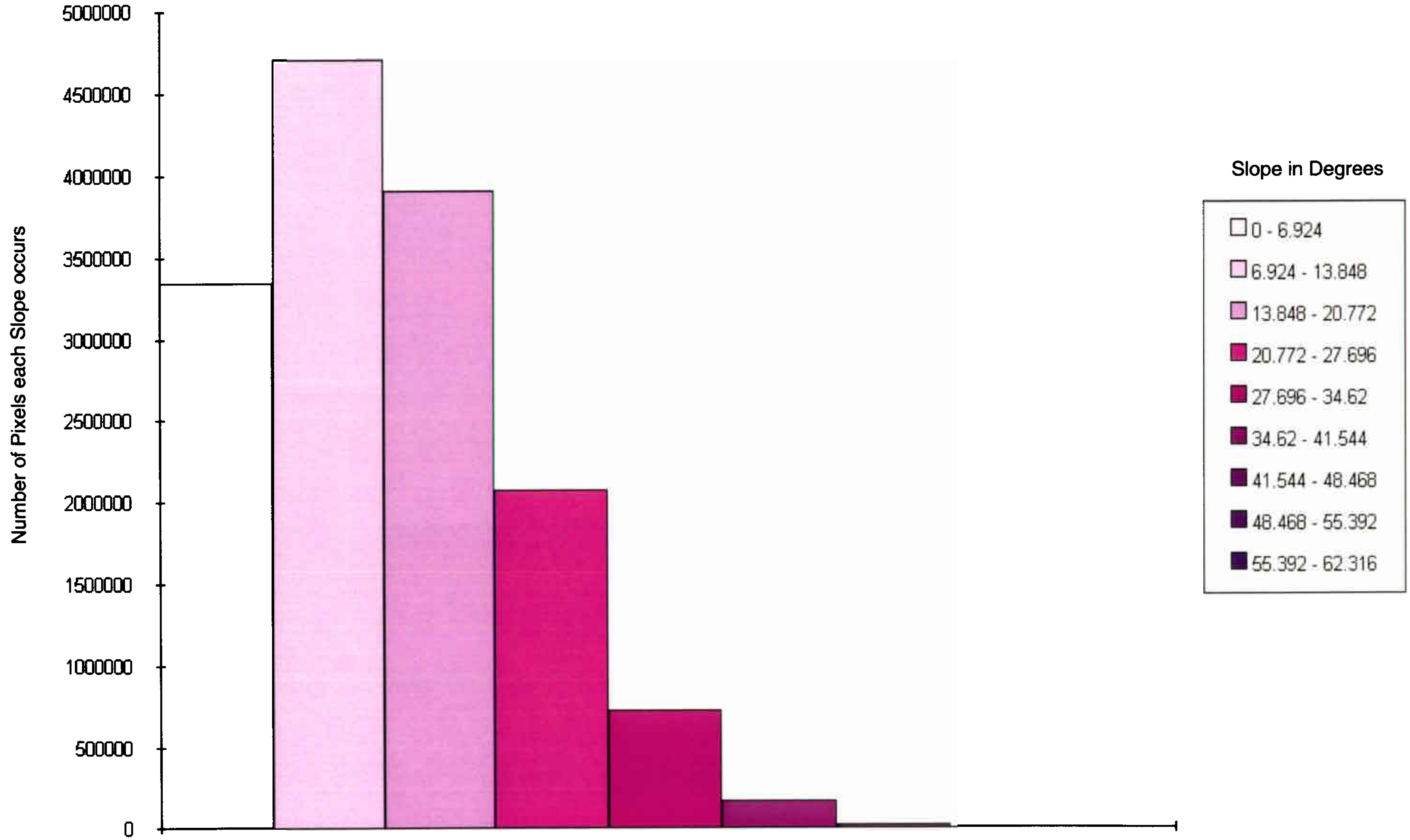
MAP 12
3-Dimensional View of Snyder Knob NE DOQQ (NAD83) based on NAD83 Digital Elevation Model



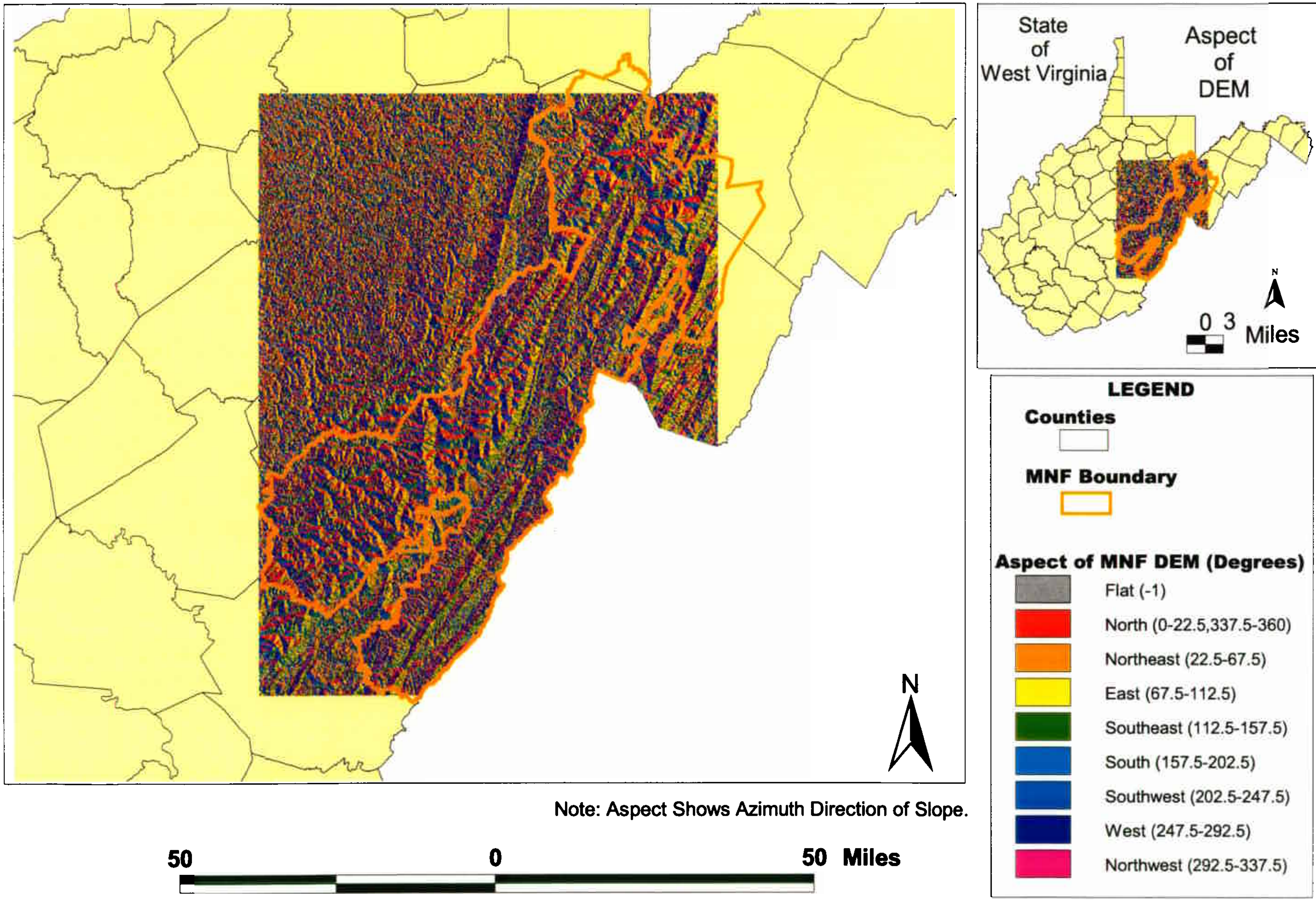
MAP 13
Slope of Digital Elevation Model (NAD83) in Degrees of Monongahela National Forest



Graph 1
Histogram of Slope of Mon Forest Elevation:Value



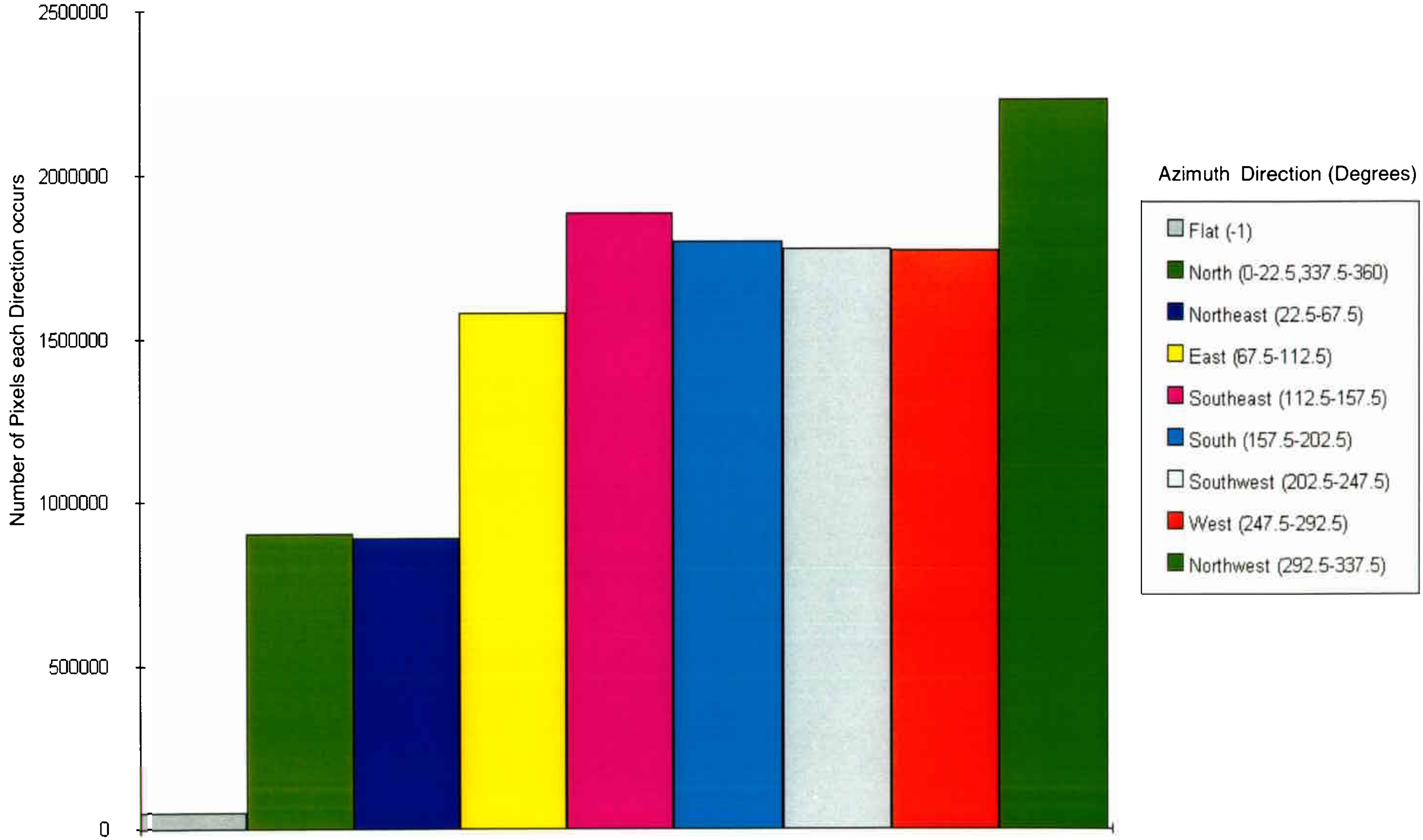
MAP 14
Aspect of Digital Elevation Model (NAD83) in Degrees of Monongahela National Forest



