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USE OF REMOTELY SENSED DATA FOR ANALYSIS OF HARD ROCK NORTH SEEPAGE AREA, FABIUS MINES, ALABAMA

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Anita Polk-Conley

June 1987

DEDICATION

To my friend and husband George and my son Sky, I dedicate this scientific effort as one more stone is turned such that we will continue to reach for a higher and more intellectual plane from which to grow.

ACKNOWLEDGMENTS

Sincere gratitude is extended to the Tennessee Valley Authority, Mapping Services Branch, and more specifically to the staff of the Photogrammetry and Remote Sensing Section for providing their assistance and services which made this research possible.

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To the author's husband George, family and friends, a deep expression of gratitude is extended for always being there when needed.

ABSTRACT

A study was undertaken on the Hard Rock North area of the Fabius Coal Mines in Jackson County, Alabama, to aid in the determination of the source of a seep. This evaluation provided information concerning the land conditions prior to mining, during mining and after reclamation through the use of multidate and multiscale aerial photography. Also, a fracture trace analysis of the area determined that the main stream channel prior to mining was fracture controlled.

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CHAPTER I

INTRODUCTION

As the world's most abundant source of energy, coal has been extracted from the earth to supply large amounts of electrical power for over 100 years. Today, the two main methods of removing coal from the ground are surface mining and underground mining. Both processes have environmental problems. Underground mining causes damage and sinking of the ground and surface structures. Surface mining causes acid mine drainage which may find its way into surrounding streams, lakes and groundwater. This study will focus on the seepage problems associated with the reclamation efforts of the Hard Rock North (HRN) area of the Fabius Coal Mines located in Jackson County, Alabama. This seepage area was found after the 400-acre area of HRN was regraded but not dewatered prior to reclamation. As a part of the Office of Surface Mining's (OSM) evaluation process of reclaimed mined areas, field surveys are done with some emphasis placed on locating seepage problems. Presently, HRN meets most of the reclamation requirements for vegetation, but problems associated with seepage areas persist.

The HRN seep has increased its flow from less than 100 gallons per minute to upwards of 500 gallons per minute from the period of 1981 to 1986 (see Appendix). This increase in flow causes concern not only about the source of the seep, but also the flow increase. The one benefit with the increase in flow is an increase in pH.

To obtain an overview of the problem, a historical review of the HRN Seep Watershed Area was accomplished with the use of aerial photography extending from 1946 through 1986. These aerial views provide vital information as to the nature of the coal mining process and its effect on the land cover and drainage area of the HRN Seep. This evaluation used color infrared (CIR) and black and white (B/W) low altitude photography. For historical data prior to 1980 only B/W photography was available for the study area through the Tennessee Valley Authority (TVA) Mapping Services Branch.

CHAPTER II

STUDY AREA

Test Site

The Hard Rock North area of the Fabius Coal Mines is located in Jackson County in northeastern Alabama (Figure 1). It is located on the Stevenson 7.5 minute quadrangle, TVA 95-SE (Figure 2). HRN lies in the southern end of the Eastern Coal Province on Sand Mountain in the Cumberland Plateau section of the Appalachian Plateaus province. Generally, Sand Mountain chiefly consists of rocks of Pennsylvanian age (Pottsville Formation) containing alternate beds of sandstone, shale, conglomerate, siltstone, underclay and coal (Figure 3). All surface drainage in Hard Rock North flows into Rocky Branch Creek which eventually reaches the Tennessee River Basin.

Mining Practices

Although other areas of the Fabius Coal Mines began extracting coal in the mid-1960s, mining began in the HRN area during 1976 in the lower southwestern corner, moving north and around to the southeastern section by the middle of 1979. The type of mining used was area strip mining identified through aerial photographs and listed on one of the first mining permits for the area (Alabama Surface Mining Reclamation Commission, Permit No. P-1388, 1977). This method is used on relatively flat terrain with shallow overburden and thick seams (Figure 4). It begins with an initial box cut exposing the coal seam.

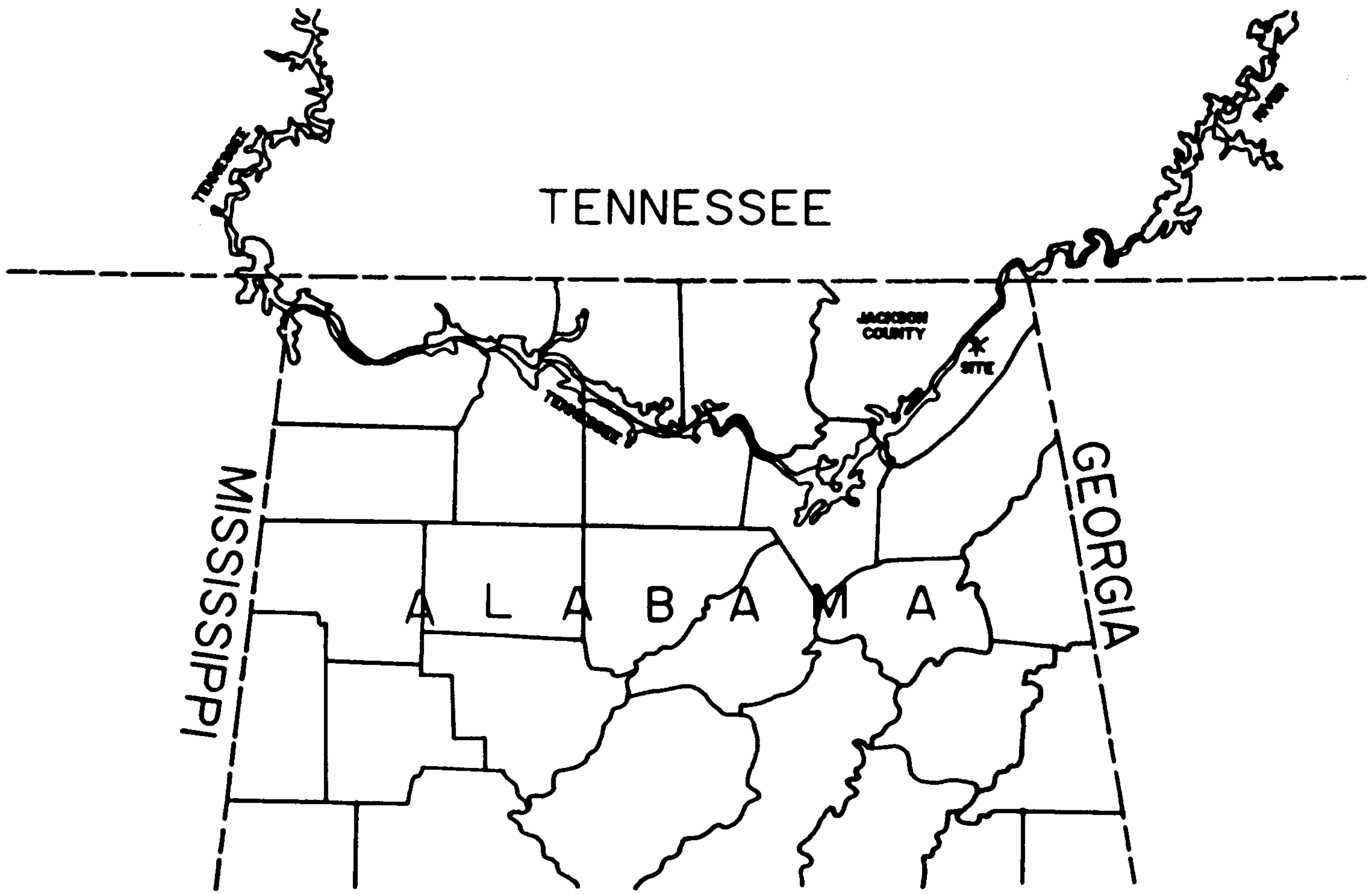


Figure 1. Northern Alabama and surrounding states.

