OSM MID-CONTINENT REGION TECHNOLOGY TRANSFER AMD WORKSHOP

Collinsville, Illinois

Participants Contact Information
Presentation Abstracts

TUESDAY, September 11, 2007

1:00 PM — **Introductions and Program** (20 minutes)
Larry Lewis (Chairperson), Illinois AML Program

1:15 PM — **SESSION 1: INTERACTIVE AMD TECHNOLOGY & CASE STUDIES**

Carbon Recovery versus Prevention and Passive Treatment for the Elimination of AMD at an AML Eligible Slurry Impoundment; a Case Study of the Chinook Slurry Pond
Steve Herbert, Indiana Division of Reclamation, Jasonville, IN

Cane Creek AMD Remediation (PHASE IV)
Larry Barwick, Alabama Mining & Reclamation, Abandoned Mine Lands, Birmingham, AL

2:45 PM — **Break**

3:15 PM — **AMD Remediation at Superior C.C. #4 (30-40 min)**
Larry Lewis, Illinois Office of Mines and Minerals, AMLR Division Springfield, IL

Passive Treatment of Artisian Mine Pool Discharges in Oklahoma
(20 min)
Paul Behum, Office of Surface Mining, Alton, Illinois

Participant — **Interactive Discussion**

5:00 PM — **ADJOURN**

WEDNESDAY, September 12, 2007

FIELD EXERCISE

8:00 AM Orientation of the Superior #4 and Consol #7 site problems.

9:00 AM Drive to Superior #4

9:45 AM Tour Superior #4: Site investigation, data collection, and field problem
solving on site. **Superior #4 Tour Packet**

12:00 Noon Drive to Staunton, IL for Lunch

1:00 PM Tour Consol #7: Site investigation, data collection, and field problem
solving on site. **Consol #7 Tour Packet**

4:00 PM Return to hotel & prepare design for re-mediation of AMD

THURSDAY, September 13, 2007

8:00 AM **SESSION 2: RESTORATION OF AMD IMPACTED**
WATE RSHED AREAS

AML Reclamation Activities, Past Present and Future, in the South
Fork Patoka River Watershed
Mark Stacy, Indiana Division of Reclamation

AMD Status and Remediation in Alabama
Larry Barwick, Alabama Department of Industrial Relations

9:55 AM **Break**

10:25 AM **How AMD is Impacting the South Fork River in Illinois (30-40 min)**
Ron Kiser, Illinois Office of Mines and Minerals, AMLR Division,
Benton, Illinois

Geomorphology and Hydrogeology of Hartshorne Coal Basin in
Oklahoma and the Impact on Remediation of Acid Mine Drainage
(20 Min)
Paul Behum, Office of Surface Mining, Alton, Illinois

Participant Interactive Discussion

12:00 Noon **ADJOURN**

Mid-Continent Region Technology Transfer Acid Mine Drainage Workshop
September 11-13, 2007
Collinsville, Illinois

Olga M. Aranazubia Illinois DNR/AML 503 E. Main St Benton, IL 62812 618-439-9111 x 243 Olga.aranzubia@illinois.gov	Lonnie Barrier Mississippi DEQ P.O. Box 20307 Jackson, MS 39285-1307 601-961-5518 Lonnie_Barrier@deq.state.ms.us
Larry Barwick AL Dept. of Industrial Relations, AML 11 West Oxmoor Rd Birmingham, AL 35209 205-945-8671 amlplanning@bellsouth.net	Paul Behum Office of Surface Mining 501 Belle St. Alton, IL 62002 618-463-6463 x 5122 pbehum@osmre.gov
Mike Bourland IA Division of Soil Conservation 502. E. 9th St. Des Moines, IA 50319 515-242-6130 mike.bourland@idals.state.ia.us	Mark Bredehoft IN Division of Reclamation RR 2, Box 129 Jasonville, IN 47438 812-665-2207 mbredehoft@dnr.in.gov
John Coleman Office of Surface Mining 501 Belle St. Alton, IL 62002 618-463-6463 x 5107 jcoleman@osmre.gov	Marvin Ellis IN Division of Reclamation RR 2, Box 129 Jasonville, IN 47438 812-665-2207 mellis@dnr.in.gov
Mary-Lou Flowers Illinois DNR/AML One Natural Resources Way Springfield, IL 62702 217-782-0588 marylou.flowers@illinois.gov	Nick Grant Office of Surface Mining 501 Belle St. Alton, IL 62002 618-463-6463 x 5148 ngrant@osmre.gov
Steve Herbert IN Division of Reclamation RR 2, Box 129 Jasonville, IN 47438 812-665-2207 sherbert@dnr.in.gov	Brian Hicks Office of Surface Mining 501 Belle St. Alton, IL 62002 618-463-6463 x 5121 bhicks@osmre.gov
Randy Hoffman IN Division of Reclamation RR 2, Box 129 Jasonville, IN 47438 812-665-2207	Ron Kiser Ilinois DNR, AML Division 503 E Main St Benton, IL 62812 618-439-9111 ron.kiser@illinois.gov

Larry Lewis IL DNR, AML Division One Natural Resources Way Springfield, IL 62702 217-524-6513 Larry.l.lewis@illinois.gov	Thor Lindquist IL DNR/AML 503 E Main Benton, IL 62812 618-439-9111 x 248 thor.lindquist@illinois.gov
Charles McCool AR DEQ, Surface Mining Div. 1220 W. 2nd St. Russellville, AR 72801 501-682-0801 mccool@adeq.state.ar.us	Greg Melton AR DEQ, Surface Mining Div. 5301 Northshore Dr. North Little Rock, AR 72218 501-682-0801 melton@adeq.state.ar.us
Jim Metzger IN Division of Reclamation RR 2, Box 129 Jasonville, IN 47438 812-665-2207 jmetzger@dnr.in.gov	Tom Nelson IL DNR, AML Division One Natural Resources Way Springfield, IL 62702 217-785-5196 tom.nelson@illinois.gov
Vinod Patel IL DNR, AML Division One Natural Resources Way Springfield, IL 62702 217-782-0119 vinod.patel@illinois.gov	Goran Radinovic OK Department of Mines, Surface Coal Program 4040 N. Lincoln Blvd., Suite 107 Oklahoma City, OK 73105 405-427-3859
Phil Smith IL DNR, AML Division One Natural Resources Way Springfield, IL 62702 217-524-6513	Mark Stacy IN Division of Reclamation RR 2, Box 129 Jasonville, IN 47438 812-665-2207 mstacy@dnr.in.gov
Stan Thieling MS DEQ, Coal Mining Division P.O. Box 20307 Jackson, MS 39289 601-961-5519 stan_thieling@deq.state.ms.us	Dan Trout Office of Surface Mining 1645 South 101st East Ave, Suite 145 Tulsa, OK 74128 918-581-6431 x 27 dtrout@osmre.gov
Tekleab Tsegay OK Department of Mines, Surface Coal Program 4040 N. Lincoln Blvd., Suite 107 Oklahoma City, OK 73105 405-521-3859 Tekleab.Tsegay@mines.state.ok.us	Janet Uglum IL DNR/AML 503 E Main Benton, IL 62812 618-439-9111 x 244 janet.uglum@illinois.gov

Wayne Van Buren AR DEQ 1220 West 2nd Street Russellville, AR 72801 479-968-7339 vanburen@adeq.state.ar.us	Kim Vories Office of Surface Mining 501 Belle St. Alton, IL 62002 618-463-6463 x 5103 kvories@osmre.gov

Name: Organization: Address: Phone: Email:	Name: Organization: Address: Phone: Email:
Name: Organization: Address: Phone: Email:	Name: Organization: Address: Phone: Email:
Name: Organization: Address: Phone: Email:	Name: Organization: Address: Phone: Email:
Name: Organization: Address: Phone: Email:	Name: Organization: Address: Phone: Email:

<table>
<tr><td>Name:

Organization:

Address:

Phone:

Email:</td><td>Name:

Organization:

Address:

Phone:

Email:</td></tr>
<tr><td>Name:

Organization:

Address:

Phone:

Email:</td><td>Name:

Organization:

Address:

Phone:

Email:</td></tr>
<tr><td>Name:

Organization:

Address:

Phone:

Email:</td><td>Name:

Organization:

Address:

Phone:

Email:</td></tr>
<tr><td>Name:

Organization:

Address:

Phone:

Email:</td><td>Name:

Organization:

Address:

Phone:

Email:</td></tr>
</table>

Name: Organization: Address: Phone: Email:	Name: Organization: Address: Phone: Email:
Name: Organization: Address: Phone: Email:	Name: Organization: Address: Phone: Email:
Name: Organization: Address: Phone: Email:	Name: Organization: Address: Phone: Email:
Name: Organization: Address: Phone: Email:	Name: Organization: Address: Phone: Email:

SESSION 1:

Carbon Recovery versus Prevention and Passive Treatment for the Elimination of AMD at an AML Eligible Slurry Impoundment; a Case Study of the Chinook Slurry Pond

Steve Herbert, Indiana Division of Reclamation, Jasonville, IN

The Indiana AML Program undertook initial reclamation activities at the Chinook slurry pond in 1997, and completed the major effort to stabilize the pond in 2002. Experimental reclamation included incorporating a mixture of spent mycelial sludge from Eli Lilly Tippecanoe Laboratories and fluidized bed ash from the Purdue University power plant, to a depth of twelve inches into the barren exposed slurry material.

A chronic problem persists in a major AMD seep, and several lesser seeps scattered around the base of the retaining levee of the pond. Passive treatment installed at the time of initial construction activities was unsuccessful in dealing with this AMD problem.

The Indiana AML program received offers in 2006 to reprocess the entire slurry pond for carbon recovery. All reprocessing would be AML enhancement work, thus no permit would be required for the activity. Coal would either be removed from the site and transported to a nearby permitted processing facility, or it would be reprocessed on site with waste material buried in the base of the pond. The state of Indiana, owner of the site, would receive royalty payments for the carbon.

The decision process on whether reprocessing or additional AML remediation work, including both preventing AMD formation, and passive treatment after formation, was complex. An in-depth hydrologic investigation, assessing the probability of success under all alternatives, commitment of AML program resources (financial and manpower), and the ability to structure a reprocessing agreement that would minimize the exposure of the state to future reclamation issues were all factors in the decision. The value of the in-place carbon materials was also an issue that was unknown.

Escalating energy costs will continue to make the recovery of carbon from AML sites, both reclaimed and unreclaimed, an intriguing proposition nationwide. The technical and administrative issues that must be addressed in the decision making process are complex, polarizing, and difficult. A discussion of these issues by AMD forum attendees will hopefully assist other AML programs in determining the best technology to apply in each particular situation.

Cane Creek AMD Remediation (PHASE IV)

Larry Barwick, Alabama Mining & Reclamation, Abandoned Mine Lands, Birmingham, AL

The Cane Creek watershed has traditionally supported forest production, extensive underground and surface coal mining and various recreational activities such as fishing, swimming and hiking. Some of the recreational activities as well as stream flora and fauna have been severely impacted by acid mine drainage.

The project area is located on Black Branch, a tributary of Cane Creek. This area has had a long history of coal mining. Records maintained by the Alabama Department of Industrial Relations, Office of Mine Safety and Inspection indicate that the area was mined by the Coal Valley Coal Company in 1920, Debardelaben Coal Company from 1927 to 1945 and others. Underground mining closed in 1945. Surface coal mining was active from the 1960's through the 1980's and the area was also used for coal processing and shipping. All of these mining activities have contributed to the acid mine drainage in the watershed. However, the major contributors to AMD are the abandoned underground mine seeps and two coal refuse piles totaling 20 acres that were deposited in the stream bed and flood plain of Black Branch and its tributaries.

The Alabama Department of Industrial Relations, Mining and Reclamation Division, has completed three reclamation projects at the site but it remains a major source of pollution in the Cane Creek watershed.

In 2006, partnership between the Alabama Department of Industrial Relations and the Alabama Department of Environmental Management was initiated to eliminate the nonpoint source pollution flowing from the Cane Creek site. The coal refuse pile will be moved from the Black Branch flood plain and streambed and covered with 24" of natural soil onsite. Trapped acid water will be allowed to flow into constructed drainageways instead of seeping through acidic mine spoil, and a vertical flow wetland and oxidation pond will be constructed on site.

AMD Remediation at Superior C.C. #4

Larry Lewis, Illinois Office of Mines and Minerals, AMLR DivisionSpringfield, IL

In 1988 when the Illinois Abandoned Mined Lands Reclamation Council, now known as the Abandoned Mined Lands Division of the Office of Mines and Minerals, Illinois Department of Natural Resources, (AMLR), agreed to address potential public hazards and acid mine drainage problems from an abandoned coal mine site located near Wilsonville, in Macoupin County, little did they know what it would do for their program.

What was known, was that it would be extremely challenging to create a design that must control the subsurface flow out of a 30 acre barren pile of very porous and acidic mine refuse material. This was crucial because the pile was part of a landfill, containing some toxic waste material that remained around it, despite a $40 million cleanup effort conducted previously by the Illinois Environmental Protection Agency, (IEPA).

This paper reports how the design, construction, and follow-up maintenance of the site all contributed to make this one of the program's best reclamation projects in the history of the program. Today, it serves as a model that has helped to establish many of the program's design standards for remediating mine refuse piles throughout the state.

Passive Treatment of Artesian Mine Pool Discharges in Oklahoma

Paul Behum, Office of Surface Mining, Alton, Illinois

Several new passive treatment systems have been constructed in Southeastern Oklahoma to treat artesian acid mine drainage (AMD) discharges from underground coal mines abandoned prior to August 3, 1977. To date, three passive treatment systems have been constructed. This paper will discuss the construction and preliminary results of one of these systems: the LeBosquet Clean Streams Reclamation Projects. As a part of ongoing technical assistance with the Oklahoma Conservation Commission's (OCC) Abandoned Mine Lands Program, the Office of Surface Mining Mid-Continent Region (OSM-MCR), the University of Oklahoma, CC Environmental, and the non-profit group, Watershed Restoration Incorporated, assisted in the design and evaluation of the treatment system. The project sites treat AMD discharges from an artesian seep in LeFlore County, Oklahoma. Preliminary water quality results indicated that the treatment system which is composed of an anoxic limestone drain, an oxidation cell, and a surface flow treatment wetland has been effective at mitigating the adverse impact associated with the AMD.

SESSION 2:

AML Reclamation Activities, Past Present and Future, in the South Fork Patoka River Watershed

Mark Stacy CEP, Environmental Specialist, Indiana AML Program

More than 20,000 acres in Pike County Indiana were surface mined and abandoned between the 1920's and 1970's. At one time, acid mine drainage (AMD) from surface coal mining was responsible for the eradication of fish and other aquatic flora and fauna in a portion of the Patoka River and the entire 17-mile length of the South Fork tributary. The South Fork Patoka River Watershed was considered the most heavily impacted watershed in the State of Indiana. Of the approximately 52,000 acre watershed, between 60 and 75 percent has been impacted or impaired. The environmental degradation from acid mine drainage has been well documented by numerous scientific studies. These studies have documented the loss of fish, aquatic insects and plants due to inflow of water with low pH, heavy metals, suspended sediments and precipitates that coat the stream bottom. Many local elderly people remember the "South Fork" as a river that "ran red" and could never recall ever seeing any fish there. These folks have spent their whole lives just accepting the fact that the South Fork was a dead creek. However, the Indiana Abandoned Mine Lands Program has spent the past twenty five years and nearly $30,000.000.00 in Pike County (more than any other county in the State) with the vast majority of that reclamation taking place in the South Fork Patoka River Watershed. As a result, water quality in the South Fork Patoka River has vastly improved to the point that fish and other aquatic species have returned, and in some areas, are actually flourishing. There are still however, a few stretches of the river that are impacted by AMD and in need of reclamation. This presentation will present the history, current projects, and plans for future reclamation activities by the Indiana Abandoned Mine Lands Program within the South Fork Patoka River Watershed.

AMD Status and Remediation in Alabama

Larry Barwick, Alabama Department of Industrial Relations

Alabama has fourteen (14) major river basins and approximately 77,000 miles of perennial and intermittent streams. Approximately 360 miles of streams or 0.4% of all Alabama streams are impaired by coal mining activities.

Alabama began its efforts to remediate acid mine drainage in 1996 and completed its first project in 1998. Seven AMD project have been completed to date. Five additional projects are either under construction or in the planning stages.

Three of the completed projects are working well. They continue to meet or exceed expectations. The other four completed projects have failed to meet expectations due to inadequate treatment systems, lack of water and underground coal mines.

The AMD treatment systems that have been constructed so far are all passive by design and consist of open limestone drainage ditches, limestone leach beds, limestone filled trenches, gob removal, gob plating, oxygenation ponds, and wetlands.

How AMD is impacting the South Fork River in Illinois

Ron Kiser, Resource Planner, ILDNR, OMM, AMLRD

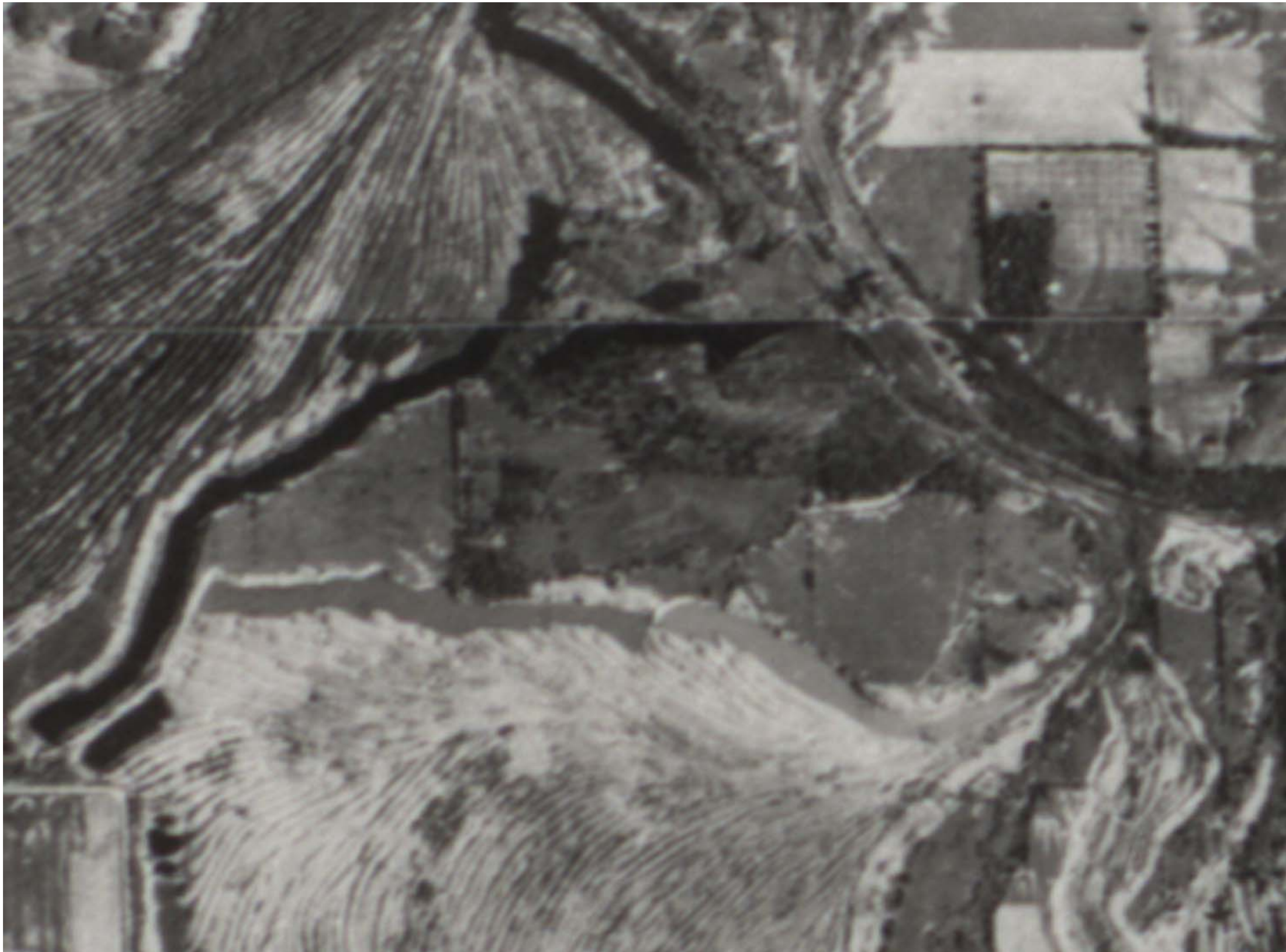
The State of Illinois is divided into 33 major watersheds by the Illinois EPA for the purpose of monitoring and reporting on water issues. The Saline River/Bay Creek watershed is in the far southeastern part of the state; it drains into the Ohio River just north of Cave in Rock. Of the many rivers and streams comprising this watershed the South Fork of the Saline River drains 281 square miles. It is severely impacted by the effects of pre-law coal mining. Approximately 490 pre-law mine sites are tributary to the Saline river system. Of 140 point source discharges into the river, 109 are coal mine related. IEPA reported “about 55 percent (19.7 miles) of the 35.9 South Fork Saline River miles assessed were considered not supporting aquatic life use”. Every major abandoned mine contributing pollution to the South Fork watershed has either been reclaimed or is currently being reclaimed. But AMD, especially non-point AMD continues to dramatically degrade the water quality. This presentation will discuss efforts by the Il AMLRD to reclaim abandoned mine sites using a variety of innovative approaches designed to add alkalinity and neutralize AMD into the subject watersheds, each of which feed the South Fork.

Geomorphology and Hydrogeology of Hartshorne Coal Basin in Oklahoma and the Impact on Remediation of Acid Mine Drainage

Paul Behum, Office of Surface Mining, Alton, Illinois

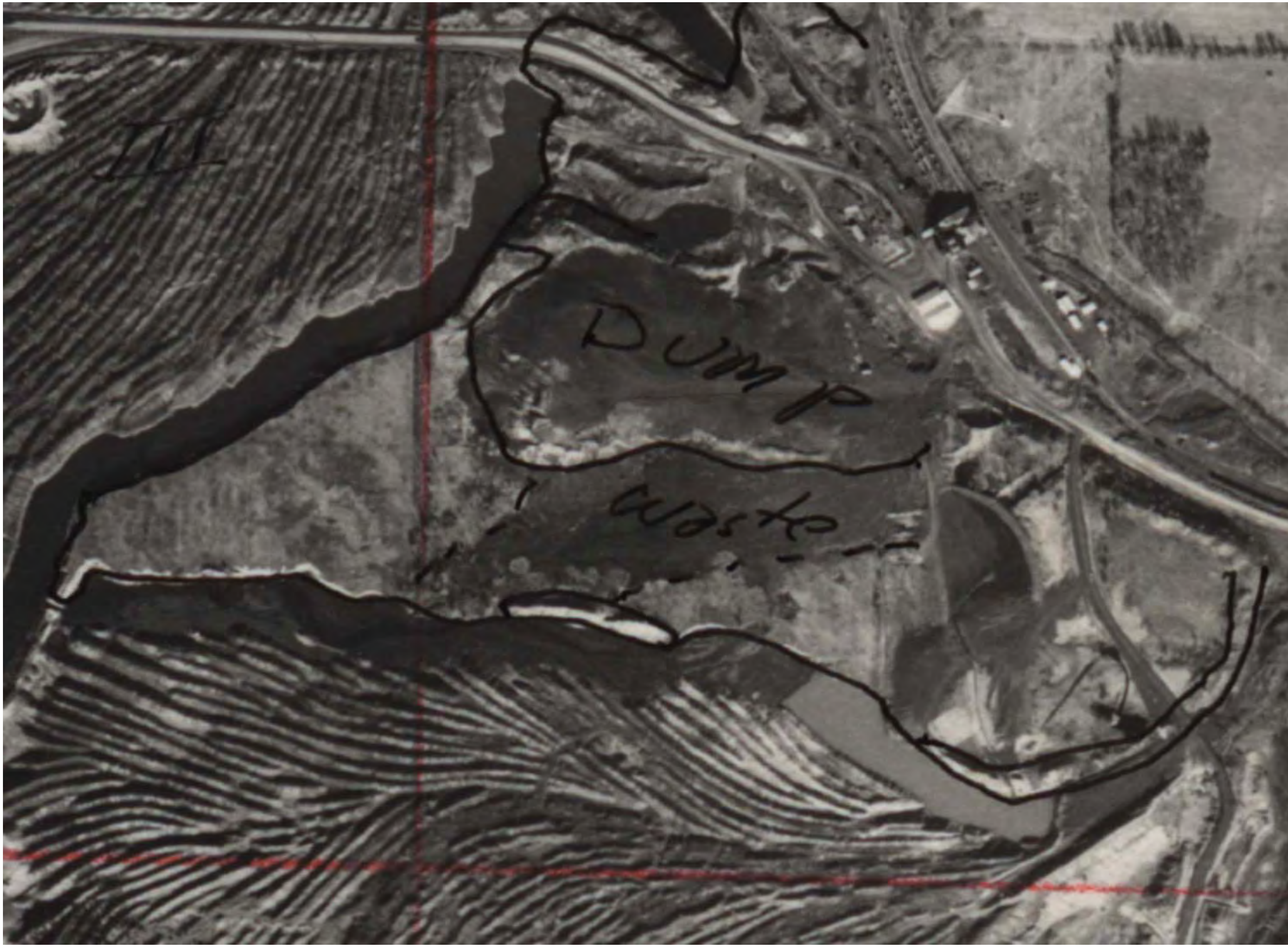
Underground mine features including workings, portals and shafts, as well as geological information were mapped using the TIPS geologic mapping software, *earthVision*. This information, along with hydrologic analysis using TIPS software will evaluate the long-term impacts of mine pool discharges in the Hartshorne Basin. The figure shows the extent of underground mining related to several Oklahoma mine pool discharges in Latimer and Pittsburg Counties, Oklahoma. Two sites within the basin currently treat Acid Mine Drainage (AMD) discharges from artesian seeps. Additional treatment facilities are planned using TIPS-supplied LIDAR (*Light Detection and Ranging*) topographic data. The use of LIDAR technology is necessary because most mine pool discharges occur near in the center of the basin in an area of the low topographic relief (and forest cover). As a consequence, there is limited hydrologic head available to maintain flow through the cascading passive treatment cells necessary to remediate the AMD. Also, the readily available digital topographic data is too coarse (20-foot contour interval) for use in treatment design. LIDAR data used to generate 2-foot contour intervals on the northern limb of the basin floor (Gowen 40, Jeffrey's Field and GCI Discharges) this will provide data for design activity for the treatment of two of these discharges from one large mine pool using *earthVision* and TIPS computer-aided design CAD software. A second pool exists along the southern limb where there are three additional discharges (the McHugh Borehole, Rock Island Mine 7 Airshaft and Paul Madden Discharges). Visualization of proposed treatment systems using color-keyed perspective views developed with *earthVision* will be used to aid decision-makers, landowners and the public

Carbon Recovery versus Prevention and Passive Treatment for the Elimination of AMD at an AML Eligible Slurry Impoundment; a Case Study of the Chinook Slurry Pond



1939

1946

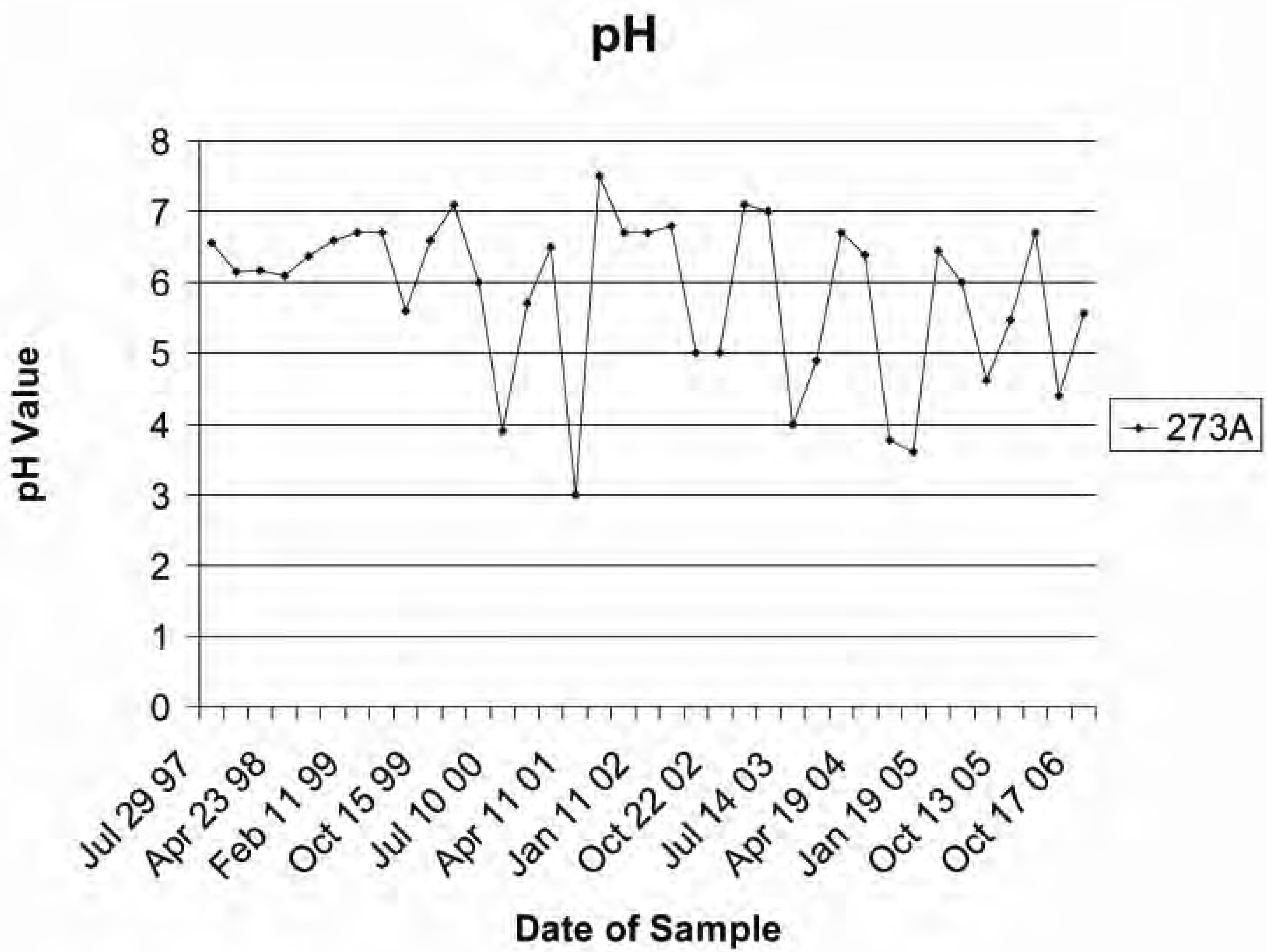


1946

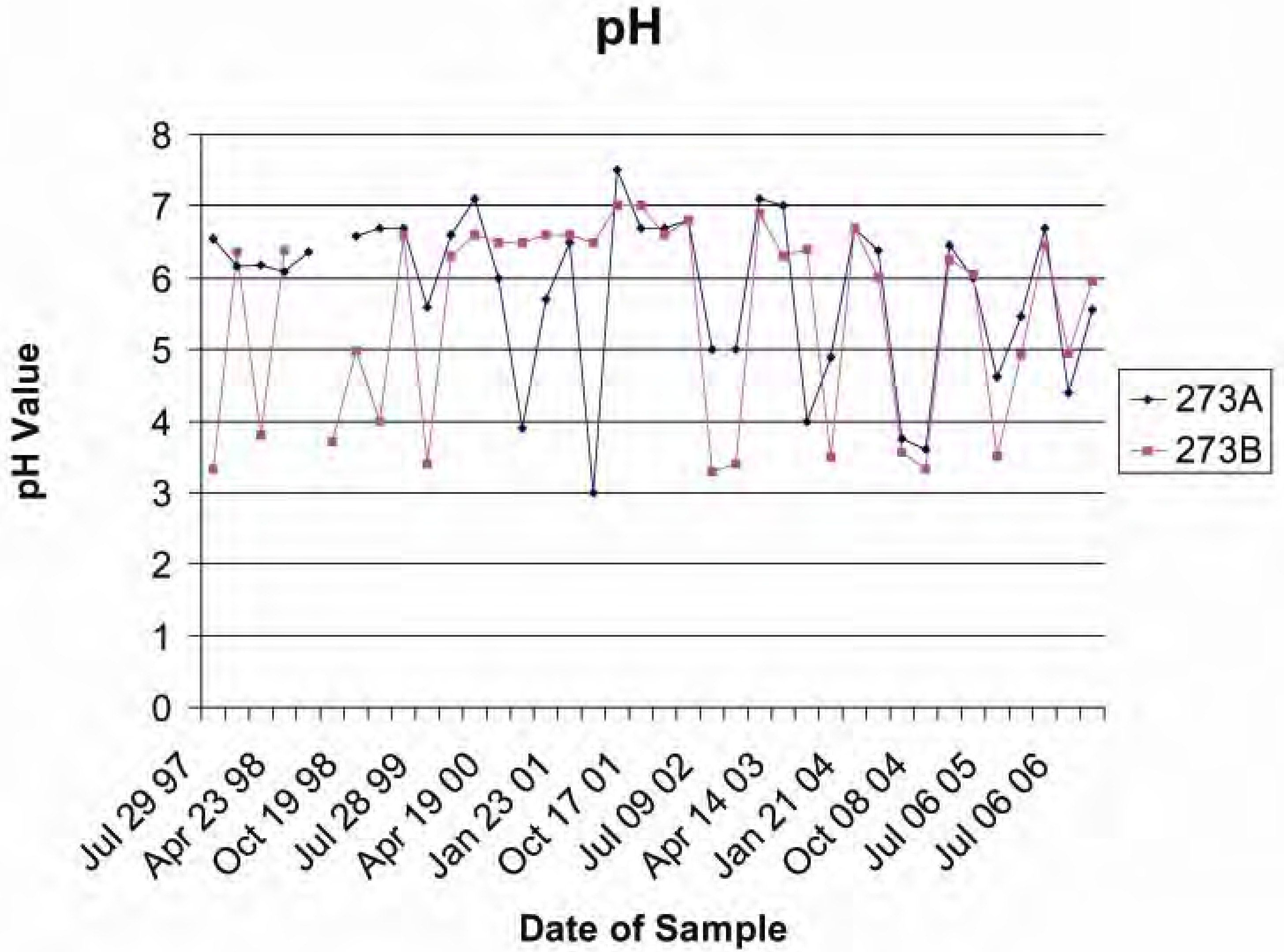
1954

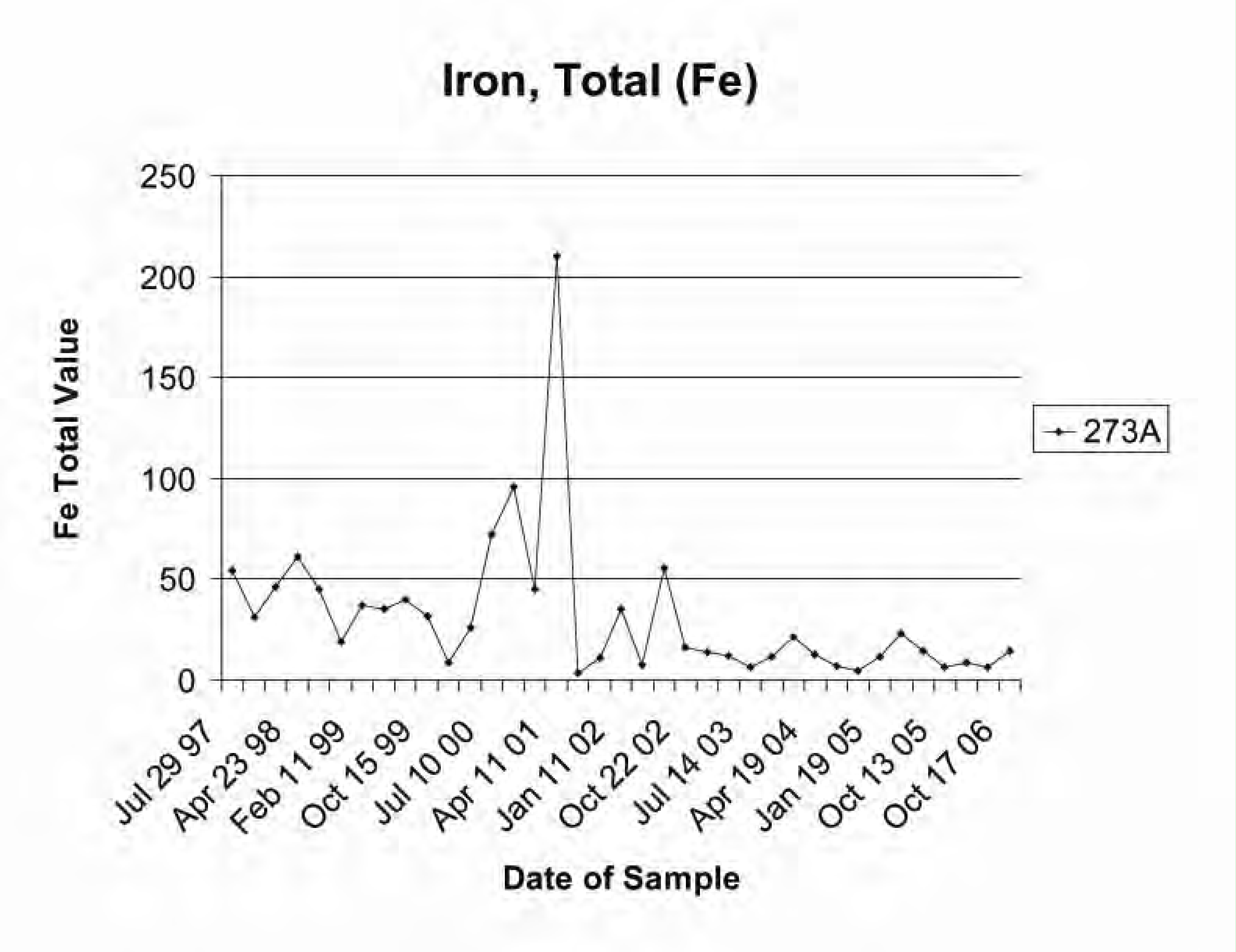
_1996_

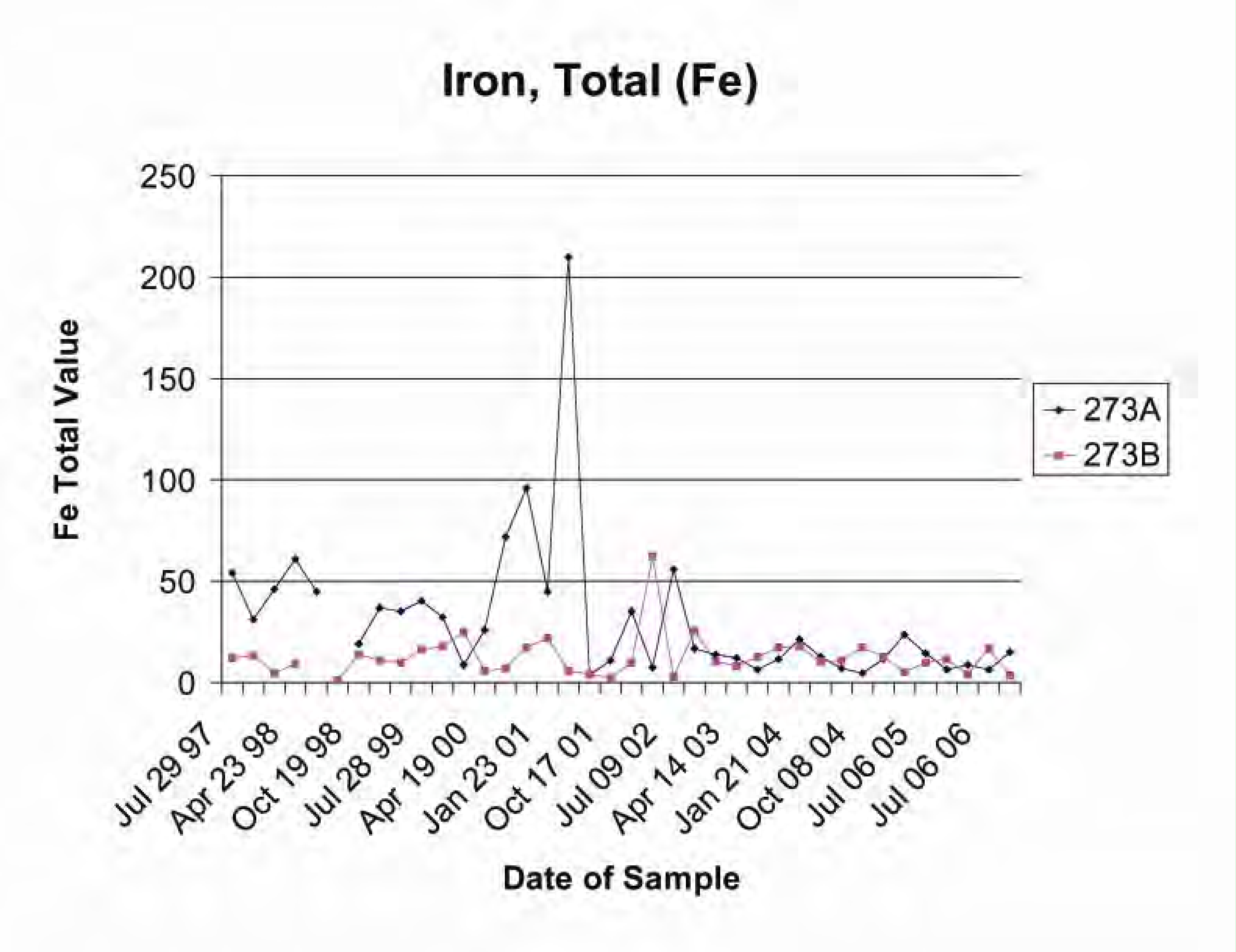
Surface Water Sampling Locations



pH
8
7
6
5
4
3
2
1
0
pH Value
273A
Jul 29 97
Apr 23 98
Feb 11 99
Oct 15 99
Jul 10 00
Apr 11 01
Jan 11 02
Oct 22 02
Jul 14 03
Apr 19 04
Jan 19 05
Oct 13 05
Oct 17 06
Date of Sample

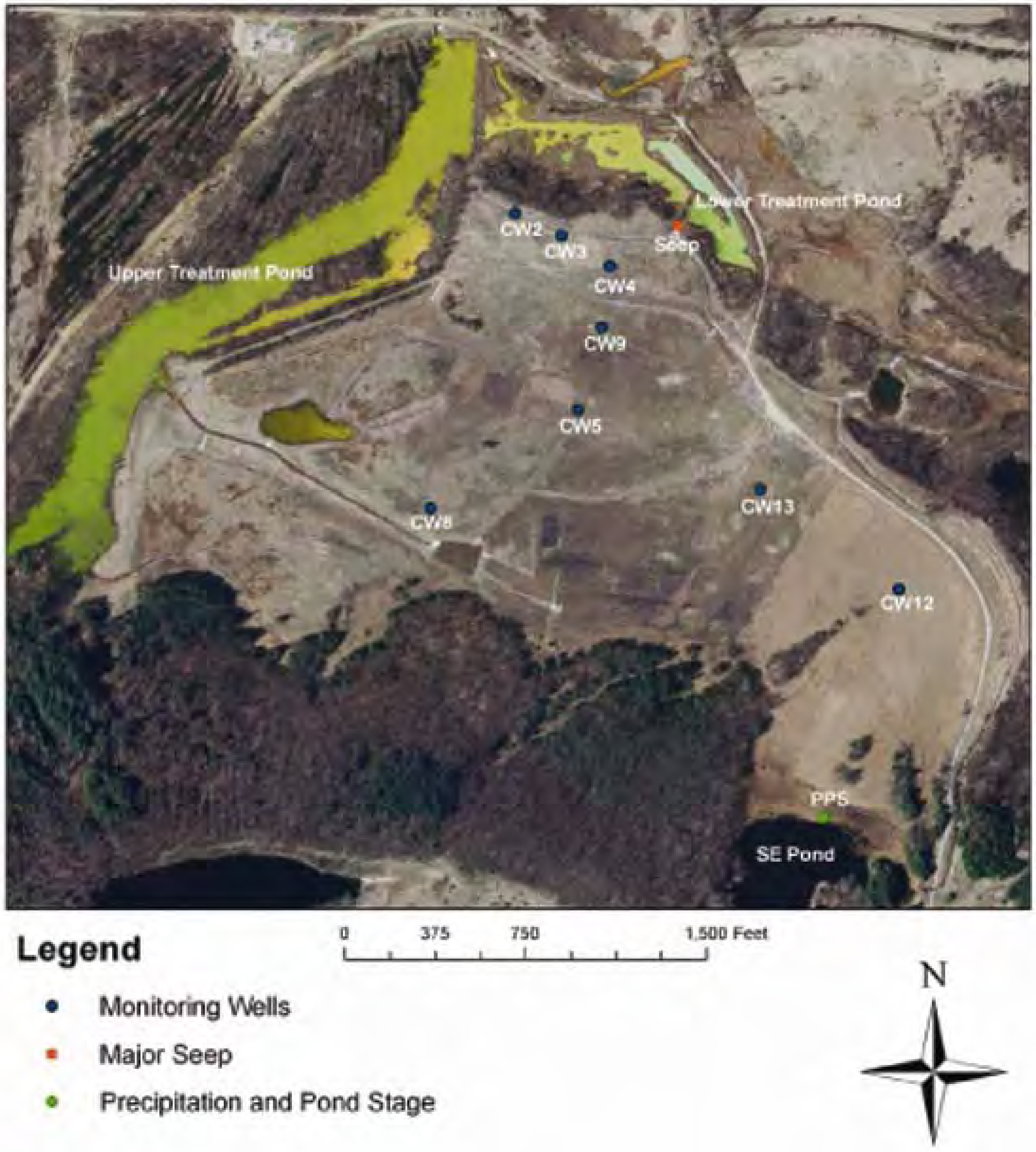

pH
pH Value
8
7
6
5
4
3
2
1
0
Jul 29 97
Apr 23 98
Oct 19 98
Jul 28 99
Apr 19 00
Jan 23 01
Oct 17 01
Jul 09 02
Apr 14 03
Jan 21 04
Oct 08 04
Jul 06 05
Jul 06 06
Date of Sample
273A
273B


Iron, Total (Fe)
Fe Total Value
250
200
150
100
50
0
273A
Jul 29 97
Apr 23 98
Feb 11 99
Oct 15 99
Jul 10 00
Apr 11 01
Jan 11 02
Oct 22 02
Jul 14 03
Apr 19 04
Jan 19 05
Oct 13 05
Oct 17 06
Date of Sample



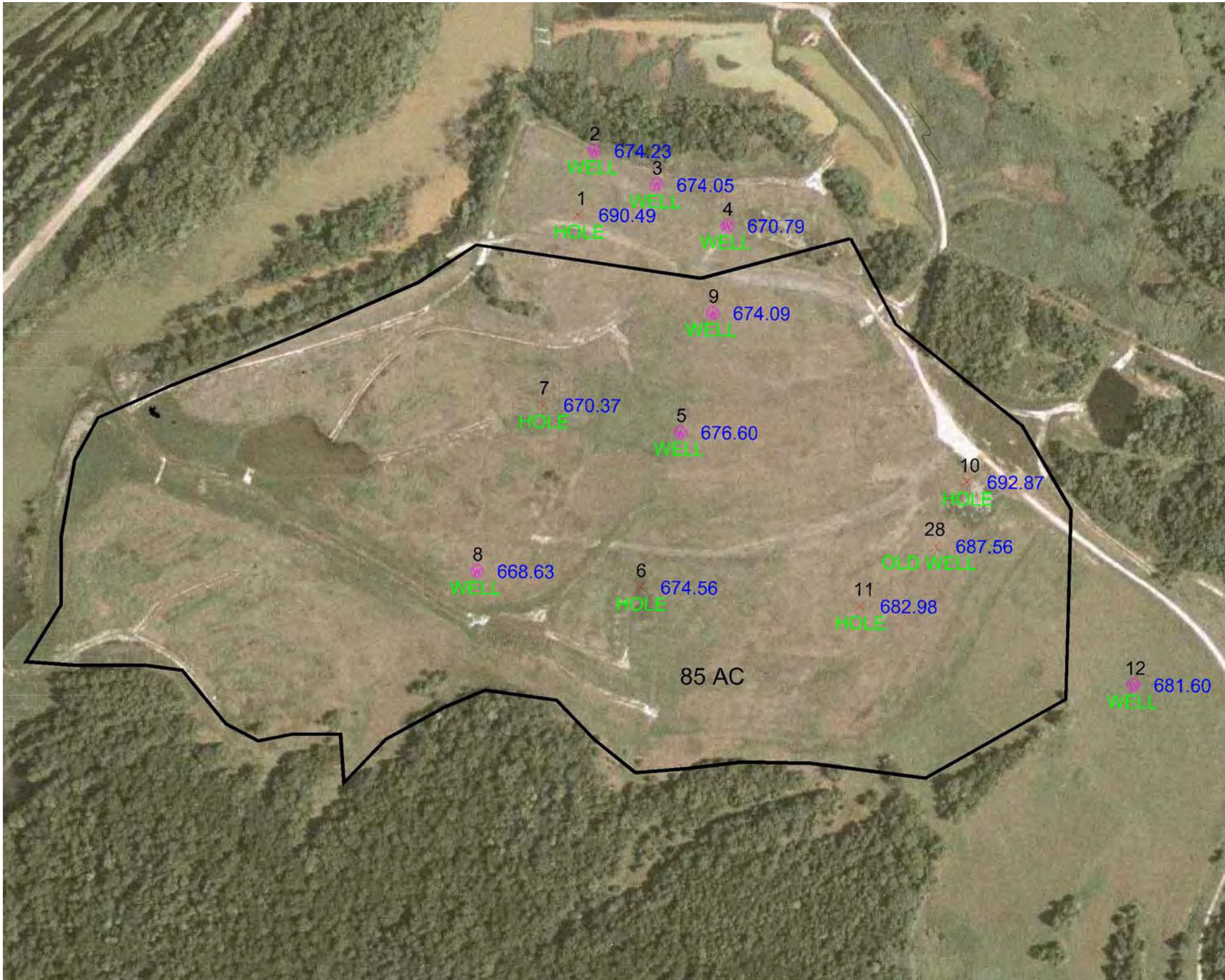
Iron, Total (Fe)
Fe Total Value
250
200
150
100
50
0
273A
273B
Jul 29 97
Apr 23 98
Oct 19 98
Jul 28 99
Apr 19 00
Jan 23 01
Oct 17 01
Jul 09 02
Apr 14 03
Jan 21 04
Oct 08 04
Jul 06 05
Jul 06 06
Date of Sample

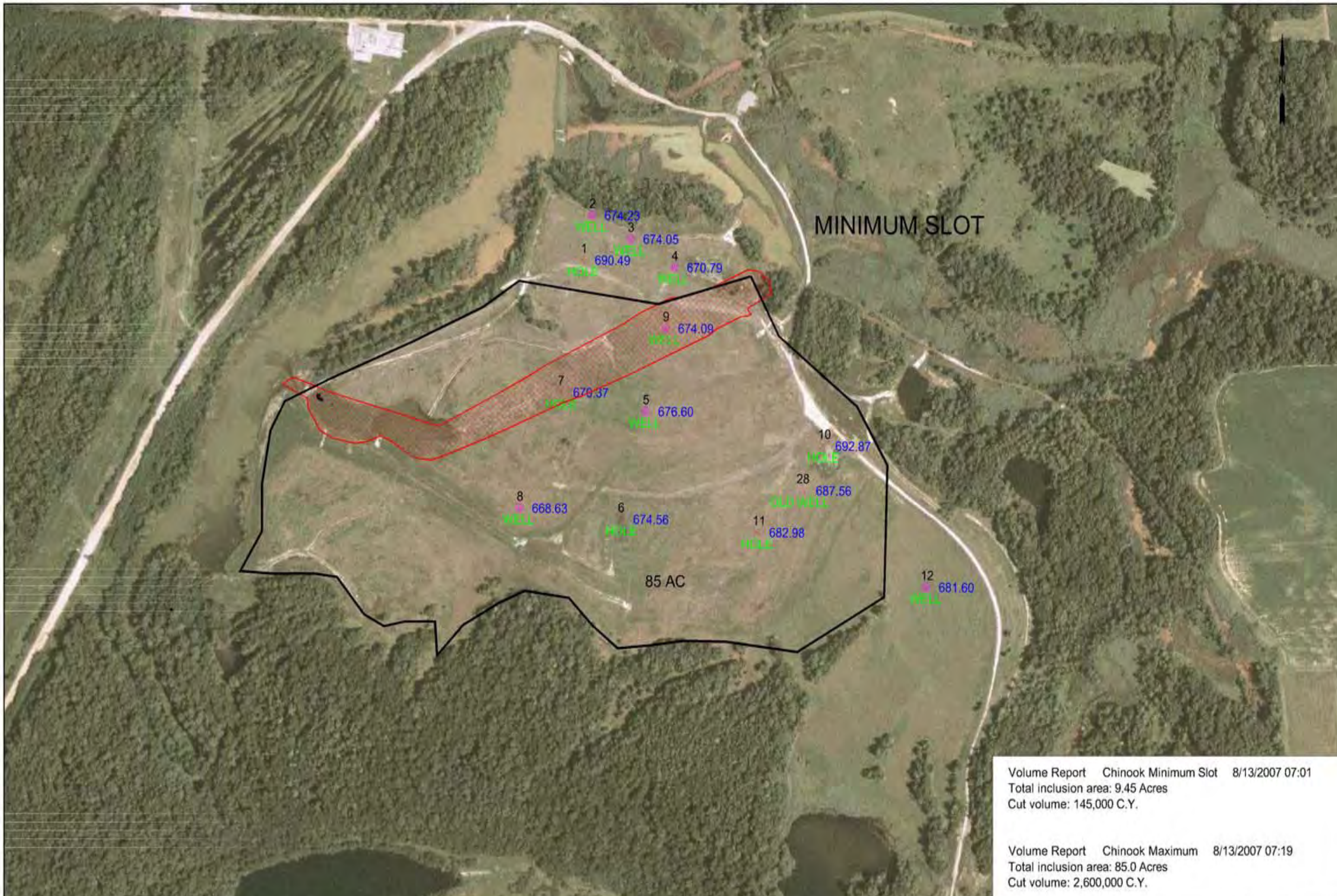
Chinook Hydrologic Monitoring Stations



Elevations and Well Specifications

Site	Material	Elevation (feet)	Total Depth	Stick Up
CW2 Gob		677.2	47.0	3.0
CW3 Gob		677.3	40.3	3.2
CW4 Gob		674.0	31.9	3.2
CW5 Tailing	s	679.8	35.9	3.1
CW8 Tailing	s	671.2	21.4	2.7
CW9 Tailing	s	677.3	48.4	3.1
CW12 Tailing	s	684.5	52.6	3.3
CW13 Tailing	s	688.3	32.5	0.5
SE Pond		676.8		
UT Pond		656.0		
LT Pond		643.8		
M Seep		654.1		


2
674.23
WELL
3
674.05
WELL
1
690.49
HOLE
4
670.79
WELL
9
674.09
WELL
7
670.37
HOLE
5
676.60
WELL
10
692.87
HOLE
28
687.56
OLD WELL
8
668.63
WELL
6
674.56
HOLE
11
682.98
HOLE
85 AC
12
681.60
WELL



SITE	PROJECT	DATE MADE	DESIGNED BY	SCALE	STATE OF INDIANA	TITLE	SHEET NO.
405	E008???	5/30/07	DRH	1"-400'	DEPARTMENT OF NATURAL RESOURCES	CHINOOK DATA	1
		DATE REVISED	DRAWN BY DRH		DIVISION OF RECLAMATION		


The Beer Store

Cane Creek AMD Remediation Phase IV

Alabama Department of Industrial Relations

Mining and Reclamation Division

Partners

- U.S. Geological Survey
- National Mine Land Reclamation Center
- National Resources and Conservation Service
- Auburn University
- Office of Surface Mining
- Oakman High School

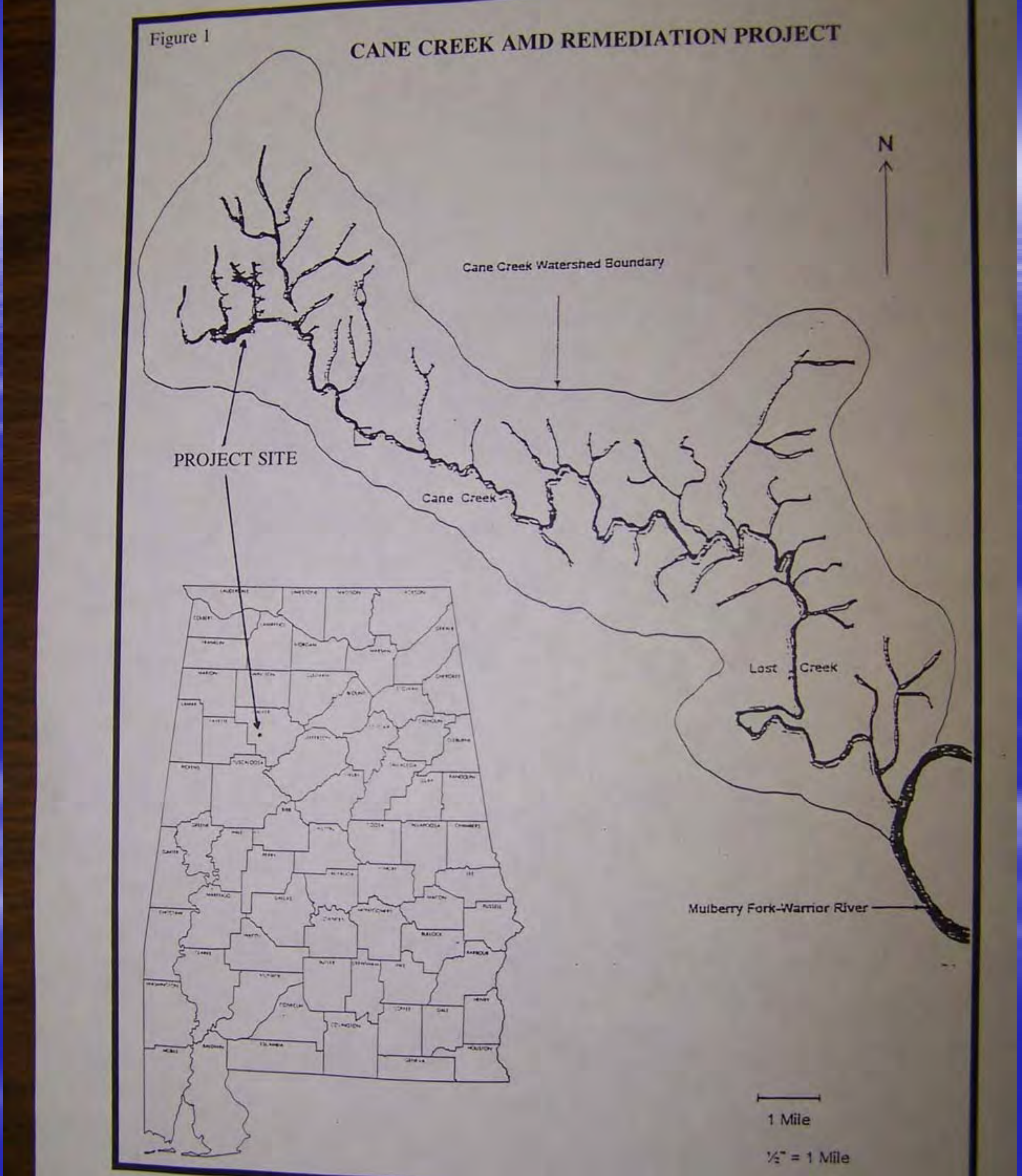
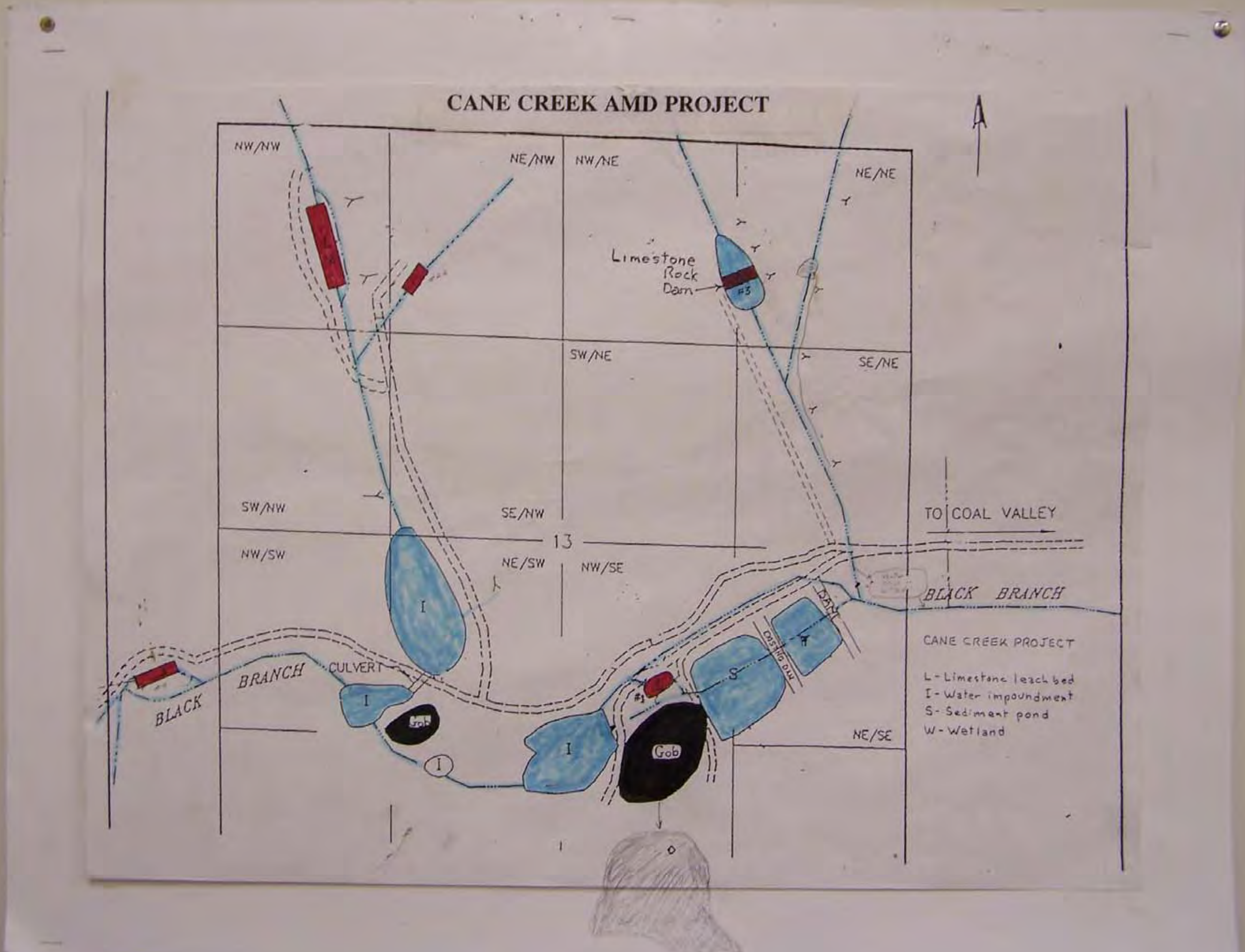
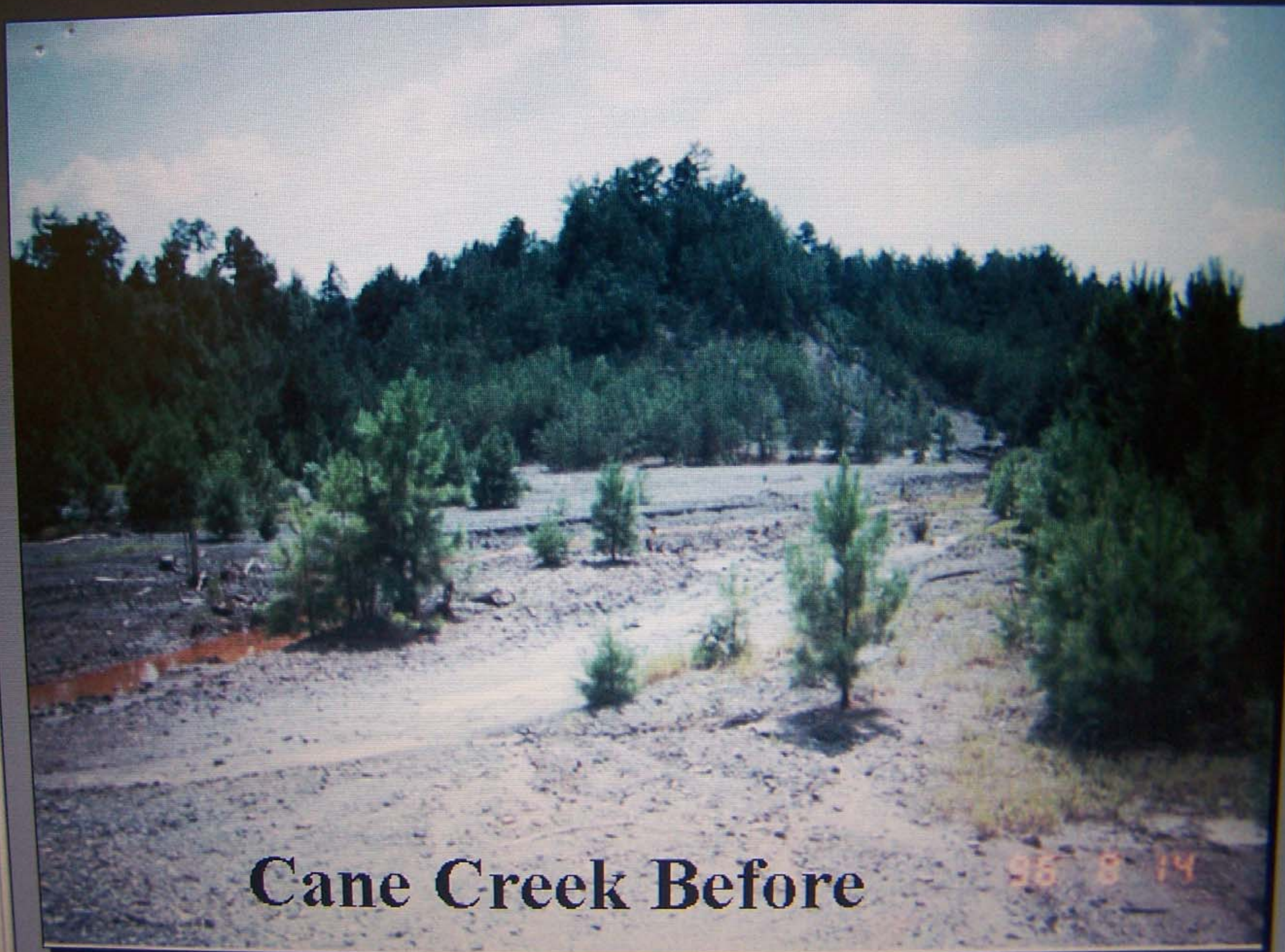