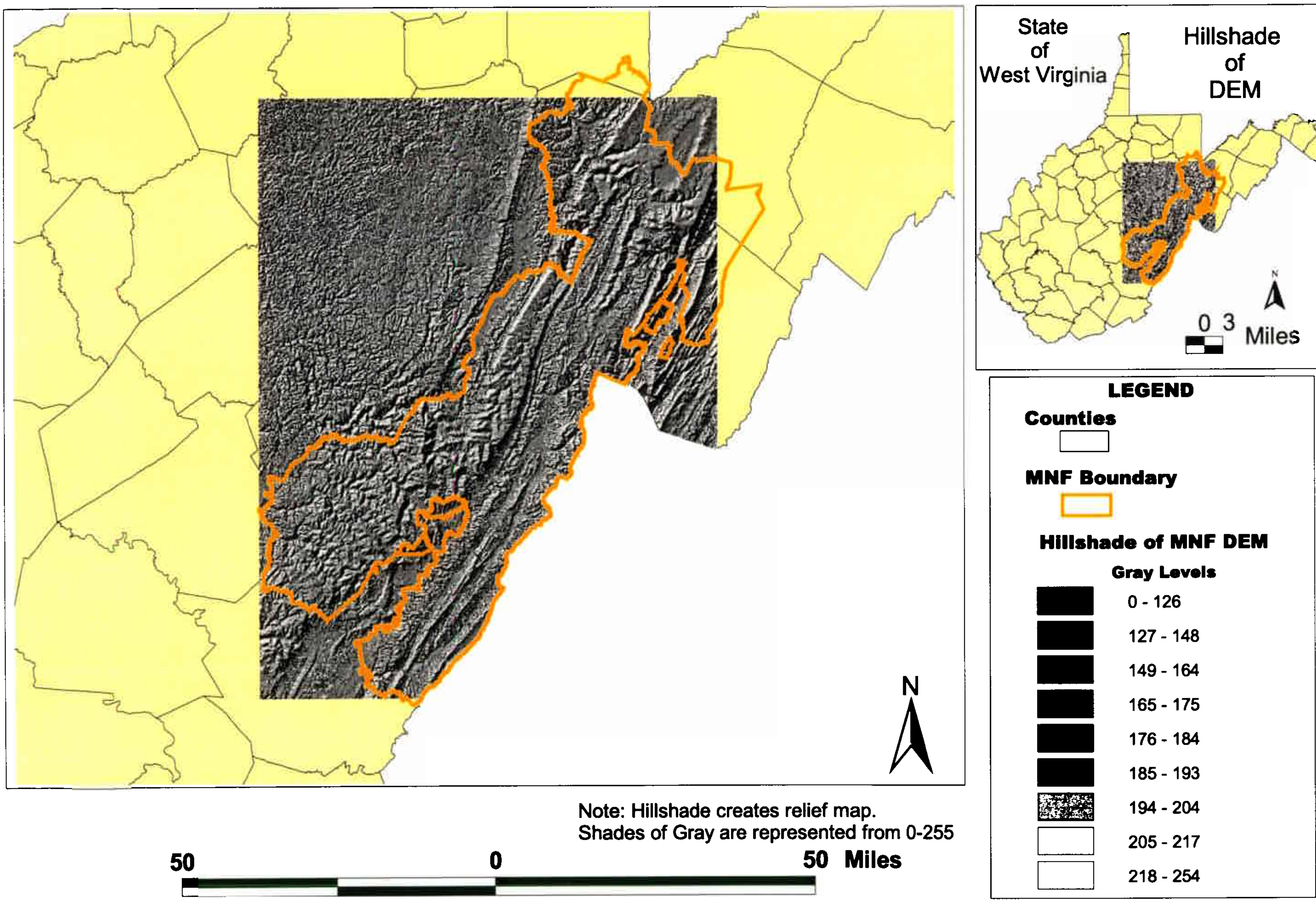
Note: Aspect Shows Azimuth Direction of Slope.

Graph 2

Histogram of Aspect of Mon Forest Elevation:Value



MAP 15
Hillshade of Digital Elevation Model (NAD83) of Monongahela National Forest



CHAPTER V CONCLUSIONS AND FUTURE TRENDS

Conclusions

Overview Conclusions

The Abandoned Mine Lands inventorying process was assigned to the U.S. Army Corps of Engineers (USACE) in 1998 by the United States Forest Service (USFS). This process required the USACE to conduct a GPS survey of post-mining related features, providing descriptions and georeferenced locations for each encountered feature. The collection datum was set to the North American Datum of 1927 (NAD27) for compliance with United States Geological Survey (USGS) 7.5-minute digital georeferenced topographic maps, or digital raster graphics (DRG). The use of NAD27 for data collection or reference maps does not accurately portray the shape of today's earth. The NAD27 datum model was based on the Clarke Ellipsoid of 1866 (USGS, 1999). The more modern datum, the World Geodetic System of 1984 (WGS-84), was developed to accommodate more accurately the changes in the dimensions of the earth (Trimble, 1996a). Differential correction of the GPS collected points was made using the Morgantown base station, maintained by the WVDEP. This base station was located 90 kilometers at the northern most point that was surveyed to 150 kilometers at the southern most point, within the Monongahela National Forest. A 10 mm degradation of accuracy is introduced for every kilometer the roving GPS unit is away from the base station which would result in an error of 0.9 to 1.5 meters. In order to overcome the error introduced by differentially corrected points with a base station located over 100 kilometers away, it may be more prudent to use a GPS unit with real-time differential correction or a second unit as an established basestation that lies within the recommended distance for accuracy, which can reduce accuracy errors to the decimeter level.

The North American Datum of 1983 (NAD83) is a local datum, though can be made applicable worldwide, that was created to reflect the shape of the earth with reference to North America. It is now based on the WGS-84 model and modified to

NAD84 by using corrected GPS positioning on earth and is the most current datum used for georeferencing satellite, aerial, and related imagery (USGS, 1999). GPS receivers collect data from satellites using the WGS84 datum and then convert this to the desired datum for projection. The USACE inventory was converted to NAD27 internally by calculations made in the GPS receiver; however, an error will still exist (Trimble, 1996a) because even the most accurate conversion programs, based on the National Geodetic Surveys, NADCON (North American Datum Conversion) leave an error of 0.5 meters (USGS, 1999). This difference is a minimum as larger differences exist depending upon location in different parts of North America (USGS, 1999). However, as seen in the calculations of Table 1 the actual difference can measure to more than a meter in the north-south direction when dealing with large areas. Differences between the two datums prior to conversion can measure up to at least 200 meters in the north-south direction (USGS, 1999) and nearly 16 meters in the east-west direction.

The USGS 7.5-minute georeferenced, digital, topographic maps, DRG's, are based on the standard USGS 7.5-minute paper quadrangle maps which were initiated in the 1930's and are projected to the NAD27 datum. The average date of currency for these maps is 1967; however, installation of a revision program improved the currency to 1979 (Moore, 2000). Use of these maps as GIS base maps can prove costly predicated on their date of currency, as well as the projection into the NAD27 datum.

Introduction of USGS Digital Orthophoto Quarter Quadrangles began in 1991. This is a computerized image of an aerial photograph combining the quality of an image with the characteristics of a map (USGS, 1998b). Using color infrared photography, these images possess a 1-meter ground resolution and represent an area just slightly larger than 3.75 x 3.75 minutes, or a quarter of a quadrangle. This overlap area ranges between 50 to 300 meters to allow for image processing techniques such as mosaicing and color balancing. Photographs were taken between 1996 and 1999 during leaf off periods of deciduous trees (USGS, 1996a). The DOQQ's were projected using the more current and accurate NAD83 datum.

Research Conclusions

A Geographical Information System (GIS) was used as a compilation and database tool for assembling inventory data and comparing the use of NAD27 to NAD83 and DRG's to DOQQ's. This powerful mapping system allows the data entered to be updated and maintained with relative ease. A GIS presents the information of a paper map merged with the graphic and visual representation of the real world. Arcview 3.2a (ESRI, 1996) was the chosen GIS software, based on its ease of use and wide distribution among government agencies. Advantages of using the GIS as a tool for managing the georeferenced data include, but are not limited to, ease of database maintenance, availability of presentation quality maps, visual representation of data, paper map accuracy, and querying tools available with the Arcview (ESRI, 1996) software. These tools allow for features to be selected based on user established parameters. Implementation of a system with this technology saves time and money when dealing with data as large as the Monongahela National Forest Inventory.

The creation of the GIS database was used to demonstrate the objectives of this thesis, the comparison of NAD27 data versus NAD83, the use of DRG's versus DOQQ's with reference to a GIS database, and the creation of such database using the georeferenced inventory collected by the U.S. Corps of Engineers. Upon review of the accompanying maps it can be seen that modifications need to be made regarding the GPS collection techniques from the outdated NAD27 to the more current, accurate, and versatile NAD83 or WGS84, to reduce the amount of error associated with conversions and provide a more common global framework. Accordingly, the use of USGS 7.5-minute digital georeferenced, topographic maps as base maps does not provide the level of detail nor GPS accuracy that can be found in USGS DOQQ's. This research has provided the basis for evidence that improvements in both areas need to be made in order to provide a product demonstrating excellence.

Future Trends

The completion of this research through the use of a Geographical Information System creates additional possibilities with respect to managing data with minimal effort and maximum accessibility. One such way to do this is through the implementation of ERMapper's Image Web Server (Earth Resource Mapping, 2001) or ArcView's ARCIMS (ESRI, 2001). These internet based servers deliver GIS data through the use of a web browser and allow users with no prior GIS training to access it (ESRI, 2001). The use of this technology creates endless possibilities with data management, such as the geobiophysical modeling inventory of this research. Implementation of the internet mapping services for inventorying and related USFS work performed by the USACE could be made possible through a cooperative agreement between the two agencies and Marshall University. Additional analysis of the inventory data was made by the USFS to determine the areas of greatest need for reclamation and did not fall within the scope of this research. However, a statistical analysis of the inventory results through the use of a GIS may be done as future work.

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Appendices

Appendix I Data Dictionary of Terms

DATA DICTIONARY OF TERMS

ArcView Geographic Information System developed by Environmental Systems Research Institute

ASCII American Standard Code for Information Interchange

Azimuth Directions North (N), South (S), East (E), West (W), Northwest (NW), Northeast (NE), Southwest (SW), Southeast (SE)

Clark 1866 Geoid Early model of the shape of the earth; basis for USGS DRG

DBMS Database Management System

DEM Digital Elevation Model

DOQQ Digital Orthophoto Quarter Quadrangles

DLG Digital Line Graph

DRG Digital Raster Graphics

DRG Clipper 2.0/3.0 ArcView extension used to clip the white border from a Digital Raster Graphic, topographic map.