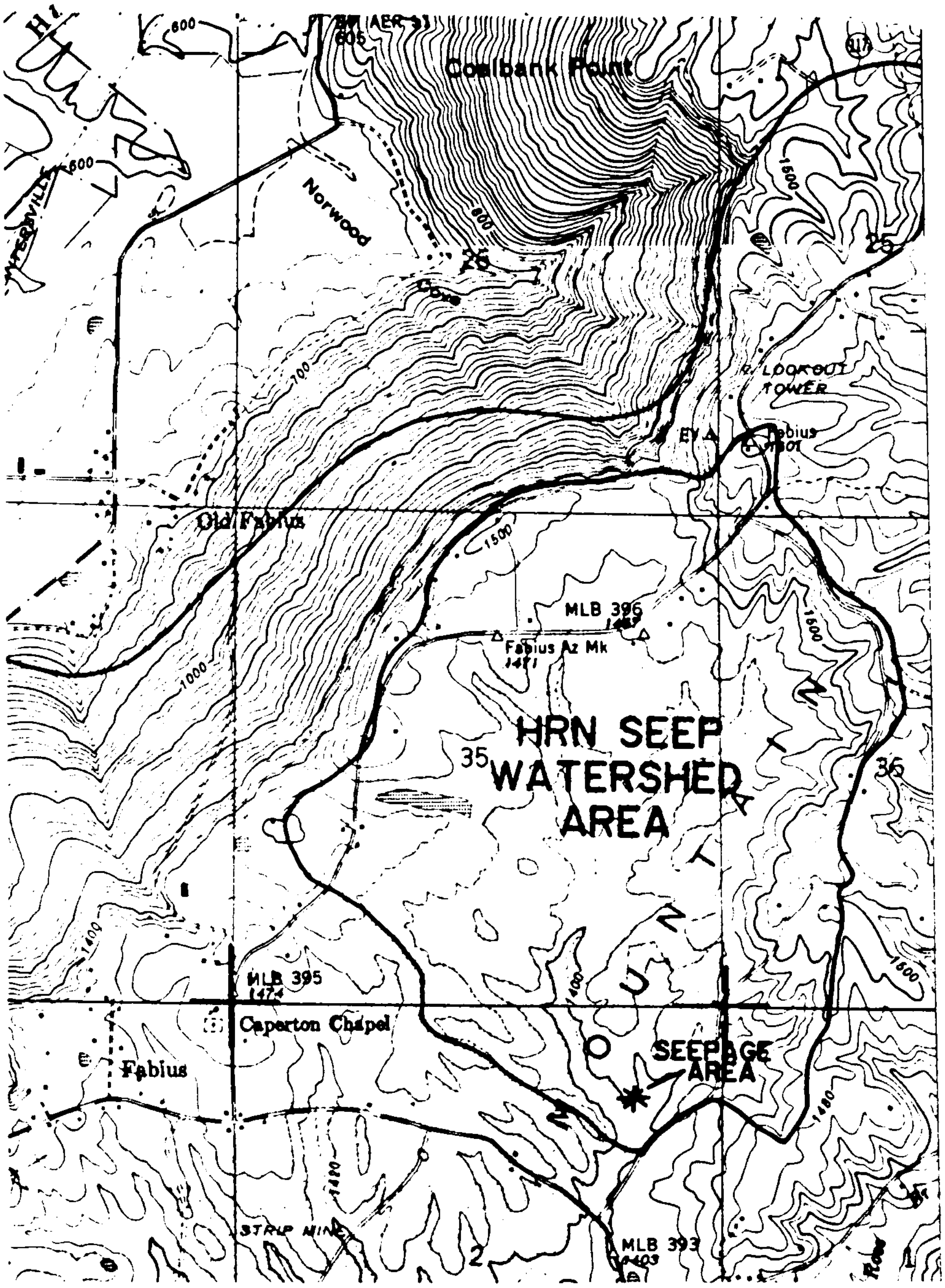


Figure 2. HRN watershed area on the Stevenson quadrangle, 7.5 minute, TVA 95-4.

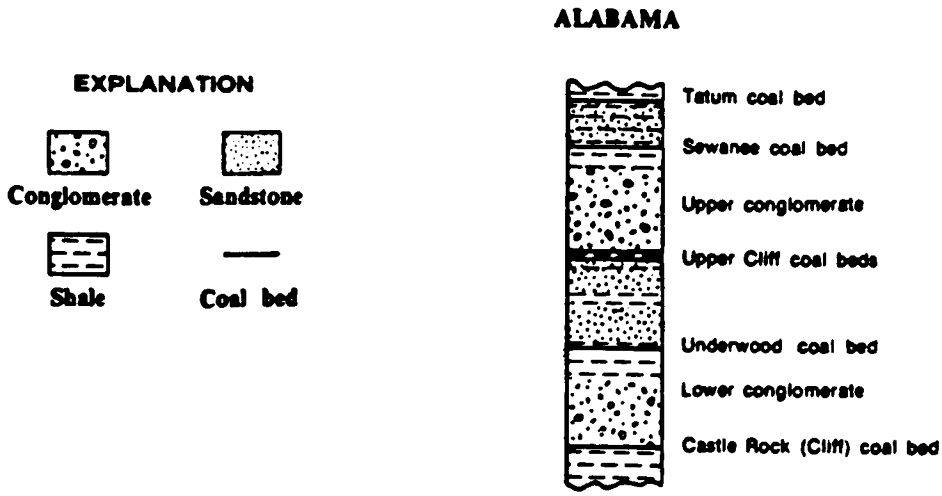


Figure 3. Stratigraphic column showing distribution of coal beds in Pennsylvanian rocks (adapted from Smith, 1979, p. I26).

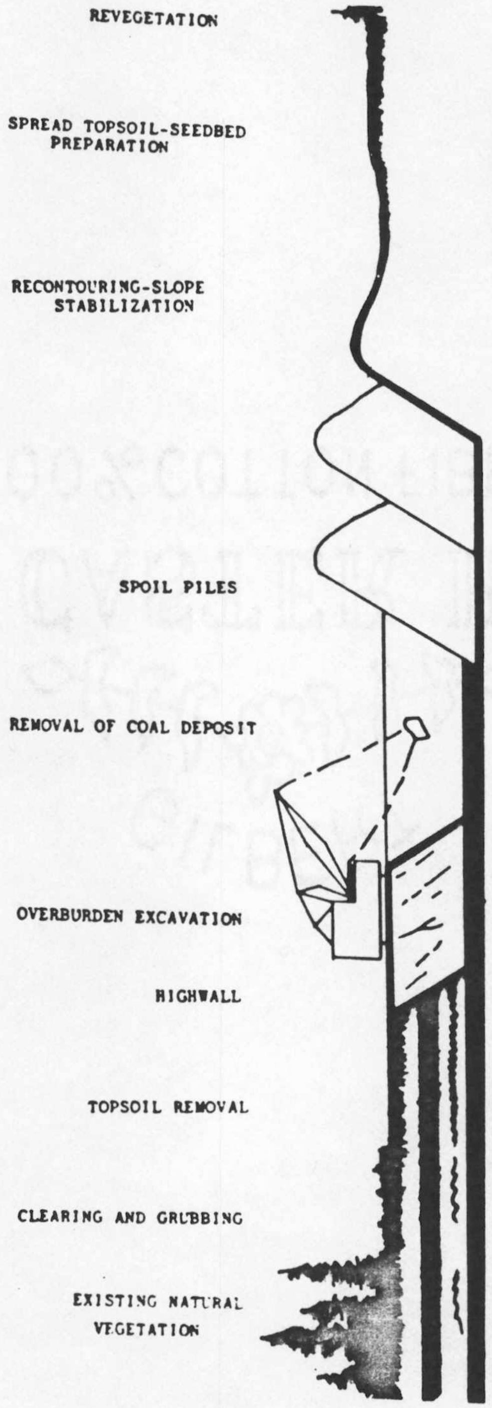


Figure 4. Area strip mining (Law, 1984, p. 6).

The overburden including topsoil, rock and other strata lying above the seam is placed in piles (spoils) and used to backfill box cuts previously made (Law, 1984). The box cuts at HRN were generally 50 to 60 feet deep and made in successive parallel cuts.

Also identified in the aforementioned mining permit was the mined coal seam: Underwood coal bed. According to May (1983), this seam falls above another thicker seam, Castle Rock (Cliff) coal bed, and below two smaller seams (see Figure 3).

The Law

The HRN was originally mined after the enactment of the Alabama State Mining Law of 1975 which basically required that the tops of spoil piles be graded along with planting of grass and shrubs. Prior to this legislation no reclamation was required by the state (Honea, 1984).

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) approved by Congress provided for mining to be carried out in an environmentally safe way, reclamation of mined lands as closely as possible to its pre-mined condition including restoration to approximate original contour (AOC), and maintaining recharge capacity with prevailing hydrologic balance (Law, 1984). Even before the two previously mentioned legislations were passed TVA had its own reclamation provisions included in contracts with companies from which they bought coal. It was the only major purchaser of coal to provide for reclamation or surface coal mined areas in its contractual agreements in the United States (Sanger, 1978). These provisions included topping spoil piles, elimination of open pits, covering the final pit with 3 or 4 feet of non-toxic material, and planting of pine trees.

The HRN area was first mined in the wake of the SMCRA legislation and partially falls under the interim program and its standards. The Office of Surface Mining (OSM), created because of this act, is the enforcing agency until such time as any state program meets federal standards. OSM agents inspect mined areas before, during and after mining operations to assure compliance with federal regulations. Presently, HRN is still inspected by OSM agents in Alabama. It is also interesting to note that mining operations ceased at HRN in 1979 prior to the national law becoming a permanent program with additional requirements.

Reclamation Efforts

Since HRN was mined partly under the Alabama law and partly under SMCRA, it is difficult to assess accurately and completely the specific method of reclamation used by the mining company in all mined areas.

A brief but non-specific description of the plan for reclamation at HRN was included in the mining permit issued by the state of Alabama Surface Mining Commission. This section indicated that the following should be accomplished: (1) backfilling of final pit and grading of spoil piles in accordance with the law; (2) gravity separation and/or chemical treatment in settlement ponds, (3) elimination of haul roads, (4) planting of grass and trees, (5) mulch and seed used for soil stabilization, and (6) lime and fertilizer used for neutralization of acid soil (Alabama Surface Mine Permit No. P-1388). It appears that the major difference in the above reclamation plan and that provided in the interim SMCRA law is the stockpiling and replacing of topsoil and the number of trees plus type and amount of vegetative cover.