Figure 1
CANE CREEK AMD REMEDIATION PROJECT
N
Cane Creek Watershed Boundary
PROJECT SITE
Cane Creek
Lost Creek
Mulberry Fork-Warrior River
1 Mile
½" = 1 Mile


CANE CREEK AMD PROJECT
NW/NW
NE/NW
NW/NE
NE/NE
Limestone Rock Dam
#3
SW/NE
SE/NE
SW/NW
SE/NW
13
NW/SW
NE/SW
NW/SE
TO COAL VALLEY
BLACK BRANCH
CULVERT
BRANCH
BLACK
I
S
Gob
#1
DAM
NE/SE
CANE CREEK PROJECT
L - Limestone leach bed
I - Water impoundment
S - Sediment pond
W - Wetland


Cane Creek Before


CAT
311

Table 1 – Black Branch Water Quality Data

Parameter	Pre-Construction 6/96 – 7-97	During Construction 7/97 – 4/98	Post-Construction 2006
pH	3.37	3.65	3.59
Acidity mg/l	-	-	65.83
Alkalinity mg/l	0.29	19.0	0.01
Conductivity	556	834	538
Fe (total)	0.76	0.80	0.28
Mn	3.75	2.90	1.59
Al	7.30	6.97	2.37
Fe (ferrous)	-	-	<0.60

Table 2 – Black Branch Water Quality Data

May, June & July 2006

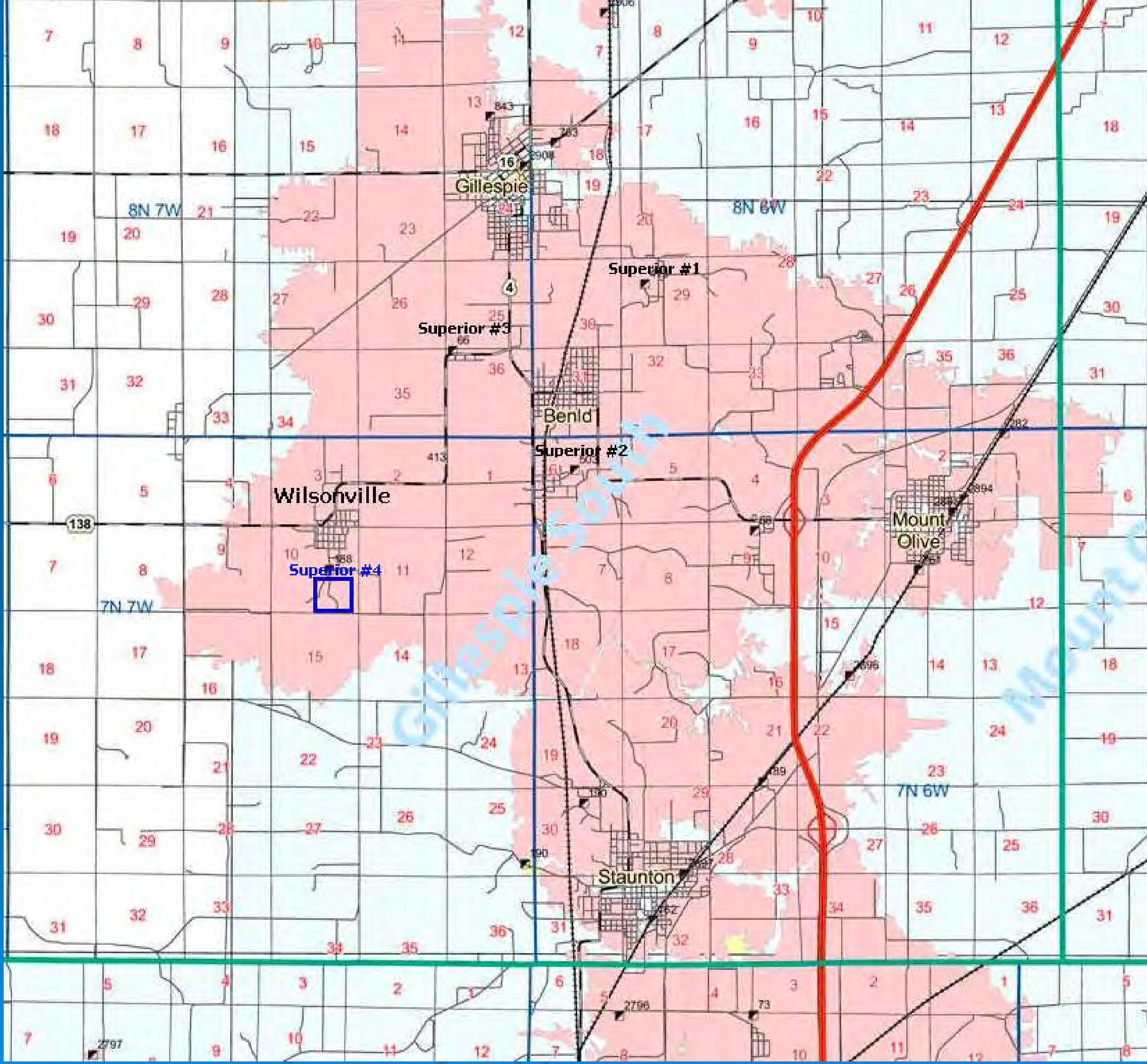
Parameter	Gob Pile	Red Branch	Bridge
pH	3.71	3.32	3.59
Acidity mg/l	362.33	99.20	65.83
Alkalinity mg/l	<0.01	<0.01	<0.01
Conductivity	1216	642	538
Fe (total)	41.81	1.74	0.28
Mn	2.59	2.93	1.59
Al	8.82	2.98	2.37
Fe (ferrous)	19.9	1.65	<0.60

AMD REMEDIATION
AT THE
SUPERIOR C.C. #4
MINE

Lawrence L. Lewis, P.E.
Supervisor of Engineering Design and Tech Support
AMLR Div. of Office of Mines & Minerals
Illinois Department of Natural Resources


JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
MC HENRY
LAKE
CARROLL
OGLE
DE KALB
KANE
DU PAGE
COOK
WHITESIDE
LEE
KENDALL
NORTHERN REGION
BUREAU
LA SALLE
WILL
ROCK ISLAND
HENRY
GRUNDY
MERCER
PUTNAM
KANKAKEE
STARK
MARSHALL
HENDERSON
WARREN
KNOX
LIVINGSTON
PEORIA
WOODFORD
IROQUOIS
TAZEWELL
FULTON
MC DONOUGH
MC LEAN
FORD
HANCOCK
MASON
SCHUYLER
DE WITT
LOGAN
CHAMPAIGN
VERMILION
ADAMS
BROWN
CASS
MENARD
PIATT
MACON
CENTRAL REGION
MORGAN
SANGAMON
DOUGLAS
PIKE
SCOTT
MOULTRIE
EDGAR
CHRISTIAN
COLES
GREENE
SHELBY
CLARK
MONTGOMERY
CUMBERLAND
MACOUPIN
CALHOUN
JERSEY
EFFINGHAM
FAYETTE
JASPER
CRAWFORD
BOND
MADISON
CLAY
RICHLAND
LAWRENCE
Wilsonville
MARION
CLINTON
ST. CLAIR
WAYNE
EDWARDS
WABASH
WASHINGTON
JEFFERSON
MONROE
SOUTHERN REGION
RANDOLPH
PERRY
HAMILTON
WHITE
FRANKLIN
JACKSON
WILLIAMSON
SALINE
GALLATIN
UNION
JOHNSON
POPE
HARDIN
ALEXANDER
PULASKI
MASSAC

Underground Coal Mine operated from 1918 -1954

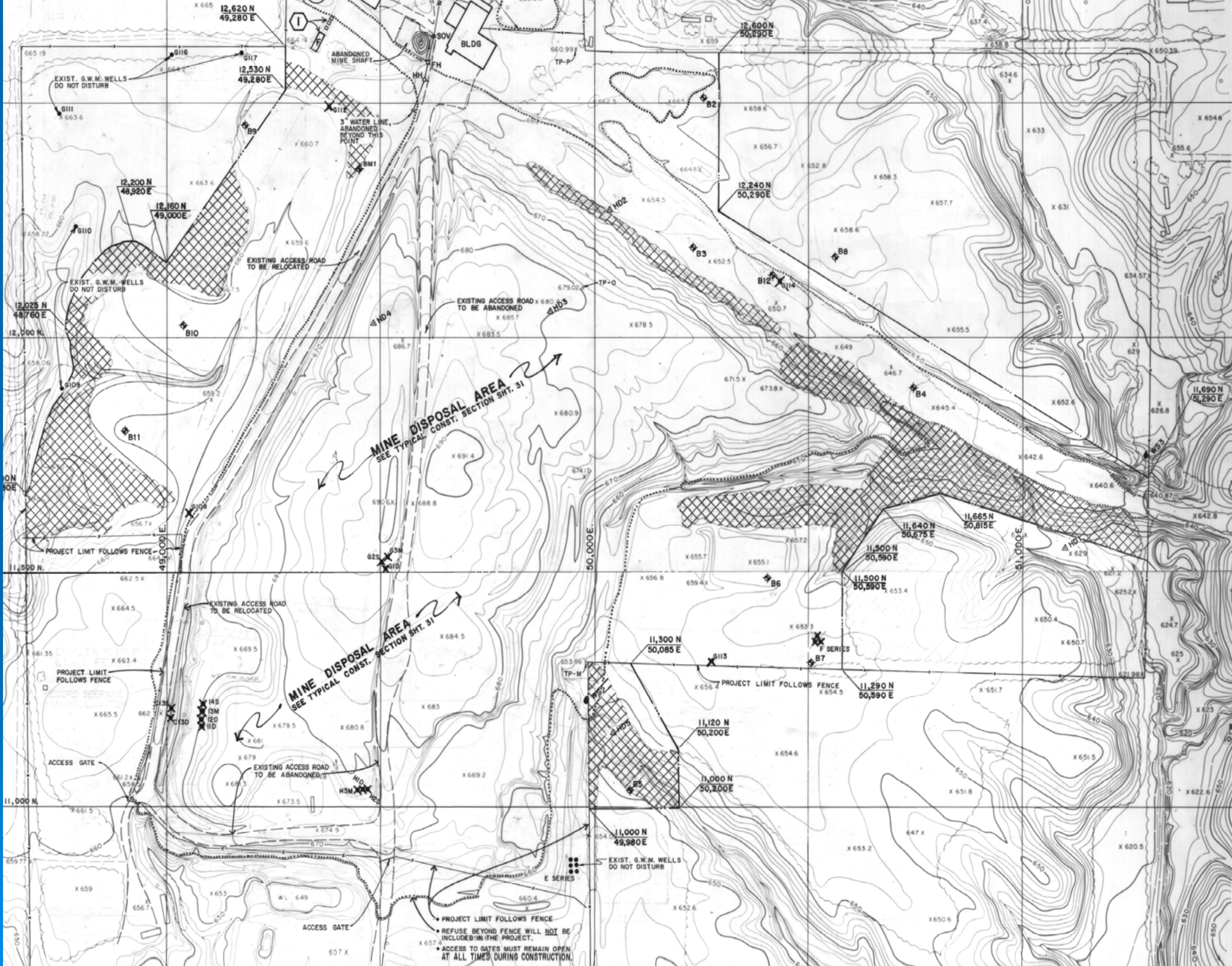


AML PROBLEMS LEFT:

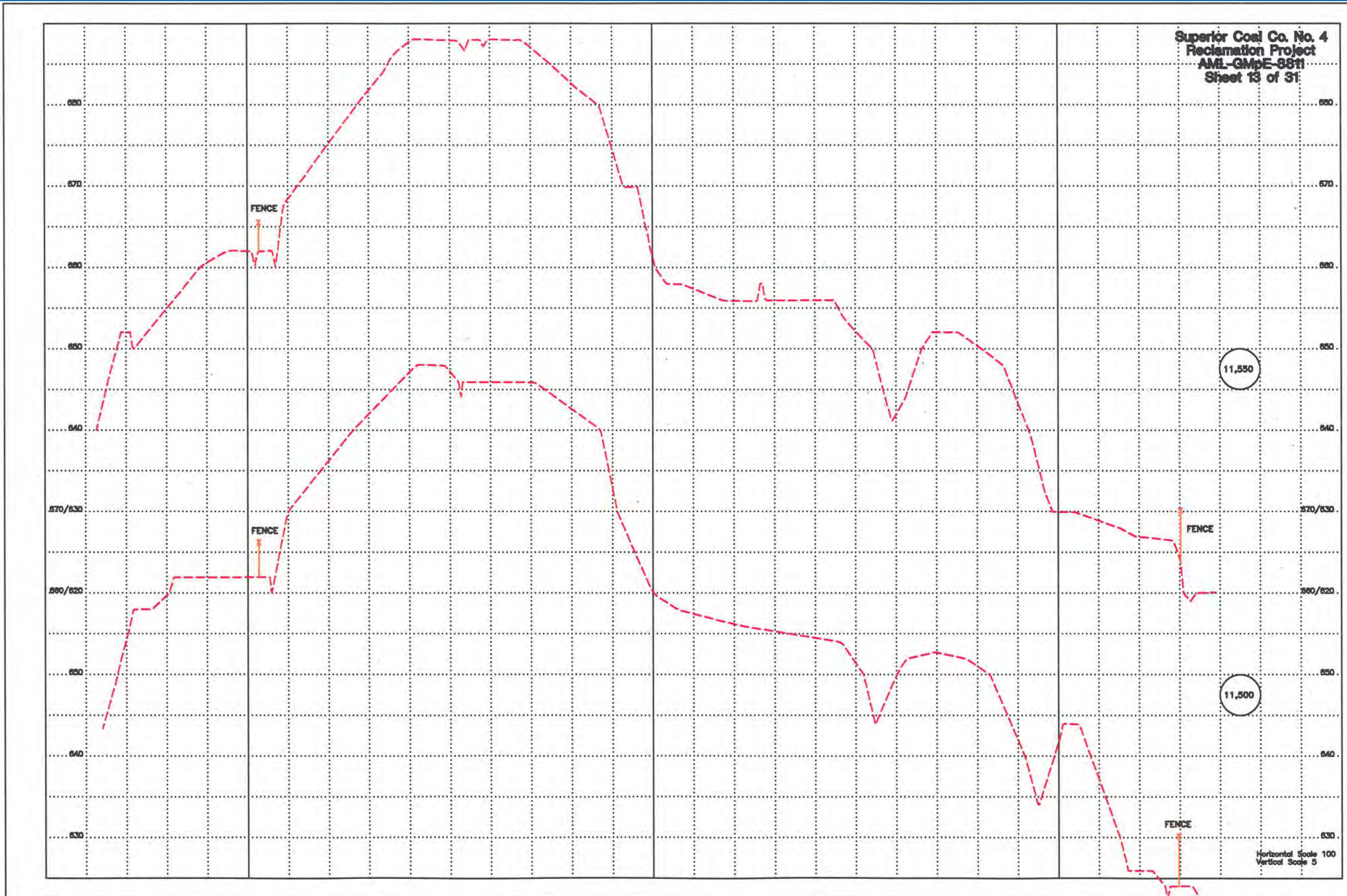
2 OPEN MINE SHAFTS

40 Acres of barren mine refuse

Streams severely impacted by AMD



12,620 N 49,280 E
ABANDONED MINE SHAFT
BLDG
12,600 N 50,290 E
EXIST. G.W.M. WELLS DO NOT DISTURB
12,530 N 49,280 E
3" WATER LINE, ABANDONED BEYOND THIS POINT
12,200 N 48,920 E
12,160 N 49,000 E
12,240 N 50,290 E
EXISTING ACCESS ROAD TO BE RELOCATED
EXIST. G.W.M. WELLS DO NOT DISTURB
12,025 N 48,760 E
12,000 N.
EXISTING ACCESS ROAD TO BE ABANDONED
MINE DISPOSAL AREA
SEE TYPICAL CONST. SECTION SHT. 31
11,690 N 51,290 E
11,640 N 50,675 E
11,665 N 50,815 E
11,500 N 50,590 E
11,500 N 50,590 E
PROJECT LIMIT FOLLOWS FENCE
49,000 E.
50,000 E.
51,000 E.
11,500 N.
EXISTING ACCESS ROAD TO BE RELOCATED
MINE DISPOSAL AREA
SEE TYPICAL CONST. SECTION SHT. 31
11,300 N 50,085 E
F SERIES
PROJECT LIMIT FOLLOWS FENCE
11,290 N 50,590 E
PROJECT LIMIT FOLLOWS FENCE
11,120 N 50,200 E
ACCESS GATE
EXISTING ACCESS ROAD TO BE ABANDONED
11,000 N 50,200 E
11,000 N.
11,000 N 49,980 E
EXIST. G.W.M. WELLS DO NOT DISTURB
E SERIES
ACCESS GATE
PROJECT LIMIT FOLLOWS FENCE
REFUSE BEYOND FENCE WILL NOT BE INCLUDED IN THE PROJECT.
ACCESS TO GATES MUST REMAIN OPEN AT ALL TIMES DURING CONSTRUCTION.

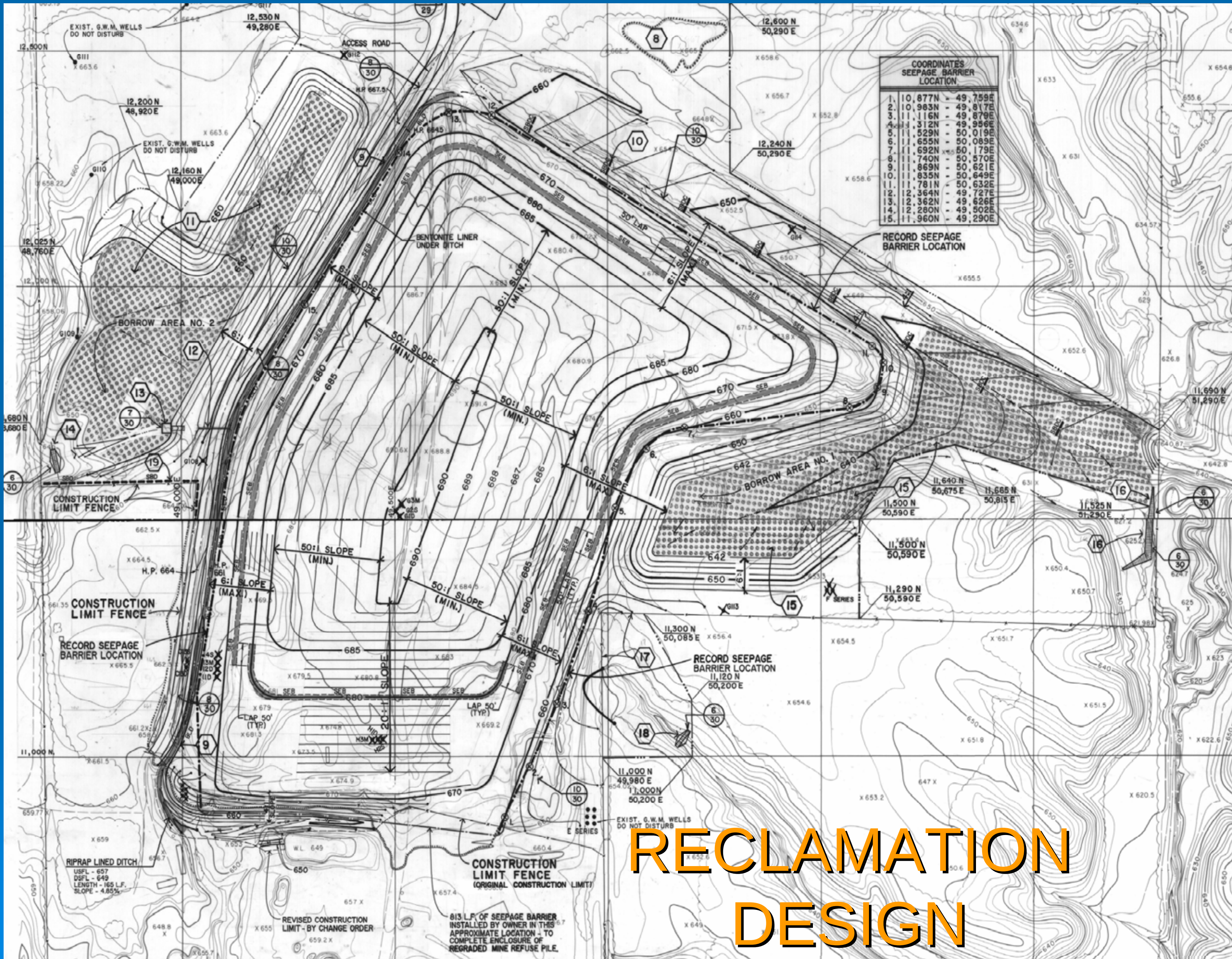


Superior Coal Co. No. 4
Reclamation Project
AML-GMpE-8811
Sheet 13 of 31
680
670
FENCE
660
650
11,550
640
670/630
FENCE
660/620
650
11,500
640
630
FENCE
Horizontal Scale 100
Vertical Scale 5

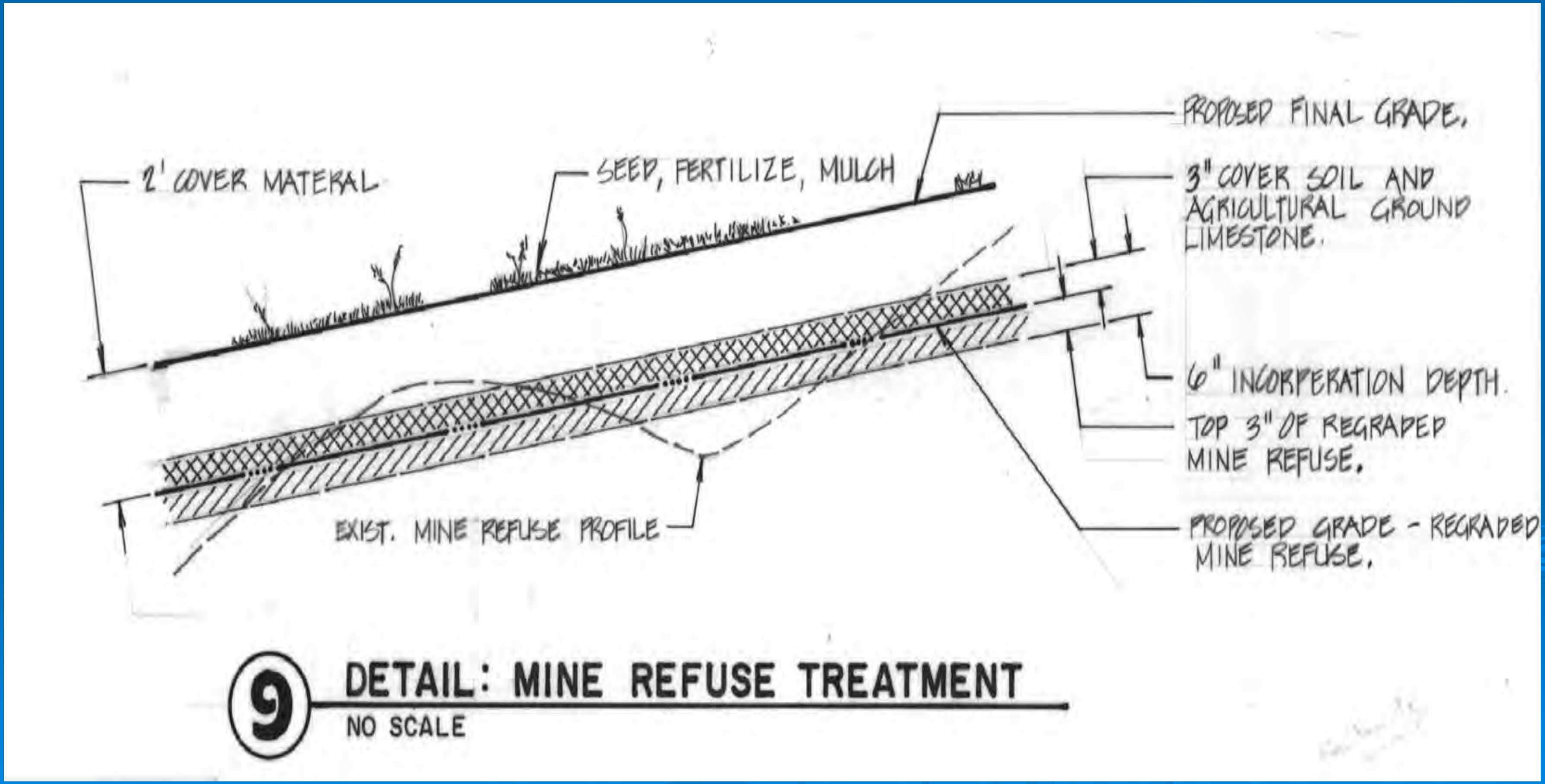
Quality of AMD leaving the site

Acidity (mg/l)	6,000
ph	3.0
Sulfate (mg/l)	6,600
Chloride (mg/l)	90
Iron (mg/l)	680
Manganese (mg/l)	22
Aluminum (mg/l)	80

RECLAMATION DESIGN



Mine Refuse Treatment with agricultural ground limestone



Agricultural ground limestone being applied at 50 Tons/Acre

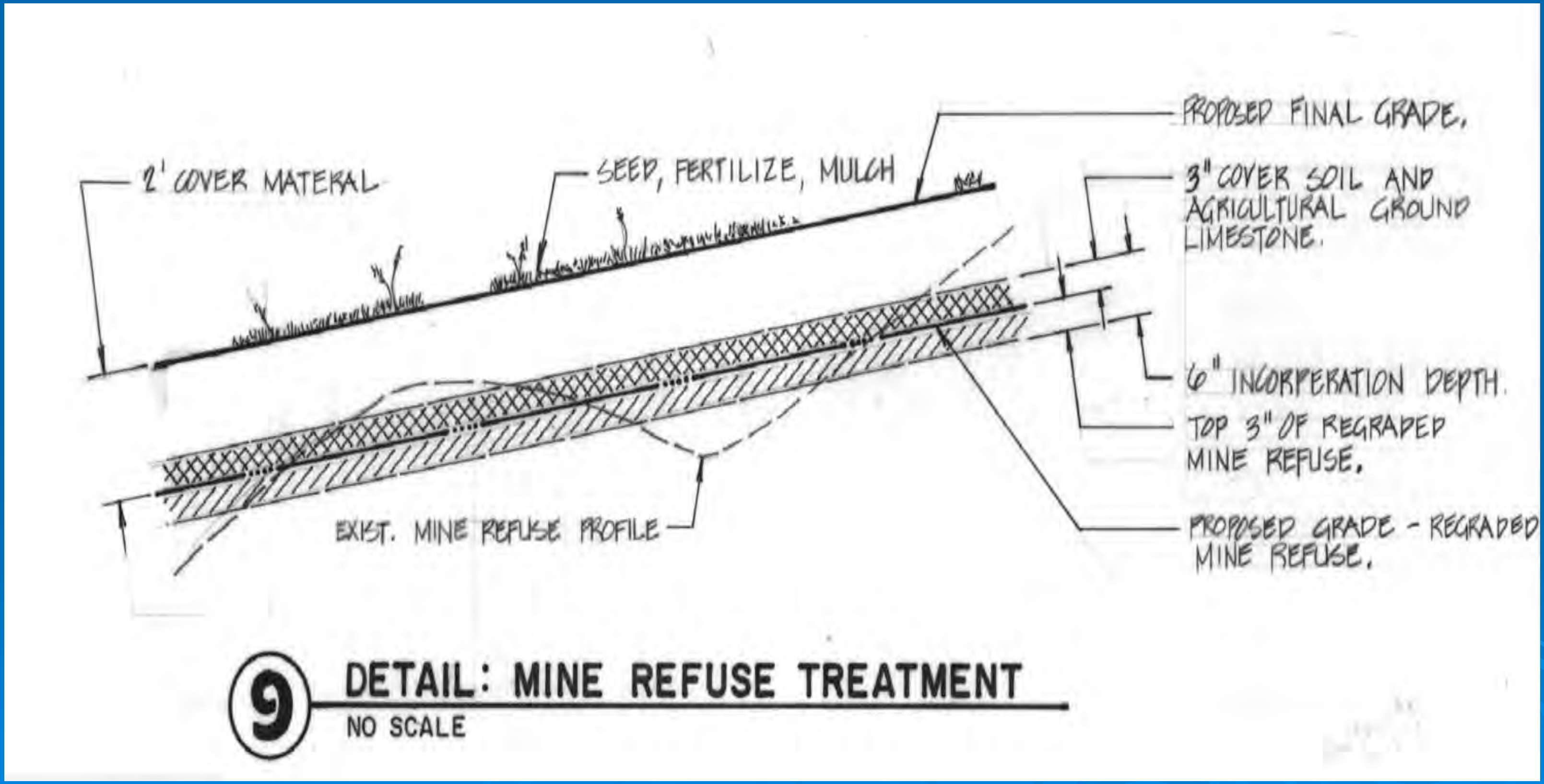
Section 207 Mine Site Compaction

Section 207 Mine Site Compaction

To use tamping-type roller (sheep's foot) & Agricultural disc

Section 207 Mine Site Compaction

Applied to mine refuse sub-grade & soil cover (except top 12”) over entire mine refuse area



Section 207 Mine Site Compaction

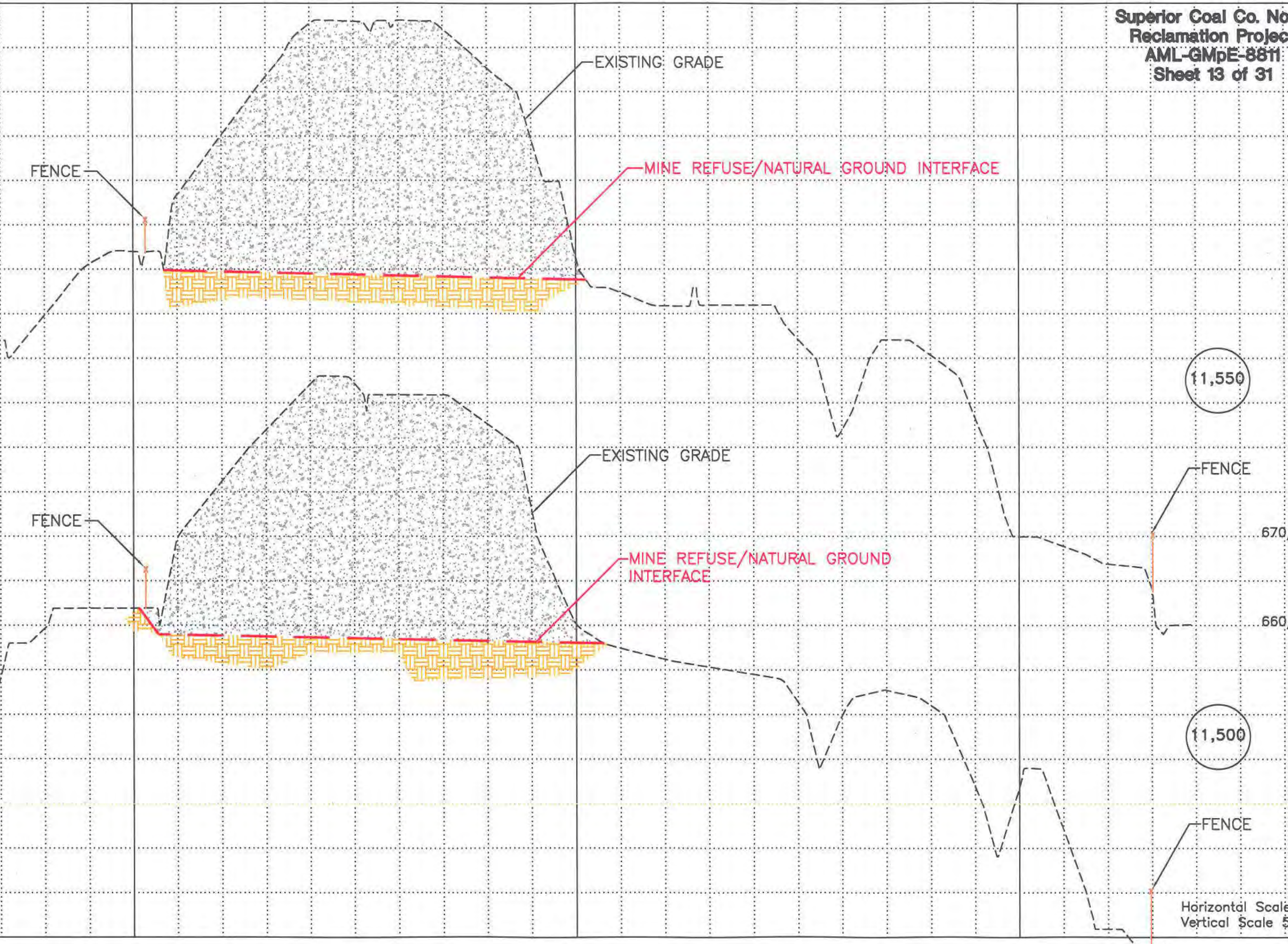
8 " maximum per layer

one pass over soil per inch of thickness

If soil is wet more discing is required

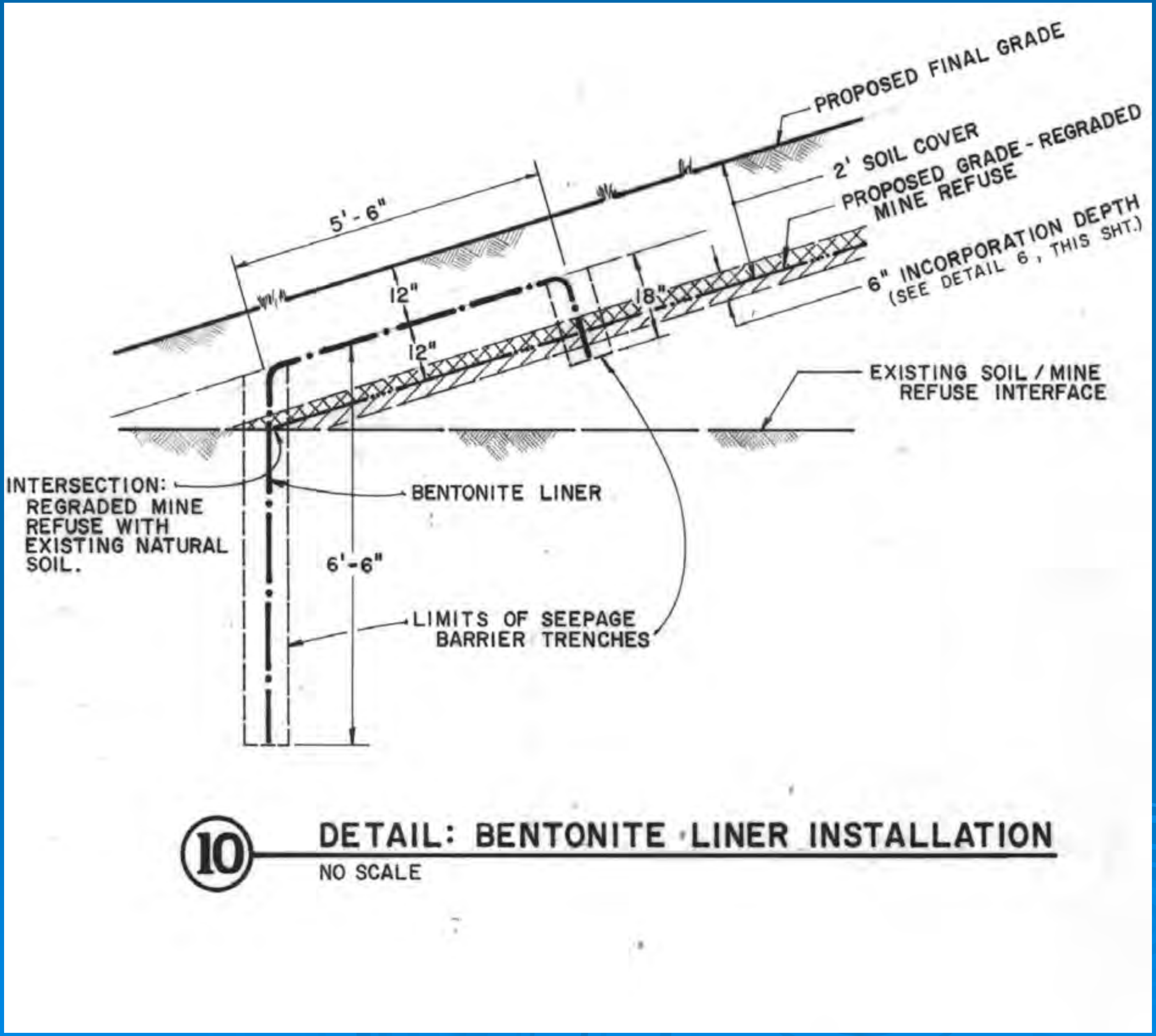
Section 207 Mine Site Compaction

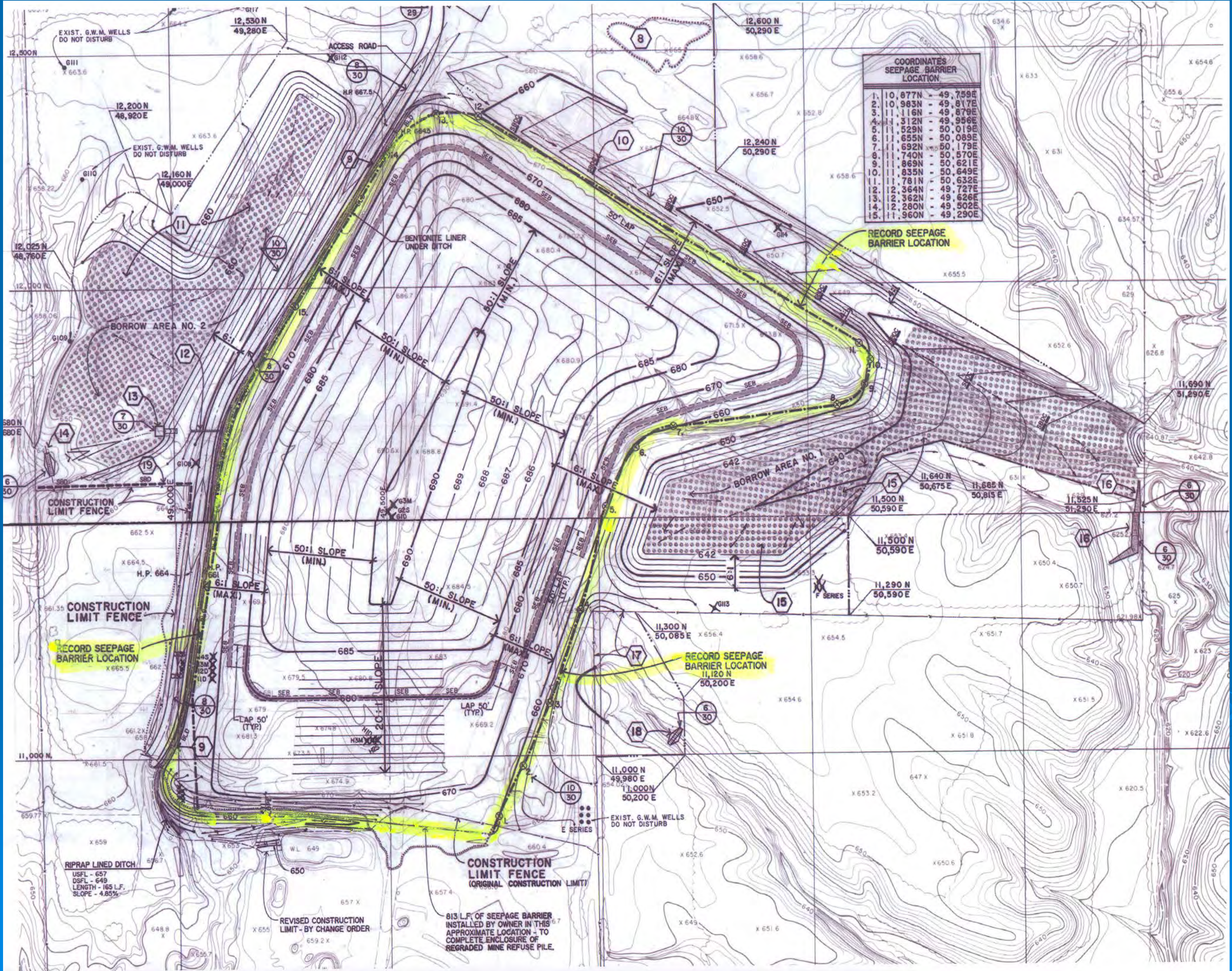
Layer will be considered compacted when tamping feet of roller penetrates no more than 3” into 8” lift or 1/3 of the depth of layer being placed



Superior Coal Co. No
Reclamation Projec
AML-GMpE-8811
Sheet 13 of 31
EXISTING GRADE
FENCE
MINE REFUSE/NATURAL GROUND INTERFACE
11,550
EXISTING GRADE
FENCE
FENCE
670
MINE REFUSE/NATURAL GROUND INTERFACE
660
11,500
FENCE
Horizontal Scale
Vertical Scale

Seepage Barrier Detail




EXIST. G.W.M. WELLS DO NOT DISTURB
12,530 N 49,280 E
ACCESS ROAD
12,600 N 50,290 E
COORDINATES SEEPAGE BARRIER LOCATION
1. 10,877N - 49,759E
2. 10,983N - 49,817E
3. 11,116N - 49,879E
4. 11,312N - 49,956E
5. 11,529N - 50,019E
6. 11,655N - 50,089E
7. 11,692N - 50,179E
8. 11,740N - 50,570E
9. 11,869N - 50,621E
10. 11,835N - 50,649E
11. 11,781N - 50,632E
12. 12,364N - 49,727E
13. 12,362N - 49,626E
14. 12,280N - 49,502E
15. 11,960N - 49,290E
12,200 N 48,920 E
EXIST. G.W.M. WELLS DO NOT DISTURB
12,160 N 49,000 E
12,240 N 50,290 E
RECORD SEEPAGE BARRIER LOCATION
BENTONITE LINER UNDER DITCH
12,025 N 48,760 E
BORROW AREA NO. 2
50:1 SLOPE (MIN.)
6:1 SLOPE (MAX.)
CONSTRUCTION LIMIT FENCE
BORROW AREA NO. 1
11,690 N 51,290 E
11,640 N 50,675 E
11,665 N 50,815 E
11,500 N 50,590 E
11,525 N 51,290 E
11,290 N 50,590 E
F SERIES
11,300 N 50,085 E
RECORD SEEPAGE BARRIER LOCATION
11,120 N 50,200 E
RECORD SEEPAGE BARRIER LOCATION
LAP 50' (TYP.)
20:1 SLOPE
11,000 N 49,980 E
11,000N 50,200 E
EXIST. G.W.M. WELLS DO NOT DISTURB
E SERIES
RIPRAP LINED DITCH
USFL - 657
DSFL - 649
LENGTH - 165 L.F.
SLOPE - 4.85%
CONSTRUCTION LIMIT FENCE (ORIGINAL CONSTRUCTION LIMIT)
REVISED CONSTRUCTION LIMIT - BY CHANGE ORDER
813 L.F. OF SEEPAGE BARRIER INSTALLED BY OWNER IN THIS APPROXIMATE LOCATION - TO COMPLETE ENCLOSURE OF REGRADED MINE REFUSE PILE.

Section 225 Seepage Barrier Trench

Consists of trench and upper locking trench & contain no vegetation, protrusions, or rocks

Section 225 Seepage Barrier Trench

- Bentonite liner shall not be installed in standing water or during heavy rain.

Section 225 Seepage Barrier Trench

Bentonite liner to be pulled tight to smooth out creases or irregularities with polypropylene side up

Section 225 Seepage Barrier

To be locked into trenches at the top & bottom of slopes, backfilled with soil

Section 225 Seepage Barrier

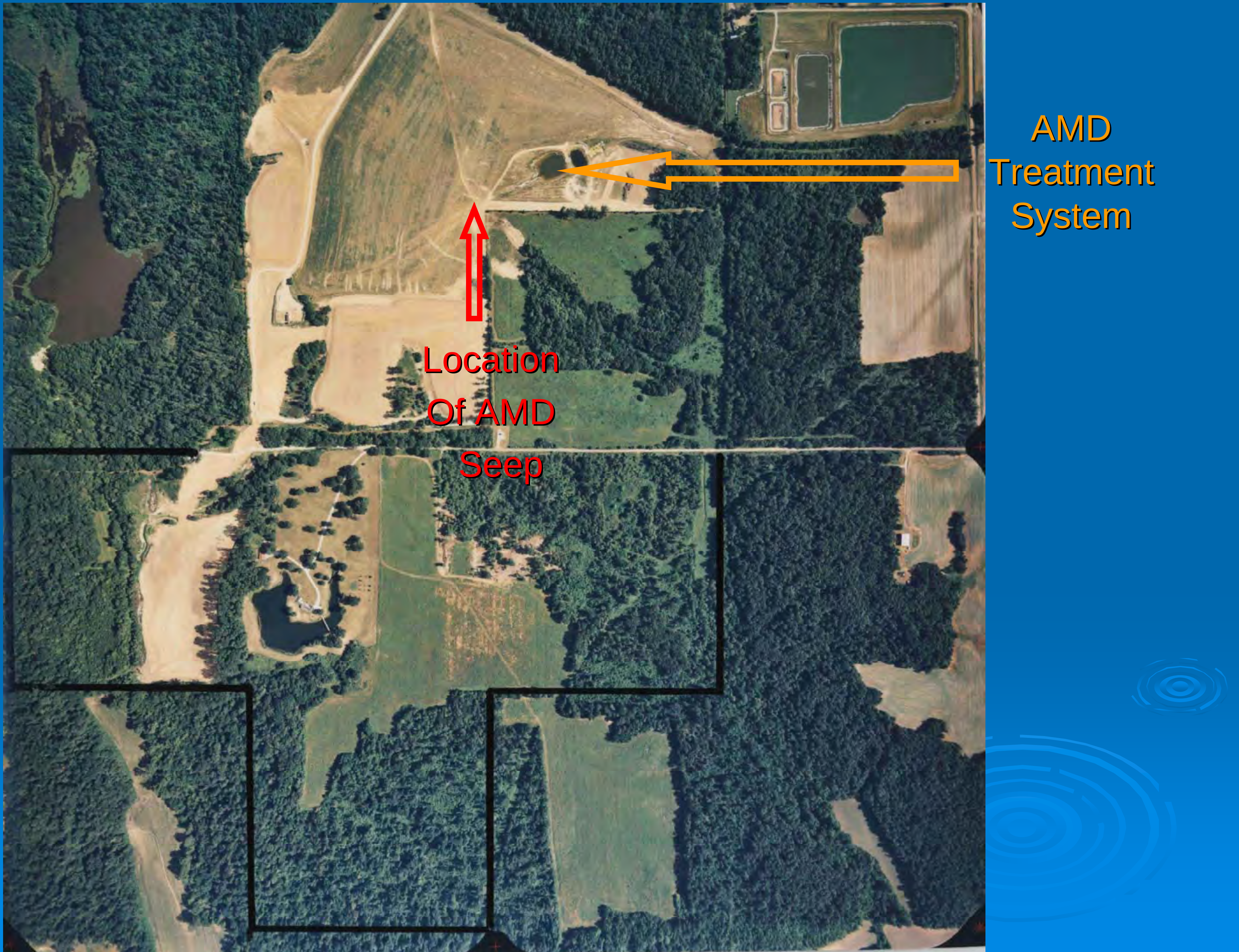
All seams to be overlapped 6”

Bid cost to install liner in 1988 $0.75 per square foot

Location where liner was opened

Treatment Basins constructed

Sections of manhole for collection basin


AMD Treatment System
Location Of AMD Seep

Key Points Derived from the project

Identify mine refuse / soil interface

Compaction of soil cap very critical

Exercise vigilant field inspection

Be proactive in trying to direct AMD flow

Restrict access if possible to reclaimed sites

Employ regular mowing of post-reclamation vegetation

Design standard established to improve reclamation work

Success of AMD reclamation work

Improvement in water quality leaving the site

The quality of vegetation on the site

The condition of the site over a long period of time

Water Quality :Before vs. After

Acidity (mg/l)	6,000	26
ph	3.0	7.23
Sulfate (mg/l)	6,600	762
Chloride (mg/l)	90	21
Iron (mg/l)	680	0.38
Manganese (mg/l)	22	1.72
Aluminum (mg/l)	80	0.04

Vegetation: Before vs. After


SUPERIOR
10/2/2002 11:56am

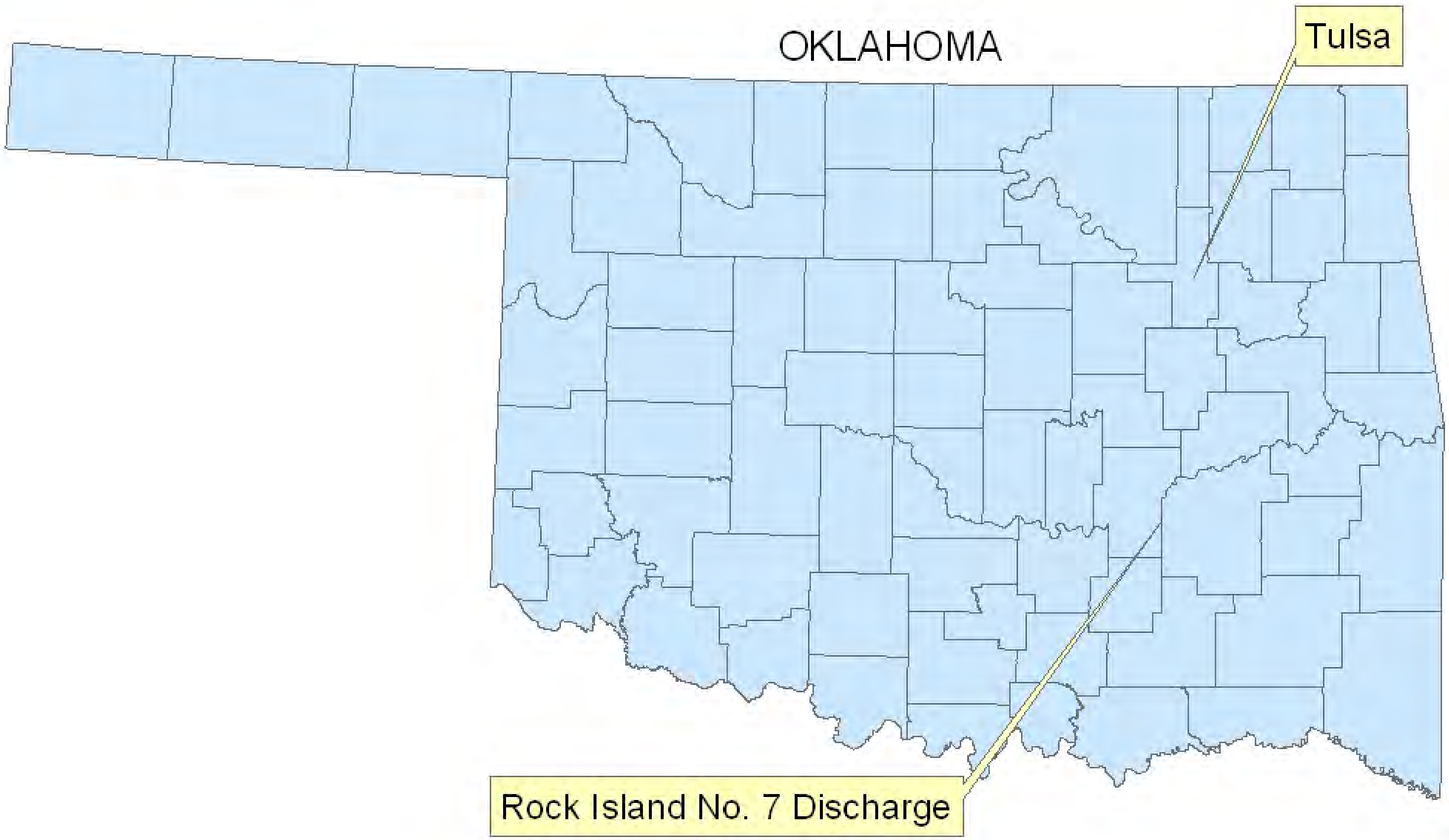
Passive Treatment of Artesian Mine Pool Discharges in Oklahoma

By
Paul T. Behum
Hydrologist, Office of Surface Mining
Alton, IL

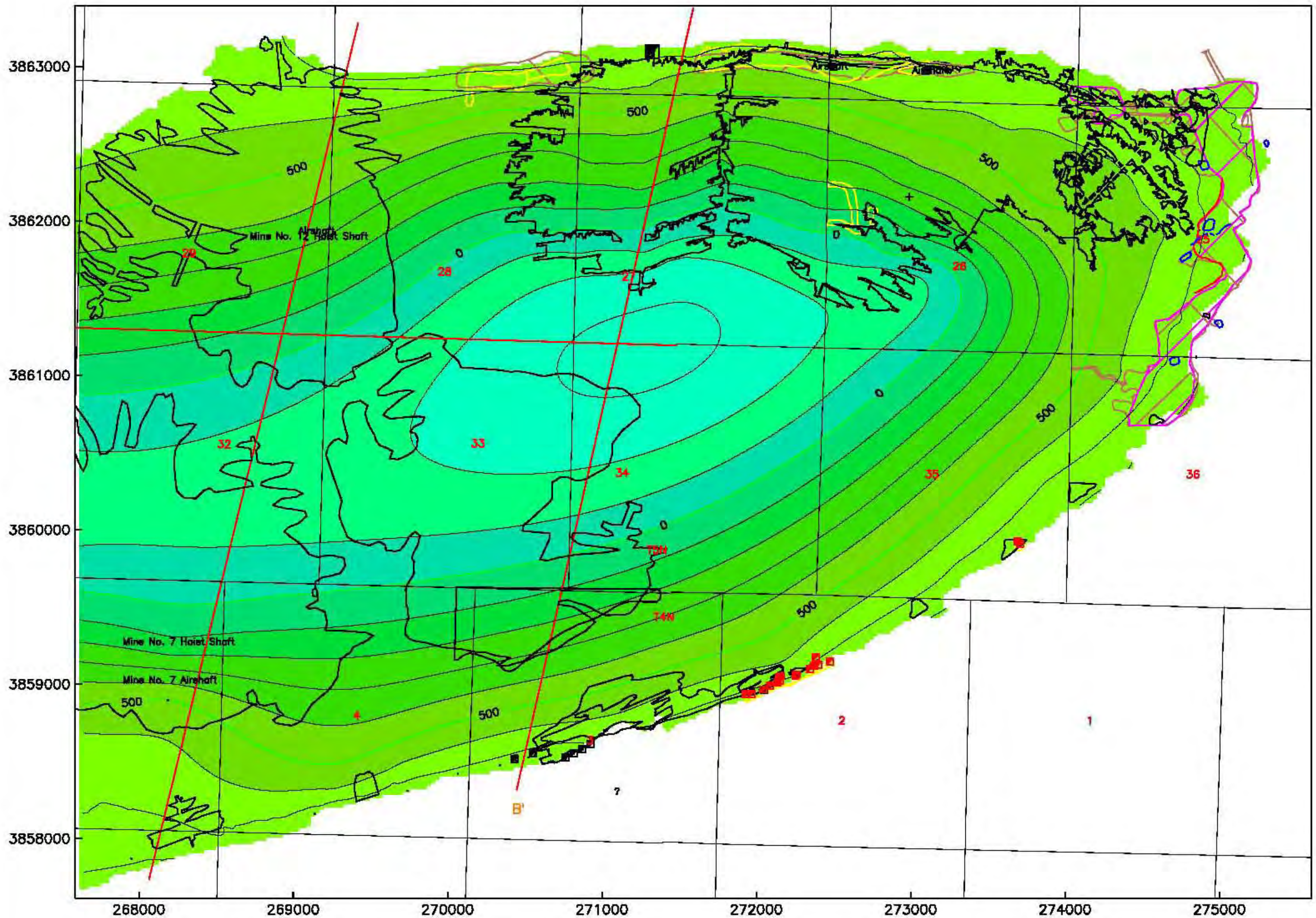
Project Areas

- Hartshorne Coal Basin, Pittsburg and Latimer Counties
  - Rock Island No. 7 Airshaft Discharge
  - GCI Permit 4105 (Title V)
- Red Oak – Fanshawe Area, Latimer and LeFlore Counties
  - Red Oak
  - LeBosquet

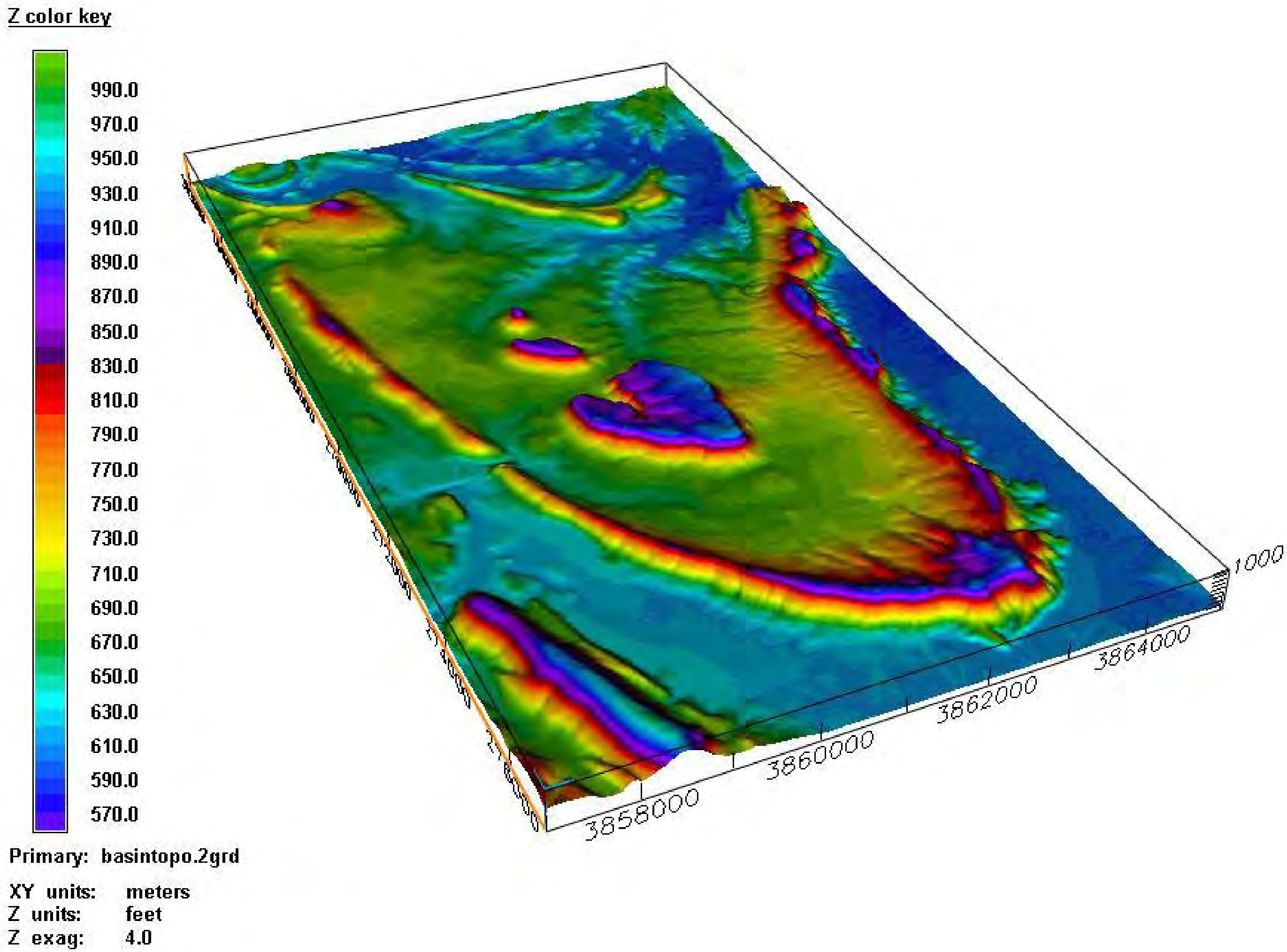
Hartshorne Coal Basin



Isopach Map of the Base of the Hartshorne Coal Bed



Hartshorne Coal Basin, Pittsburg and Latimer Counties, Oklahoma



Problem

- AMD primarily due to underground mining of the Hartshorne Coal Bed between 1900 and the mid-1930’s.
- Additional AMD sources from surface mining in the 1980’s.
- Impacting Lake Eufaula a large COE reservoir.