ESRI Environmental Systems Research Institute

ERMapper Geographical Information System developed by Earth Resource Mapping Inc.

GIS Geographical Information System

GPS Global Positioning System

GRS-80 Geodetic Reference System of 1980

Hydrolab Water Quality data collector developed by the Hydrolab Corporation

Microsoft Excel Database Management System developed by Microsoft

MrSID Multi-Resolution Seamless Image Database

NAD83 North American Datum of 1983

NAD27 North American Datum of 1927

NADCON North American Datum Conversion program

NED National Elevation Dataset

Ph A measure of water acid levels; from 1-14 from acidic to basic respectively

SQL Structured Query Language

USACE United States Army Corps of Engineers

USFS United States Forest Service

USDOD United States Department of Defense

UTM Universal Transverse Mercator

WGS84 World Geodetic System of 1984

WGS83 World Geodetic System of 1983

WVDEP West Virginia Department of Environmental Protection

WV GIS Technical Center Center of GIS data and management located at West Virginia University

Zone 17 One of 60 zones with the world has been divided for the Universal Transverse Mercator, which fall between 84° N and 80 ° S each of which is 6° wide in longitude.

Appendix II Scope of Work

L.Tracy 4/13/99

Monongahela National Forest
Coal Mine Ponds Deferred and Annual Maintenance Condition Survey
FY 1999

SCOPE OF WORK

1. Collect required data at each water impoundment, pond, or dam within coal mine sites on National Forest System (NFS) land;
2. Add specified information to the Monongahela National Forest Abandoned Mine Lands Inventory (MNF AMLI);
3. From data collected, prepare a dollar estimate of Monongahela National Forest (MNF) coal mine pond a)deferred maintenance needs, and b)annual maintenance costs; and
4. Furnish data in digital format to prescribed standard in the existing MNF AMLI data file.

1. On mine sites identified in the Monongahela National Forest Abandoned Mine Lands Inventory and other mine sites identified by the Forest Service which are not in the inventory, collect and record data as described in the attached "Abandoned Mines Data Dictionary", Addended April 1999.

a) For mine sites currently in the inventory, collect data specified in Item 34. Mine Ponds Conditions.

b) For mine sites not currently in the inventory, record mine site number furnished by the Forest Service (data item 1), complete data item 3 (Survey Date, Mine site surveyor), collect data items 7 (Elevation) and 9 (Coordinates:UTM), and 34 (Mine Pond Conditions).

2. Data collection schedule and review.

a) Complete data collection and recordation in the Shavers Fork watershed first, including deferred and annual maintenance costs. Meet with the Forest Service for review and concurrence.

b) Complete data collection, recordation, deferred and annual maintenance costs on the rest of the Forest mine sites.

c) Forward completed entire project (finished product) to the Forest Service by August 30, 1999.

3. Prepare a spreadsheet identifying deferred maintenance needs and costs, and annual pond maintenance costs for each inventoried pond based on the condition survey findings. Generate total Forest deferred and annual mine pond maintenance costs.

4. Data format and standards:

a) Data prepared in-

***UTM Coordinates - Zone 17;**

***NAD 27;**

***Coal mine ponds will be labeled as a mine site feature each with a unique code**

***furnished in ARC generate format.**

b) GPS -
***corrected resource grade survey**
***GPS receiver requirements 3d pdop**
***furnish points data in .dxf format**
***file names are to be referenced/indexed to attribute data (e.g. file name is the same as mine site feature number)**

Appendix III Inventory Data Dictionary

ABANDONED MINES DATA DICTIONARY

Monongahela National Forest

6/22/98 (taken from R3's AIM data dictionary and other sources as indicated)

L.Tracy

Data Item and Terminology Definitions:

These definitions are written for persons collecting inventory data to describe what information to collect at abandoned mine sites and record in the data base or field data recorder, as appropriate.

Definition component for mine sites:

Description: A plain English explanation of a term or data field, namely what each code means, what units are to be used and to what precision.

Entry format: Describes, to the person designing the database and the person entering the data, exactly what data is to be entered. For example, the length of the field, the type of data (numeric, alpha character, etc.), the valid codes, that the field is for description, in any form useful to the user.

Source: The source from where the description has been taken.

Definition component and data needs for mine site features:

Data to be collected: A description of the data to be collected to attribute each mine site feature identified, what each code means, what units are to be used and to what precision.

Source: The source from where the data to be collected has been taken.

General Definition - **MINE SITE -** A location where coal has been extracted from the earth. The site may contain several features such as highwalls, ponds, mine portals or openings to underground mine workings, spoil or gob piles, equipment, foundations, old buildings, rubbish deposits.

1. Mine Site Number.

Description: An identifying four digit number that is the same as the Problem Area (PA) number shown on the U.S.D.I., Office of Surface Mining (OSM), Abandoned Mine Land Inventory (AMLI) form. Obtain number for new mine sites from WVDEP Joe Zambelli (304 457 3219).

Entry format: numeric records; e.g.1567

Valid Entry: 4-digit code from WVDEP

Source: Decision made by L. Tracy (USFS) and Marshall Leo (WVDEP), 4/7/98.

1a. Region Code:

Description: A two digit code representing the Forest Service Eastern Region.

Entry format: numeric Valid Entry: 09

Source: Standard code for Forest Service Eastern region.

1b. Forest Code:

Description: A two digit code which combined with Region code, uniquely identifies a National Forest.

Entry format: numeric Valid Entry: 21

Source: Standard code for Monongahela National Forest.

1c. District Code:

Description: A two digit code which combined with Region and Forest codes, uniquely identifies a Forest Service Ranger District.

Entry format: numeric Valid Entry: 01 (Cheat), 02 (Gauley), 03 (Greenbrier), 04 (Marlinton), 05 (Potomac), 06 (White Sulphur Springs).

Source: Standard code for Monongahela National Forest Ranger Districts.

2. Mine Site Name:

Description: Problem Area name identified on USDI, OSM, AMLI form. Use historical name or local geographic feature for new sites identified.

Entry format: character Valid Entry: Fork Mountain Highwall

Source: Decision made by L. Tracy (USFS) and Marshall Leo (WVDEP), 4/7/98.

3. Survey Date, Mine site surveyor:

Description: The date of the on-the-ground mine site survey as month, day, year.

Entry format: numeric, character Valid Entry: 011298, L.Tracy

Source: Decision by L.Tracy (USFS) 4/9/98.

4. FedPlan Id.

Description: The Federal Facilities Identification number is assigned by GSA. Each Region and Forest will have a unique FFID number.

Entry format: numeric | Valid Entry: (same for each mine site on MNF)

Source: FEDPLAN update instructions.

5. State code:

Description: A two character abbreviation for States.

Entry format: character | Valid Entry: WV

Source: Standard code for West Virginia.

6. County Code:

Description: A three digit code which combined with State code, uniquely identifies the County in which the mine site is located.

Entry format: numeric | Valid entry: 001 (Barbour), 023 (Grant), 025 (Greenbrier), 067 (Nicholas), 071 (Pendleton), 075 (Pocahontas), 077 (Preston), 083 (Randolph), 093 (Tucker), 101 (Webster).

Source: Standard codes for WV Counties.

7. Elevation:

Description: Vertical distance from a datum, usually mean sea level, to a point on the earth's surface, in feet. The elevation is to be based on GPS-obtained mine site location.

Entry format: numeric | Valid entry: 3820

Source: Common usage.

8. Quad Name:

Description: U.S. G.S. 7.5 minute quadrangle on which most or all of which the mine site occurs as shown on USDI,OSM, AMLI Update Form, item 14, principal Quad.

Entry format: character Valid Entry: Fork Mountain

Source: Decision by L. Tracy (USFS) and Marshal Leo (WVDEP), 4/7/98.

9. Coordinates: UTM

Description: GPS obtained location information near the center of the mine site recorded as UTM:North/UTM:East. Universal Transverse Mercator (UTM) is one of sixty zones dividing the globe each spanning 6 degrees of longitude. Each zone has its own principal meridian. UTM:North (also YUTM) is the coordinate (in meters) of the UTM zone, and UTM:East (also XUTM) is the coordinate (in meters) of the UTM zone.

Entry format: alpha numeric Valid Entry: UTM: 4220000N UTM: 543000E

Source: Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98.

10-11. Coordinates: Latitude and Longitude

Description: GPS obtained location information near the center of the mine site recorded as latitude/longitude. Latitude is the angular distance measured in degrees north or south of the equator, recorded in degrees, minutes and seconds. Longitude is the arc or portion of the earth's equator intersected between the meridian of a given place and the prime meridian, recorded in degrees, minutes and seconds.

Entry format: alpha numeric Valid Entry: 380730N, 803730E

Source: Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98.

12. Hydrologic Unit code:

Description: An 8-digit code identifying to 4th order watersheds.

Entry format: numeric Valid Entry: e.g. 05020004

Source: Hydrologic Unit Codes from Forest Service 2510 Manual supplement No. 2500-90-2 and Hydrologic Units used for Ecological Classification in the Mon NF (draft 7/10/96, Bob Reis), Table 2.

13. Subbasin Hydrologic Unit code:

Description: A 6-digit code identifying 5th and 6th order watersheds.

Entry format: numeric Valid Entry: e.g. 010030

Source: Hydrologic Units used for Ecological Classification in the Mon NF (draft 7/10/96, Bob Reis), Table 2.

14. Land Ownership:

Description: The classification of federal administration, private, local or state holdings of the surface estate. However, only sites on Monongahela National Forest System Land are to be entered into data base.

Entry format: Character

Valid Entry: FS

Source: Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98.

15. Mineral Ownership.

Description: Mineral estate ownership (owner with controlling or >50% interest)(from Forest Service Lands Status records.

Entry format: character

Valid Entry: FS (US minerals beneath NFS land) PRI (Privately owned minerals)
UN (Unknown mineral ownership)

Source: Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98.

16. Status

Description: Present status of mine site.

Entry format: character

Valid Entry: AB (abandoned, incl. mines in bond forfeiture) AC (Active), IN (Inactive, incl. with permit in an inactive status), UN (Unknown).

Source: Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98, and Decision by L.Tracy 4/9/98.

17. Type of Coal Mining:

Description: Identify the most recent method of coal removal at the mine site.

Entry format: character

Valid Entry: S (surface mining, incl. auger), U (underground mining), B (combination surface and underground mining), P (Coal processing, including cleaning and loading).

Source: USDI, OSM, AMLI Update form.

18. Size

Description: Approximate size, to the nearest 5 acres, of the mine site.

Entry format: numeric   Valid Entry: <5, 5 to <10, 10 to <15, 15 to <20, etc.

Source: Decision made by L. Tracy, 4/9/98.

19. Earth Disturbance

Description: Approximate area, to the nearest 1 acre, with less than 80% vegetative cover.

Entry format: numeric   Valid Entry: 0 and any whole number; e.g. 2.

Source: Decision made by L. Tracy, 4/9/98 to use WV mine reclamation revegetation standard.