Presently, responsibility for reclamation of the HRN area to the standards set by OSM in accordance with SMCRA remain with the owners of the mineral rights for this area, Tennessee Valley Authority.

CHAPTER III

PHOTOGRAPHIC ANALYSIS

Land Use and Land Cover

A historical photographic analysis was performed using B/W aerial photography from 1946, 1977, 1979 and 1980. In addition, CIR photography was analyzed for 1986. These photographs provide a permanent record of premined and mined conditions. Table 1 lists the dates, scales and frame numbers.

Table 1. Photo coverage, Stevenson 95-SE, Flat Rock 101-SW (TVA Mapping Services Branch).

Date	Scale		Frame Numbers
1946	2-15	1:36000	95-6-1R,2R,3R
1977	10-14	1:20000	138-180,181,182
1979	11-4	1:20000	1920-187,188
1980	10-12	1:20000	2006-57,58,59
1986	3-5	1:24000	2271-193,194

These photographs were interpreted stereoscopically using the classification system listed in Figure 5. Information analyzed included land use/land cover (LU/LC), drainage patterns, mining/reclamation practices and environmental problems. The HRN seep watershed area was photographically analyzed for all years. The total acreage for the HRN Seepage Area is approximately 1000 acres and 400 for the mined area. The acreage for the following classes for all years analyzed is shown in Table 2.

Drainage Patterns

The surface drainage from the HRN watershed area flows directly into the Rocky Branch Stream which flows into Dry Creek and into Coon Creek emptying into the Guntersville Lake which is a part of the Tennessee River system (Figure 6). These tributaries of Coon Creek are a part of the Dry Creek watershed area.

Drainage patterns were completed on the 1946 (premined) and the 1980 (post reclamation) photographic analysis. During the mined years photographic analyses consist of direction of surface drainage on haul roads and location of pit areas with water. Most drainways in all analyses were ephemeral (drainways lasting for short periods, usually after rain) in nature and recognizable as linear depressions running downslope. Most drainage in the mined areas ended up in the pit, and very little in the diverted drain located to the northeast of the mined area.

2 Agricultural: pastures, cropland

4 Forest

5 Water

51 streams
52 ponds
54 sedimentation pond

6 Wetland

7 Barren land

75 active stripmine

751 pit area with minimal quantity of water
752 pit area with open water

79 reclaimed

791 completed or close to completion
792 regrading in progress

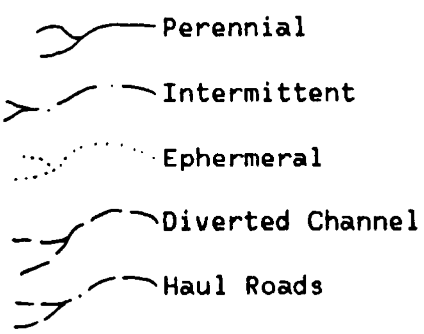
8 Environmental Problems

83 gully erosion
84 rill erosion

<u>Modifiers</u>

A	grass	B	trees
C	mixed	D	none
E	spoil	F	topsoil

<u>Drainage</u>



Example:

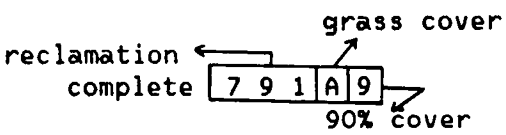


Figure 5. HRN seepage area classification scheme (U.S. Geological Survey Professional Paper 964, 1976).

Table 2. Land use/land cover acreage per class.

Class	Year 1946	1977	1979	1980	1986
2	206	169	141	146	161
4	589	389	233	287	327
52	---	41	4	16	13
6	---	---	3	2	1
751	---	9	72	---	---
752	---	128	20	---	---
791	---	21	156	367	399
792	---	31	---	---	---
793	---	---	141	36	---
83	---	---	---	---	17
84	---	---	2	---	45

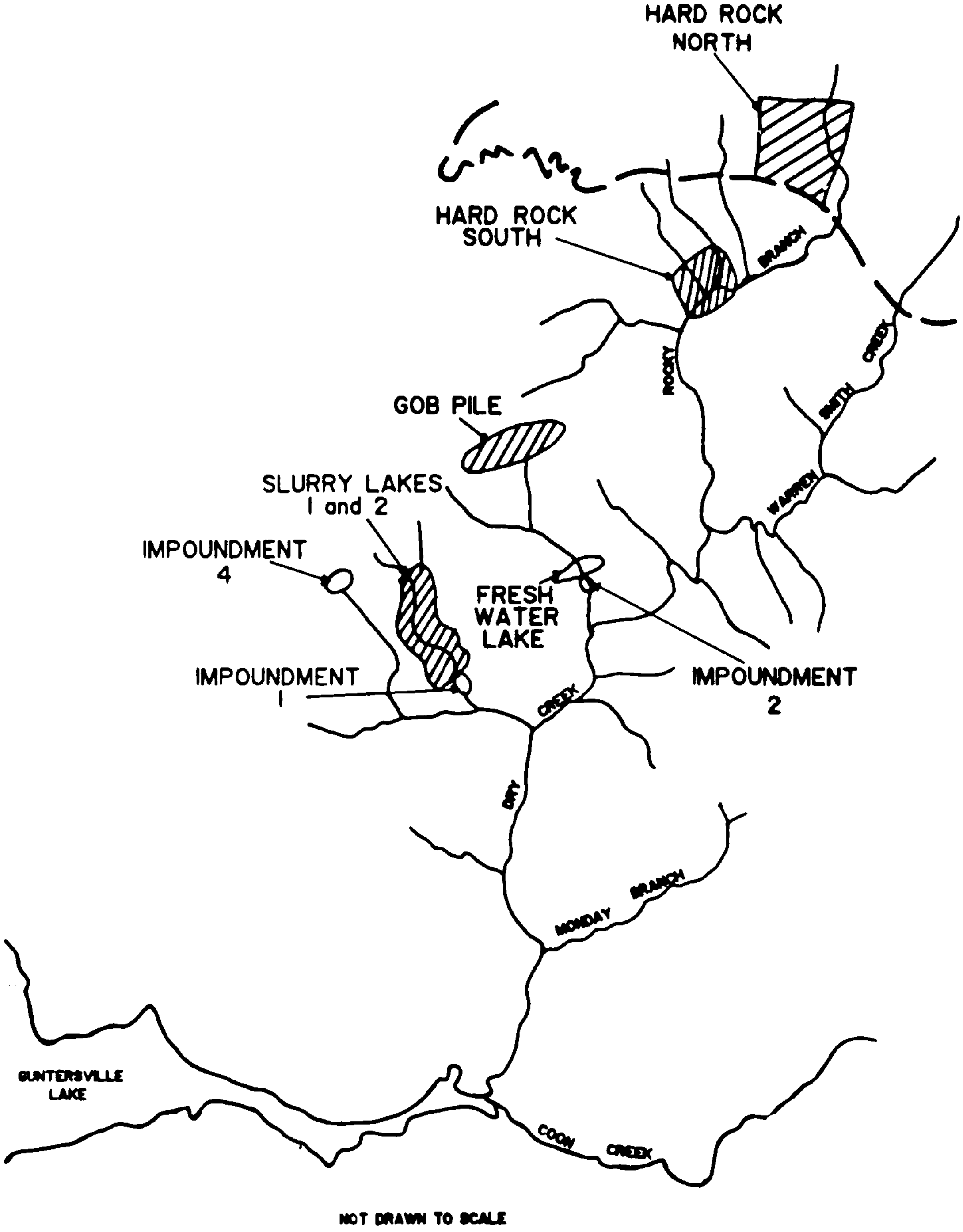


Figure 6. HRN test site area and man-made wetland impoundment sites.

Mined/Reclaimed Areas

The type of mining at HRN was identifiable on both B/W and CIR photography due to the presence of parallel spoil pile lines associated with area strip mining. The areas under reclamation were identified by the presence of large earth-moving equipment and by the process of smoothing of the rough spoil pile lines. Upon completion of reclamation a smooth appearance is apparent due to the area being regraded and topsoil replaced (Singer, 1978).

The vegetative cover for these areas on B/W film was recognizable by the appearance of small dots associated with planting of trees and tonal variations. Usually on CIR film vegetation has a reddish-pink tone indicating vigorous vegetation and the regraded area appears as light tan.

CHAPTER IV

EVALUATION OF PRE-EXISTING TO EXISTING CONDITIONS

Geology

Surface excavations cause dramatic changes in the geology of an area. This physical disturbance disrupts the existing drainage patterns both above and below the surface, and destroys the soil and rock strata resulting in a complete reshaping of the surface. Geological disturbances fall into two major categories: pedological, having to do with soils, and hydrological, having to do with surface and subsurface water (Law, 1984, p. 34).

Pedology

The soils prior to mining were mapped and a copy of their placement at HRN is given in Figure 7 (Jackson County, Alabama, Soils Map, Series 1941). Table 3 indicates name, parent material, internal drainage and consistency. Although this soils map is no longer valid for the mined area in its present condition, it gives an indication of the type of conditions that existed prior to disturbances of the land at HRN.