Hartshorne Basin AMD Discharges

Gowan 40 Old Seep

Rock Island No. 7 Airshaft

Table 1. Design Parameters: Untreated AMD Quality and Contaminant Load for the Rock Island Mine 7 Discharge, Oklahoma.*

Parameter	Range	Median	Units	Comments
pH	5.29 to 5.54	5.42	S.U.	24 measurements
Eh (est.)		90	mv	5 measurements
Conductivity		11,445	uS	22 measurements
DO		0.3	mg/L	22 measurements, mean = 0.4 mg/L
Fe		770	mg/L	23 analyses, mean = 858 mg/L
Al		0.18	mg/L	22 analyses, mean = 0.48 mg/L
Mn		17.4	mg/L	22 analyses, mean = 20.8 mg/L
T. Acidity		1,454	mg/L	15 analyses, mean = 1,500 mg/L
T. Alkalinity		112	mg/L	21 analyses, mean = 121 mg/L
Calcium		318	mg/L	11 analyses, mean = 313 mg/L
Magnesium		230	mg/L	9 analyses, mean = 241 mg/L
Sulfate		7,146	mg/L	18 analyses, mean = 8,029 mg/L
Sodium		1,813	mg/L	6 analyses, mean = 1,995 mg/L
Flow @ Inlet		0.32	L/sec	5 GPM is a typical value

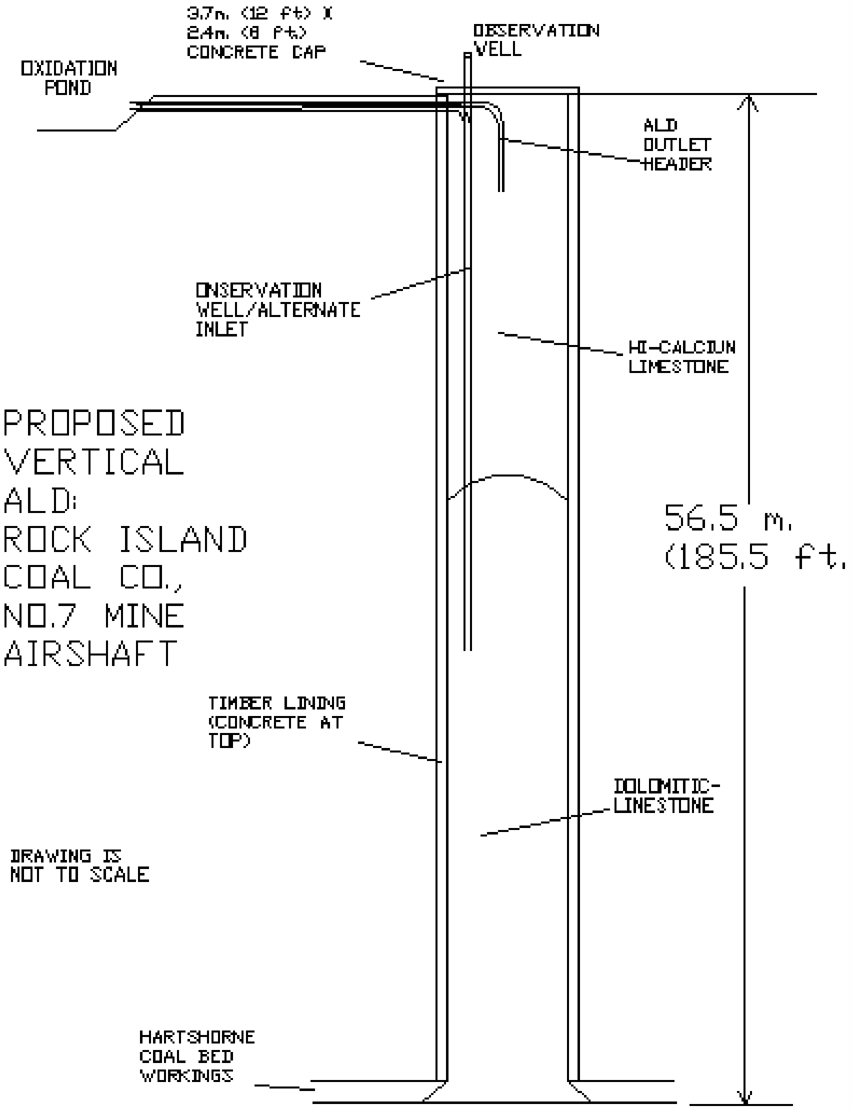
*These tests are a combination of OCC and OSM-MCRCC field measurements, OCC/Oklahoma University lab, OSM field and in-house lab analysis and EPA-certified lab analysis.

Solution

- Title V site conducting active treatment: lime neutralization.
- Passive treatment is planned for AML discharges:
  - Gowan 40 Discharge.
  - Rock Island No. 7 Airshaft Discharge.
  - Jeffries Field Discharge.

No. 7 Airshaft System Design

- Vertical ALD (VALD)
- Oxidation Cells
- 2 Vertical Flow Ponds (VFP)
- Aerobic Surface Flow Wetland

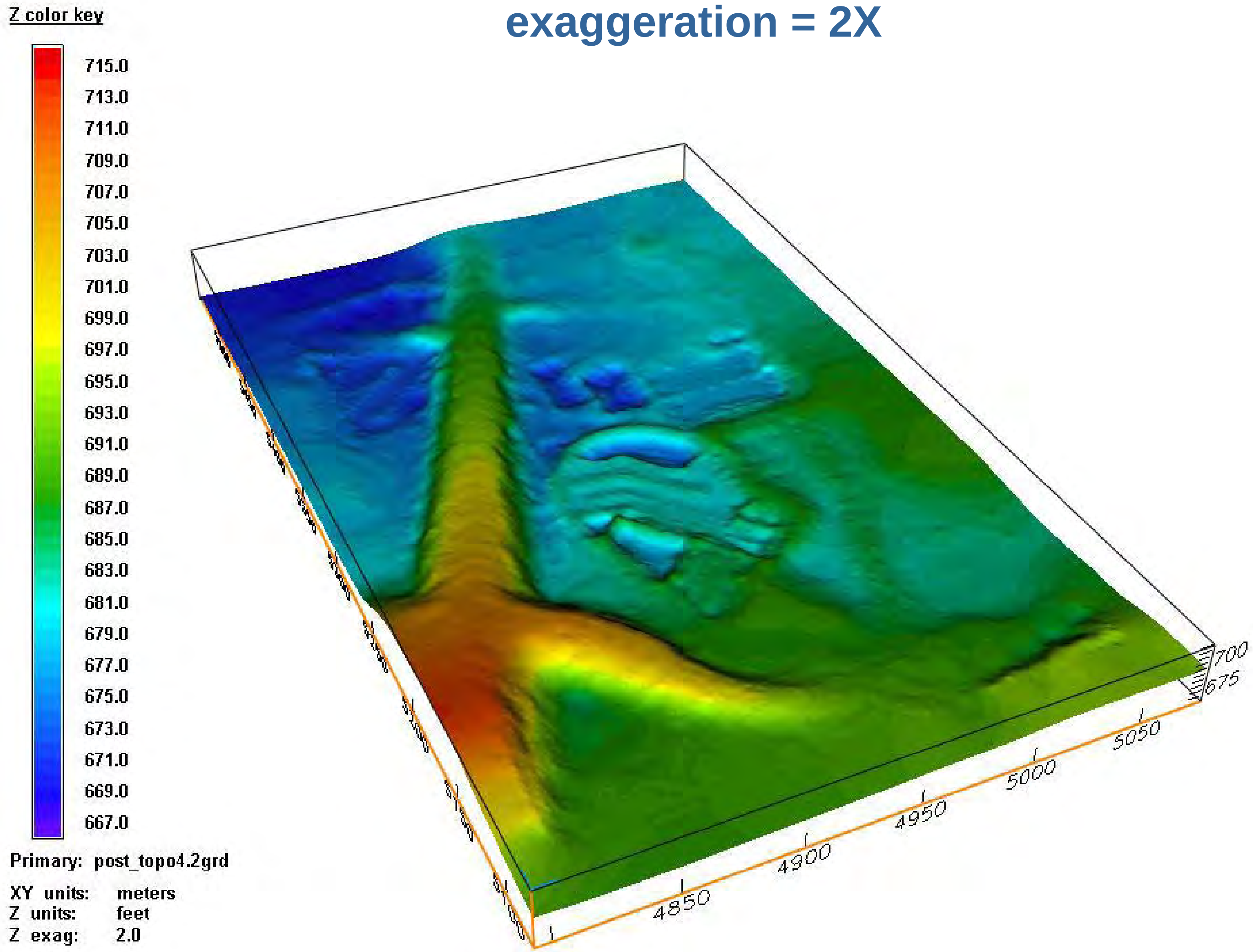


Rock Island No. 7 Airshaft Discharge.

CAD design drawn by P. Behum Nov. 2004 using SurvCADD XML.

Topographic Model showing the AMD Passive Treatment Structures.

Model created by P. Behum using *earthVision 7.5*, Nov. 2004; vertical exaggeration = 2X



Preliminary Post-Construction Results

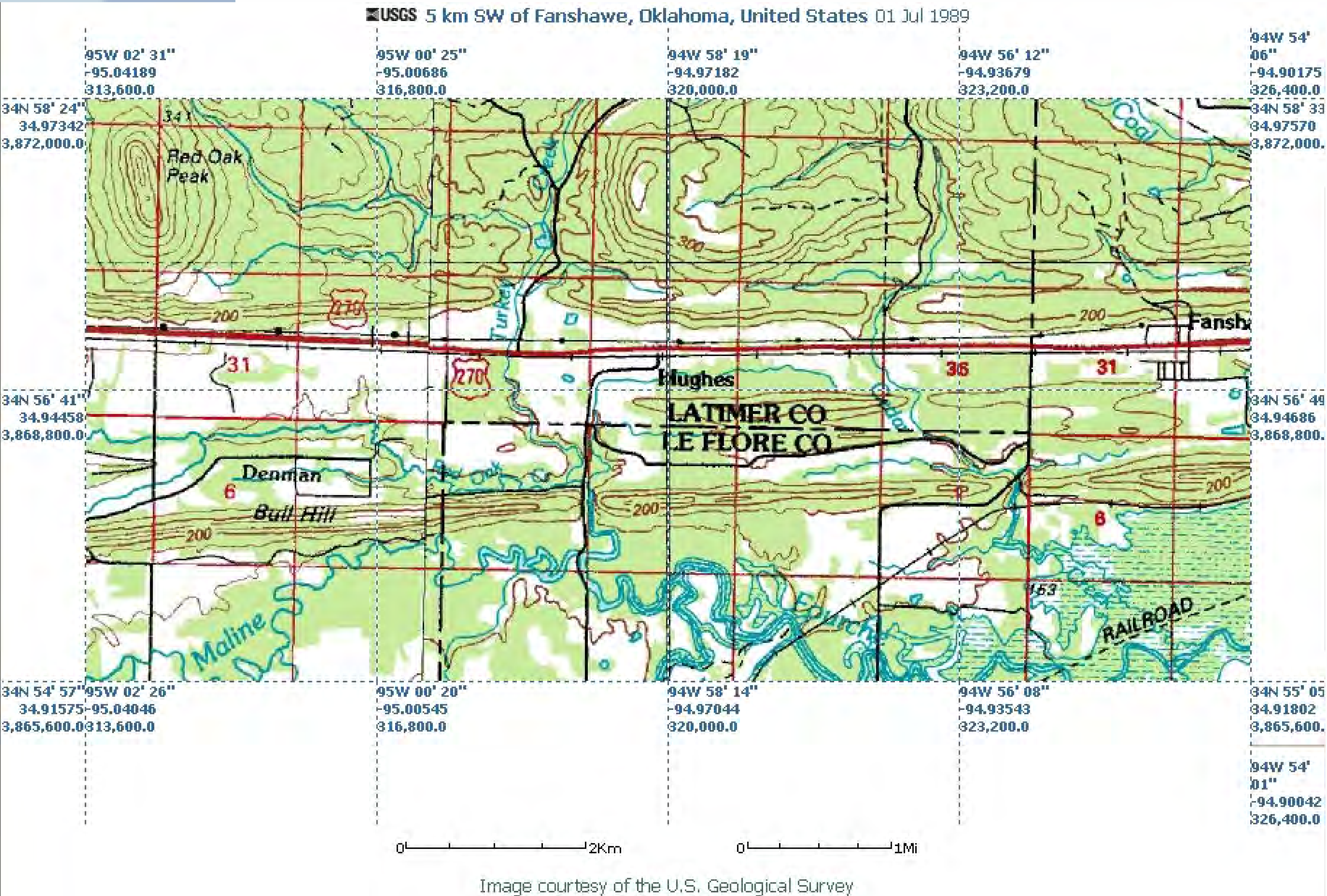
Parameter		VALD Out		VFP 1 In		VFP 1 Out		VFP 2 In		VFP 2 Out		Wetland In	Units
Flow		NT		10.2		8.1		10.2		8.12		3.6	GPM
pH		6.32		3.26		6.36		8.31		7.03		7.79	S.U.
Specific Conductance		6,710		8,150		8,680		9,040		8,170		7,970	micro S
D. Fe (field)		306		114		23.7		0.17		0.03		0.12	mg/l
D. Fe^{+2}(field)		124		95		15.8		0.17		0.03		0.03	mg/l
D. Fe^{+3}(calc)*		182		19		7.9		0		0		0.09	mg/l
lab pH		6.19		3.01		6.33		8.37		7.08		7.92	S.U.
D. Fe (lab)		300.00		111.00		22.60	<	0.500	<	0.500	<	0.500	mg/l
D. Al	<	0.050	<	0.050	<	0.050	<	0.050	<	0.050	<	0.500	mg/l
D. Mn		5.58		10.40		10.50		7.08		6.47		4.47	* mg/l
Sulfate		2,880		3,770		4,570		5,250		4,370		4,170	mg/l
Chloride		110.00		140.00		140.00		160.00		140.00		130.00	mg/l
T. Acidity (calc)**		719.38		267.20		68.77		13.45		12.10		11.20	mg/l
T. Acidity (lab)		182.00		310.00	<	1.50	<	1.50	<	1.50	<	1.50	mg/l
T. Alkalinity (lab)		284.00	<	2.50		232.00		156.00		250.00		222.00	mg/l
T. Alkalinity (field)		390.0		0.0		336.0		107.0		320.2		280.0	mg/l
Net Acidity		435.38		265.95		-163.23		-142.55		-237.90		-210.80	mg/l

* By subtraction.

** Acidity Calculation Formula: $50*(2*Fe2+/56+3*Fe3+/56+3*Al/27+2*Mn/55+1000*10^{-pH})$

Rock Island No 7 Passive treatment System

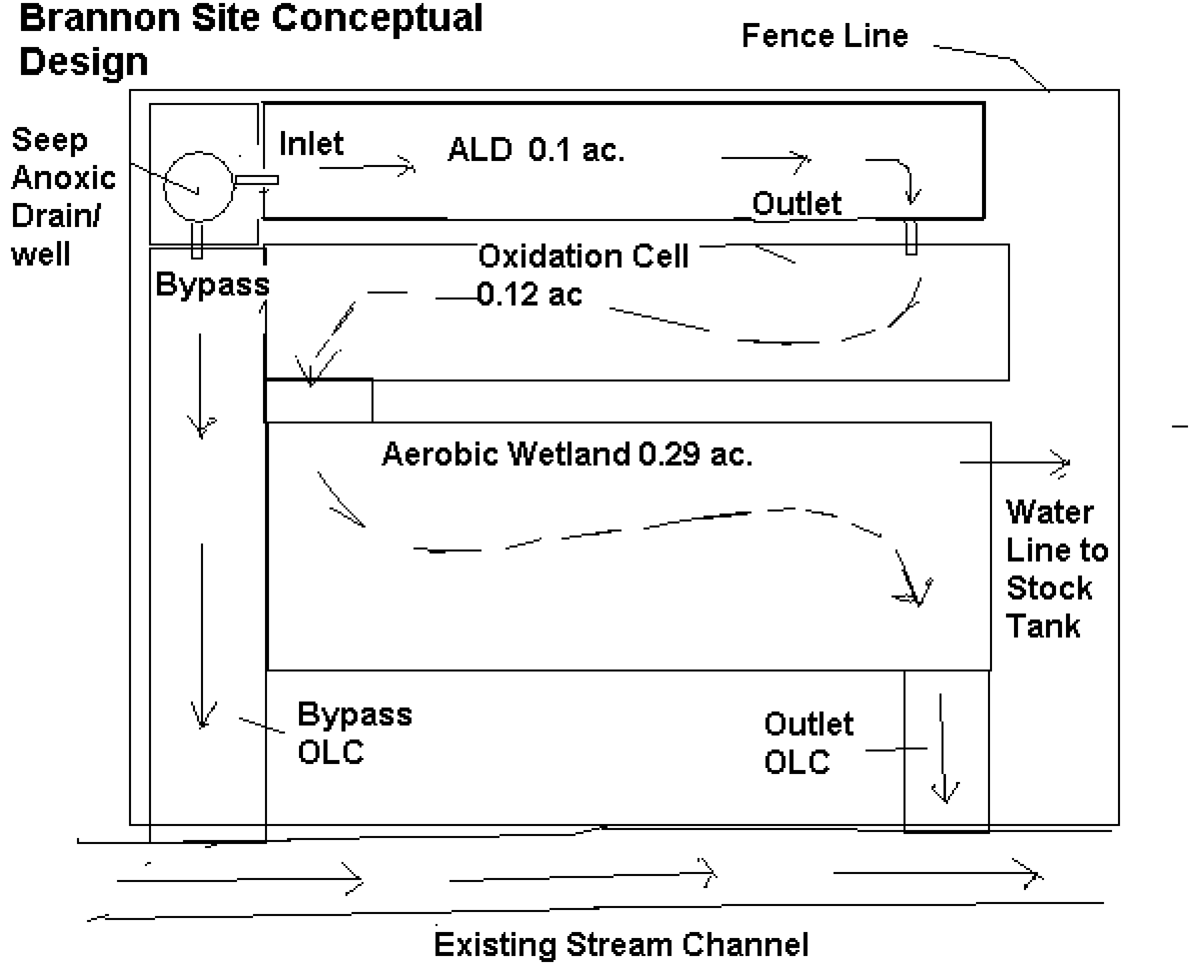
Red Oak – Fanshawe Area

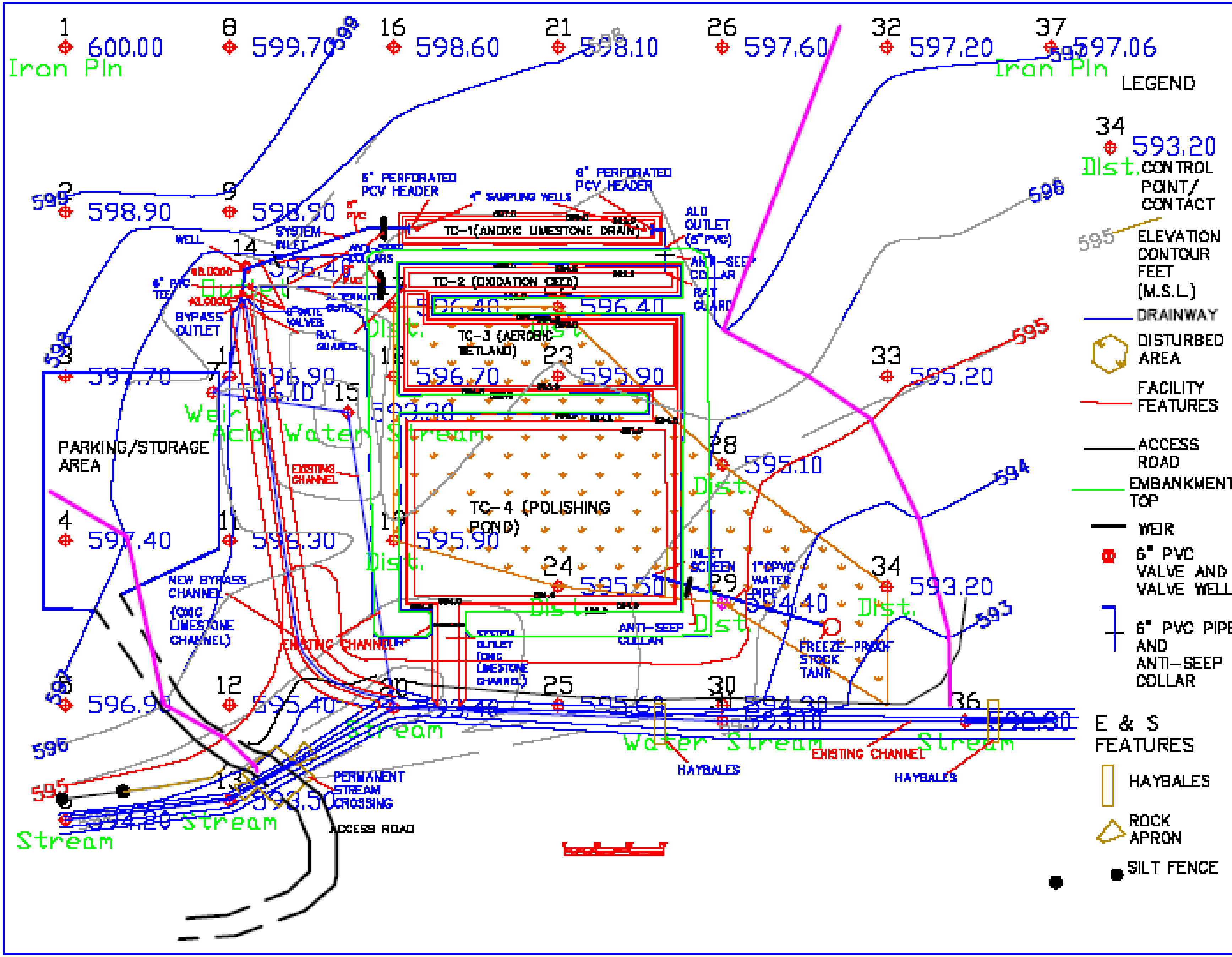


Problem

- AMD primarily due to underground mining of the moderately dipping (>20 degrees) Hartshorne Coal Bed between in the early 1900’s.
- Post-closure mine pools have developed with artesian discharged from former dewatering wells.

Brannon Site Conceptual Design





1 600.00
8 599.70
16 598.60
21 598.10
26 597.60
32 597.20
37 597.06
Iron Pin
Iron Pin
2 598.90
9 598.90
3 597.70
4 597.40
11 595.30
5 596.90
12 595.40
25 595.60
23 595.90
24 595.50
28 595.10
33 595.20
34 593.20
29 594.40
6" PERFORATED PCV HEADER
6" PERFORATED PCV HEADER
4" SAMPLING WELLS
TC-1 (ANOXIC LIMESTONE DRAIN)
TC-2 (OXIDATION CELL)
TC-3 (AEROBIC WETLAND)
TC-4 (POLISHING POND)
ALD OUTLET (6" PVC)
ANTI-SEEP COLLAR
RAT GUARD
SYSTEM INLET
WELL
BYPASS OUTLET
EXISTING CHANNEL
PARKING/STORAGE AREA
Weir
Acid Water Stream
NEW BYPASS CHANNEL (OXIC LIMESTONE CHANNEL)
SYSTEM OUTLET (OXIC LIMESTONE CHANNEL)
INLET SCREEN
1" CPVC WATER PIPE
ANTI-SEEP COLLAR
FREEZE-PROOF STOCK TANK
Dist.
Stream
Water Stream
HAYBALES
HAYBALES
EXISTING CHANNEL
PERMANENT STREAM CROSSING
ACCESS ROAD
LEGEND
CONTROL POINT/ CONTACT
ELEVATION CONTOUR FEET (M.S.L.)
DRAINWAY
DISTURBED AREA
FACILITY FEATURES
ACCESS ROAD
EMBANKMENT TOP
WEIR
6" PVC VALVE AND VALVE WELL
6" PVC PIPE AND ANTI-SEEP COLLAR
E & S FEATURES
HAYBALES
ROCK APRON
SILT FENCE

LeBosquet Construction
(Fall 2003-Spring 2004)

LeBosquet Passive Treatment System

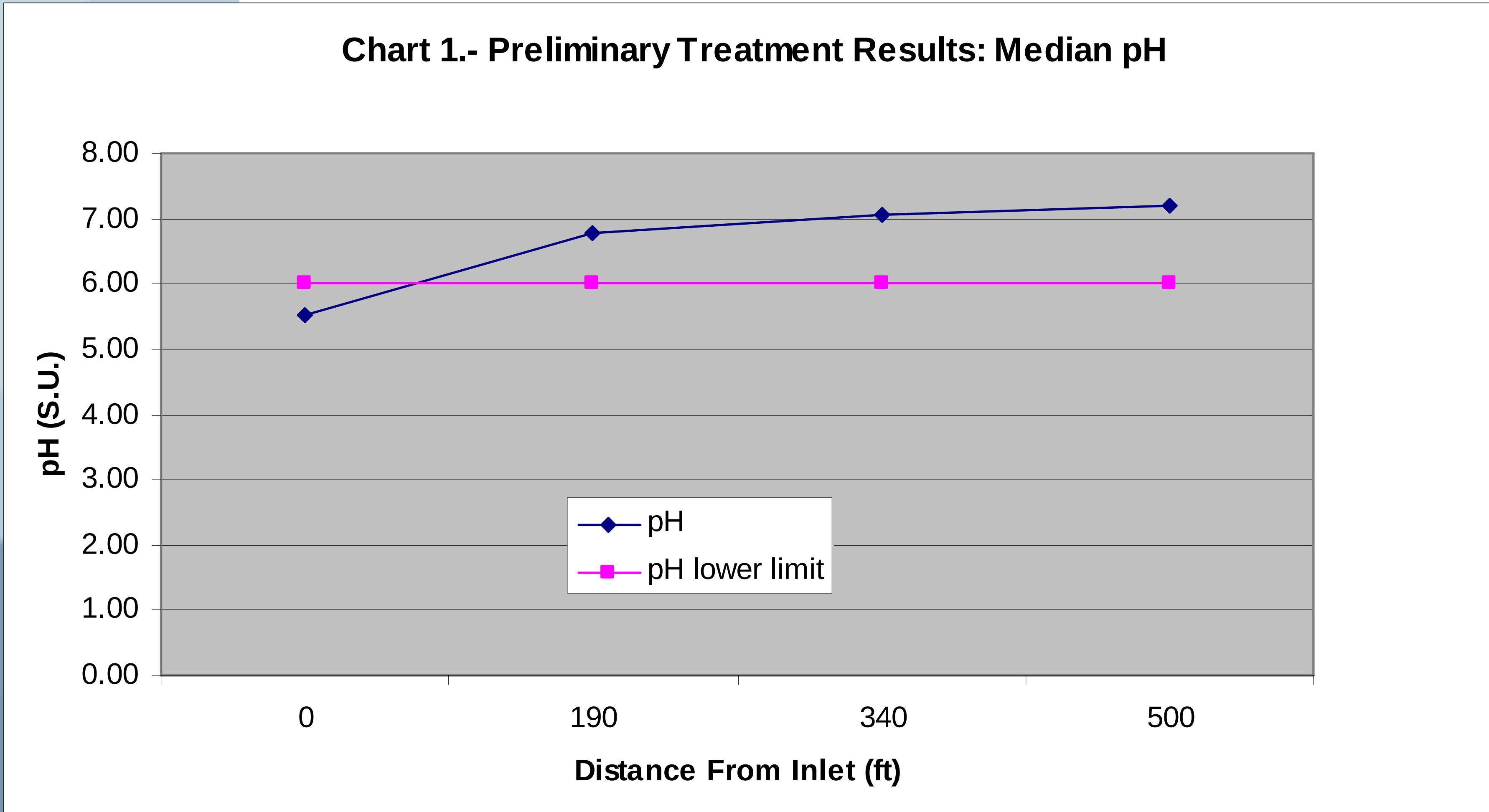
Lebosquet Preliminary Water Quality Data

Parameter	Baseline	System Inlet (ALD Inlet)	ALD Outlet	Oxygen Outlet	Wetland (System) Outlet	Units
pH*	6.00	5.51	6.77	7.05	7.21	S.U.
SC	587	486	560	484	507	uS/cm
T. Fe	31.75	36.60	32.85	2.52	5.32	mg/L
D. Fe	35.45	36.92	29.90	0.16	0.83	mg/L
D. Al	0.57	0.09	0.05	0.05	0.05	mg/L
D. Mn	1.71	1.55	1.45	1.01	0.58	mg/L
Sulfate	104.00	114.60	118.25	119.50	105.50	mg/L
T. Acidity**	89.41	79.31	66.46	5.17	2.01	mg/L***
T. Alkalinity	5.80	12.90	160.10	125.00	144.88	mg/L***
Net Acidity	83.61	73.42	-67.54	-114.73	-135.18	mg/L***

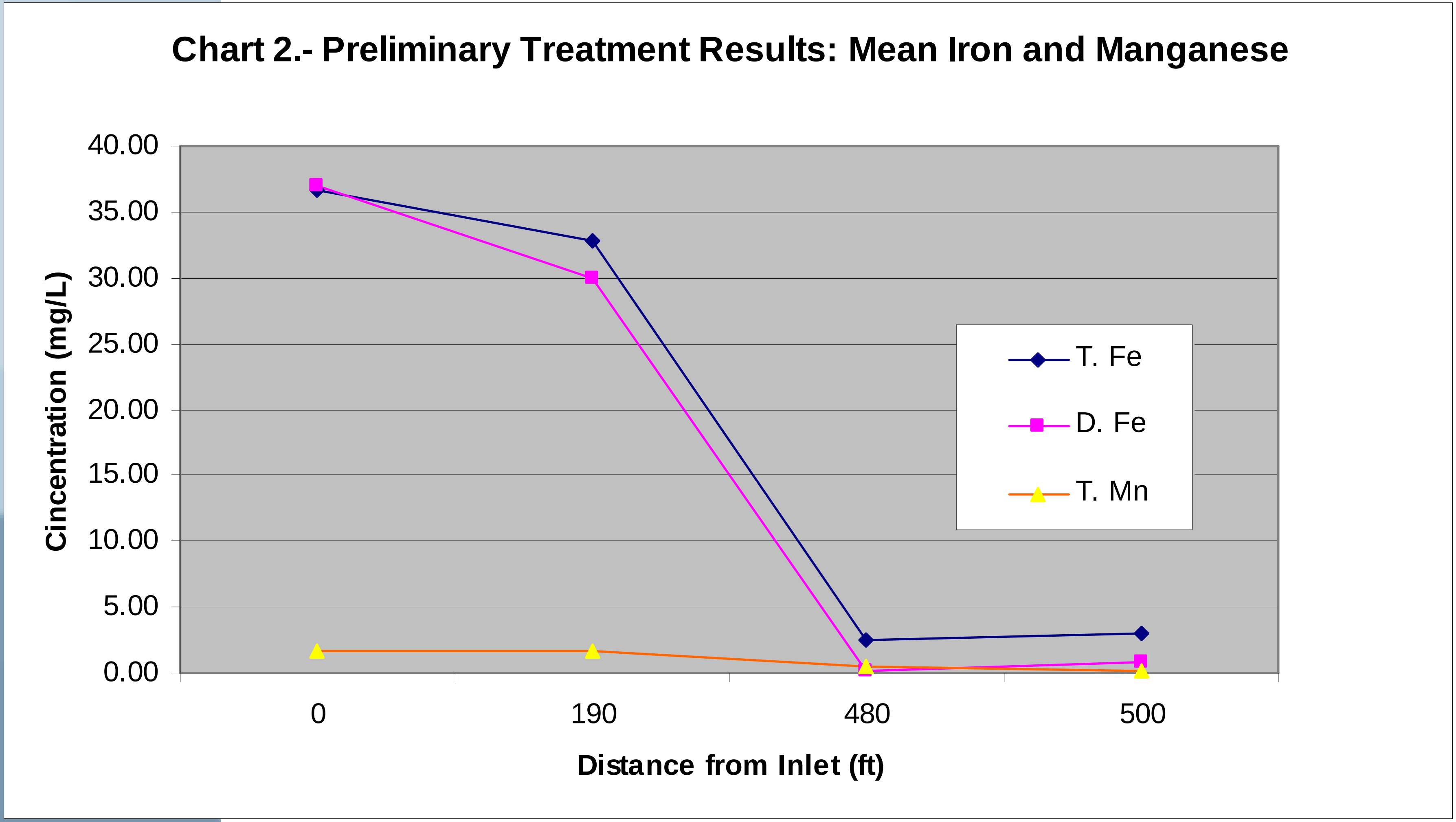
* Median values all others are mean values

** Calculated from metal and pH values.

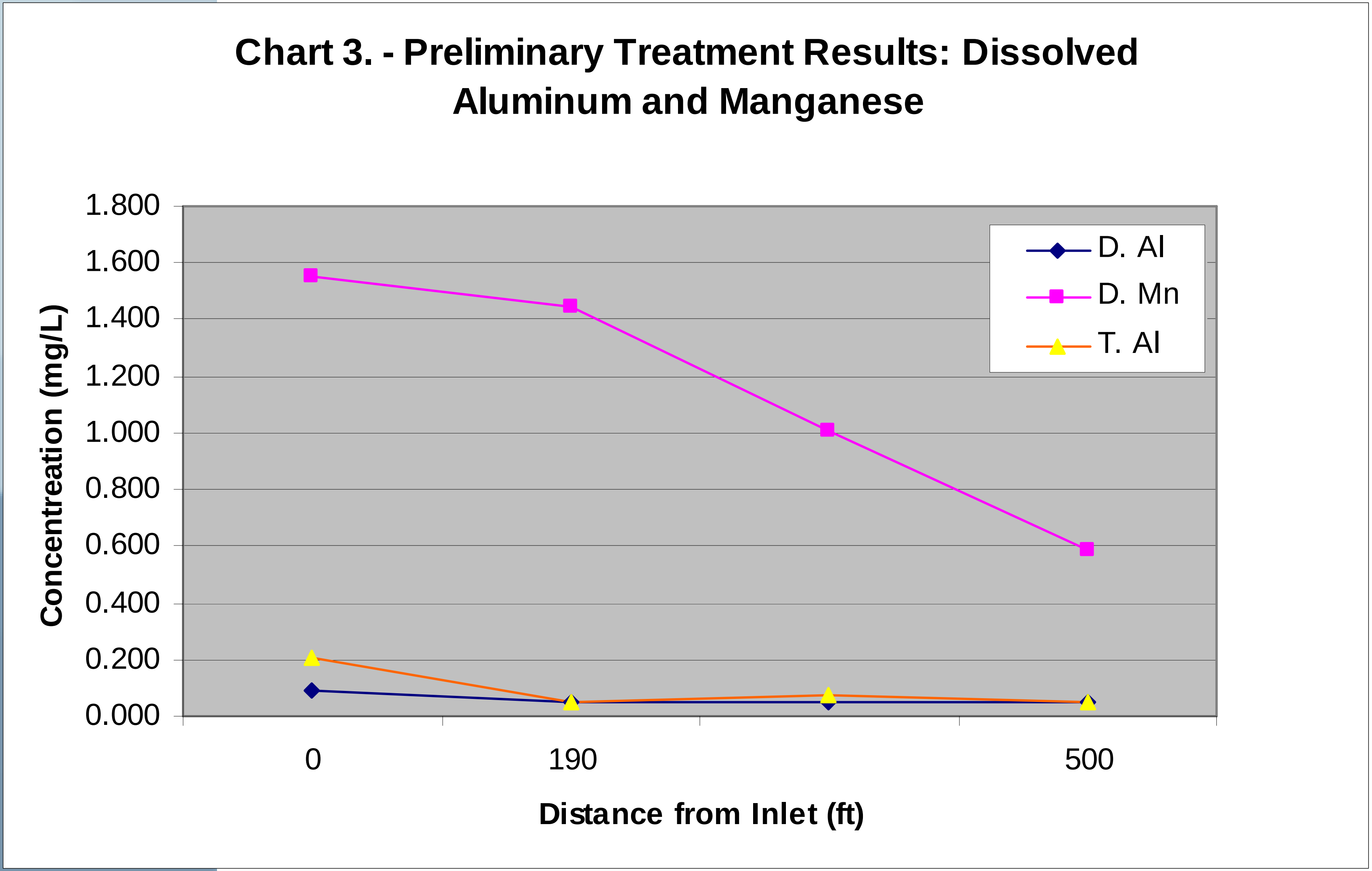
*** Calcium carbonate equivalent.



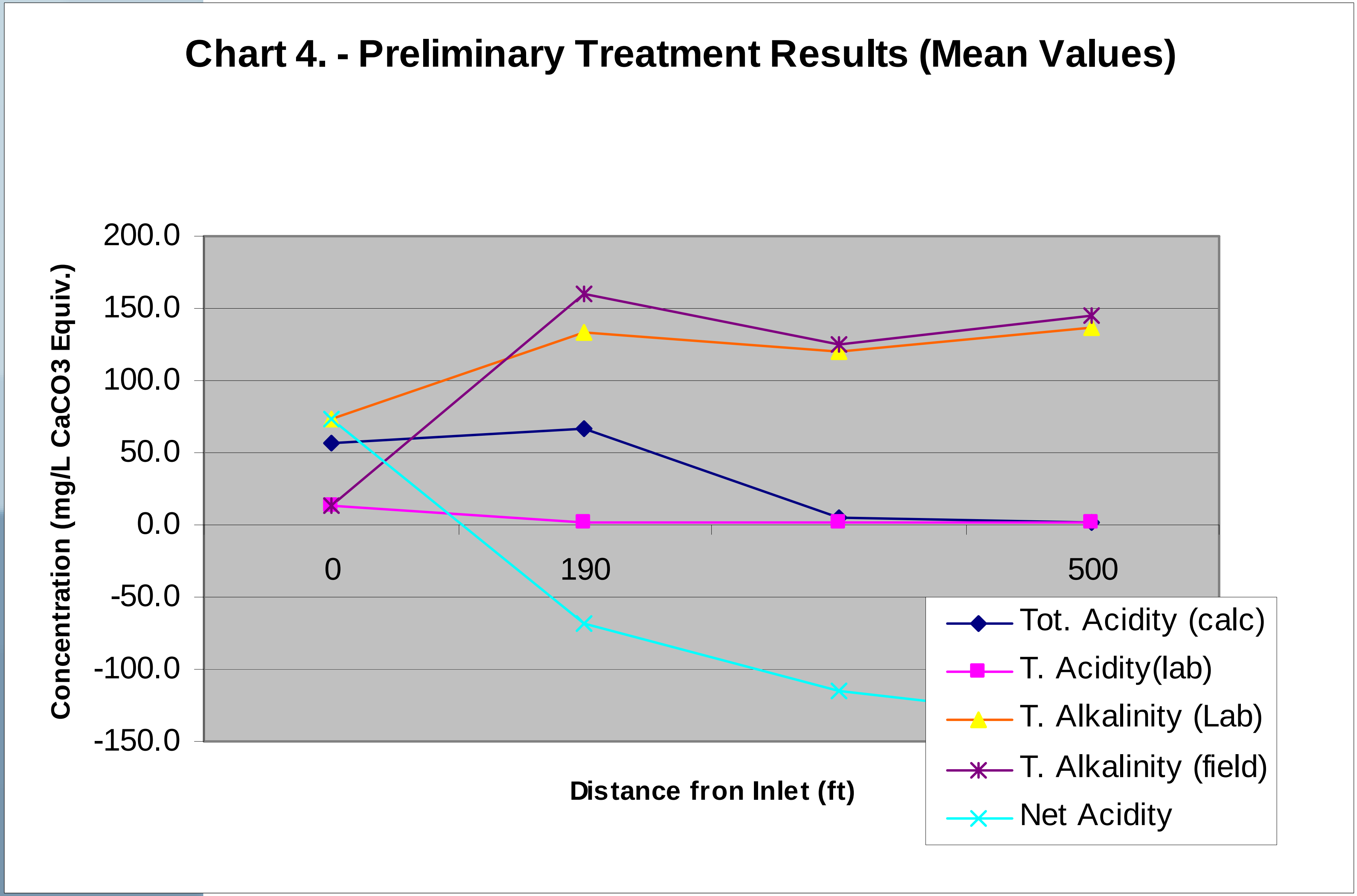
Beneficial pH is maintained throughout the treatment system.



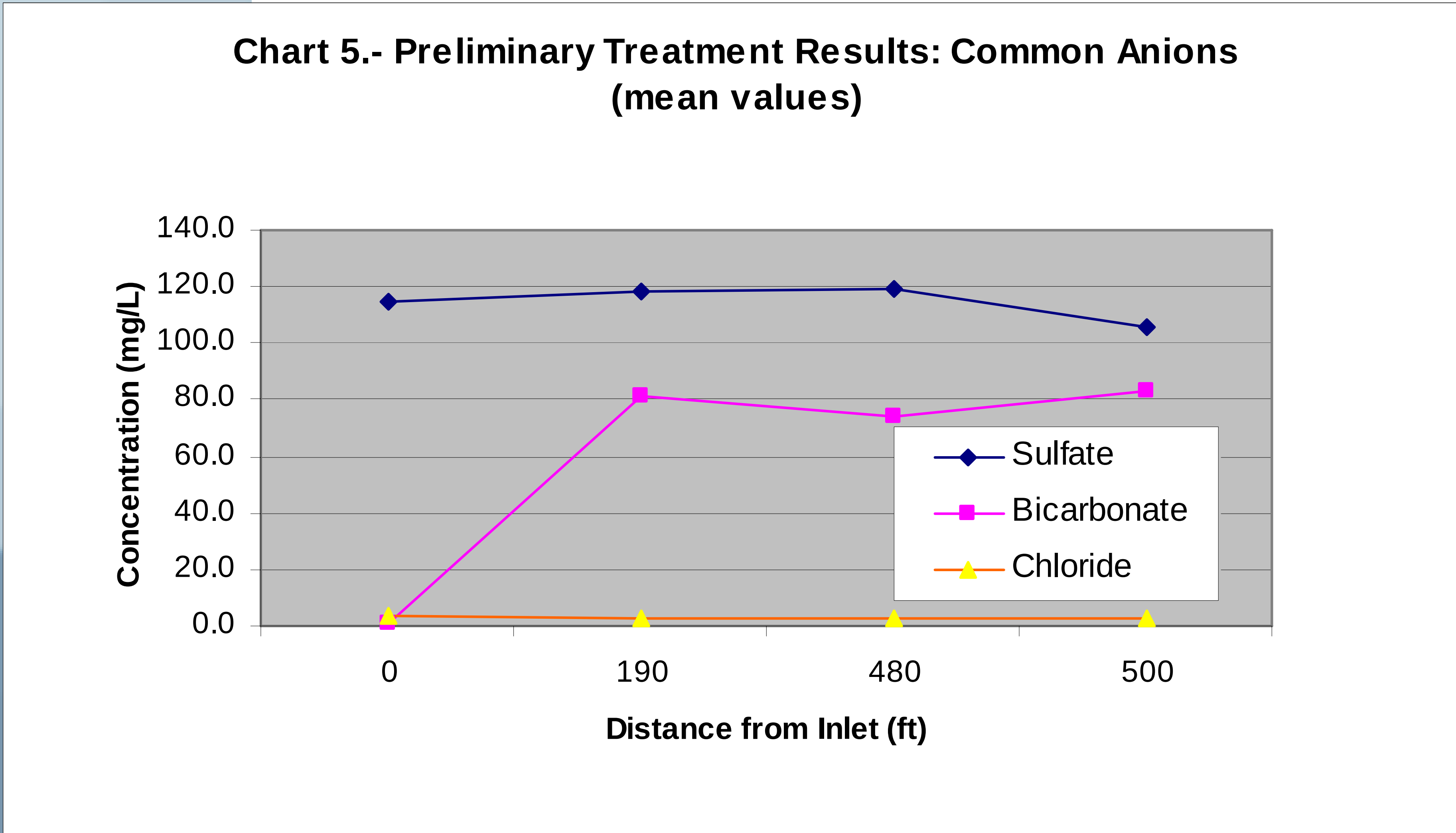
Iron is removed to a low level in the oxidation pond. Some iron is undesirably removed in the ALD. Manganese is low at this site.



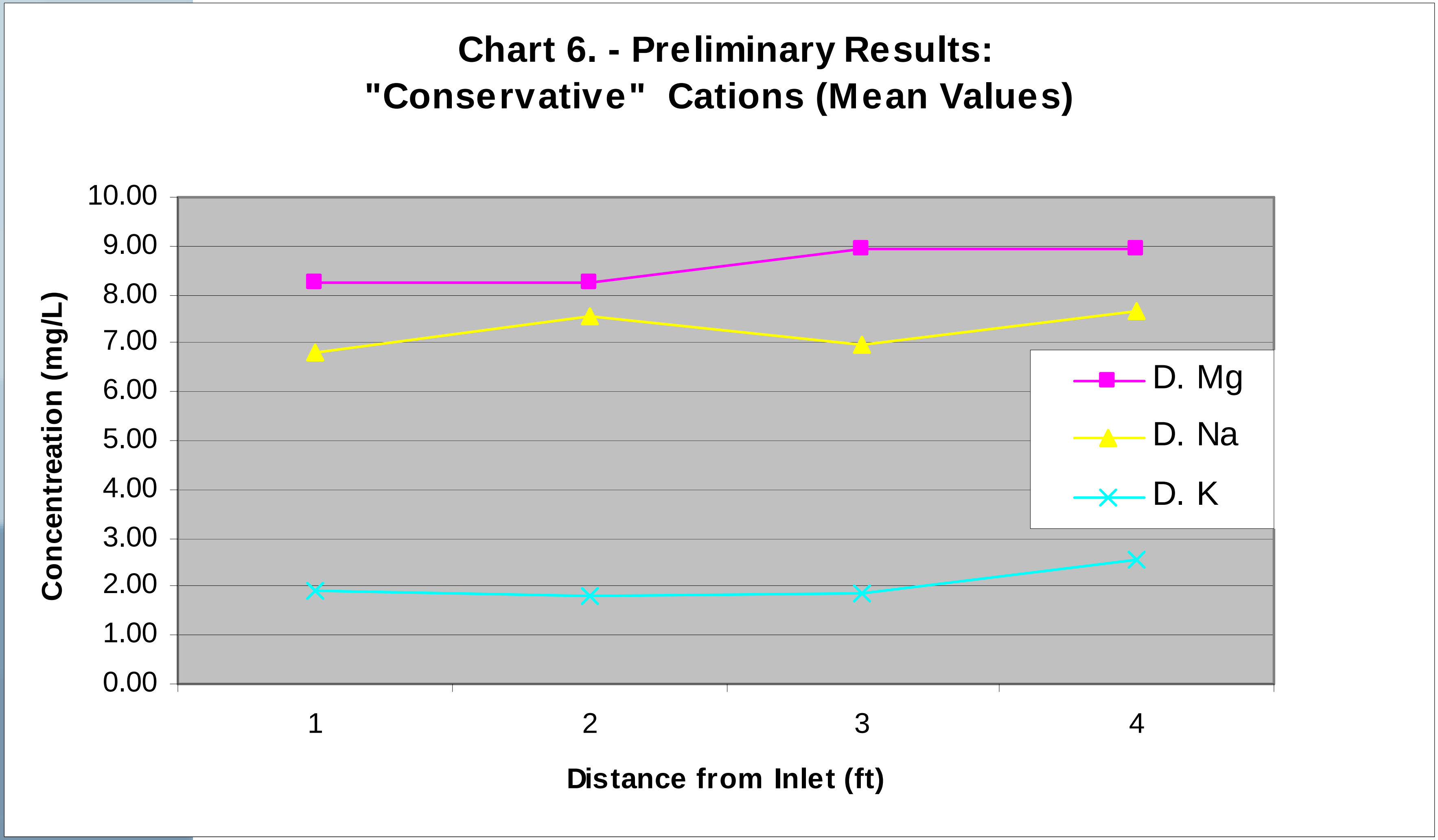
Manganese is significantly reduced in the system. Aluminum is low in the input seep and is entirely removed <u>in</u> the ALD.



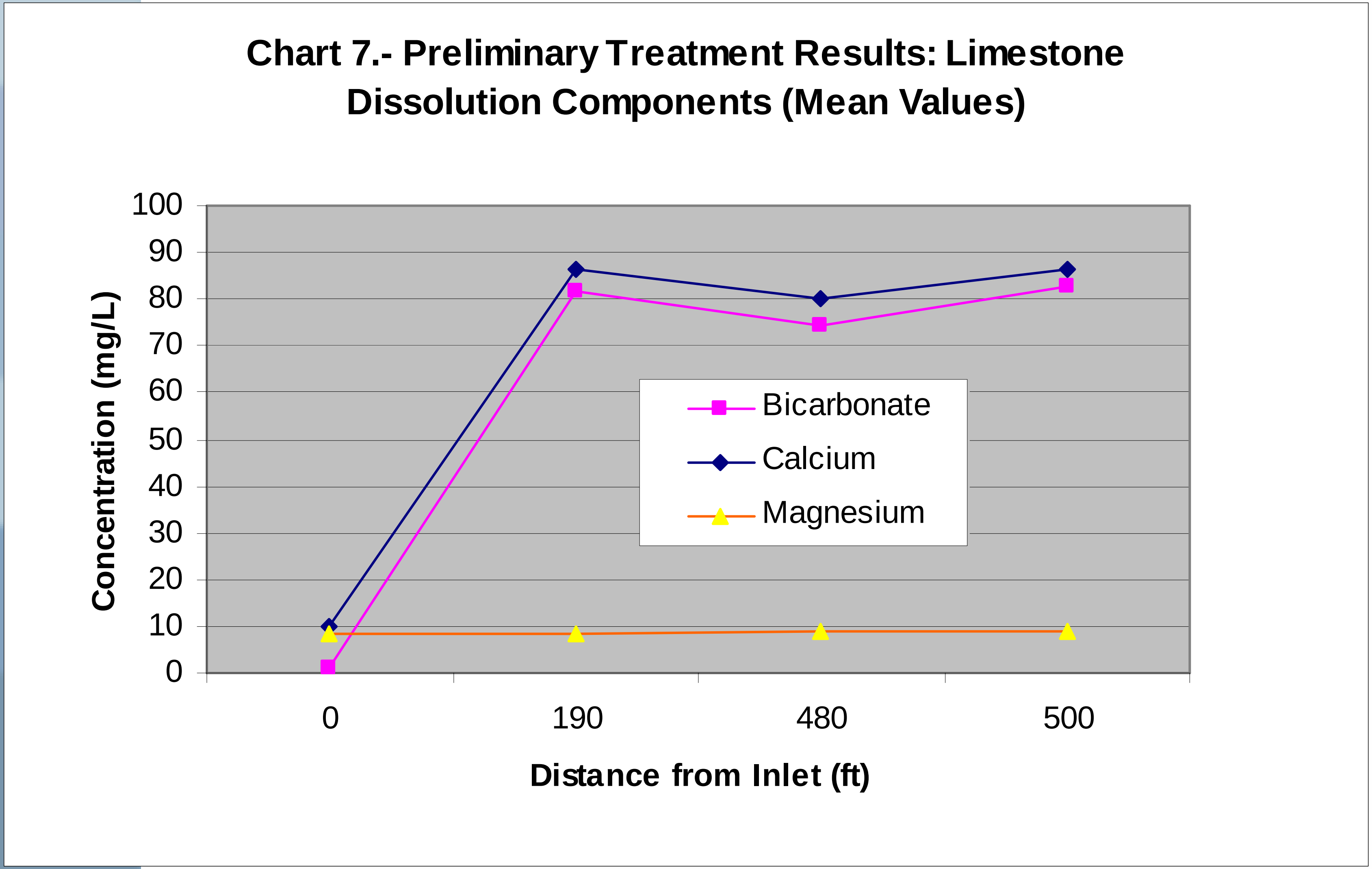
Large amount of alkalinity generated by the ALD produces net alkaline drainage. Note the discrepancy in lab and field alkalinity .



Sulfate and chloride are conservative anions and pass through the system unchanged. Considerable bicarbonate (HCO_3^{2-}) is generated by the ALD that more than offsets the acidity.



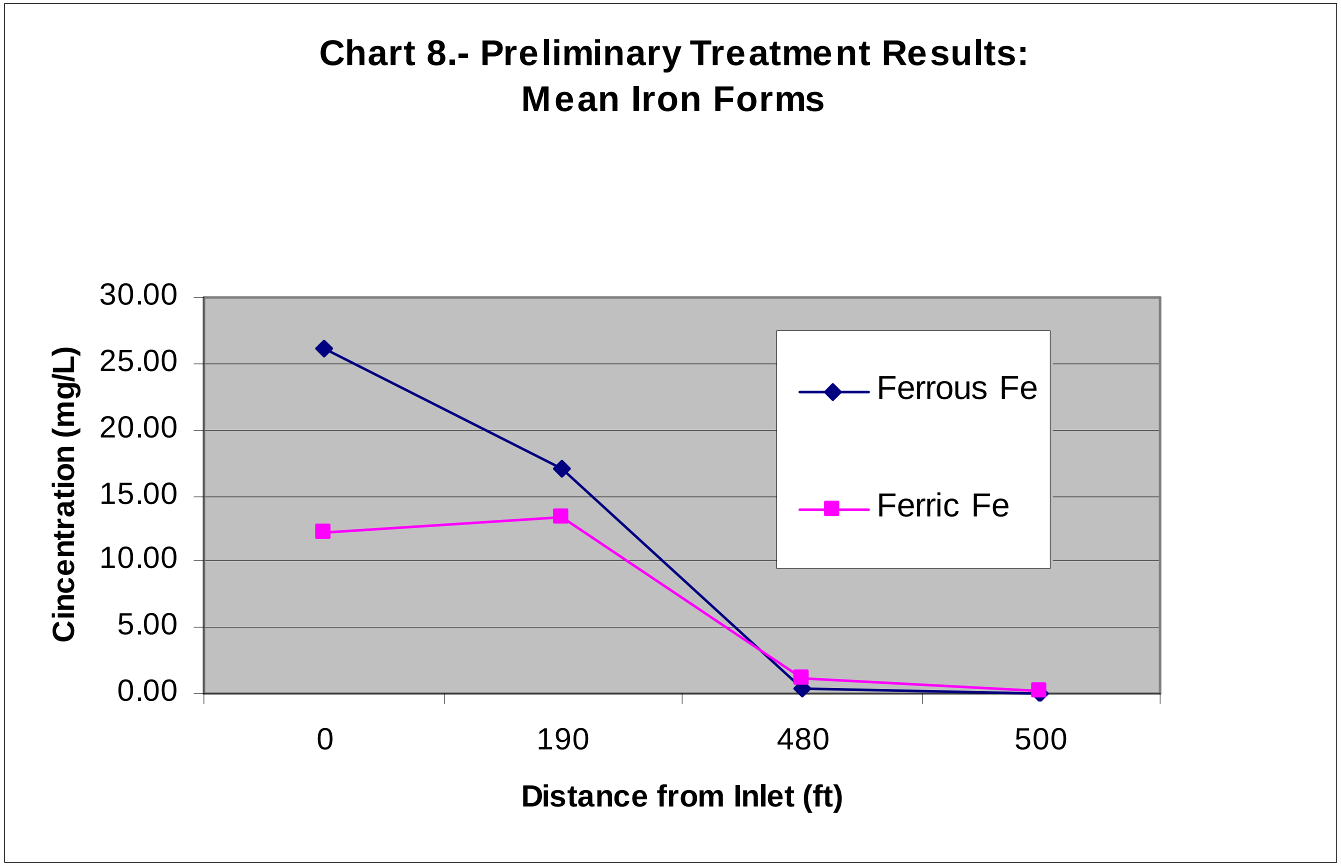
Major cations magnesium, sodium and potassium are low and pass though the system.



High-calcium limestone from Oklahoma source rapidly dissolves in the ALD into calcium and bicarbonate ions. Low magnesium content indicated low amount of dolomite in the stone.

Operational Problems:

- Ferric Iron is measured in the inlet AMD.
- Iron is being retained in the ALD



Solution:
Reduce oxygen inlet into outlet pipe

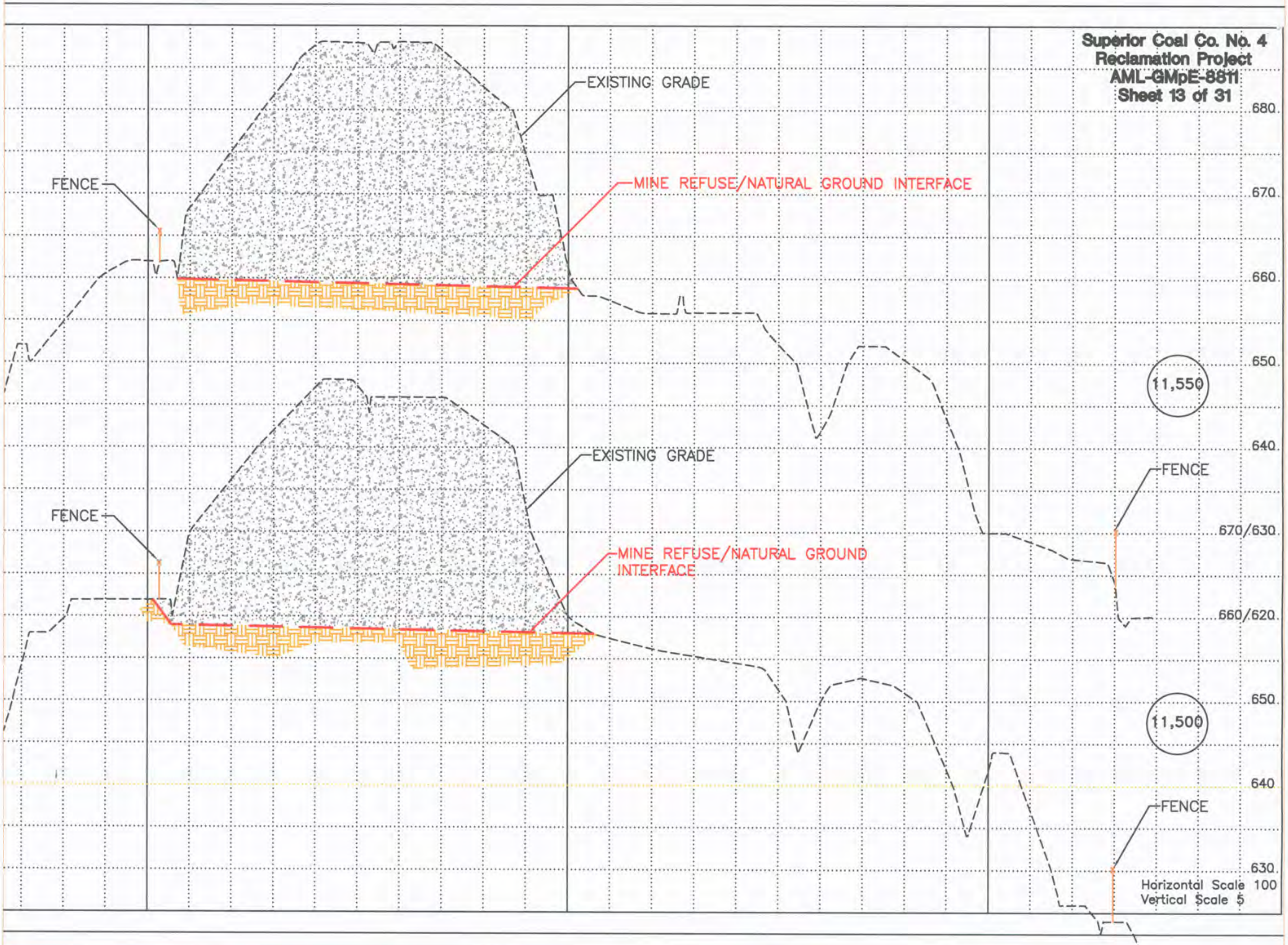
Before

After

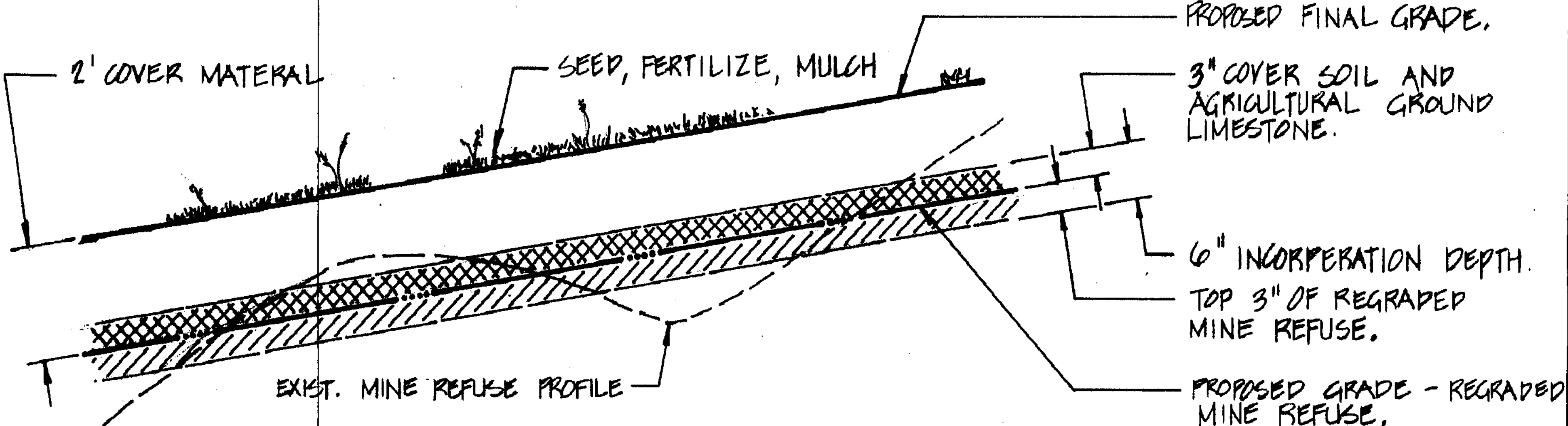
Acknowledgements

- Mike Kastl, Mike Sharp and Henry Roy of Oklahoma Conservation Commission Abandoned Mine Land Reclamation Program managed the project activity and assisted in water sampling.
- Brian Hicks and Kwang (Min) Kim served as OSM co-investigators.
- Geoff Canty formerly of the Oklahoma Conservation Commission provided water quality data for the Rock Island No. 7 site.
- Dan Trout, LaChelle Harris and Jeff Zingo, OSM-Tulsa assisted in water quality data collection.