20. Functioning Channels created by or occurring on Mine Site

Description: Number of functioning channels (a well defined channel that clears itself at least once a year of small debris and litter, exhibits channel bank formation, and may often contain alluvial deposits of sand, gravel, and/or rubble in the channel bed (MNF FEIS, p E-14)) that originate on the mine site, or new or unnatural functioning channels off of the mine site that have been created by the mine site or as a result of mining.

Entry format: numeric   Valid Entry: 0 and any whole number; e.g. 2.

Source: Decision made by L. Tracy and B.Edgerton (USFS Hydrologist).

21. Functioning Channels Near Mine Site:

Description: Identify the approximate distance to the nearest 50 feet, to the closest, naturally occurring functioning channel from the mine site, up to approximately 500 feet from the mine site.

Entry format: numeric   Valid Entry: 50

Source: Decision made by L.Tracy and B. Edgerton.

22. Mine site Diversion of Existing Functioning Channel(s).

Description: Number of existing functioning channels that have been diverted from original channel by mine site development.

Entry format: numeric Valid Entry: 0 and any whole number; e.g. 2.

Source: Decision made by L. Tracy and B. Edgerton

23. Water Conditions that create unstable soil/rock materials.

Description: Number of areas on the mine site with water conditions that present a risk for creating slumps or slides, such as overland flow concentration into an unstable area, and ponds showing evidence of instability, such as located on unstable slopes, unstable fill as evidenced by cracks in the fill or slumps, evidence of uncontrolled discharge, overtopping or leakage, or more than 2 ponds connected in series.

Entry format: numeric Valid Entry: 0 and any whole number; e.g. 2.

Source: Decision made by L.Tracy and B.Edgerton

24. Mine site Erosion

Description: Number of gullies that average at least 1 foot deep on or immediately downstream of the mine site.

Entry format: numeric Valid Entry: 0 and any whole number; e.g. 2.

Source: Decision by L. Tracy and B. Edgerton.

25. Potential Hazardous Materials: Mine-Related Discharge(s) pH 4.0 or less.

Description: Number of mine-related pond discharges with pH 4.0 or less.

Entry format: numeric Valid Entry: 0 and any whole number; e.g. 2.

Source: Decision by L.Tracy 5/5/98 based on Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98

26. Potential Hazardous Materials: Explosives, Petroleum, Chemicals/Transformers.

Description: Number of mine site features containing evidence of potentially hazardous material.

Entry format: numeric Valid entry: 0 and any whole number; e.g. 2.

Source: Decision by L.Tracy 5/5/98 based on Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98

27. Past Reclamation Efforts.

Description: Is there evidence of reclamation work completed more recently than 1978?
Yes (Y) or No (N) Check all that apply:

____ regrading, including highwall elimination, erosion repair, pond removal
____ mine seal installation
____ mine portal or opening backfilling
____ revegetation
____ mine water discharge treatment installation

General Definition - **MINE SITE FEATURE** - Any one of a number of objects or physical conditions present within a mine site that are remnant of the mining operation. Typical features include, but are not limited to, highwalls, ponds, mine portals or openings to underground mine workings, mine-related water discharges, spoil or gob piles, rubbish deposits, pieces of equipment, foundations, old buildings or structures. GPS obtained UTM coordinates identify each feature or group of features, then information is collected about the feature as described.

28. Highwall(s).

Data to be collected:

- GPS obtained UTM coordinates at one point representing the highwall. (Valid entry: 4220000N, 543000E)
- Estimated total length of highwall (to the nearest 100 feet)
- Representative or approximate average height of highwall (to the nearest 10 feet)
- Representative or approximate average slope of the highwall (to the nearest 10%).

Source: Decision by L. Tracy 5/5/98.

29. Pond(s).

Data to be collected:

- GPS obtained UTM coordinates of each pond that has a discernable discharge and does not discharge to another pond. (Valid entry: 4220000N, 543000E)
- For each pond that has a discernable discharge and does not discharge to another pond report the following, collected as close to the discharge outlet as possible: Measured discharge volume (to the nearest gallon per minute or indicate seep (S), pH (field), conductivity in UMHOS (field), hot acidity in MG/L (laboratory), Total Iron in UG/L (laboratory).
- Does the pond have unusual surface water discoloration, excluding color expected from organics or iron?
  Yes (Y) or No (N).

Source: Decision by L.Tracy and B.Edgerton.

30. Mine Portals or Openings to Underground Workings

Data to be collected:

- GPS obtained UTM coordinates of each mine portal or opening identified. (Valid entry: 4220000N, 543000E)
- Could portal or opening provide access allowing public or animal entry to underground workings?
  Yes (Y) or No (N).
- Does portal or opening discharge water? Yes (Y) or No (N).
- For each mine opening with a water discharge (Y above), report the following, collected as close to the discharge outlet as possible: Estimated discharge volume (to the nearest gallon per minute or seep (S)), pH (field), conductivity in UMHOS (field), hot acidity in MG/L (laboratory), Total Iron in UG/L (laboratory).
- Does the discharge have unusual surface water discoloration, excluding color expected from organics or iron?
  Yes (Y) or No (N).

Source: Decision by L.Tracy and B.Edgerton.

31. Coal Spoil or Gob piles.

Data to be collected:

- GPS obtained UTM coordinates of each coal spoil or gob pile identified. (Valid entry: 4220000N, 543000E)
- Estimate area (in square feet) occupied by the coal spoil or gob pile (dimensions to the nearest 10 feet).
- Estimate average height (in feet) of the coal spoil or gob pile (to the nearest 20 feet).
- Is there evidence that the coal spoil or gob has burned? Yes (Y) or No (N).

Source: Decision by L.Tracy 5/5/98.

32. Rubbish Deposits.

Data to be collected:

- GPS obtained UTM coordinates of rubbish deposits, excluding individual discarded items unless they are suspected to contain potentially hazardous materials. (Valid entry: 4220000N, 543000E)
- Estimate area (in square feet) occupied by the rubbish deposit (dimensions to the nearest 10 feet or individual item (I)).
- Estimate average height (in feet) of the rubbish deposit (to the nearest 10 feet or individual item (I)).

- Does rubbish deposit contain evidence of potentially hazardous material such as explosives, petroleum, chemicals/transformers?
  Yes (Y) or No (N).
- Remarks: Include general description of rubbish deposit content, including specific description of items that could contain potentially hazardous materials.

Source: Decision by L.Tracy 5/5/98 based on Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98.

33. Buildings, Foundations, Structures.

Data to be Collected:

- GPS obtained UTM coordinates of each building, foundation or structure, or group of buildings, foundations, or structures if located within a 100 ft by 100 ft area. (Valid Entry: 4220000N, 543000E)
- Do buildings, foundations or structures contain evidence of potentially hazardous material such as explosives, petroleum, chemicals/transformers?
  Yes (Y) or No (N).
- Remarks: Include general description of buildings, foundations or structures and their condition (Intact (I), Dilapidated (D), or Remnant (R)), including specific description of items that could contain potentially hazardous materials.

Source: Decision by L.Tracy 5/5/98 based on Region 3 Abandoned and Inactive Mines Data Dictionary, 3/9/98.

Appendix IV Support Agreement

<u>SUPPORT AGREEMENT</u>: Number MNF-02-98

<u>Project</u>: Abandoned Mine Lands Inventory

Huntington District of US Army Corps of Engineers (LRH) proposes to perform the work described below for the Monongahela National Forest (MNF). This support agreement is based on the scope of work (dated June 22, 1998) provided by Linda Tracy of MNF. We perceive the work as follows:

-Identify abandoned coal mine sites on Monongahela National Forest System (NFS) Land;

-Collect required data at each site; and

-Furnish inventory data in digital format to prescribed standards in order to be able to incorporate inventory into MNF's GIS system.

Actual work items to be performed:

1. Using "Inventory Listing of Identified AML & R Sites within the Monongahela National Forest (Nov 1997)" and U.S. Department of the Interior, Office of Surface Mining, Abandoned Mine Lands Inventory records (rec'd from WV DEP AML Division) as an approximate inventory:

    a) verify site location and occurrence on NFS land, and document AML features using GPS technology (see item 3 below) for approximately 55-60 sites identified either from MNF files as provided by MNF representatives prior to the start of the work, or as depicted on 13 U.S.G.S. 7.5 min. quads with mine sites identified and 13 U.S.G.S. 7.5 min. quads modified for Forest Service use which have already been provided by MNF.

    b) examine adjacent nearby areas likely to contain undocumented additional AML features or facilities; and

    c) complete field examination of sites primarily during leaf-off periods (approximately October - April) to increase the likelihood of finding AML features.

2. LRH will collect data at each site as described in the MNF "Abandoned Mines Data Dictionary," dated June 22, 1998 (by L. Tracy) The data will be collected as set forth in the data dictionary. LRH will observe, describe, and record all applicable features and conditions discovered on each site. The data will be collected and installed into a GPS field data recorder where appropriate. The survey data will be reduced and adjusted using the computer program "Trimnet." After reduction of survey data, all entries will be entered into an Excel

spreadsheet, specifically designed to integrate with the USFS GIS system. If the data dictionary format requires slight modifications, LRH will obtain approval from MNF for such modifications prior to initiation of the work or at appropriate times throughout the execution of the work.

3. LRH will prepare a file (hardcopy) for each mine site on National Forest System Land that includes:

a) mine site location shown on U.S.G.S. 7.5 min. quad. map;

b) photographs (35 mm, 3.5" x 5" double prints) of mine site including:
i) an overall view that is representative of the site, and
ii) each mine site feature;

c) hardcopy of the information contained within the data dictionary file for each mine site, and each of its features.

4. LRH will collect data as requested by MNF in the following formats and to the standards as listed below:

a) Data prepared as follows -
*in UTM Coordinates - Zone 17, AND latitude and longitude for mine sites only
*in NAD 27, NGVD 29
*sites will be labeled with a unique number per OSM's site listing
*mine site features will be labeled per Forest Service identified code
*furnished in ARC generate format

b) GPS -
*corrected resource grade survey
*GPS receiver requirements 3d pdop
*furnish point data in .dxf format
*file names will be referenced/indexed to attribute data (e.g. file name is the same as mine site feature number)

c) Media -
*all electronically generated information will be provided to MNF on CD-ROM upon completion of the work, or at intervals throughout the work if requested by MNF

5. Details on procedures and equipment to be used:

a. <u>Laboratory Testing Procedures</u>:

pH. We propose to measure pH in the field using the handheld "Oakton Waterproof pHTestr 2," which will measure in a range from -1.0 to 15.0, resolution 0.01 pH, Accuracy +/- 0.1 pH. This tester has an operating range from 32 degrees F to 122 degrees F. "Oakton pH Calibration Singles" are proposed for use in calibration of this meter. The "Oyster Portable pH/Conductivity/Temperature Kit" may also be used for measuring pH. This instrument measures pH in a range from 0.01 to 14 with an accuracy of 0.01, and is operable at temperatures as low as -30 degrees F. A Forestry Suppliers catalog description of these items is attached.