The majority of the soils covering the HRN mined area prior to mining were a part of the Hartsells fine sandy loam soil group. Water flowed to the subsurface at a moderate rate because this soil group is a combination of weathered sandstone, conglomerate and weathered acid shale.

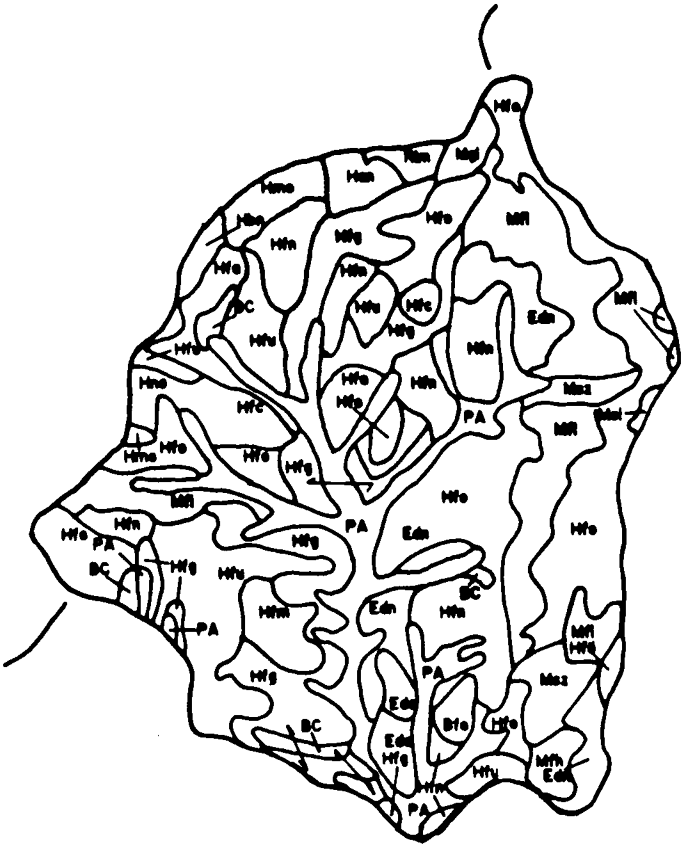


Figure 7. HRN watershed area soils (Jackson County, Alabama, Soils Survey, Series 1981, No. 8, U.S. Department of Agriculture, Soil Conservation Service, Sheet No. 7).

Table 3. Soil characteristics (Jackson County Soils Survey, Series 1941).

Symbol	Name	Parent Material--Internal Drainage--Consistency
PA	Philo-Atkins silt loam	Alluvium of material derived chiefly from sandstone and shale--slow to very slow--friable
Hfn, Hfa Hfe, Hfm Hfg, Hfo Hfu	Hartsells fine sandy loam	Residual material from weathered sandstone and conglomerate in places weathered acid shale--moderate--friable
RLM	Rolling stony land: Muskingum soil material	Residual material from weathered sandstone--moderate to slow--very friable
MSL, MSZ	Muskingum stony fine sandy loam	Residual material from weathered sandstone and some conglomerate and shale--rapid--very friable
MFH, MFL	Muskingum fine sandy loam	Same as MSL and MSZ--rapid--very friable
HNN, HNO	Homeville fine sandy loam	Same as RLM--moderate--friable
Edn, Edo	Enders silt loam	Mainly residium from acid shale and some sandstone--moderate to slow--firm, moderately plastic
BC	Barbourville Cotaco fine sandy loam	Local alluvium or local wash from areas of sandstone or sandstone and shale mixed--moderate to slow--friable

Due to the removal and breakup of the soils and rock 40 to 60 feet below the surface during mining, the stratigraphy at HRN as it exists today closely resembles the stratigraphic layout of Figure 8.

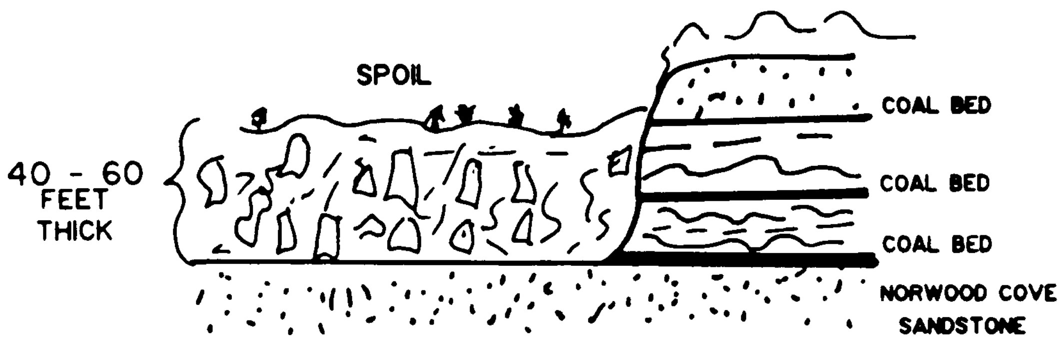


Figure 8. Present stratigraphic layout (adapted from field investigation) (see Appendix).

Hydrology

In 1946 the drainage was primarily ephemeral except for the intermittent drain running almost through the center of the HRN seep area. Although the man-made drainway built near the center of HRN was established to closely resemble the original stream, very little water actually flows through this area, but is labeled as an intermittent stream due to the definitive path that it maintains. All other drainage on the 1986 photography is ephemeral.

Aside from the actual mined areas, the most significant change in land cover occurs with surface water. In 1946 there was no surface water, such as ponds, and as the mined area increased so did the amount of surface water. The most outstanding change in surface water occurred between 1977 and 1979 as the amount of water increased dramatically, especially on the mined site. Further evaluation of the study area with large-scale photography at 1:3000 monoscopically revealed that the pit area in 1978 had very little water, and even in January of 1979 the pit was only partially covered. By June 1979 the pit area was at least 95% covered with water. This may be indicative of changes in the ground flow. Figure 9 shows ground water in the Cumberland Plateau. Groundwater in the Cumberland Plateau coal reserve areas occurs primarily in fracture zones of the sandstone, shale and conglomerate. Even though a low intergranular permeability is associated with these types of rocks, fractures provide openings for storage and movement of groundwater. According to May (1983) these numerous aquifer-type systems generally occur 100 feet deep with low water yields. Also during 1979 HRN became inactive and the coal in the last pit was not removed due to the amount of water covering the coal.

Mined/Reclaimed Areas

The majority of the land use prior to mining was forest with few agricultural areas; reclamation efforts are re-establishing a similar cover of trees and grass. Also the area has been regraded to closely approximate the original contour. Due to the high cost of mining, quantity of coal and low cost of coal, HRN probably would not be mined today.

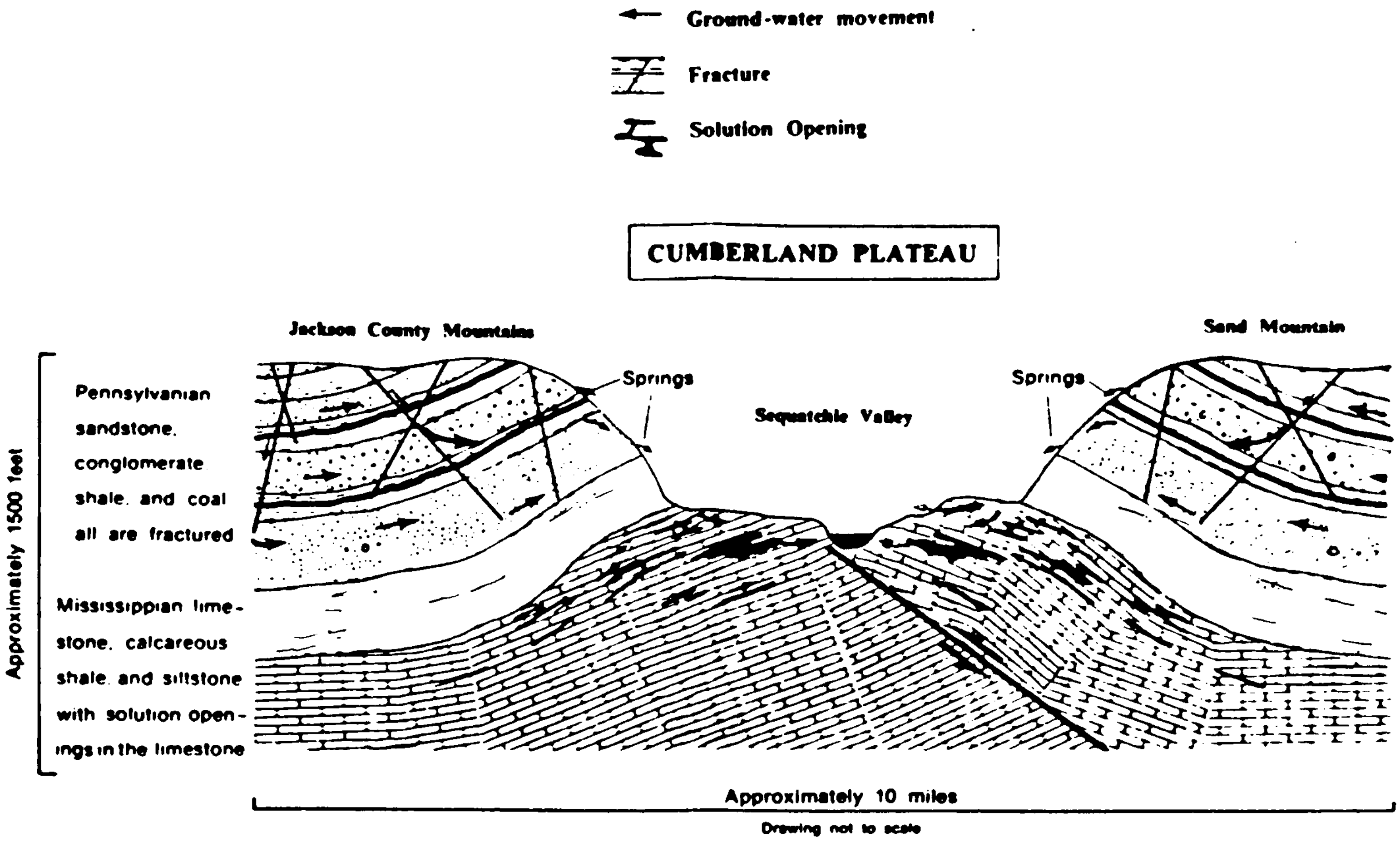


Figure 9. Groundwater movement in the Cumberland Plateau (May, 1983, p. 61).