SUPERIOR #4 SITE TOUR
N
W
E
S
TREATMENT CELLS
COLLECTION SYSTEM



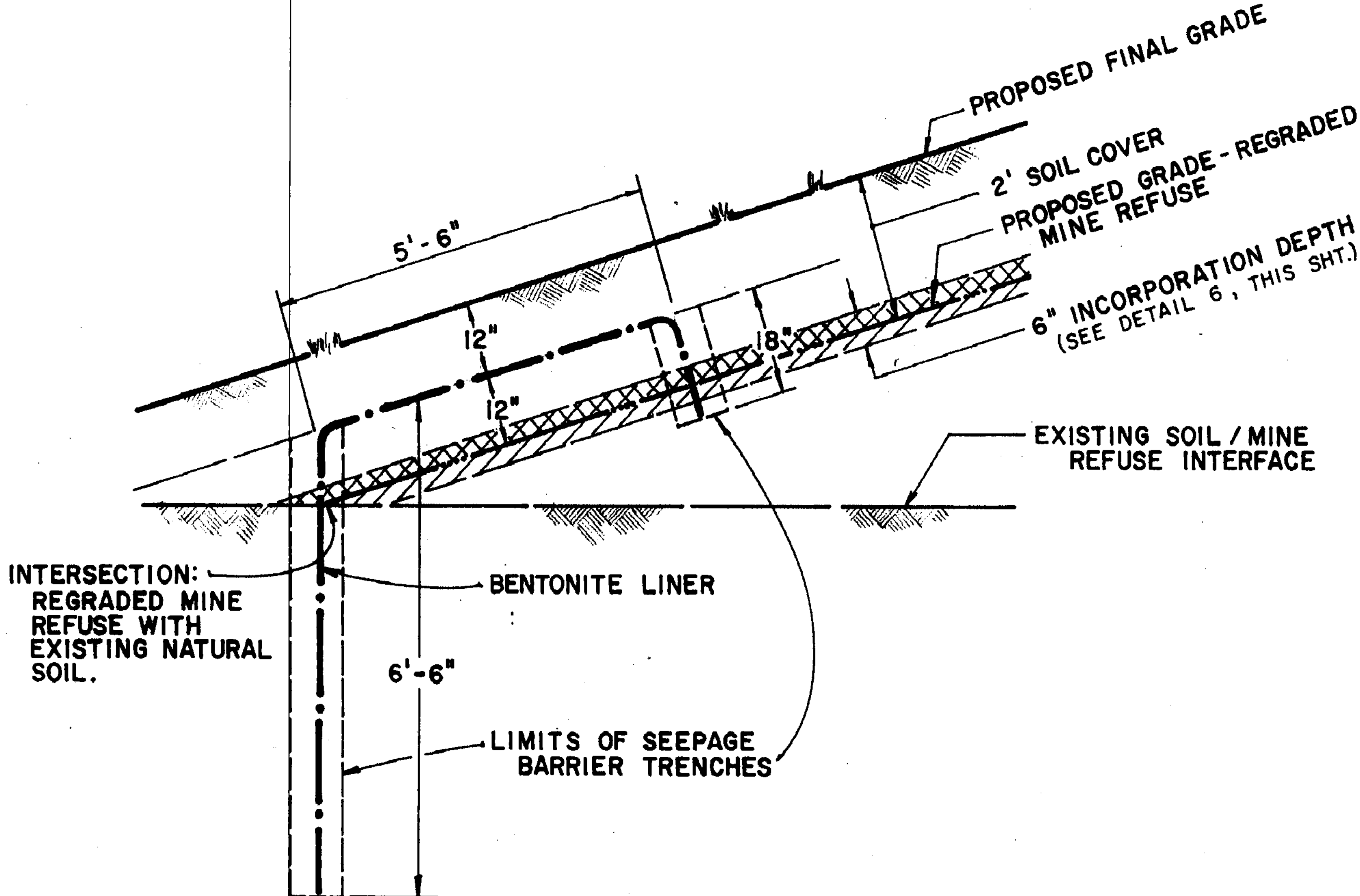
Superior Coal Co. No. 4
Reclamation Project
AML-GMpE-8811
Sheet 13 of 31
EXISTING GRADE
FENCE
MINE REFUSE/NATURAL GROUND INTERFACE
680
670
660
650
640
670/630
660/620
630
11,550
11,500
Horizontal Scale 100
Vertical Scale 5



9

DETAIL: MINE REFUSE TREATMENT

NO SCALE



10 DETAIL: BENTONITE LINER INSTALLATION

NO SCALE

Appendix - Attachment #1

Superior Coal Company #4
Macoupin County, Illinois
AML-GMpE-8811

SECTION 207: EMBANKMENT — (Delete entire Section and replace with following)

SECTION 207: MINE SITE COMPACTION

Article 207.01 Description

This shall consist of the preparation of the mine refuse subgrade and the placement and compaction of the earth cover materials to the required elevation and cross section as shown on the plans and in accordance with the following requirements.

Article 207.02 Equipment

Equipment used shall conform to the following requirements.

A. Tamping-Type Roller shall consist of one or more cylindrical sections having studs or feet projecting not less than 6 ½ inches from the surface of the drum. The number of tamping feet and the area of feet shall be such that the pressure on a single row of feet approximately parallel to the axis of the drum is not less than 200 p.s.i. when supporting the weight of the roller.

B. Discs:

1. Tandem Axle — Disc Harrow. The disc harrow shall be the tandem type and shall meet the approval of the Engineer prior to its use. The disc shall be of sufficient size and weight to perform the tillage required. It shall contain all of the manufactured parts or replacement parts.

2. Single Axle Disc. The single axle disc shall be the off-set type and meet the approval of the Engineer prior to its use. The disc shall be of sufficient size and weight to perform the tillage required. It shall contain all of the manufactured parts or replacement parts.

Article 207.03 Preparation of the Subgrade for Earth Cover

When the mine refuse has been graded to the subgrade shown in the plans, MINE REFUSE TREATMENT -LIMESTONE shall be performed on the subgrade in accordance with Section 221 of these Special Provisions. The subgrade shall then be compacted with a roller until the tamping feet of the roller penetrate not more than two inches into the subgrade or to the satisfaction of the Engineer.

Article 207.04 Placing Earth Cover Material

All earth materials to be used for covering the mine refuse shall be compactable and develop a stability satisfactory to the Engineer. No rock, stones, broken concrete, frozen material or any material which, by decay or otherwise, might cause settlement, shall be placed or allowed. Sufficient earth cover shall be provided to account for shrinkage from compaction to attain the final lines, grades, and cross—sections shown in the plans.

Each layer of earth material shall extend over the entire area of mine refuse being covered. The material shall be leveled by means of bulldozers, blade graders or other equipment approved by the Engineer. Each layer shall be not more than eight inches thick when in loose condition, shall be uniform in cross-section, and shall be thoroughly compacted before the next layer is started.

The use of drag-line excavators or similar equipment which excavate and deposit material in large unit masses will not be permitted, unless all materials excavated in this manner are spread as provided herein and compacted as required in Article 207.05, or as directed by the Engineer.

Article 207.05 Compaction

Each layer of earth material except for the top twelve inches shall be disced sufficiently to break down oversized clods, mix the different materials, secure a uniform moisture content, and ensure uniform compaction. A discing shall consist of a complete coverage of the layer with either a tandem-axle disc or a single-axle disc. The disc shall be so designed and operated to cut and stir to the full depth of the layer. If wet earth or soils are encountered, the Engineer may require additional discings with intervals up to two hours between them to reduce the moisture content.

Each layer of the earth material except for the top twelve inches shall be compacted by a roller making one pass over the layer for each inch of loose earth material in the layer. The layer will be considered compacted when the tamping feet of the roller penetrates not more than three inches into an eight inch lift or one-third of the depth of the layer being placed.

The earth cover material shall be sprinkled with water when it is necessary to increase the moisture content of the soil to achieve the required compaction. This will not be paid for directly but shall be considered as incidental to the various items of excavation.

Compacting equipment and compacting operations shall be coordinated with the rate of placing the earth materials so that the required compaction is obtained.

Article 207.06 Method of Measurement

Mine Site Compaction will not be measured for payment.

Article 207.07 Basis of Payment

No compensation will be allowed for delays occasioned by the order of discing or for any additive applied. Mine Site Compaction will not be paid for directly but shall be considered as incidental to Section 202: ABANDONED MINE SITE EXCAVATION and the cost of their construction shall be included in the unit prices bid for these items.

End of Revision to SECTION 207:MINE SITE COMPACTION

Appendix - Attachment #2

Superior Coal Company #4
Macoupin County, Illinois
AML-GMpE-8811

SECTION 225: SEEPAGE BARRIER TRENCH — (add this Section)

Article 225.01 Description

This item shall consist of excavating seepage barrier trenches and installing a bentonite liner as shown in the plans and specified herein.

Article 225.02 Materials

The bentonite liner shall be Claymax LC as manufactured by Clem Environmental Corporation of Fairmont, Georgia or equal. The bentonite liner shall conform to the following requirements:

TYPICAL PRODUCT SPECIFICATION

Bentonite Content	1.0 lbs per square foot Liner
Thickness	1/4 inch
Liner Dimensions	13.5 feet x 82 feet
Effective Area Covered	1059.5 square foot (assume 6" overlap along one side and one end).
Roll Weight/Unit	1130 lbs. (minimum)
Permeability Coefficient	1X10-9cm per second @ 35' head pressure

PRIMARY BACKING — MATERIAL SPECIFICATIONS

Color	Natural White
Fiber Filler	Nylon
Substrate	24 x 10 delustered woven polypropylene non-toxic, water permeable
Weight	4 oz. per square yard
Tensile Strength	78 lbs. per square inch (minimum)
Grab Strength (ASTM D-1682)	Warp 95 lbs., Fill 70 lbs.
Mullen Burst Strength (ASTM-774)	250.25 lbs. per square inch
Puncture Strength (5/16" mandril ASTM D-3787 MOD.)	249 lbs.
Melting Point	329 degrees F.
Elongation (ASTM D-1682)	Warp 15%, Fill 18%
Shrinkage	
Hot Water	Nil
Dry (20 min. @ 270 degr F)	2%
Cover Fabric	100% spunlace polyester; open weave allows for expansion of bentonite
Weight	1 oz. per square yard
Grab Strength	Warp 30 lbs., Fill 13.6 lbs.
Burst Strength	35 lbs. per square inch
Bentonite (Sodium Montmorillonite)	
Sizing	Specially graded, 6 mesh and 30 mesh granules
Mineralogical Composition	90% Montmorillonite (minimum)
Adhesive	Water soluable, non-toxic
Storage	On ground under roof or protective covering

Article 225.03 Installation Requirements

a) The seepage barrier trench and upper locking trench shall be excavated in the field as staked by the Engineer.

b) The trenches shall be excavated to the dimensions shown in the plans Suitable material excavated from the trenches shall be used to backfill the same.

c) The bentonite liner shall be placed in the trench as shown in the plans and temporarily secured for the placement of suitable backfill to the satisfaction of the Engineer.

d) All trench excavation shall be well contoured and free of all vegetation., protrusions, and rocks larger than 2 inches in diameter.

e) All bentonite liners shall be locked into the trenches at the top and bottom of the slopes, covered with fill and compacted to prevent slippage. Both trenches shall be excavated to the dimensions shown in the plans.

f) All bentonite liners shall be pulled tight to smooth out creases or irregularities. The liner shall be installed with the polypropylene side up. All seams must be overlapped 6" and stapled or pinned to the base soil to prevent seam openings during the installation process. All dirt and foreign material shall be removed from the over1ap area of the liner.

g) The bentonite lining shall not be installed in standing water or while heavy rain is falling. The contractor will be responsible for pumping any water in the trench which shall be considered incidental to the trench excavation.

h) Upon completion of work at the end of the day, no open trench shall remain. Article 225.04 Method of Measurement

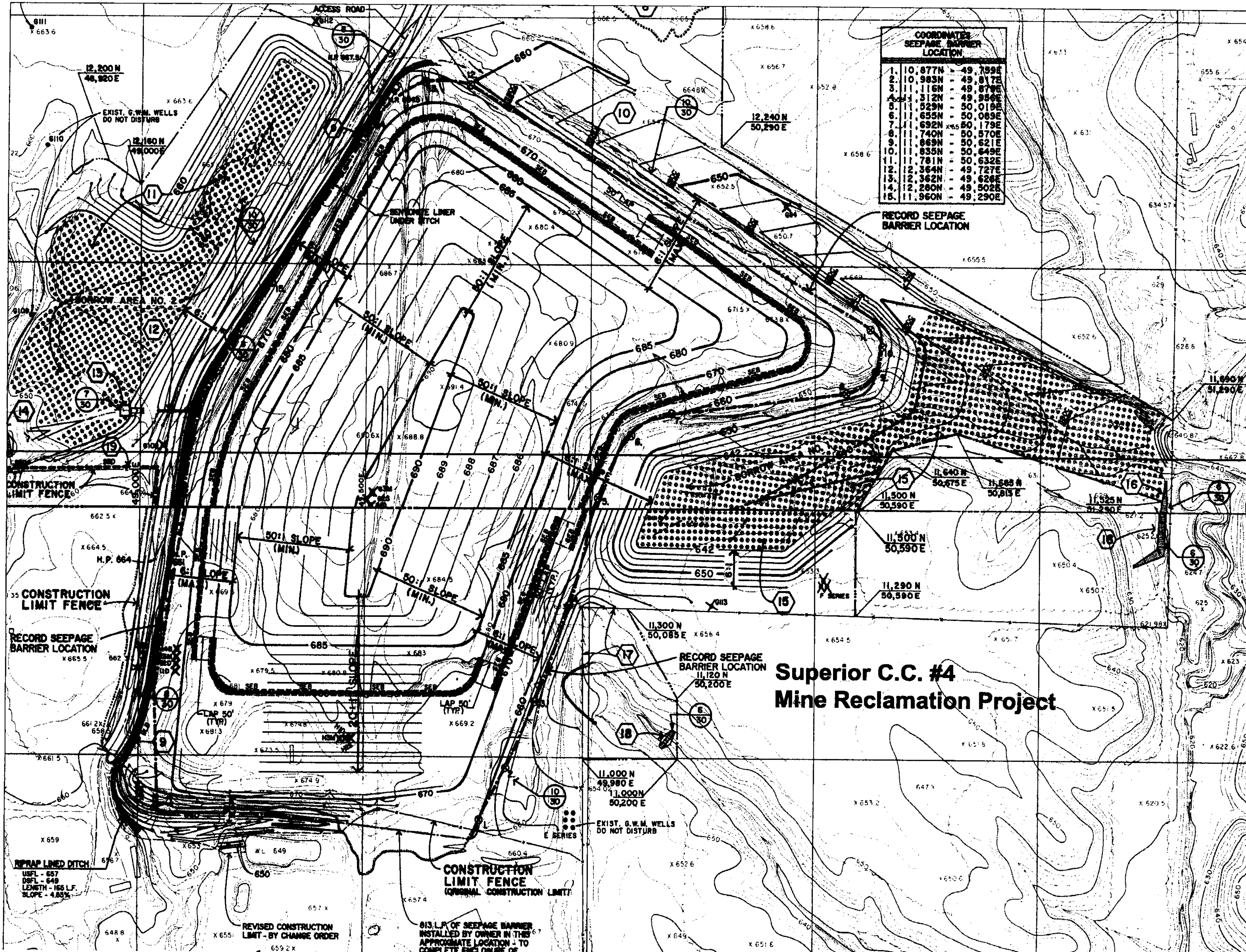
 a) Bentonite liner shall be measured in square feet of actual material used.

 b) Seepage barrier trench excavation shall be measured in lineal feet when excavated as shown in the plans. The upper locking trench will not be measured for payment.

Article 225.05 Basis of Payment

The seepage barrier trench and bentonite liner will be paid for at the contract unit prices per square foot for BENTONITE LINING and per lineal foot for SEEPAGE BARRIER TRENCH EXCAVATION, measured as specified herein. The upper locking trench will not be paid for directly but shall be considered as incidental and included in the contract unit price for SEEPAGE BARRIER TRENCH EXCAVATION.

End of Revisions to Section 225: SEEPAGE BARRIER TRENCH
End of Revisions to SECTION 200: EARTHWORK



COORDINATES SEEPAGE BARRIER LOCATION

1.	10,877N - 49,759E
2.	10,983N - 49,817E
3.	11,116N - 49,879E
4.	11,312N - 49,956E
5.	11,529N - 50,019E
6.	11,655N - 50,089E
7.	11,692N - 50,179E
8.	11,740N - 50,570E
9.	11,869N - 50,621E
10.	11,835N - 50,649E
11.	11,781N - 50,632E
12.	12,364N - 49,727E
13.	12,362N - 49,626E
14.	12,280N - 49,502E
15.	11,960N - 49,290E

Superior C.C. #4
Mine Reclamation Project

CONSOLIDATED COAL CO. MINE #7
Staunton, IL

The Consolidated Coal Company of St. Louis operated this underground room and pillar mine from 1881 until 1952. Total production was approximately 19 million tons of coal. The mine operated in the 7 foot thick Herrin (#6) seam at a depth of 350 feet. When mining operations ceased, two large areas of acidic mine waste were left at the site (Fig. 1). The first, consisting of about 30 acres of spoil graded to form three low hills, called the "old" area, was reclaimed in the late 1960's by the Illinois Department of Transportation in association with construction of Interstate 55. This area was covered with 0.5 feet of non-acidic soil and contained a 1.5 acre acidic pond at its northern edge adjacent to the interstate. The IDOT reclamation stabilized the piles and provided a vegetative cover of grasses and shrubs. The second, or "new", un-reclaimed area directly to the southwest was a 135 foot high gob (coal processing waste) pile covering 16 acres. The pile was devoid of vegetation and contributed large amounts of acidic sediment to a tributary of Cahokia Creek located several miles to the south. The outlet, which still exists (Fig. 2), directs acid mine drainage through a box culvert under the railroad tracks to a settling pond and spillway about ½ mile to the west. As with most gob, this pile is extremely heterogeneous, containing 60-80% sand, 20-30% silt, and up to 10% clay. It has an inorganic sulfur content of 1 to 3% and very little neutralization potential in the form of carbonates. Hydraulic conductivities of similar gob from nearby sites range from 10^{-3}cm/s to 10^{-7}cm/s.

The Abandoned Mined Lands Reclamation Division (now part of the IL Department of Natural Resources) began reclamation of the "new" area in 1983 and continuing through 1986. The main effort was to re-grade the pile to lower slopes, improve drainage and provide enough soil cover to establish and maintain vegetation (Fig. 2). Re-grading involved moving about 265,000 c.y. of gob in cut and fill operations. Roughly 50,000 c.y. of borrow soil was excavated at the southwest edge of the site to provide an18 inch thick cover. The borrow pit is now an acid pond with a large AMD seep along its north side. In order to drain the ponded water in the "old" area at the north end of the site adjacent to Interstate 55, a 1260 ft. long 12" PVC pipe was buried up to 12 feet deep in a trench running southwest along the railroad ROW and exiting near the box culvert under the railroad. Although this pipe still has a continuous discharge, it has not succeeded in draining the acidic pond and its discharge has caused erosion of the pile near its outlet.

The 1983-1986 reclamation resulted in major improvements at the site. A good vegetation cover was established, drainage was improved via redirection of surface runoff through limestone riprap-armored channels, and acidic sediment transport off-site was almost eliminated. By the early to mid 1990's, however, the site began to develop serious AMD problems. A large, ½ acre size seep developed on gently sloping land along the southeast boundary adjacent to "old" Route 66. This seasonally active seep discharged an average of 10 gpm of AMD into a drainage ditch that crosses residential properties and active farmland. All other drainage from the site, an average of 70 gpm, exits to the northwest through the box culvert under the railroad. Two other large seeps developed as seepage faces in eroded mine spoil, one at the northeast corner of the borrow pond, the other in a low area adjacent to the box culvert. All of the seeps are active from a few days to a few weeks following large precipitation events. In addition, AMD seepage from the south and west sides of the toe of the reclaimed gob pile into adjacent drainage cuts is active during periods of high water table (Fig. 5). During dry periods, the only discharge from the site is from the buried drainage pipe, which is below the local (perched) water table (Fig. 4).

In 2001, the AML installed 9 groundwater monitoring wells, 7 piezometers and two v-notch weirs at the site to better understand its hydrology. Well water levels and weir discharges were measured at regular weekly intervals. Water quality sampling was performed at least quarterly for about one year. Previous investigations at this site indicated that the water table near the base of the main pile is semi-perched, and downward migration of contaminated groundwater into the low hydraulic conductivity till layer underneath is very limited. This is also shown by water quality results from monitoring wells #8 and #9 (Table 1).

WEIR DISCHARGES

Two v-notch weirs were installed to measure total runoff from the site. A small weir measured discharge from the large but intermittent seep along "Old" Route 66. The other, larger weir was installed downstream from the box culvert through which approximately 80% of site runoff flows. There was no flow through the small weir for about half the year. Periods of discharge closely corresponded with monthly precipitation totals, with a peak flow of 53 gpm in March, 2001. The feeder seep is a result of water table fluctuations between 649 ft. and 651 ft. at this location. The larger weir measured positive flows year-round, ranging from 2 gpm to 387 gpm. At low flows the buried drainage pipe supplies almost all discharge. At higher flows, 3 discrete seeps and widespread toe seepage become active around the southern and western fringes of the pile (Fig. 5). The largest seep, adjacent to the box culvert, is activated at groundwater elevations above 646 ft.

Water elevation changes in the monitoring wells and piezometers reflect discharge changes at the weirs with a lag time of a few days to a week or more. After wet periods a groundwater mound of ~4 ft. height develops at the base of the pile. The mound gradually flattens to ~1 ft. during dry periods (Fig. 3).

WATER QUALITY

Subsurface water samples were collected from the monitoring wells and surface samples at both weirs and the exit point of the underground drainage pipe. The results are summarized in Table 1. Well #9 was screened in the underlying till and shows generally good quality. All other wells were screened in mine spoil and are highly contaminated with AMD, with pH's ranging between 2 and 5. Acidities in these wells and the surface sampling points average ~4000 mg/l. Iron (1000 mg/l) and aluminum (100 mg/l) concentrations are consistently high. Sulfates vary widely from point to point and temporally, but are generally in the 5000 to 15,000 mg/l range. Water quality in the contaminated wells and at the two weirs has a roughly inverse correlation with water table elevations and weir discharges. This suggests that groundwater residence time within the pile is the main determinant of water quality in the wells.

During low water periods, many of the seep areas around the toe of the pile are inactive. Inactive seeps and drainage-ways contain a patchy coating of yellowish to white, poorly crystallized iron and aluminum sulfate salts. These salts are formed from evaporation of AMD and are highly soluble. When seepage is reactivated, the salts dissolve and produce a "slug" of H^+ acidity which rapidly moves off-site to a farm field and to Cahokia Creek. With further water table rise, the water quality improves slightly.

STOP 1: Southeast Seep

Perched water table
Water table fluctuations (maps)
Weir discharge
Water quality
Downstream impacts

STOP 2: Box Culvert

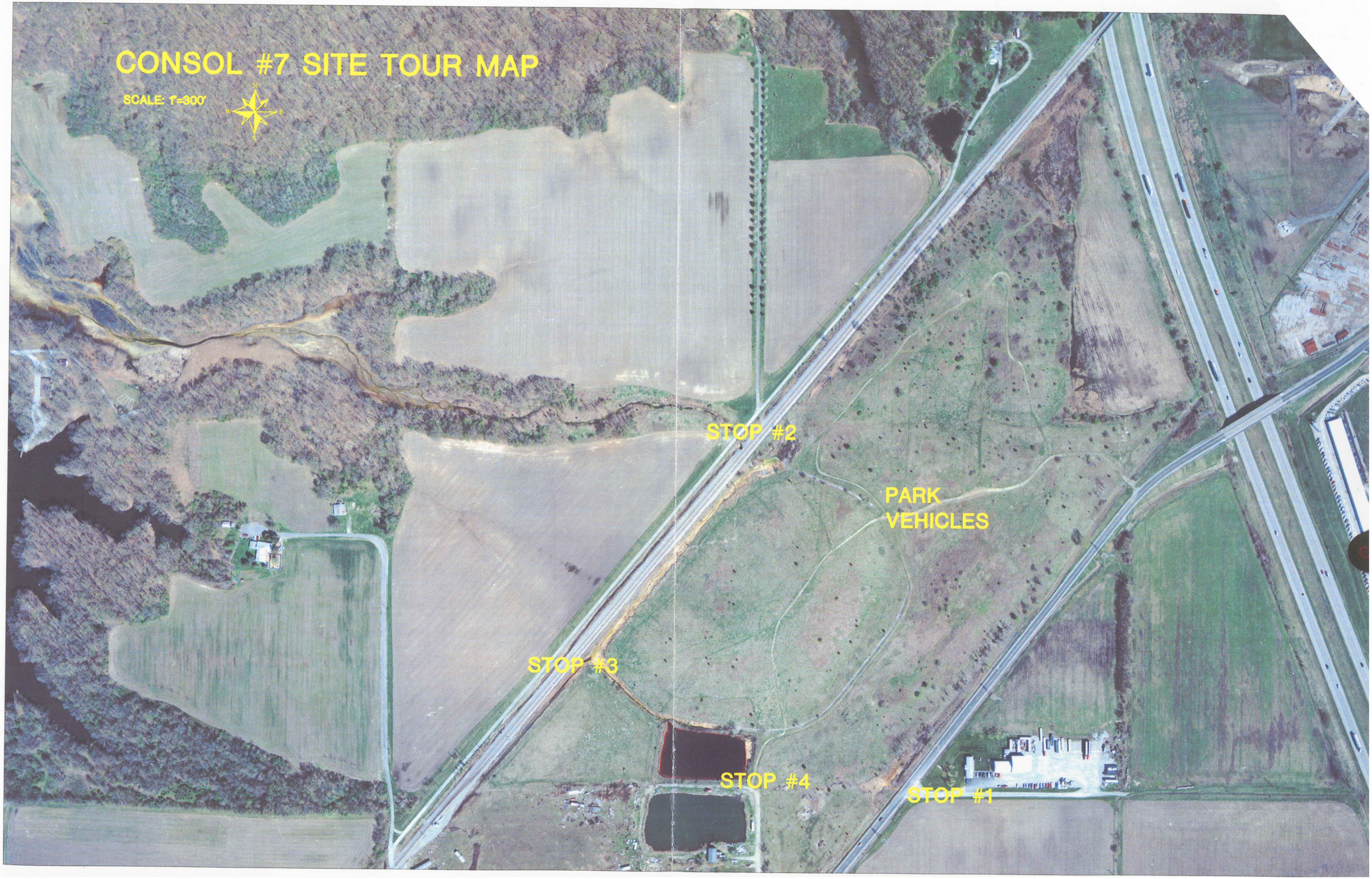
AMD drainage paths & recharge areas
Buried pipe
Perennial seep
Weir discharge
Water quality
Downstream impacts

STOP 3: Drainage Confluence

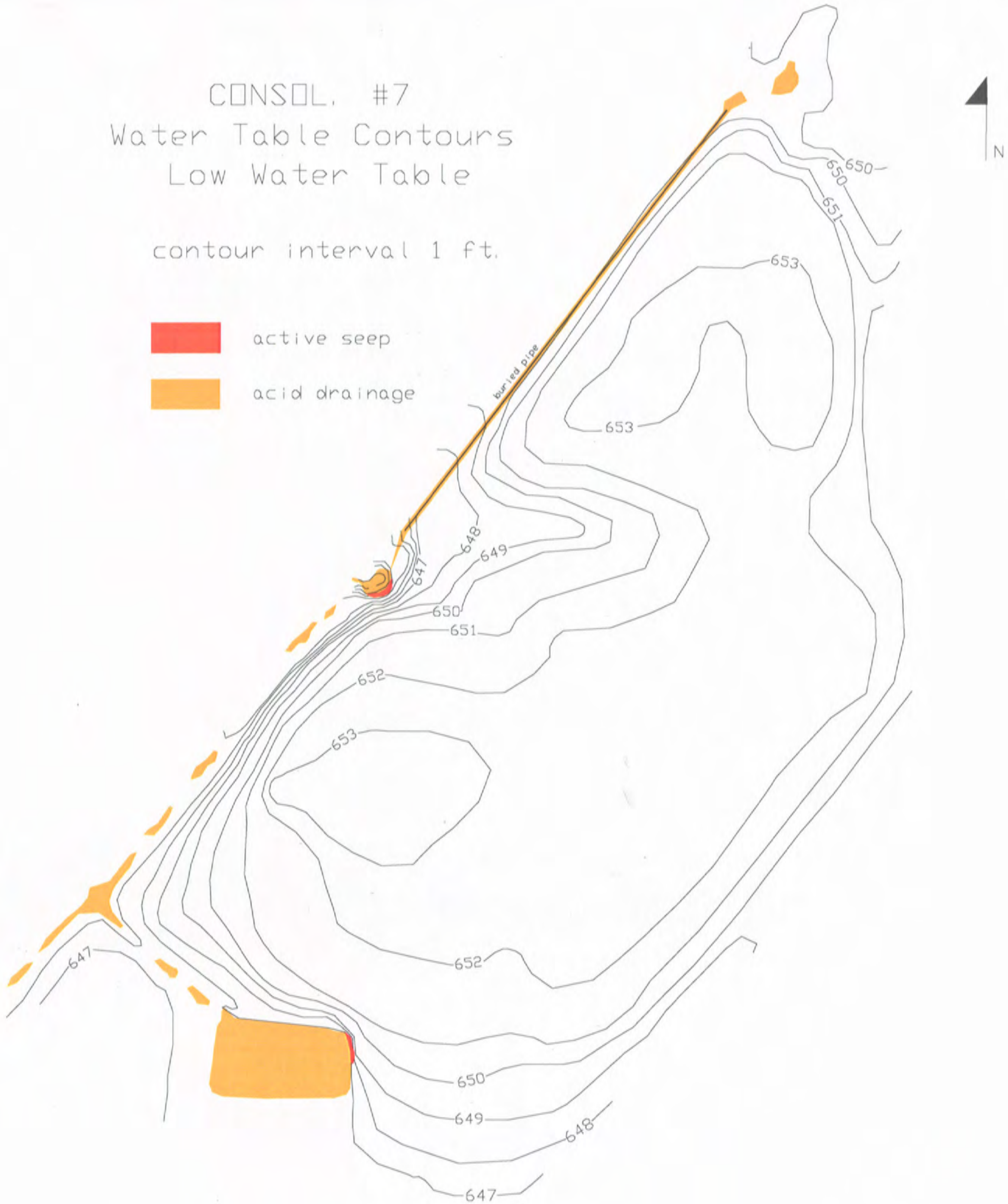
AMD sources
Acid sulfate salts, acid "slugs"
Perched WT & toe seepage (X-section)

STOP 4: Acid Pond

Origin
AMD sources
Failed rip-rap drainage-ways
Conclusions

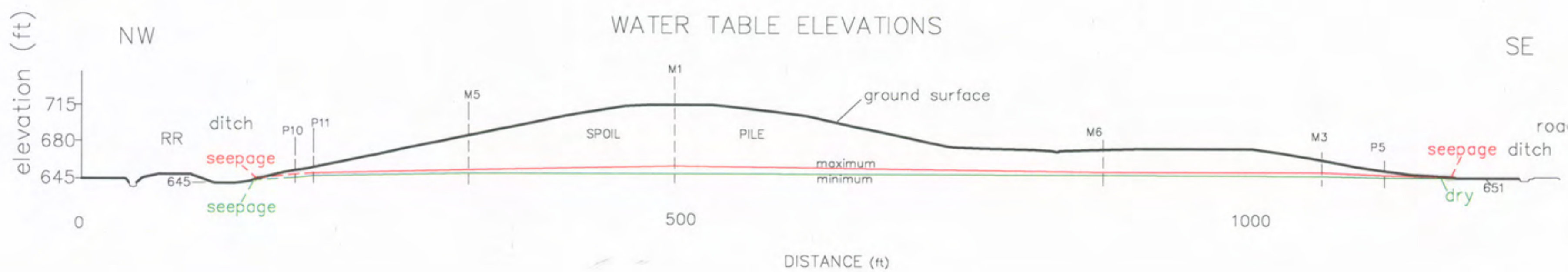

CONSOL #7 SITE TOUR MAP
SCALE: 1"=300'
STOP #2
PARK
VEHICLES
STOP #3
STOP #4
STOP #1


N
S4
M8
M9
M7
DP
P12
P6
P8
P1
P9
P10
P11
M6
P2
M1
P7
P3
M2
M4
M3
P5
P4
S2
S1
CONSOLIDATED COAL CO. #7
SCALE : 1"=50'
50' 0 50'100'
CONTOUR INTERVAL 1 FOOT
ACID POND
ACID DRAINAGE
ACID SEEPS
NON-ACID POND
P PIEZOMETER
M MONITORING WELL
S SURFACE SAMPLING POINT
DP DRAINAGE PIPE EXIT
WEIR

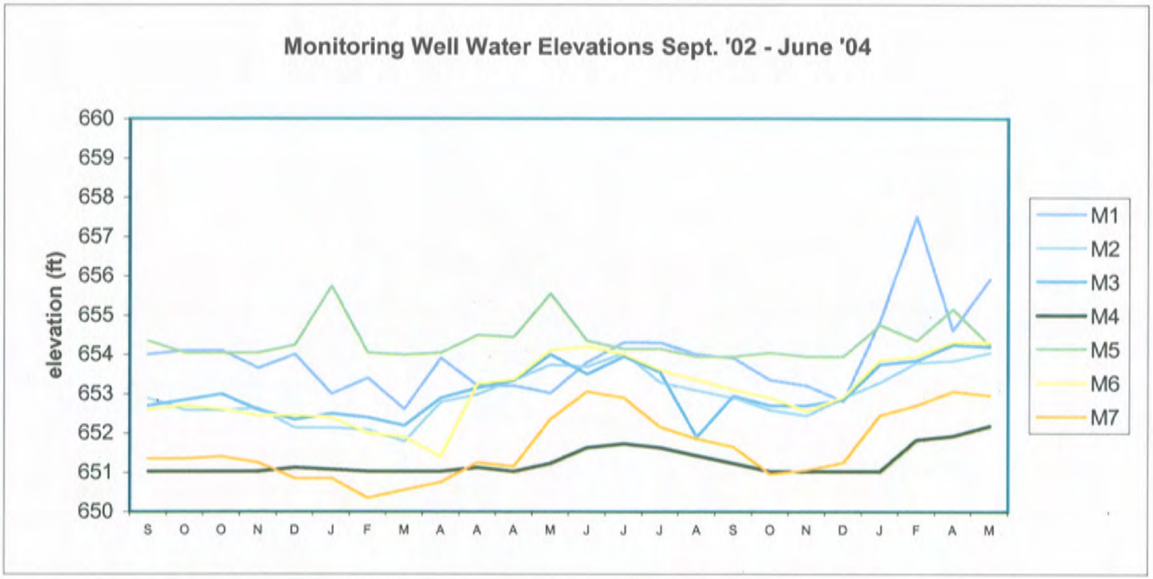


CONSOL. #7
Water Table Contours
Low Water Table
contour interval 1 ft.
active seep
acid drainage
N
buried pipe
650
650
651
653
653
648
649
647
650
651
652
653
652
647
650
649
648
647

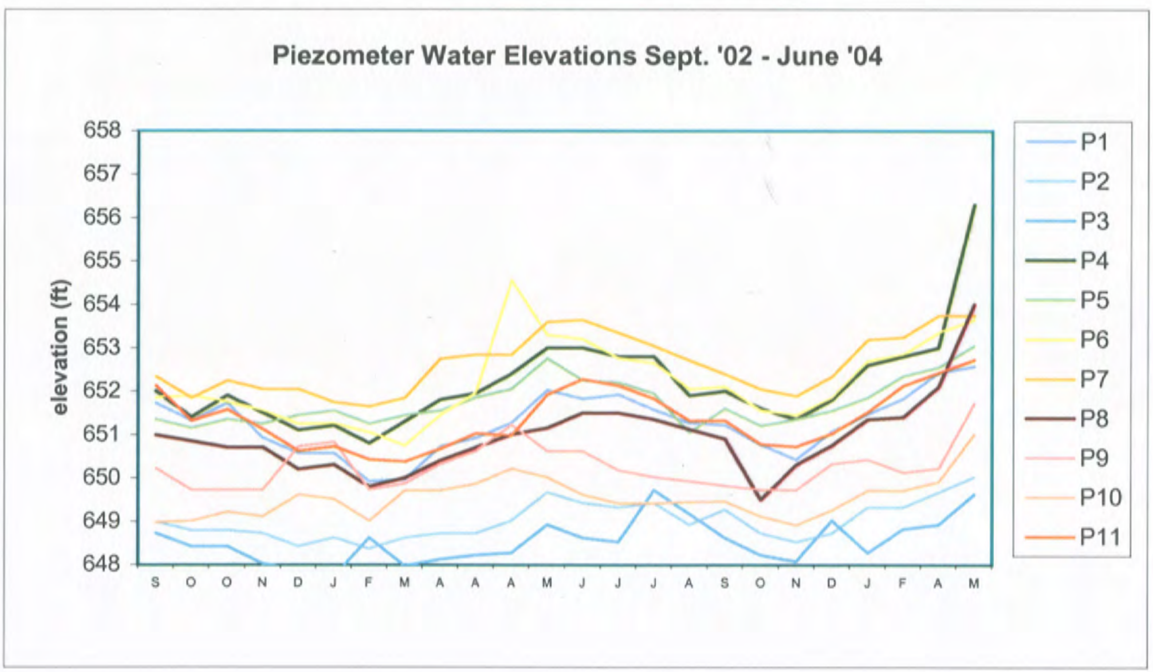

CONSOL #7
Water Table Contours
High Water Table
contour interval 1 ft.
active seepage
acid drainage
acid pond
buried pipe
acidic
N



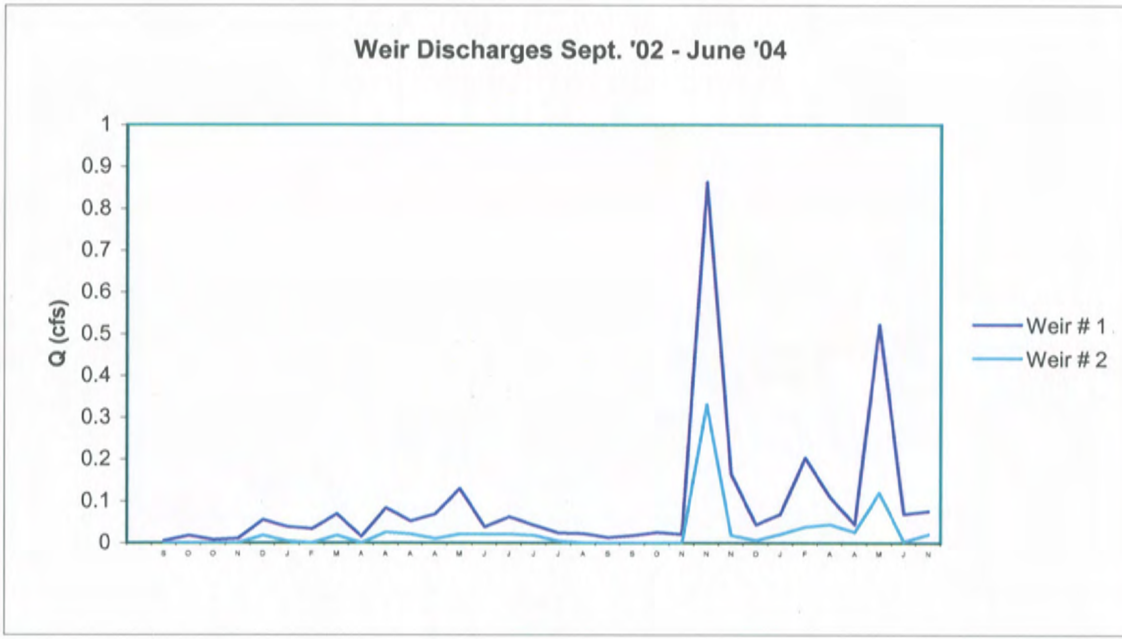
WATER TABLE ELEVATIONS
NW
SE
elevation (ft)
715
680
645
RR
ditch
seepage
645
seepage
P10
P11
M5
M1
SPOIL
PILE
ground surface
maximum
minimum
M6
M3
P5
road
seepage
ditch
dry
651
0
500
1000
DISTANCE (ft)



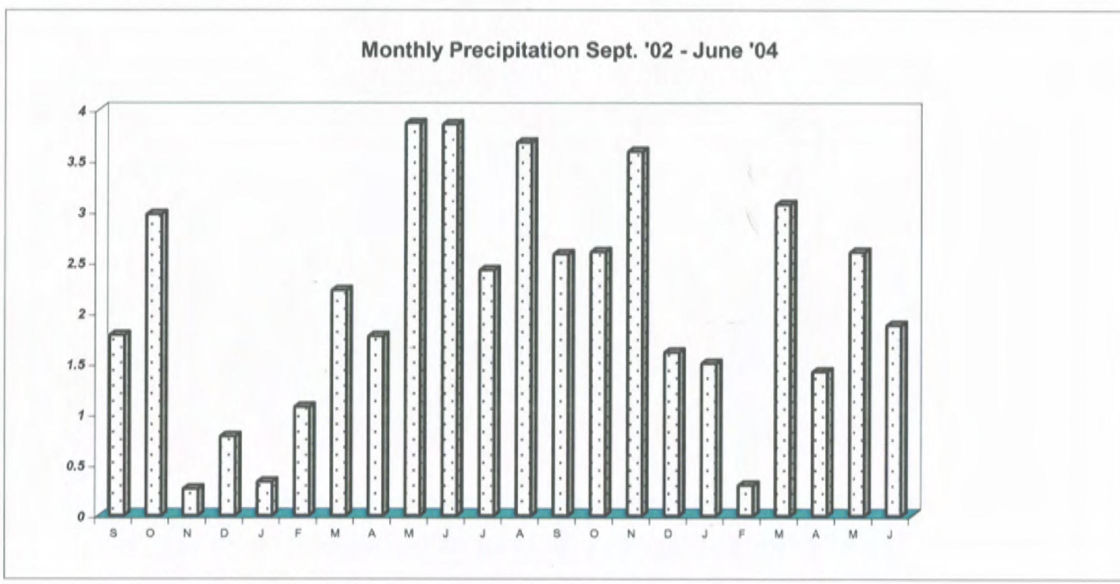
Monitoring Well Water Elevations Sept. '02 - June '04
660
659
658
657
656
655
654
653
652
651
650
elevation (ft)
S O O N D J F M A A A M J J J A S O N D J F A M
M1
M2
M3
M4
M5
M6
M7



Piezometer Water Elevations Sept. '02 - June '04
658
657
656
655
654
653
652
651
650
649
648
elevation (ft)
S O O N D J F M A A A M J J J A S O N D J F A M
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11

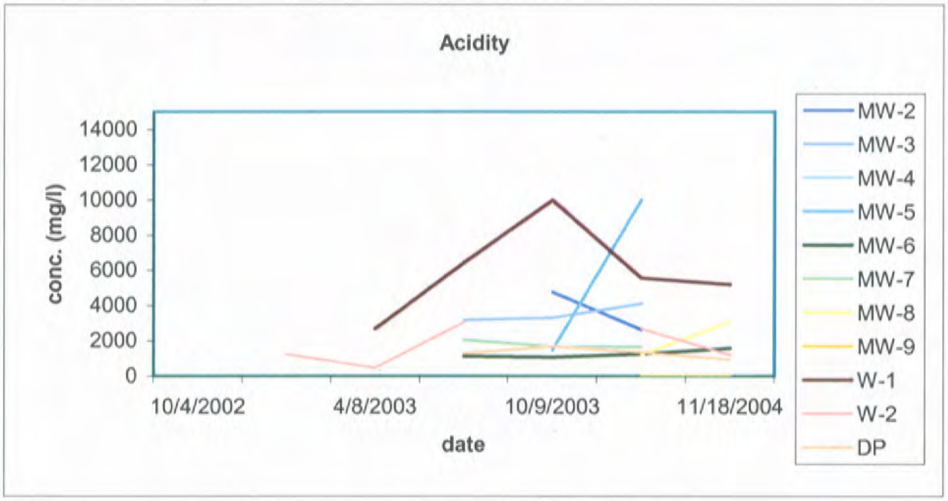


Weir Discharges Sept. '02 - June '04
Q (cfs)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Weir # 1
Weir # 2

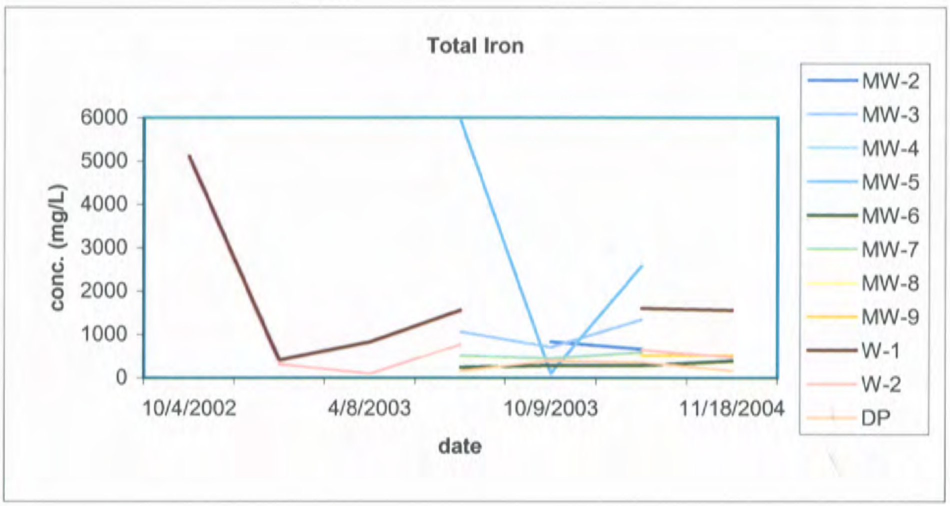


Monthly Precipitation Sept. '02 - June '04
4
3.5
3
2.5
2
1.5
1
0.5
0
S O N D J F M A M J J A S O N D J F M A M J

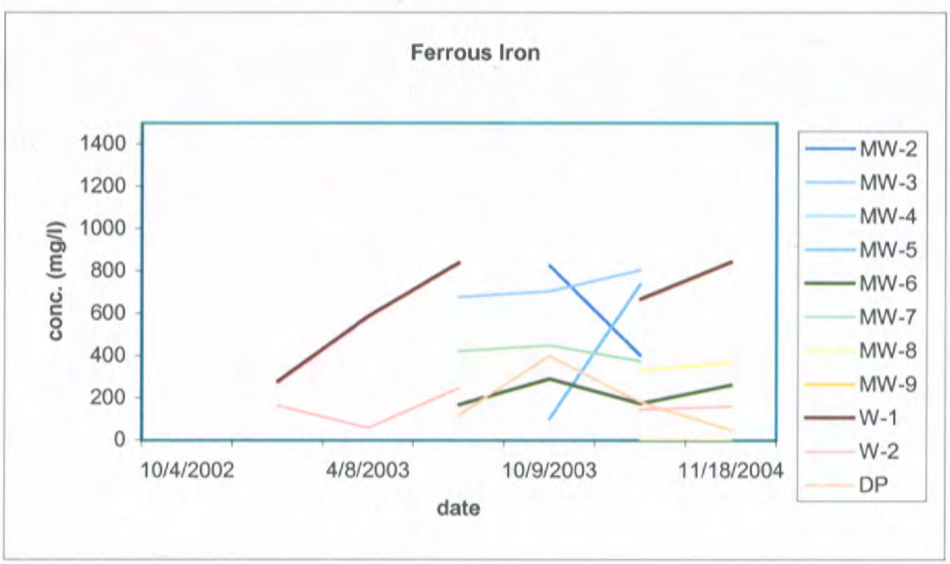
Ionic Concentrations



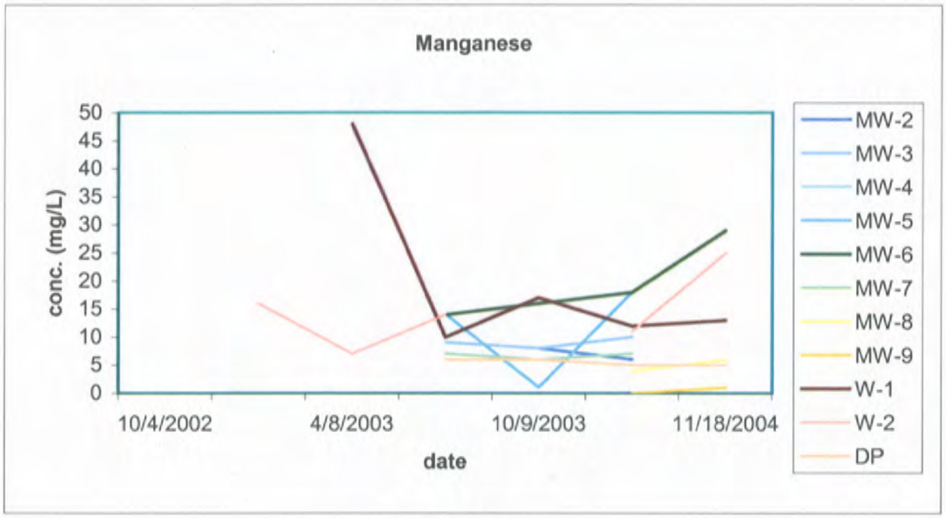
	max.	min.	avg.
M2	5235	2620	4101
M3	4100	2381	3235
M4			5500
M5	10000	1460	5730
M6	1250	617	1017
M7	2040	1480	1712
M8			1220
M9	15	0	7
W1	12990	2688	7839
W2	3060	481	1871
DP	1700	1300	1478



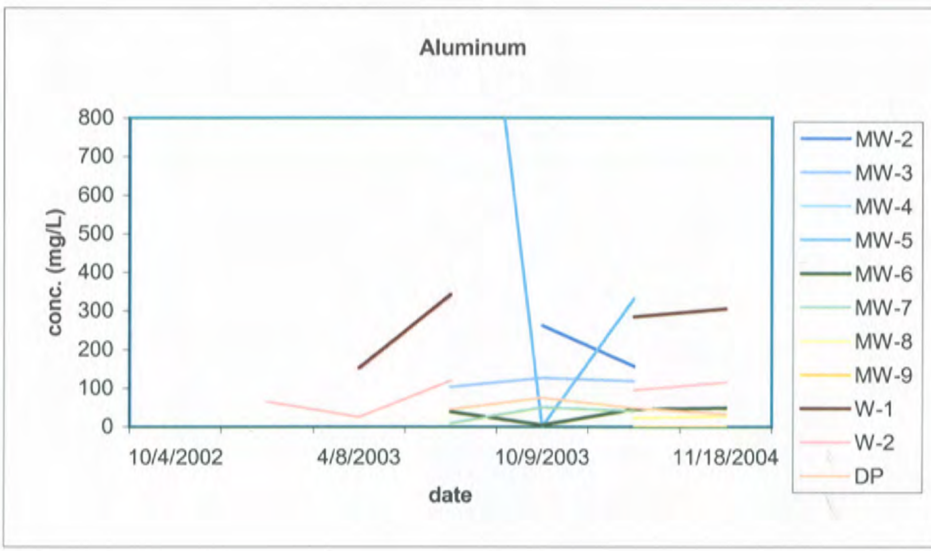
	max.	min.	avg.
M2	2931	662	1473
M3	1387	705	1123
M4	7630	1720	4675
M5	5920	101	2867
M6	292	248	277
M7	1473	449	755
M8			523
M9			0
W1	5113	415	1905
W2	769	104	458
DP	401	162	309



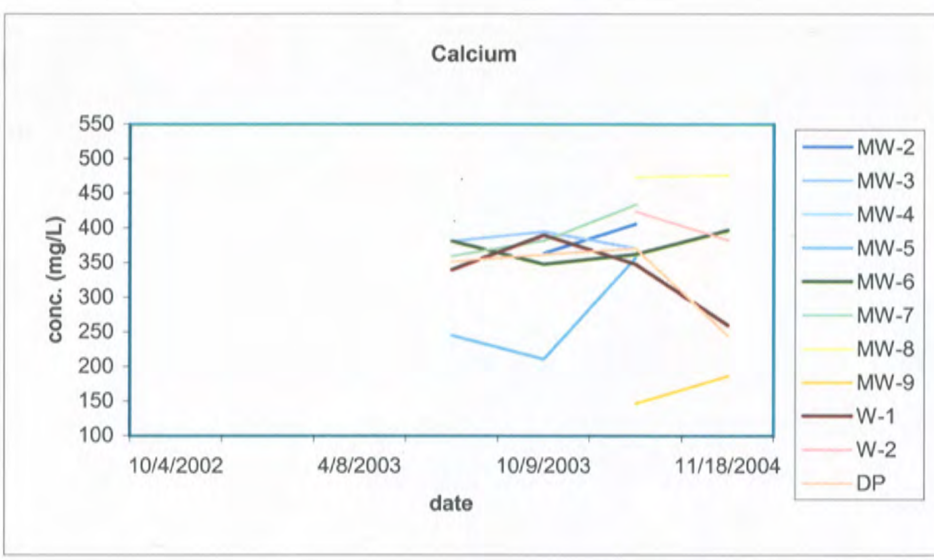
	max.	min.	avg.
M2	826	402	614
M3	805	678	729
M4			1040
M5	738	101	420
M6	291	168	211
M7	449	376	416
M8			335
M9			0
W1	840	278	594
W2	248	60	155
DP	401	121	234



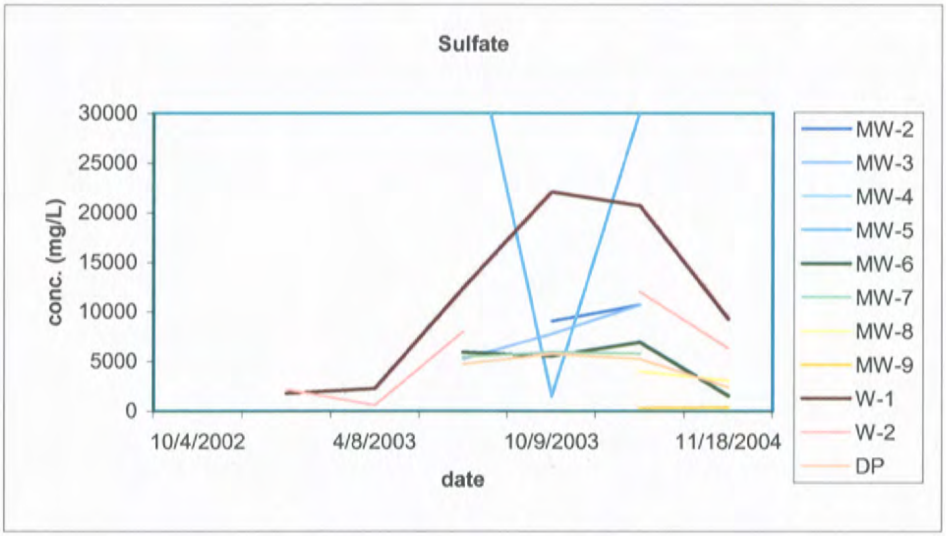
M2	8	6	7
M3	10	8	9
M4	33	13	23
M5	18	1	11
M6	18	14	16
M7	7	6	7
M8			4
M9			0
W1	48	10	22
W2	16	7	12
DP	6	5	6



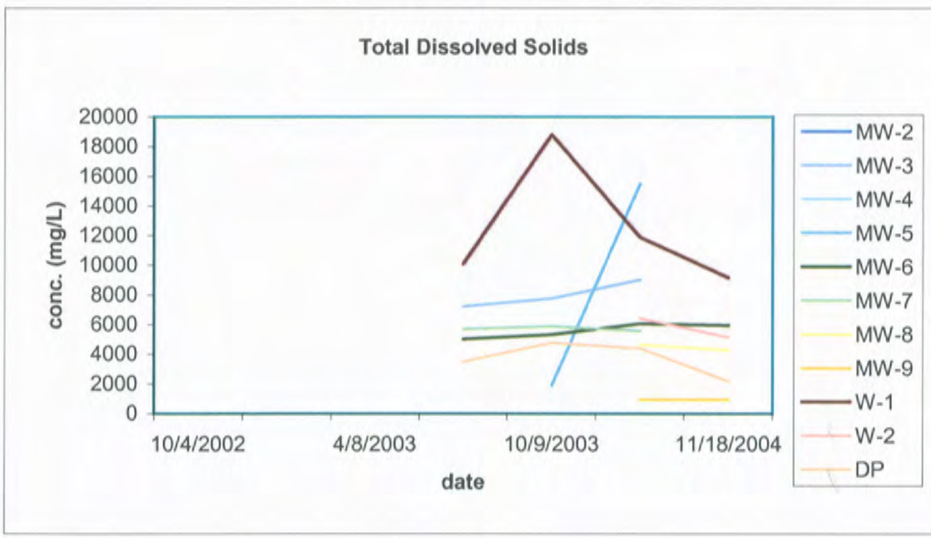
M2	262	156	209
M3	126	103	116
M4	1900	236	1068
M5	1930	1	764
M6	46	5	27
M7	51	9	34
M8			24
M9			0
W1	343	153	260
W2	120	26	77
DP	76	46	57



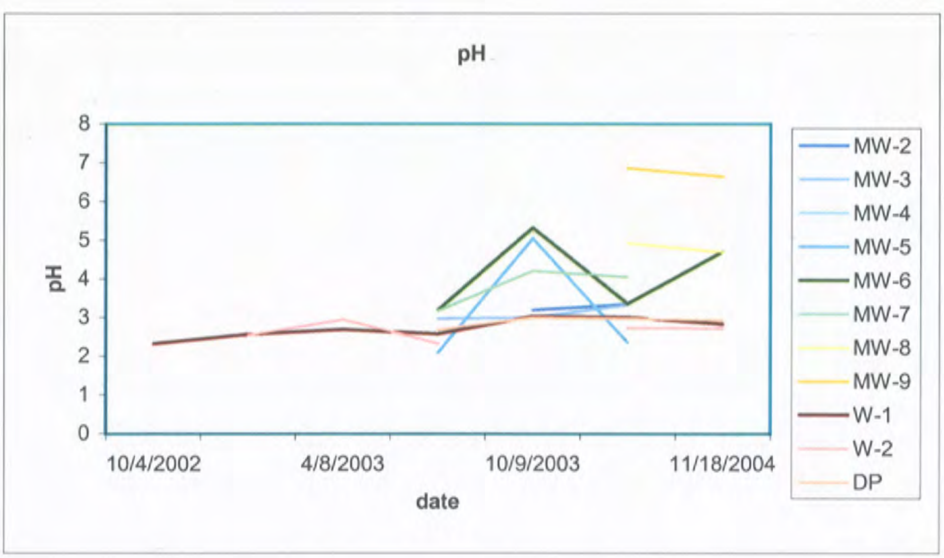
M2	406	364	385
M3	395	371	382
M4	424	332	378
M5	357	211	271
M6	397	348	372
M7	434	360	392
M8	477	474	476
M9	187	147	167
W1	390	260	334
W2	424	361	389
DP	371	245	332



M2	10700	9040	9870
M3	10700	5240	7893
M4	39900	14300	27100
M5	42400	1460	24720
M6	6940	1540	4977
M7	5950	5460	5733
M8	4030	3090	3560
M9	414	364	389
W1	22100	1800	11435
W2	12000	600	5828
DP	5750	2420	4545



M2			6960
M3	9020	7210	7796
M4	39000	10900	24950
M5	15500	1880	8690
M6	6070	5030	5595
M7	5900	5570	5723
M8	4670	4320	4495
M9	976	976	976
W1	18800	9170	12492
W2	6730	5150	6103
DP	4790	2220	3738