Conductivity. We propose to measure conductivity in the field using the handheld "Oakton TDSTestr 3," which will measure in a range from 0 to 1990 µS Conductivity, Accuracy +/- 2%. This tester has an operating range from 32 degrees F to 122 degrees F. "Oakton Conductivity Calibration Singles" or Oakton Calibration solutions are proposed for use in calibration of this meter. The "Oyster Portable pH/Conductivity/Temperature Kit" may also be used for measuring conductivity. This instrument measures conductivity in a range from 10 to 19,900 µS/cm with an accuracy of +/- 0.5%, and is operable at temperatures as low as -30 degrees F. A Forestry Suppliers catalog description of these items is attached.

Hot Acidity. Hot Acidity will be measured in controlled laboratory conditions. It is currently envisioned that either REI Consultants Inc. of Beckley, WV, or Sturm Environmental Laboratory of Bridgeport, WV will be contracted to do the testing. Depending upon availability of additional laboratory contracts, LRH may request the use of another laboratory, however this would only be after discussion with, and approval by MNF. The test method to be used is described in "Standard Methods, 18th Edition" for acidity, page 2-23, Section 2310, included as an attachment.

Iron. Iron content will be measured in a laboratory as well. It is currently envisioned that either REI Consultants Inc. of Beckley, WV, or Sturm Environmental Laboratory of Bridgeport, WV will be contracted to do the iron testing. Depending upon availability of additional laboratory contracts, LRH may request the use of another laboratory, however this would only be after discussion with, and approval by MNF. Although the test is fairly common and straightforward, the test method to be used is not easily provided since the descriptive literature is somewhat voluminous. LRH will facilitate discussions between MNF representatives and the chosen laboratory, or make further efforts toward providing the actual methodology if requested by MNF. As an alternative to laboratory testing, LRH may request to use an iron meter to make the measurements. If so, LRH would make the request, and present the model number and specifications of the instrument(s) to MNF for prior approval.

b. Measurements.

Flow measurement. Measurement of flow in seeps and channels as required in the data dictionary will be performed using various methods as deemed appropriate to the particular stream.

GPS Measurements. We propose to take actual GPS field location measurements using either a Trimble GeoExplorer II, or a similar unit which would be proposed by LRH prior to initiation of the work and for approval by MNF.

Miscellaneous Measurements. Measurements of aerial extents, heights, slopes, etc. of highwalls, coal spoil or gob piles, and rubbish deposits, as applicable, will be made using visual estimation, pacing, rangefinders, clinometers, Abney levels, Brunton compasses, and other similar instruments useful for approximating such dimensions with reasonable accuracy. Precise surveying methods, except for the specific GPS locations required in the data dictionary, will not be used to make these types of measurements.

6. Project Team. We propose to use LRH in-house labor to execute the work. Short biographical sketches for the two LRH representatives to be primarily involved in the daily activities of collecting and compiling the data required to complete the inventory will be provided. Depending upon scheduling, weather, and similar concerns, additional LRH personnel may participate in the data gathering. A civil engineer specializing in computer applications of mapping and GIS will set up the Excel spreadsheet, assure its compatibility with ARC generate, prepare the project's metadata file, and transfer all data to CD-ROM for final presentation to MNF. All manipulation, reduction, and adjustment of GPS data will be performed by a civil engineer who specializes in computer applications of surveying.

7. General Precautions. LRH will enter no mine openings while performing AML inventory field work. LRH will avoid any hazardous or suspect hazardous substances. Presence of such substances will be documented and reported to the Monongahela National Forest HazMat Coordinator immediately.

8. Schedule. All work is proposed to be completed prior to 31 January 1999, with a draft of the final product provided to MNF by 31 December 1998. It must be considered that laboratory test results of water samples taken later in December may not be available until sometime in January. All sites will be inspected during the leaf-off period beginning in late September 1998. Because of the condensed nature of the schedule, some sites may be investigated prior to leaf-off to collect any information that is obtainable under such conditions, with subsequent visits to make final observations. MNF will be contacted prior to initiation of any field work to allow for field meetings, additional instruction, or adjustment to scope. It is expected that all work phases (i.e. data collection,

compilation, testing, analysis, reporting) will go on essentially concurrently to assure that the schedule can be met. The schedule will generally be as follows:

ITEMS OF WORK	July	August	September	October	November	December	January
Finalize Scope							
Negotiate Costs							
Initiate office work							
Set up spreadsheet							
Initiate Field Work							
Leaf-off inspections							
Provide draft product							
Revise draft							
Provide final product							

Appendix V Abandoned Mine Inventory Database

TABLE 1 MINE PORTALS - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Portal Number	Highwall number	Access	Discharge Water	Discharge Volume	pH	Conductivity UMHOS	Hot Acidity MG/L*	Total Iron UG/L**	Discolor-ation	Remarks
MF-1005	4265522	591691	1 of 2	n/a	NO	YES	1.0	4.6	96	6.2	87	NO	
MF-1005	4265572	591684	2 of 2	n/a	NO	YES	5.0	4.5	72	6.0	118	NO	
MF-1006	4258046	570495	1 of 4	n/a	NO	NO							
MF-1006	4258044	570459	2 of 4	n/a	NO	YES	3.0	4.1	251	31.5	516	NO	
MF-1006	4258026	570439	3 of 4	n/a	NO	NO							
MF-1006	4258041	570389	4 of 4	n/a	NO	NO							
MF-1007	4247636	549664	1 of 1	1 of 1	NO	NO							add to MF-1007
MF-1013	4223381	555635	1 of 2	1	NO	NO							
MF-1013	4223392	555615	2 of 2	1	NO	YES	0.5	3.8	369	46.2	115	NO	mine portal 2 dis.
MF-1014	4223608	555310	1 of 1	1	NO	NO							
MF-1015	4223679	555991	1 of 1	1	NO	YES	3.0	3.6	424	61.6	2900	NO	mine portal 1 dis.
MF-1016	4223641	556548	1 of 1	1	NO	YES	0.2	3.7	165	43.0	615	NO	mine portal 1 dis.
MF-1017	4234788	533924	1 of 1	1	NO	NO							
MF-1019	4231607	551194	1 of 2	1	YES	YES	0.2	6.3	134	1.0	2840	NO	mine portal 1 dis.
MF-1019	4231623	551235	2 of 2	1	YES	NO							mine portal 2
MF-1022	4246685	566869	1 of 1	1	YES	NO							
MF-1027	4296521	607843	1 of 1	n/a	NO	YES	30.0	6.0	93	1.0	1000	NO	mine portal 1 dis.
MF-1029	4247186	567513	1 of 1	1	NO	YES	3.0	6.2	175	1.0	35	NO	mine portal 1 dis.
MF-1030	4245814	549543	1 of 3	1 of 1	NO	YES	1.0	6.8	48	243.0	7440	NO	
MF-1030	4245795	549570	2 of 3	1 of 1	NO	YES	1.0	6.2	66	52.9	6920	NO	
MF-1030	4245758	549567	3 of 3	1 of 1	NO	YES	1.0	7.0	84	1.0	6390	NO	
MF-1031	4245356	549722	1 of 3	1 of 1	NO	YES	1.0	6.5	30	1.0	223	NO	
MF-1031	4245314	549737	2 of 3	1 of 1	NO	NO							
MF-1031	4245298	549743	3 of 3	1 of 1	YES	YES	3.0	6.3	30	1.0	292	NO	
MF-1032	4245005	550148	1 of 3	1 of 1	YES	NO							
MF-1032	4245002	550172	2 of 3	1 of 1	YES	YES	1.0	6.9	122	1.0	7	NO	
MF-1032	4244982	550194	3 of 3	1 of 1	NO	YES	2.0	6.7	126	1.0	1490	NO	
MF-1033	4244917	551017	1 of 1	1 of 1	NO	YES	1.0	7.0	50	2.2	8520	NO	
MF-1034	4246293	550458	1 of 5	1 of 4	NO	NO							poss. collapsed port.
MF-1034	4246270	550465	2 of 5	2 of 4	NO	NO							poss. collapsed port.
MF-1034	4246108	550522	3 of 5	3 of 4	NO	NO							
MF-1034	4246087	550525	4 of 5	3 of 4	NO	NO							
MF-1034	4245868	550584	5 of 5	4 of 4	NO	NO							
MF-1036	4246708	550199	1 of 4	1 of 2	NO	NO							

*VALUES REPORTED AS 1.0 ON HOT ACIDITY WERE BELOW LABORATORY DETECTABLE LIMITS
**VALUES REPORTED AS 7 ON TOTAL IRON WERE BELOW LABORATORY DETECTABLE LIMITS

TABLE 1 MINE PORTALS - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Portal Number	Highwall number	Access	Discharge Water	Discharge Volume	pH	Conductivity UMHOS	Hot Acidity MG/L*	Total Iron UG/L**	Discolor-ation	Remarks
MF-1036	4246732	550186	2 of 4	1 of 2	YES	NO							
MF-1036	4246743	550175	3 of 4	1 of 2	YES	YES	1.0	6.5	44	1.8	3560	NO	
MF-1036	4246644	550259	4 of 4	2 of 2	NO	NO							
MF-1037	4246431	550489	1 of 1	1 of 1	NO	YES	1.0	7.2	56	2.0	30700	NO	
MF-1038	4241162	554700	1 of 3	1 of 1	NO	YES	1.0	6.2	39	4.1	2430	NO	seeps to 10'x10' pond
MF-1038	4241183	554699	2 of 3	1 of 1	NO	YES	0.5	6.1	43	3.7	705	YES	gray w/sulfur smell
MF-1038	4241234	554681	3 of 3	1 of 1	NO	NO							
MF-1039	4241914	553255	1 of 6	1 of 2	NO	YES	0.5	6.5	29	15.2	14600	NO	
MF-1039	4241930	553264	2 of 6	1 of 2	YES	YES	0.5	6.5	68	8.2	35500	NO	
MF-1039	4241938	553271	3 of 6	1 of 2	YES	YES	0.5	6.6	47	144.0	37300	NO	
MF-1039	4241954	553279	4 of 6	1 of 2	YES	YES	1.0	6.4	136	1.0	1650	NO	
MF-1039	4241960	553230	5 of 6	2 of 2	NO	SEEP							Moisture/Veg
MF-1039	4241969	553240	6 of 6	2 of 2	NO	SEEP							Moisture/Veg
MF-1042	4231509	552280	1 of 3	1 of 1	NO	NO							
MF-1042	4231509	552280	2 of 3	1 of 1	NO	NO							
MF-1042	4231509	552280	3 of 3	1 of 1	NO	NO							
WV-0967	4245597	550884	1 of 3	1	YES	NO							
WV-0967	4245661	550718	2 of 3	1	NO	YES	30.0	7.1	343	1.0	1060	NO	Discharges into pond
WV-0967	4245609	550862	3 of 3	1	YES	NO							
WV-1531	4263489	572445	1 of 1	1	YES	NO							
WV-2267	4275602	595738	1 of 1	n/a	NO	YES	0.4	6.4	141	1.0	1340	NO	
WV-2490	4308966	614538	1 of 1	1	NO	NO							
WV-2491	4307840	614687	1 of 2	n/a	NO	YES	5.0	4.3	107	11.8	250	NO	Partial reclam. Portal
WV-2491	4307914	614859	2 of 2	n/a	NO	YES	0.1	5.4	112	2.8	1450	NO	
WV-2491	4307914	614859	2 of 2	n/a	NO	YES	5.0	7.7	220	1.0	7	NO	