One of the first permits issued for HRN also indicated that there were only 72 acres mined at that time. Eventually a little less than 500 acres were mined by 1979. From all indications, the area was mined and reclaimed as the mining proceeded. There appeared to be no real problems associated with the mine site until the final pit became filled with water. At this point the reclamation proceeded as usual by filling in the pit and regrading the area. But the pit was not lined with an impermeable surface nor was it dewatered. The drainage was channeled through a sedimentation pond which is below the actual HRN seep. As the pit was being regraded the water depth in the southeasterly direction became higher and the channel closest to the HRN seep widened.

Contour Profiles

A set of parallel points moving in the east to west direction in seven rows and five columns covering all of HRN and parts of other mined areas plus areas of undisturbed land were plotted by contours from the 7.5 minute Stevenson quadrangle (Figure 10). Figures 11 and 12 display the contour points and their profiles. To help dispel a theory that Lake A (point 19) may be draining into the HRN seep (point 7) through underground movement of water, these topographic points and other points were used for elevation comparisons. Points 19 and 7 were found to be at nearly the same elevation level prior to mining, therefore no significant underground drainage would occur between the two points. The list of special points corresponding to elevation levels are in Table 4.

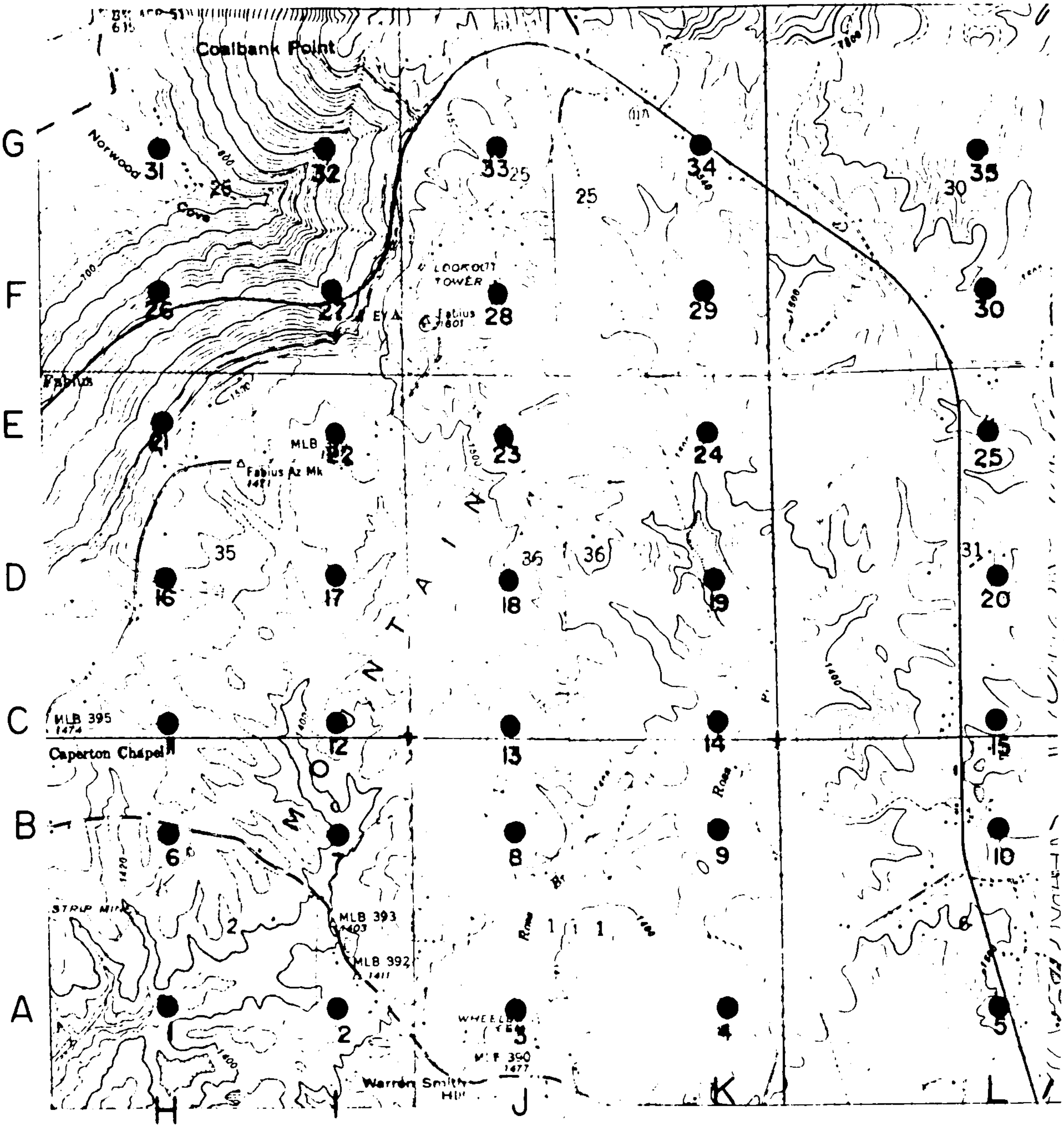


Figure 10. Plotted points on quads.

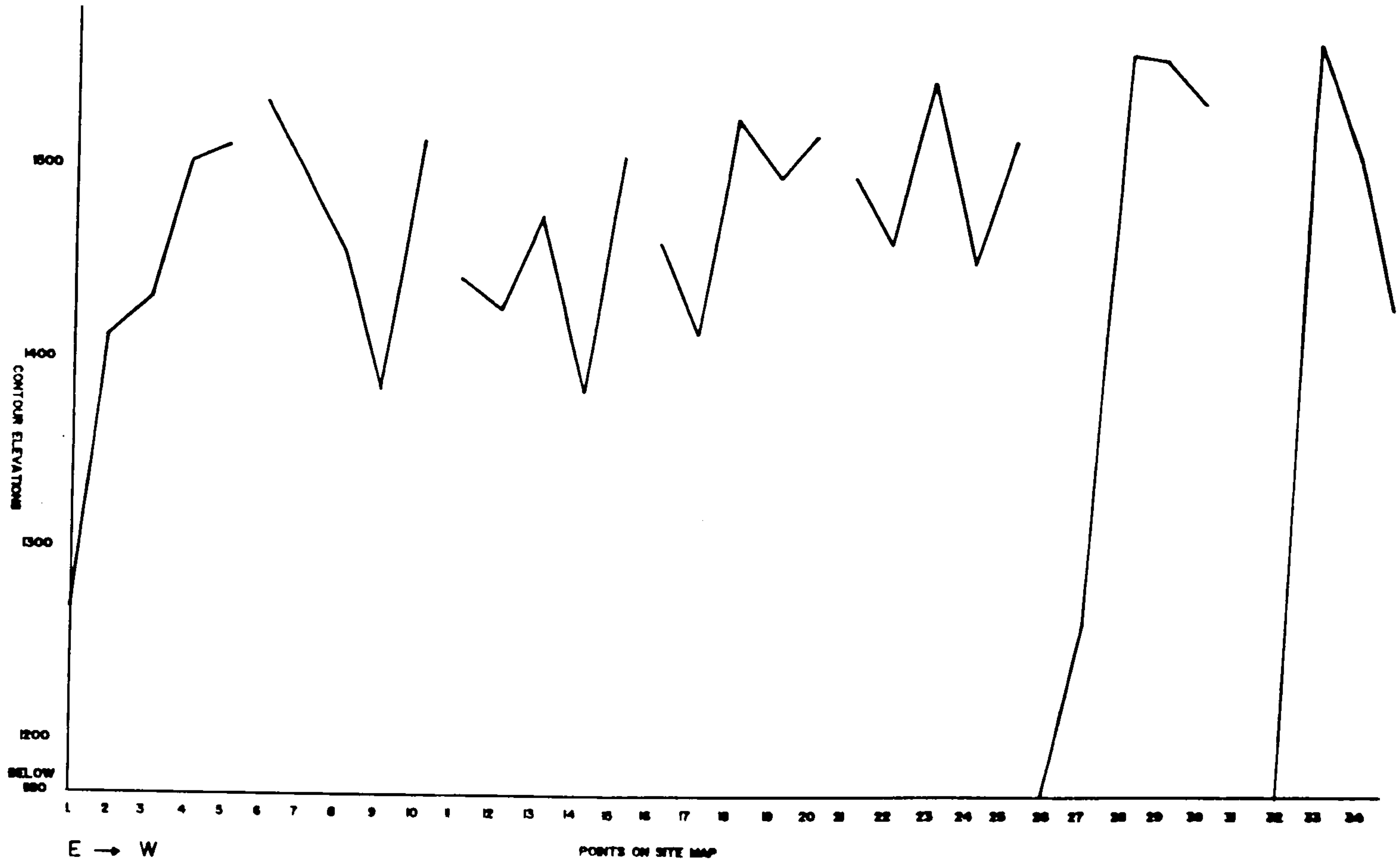


Figure 11. Contour points and profiles, east to west.