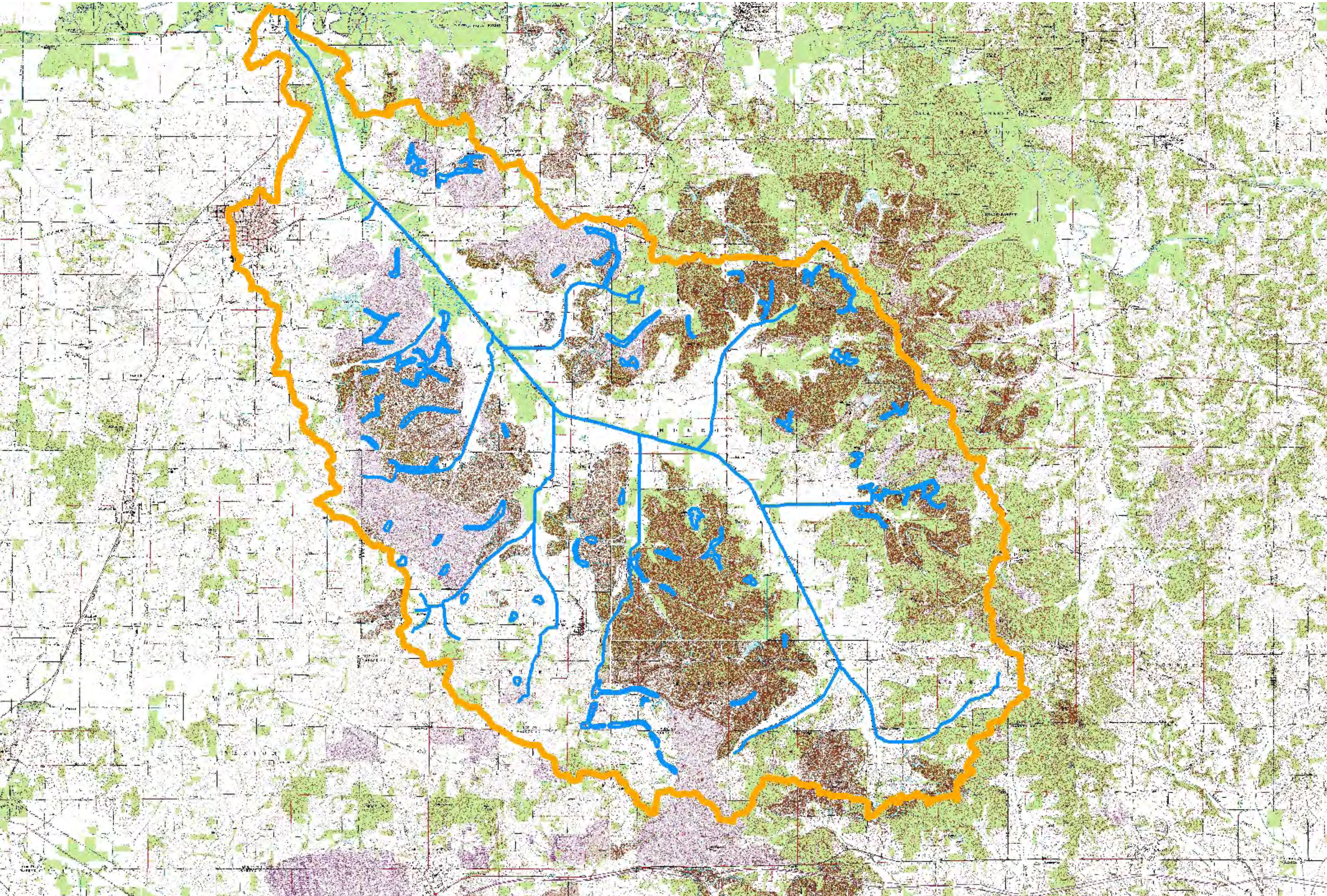


M2	3.35	1.95	2.83
M3	3.33	2.01	2.83
M4	2.8	2.79	2.8
M5	5.05	2.1	3.17
M6	5.32	2.15	3.75
M7	4.21	2.27	3.43
M8	4.94	4.7	4.82
M9	6.87	6.65	6.76
W1	3.04	2.33	2.72
W2	2.96	2.34	2.67
DP	3.01	2.7	2.91

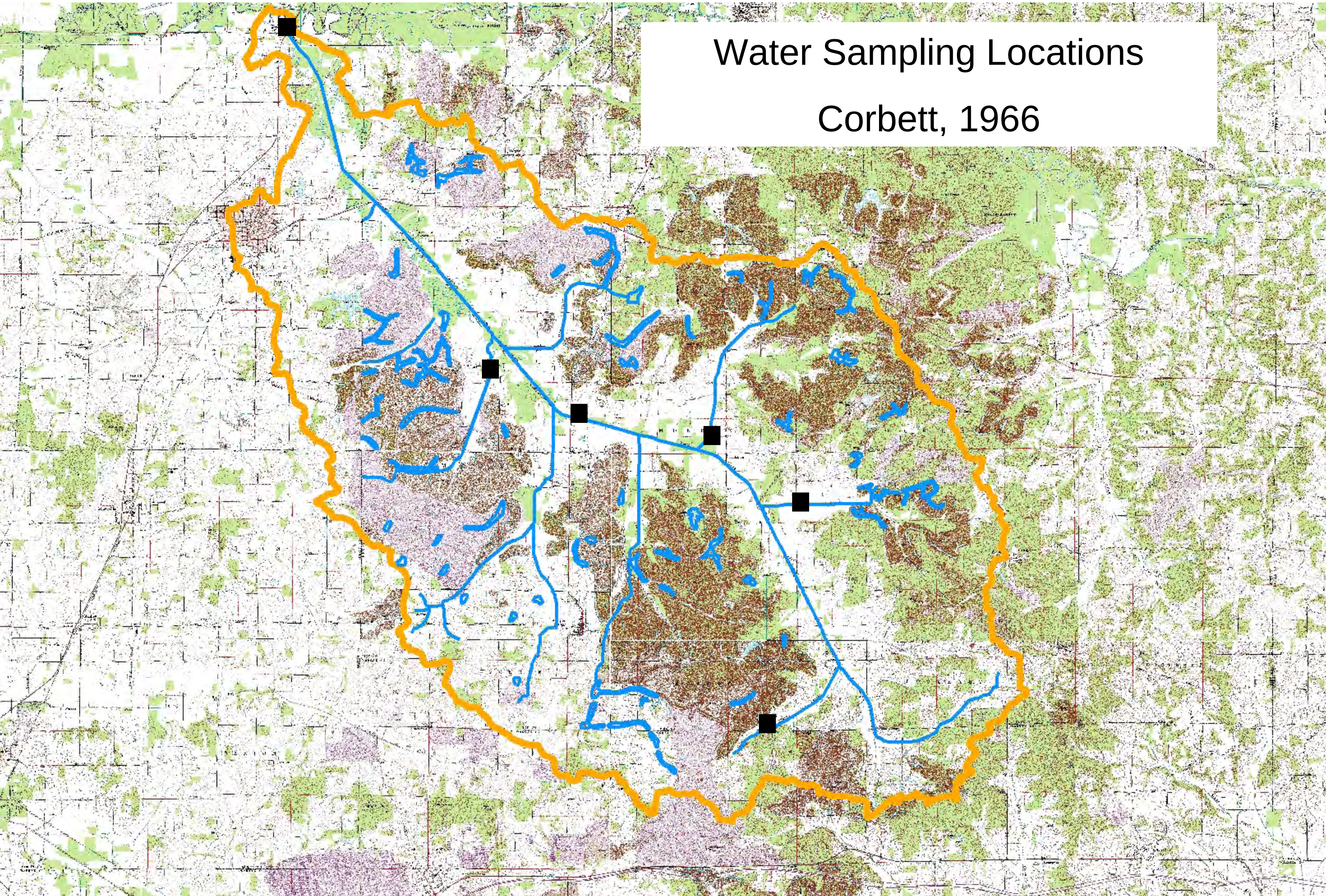
AML Reclamation Activities, Past, Present and Future, in the South Fork Patoka River Watershed

Mark Stacy CEP, Environmental Specialist, Indiana AML Program

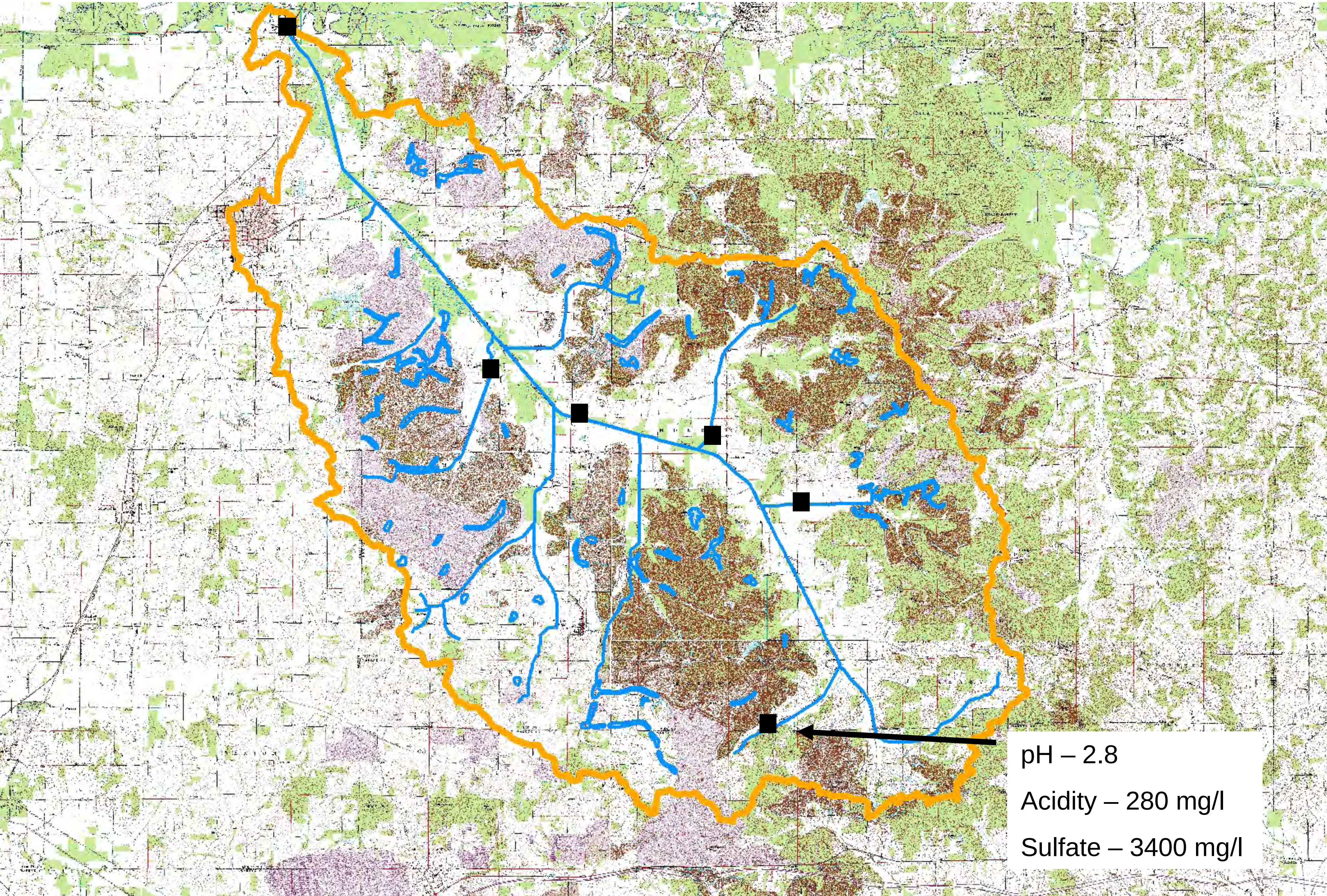
South Fork Patoka River Watershed



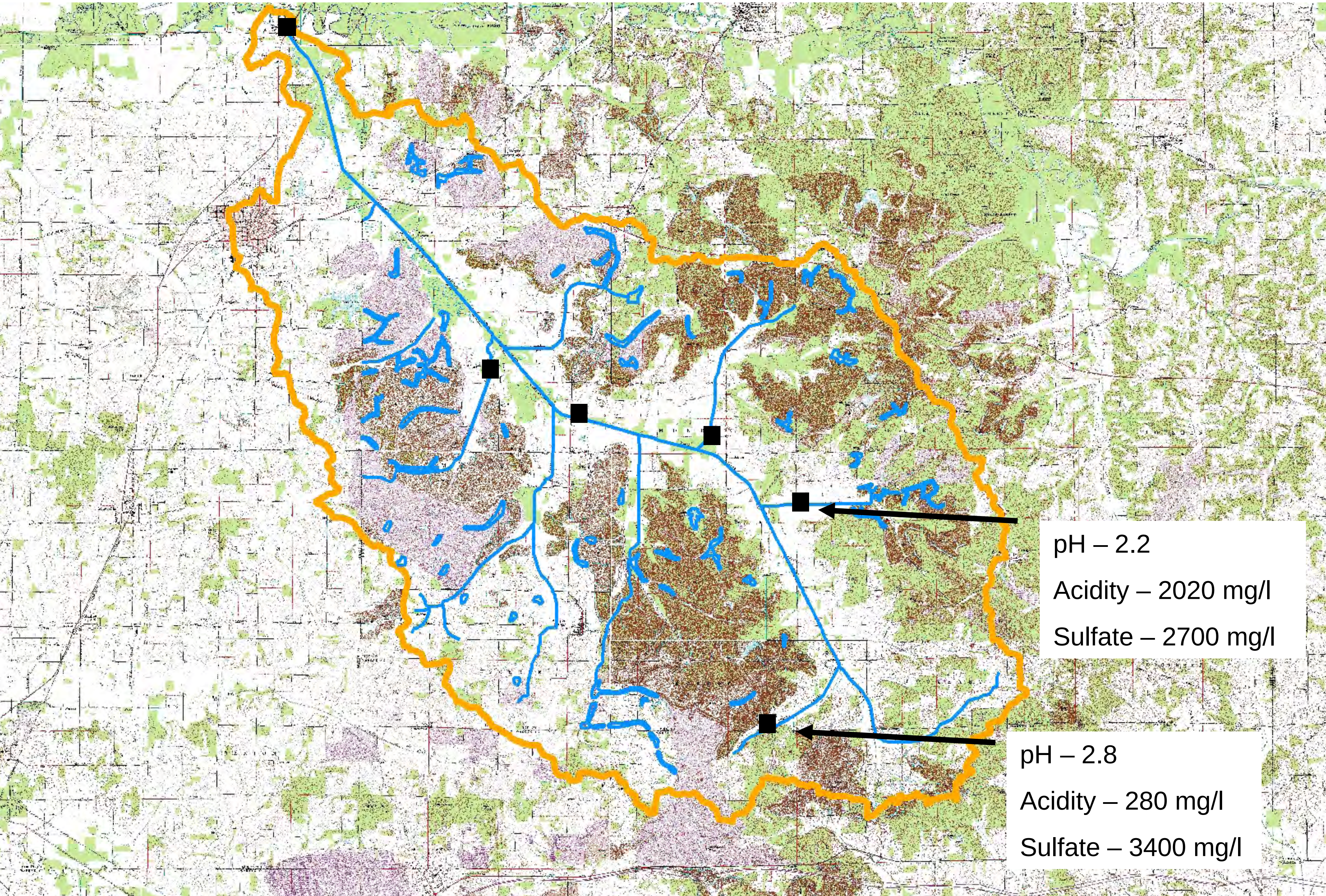
South Fork Patoka River Watershed



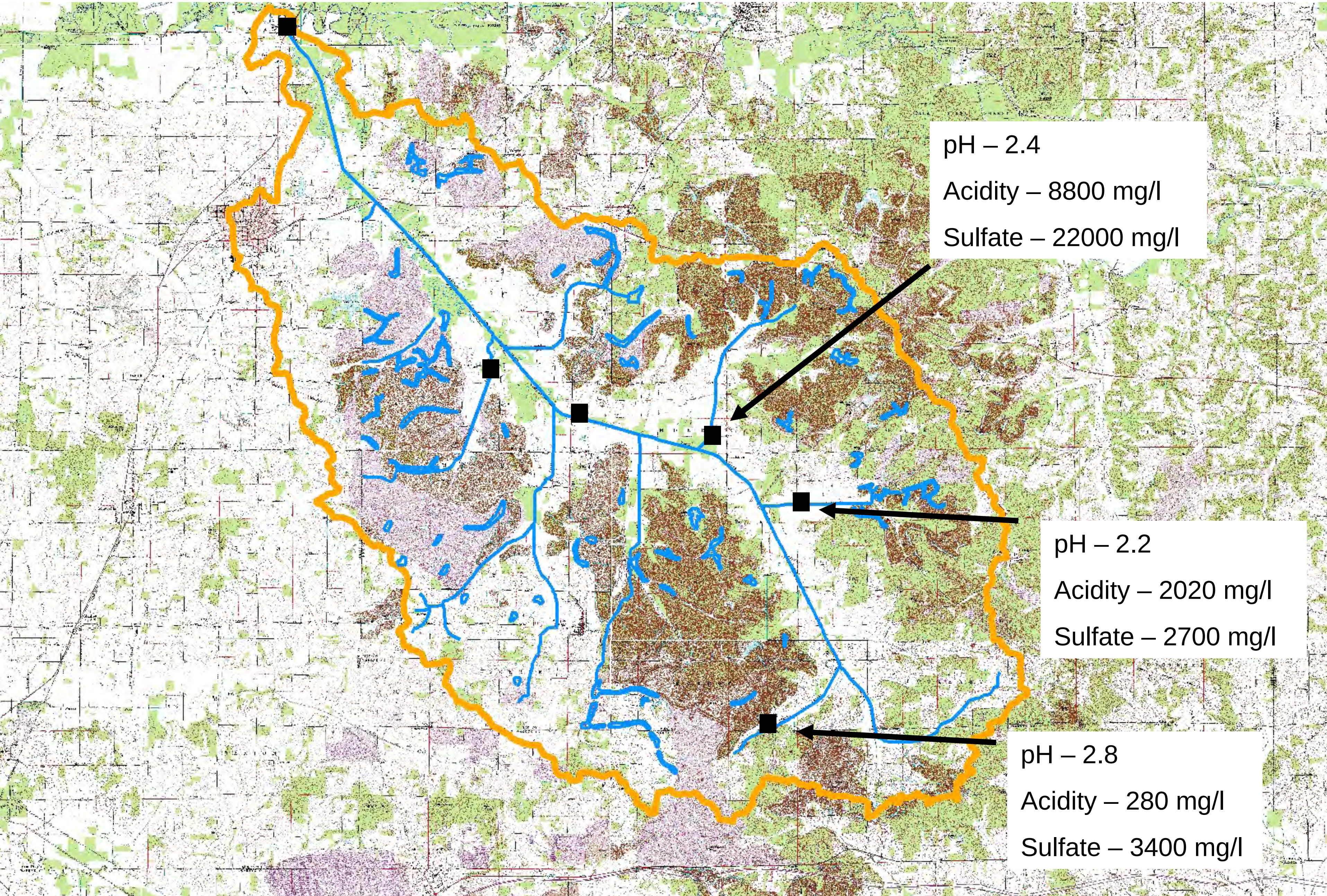
South Fork Patoka River Watershed



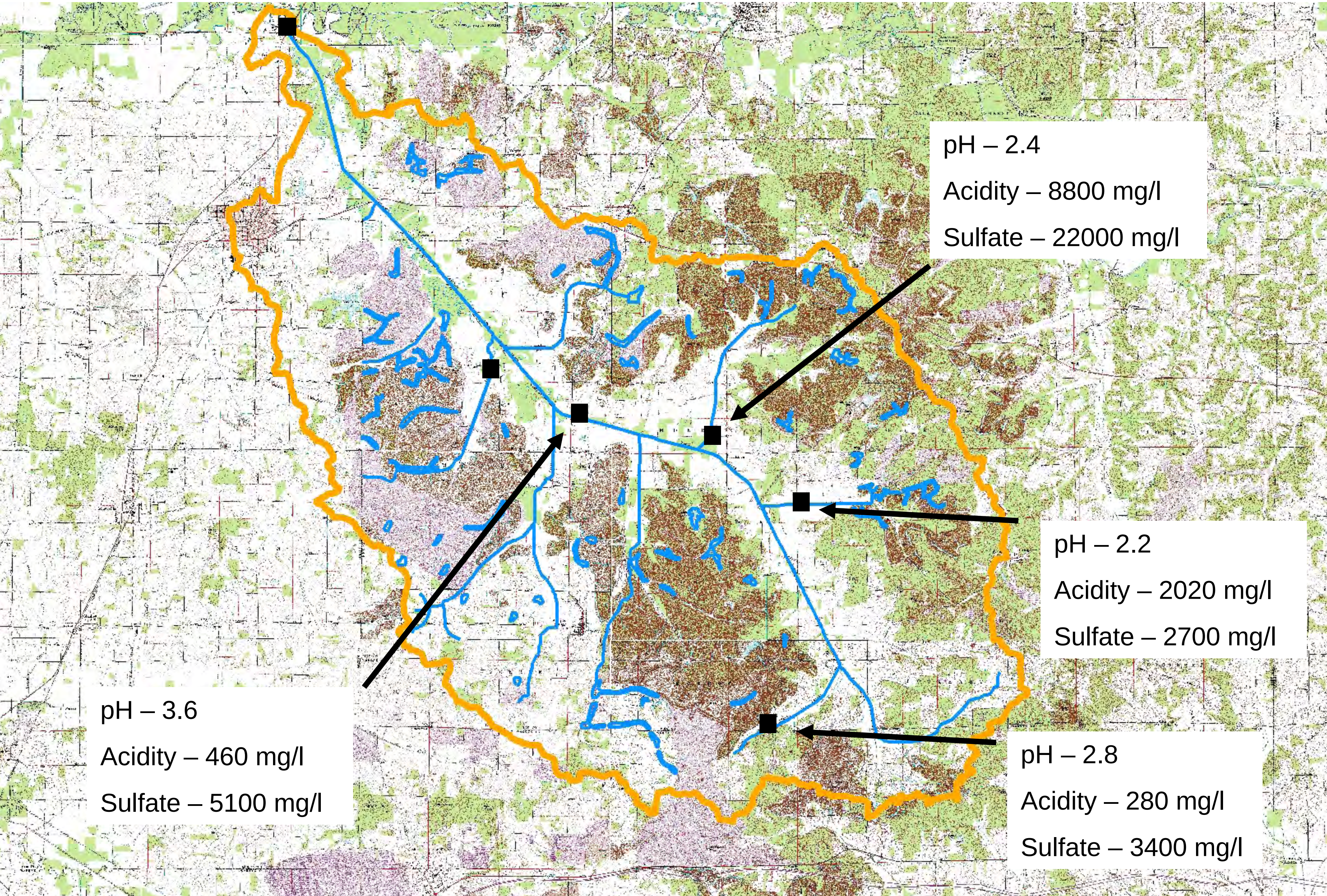
South Fork Patoka River Watershed



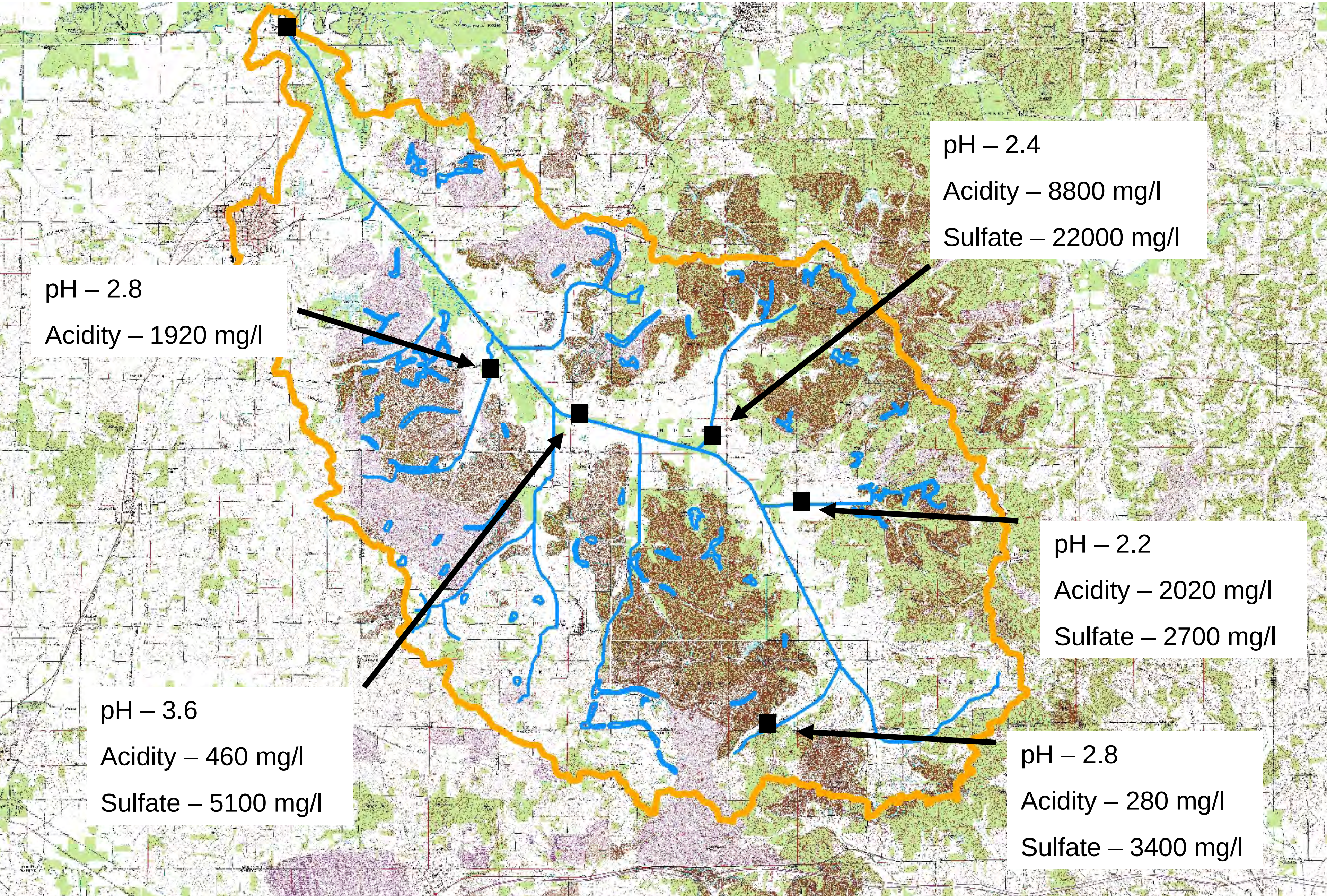
South Fork Patoka River Watershed



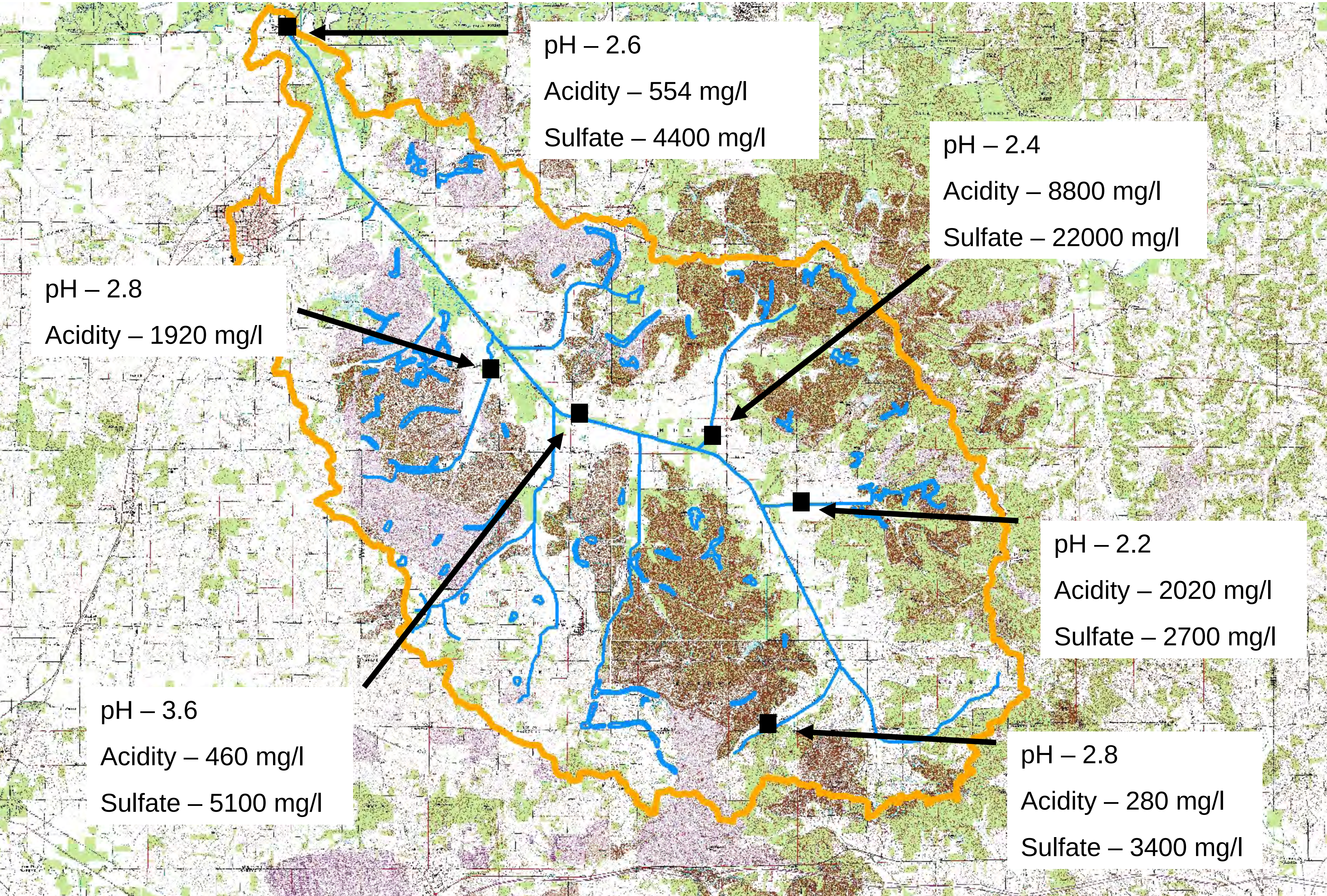
South Fork Patoka River Watershed



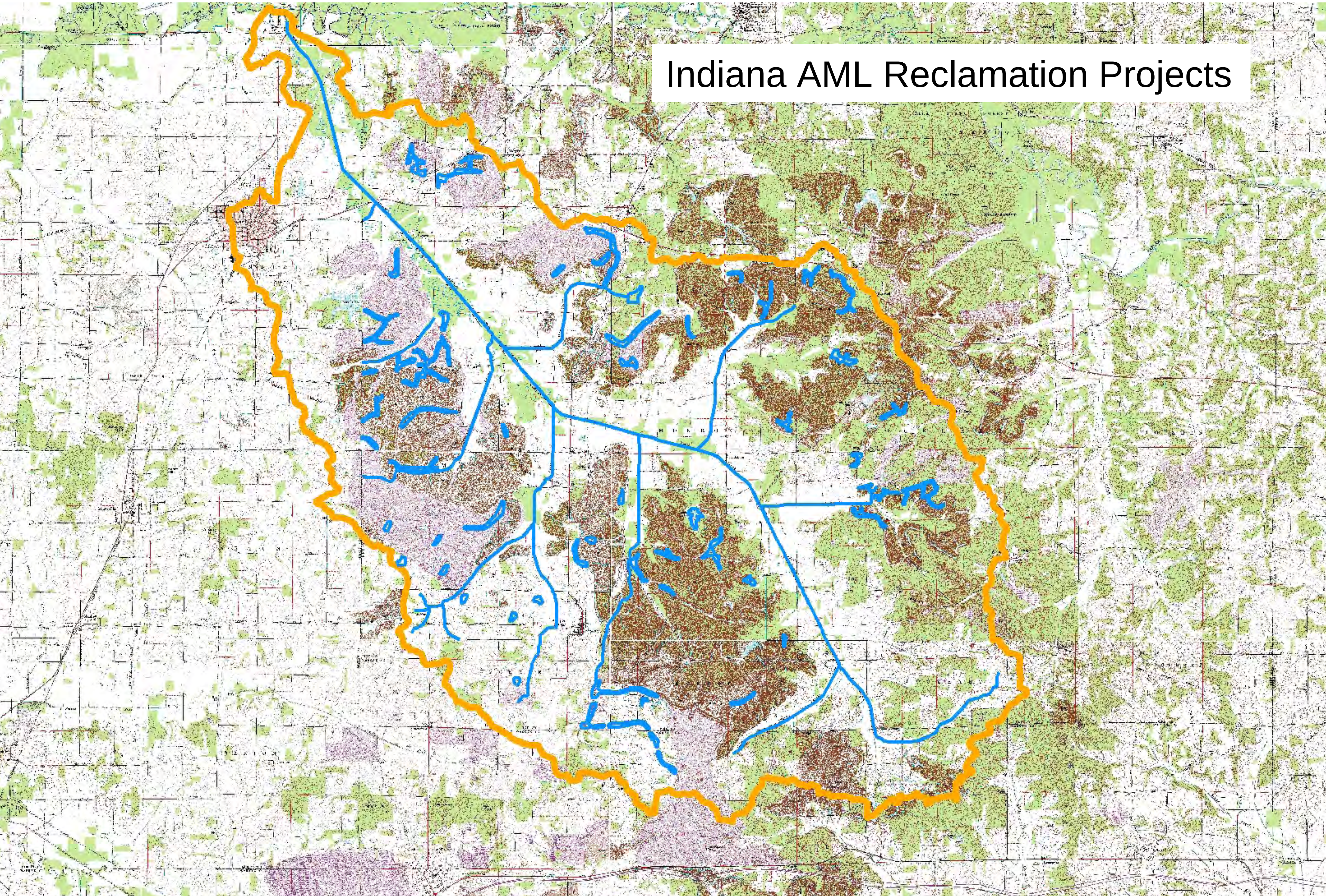
South Fork Patoka River Watershed



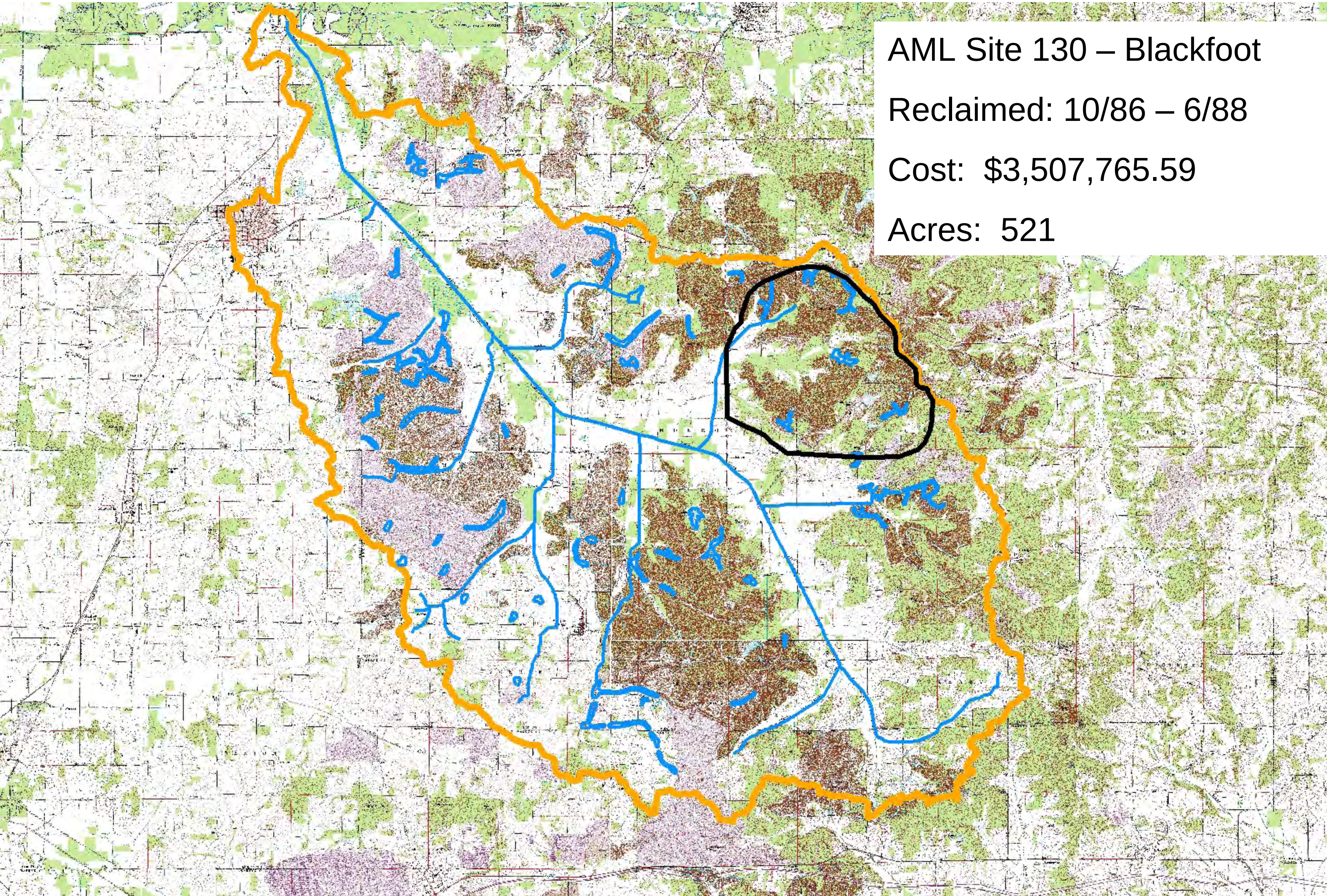
South Fork Patoka River Watershed



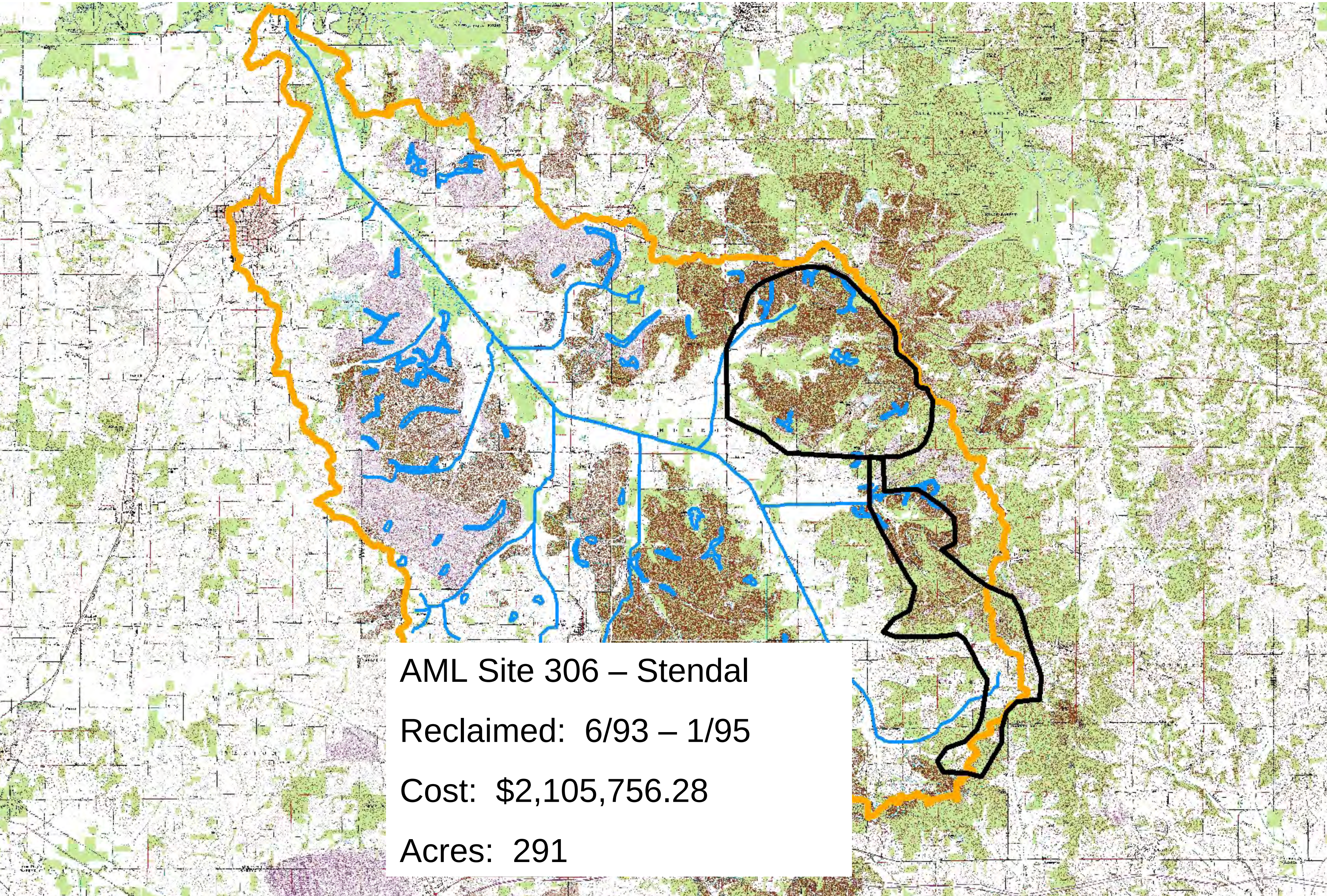
South Fork Patoka River Watershed



South Fork Patoka River Watershed



South Fork Patoka River Watershed



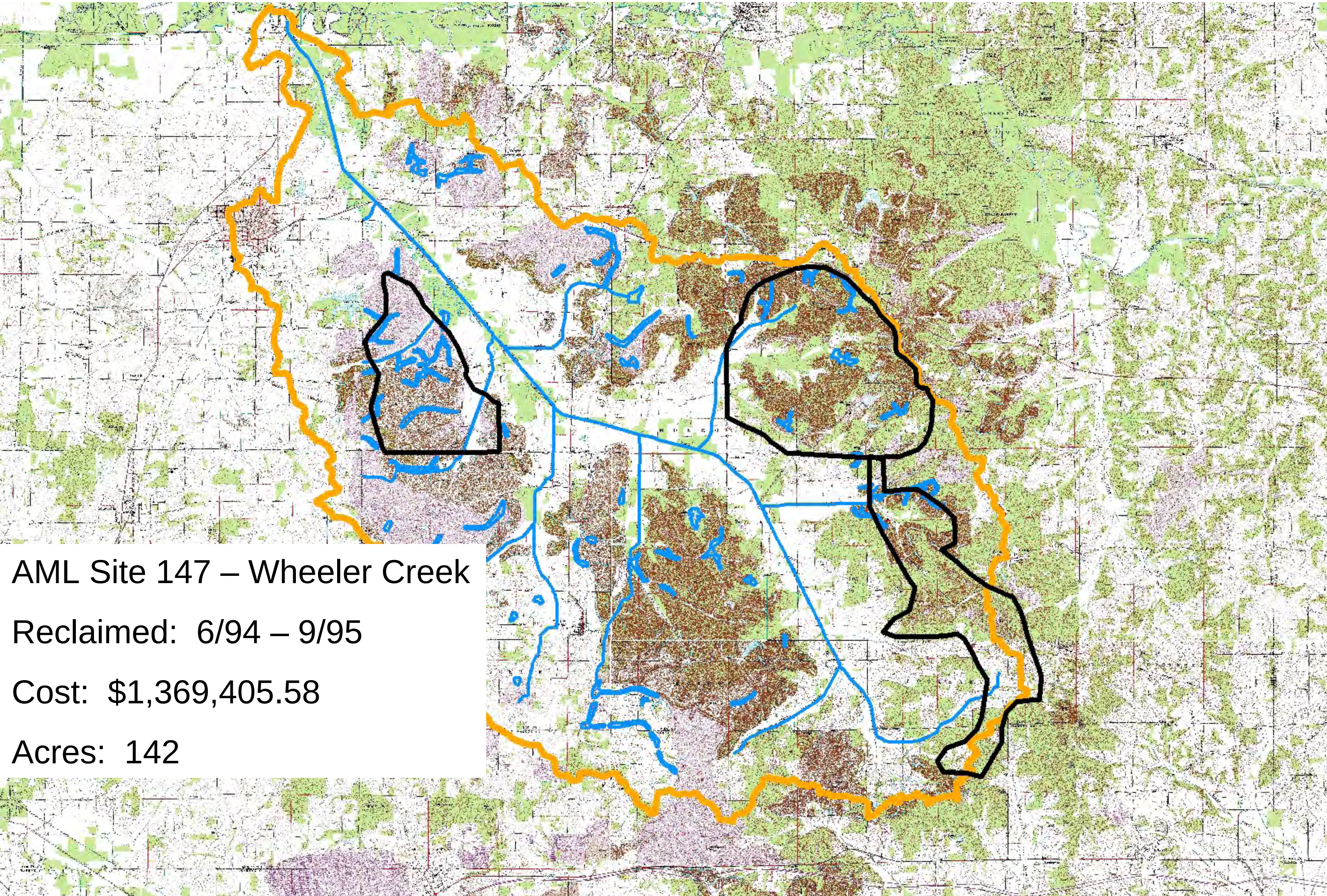
AML Site 306 – Stendal

Reclaimed: 6/93 – 1/95

Cost: $2,105,756.28

Acres: 291

South Fork Patoka River Watershed



AML Site 147 – Wheeler Creek

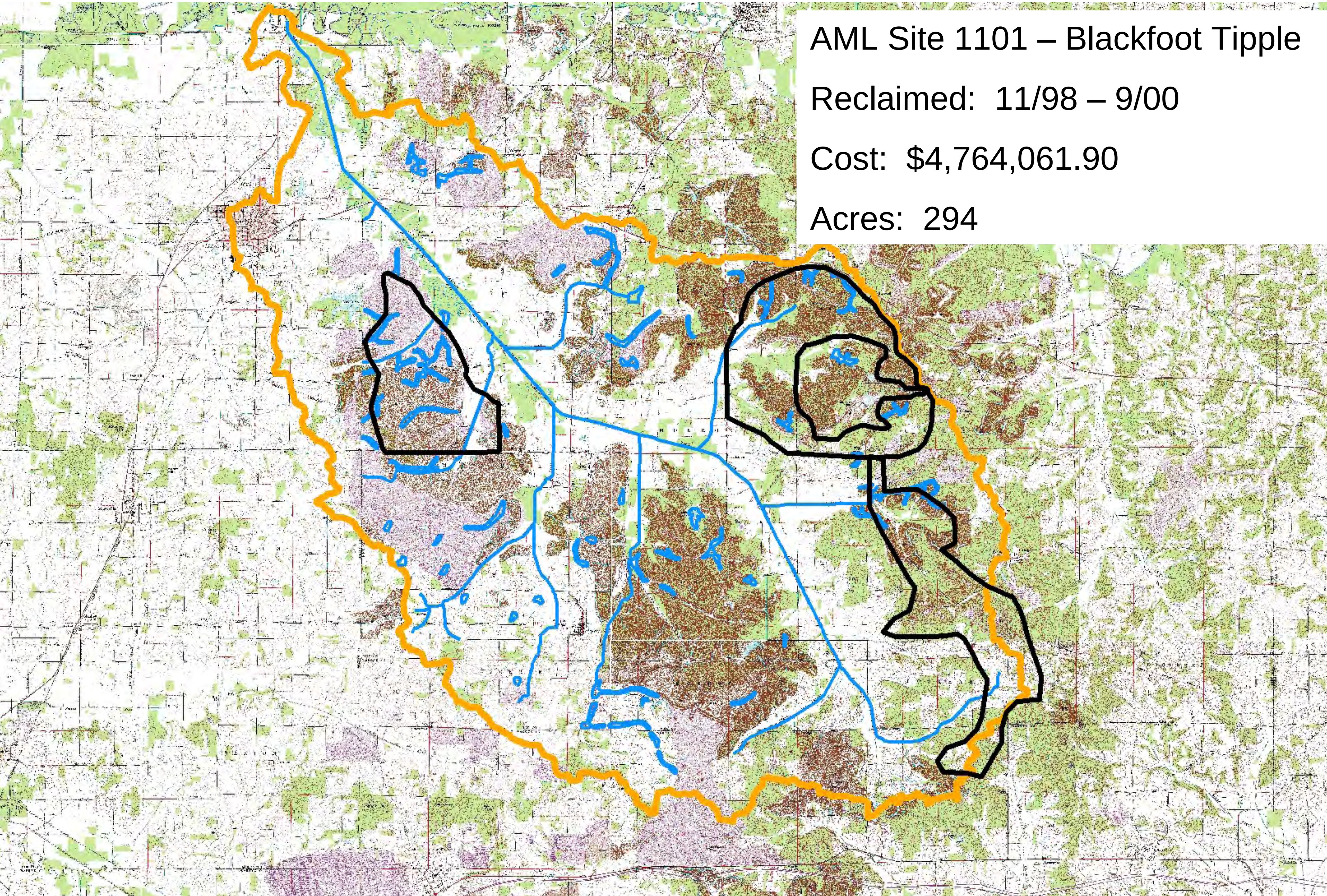
Reclaimed: 6/94 – 9/95

Cost: $1,369,405.58

Acres: 142


DEPARTMENT OF NATURAL RESOURCES
ABANDONED MINE
RECLAMATION PROJECT
DNR
INDIANA DEPARTMENT OF NATURAL RESOURCES
RECLAMATION
INDIANA
DIVISION OF
RECLAMATION
DELICATE ENVIRONMENT
PLEASE NO HORSES OR
WHEELED VEHICLES
FOR INFORMATION CALL (800) 772-6463