*VALUES REPORTED AS 1.0 ON HOT ACIDITY WERE BELOW LABORATORY DETECTABLE LIMITS
**VALUES REPORTED AS 7 ON TOTAL IRON WERE BELOW LABORATORY DETECTABLE LIMITS

TABLE 2 COAL SPOILS - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Area (Nearest 100 SQ FT)	Average Height (ft)	Burned	Remarks
MF-1004	4249833	570970	1 of 1	2000	15	NO	spoil pile 1 parallels highwall
MF-1004	4250021	570902	1 of 1	8000	30	NO	spoil pile 2 parallels highwall
MF-1005	4265551	591697	n/a	5000	10	NO	spoil area in center of mine
MF-1006	4258064	570445	n/a	1000	7	NO	gob pile 1 (spoil pile 1)
MF-1006	4258072	570426	n/a	15000	40	NO	gob pile 2 (spoil pile 2)
MF-1007	4247610	549476	1 of 1	400	6	NO	spoil pile 1
MF-1008	4248374	548678	1 of 1	20000	10	NO	spoil pile 1
MF-1008	4248444	548709	1 of 1	5000	10	NO	spoil pile 2
MF-1011	4238004	576413	1 of 1	300	5	NO	spoil pile 1
MF-1011	4238028	567424	1 of 1	100	4	NO	spoil pile 2
MF-1011	4238033	567425	1 of 1	200	4	NO	spoil pile 3
MF-1011	4237964	567455	1 of 1	1500	15	NO	spoil pile 4
MF-1013	4223427	555589	1 of 1	200	5	NO	gob pile 1
MF-1015	4223699	556034	1 of 1	100	5	YES	spoil pile 1
MF-1017	4234761	533990	1 of 1	100000	10	NO	spoil pile 1
MF-1017	4234777	533883	1 of 1	40000	10	NO	spoil pile 2
MF-1017	4234820	533733	1 of 1	200	5	NO	spoil pile 3
MF-1018	4221794	557063	1 of 1	37500	10	NO	spoil pile 1
MF-1018	4221802	556900	1 of 1	30000	20	NO	spoil pile 2
MF-1018	4222135	556899	1 of 1	1000	10	NO	spoil pile 3
MF-1020	4231892	552189	1 of 1	1500	5	NO	spoil pile 1
MF-1034	4246083	550528	3 of 4	300	3	NO	spoil pile 1 located adjacent to portal 4.
MF-1034	4245886	550561	4 of 4	2000	5	NO	spoil pile 2 located near portal 5.
MF-1034	4245873	550580	4 of 4	800	5	NO	spoil pile 3 located near portal 5.
MF-1034	4245843	550594	4 of 4	1200	10	NO	spoil pile 4 located near portal 5.
MF-1038	4241206	554710	1 of 1	1000	10	NO	spoil pile 1 located between portals 2 & 3.
MF-1038	4241248	554686	1 of 1	100	5	NO	spoil pile 2 located adjacent to portal 3.
MF-1042	4231509	552280	1 of 1	200	6	NO	spoil pile 1 (used center shot as spoil location)
MF-1042	4231509	552280	1 of 1	10000	8	NO	spoil pile 2 (used center shot as spoil location)
WV-0967	4245405	550247	1 of 1	600	10	NO	spoil pile 1
WV-0967	4245360	550492	1 of 1	10000	10	NO	spoil pile 2
WV-0967	4245633	550639	1 of 1	8000	5	NO	spoil pile 3
WV-1554	4255092	572690	2 of 3	160	5	NO	spoil pile 1

TABLE 2 COAL SPOILS - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Area (Nearest 100 SQ FT)	Average Height (ft)	Burned	Remarks
WV-1560	4252391	572372	3 of 3	2500	20	NO	spoil pile 1 large vegetated spoil pile
WV-1560	4252278	572384	3 of 3	300	5	NO	spoil pile 2 loc. in center of shallow pond.
WV-1560	4253507	571931	1 of 3	40000	20	NO	spoil pile 1
WV-1562	4250591	572408	1 of 3	600	10	NO	spoil pile 1
WV-1562	4250358	572509	1 of 3	700	3	NO	spoil pile 2
WV-1564	4249753	573435	1 of 3	1500	10	NO	spoil pile 1
WV-1564	4250482	573413	1 of 3	10000	20	NO	spoil pile 2
WV-1564	4248893	573797	1 of 3	10000	30	NO	Rock spoil pile/ southern end of WV-15641
WV-1564	4252133	572899	3 of 3	50000	20	NO	spoil pile 1
WV-1565	4249500	571212	1 of 1	24000	15	NO	large vegetated spoil pile paralelling HW
WV-2267	4275599	595734	n/a	100	0	NO	spoil pile 1
WV-2278	4330029	626579	1 of 1	17500	10	NO	spoil pile 1
WV-2278	4329826	626487	1 of 1	150000	10	NO	spoil pile 2
WV-2278	4329688	626333	1 of 1	10000	10	NO	spoil pile 3
WV-2279	4329846	625027	2 of 2	30000	20	NO	spoil pile 1
WV-2279	4329710	625089	2 of 2	90000	15	NO	spoil pile 2
WV-2489	4309339	615704	1 of 1	5000	4	NO	spoil pile 1
WV-2489	4309444	615638	1 of 1	500	10	NO	spoil pile 2
WV-2491	4308018	614900	1 of 1	12000	50	NO	large unvegetated gob pile (spoil pile 1)
WV-2491	4308286	615203	1 of 1	450	10	NO	spoil pile 2
WV-2491	4308261	615174	1 of 1	500	5	NO	spoil pile 3
WV-2491	4308234	615138	1 of 1	4500	12	NO	spoil pile 4
WV-3216	4250513	572886	3 of 3	500	4	NO	spoil pile 1
WV-3746	4274883	596711	1 of 2	800	10	NO	spoil pile 1
WV-3746	4274876	596617	1 of 2	80000	15	NO	spoil pile 2 large vegetated spoil pile

TABLE 3 RUBBISH DEPOSITS - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Area (Nearest 100 SQ FT)	Average Height	Hazardous Materials	Remarks
MF-1039	4241952	553274	1 of 2	100	2	NO	concrete slabs / sheet metal.
WV-0967	4245401	550252	1 of 1	100	2	NO	wood coal hopper
WV-1562	4250820	572403	1 of 3	100	5	NO	approx. 15 pieces rusted CMP
WV-2267	4275600	595737	n/a	100	0	NO	household trash
WV-2491	4308035	614937	1 of 1	225	5	NO	rusted mine cars

TABLE 4 STRUCTURES - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Hazardous Materials	Remarks
MF-1005	4265409	591715	n/a	NO	Structure 1 intact concrete bunker
MF-1005	4265636	591684	n/a	NO	Structure 2 remnant wood timber structure
MF-1006	4258049	570496	n/a	NO	Brick mine portal entrance
MF-1011	4237980	567422	1 of 1	NO	Remnant loading facility w/ concrete foundation
MF-1017	4234673	533893	1 of 1	NO	3 2'x2' concrete piers
MF-1017	4234730	533599	1 of 1	NO	5 remnant bridge piers crossing Cherry River
MF-1031	4245196	549741	1 of 1	NO	3X3X3 Concrete block building.
WV-0967	4245437	550281	1 of 1	NO	40 remnant concete piers (structure 1)
WV-0967	4245462	550312	1 of 1	NO	remnant concrete bunker/ piers (structure 2)
WV-0967	4245401	550280	1 of 1	NO	15'x25' remnant concrete slab (structure 3)
WV-0967	4245390	550137	1 of 1	NO	10'x45' remnant concrete foundation (structure 4)
WV-0967	4245436	550480	1 of 1	NO	remnant bridge crossing Williams River (structure 5)
WV-0967	4245592	550888	1 of 1	NO	remnant concrete foundation (structure 6)
WV-0967	4245599	550865	1 of 1	NO	remnant building 50'x50' (structure 7)
WV-0967	4245721	550638	1 of 1	NO	remnant concrete foundation 50'x20' (structure 8)
WV-0967	4245794	550591	1 of 1	NO	remnant concrete foundation 80'x40' (structure 9)
WV-0967	4246062	550497	1 of 1	NO	2 intact 5'x5' buildings w/ steel doors (structure 10)
WV-0967	4245893	550547	1 of 1	NO	6'x10' remnant concrete foundation (structure 11)
WV-1560	4253577	571978	1 of 3	NO	REMNANT concrete cinderblock foundation
WV-1561	4253946	572430	2 of 3	NO	Structure 1 20'x20' remnant building
WV-1561	4253960	572442	2 of 3	NO	Structure 2 remnant burned trailer
WV-1561	4253956	572468	2 of 3	NO	Structure 3 intact outhouse
WV-1562	4250611	572407	1of 3	NO	Structure 1 12'x20' remnant concrete foundation
WV-1562	4250584	572423	1 of 3	NO	Structure 2 remnant wood timber structure
WV-1562	4249450	571322	3 of 3	NO	remnant concrete bunker
WV-1562	4249898	571828	2 of 3	NO	remnant concrete bunker
WV-1564	4249932	573351	1 of 3	NO	Two 4' X 4' concrete footers
WV-2490	4308952	614559	1 of 1	NO	Remnant steel hopper with pump
WV-2491	4307874	614682	1 of 1	NO	8' X 12 ' X 5' Intact concrete building
WV-2491	4308028	614932	1 of 1	NO	Several sets of remnant timber cribs extending downslope approx 300'
WV-2491	4308077	614998	1 of 1	NO	Remnant tipple w/ concrete piers approx 1'x10'x6'
WV-2491	4308118	614999	1 of 1	NO	Remnant explosives bunker approx. 12' x 35' x 4'

TABLE 5 HIGHWALLS - USFS 1999 AML INVENTORY, MONONGAHELA NATIONAL FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Length (ft)	Height (ft)	Slope (%)
MF-1000	4254417	571013	1 of 1	2500	20	95
MF-1001	4253800	572811	1 of 1	1500	30	80
MF-1002	4250367	570451	1 of 1	500	30	85
MF-1003	4250617	570345	1 of 2	3800	30	100
MF-1003	4250355	570283	2 of 2	500	30	82
MF-1004	4249986	570987	1 of 1	1500	30	85
MF-1007	4247631	549570	1 of 1	600	25	80
MF-1008	4248411	548732	1 of 1	300	35	86
MF-1009	4248995	549013	1 of 1	200	20	54
MF-1010	4247856	544782	1 of 1	600	60	76
MF-1011	4238028	567419	1 of 1	200	30	75
MF-1012	4231370	552442	1 of 1	2000	30	74
MF-1013	4223386	555616	1 of 1	150	20	65
MF-1014	4223614	555294	1 of 1	150	20	90
MF-1015	4223685	556007	1 of 1	100	20	60
MF-1016	4223630	556527	1 of 1	100	40	70
MF-1017	4234802	533857	1 of 1	1500	40	75
MF-1018	4222121	556810	1 of 1	5000	30	75
MF-1019	4231614	551235	1 of 1	400	40	100
MF-1020	4231858	552194	1 of 1	200	25	60
MF-1021	4246945	567027	1 of 1	300	35	70
MF-1022	4246706	566879	1 of 1	300	25	70
MF-1023	4245704	566375	1 of 1	400	40	90
MF-1024	4245595	566148	1 of 1	200	40	70
MF-1025	4245811	565649	1 of 1	300	30	65
MF-1026	4245590	565476	1 of 1	200	40	75
MF-1028	4246520	567217	1 of 1	1400	35	70
MF-1029	4247186	567513	1 of 1	300	35	60
MF-1030	4245758	549565	1 of 1	300	50	85
MF-1031	4245354	549725	1 of 1	300	50	65
MF-1032	4244999	550171	1 of 1	200	50	90
MF-1033	4244907	551029	1 of 1	300	40	100
MF-1034	4246297	550476	1 of 4	50	25	55
MF-1034	4246268	550472	2 of 4	50	25	60
MF-1034	4246106	550515	3 of 4	100	25	70
MF-1034	4245875	550585	4 of 4	100	20	85
MF-1035	4246938	549888	1 of 1	600	30	65
MF-1036	4246726	550186	1 of 2	250	20	90