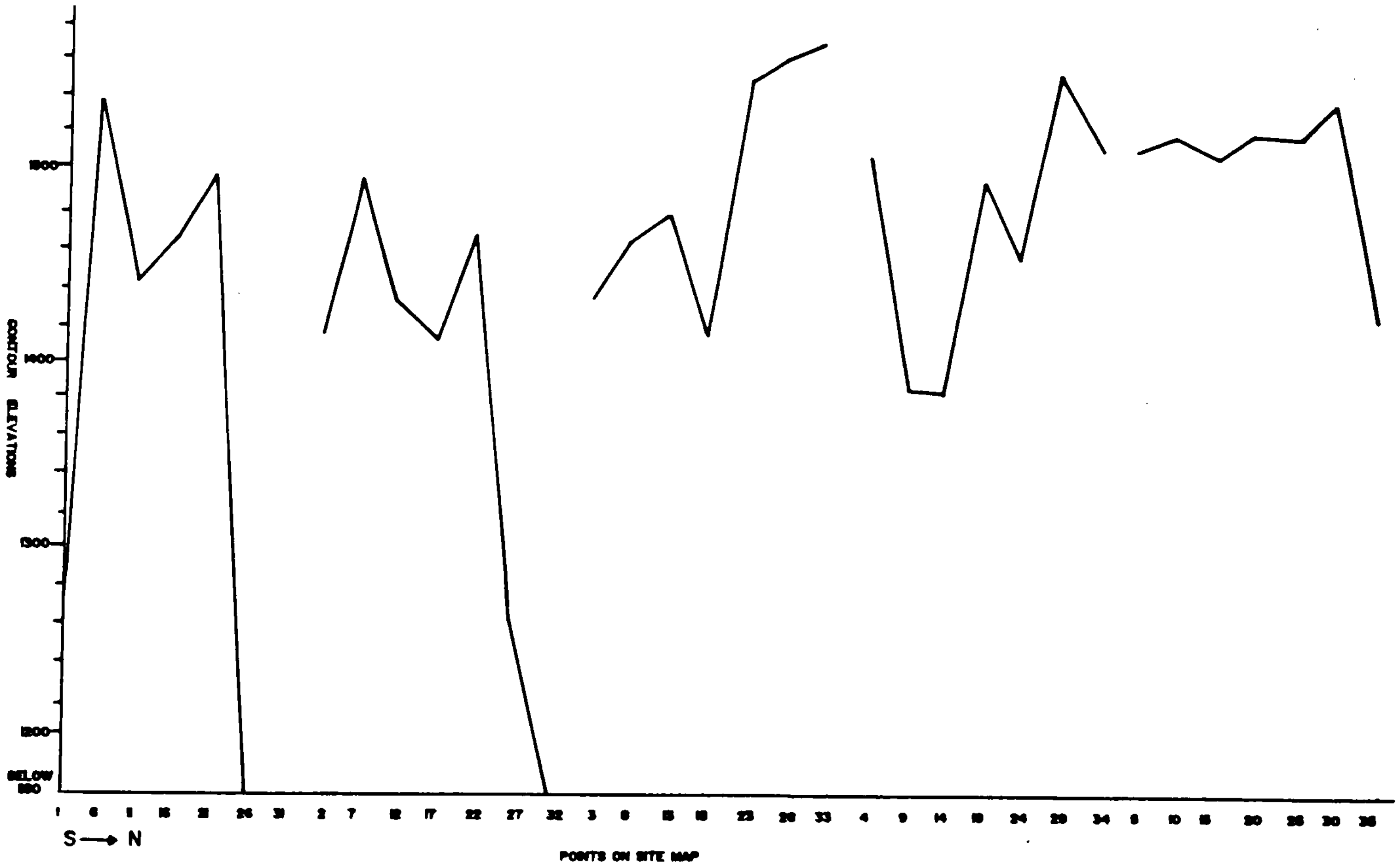


Figure 12. Contour points and profiles, south to north.

Table 4. Contour points comparison chart.

	H	I	J	K	L
G	31 610	32 1040	33 1565	34 1510	35 1416
F	26 1040	27 1280	28 1539	29 1532	30 1517
E	21 1478	22 1460	23 1543	24 1430	25 1445
D	16 1458	17 1429	18 1525	19 1496	20 1518
C	11 1440	12 1425	13 1475	14 1379	15 1504
B	6 1430	7 1493	8 1458	9 1382	10 1515
A	1 1366	2 1410	3 1430	4 1502	5 1510

Point 7 seepage area located on Contour 1493; 19 Lake A located on Contour 1496. These elevations are in feet above sea level.

Fracture Traces/Lineaments

A fracture trace examination was performed on the 1946 premining photography. Over 300 lineaments were found, mostly in the northwestern direction varying in length from .1 mile to 1.5 miles.

When those fracture traces were analyzed with the accompanying LU/LC for 1946, the stream was found to be fracture controlled.

Environmental Problems

As with any mined area, environmental problems are an inherent part of the process. During and after completion of this total surface and subsurface restructuring, it is difficult (to say the least) to closely approximate the original cover and geology of such an area. The biggest problem in surface mining in the United States until the late 1970s was probably abandoned mined sites, where nature has to rebuild what man destroyed with little or no assistance.

Fortunately, man has seen fit to help nature rebuild consistent with prior land use, yet environmental problems persist as in this case.

The problems at HRN requiring the most attention and causing the most negative environmental concerns are hydrologically related. During mining, haul roads are associated with a tremendous amount of surface run-off and may contribute to the amount of water in surface ponds and in the mining pits. The haul roads at HRN were virtually eliminated during reclamation.

The vegetative cover appears as scrub-shrub from aerial photography instead of small trees. The trees appear to be somewhat stunted for

for a stand 5 to 6 years old in most places. Another somewhat minor problem is subsidence. There was a small sinkhole observed during field observations which has been used as a trash dump, apparently by local residents.

Environmental problems associated with soil erosion occurred in HRN as rills and gullies and are easily detectable through aerial photography as patches of linears on a downslope (Figure 13).

The major problem, according to OSM agents, and the one causing the most long-reaching environmental concern, is seepage areas. These areas are common to reclaimed areas and crop out in unpredictable places at various stages of reclamation. Usually they have high contents of iron and manganese which are major contents of acid mine drainage. This drainage will often reach major streams and rivers, as in this case. Also indicative of seepage areas is the presence of natural wetlands, which serve as filtering systems. These wetland areas prompted further research and development into man-made areas of filtration for the treatment of acid mine drainage in other Fabius mined areas by TVA. Greg Brodie, an environmental scientist, serves as project engineer for TVA's man-made wetlands experiment. In several locations throughout the Fabius Mines, man-made wetlands have been built since 1985 with very good results in a majority of the areas. Further experimentation was needed and an extensive wetlands research project is near completion at HRN. This experiment will divert water from the HRN seep through culverts containing different combinations of substrates and vegetation. Preliminary results indicate that this