South Fork Patoka River Watershed



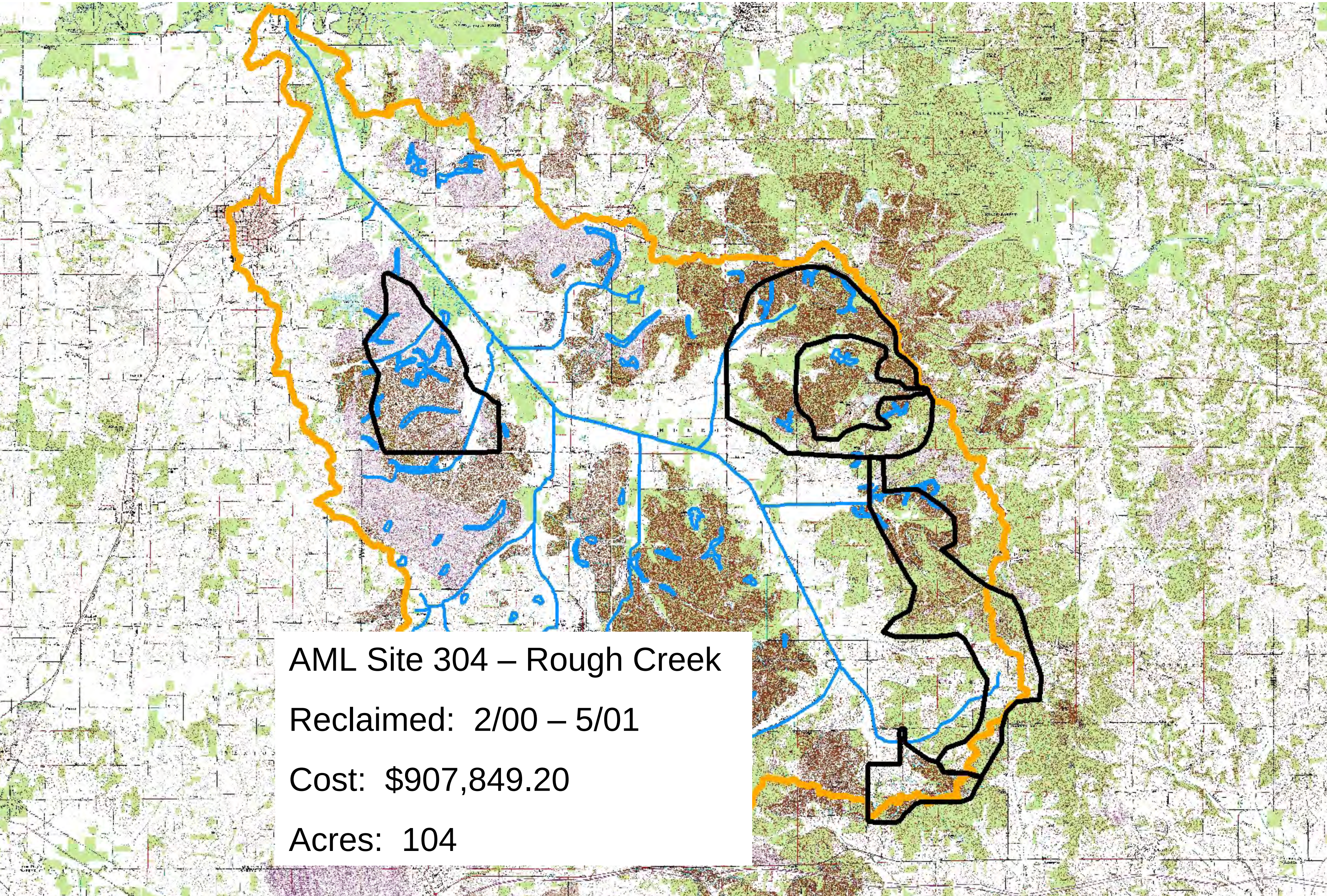
AML Site 1101 – Blackfoot Tipple

Reclaimed: 11/98 – 9/00

Cost: $4,764,061.90

Acres: 294

South Fork Patoka River Watershed



AML Site 304 – Rough Creek

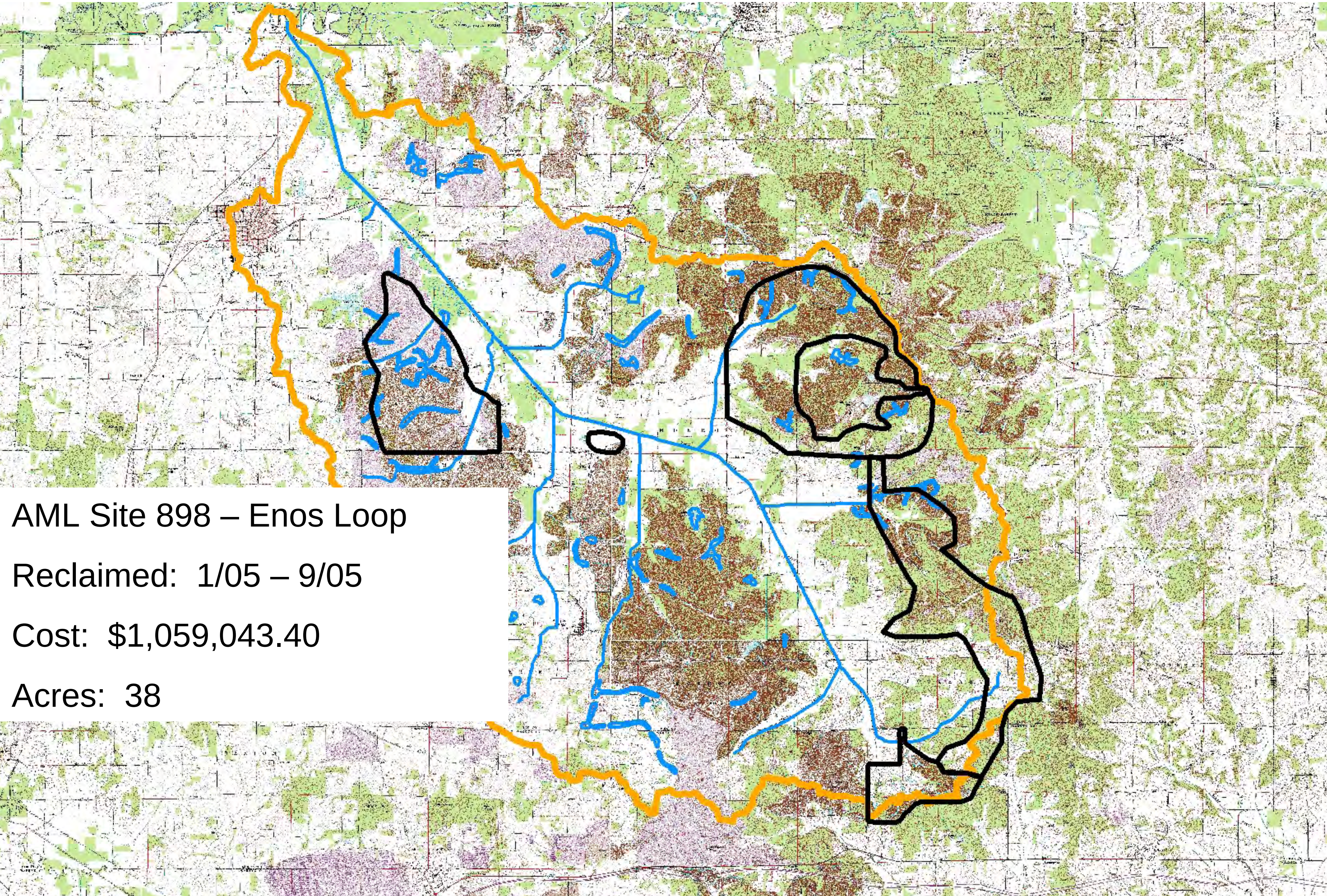
Reclaimed: 2/00 – 5/01

Cost: $907,849.20

Acres: 104


Fish & Wildlife
Management Area

South Fork Patoka River Watershed



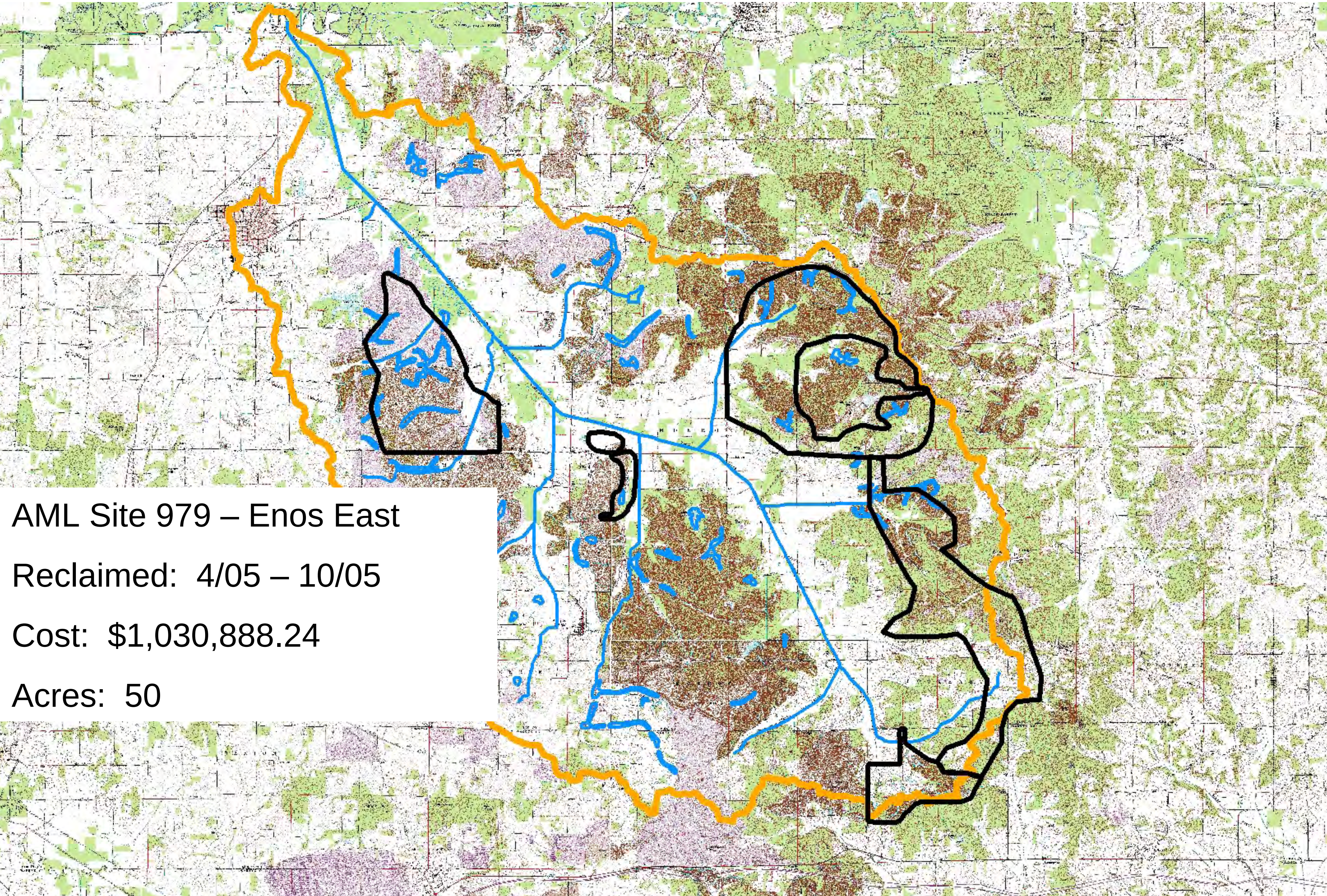
AML Site 898 – Enos Loop

Reclaimed: 1/05 – 9/05

Cost: $1,059,043.40

Acres: 38

South Fork Patoka River Watershed



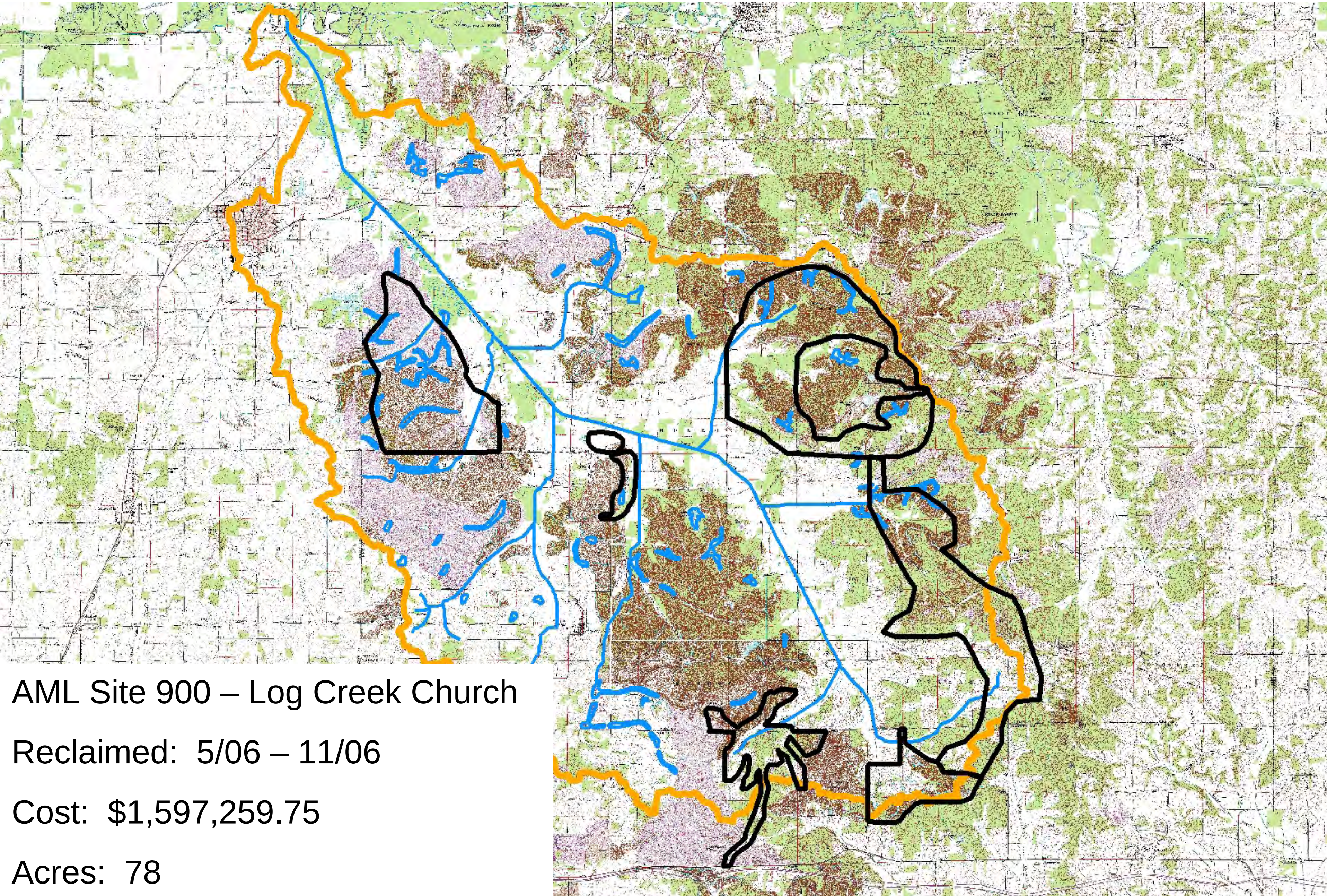
AML Site 979 – Enos East

Reclaimed: 4/05 – 10/05

Cost: $1,030,888.24

Acres: 50

South Fork Patoka River Watershed



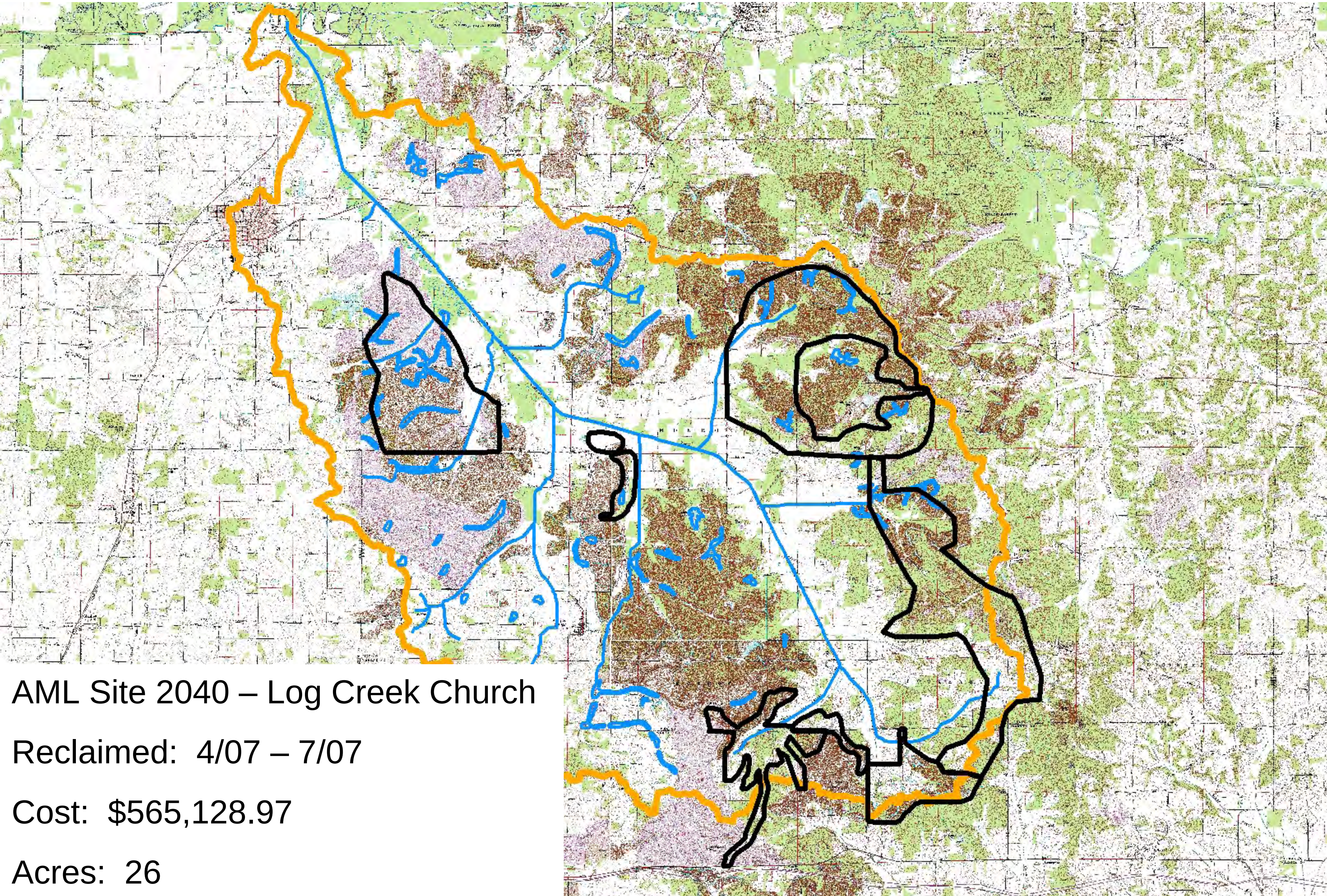
AML Site 900 – Log Creek Church

Reclaimed: 5/06 – 11/06

Cost: $1,597,259.75

Acres: 78

South Fork Patoka River Watershed



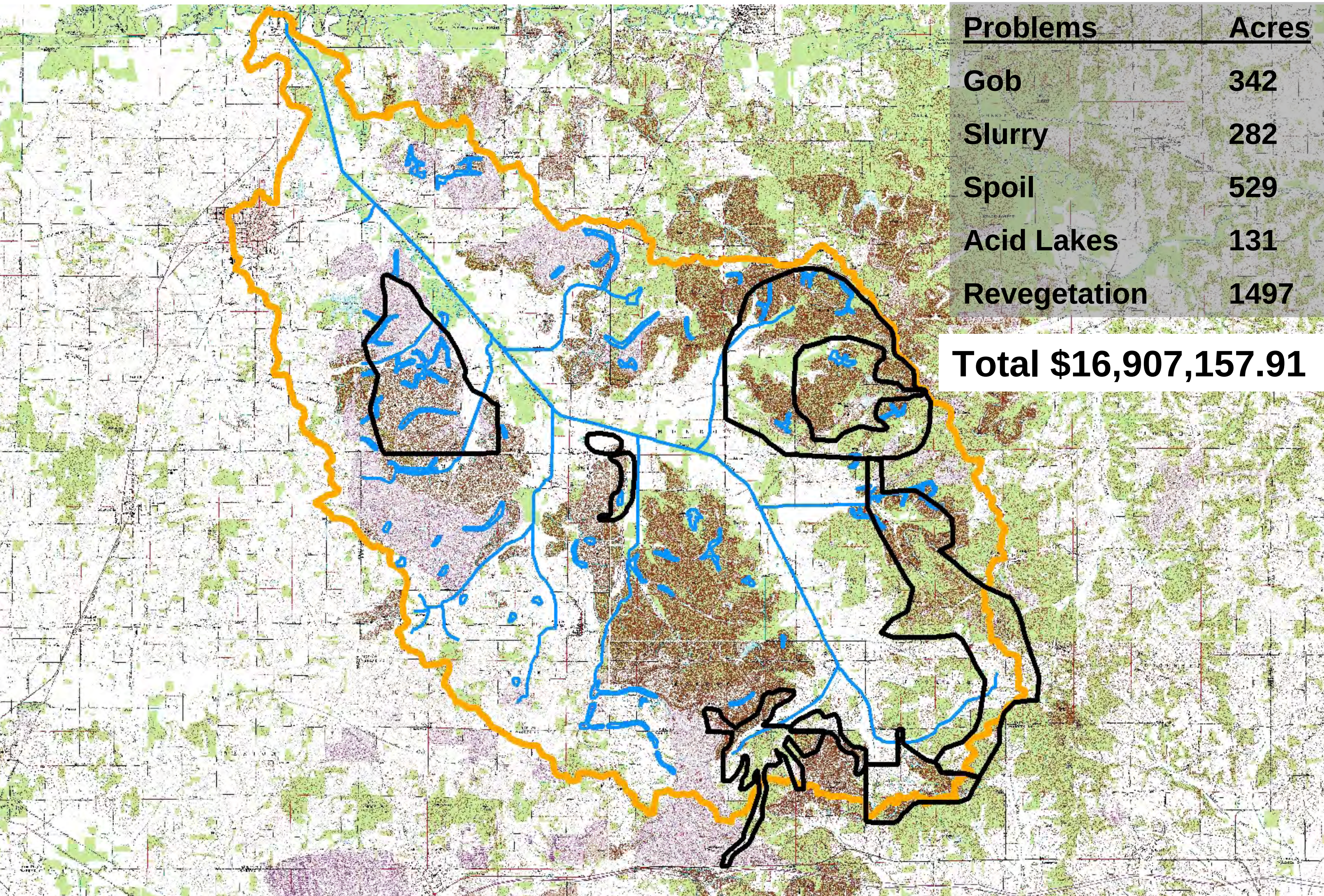
AML Site 2040 – Log Creek Church

Reclaimed: 4/07 – 7/07

Cost: $565,128.97

Acres: 26

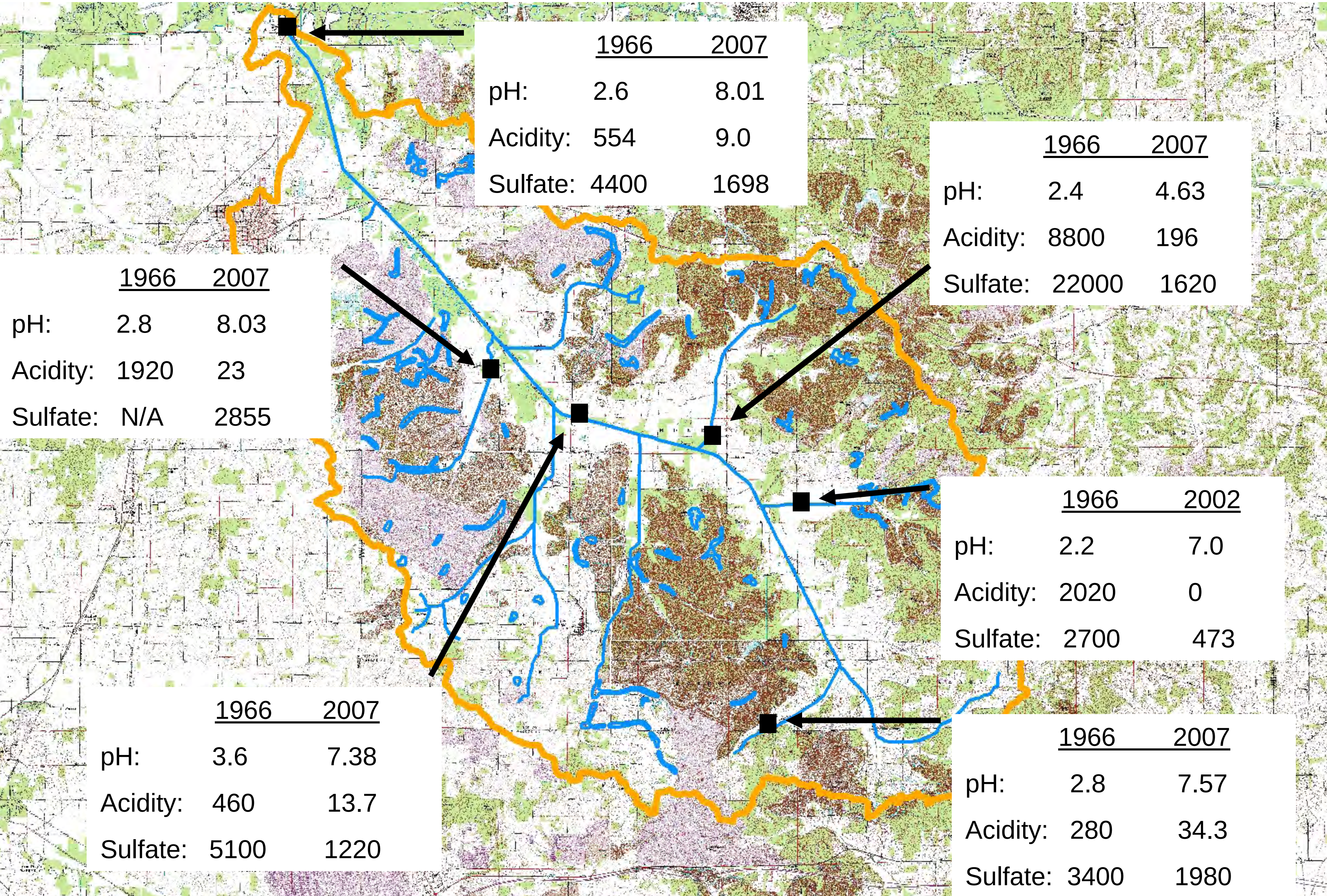
South Fork Patoka River Watershed



Problems	Acres
Gob	342
Slurry	282
Spoil	529
Acid Lakes	131
Revegetation	1497

Total $16,907,157.91

South Fork Patoka River Watershed



	1966	2007
pH:	2.6	8.01
Acidity:	554	9.0
Sulfate:	4400	1698

	1966	2007
pH:	2.4	4.63
Acidity:	8800	196
Sulfate:	22000	1620

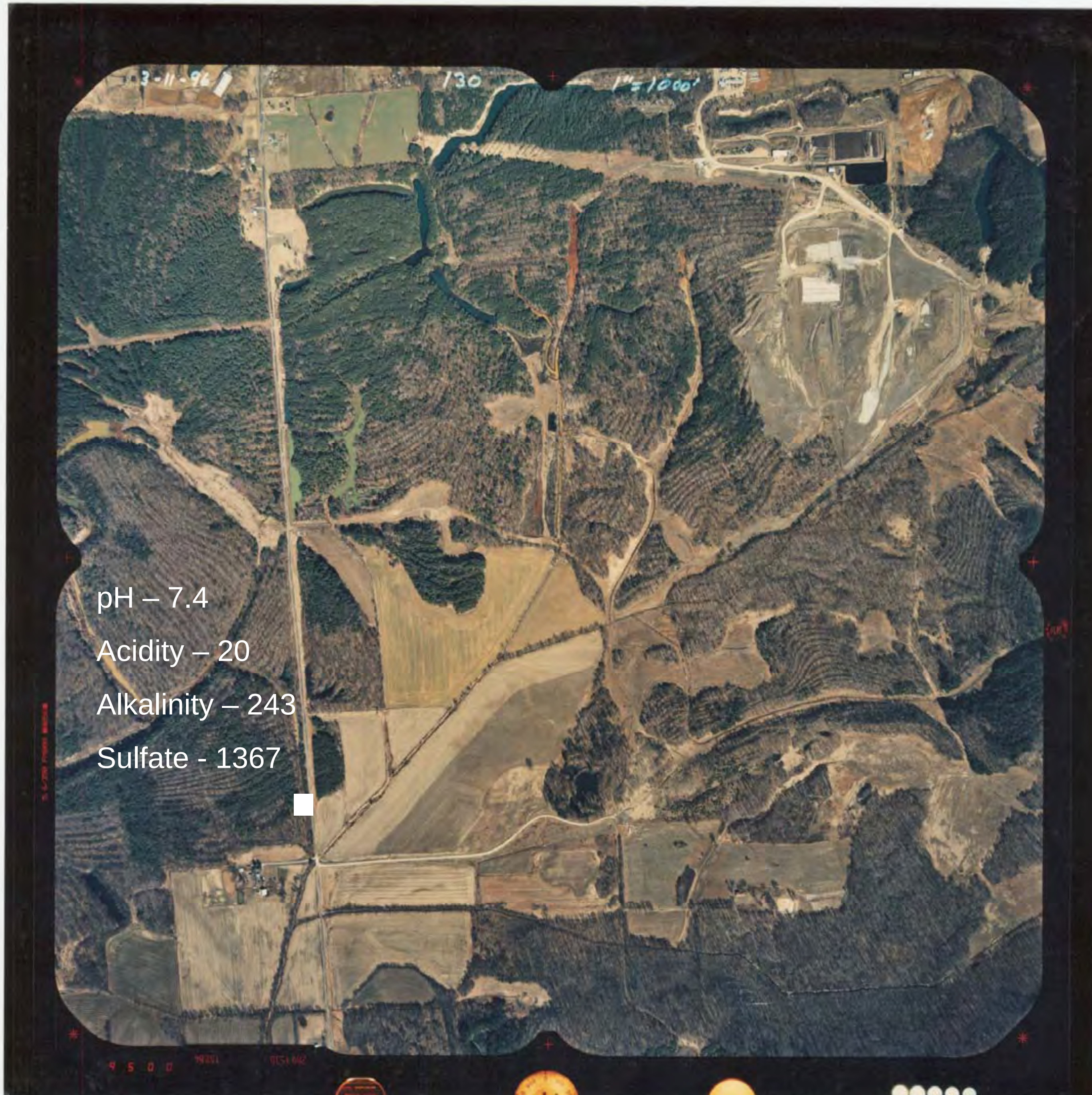
	1966	2007
pH:	2.8	8.03
Acidity:	1920	23
Sulfate:	N/A	2855

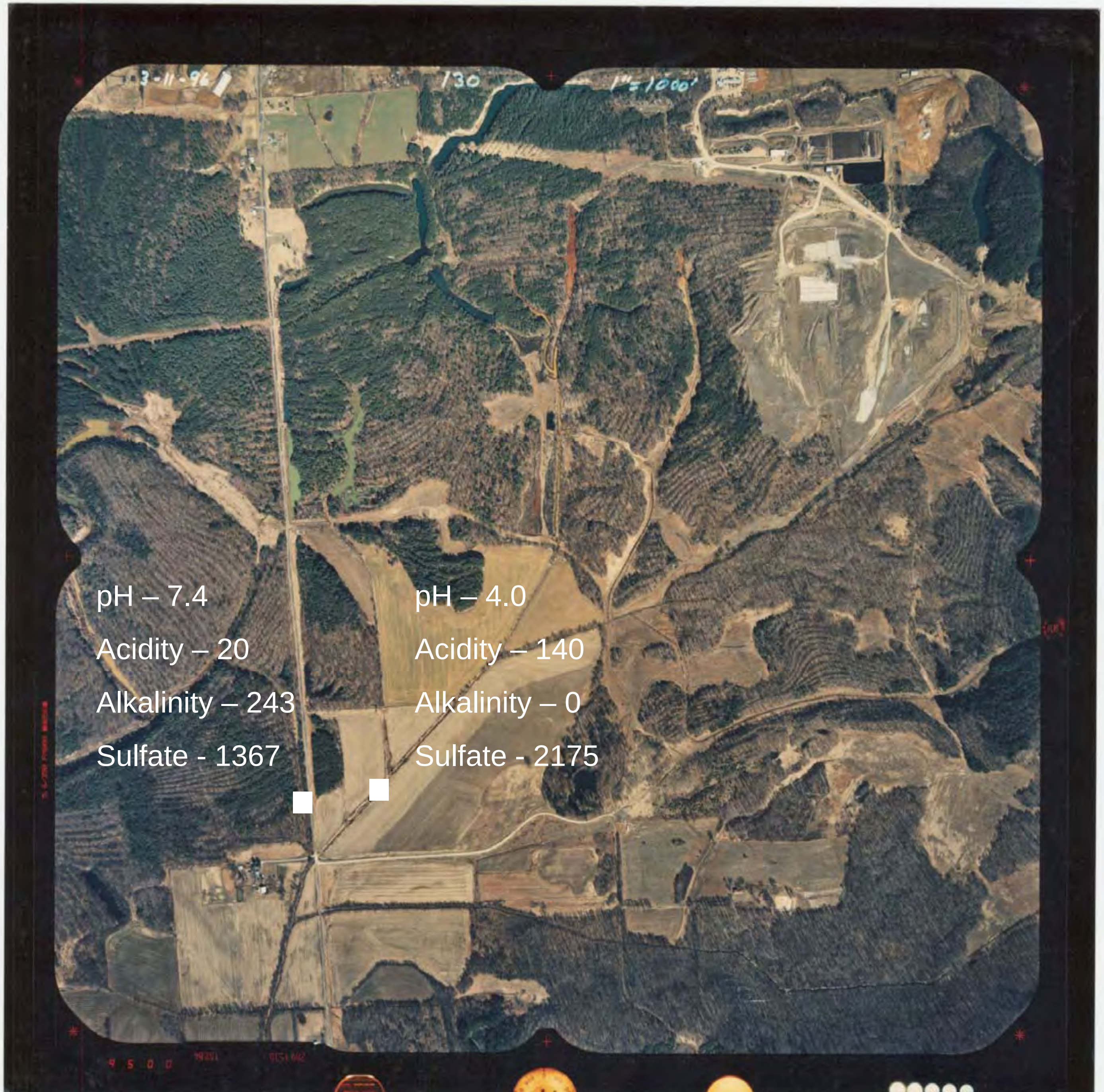
	1966	2002
pH:	2.2	7.0
Acidity:	2020	0
Sulfate:	2700	473

	1966	2007
pH:	3.6	7.38
Acidity:	460	13.7
Sulfate:	5100	1220

	1966	2007
pH:	2.8	7.57
Acidity:	280	34.3
Sulfate:	3400	1980

3-11-96
130
1"=1000'

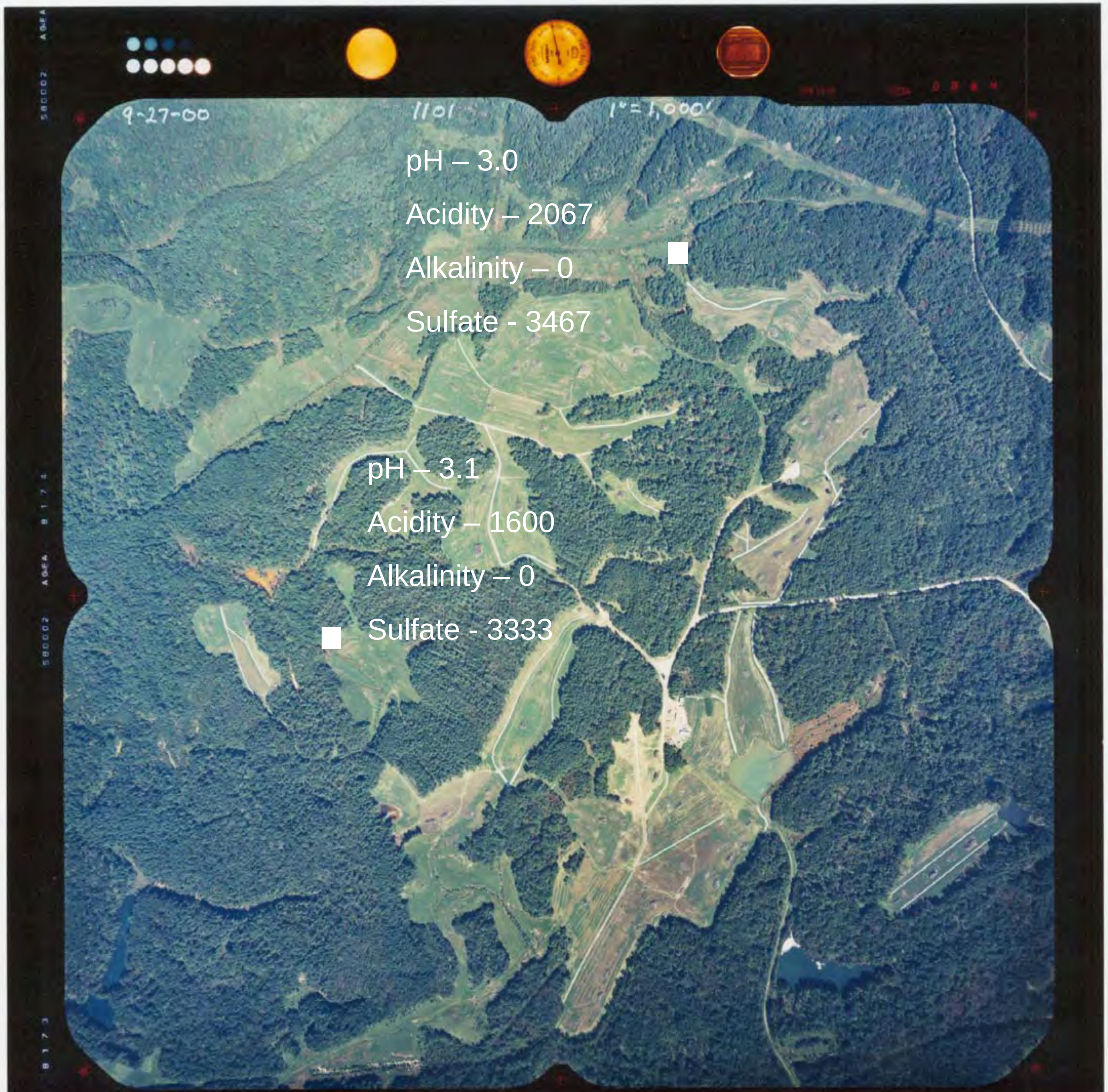

3-11-96
130
1"=1000'
pH – 7.4
Acidity – 20
Alkalinity – 243
Sulfate - 1367


3-11-96
130
1"=1000'
pH – 7.4
Acidity – 20
Alkalinity – 243
Sulfate - 1367
pH – 4.0
Acidity – 140
Alkalinity – 0
Sulfate - 2175

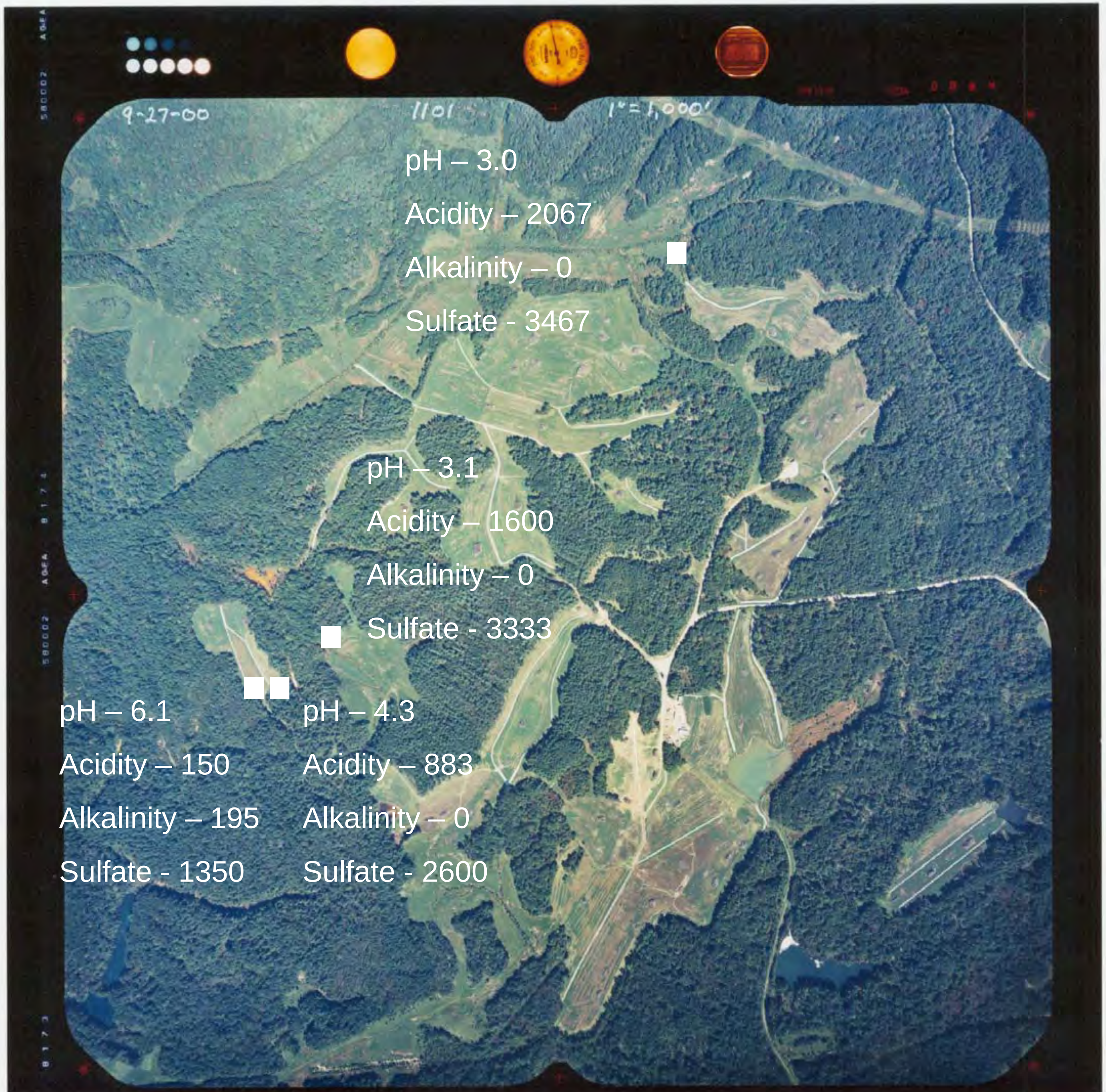

3-11-96
130
1"=1000'
pH – 7.4
Acidity – 20
Alkalinity – 243
Sulfate - 1367
pH – 4.0
Acidity – 140
Alkalinity – 0
Sulfate - 2175
pH – 3.3
Acidity – 380
Alkalinity – 0
Sulfate - 1600

9-27-00
1101
1"=1,000'


9-27-00
1101
1" = 1,000'
pH – 3.0
Acidity – 2067
Alkalinity – 0
Sulfate - 3467


9-27-00
1101
1" = 1,000'
pH – 3.0
Acidity – 2067
Alkalinity – 0
Sulfate - 3467
pH – 3.1
Acidity – 1600
Alkalinity – 0
Sulfate - 3333

9-27-00
1101
1" = 1,000'
pH – 3.0
Acidity – 2067
Alkalinity – 0
Sulfate - 3467
pH – 3.1
Acidity – 1600
Alkalinity – 0
Sulfate - 3333
pH – 4.3
Acidity – 883
Alkalinity – 0
Sulfate - 2600


9-27-00
1101
1" = 1,000'
pH – 3.0
Acidity – 2067
Alkalinity – 0
Sulfate - 3467
pH – 3.1
Acidity – 1600
Alkalinity – 0
Sulfate - 3333
pH – 6.1
Acidity – 150
Alkalinity – 195
Sulfate - 1350
pH – 4.3
Acidity – 883
Alkalinity – 0
Sulfate - 2600

AMD Status and Remediation in Alabama

Alabama Department of Industrial Relations

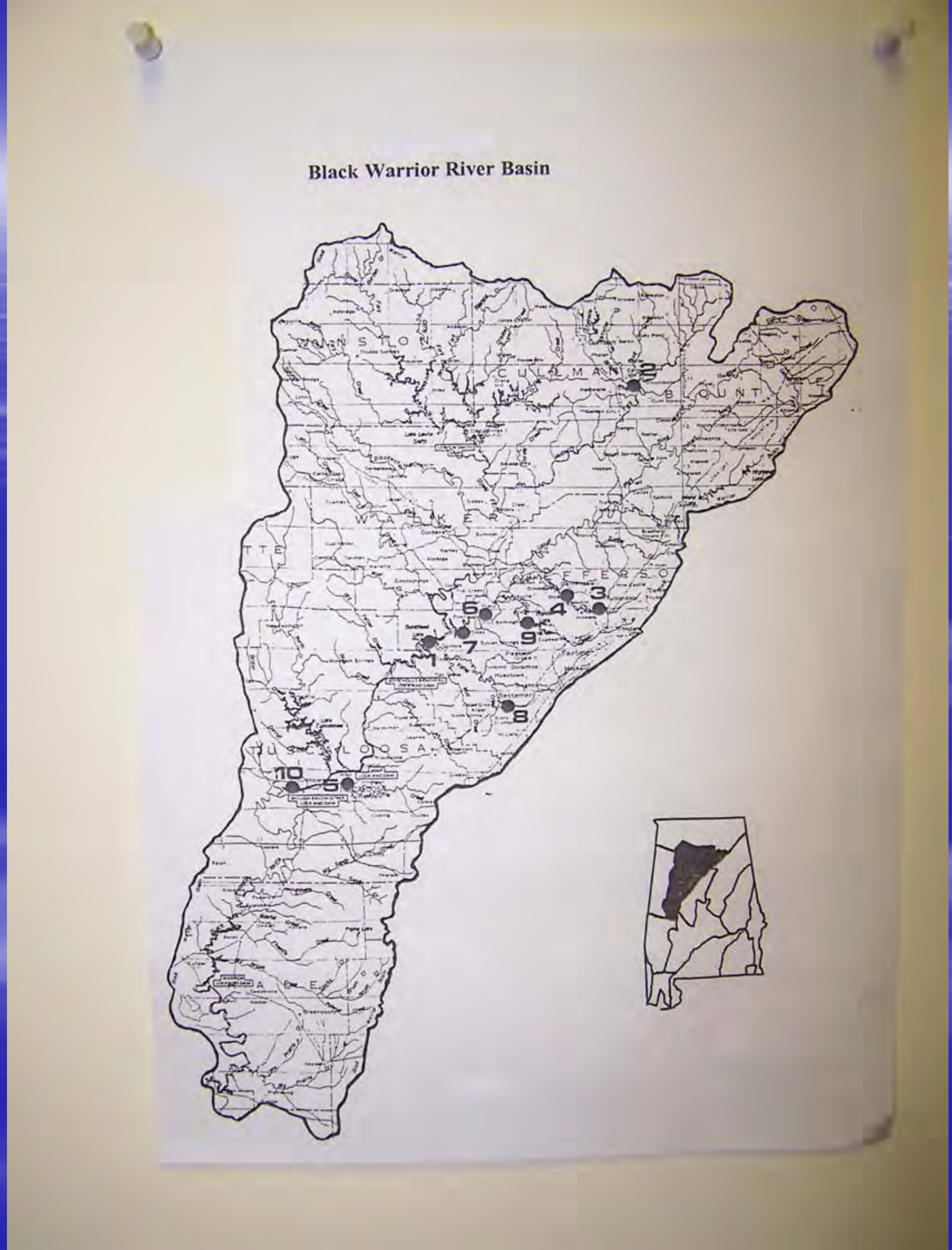
Mining and Reclamation Division

Partners

- Office of Surface Mining
- OSM Vista Volunteers
- Department of Industrial Relations

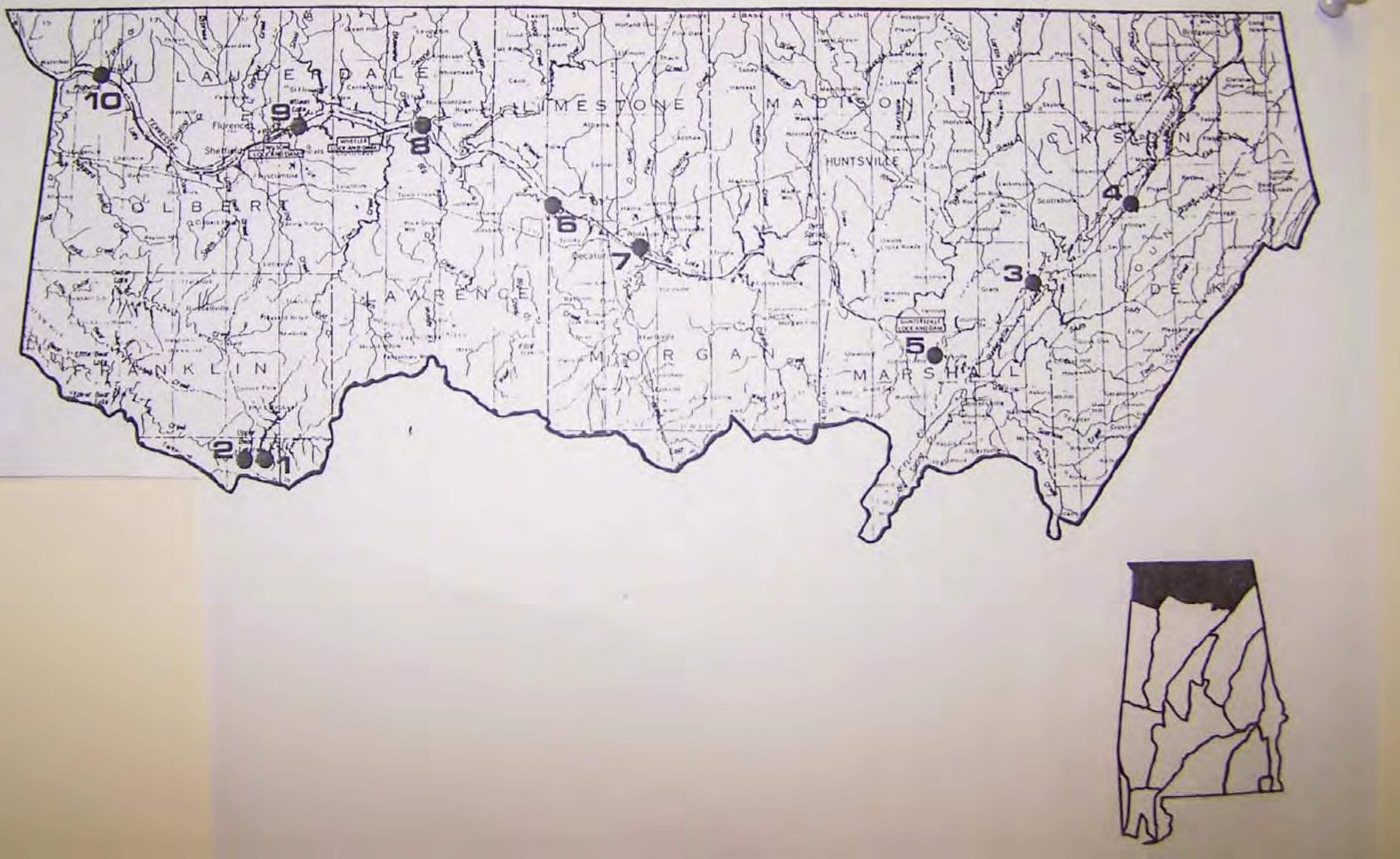
Alabama

LAUDERDALE
LIMESTONE
MADISON
COLBERT
LAWRENCE
FRANKLIN
MORGAN
MARION
CHEROKEE
LAMAR
CALHOUN
JEFFERSON
CLEBURNE
PICKENS
TALLADEGA
CLAY
RANDOLPH
COOSA
TALLAPOOSA
CHAMBERS
GREENE
HALE
CHILTON
PERRY
LEE
AUTAUGA
ELMORE
SUMTER
MACON
MARENGO
DALLAS
RUSSELL
MONTGOMERY
CHOCTAW
LOWNDES
BULLOCK
WILCOX
BARBOUR
CLARKE
BUTLER
PIKE
HENRY
CRENSHAW
COFFEE
DALE
WASHINGTON
MONROE
CONECUH
COVINGTON
HOUSTON
ESCAMBIA
GENEVA
MOBILE
BALWIN
N
Plateau Coal Field
Warrior Coal Field
Cahaba Coal Field
Coosa Coal Field
Lignite Belt
10 0 10 20 30 MI


Black Warrior River Basin
1
2
3
4
5
6
7
8
9
10

Cahaba River Basin

Tennessee River Basin




Aluminum in Stream
97 2 12


Acid Mine Drainage


Rock-lined Channels

Alabama AMD Projects Completed

Project Name	***County***	***Watershed***	***Status***
Deans Ferry	Blount	Black Warrior	Working
Acmar	St. Clair	Cahaba	Working
Hurricane Creek	Tuscaloosa	Black Warrior	Not Working
Peabody Washer	Tuscaloosa	Black Warrior	Working
Barney	Walker	Black Warrior	Not Working
Cane Creek Remediation I, II & III	Walker	Black Warrior	Working (Limited Basis)

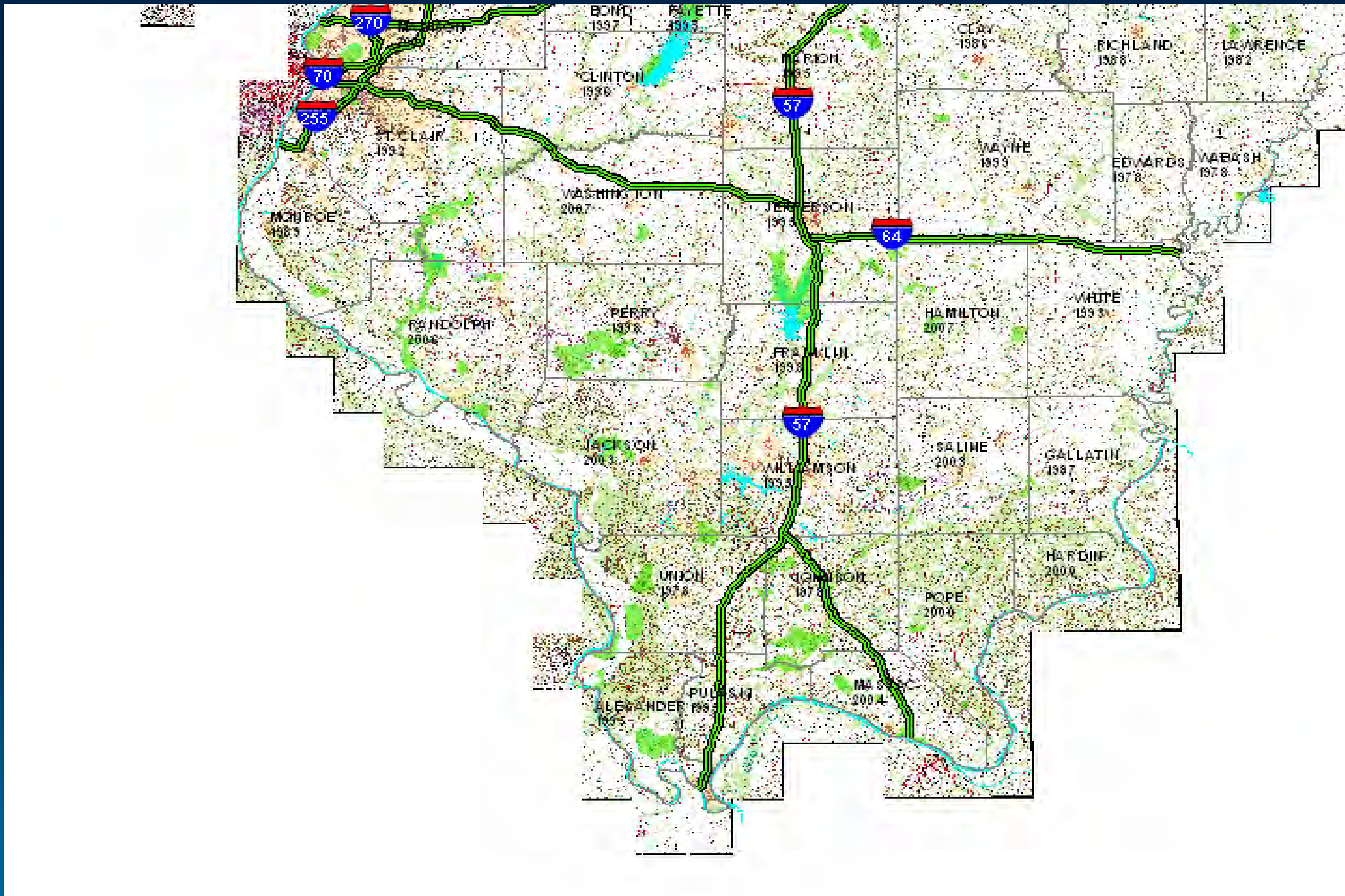
Alabama AMD Projects
Under Construction or in Planning Stages

Project Name	***County***	***Watershed***	***Status***
Dogtown Road	Dekalb	Tennessee River	Planning
Blue Creek	Jefferson	Black Warrior	Planning
Turkey Creek	Jefferson	Black Warrior	Planning
Camp Cherry Austin	Tuscaloosa	Black Warrior	Construction
Cane Creek Phase IV	Walker	Black Warrior	Construction

South Fork Saline River

WQ Restoration of a Coal Mining Impacted Riverine System

Southern Illinois (Egypt) Topo Map



Why Egypt?

1830-1831
“Winter of the Deep Snow”

Cairo
Thebes
Dongola
Karnak
Lake of Egypt
Egyptian HS

The Egyptian Question

Very often people come into the Sentinel asking why southern Illinois is called "Egypt." The name mistifies strangers and they say none of the natives can give them an explanation.

We would like to give you one, and we hope you will clip this out (that is why we put it up in this corner) so that next time someone asks you about "Egypt" you will then be an expert on the subject and can tell them more about it than they would probably care to hear.

First, you must always refer to the old home place as "Egypt," *never* as "Little Egypt" who was the first Go-Go girl. Little Egypt was a belly dancer at the Chicago World's Fair in 1898 and her scandalous gyrations created nationwide interest — but not in southern Illinois. If you ever see or hear this misuse of the name, it is your duty to correct it.

Second: Just where is Egypt? Here historians do disagree; but it appears that Centralia stands at the northernmost limit, if it is in Egypt at all. The old account below is not clear: the thirty-eighth parallel passes through DuQuoin and Benton. The northernmost edge of Jefferson County passes through Walnut Hill — which was a prosperous city in the day of the corn famine. Some historians say the B. & O. (Salem and Carlyle) might be a rough northern boundary of Egypt, but most feel Route 40 is too far north. This all goes to say Egypt is only that part of Southern Illinois which raised corn in 1831, and you can bet there were mighty few farmers around here then to even try. Years ago, Centralia advertised as the "Gateway to Egypt;" an expert might do well to leave it at that.

Third: Frontier life must have been dull indeed; when those Johnny-come-lately settlers up north had to come down to southern Illinois, they felt it necessary to pass off such behaviour with a joke. Traveling by oxcart was so slow, anything must have seemed funny. The Biblical passage they referred to was Jacob's statement in Genesis 42:2 "And he said, Behold, I have heard that there is corn in Egypt: get you down thither, and buy for us from thence; that we may live and not die. And Joseph's ten brethren went down to buy corn in Egypt."

The account of the famine below is from an old scrapbook presented to the Sentinel, and it is identified as appearing in the Marion County (Salem) Democrat, Feb. 14, 1889.

Why was Southern Illinois ever called Egypt, and when was the name it still carries given to this section of the state?

It seems that in the remarkable winter of 1880, familarly known as the winter of the "deep snow," snow fell throughout the northern border counties of the state to a depth of three feet. The winter was known as the severest and hardest ever recorded in Illinois, causing an unusually heavy drift upon the corn raised by the farmers, most of whom were newcomers of only two or three years.

This severe winter was followed by a reasonably late and backward spring, severe frosts being frequent until the middle of May. Therefore there was little or no corn planted north of Jefferson county in 1831 until June. This late spring was followed by a heavy and killing frost on the night of September 10, 1831, which did considerable damage to crops throughout the state, completely ruining all corn north of the thirty-eighth parallel.

Hence 1832 was known as the year of the great "corn famine" in the early history of Illinois. The state north of parallel thirty-eight had no corn.Corn was shipped in by the Mississippi and Illinois rivers for four dollars, where it had sold for ten cents a bushel.

The counties in the extreme southern part of the state, beginning with Jefferson and the counties east and west thereof, because of the sandy character of the soil and their southern latitude, were comparatively free of the damage done by the late spring and early frost and their crop was unusually large.

Therefore, while corn in the northern frontier counties was selling at three dollars and four dollars a bushel and only then in limited quantities, it was bought in the lower counties for twenty-five cents. The result was that from April 15th to the last of June there were not less than a thousand wagon loads of corn taken to the northern counties.

Wagons would go to a region and buy corn until it became scarce and higher in price, and then the next caravan would go further south and get the cheaper corn.

And so these good people, after traveling the long distance and finding corn so plentiful and to be bought with their money and being familiar with the Bible story of Jacob's ten sons going down to Egypt for corn, originated the facetious answer to the question, "Where are you going?" "We are going to Egypt for corn," or "We have heard there is corn in Egypt and we have come to buy it for ourselves and our little ones." This is the true origin for Southern Illinois being called Egypt.

Southern Illinois Salukis

Centenal Building Centralia, IL

Centenal Building Centralia, IL

IEPA: Saline River Basin Survey

Ron K.

Illinois
Environmental
Protection Agency

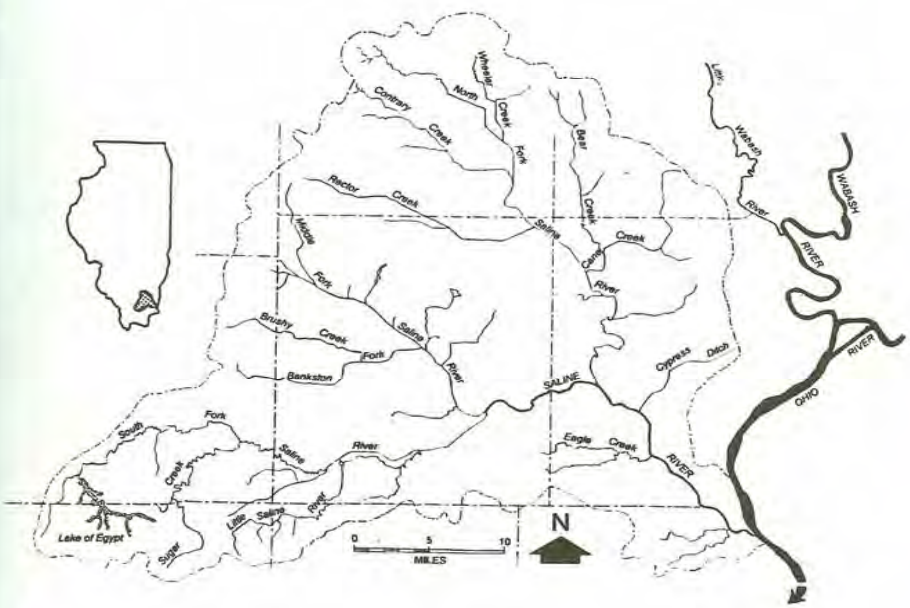
Bureau of Water
2200 Churchill Road
Springfield, IL 62794-9276

April 1996

IEPA/BOW/96-056

An Intensive Survey of the Saline River Basin

Summer 1993



Saline River Summary

Water Shed Size: 1177 miles empty to the Ohio River south of Old Shawneetown

Drains portions of 9 So Il Counties

Poorest WQ in lower sections of:
Sugar Creek
South Fork Saline

Aquatic life is "severely limited for 22 stream miles"

Cause? "Acid Mine Drainage from pre-law coal mines"

Saline River Basin

- South Fork---- 281 sq miles
- Middle Fork----242 Sq Miles
- North Fork---- 451 Sq Miles
- Main Stem---- 202 Sq Miles

- Land use:
- 48% Cropland
- 27% Woodland
- 18% Grassland
- 2% Urban
- 4% Mining

Coal Mining in the Saline Basin

- 490 Pre-law coal mine sites
- 23 Permitted mine sites

    109 authorized discharges (NPDES)

  9 of 109 pH samples below 6.5

    All these in the South Fork

No fish in 22 mile reach of lower Sugar Creek and the South Fork

Worst Mine sites

- Stonefort Mining Co (Will Scarlet)
- Palzo Mine
- Amax Coal Co (permitted)
- Old Delta Mine
- Thunderbird Collieries
- Carnac/Sahara Mining Area
- Bluebird Mining Area

Saline River Basin 1995

Delta Collieries- South Fork of the Saline River

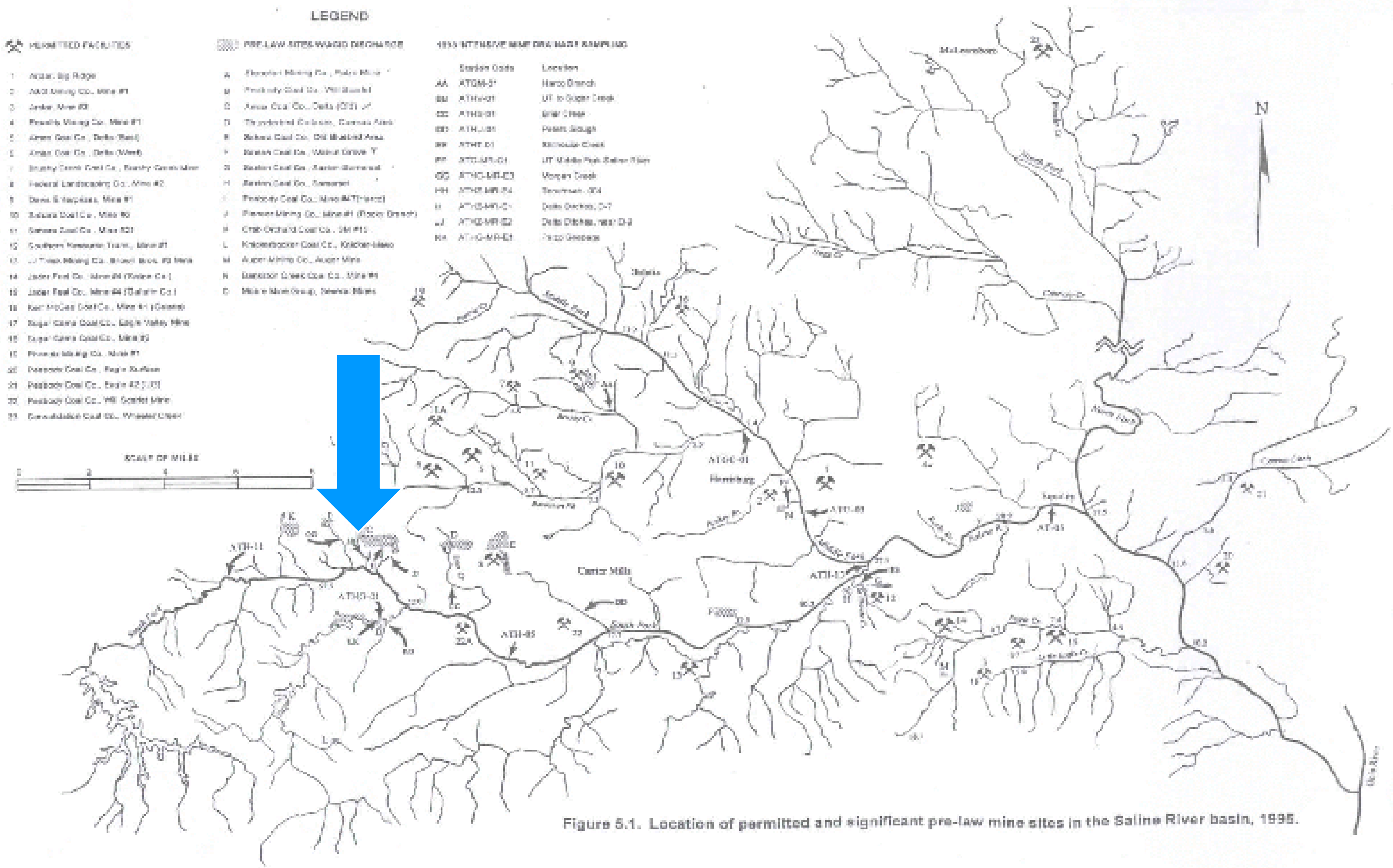
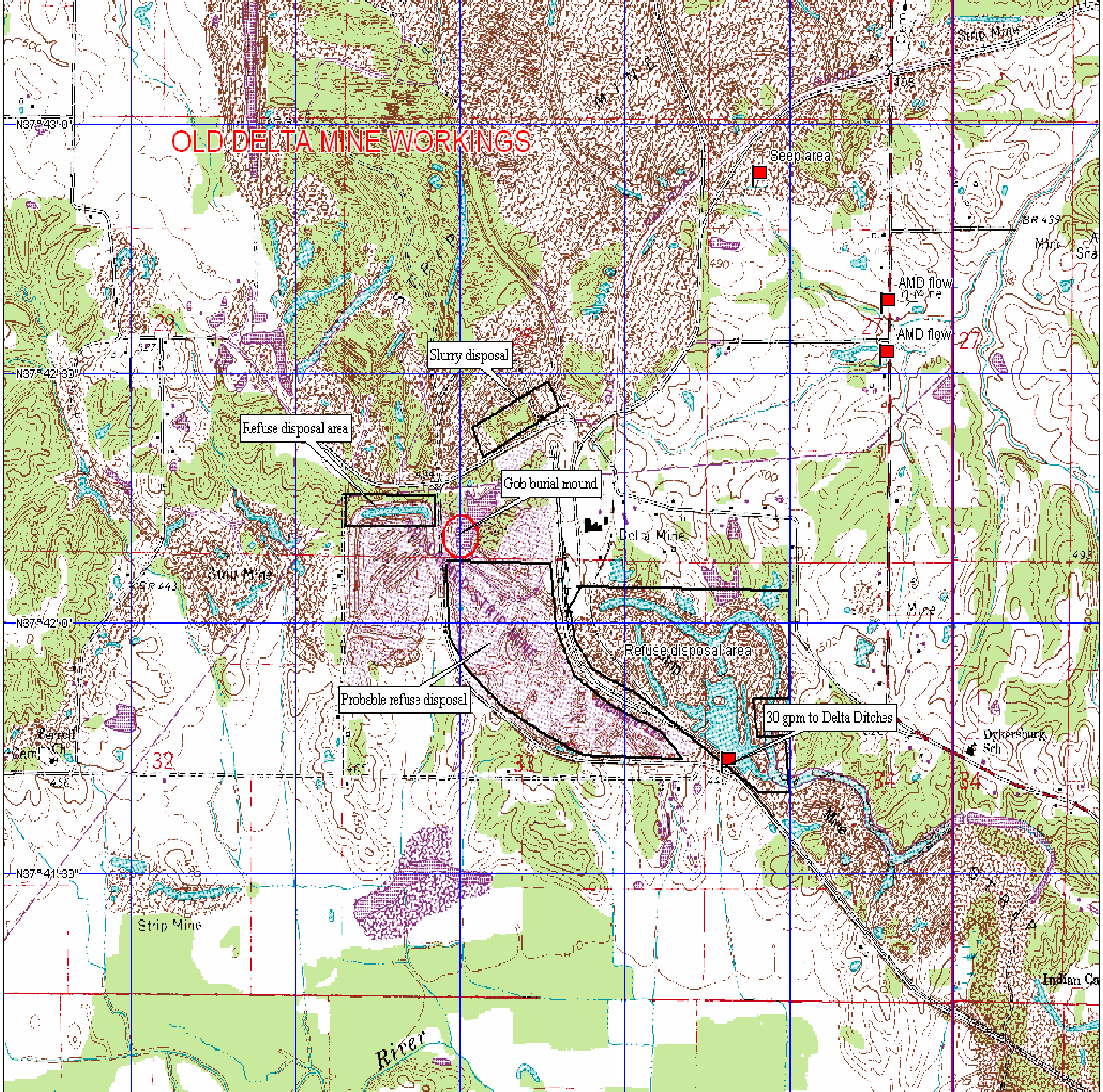
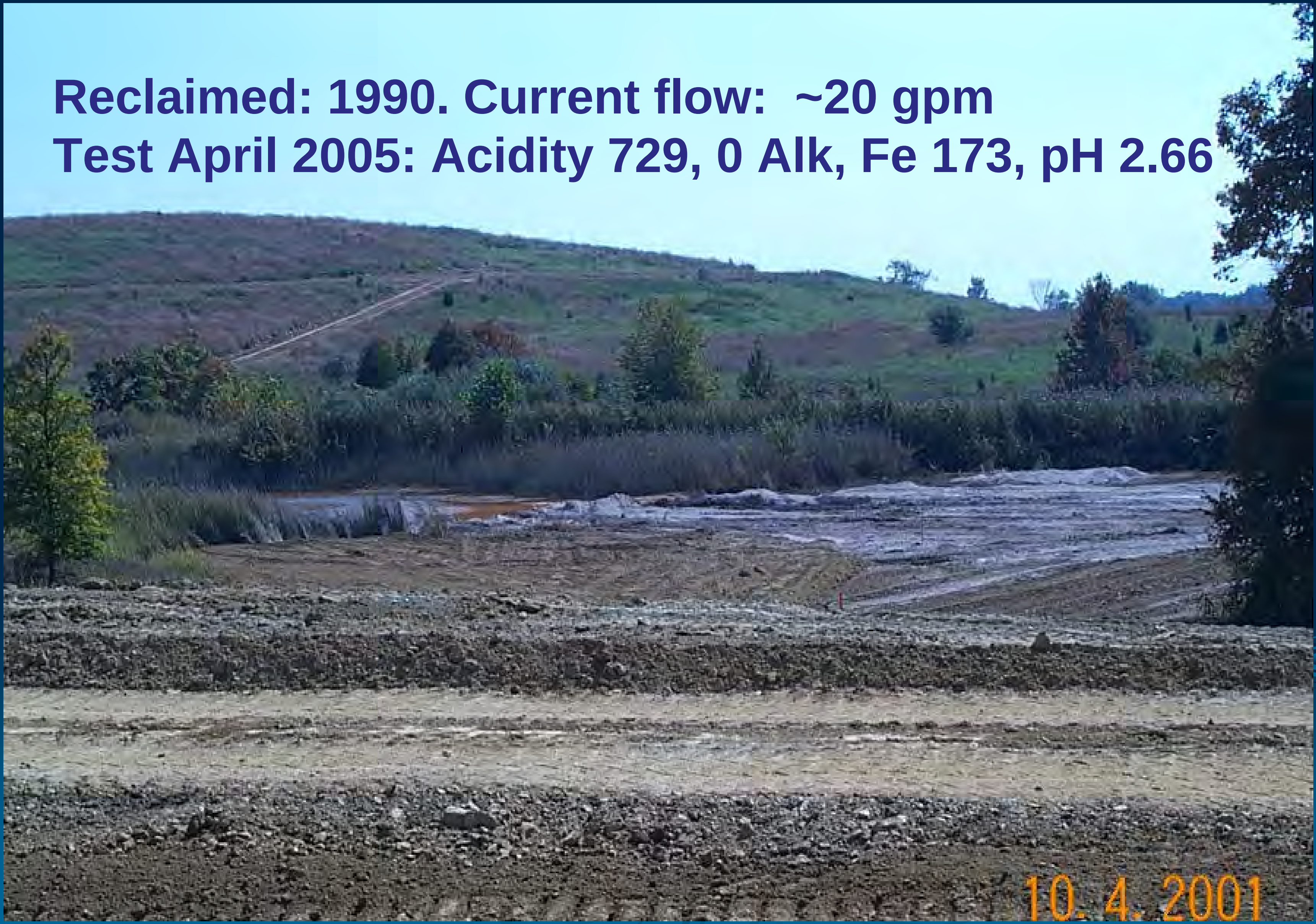


Figure 5.1. Location of permitted and significant pre-law mine sites in the Saline River basin, 1995.