TABLE 5 HIGHWALLS - USFS 1999 AML INVENTORY, MONONGAHELA NATIONAL FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Length (ft)	Height (ft)	Slope (%)
MF-1036	4246644	550260	2 of 2	150	25	100
MF-1037	4246426	550484	1 of 1	150	20	65
MF-1038	4241161	554699	1 of 1	250	40	95
MF-1039	4241935	553267	1 of 2	300	25	95
MF-1039	4241969	553240	2 of 2	50	20	65
MF-1042	4231509	552280	1 of 1	200	20	90
MF-1043	4331077	628353	1 of 1	1000	30	80
MF-1044	4330618	628231	1 of 1	6400	30	90
WV-0967	4245628	550765	1 of 1	1500	30	120
WV-1531	4263394	572440	1 of 2	1000	25	100
WV-1531	4263323	572684	2 of 2	500	20	88
WV-1554	4253930	571450	1 of 3	1000	25	80
WV-1554	4255203	572574	2 of 3	1500	25	80
WV-1554	4255194	572607	3 of 3	800	30	82
WV-1555	4248826	573524	3 of 3	800	25	95
WV-1555	4249592	572761	2 of 3	1100	35	70
WV-1555	4249290	571954	1 of 3	900	35	60
WV-1557	4253988	571354	1 of 1	1200	30	80
WV-1560	4252307	572383	3 of 3	4000	40	86
WV-1560	4253427	572737	2 of 3	3400	20	84
WV-1560	4253478	571656	1 of 3	3000	30	80
WV-1561	4253832	571822	1 of 3	1600	40	80
WV-1561	4253923	572446	2 of 3	2500	40	85
WV-1561	4254774	573132	3 of 3	1800	20	75
WV-1562	4250819	572400	1 of 3	3200	30	84
WV-1562	4249634	571364	3 of 3	3800	40	95
WV-1562	4249828	571877	2 of 3	3400	35	82
WV-1564	4249534	573407	1 of 3	7000	30	95
WV-1564	4251703	572993	2 of 3	1500	15	72
WV-1564	4252127	572868	3 of 3	1600	40	95
WV-1565	4249495	571246	1 of 1	1000	30	80
WV-1566	4223995	553797	1 of 1	900	50	80
WV-1567	4224088	553799	1 of 1	700	50	90
WV-1625	4330316	627315	1 of 1	3800	30	100
WV-1626	4329968	625715	1 of 1	1100	35	70
WV-2278	4329391	626056	1 of 1	3800	40	100
WV-2279	4329584	625091	1 of 2	200	25	75
WV-2279	4329686	625032	2 of 2	800	25	85

TABLE 5 HIGHWALLS - USFS 1999 AML INVENTORY, MONONGAHELA NATIONAL FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Length (ft)	Height (ft)	Slope (%)
WV-2489	4309314	615907	1 of 1	1600	50	100
WV-2490	4308966	614538	1 of 1	1250	25	95
WV-2491	4307951	614926	1 of 1	2900	60	80
WV-3216	4250345	572904	3 of 3	4600	40	78
WV-3216	4249888	572860	2 of 3	1800	35	76
WV-3216	4249741	571502	1 of 3	1400	35	72
WV-3744	4273707	595661	2 of 2	8900	30	85
WV-3744	4273287	596271	1 of 2	1000	30	78
WV-3745	4275752	597547	1 of 2	4800	30	85
WV-3745	4275406	597741	2 of 2	1700	30	100
WV-3746	4274731	596846	2 of 2	500	30	82
WV-3746	4274701	596610	2 of 2	100	30	80
WV-3746	4275145	597294	1 of 2	2200	25	88

TABLE 6 POND AND/OR MINE RELATED DISCHARGES - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Discharge	pH	Conductivity UMHOS	Hot Acidity MG/L*	Total Iron UG/L	Discoloration	Remarks	
MF-1000	4254182	571242	1 of 1	0.5	6.1	110	1.2	27000	NO	HW discharge	5.9
MF-1003	4250330	571108	1 of 2	3.0	7.0	88	1.0	138	NO	HW 1 Discharge 1	
MF-1003	4250474	570667	1 of 2	3.5	6.3	63	1.3	8260	NO	HW 1 Discharge 2	
MF-1003	4250400	570250	2 of 2	1.0	6.3	31	1.0	4870	NO	HW 2 Discharge 1	
MF-1004	4249971	570988	1 of 1	1.5	7.3	134	1.0	101	NO	pond 1 discharge	
MF-1008	4248425	548719	1 of 1	0.5	5.2	100	8.6	982	NO	HW discharge	
MF-1011	4238023	567415	1 of 1	0.2	4.9	42	9.6	742	NO	HW discharge	
MF-1012	4231632	552804	1 of 1	0.4	7.1	104	1.0	1740	NO	Pond 1 discharge	
MF-1018	4222044	556607	1 of 1	1.0	6.0	47	11.5	715	NO	HW discharge	
MF-1018	4221803	556790	1 of 1	0.5	4.3	48	3.6	7880	NO	pond 1 discharge	
MF-1018	4222116	556885	1 of 1	0.5	5.6	37	3.1	1260	NO	pond 2 discharge	
MF-1020	4231858	552194	1 of 1	1.0	4.7	64	1.0	1350000	NO	HW discharge	
MF-1025	4245811	565649	1 of 1	1.0	5.2	33	6.5	6910	NO	HW discharge	
MF-1026	4245590	565476	1 of 1	0.5	5.7	47	1.0	1090	NO	HW discharge	
MF-1028	4246510	567195	1 of 1	0.5	4.4	207	22.9	2180	NO	pond 1 discharge	
MF-1028	4246589	567194	1 of 1	3.0	5.6	44	2.2	968	NO	pond 2 discharge	
MF-1028	4246803	567341	1 of 1	0.5	4.9	57	1.9	984	NO	wetland/ mine site discharge	
MF-1028	4246812	567358	1 of 1	4.0	5.2	39	6.2	1670	NO	HW discharge	
MF-1029	4247169	567504	1 of 1	1.0	6.0	161	1.0	1720	NO	wetland/ mine site discharge	
MF-1035	4246885	549941	1 of 1	0.5	7.0	60	1.0	1040	NO	HW discharge	
WV-0967	4245606	550696	1 of 1	20.0	8.3	566	1.0	269	NO	pond 1 discharge	
WV-1531	4263450	572450	1 of 2	0.5	5.8	69	1.0	13	NO	HW 1 discharge	
WV-1554	4255136	572525	3 of 3	0.6	6.0	32	1.0	2550	NO	pond 1 discharge	
WV-1555	4248826	573524	3 of 3	0.4	5.7	62	1.0	3070	NO	HW discharge	
WV-1557	4253885	571226	1 of 1	0.5	6.7	156	1.0	2550	NO	spoil bench discharge	
WV-1557	4254062	571250	1 of 1	1.0	6.3	50	1.0	921	NO	beaver pond discharge	
WV-1557	4254077	571191	1 of 1	0.5	5.6	136	19.8	14000	NO	highwall discharge	
WV-1560	4252578	572347	3 of 3	1.0	6.7	46	1.0	582	NO	Pond 1 dis./seep under/thru road fill.	
WV-1560	4252345	572349	3 of 3	9.0	6.0	38	1.0	597	NO	Pond 2 discharge	
WV-1560	4253589	572318	1 of 3	1.0	5.8	37	2.4	3570	NO	pond 1 discharge	
WV-1560	4253613	572266	1 of 3	1.0	5.3	30	2.0	1240	NO	pond 2 discharge	
WV-1560	4253484	571573	1 of 3	0.2	5.8	74	1.0	798	NO	beaver pond 3 discharge	
WV-1560	4253507	571931	1 of 3	0.5	6.3	75	1.0	1650	NO	spoil discharge	
WV-1560	4253491	571521	1 of 3	0.1	5.8	74	1.0	914	NO	beaver pond 3 discharge 2	
WV-1561	4254301	572955	3 of 3	1.0	6.5	85	3.3	138	NO	HW discharge point 1	
WV-1561	4254345	573036	3 of 3	1.0	5.8	31	3.2	87	NO	pond 1 discharge	
WV-1561	4254512	573101	3 of 3	1.0	5.0	30	23.8	9370	NO	HW discharge point 2	
WV-1561	4254876	573019	3 of 3	0.8	4.5	48	14.3	1870	NO	HW discharge point 3	