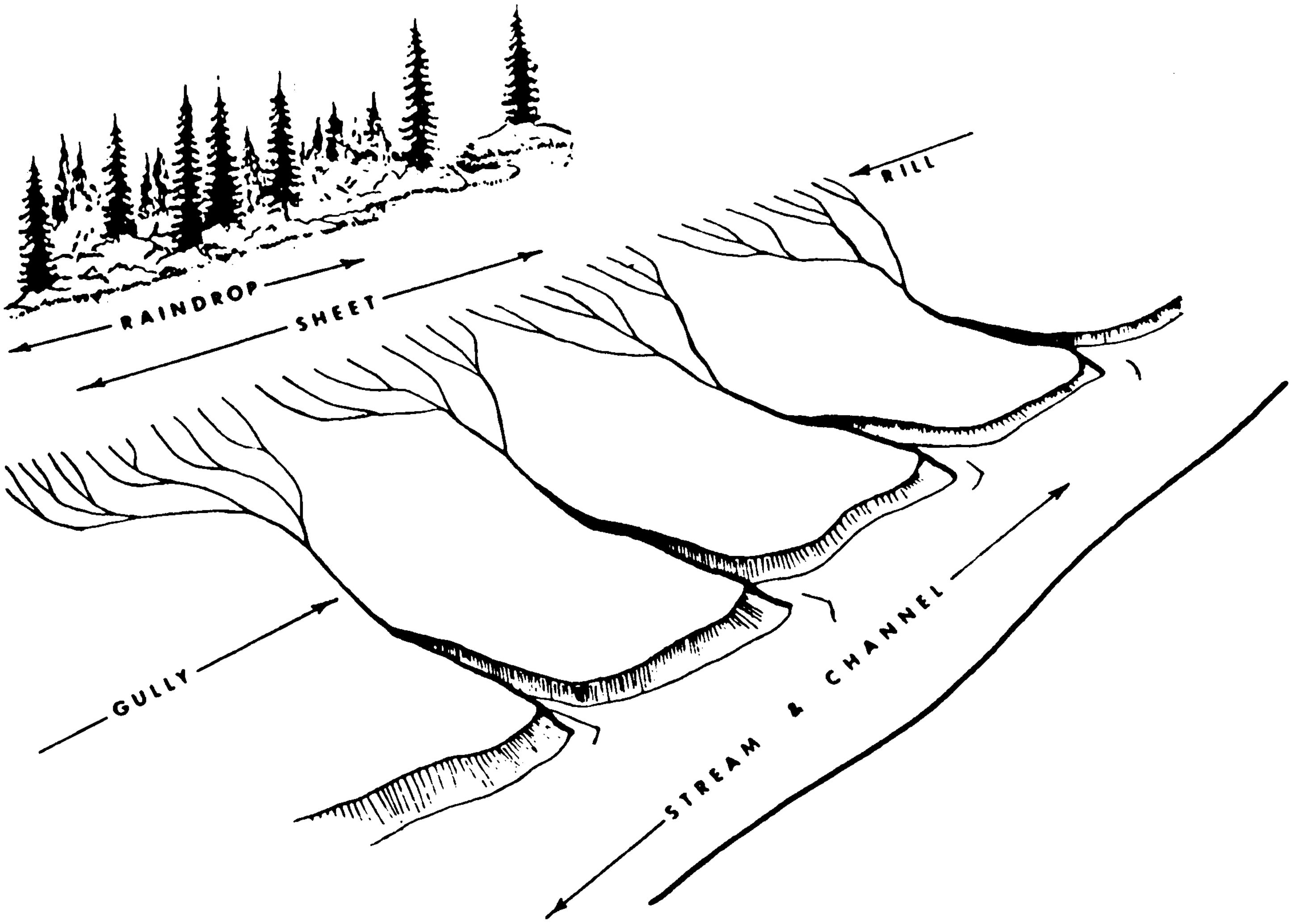


Figure 13. Types of erosion (Law, 1984, p. 18).

process is an excellent alternative to chemical treatment of seepage problems.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Seepage areas at reclaimed mined sites will continue as major sources of hydrological problems. They pose a threat throughout the area waterways in groundwater and surface runoff. The source of seeps are very difficult to assess. Therefore, remote sensing techniques were applied to aid in the development of a drainage pattern for the HRN seepage area.

Several theories as to the source of the seep have developed: (1) HRN area is in the process of naturally dewatering; (2) an aquifer was hit during the drilling of the last pit, which became filled with water; (3) there may be underground movement of water through a fracture in the sandstone layer; (4) the flow of water through the spoil may establish a new drainage pattern; (5) several pools of water or one large pool may be collecting on top of a cemented sandstone layer.

To aid in the verification of one or more of these theories, dye traces need to be placed in area wells and/or septic tanks, surrounding ponds and other surface drainage to see if there is drainage into the HRN seep from these surrounding areas. Also, bore sampling may need to be done at HRN. These analyses are somewhat economically prohibitive.

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APPENDIX

FIELD OBSERVATIONS

During the field examination at HRN in July 1986, several sites were observed. The HRN seepage area is now a small pond due to the placement of a man-made drainway into a small natural wetland filled with cattails. Acid mine drainage is obviously a problem at this seep with the red/orange color in the drainway and the wetland area.

The diversion channel along the eastern border of HRN was found with only puddles of water and some gully erosion on both the bottom of the channel and on the highwall area.

From the ground the general reclaimed area of HRN appears to be 90-96% covered by vegetation with scrub-shrub, grass and small trees. The channel identified near the center of HRN on the PI had no flowing water and rill erosion emptied into the channel. The channel was covered on the bottom with small rocks. There was a sinkhole observed near the bottom of pond B covering a small area but not classified on the PI. There were several cracks spreading toward the already depressed areas. There was also evidence that this sinkhole had been used as a dump for garbage. Overall the reclamation at HRN appears to be doing quite well with the exception of the seepage area and the acid mine drainage.

A second field investigation was completed during August 1986 to provide more information concerning the stratigraphy at HRN. Since the highwalls were regarded they were not exposed in the reclaimed area. Dr. Richard Bergenback (Professor of Geology, University of

Tennessee at Chattanooga) provided a probable layout of HRN as it exists today in Figure 8 (page 20). He hypothesized that surface water percolates down through the spoil at a slow rate of recharge

Table 5. HRN seep chemical analysis.

Date	Flow (gpm)	pH	Fe (mg/l)	Mn (mg/l)	TSS (mg/l)
3-80 to 10-80	60-100	4.1-5.2 (avg. 5.1)	.11-.45 (avg. .17)	36.51 (avg. 41)	2-7 (avg. 5.0)
3-6-85	NA	5.7	31	18	13
10-17-85	280	6.1	47	19	6
11-19-85	230	6.0	48.3	19.2	34
12-18-85	NA	6.0	48.3	19.8	21
1-31-86	260	6.2	33.6	15.7	17
2-14-86	420	6.1	38.7	18.4	18
3-27-86	580	5.6	NA	NA	NA

Chemical analysis of the water flowing from the HRN seep was completed for the dates listed in Table 5. It is interesting to note that during 1985 and 1986 the flow continued to increase even though this area was under the influence of a drought. The abbreviations represent the following: gpm, gallons per minute; Fe, iron; Mn, manganese; TSS, totaled suspended solids; mg/l, miligrams per liter. (Information provided by Greg Brodie, TVA.)

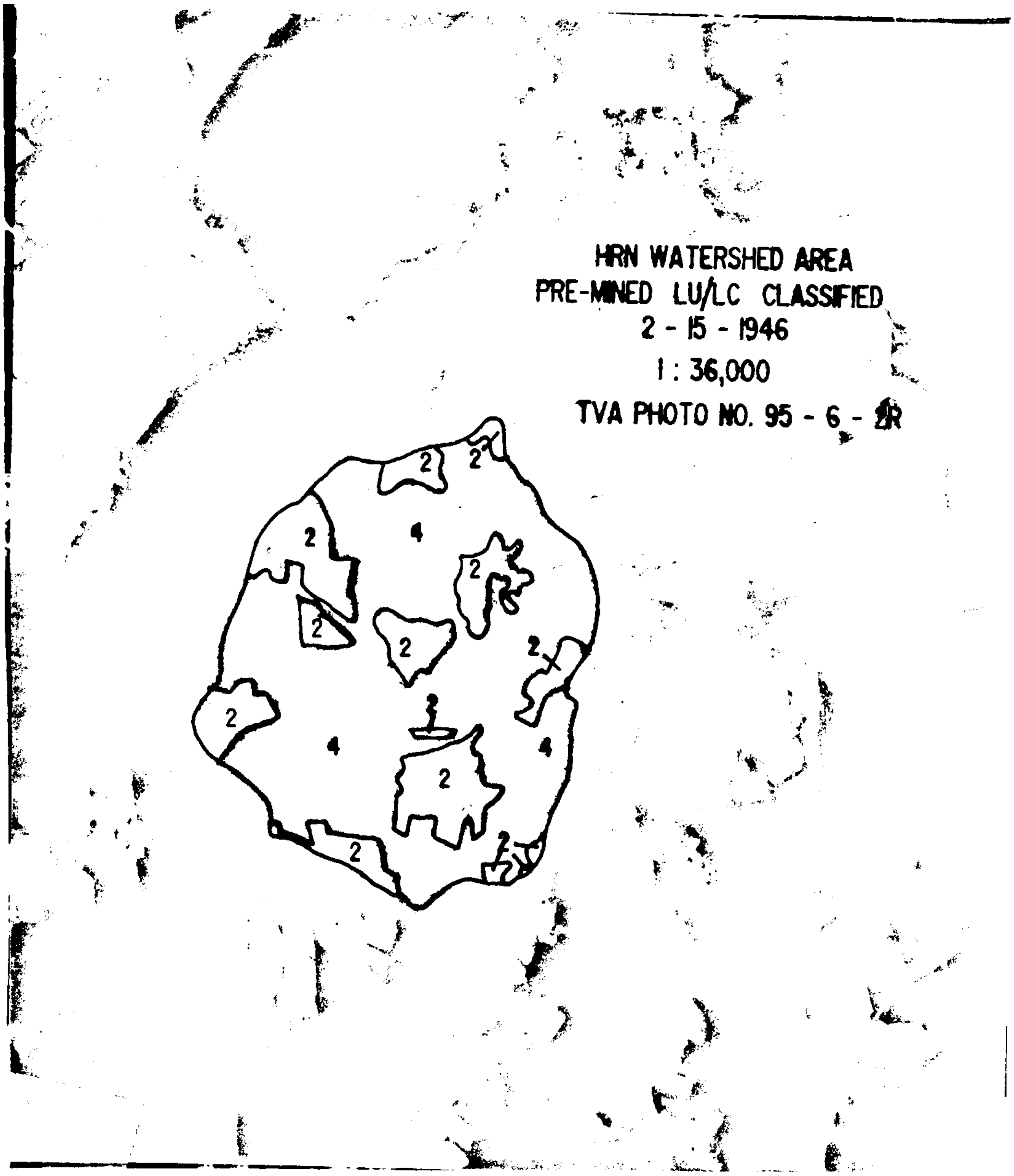

Figure 14. Premined land use/land cover, 1946.