OLD DELTA MINE WORKINGS
Seep area
AMD flow
AMD flow
Slurry disposal
Refuse disposal area
Gob burial mound
Delta Mine
Strip Mine
Refuse disposal area
Probable refuse disposal
30 gpm to Delta Ditches
Strip Mine
N37°43'0"
N37°42'30"
N37°42'0"
N37°41'30"
River

Delta Collieries, Burial Mound



Delta AMD from burial mound

Delta, AMD to West Drain

Delta Mine: Gob RR Beds

Delta North Buried Slurry

Delta AMD from burial mound

Test: April 2005: AMD flow: Average ~30 gpm
Acidity 735 Alk 0; Fe183; pH 2.69

Palzo Mine Aerial 1995

Palzo, Overburden Analysis

Premining Information
Generally, the overburden for the Palzo mine area is:

	Feet Thick
Unconsolidated Material (soil, till, loess)	6.0
Consolidated Material (sandstone, shale, minor coal)	20.0
DeKoven Coal Seam (No. 2 coal)	2.0
Parting seam (sandstone, black shale carbolith)	2.0
DeKoven, second seam	2.0
Black Shale	2.0
Davis Coal Seam (No. 2 coal)	3.0
Sub Coal Layer (sandy shale)	0.0
TOTAL	37.0

An analysis of the coal seams, their names and numbers is provided:

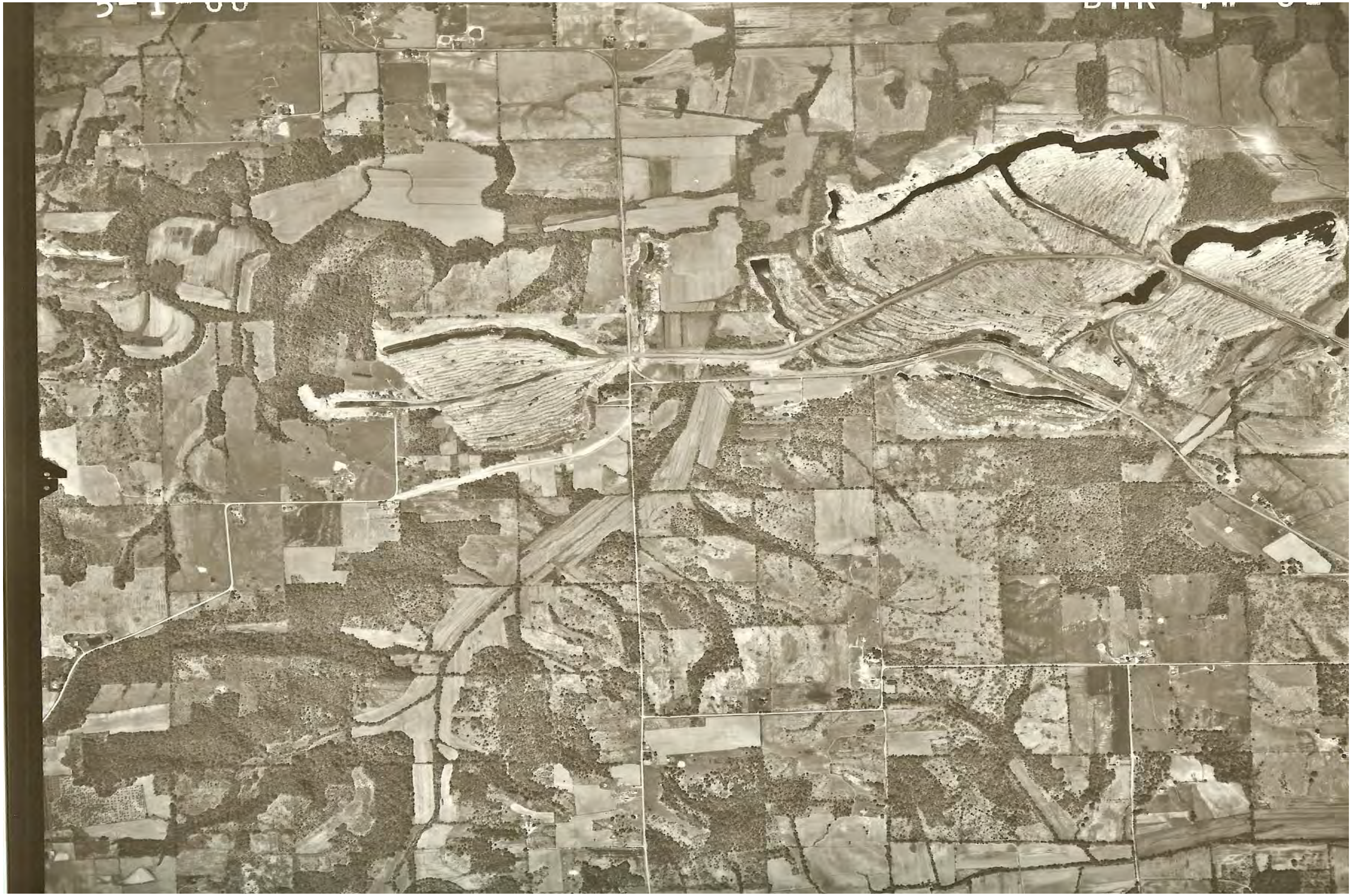
Palzo Mine, typical	Davis Coal	DeKoven Coal
Pyritic Sulfur %	2.81	3.74
Sulfate Sulfur %	.45	.54
Organic Sulfur %	1.57	1.85
Total Sulfur %	4.83	6.13

DeKoven-Davis Overburden: Stonefort Mining				
Depth (Feet)	**Rock Type**	**% Sulphur**	**pH** (1:1)	**Neutralization Potential** (Tons CaCO3/1,000 Tons)
0-5.5	Silt Loam	0.020	6.0	1.85
5.5-25.5	Mudstone and Sandstone	0.500	6.2	-5.00
25.5-27.5	Coal-DeKoven			
27.5-29.5	Carbolith (Black Shale)	12.050	2.4	-373.04
29.5-31.5	Coal-DeKoven	–	–	--
31.5-34.0	Black Shale	–	–	--
34.0-38.0	Coal-Davis	–	–	--

Table1: Davis/DeKoven Overburden aids in understanding the composition of the overburden and its potential for acidification.

12% Sulfur in Parting Shale. Req 31T lime/ 1% sulfur

Palzo Mine 1960



Palzo, unreclaimed, 1970

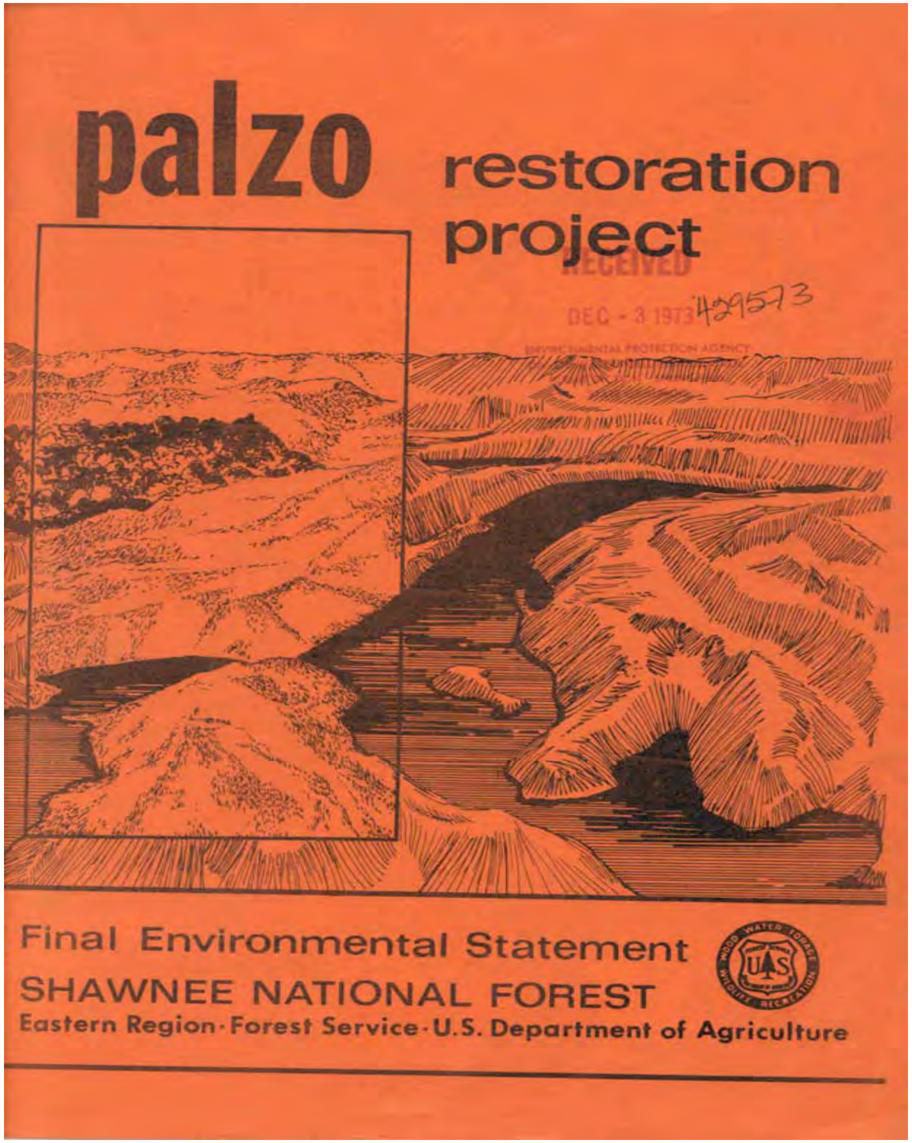
Palzo, 1972 Toxic Spoil

Palzo, Job Corp Regrading 1972

Palzo, 1972 EIS

57 Million gallons
Of Calumet IL
Sewage sludge ?

"Crude preliminary
research work"
<u>Prairie Farmer,</u>
<u>July, 1972</u>



Palzo, Sludge Application

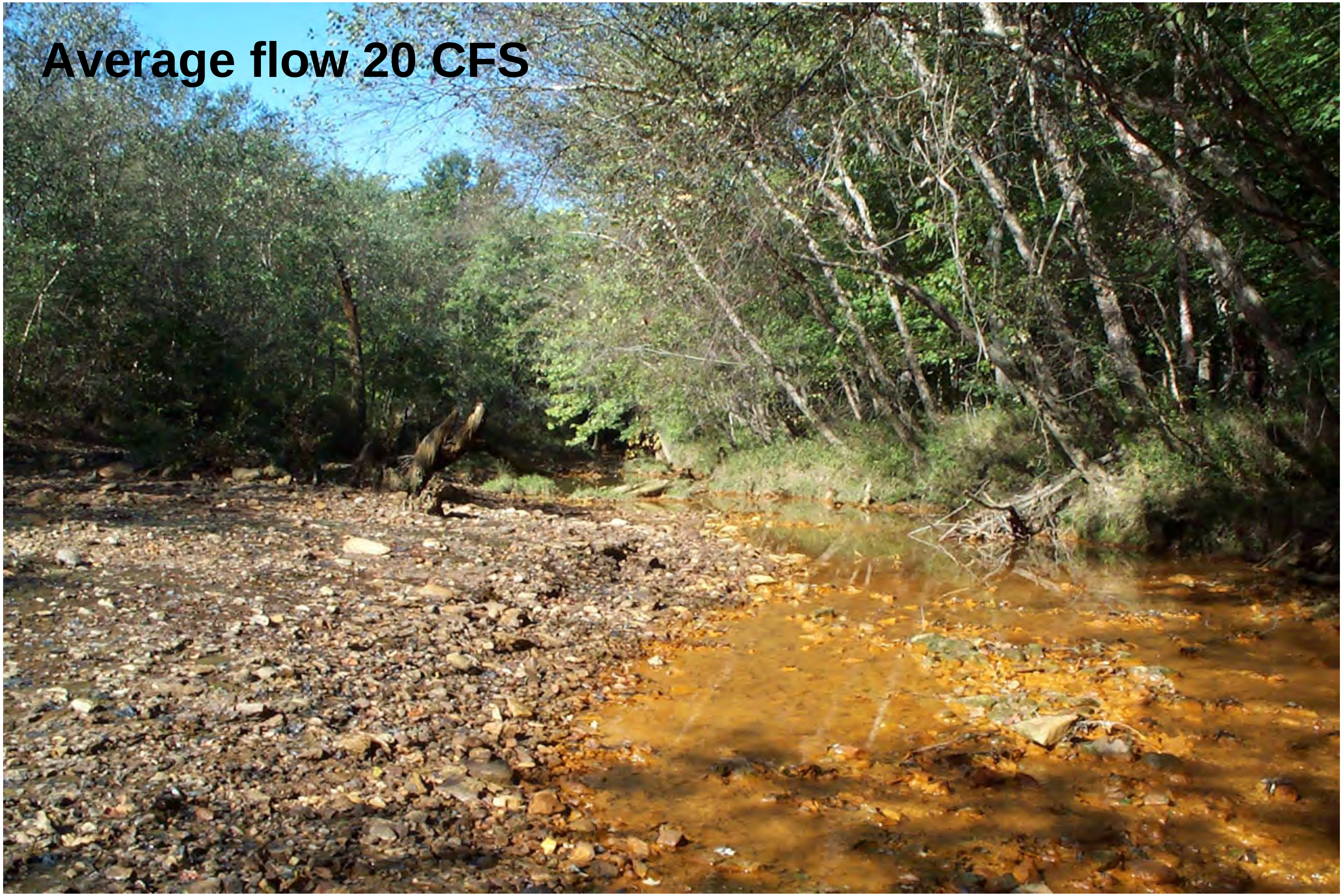
Palzo, Sludge Application

Palzo metals application (lbs/Ac)

IEPA limit	Hg	7
Palzo rate:		2,850

Palzo, 1984 Aerial

Palzo, Sugar Creek 1996



Palzo, IEPA “319” Application

Recip Share $316,000
Assist. Amt $475,000
Total $792,000

PALZO SURFACE MINE PROJECT

IEPA, NONPOINT SOURCE POLLUTION CONTROL PROGRAM
SECTION 319
APPLICATION FOR FINANCIAL ASSISTANCE

Prepared for:

Illinois Environmental Protection Agency
Bureau of Water
P.O. Box 19276
Springfield, Illinois 62974-9276

January 29, 1999

Prepared by:

ILLINOIS
DEPARTMENT OF
NATURAL RESOURCES
OFFICE OF MINES AND MINERALS
DIVISION OF ABANDONED MINED LANDS RECLAMATION
1907 A INDUSTRIAL PARK DRIVE, MARION IL 62959
PHONE 618-997-9495 FAX 618-997-5114

Palzo, Gob Haul Roads

Palzo, W. Drain Clogged Gabion Basket

Palzo, W. Drain Clogged Gabion Basket

Palzo, W. Drain Clogged Gabion Basket

Palzo, West Drain, Before

Palzo, West Drain, Before

Palzo, W. Drain at Sugar Creek

Palzo Kill Zone

Palzo,West Drain After

Palzo West DH, before

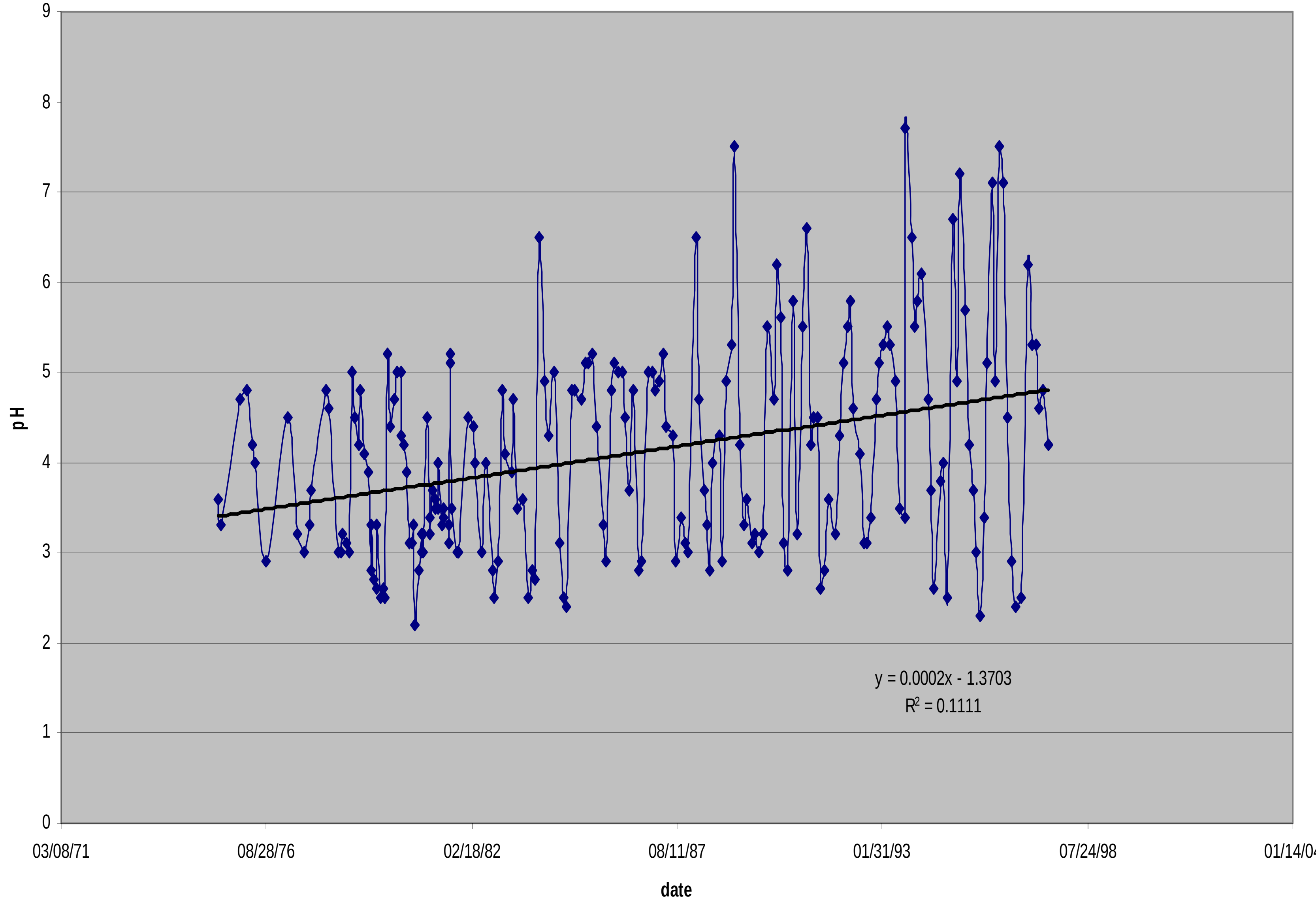
Palzo, West Drain, CKD

Palzo, West DH After

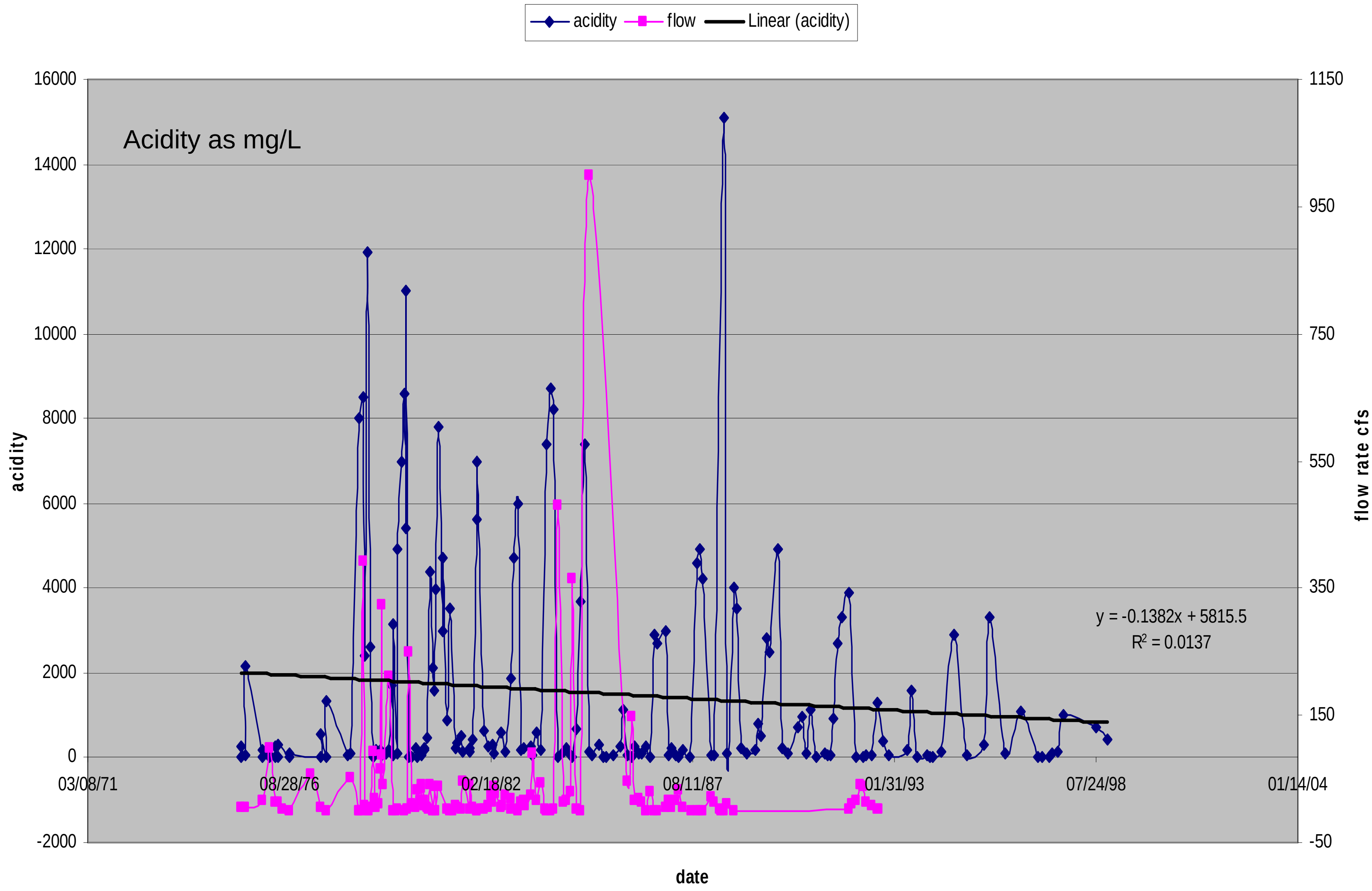
Palzo,Finished West Channel

Palzo, Cementitious Earth, 2007, NorthDrain

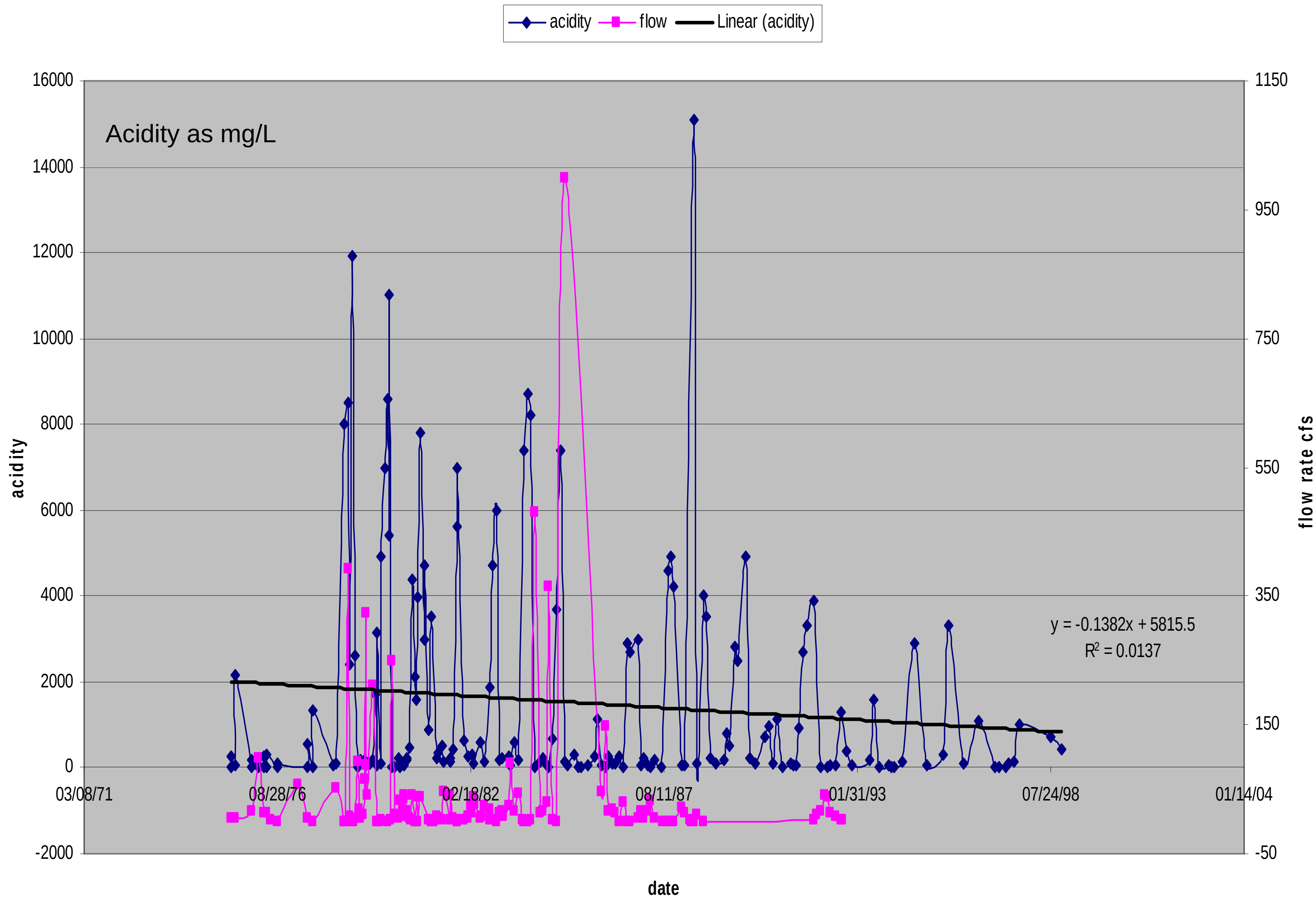
Palzo, pH: 1975 - 2004 ATHG-01



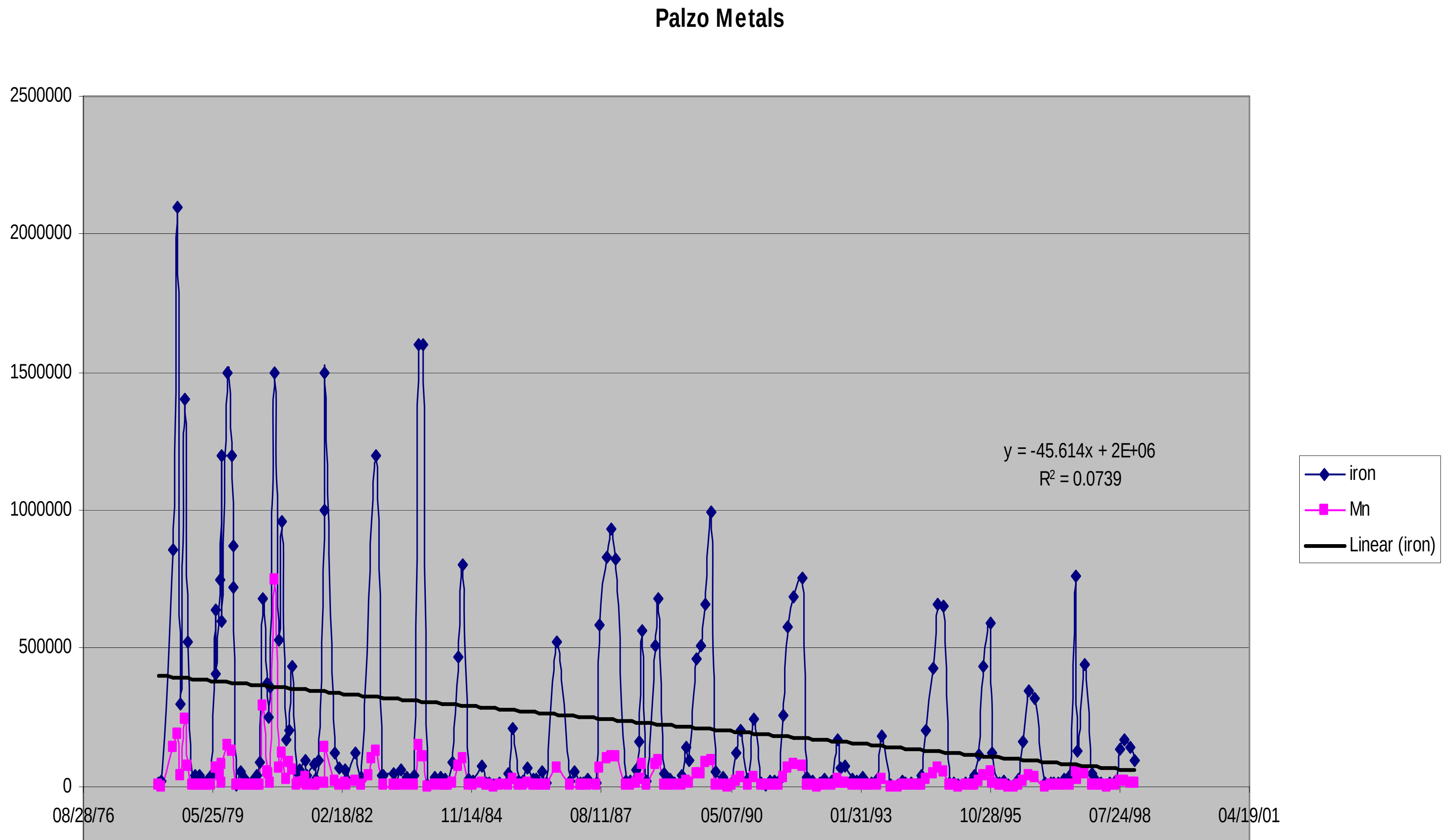
Palzo, Acidity/Flow ATHG-01



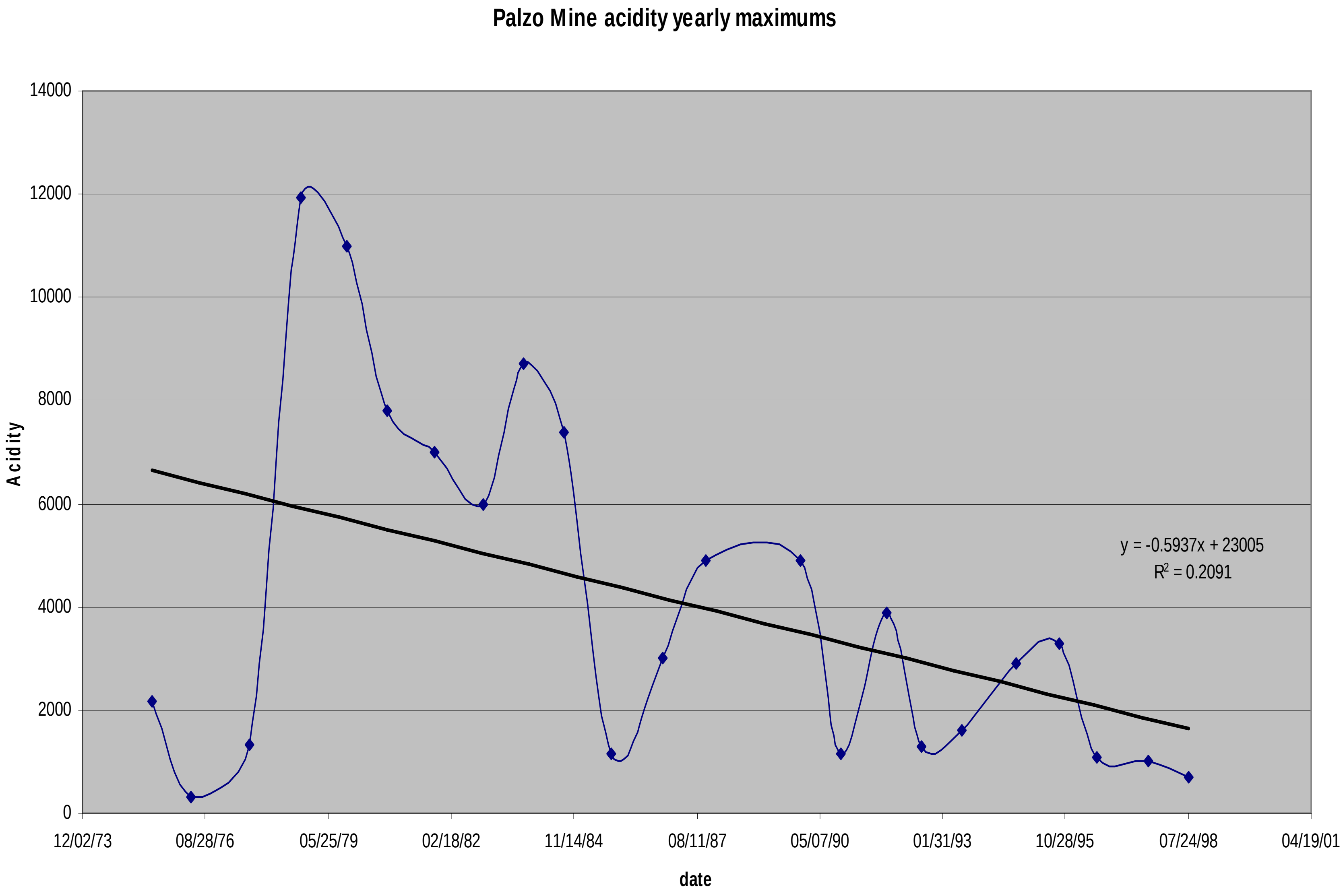
Palzo, Acidity/Flow: 1975-1998



Palzo, Fe and Mn 1978-1998



Palzo Acidity, 1976-1998



Palzo, EcoWatch

Palzo, EcoWatch Bloodworms

Index of Biotic Integrity (IBI)

- 48 pts (good) Points on the Upper Sugar Creek
- 12 pts (very poor) on the Lower Sugar Creek and the south Fork
- Most sites in the Saline Basin in the 40's

Macroinvertibrate Identification

MACROINVERTEBRATE IDENTIFICATION

CODE	ORGANISM	N	T_i	T_v
FLW	Flatworm		6.0	
AQW	Aquatic Worm	3	10.0	30
LEE	Leech		8.0	
SBG	Sowbug		6.0	
SCD	Scud		4.0	
DGF	Dragonfly		4.5	
DM1	Broadwinged Damselfly		3.5	
DM2	Narrowwinged Damselfly		5.5	
HLL	Hellgrammite		3.5	
MF1	Torpedo Mayfly		3.0	
MF2	Swimming Mayfly		4.0	
MF3	Clinging Mayfly	1	3.5	3.5
MF4	Crawling Mayfly		5.5	
MF5	Burrowing Mayfly		5.0	
MF6	Other Mayfly		3.0	
STF	Stonefly	1	1.5	1.5
CF1	Hydropsychid Caddisfly		5.5	
CF2	Non-Hydrospychid Caddisfly		3.5	
RFB	Riffle Beetle ??	5	5.0	25
WHB	Whirligig Beetle		4.0	
WPB	Water Penny Beetle		4.0	
CRF	Crane Fly		4.0	
BIM	Biting Midge		5.0	
BLW	Bloodworm	18	11.0	198
MID	Midge		6.0	
BLF	Black Fly		6.0	
SNF	Snipe Fly		4.0	
OTF	Other Fly		10.0	
LHS	Left-Handed Snail		9.0	
RHS	Right-Handed Snail		7.0	
PLS	Planorbid Snail		6.5	
LIM	Limpet		7.0	
OPS	Operculate Snail		6.0	
	TOTALS	27		258
	ΣTAXA = 5	ΣN		ΣT_v

MBI = $\Sigma T_v \div \Sigma N$ = **9.56**

258 / 27 =

<6.0 = GOOD Water Quality
6.1 - 7.5 = FAIR Water Quality
7.6 - 8.9 = POOR Water Quality
> or = 9.0 = VERY POOR Water Quality

SAMPLE DENSITY = ΣN = **27**

TAXA RICHNESS = ΣTAXA = **5**

PERCENT COMPOSTION OF INDICATOR ORGANISMS

ORGANISM	N	÷	ΣN	x 100 =	%C
MAYFLIES (PMF)	1	÷	27	x 100 =	3.70
STONEFLIES (PSF)	1	÷	27	x 100 =	3.70
CADDISFLIES (PCF)	—	÷		x 100 =	
BLOODWORMS(PBW)	18	÷	27	x 100 =	66.7
AQUATIC WORMS(PAW)	3	÷	27	x 100 =	11.1

SUBTOTAL % = 85.2

% ALL OTHERS (100 % - SUBTOTAL %) = 14.8
(PAO)

NOTES (MNT):

Ron sampled the stream alone - No help.

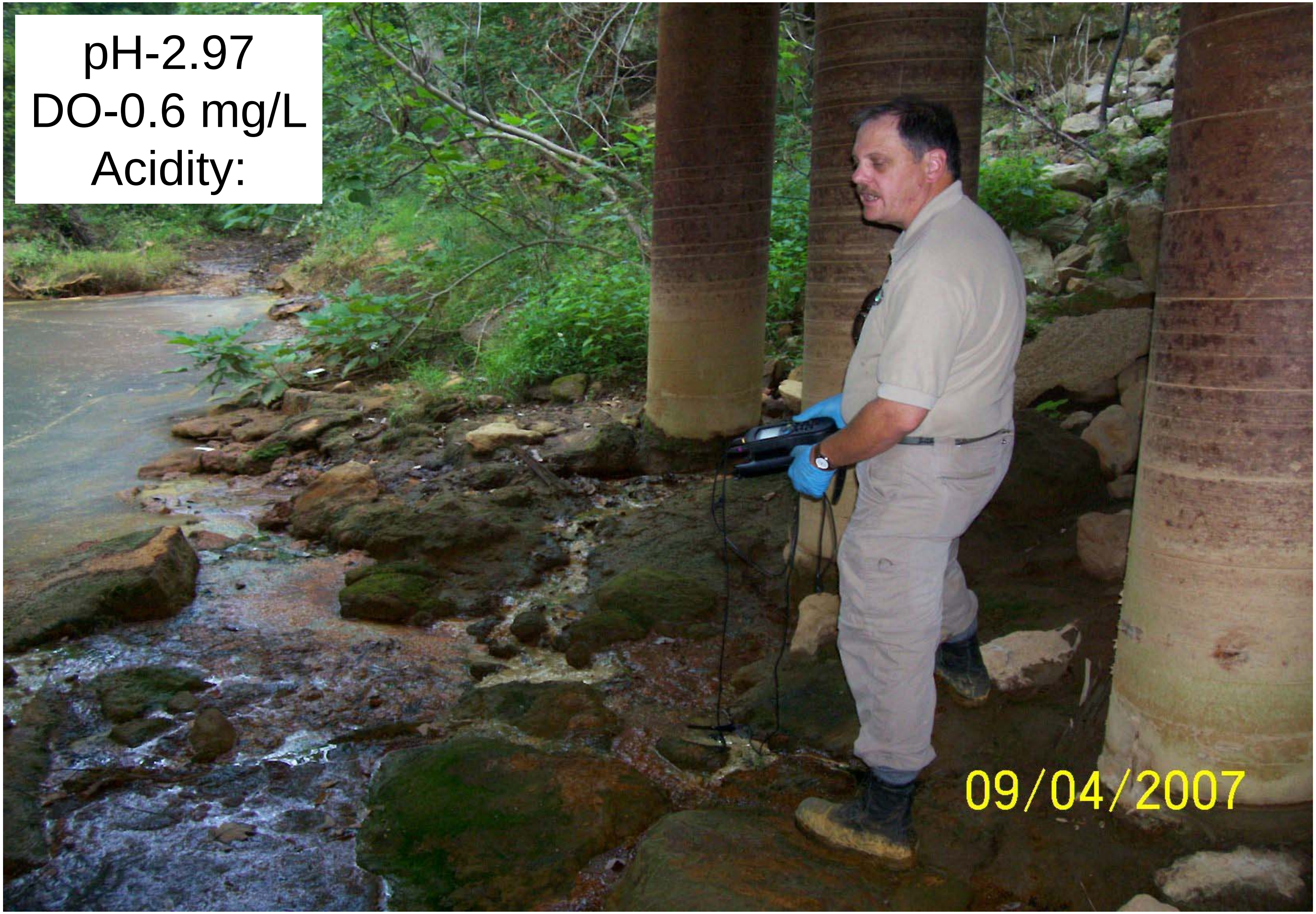
PLEASE VERIFY YOUR DATA SHEETS

CITIZEN SCIENTIST INITIALS RK DATE 06/04/07
CITIZEN SCIENTIST INITIALS ________ DATE ________
EW STAFF INITIALS ________ DATE ________

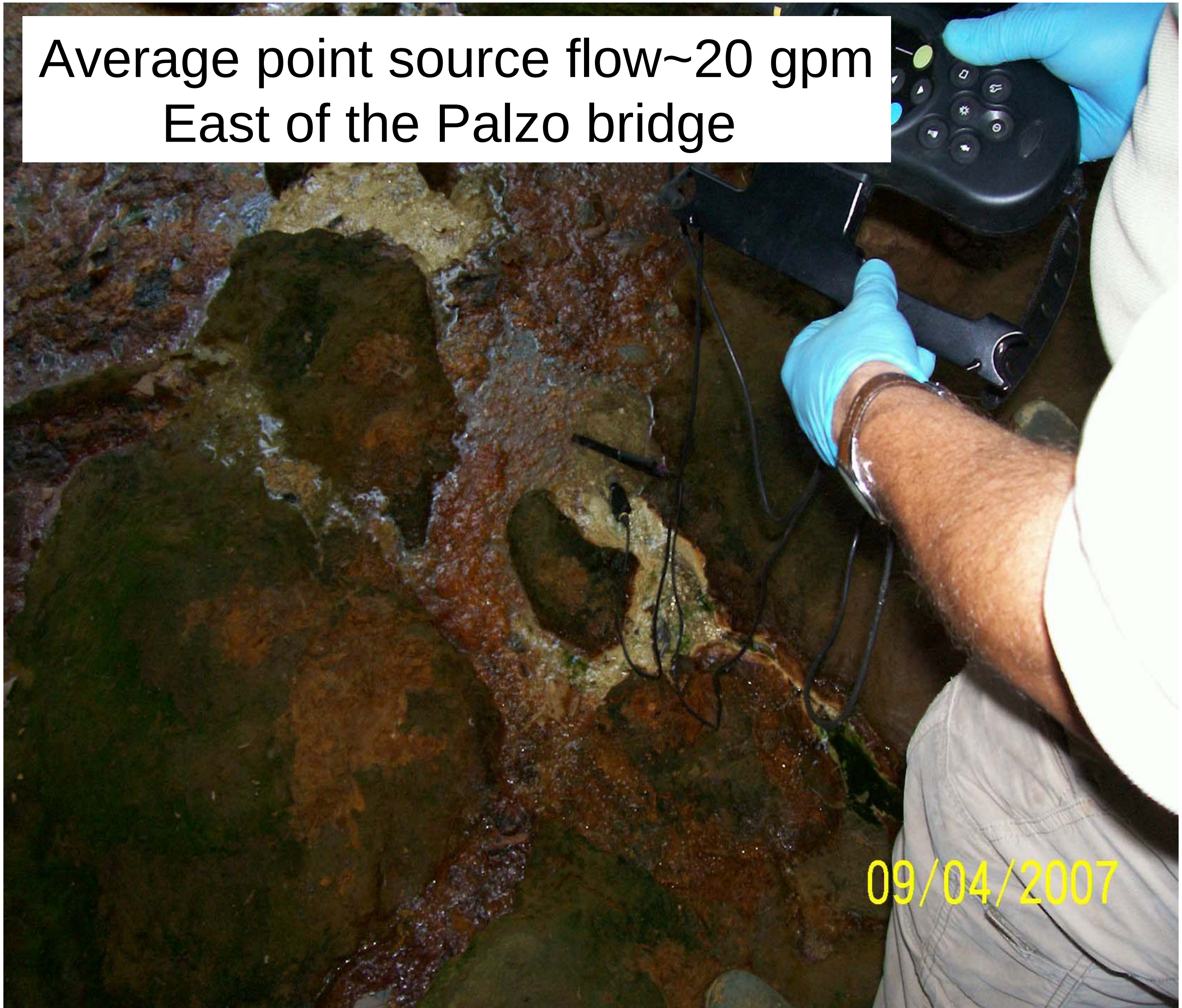
Palzo, as of September, 2007

Palzo, Seeps under the bridge

Palzo, Sampling seeps under bridge



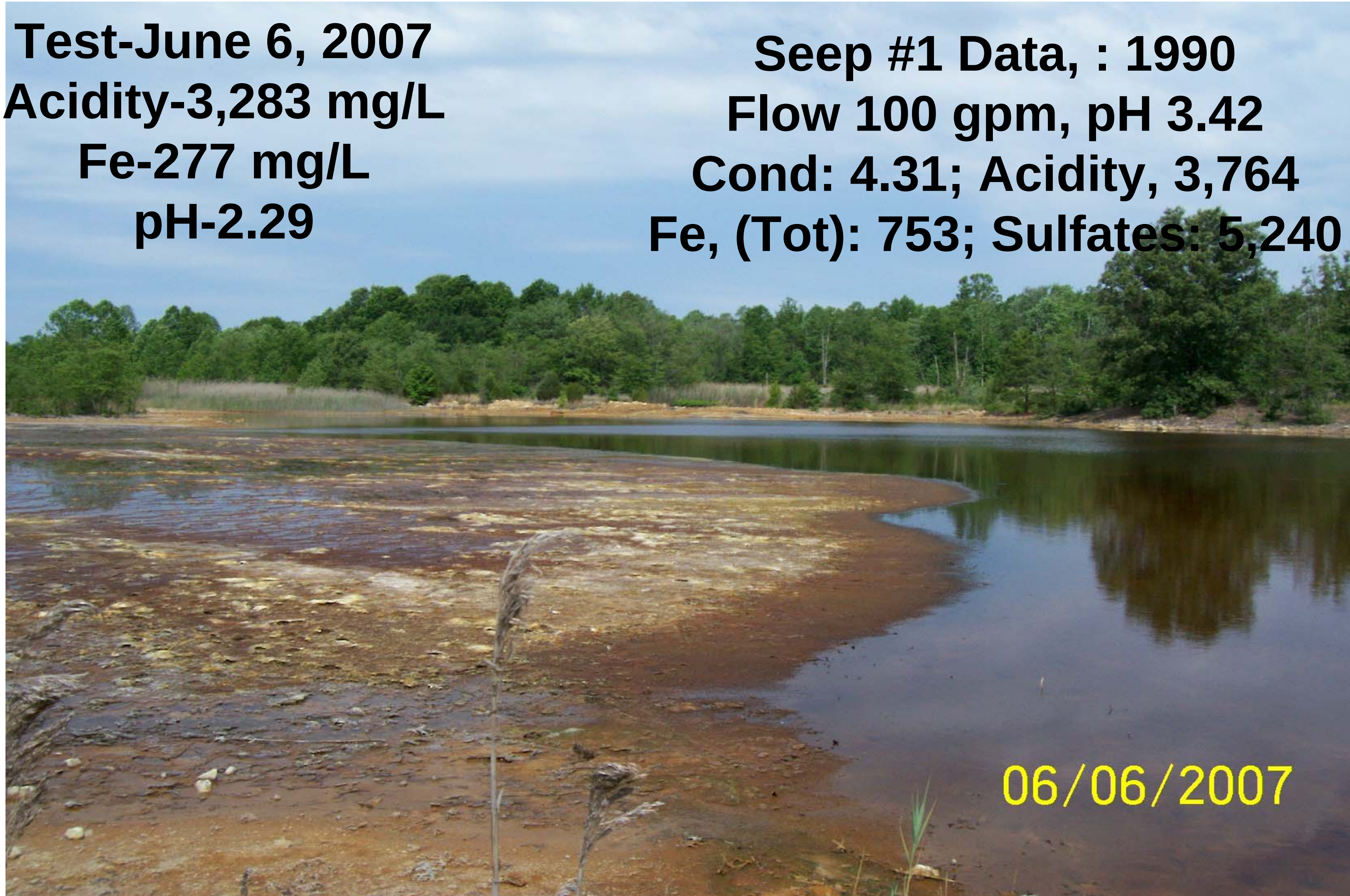
Palzo, Seeps under the bridge



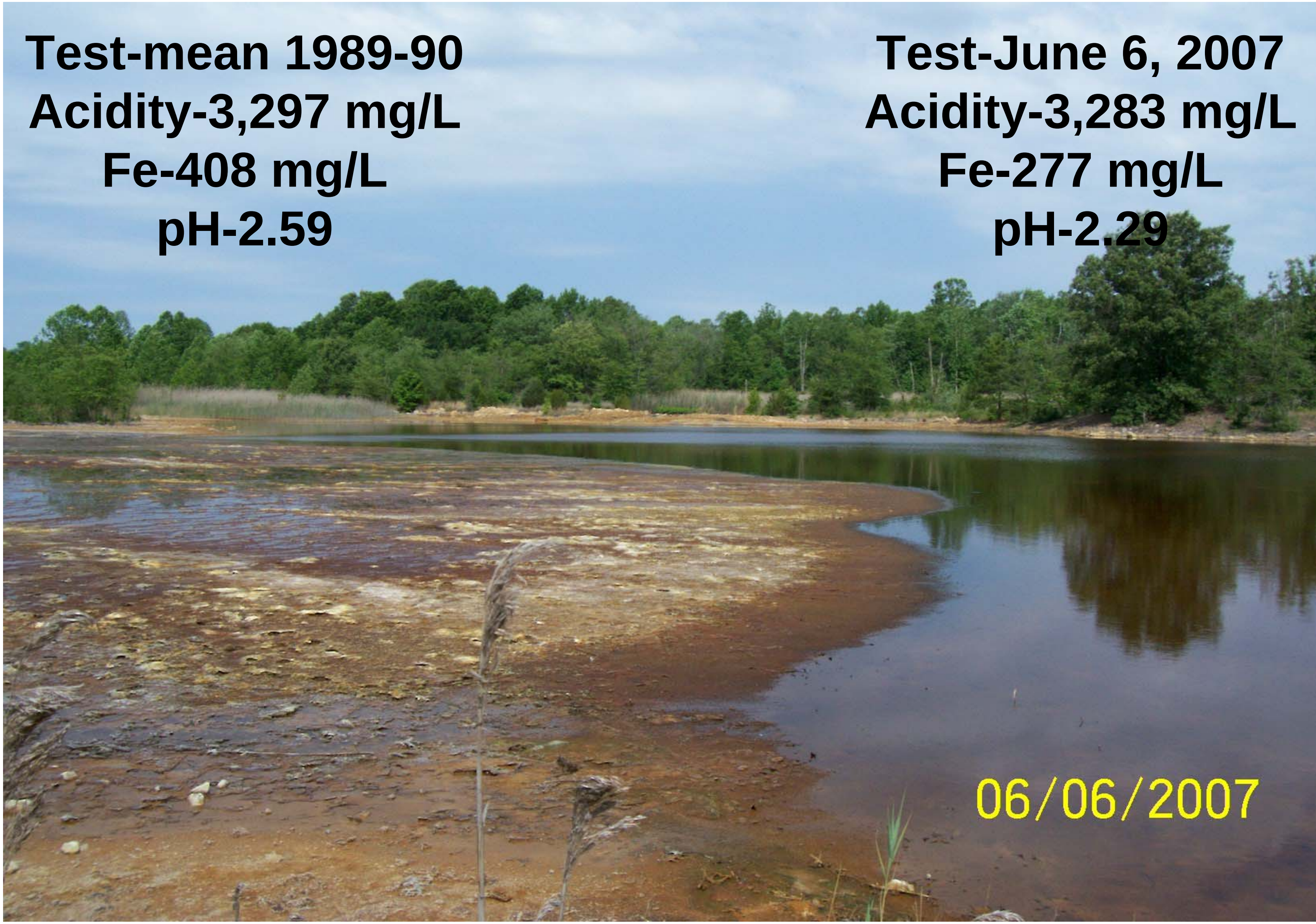
Will Scarlet Mine Aerial, 2003

Sugar Creek/ South Fork Confluence

Will Scarlet Pit 4

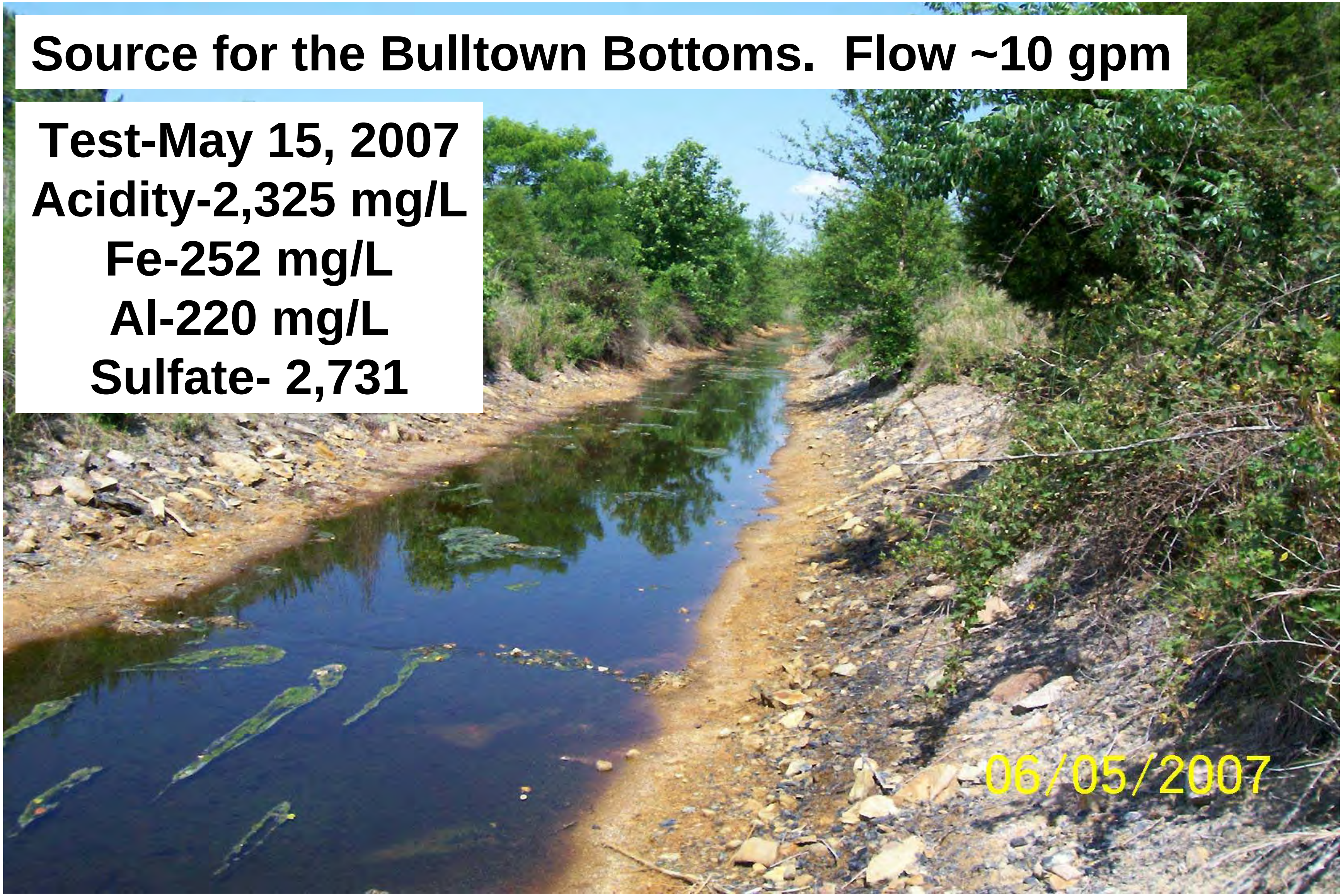


Will Scarlet, Pit #4



Will Scarlet, Pond 4, Seep 1

Will Scarlet Pit 4 Drainage Ditch



Will Scarlet AMD Pit 5

Will Scarlet Mine: Gob

Will Scarlet Carp pools

Saline River Basin 1995

Thunderbird Collieries

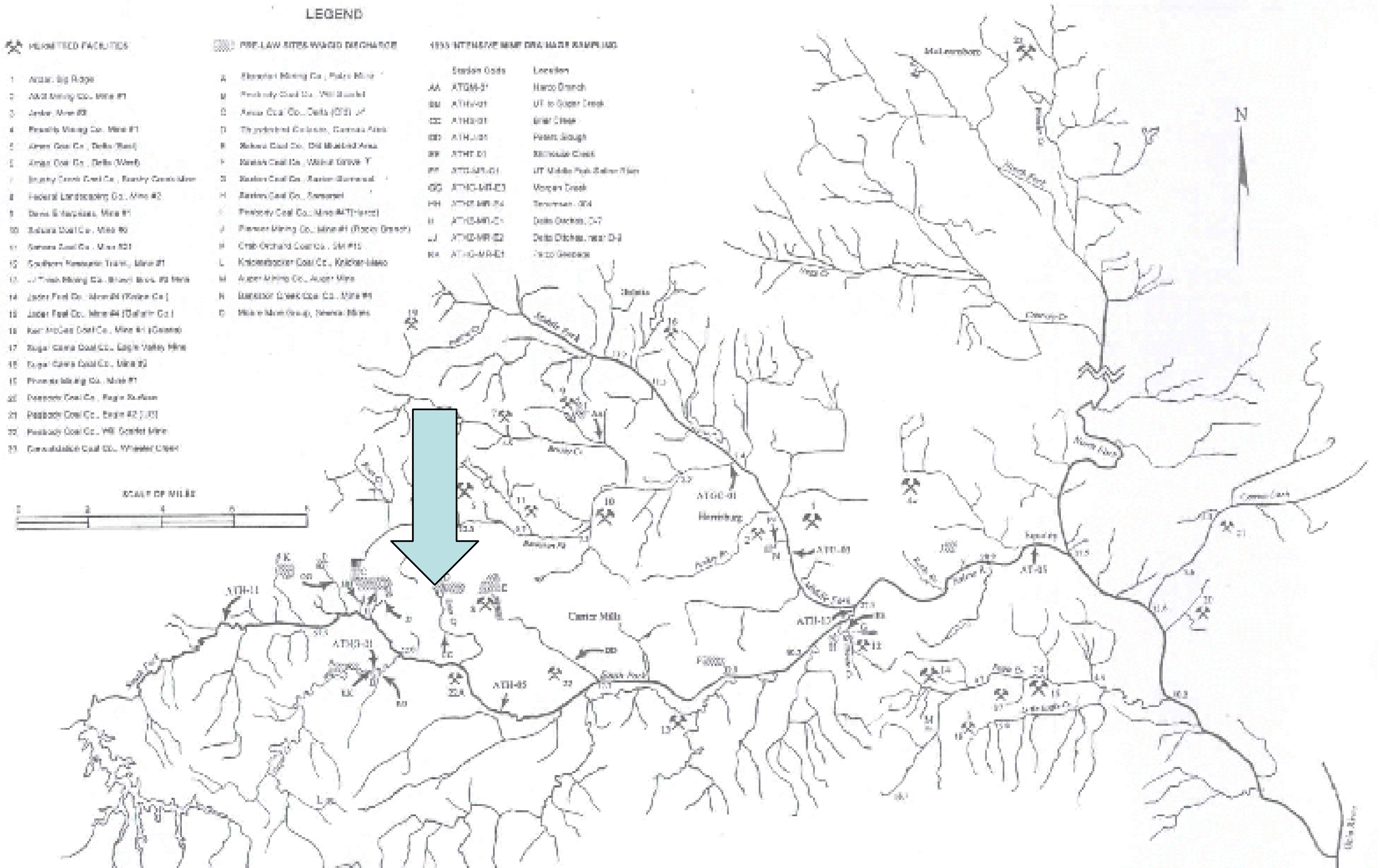


Figure 5.1. Location of permitted and significant pre-law mine sites in the Saline River basin, 1995.