*VALUES REPORTED AS 1.0 ON HOT ACIDITY WERE BELOW LABORATORY DETECTABLE LIMITS

**VALUES REPORTED AS 7 ON TOTAL IRON WERE BELOW LABORATORY DETECTABLE LIMITS

TABLE 6 POND AND/OR MINE RELATED DISCHARGES - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Discharge	pH	Conductivity UMHOS	Hot Acidity MG/L*	Total Iron UG/L	Discoloration	Remarks
WV-1561	4254226	572886	2 of 3	0.8	5.9	37	1.5	555	NO	pond 5 discharge
WV-1561	4254130	572758	2 of 3	1.0	6.1	45	1.0	10400	NO	pond 4 discharge
WV-1561	4254028	572568	2 of 3	1.0	6.3	27	5.2	1500	NO	pond 3 discharge
WV-1561	4253901	572314	2 of 3	1.0	6.1	51	1.0	10000	NO	ponds 1& 2 combined discharge
WV-1562	4250911	572738	1 of 3	4.0	4.4	242	24.0	313	YES /blue-green	pond 1/culvert present
WV-1562	4250883	572652	1 of 3	1.0	6.2	87	1.0	2640	NO	pond 2/culvert present
WV-1562	4250867	572489	1 of 3	4.0	6.8	214	1.0	212	NO	pond 3
WV-1562	4250719	572330	1 of 3	0.1	7.2	117	1.0	281	NO	HW discharge
WV-1562	4249836	571906	2 of 3	4.0	6.3	215	1.0	761	NO	pond 1 discharge
WV-1562	4249945	571710	2 of 3	1.0	6.9	187	1.0	2700	NO	pond 2 discharge
WV-1562	4250004	571625	2 of 3	3.0	6.6	256	1.0	1340	NO	pond 3 discharge
WV-1562	4250007	571572	2 of 3	2.0	7.0	239	1.0	<7.0	NO	pond 4 discharge
WV-1564	4249507	573416	1 of 3	0.3	6.5	28	1.1	2070	NO	POND 1
WV-1564	4249520	573425	1 of 3	0.3	6.9	118	15.0	28900	NO	POND 2 beaver pond/culv to func ch
WV-1564	4252353	572834	3 of 3	1.0	6.1	54	4.1	1620	NO	POND 1 crawfish present
WV-1564	4252224	572860	3 of 3	1.0	6.7	72	1.0	261	NO	POND 2
WV-1567	4224166	553671	1 of 1	1.0	6.6	113	1.0	15300	NO	Pond 1 discharge
WV-1626	4329701	625737	1 of 1	0.3	5.8	45	12.3	13500	NO	Pond 1 discharge
WV-2267	4275599	595740	n/a	0.2	5.8	166	1.0	864	NO	pond 1 dis.
WV-2278	4330008	626616	1 of 1	0.5	4.1	97	26.8	1850	NO	Pond 1 discharge
WV-2279	4329866	625085	2 of 2	1.0	3.4	247	104.0	2830	YES /blue-green	Pond 1 discharge
WV-2489	4309307	616005	1 of 1	0.5	6.3	34	1.0	62	NO	HW discharge 1
WV-2490	4309130	614779	1 of 1	0.2	6.0	50	8.4	5620	NO	HW discharge
WV-2491	4308263	615244	1 of 1	0.5	5.9	60	2.3	1360	NO	HW Discharge 1
WV-2491	4308211	615098	1 of 1	0.5	6.0	32	2.2	225	NO	HW Discharge 2
WV-3744	4273625	595927	2 of 2	1.0	6.0	35	1.0	781	NO	HW Discharge 1
WV-3744	4273703	595734	2 of 2	1.0	4.6	27	6.7	356	NO	HW Discharge 2
WV-3744	4273699	595663	2 of 2	1.0	5.4	26	3.6	1080	NO	HW Discharge 3
WV-3744	4273690	595567	2 of 2	0.5	5.6	33	1.5	2940	NO	HW Discharge 4
WV-3744	4273497	595350	2 of 2	0.5	5.5	27	1.9	4280	NO	Pond 1 Discharge
WV-3744	4273528	594765	2 of 2	1.0	5.3	29	8.8	18400	NO	HW Discharge 5
WV-3744	4273586	594700	2 of 2	0.5	4.9	26	8.9	242	NO	HW Discharge 6
WV-3744	4273569	594649	2 of 2	1.0	5.6	35	1.0	3590	NO	HW Discharge 7
WV-3744	4273644	594330	2 of 2	1.0	5.6	29	1.5	428	NO	HW Discharge 8
WV-3746	4274749	596698	2 of 2	0.4	6.2	69	2.8	1280	NO	highwall/mine site discharge
WV-3746	4274723	596603	2 of 2	0.3	6.4	69	1.0	1400	NO	POND 1 small pond W. end of mine
WV-3746	4274781	596455	1 of 2	1.0	5.5	44	6.6	3700	NO	POND 1 dis.
WV-3746	4274798	596489	1 of 2	0.5	5.8	52	133.0	42600	NO	POND 1 outlet 2

*VALUES REPORTED AS 1.0 ON HOT ACIDITY WERE BELOW LABORATORY DETECTABLE LIMITS
**VALUES REPORTED AS 7 ON TOTAL IRON WERE BELOW LABORATORY DETECTABLE LIMITS

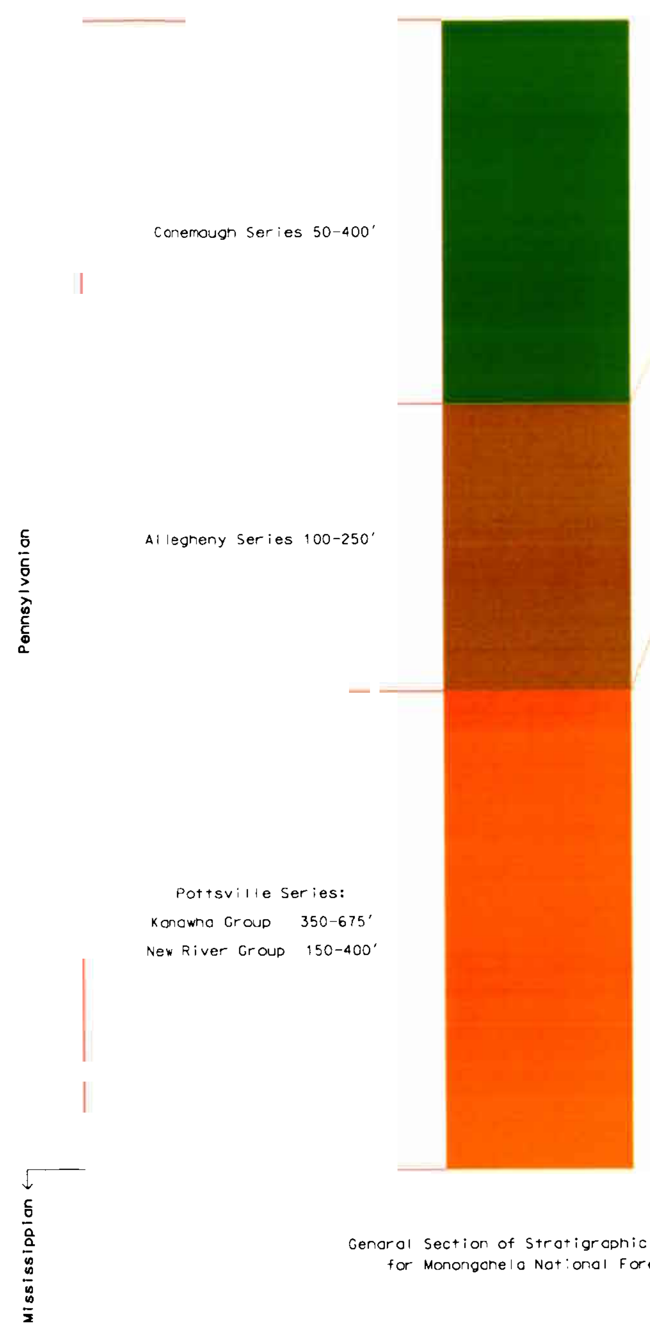
TABLE 6 POND AND/OR MINE RELATED DISCHARGES - USFS 1999 AML INVENTORY, MONONGAHELA FOREST, WV

Mine Site Number	UTM N Coordinates	UTM E Coordinates	Highwall number	Discharge	pH	Conductivity UMHOS	Hot Acidity MG/L*	Total Iron UG/L	Discoloration	Remarks
WV-3746	4274844	596560	1 of 2	0.5	5.9	47	1.0	3280	NO	pond 2 discharge
WV-3746	4274874	596672	1 of 2	1.0	6.7	44	2.2	1150	NO	HW discharge pt 1
WV-3746	4275145	597294	1 of 2	0.3	7.4	110	1.0	1050	NO	HW dis. pt 2 under LS road fill.

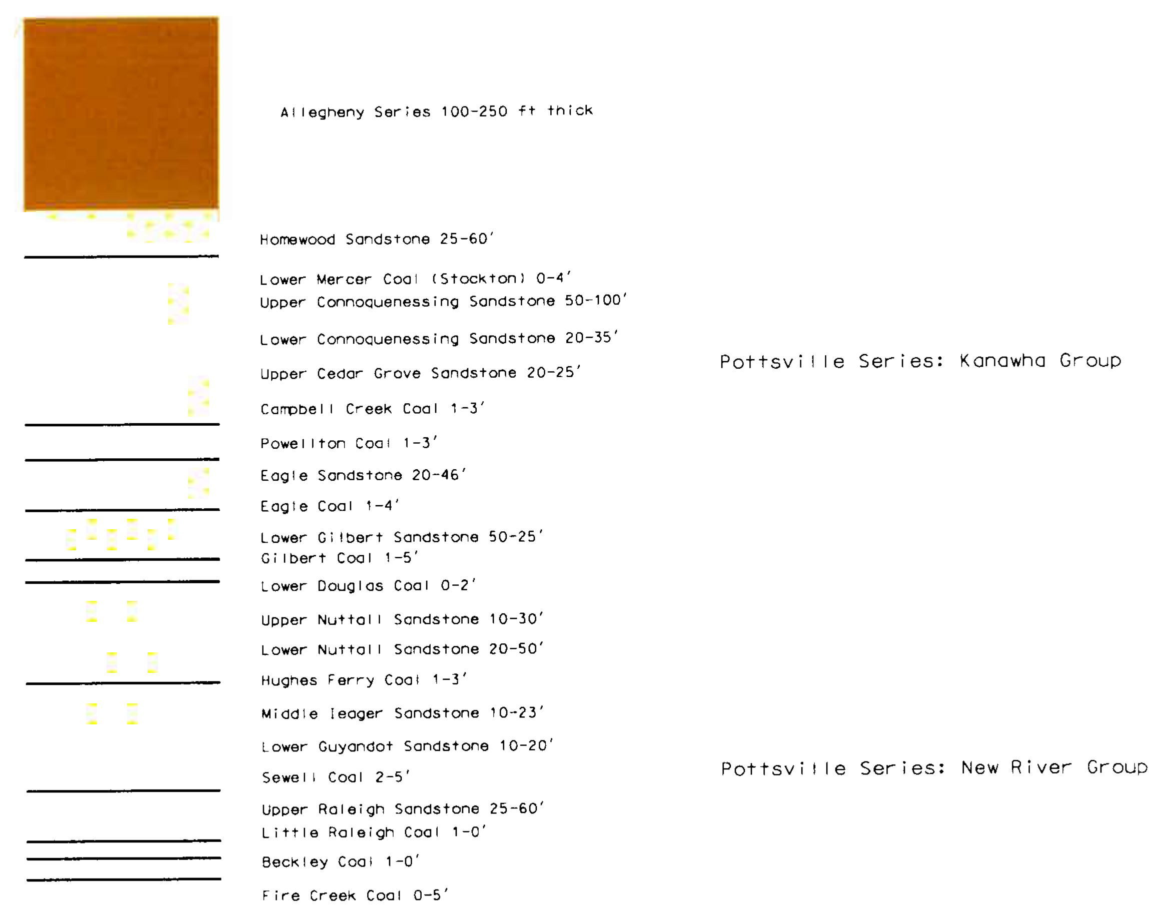
* VALUES REPORTED AS 1.0 ON HOT ACIDITY WERE BELOW LABORATORY DETECTABLE LIMITS

*VALUES REPORTED AS 1.0 ON HOT ACIDITY WERE BELOW LABORATORY DETECTABLE LIMITS
**VALUES REPORTED AS 7 ON TOTAL IRON WERE BELOW LABORATORY DETECTABLE LIMITS

Appendix VI Geologic Section



Genaral Section of Stratigraphic Order
for Monongahela National Forest



Genaral Section -- Pottsville Series
showing Siginificant Marker Beds

Notes: 1. Columns are not to scale.
2. Additional members are present, but were not displayed, thicknesses shown in red.
3. Columns adapted from Reger 1931.