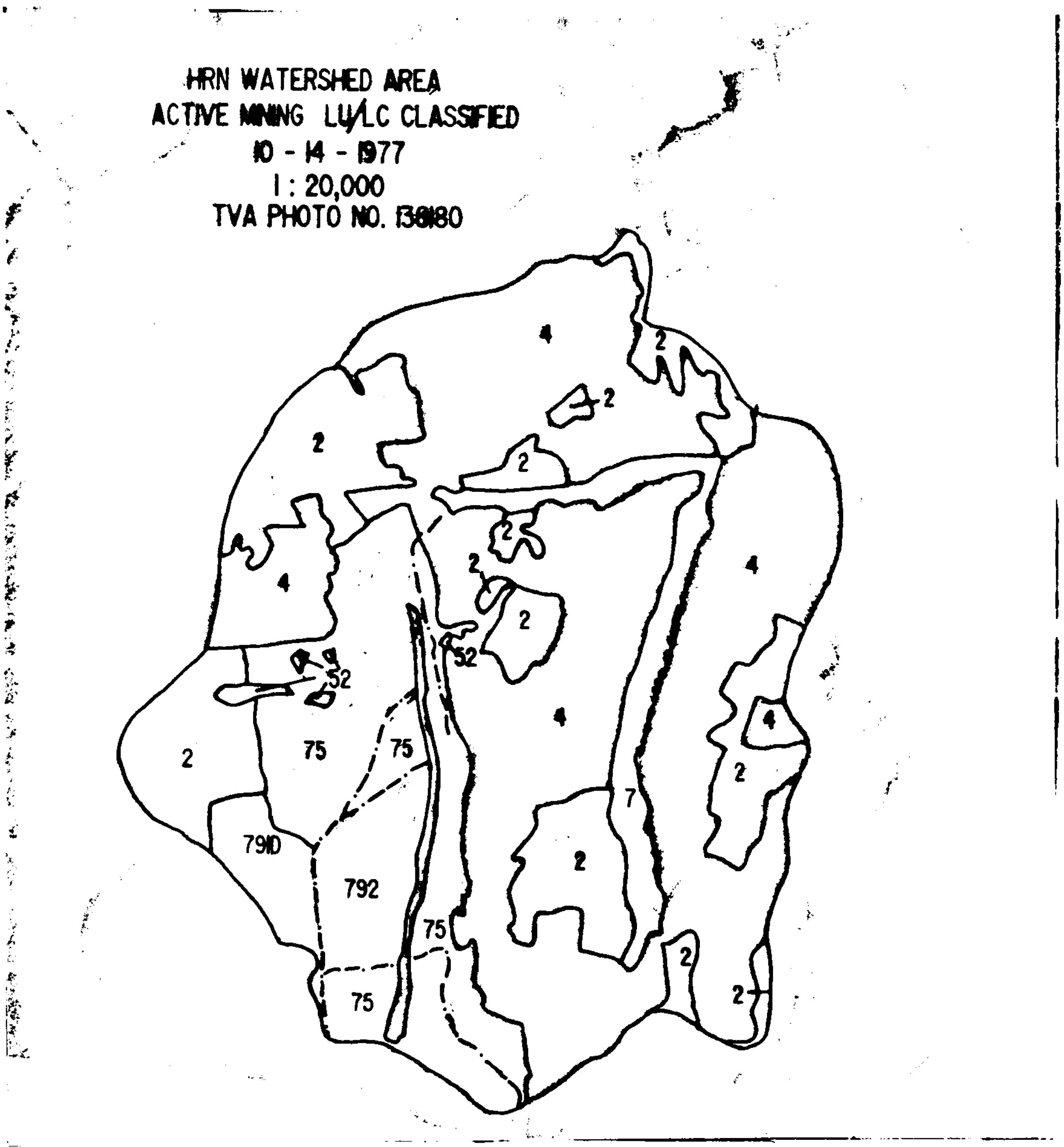

Figure 15. Active mining land use/land cover, 1977.

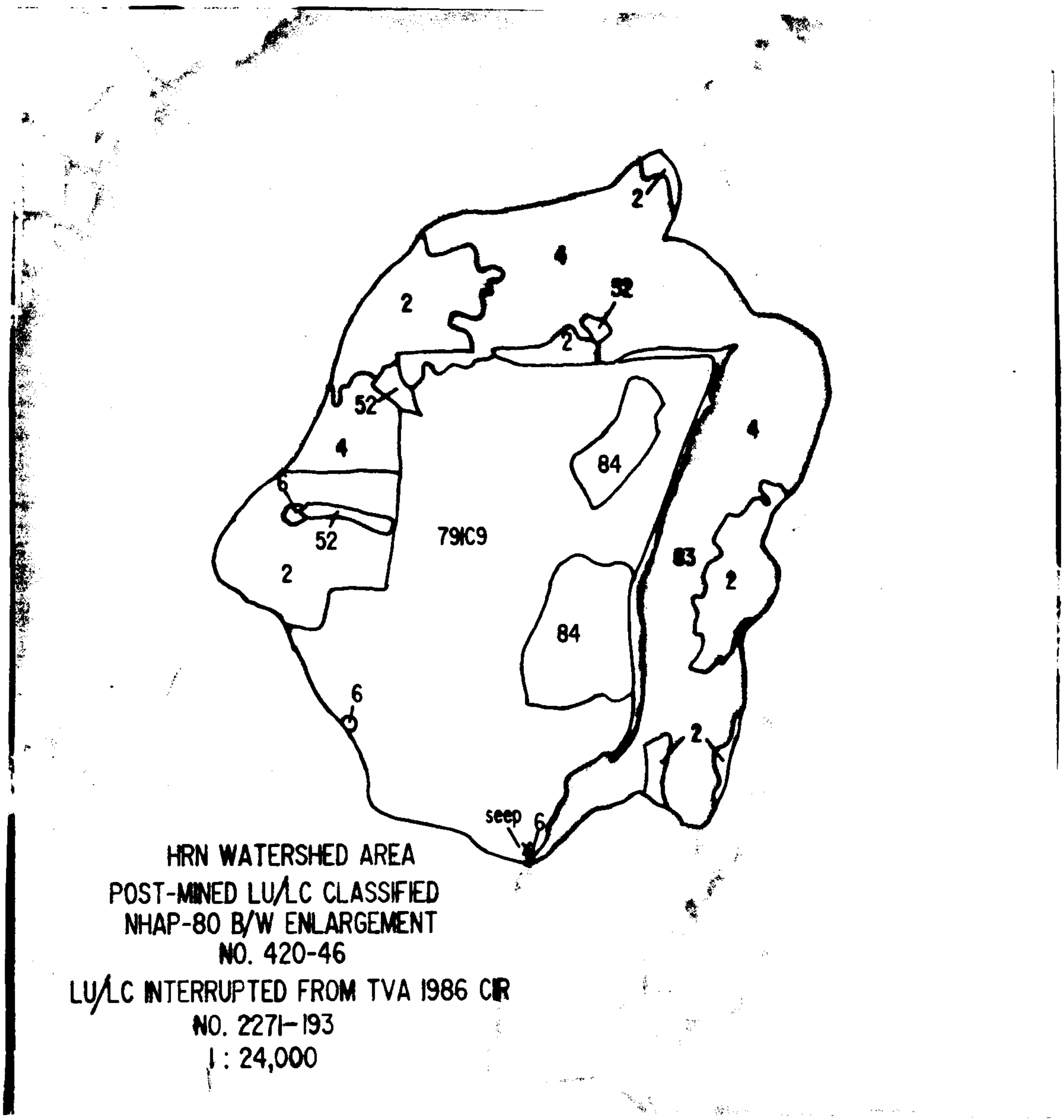

Figure 16. Post reclamation land use/land cover, 1986.

VITA

Anita Denise Polk-Conley was born in Meridian, Mississippi, on November 28, 1955. She is the daughter of Dr. and Mrs. Octavius D. Polk, Sr.

She received her Bachelor of Arts degree from The University of Tennessee at Chattanooga with a major in Chemistry in 1980. Following graduation, she entered the Engineering Science program at The University of Tennessee Space Institute where she also served as a graduate assistant in the Remote Sensing Division. She is currently employed by the Tennessee Valley Authority in Chattanooga, Tennessee.

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