Thunderbird DH, Acid Pit 2005

Fish??
pH 3.5
~50 million gallons

Pitco Top Facility (Bluebird Mining)

Pitco (Bluebird), AMD to South Fork River

Pitco(Bluebird) 10 Ac Kill Zone

Saline River Basin 1995

Saxton CC, Walnut Grove

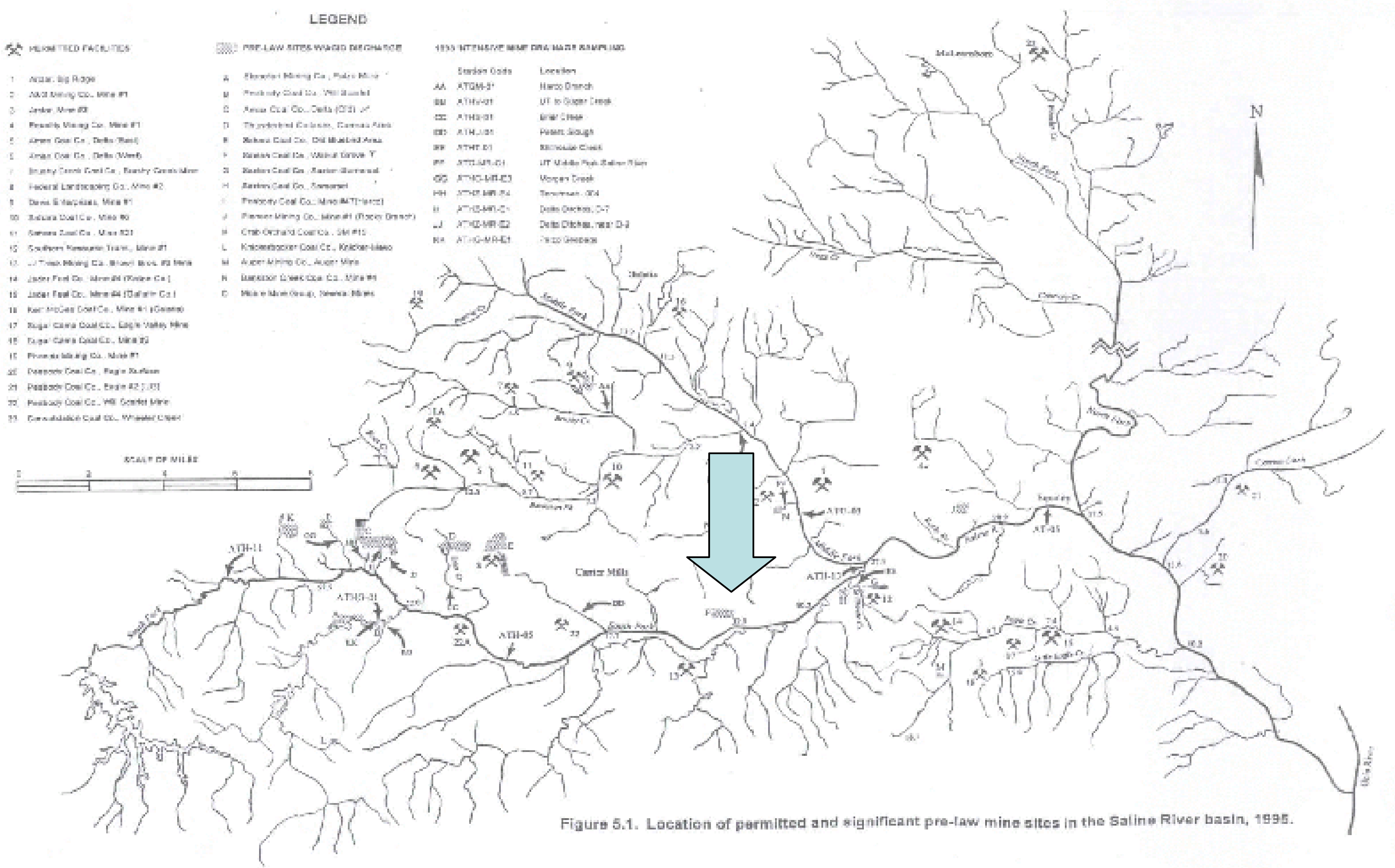
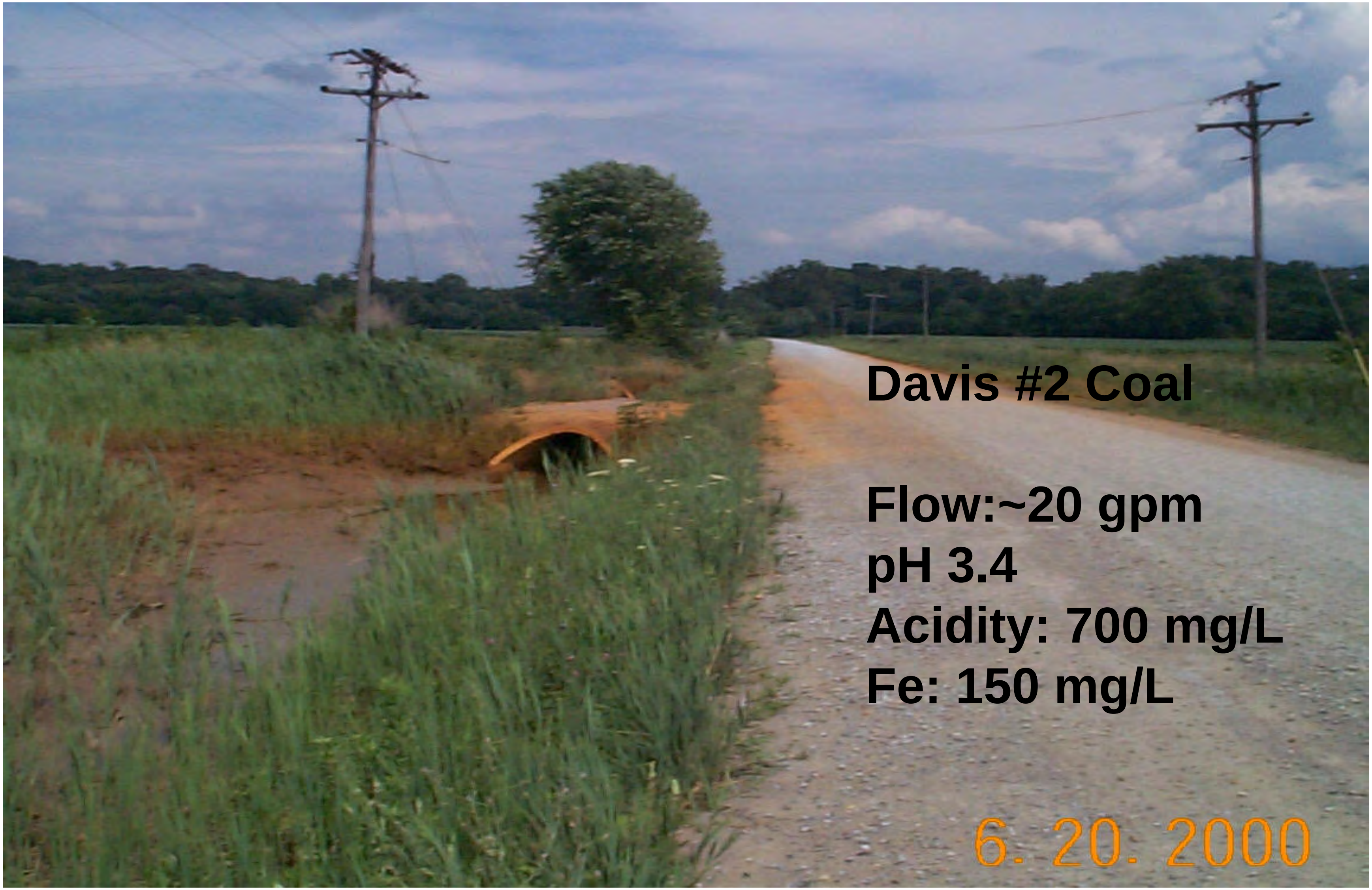


Figure 5.1. Location of permitted and significant pre-law mine sites in the Saline River basin, 1995.

Saxton Ph 1 DH, AMD

Saxton, Ph 1 DH, Pit Backfilling

Saxton Ph 1 AMD to South Fork



Saxton, Deep Lime Incorporation

Saxton, Deep Incorp. Rocks

Saline River Basin 1995

Rocky Branch Area (Marshall)

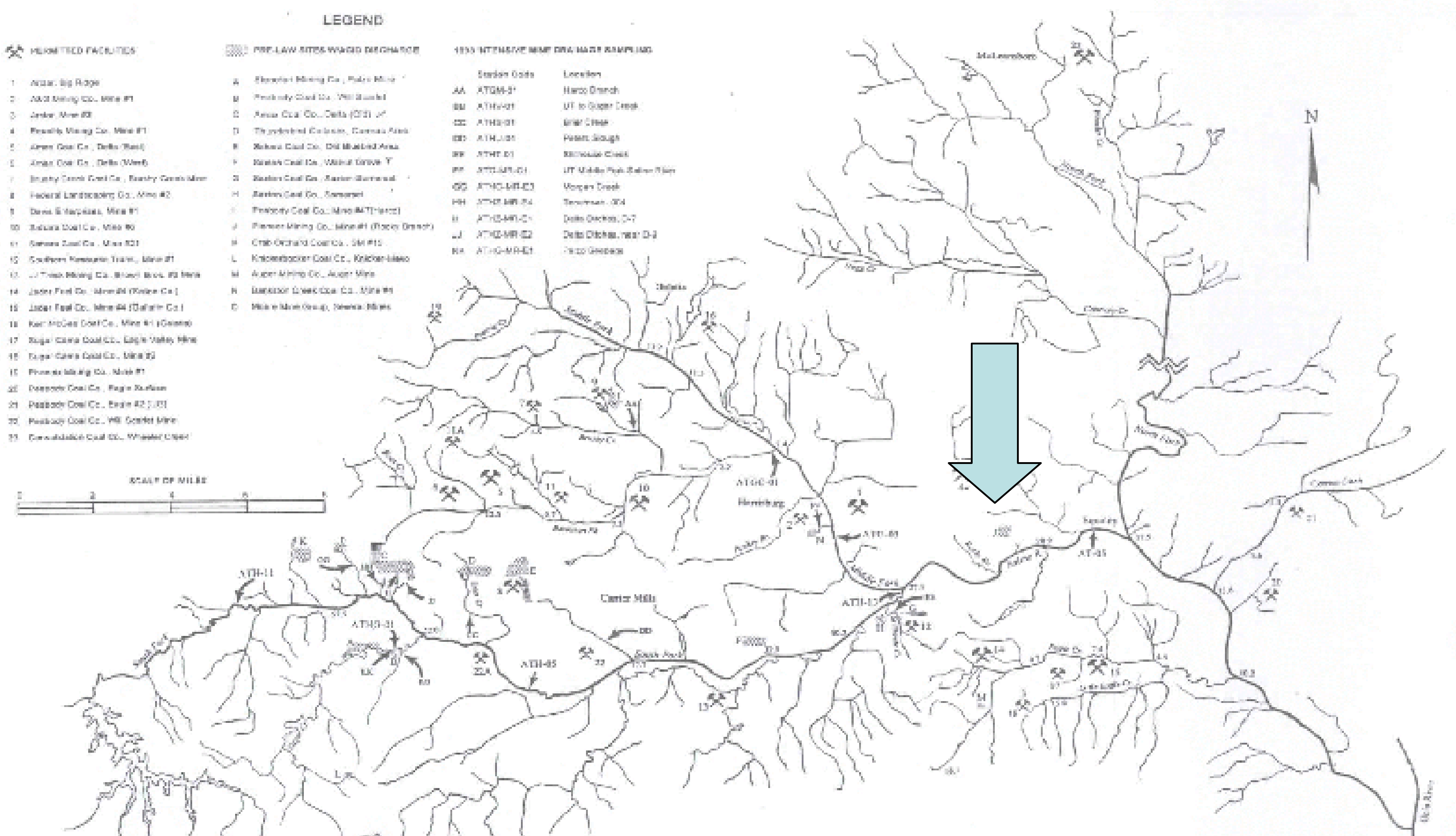
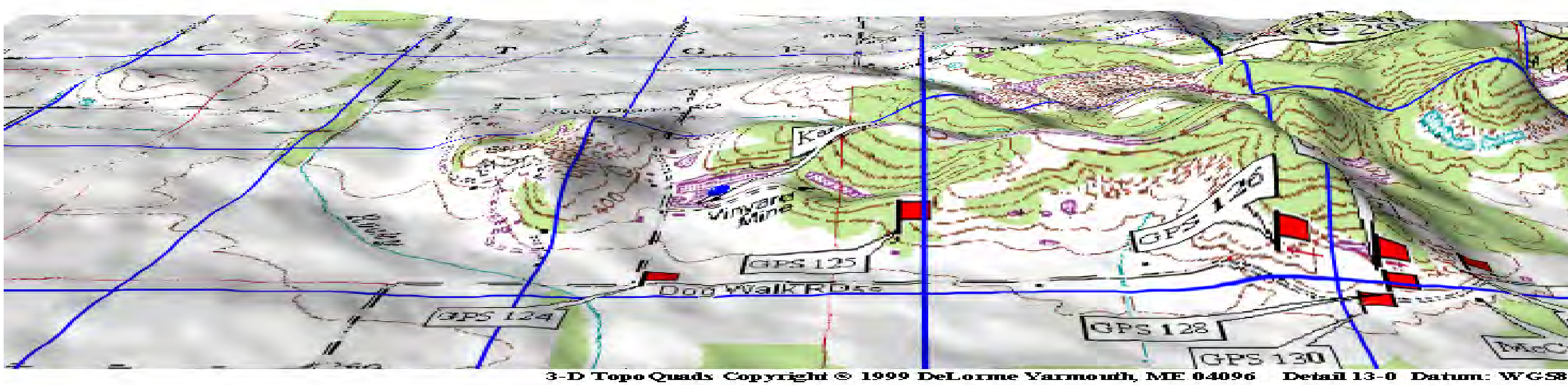


Figure 5.1. Location of permitted and significant pre-law mine sites in the Saline River basin, 1995.

Rocky Branch Site 3D Topo (Marshall Equipment)



Marshall AMD

Marshall Seep

Marshall WQ April 2006

Site 130	June 2005	Oct 2005	Jan 2006	April 2006
pH, s.u.				2.97
Acidity, mg/l				450.6
Alkalinity, mg/l				0
Aluminum, mg/l				11
TDS, mg/l				4,656
Fe, Total mg/l				75.42
Mn, Total mg/l				33.7
Sulfate mg/l				1,768
Ni, mg/l				1
Zn, mg/l				3
Conductiivty, mS				8.7
Diss Oxygen, mg/l				n/s
Flow, gpm				4
Eh				
TSS/l			6	
Temp C				16

South Fork Saline River

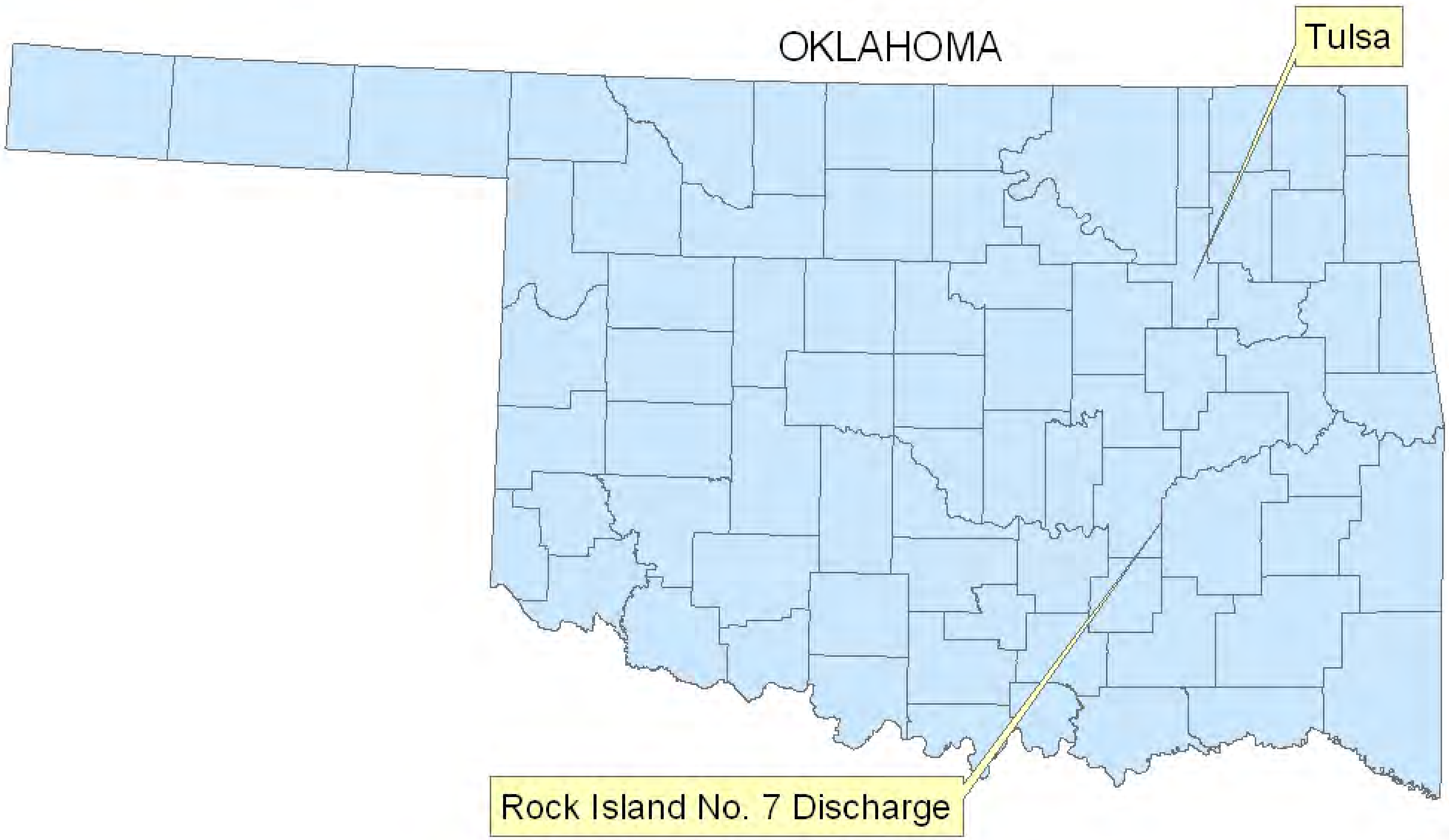
WQ Restoration of a Coal Mining Impacted Riverine System

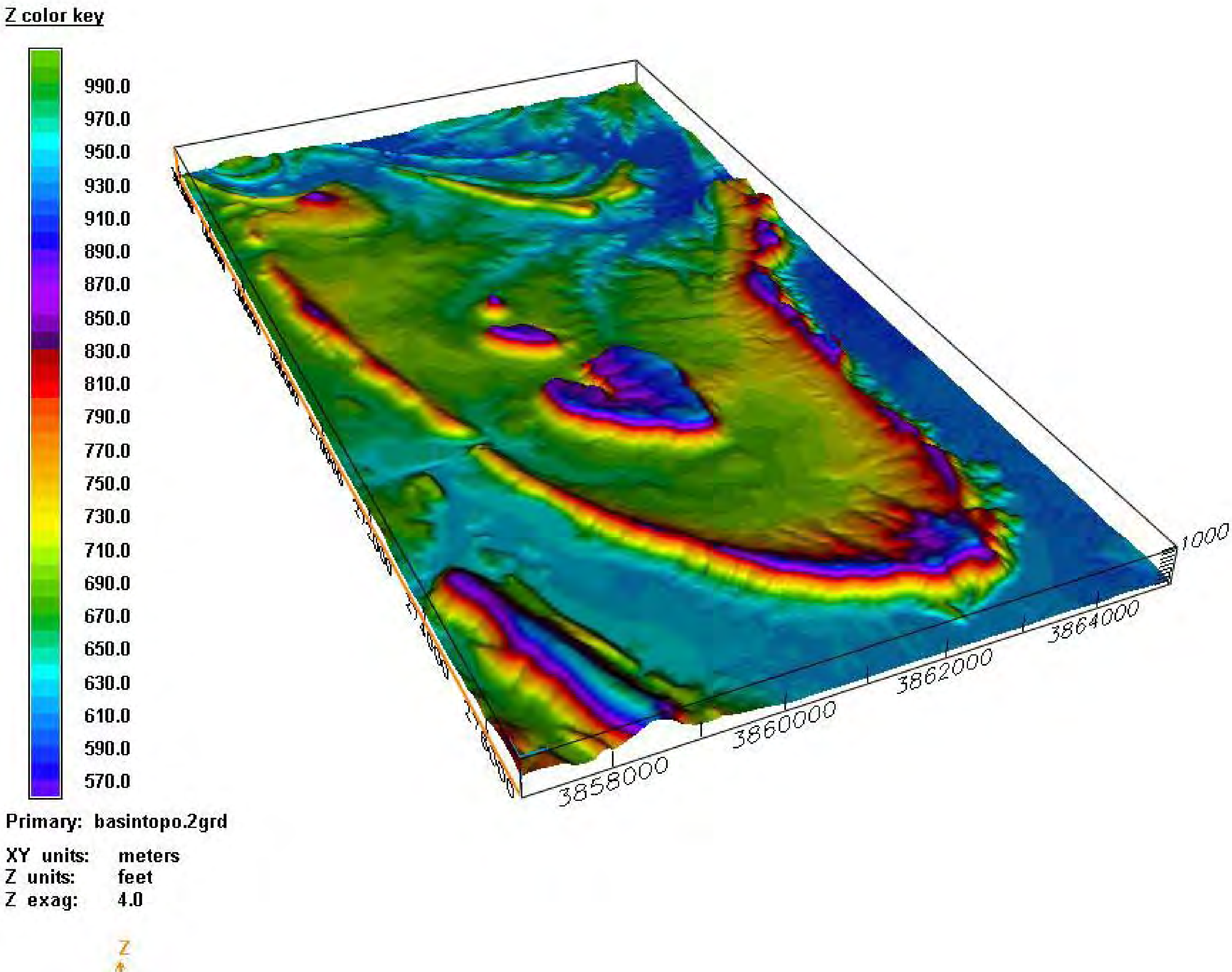
Hydrogeology of Hartshorne Coal Basin in Oklahoma and the Impact on Remediation of Acid Mine Drainage

Paul T. Behum, Hydrologist

Office of Surface Mining, Alton, Illinois

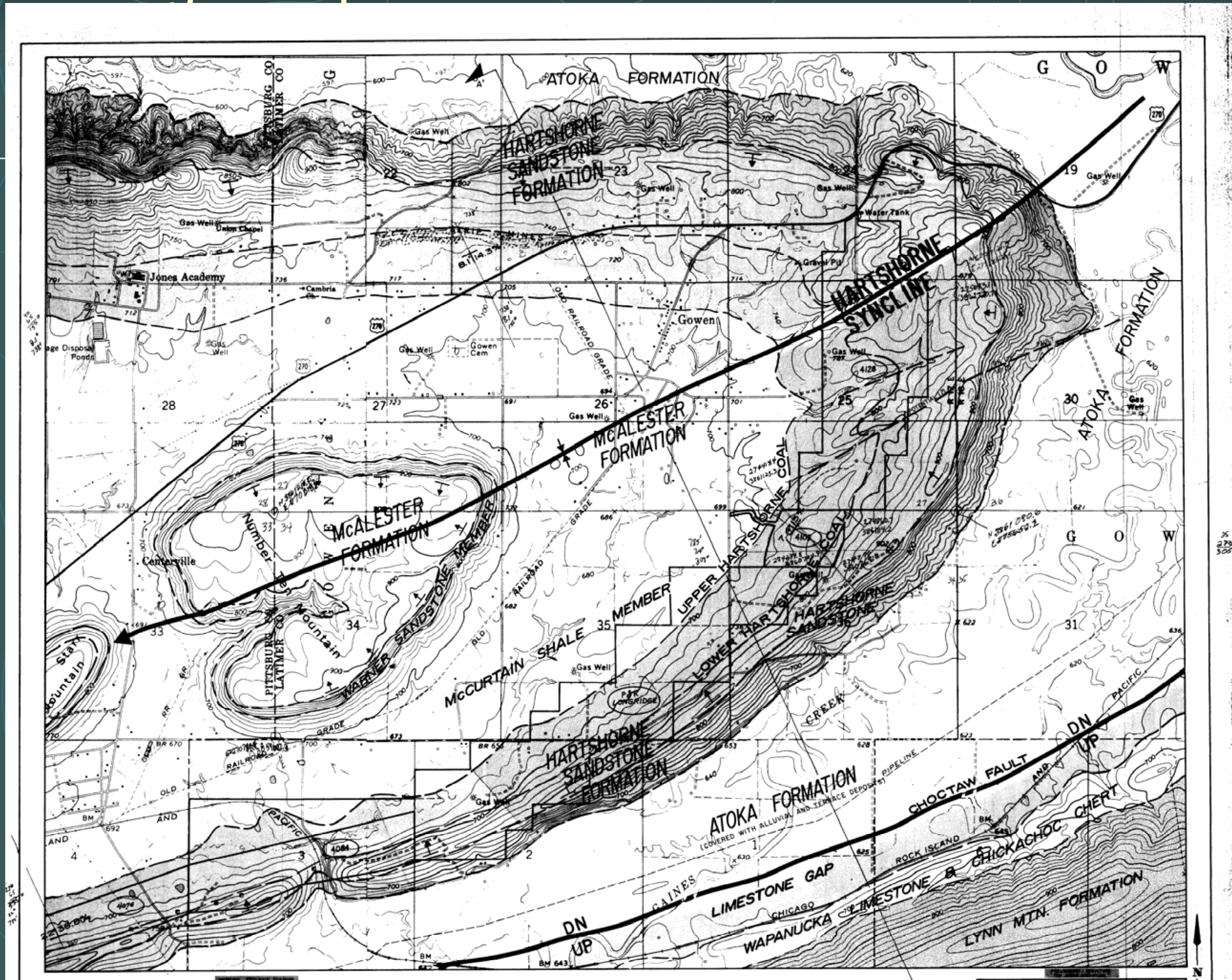
Location of the Hartshorne Coal Basin

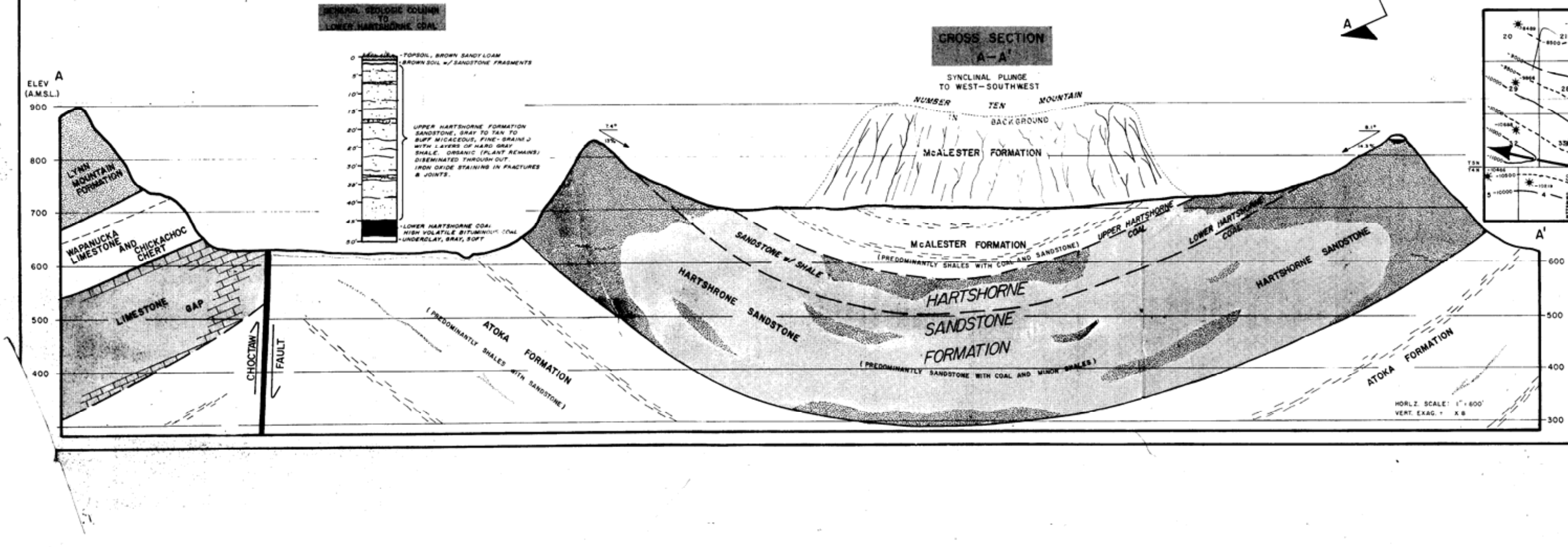




Z color key
990.0
970.0
950.0
930.0
910.0
890.0
870.0
850.0
830.0
810.0
790.0
770.0
750.0
730.0
710.0
690.0
670.0
650.0
630.0
610.0
590.0
570.0
Primary: basintopo.2grd
XY units: meters
Z units: feet
Z exag: 4.0
Z
1000
3858000
3860000
3862000
3864000

Geologic Map of the Hartshorne Coal Basin





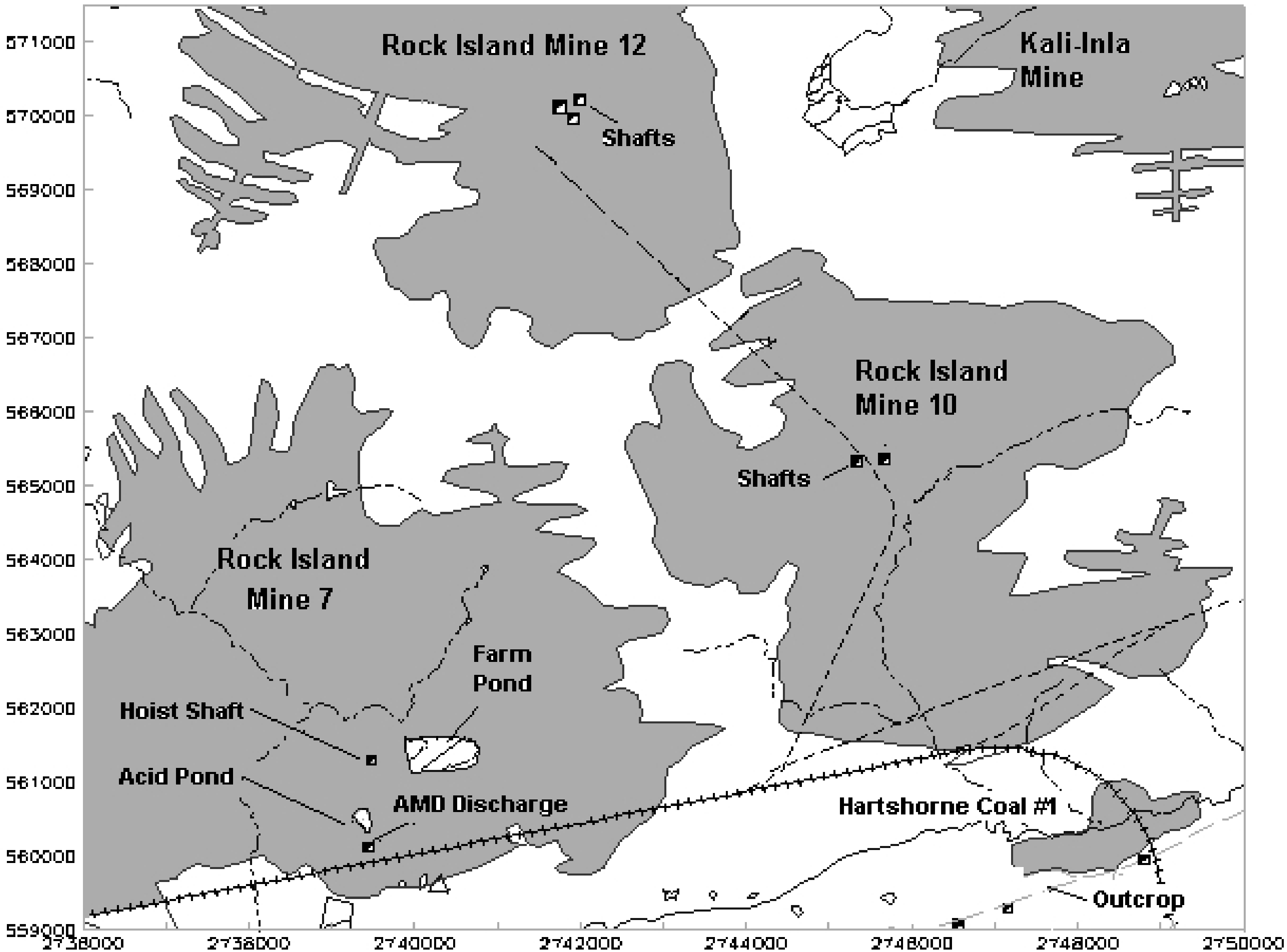
The Hartshorne Coal Basin: Synclinal Mountain Range

The underlying Hartshorne Sandstone Member is a fractured-rock aquifer confined by the overlying shale units in the Upper Hartshorne Formation.

Mine Drainage Problem Sites: Hartshorne Coal Basin, Pittsburg and Latimer Counties, Oklahoma

- Center of Coal Basin (>100 ft. depth to coal)
  - Rock Island No. 7 Airshaft Discharge
  - Jeffries Field Seep
- Basin Edge (<100 ft. depth to coal)
  - GCI Permit 4105 (Title V)
  - Gowan Mine 40 Discharge
  - McHugh Borehole

Rock Island No.7 Mine Pool Problem, Oklahoma.



Hydrologic Issues Related to AMD

- Systematic water quality variations with overburden depth.
- Presence of pre-mining non-compliance (high-iron) level discharges.
- Structural controls on AMD remediation facility locations.
- Limitations of topographic relief at AMD seep locations.

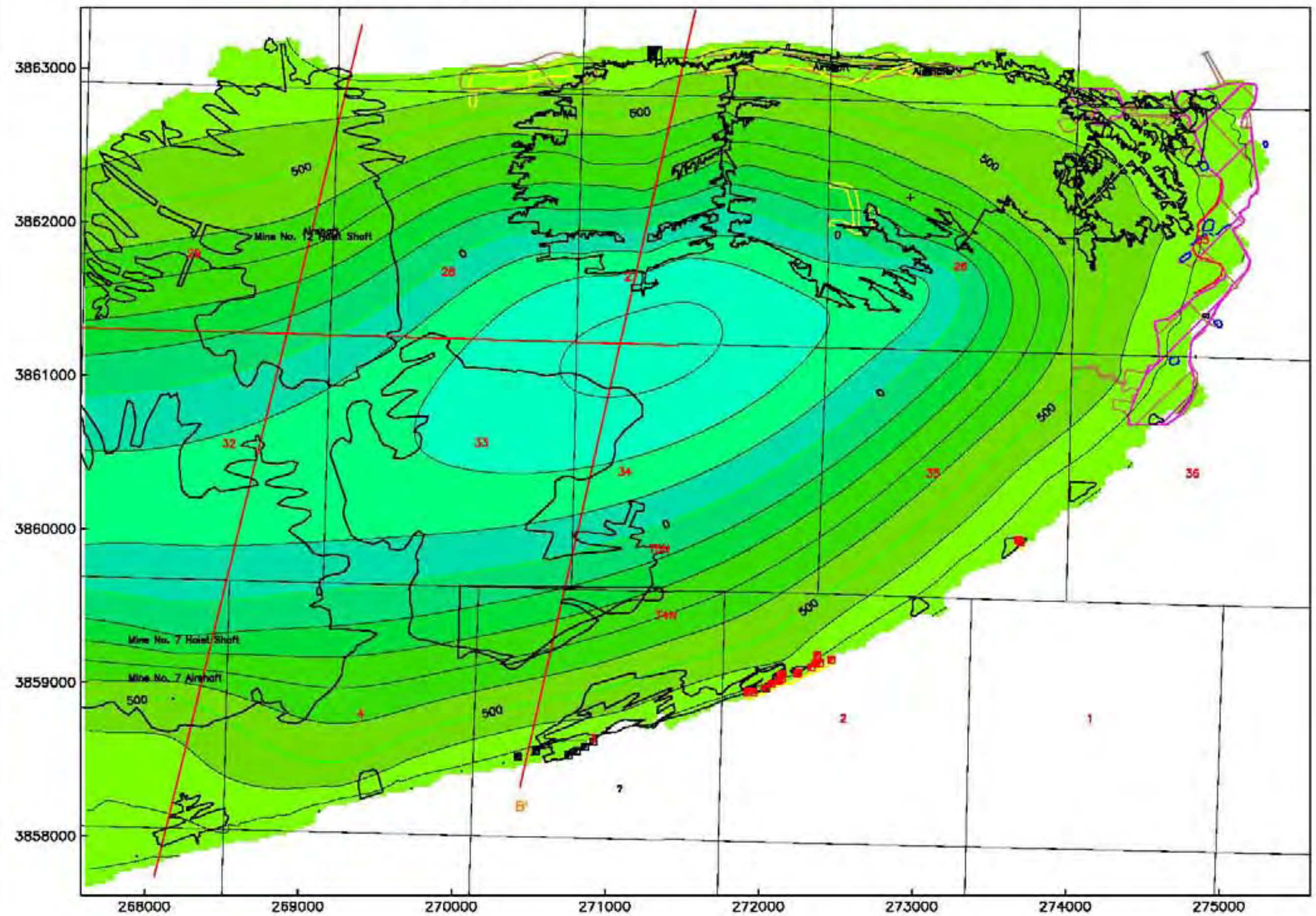
Hydrologic Issues Related to AMD

- Systematic water quality variations with overburden depth.
- Presence of pre-mining non-compliance (high-iron) level discharges.
- Structural controls on AMD remediation facility locations.
- Limitations of topographic relief at AMD seep locations.

Systematic Water Quality Variations with Overburden Depth.

- Center of Coal Basin (>100 ft. depth to coal).
  - High Conductivity/very high sulfate content.
  - High Fe (ferrous) and elevated trace metal concentrations.
  - Moderate pH/significant alkalinity/high Ca & Mg content.
  - Low aluminum content.
- Basin Edge (<100 ft. depth to coal).
  - Moderate sulfate and iron content.
  - Low pH, No alkalinity.
  - Moderately high aluminum content.
  - Lower Ca, Mn, Zn, Ni.

Isopach Map of the Base of the Hartshorne Coal Bed



Mine Drainage Problem Sites: Hartshorne Coal Basin, Pittsburg and Latimer Counties, Oklahoma

- Center of Coal Basin (>100 ft. depth to coal)
  - Rock Island No. 7 Airshaft Discharge
  - Jeffries Field Seep
- Basin Edge (<100 ft. depth to coal)
  - GCI Permit 4105 (Title V)
  - Gowan Mine 40 Discharge
  - McHugh Borehole

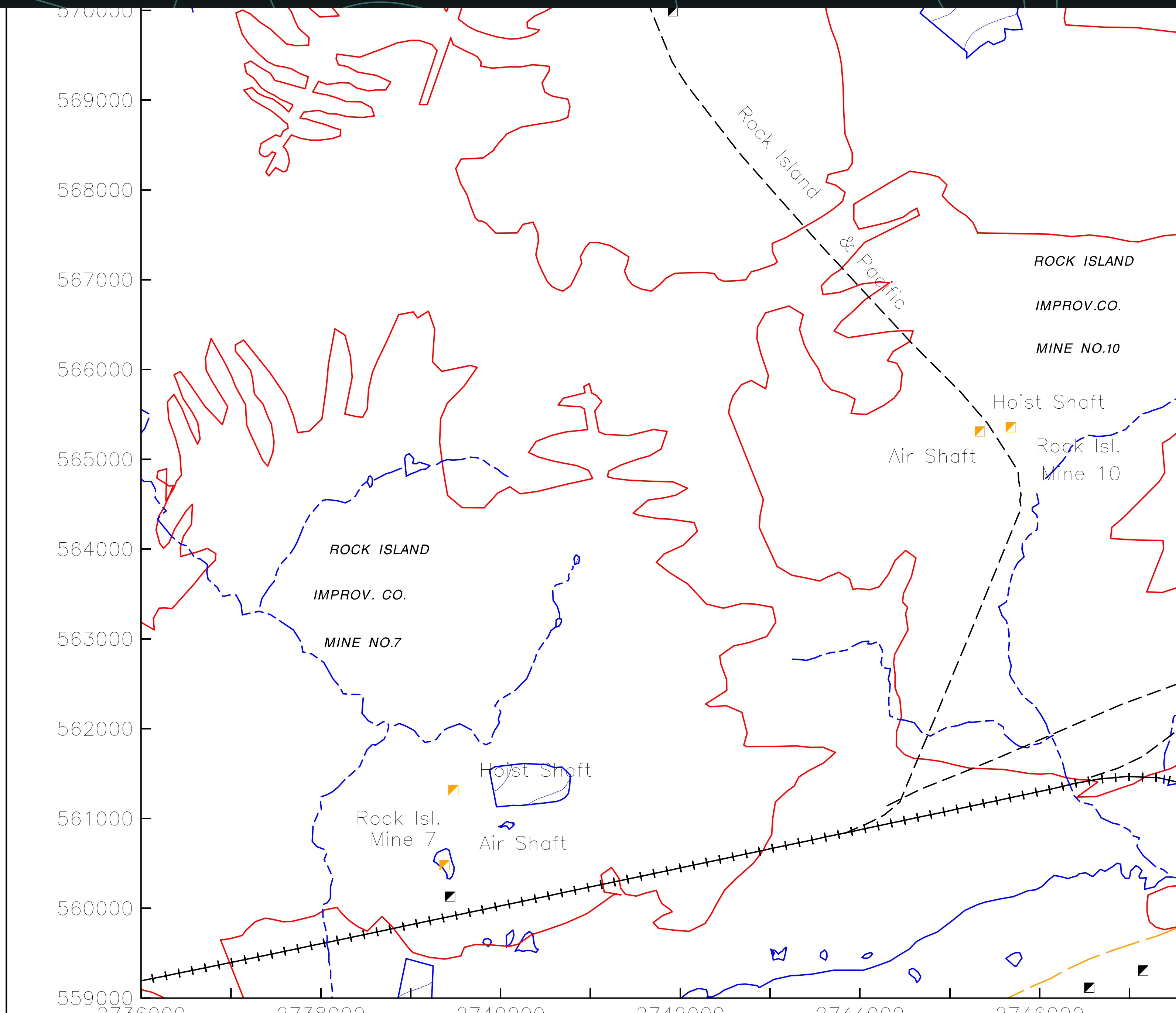

570000
569000
568000
567000
566000
565000
564000
563000
562000
561000
560000
559000
2736000
2738000
2740000
2742000
2744000
2746000
Rock Island & Pacific
ROCK ISLAND
IMPROV.CO.
MINE NO.10
Hoist Shaft
Air Shaft
Rock Isl. Mine 10
ROCK ISLAND
IMPROV. CO.
MINE NO.7
Hoist Shaft
Rock Isl. Mine 7
Air Shaft

Table 1. Design Parameters: Untreated AMD Quality and Contaminant the Rock Island Mine 7 Discharge, Oklahoma.*

Parameter	Range	Median	Units	Comments
pH	5.29 to 5.54	5.42	S.U.	24 measurements
Eh (est.)		90	mv	5 measurements
Conductivity		11,445	uS	22 measurements
DO		0.3	mg/L	22 measurements, mean = 0.4 mg/L
Fe		770	mg/L	23 analyses, mean = 858 mg/L
Al		0.18	mg/L	22 analyses, mean = 0.48 mg/L
Mn		17.4	mg/L	22 analyses, mean = 20.8 mg/L
T. Acidity		1,454	mg/L	15 analyses, mean = 1,500 mg/L
T. Alkalinity		112	mg/L	21 analyses, mean = 121 mg/L
Calcium		318	mg/L	11 analyses, mean = 313 mg/L
Magnesium		230	mg/L	9 analyses, mean = 241 mg/L
Sulfate		7,146	mg/L	18 analyses, mean = 8,029 mg/L
Sodium		1,813	mg/L	6 analyses, mean = 1,995 mg/L
Flow @ Inlet		0.32	L/sec	5 GPM is a typical value

*These tests are a combination of OCC and OSM-MCRCC field measurements, OCC/Oklahor University lab, OSM field and in-house lab analysis and EPA-certified lab analysis.

Mine Drainage Problem Sites: Hartshorne Coal Basin, Pittsburg and Latimer Counties, Oklahoma

- Center of Coal Basin (>100 ft. depth to coal)
  - Rock Island No. 7 Airshaft Discharge
  - Jeffries Field Seep
- Basin Edge (<100 ft. depth to coal)
  - GCI Permit 4105 (Title V)
  - Gowan Mine 40 Discharge
  - McHugh Borehole

Georges Colliers, Inc.
Permit 4105 AMD
Active Treatment Facility

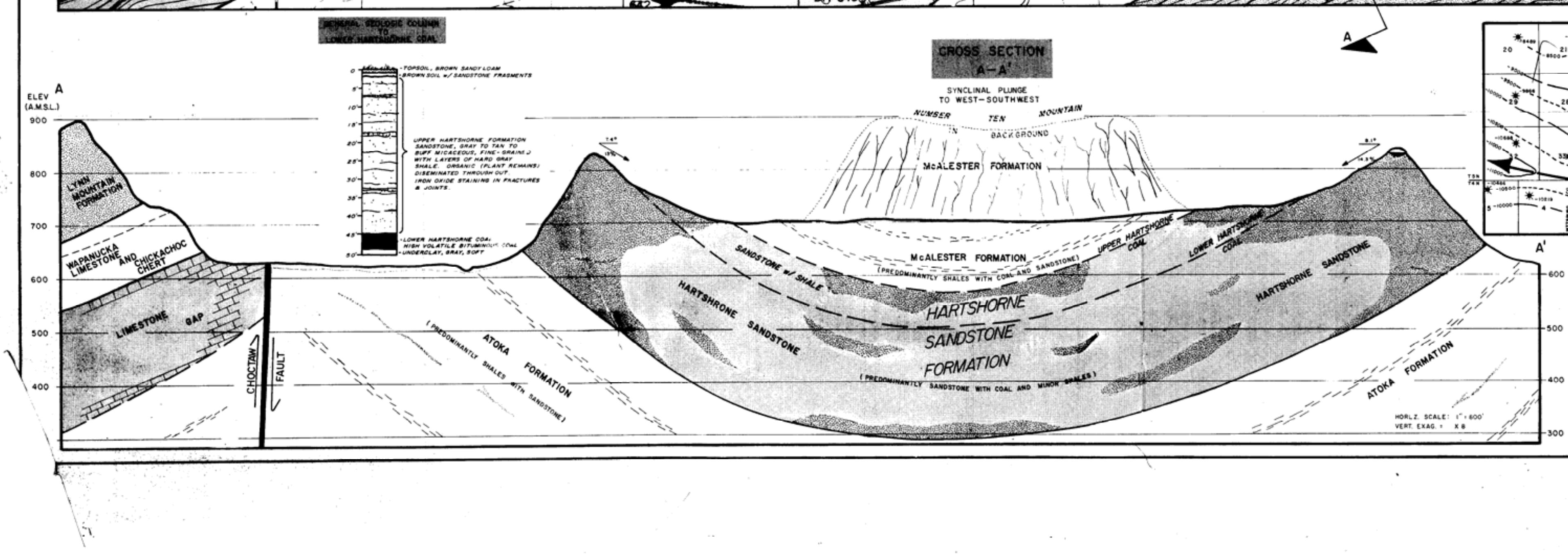
Median Water Quality
Gowan 40 and GCI 4105 Seeps

	pH	Total Alkalinity (mg/L CCE*)	Lab Acidity (mg/L CCE*)	Iron (mg/L)	Aluminum (mg/L)	Mn (mg/L)	Sulfate (mg/L)
Gowan 40	3.72	0.0	616	228	33.1	10.4	1,080
GCI 4105	3.77	0.0	392	77.2	35.4	5.0	1,120
Rock Island No. 7	5.42	112.0	1,454	770	0.2	17.4	7,146

* CCE = Calcium Carbonate Equivalent

Hydrologic Issues Related to AMD

- Systematic water quality variations with overburden depth.
- Presence of pre-mining non-compliance (high-iron) level discharges.
- Structural controls on AMD remediation facility locations.
- Limitations of topographic relief at AMD seep locations.



The Hartshorne Coal Basin: Synclinal Mountain Range

The underlying Hartshorne Sandstone Member is a fractured-rock aquifer confined by the overlying shale units in the Upper Hartshorne Formation.

Non-Mining related, ferruginous seeps

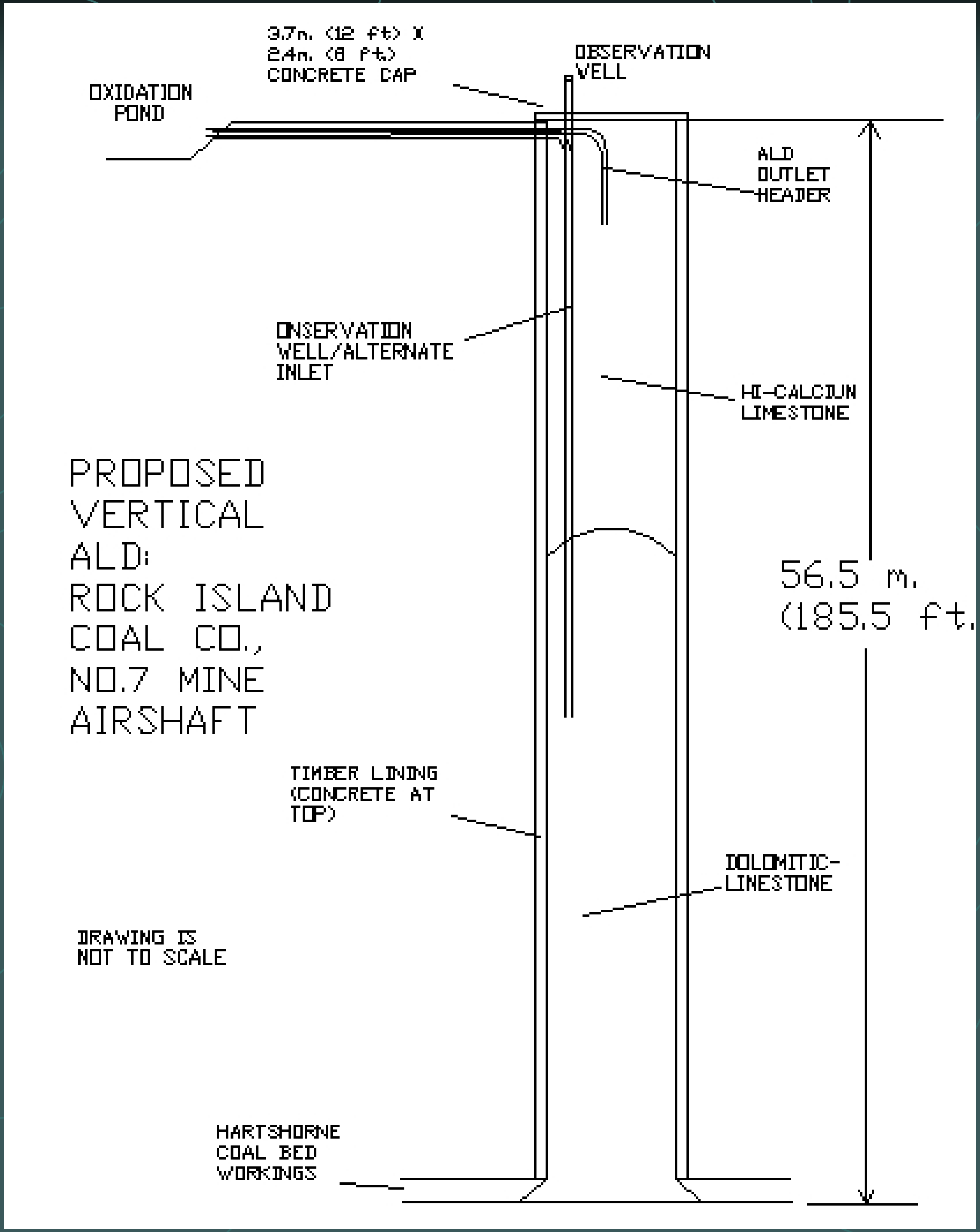
	pH	Total Alkalinity (mg/L CCE*)	Total Acidity (mg/L CCE*)	Iron (mg/L)	Aluminum (mg/L)	Mn (mg/L)
GCI Seep #3	6.51	77.0	24.3	9.1	0.03	2.0
GCI 4105	3.77	0.0	392	77.2	35.4	5.0

Hydrologic Issues Related to AMD

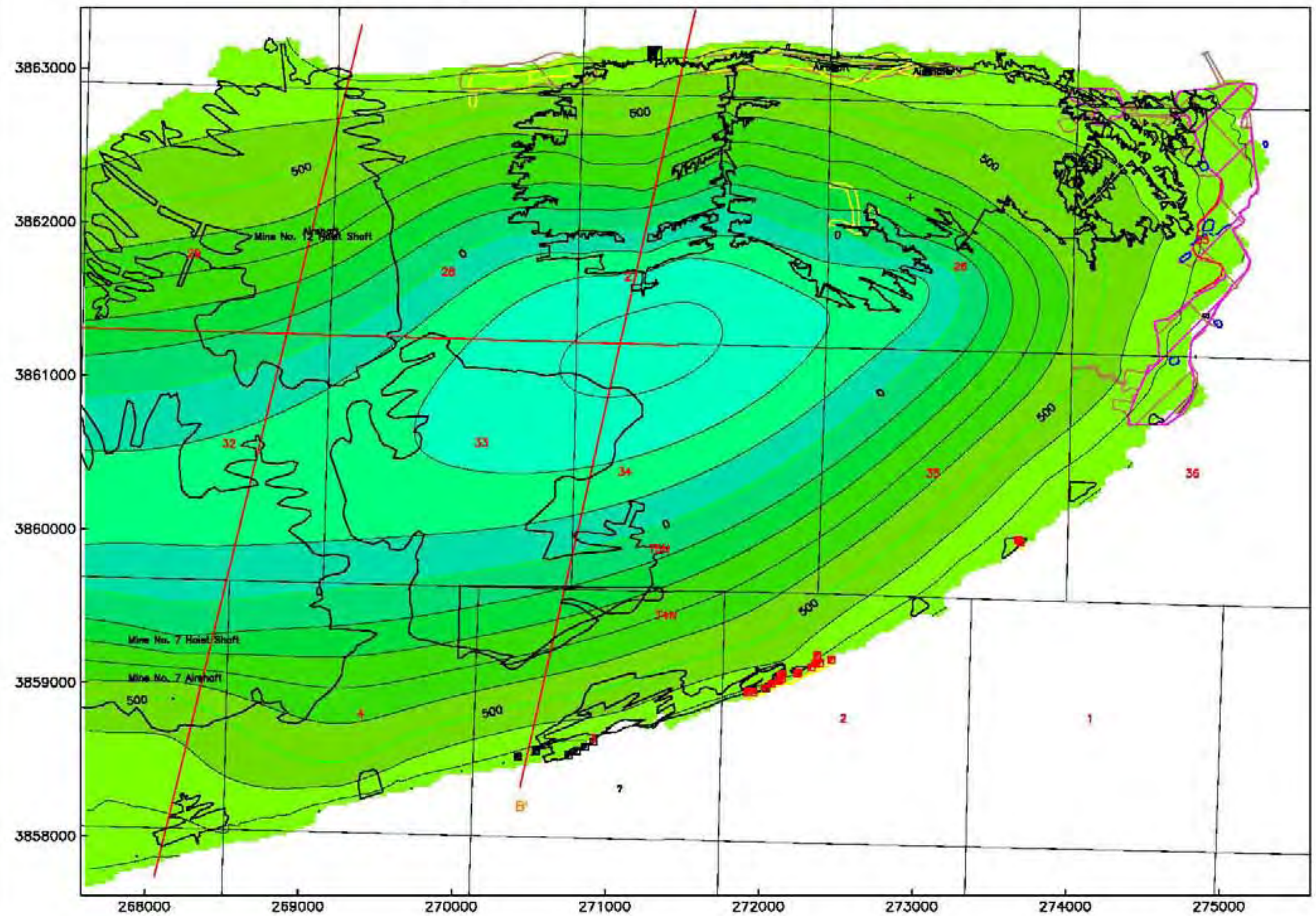
- Systematic water quality variations with overburden depth.
- Presence of pre-mining non-compliance (high-iron) level discharges.
- Structural controls on AMD remediation facility locations.
- Limitations of topographic relief at AMD seep locations.

No. 7 Airshaft System Design

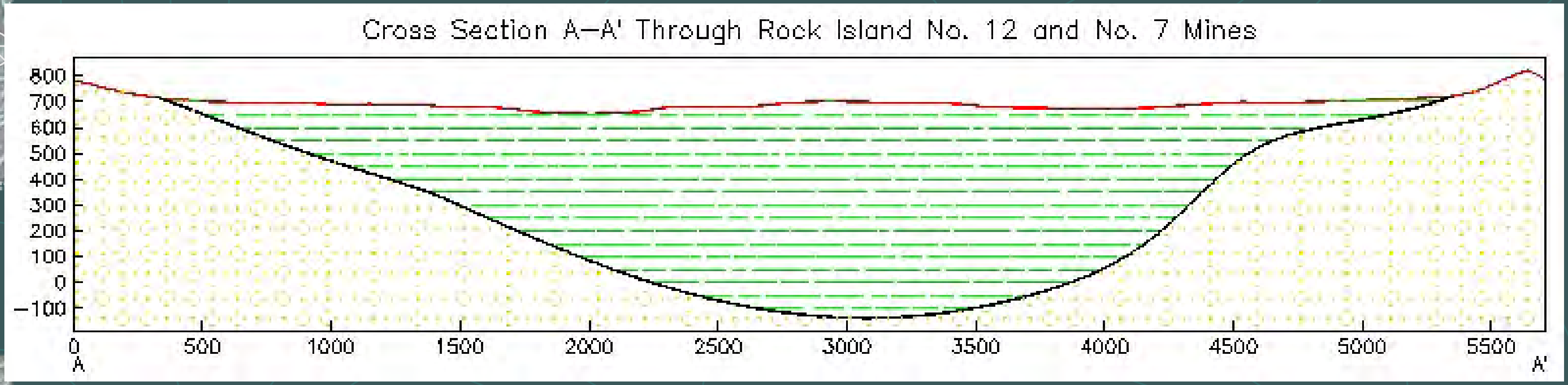
- Vertical ALD (VALD)
- Oxidation Cells
- 2 Vertical Flow Ponds (VFP)
- Aerobic Surface Flow Wetland

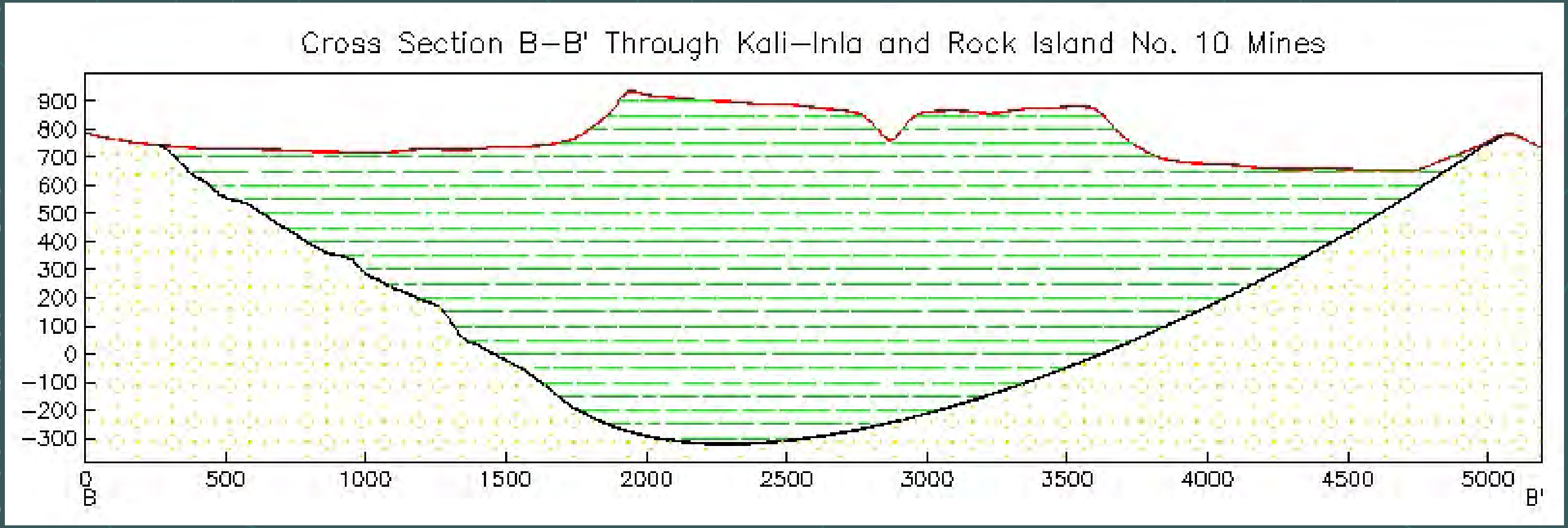


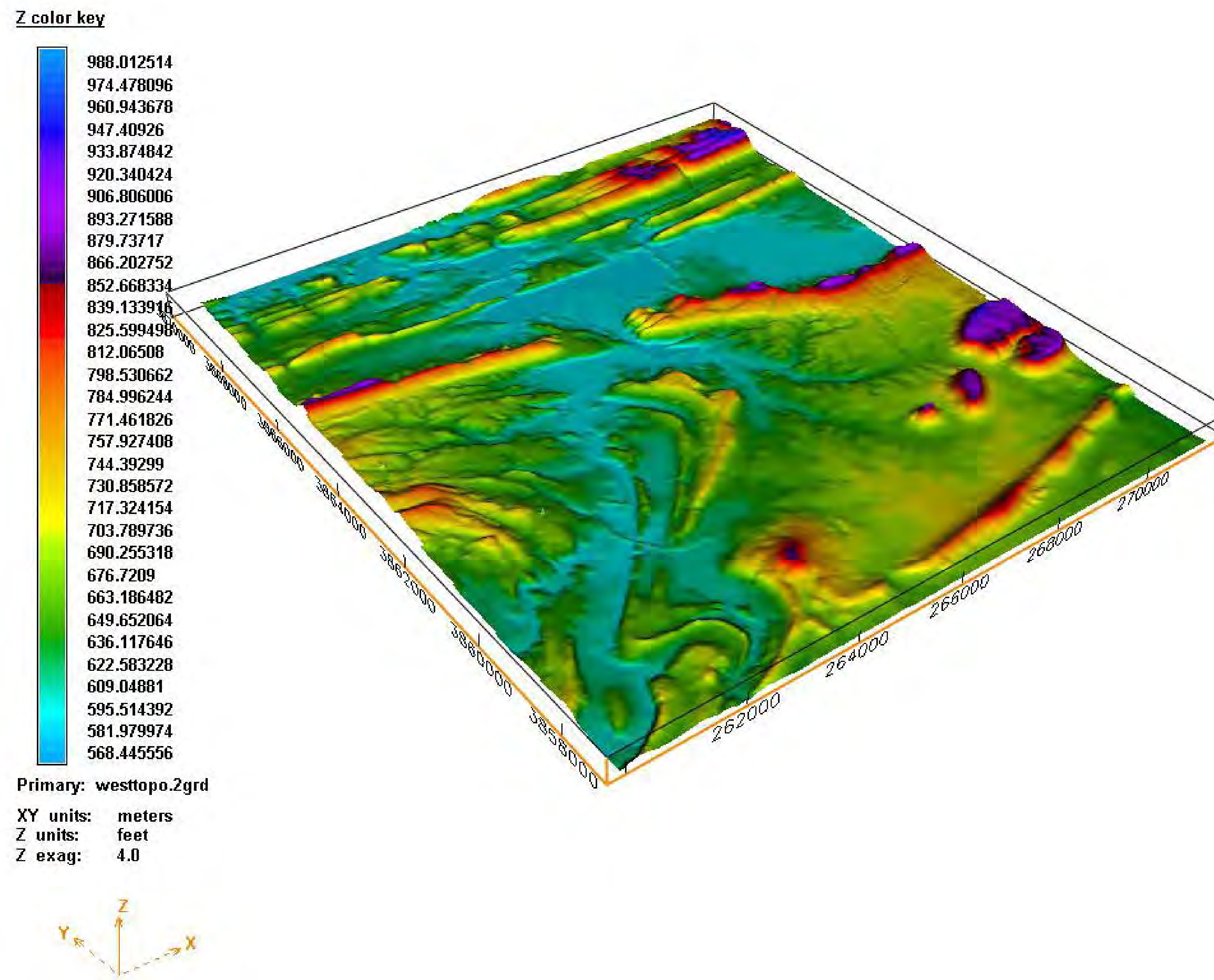
Isopach Map of the Base of the Hartshorne Coal Bed



Cross sections A – A’ and B - B’







Z color key
988.012514
974.478096
960.943678
947.40926
933.874842
920.340424
906.806006
893.271588
879.73717
866.202752
852.668334
839.133916
825.599498
812.06508
798.530662
784.996244
771.461826
757.927408
744.39299
730.858572
717.324154
703.789736
690.255318
676.7209
663.186482
649.652064
636.117646
622.583228
609.04881
595.514392
581.979974
568.445556
Primary: westtopo.2grd
XY units: meters
Z units: feet
Z exag: 4.0
3866000
3864000
3862000
3860000
3858000
262000
264000
266000
268000
270000
Z
Y
X

Hydrologic Issues Related to AMD

- Systematic water quality variations with overburden depth.
- Presence of pre-mining non-compliance (high-iron) level discharges.
- Structural controls on AMD remediation facility locations.
- Limitations of topographic relief at AMD seep locations.

Topographic Map showing the No. 7 Mine Discharge Location

Topographic Model showing the AMD Passive Treatment Structures.