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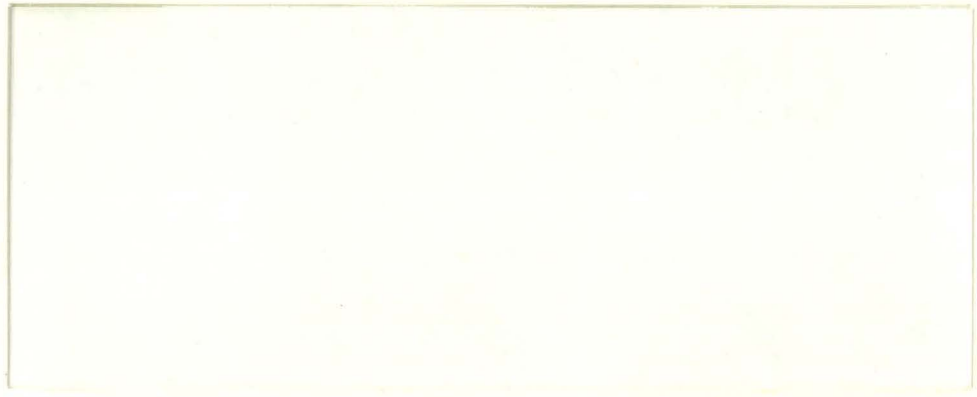

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GRUNDY COUNTY DEMONSTRATION SITE
PHASE I PLANNING
(FINAL REPORT)

by

B. B. Green and S. D. Zellmer

Energy and Environmental Systems Division

Funded by
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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GRUNDY COUNTY DEMONSTRATION SITE
PHASE I REPORT

B. B. Green and S. D. Zellmer

A. INTRODUCTION

The state of Illinois, with its valuable coal and food production and growing numbers of people, is becoming more interested in reclaiming land that has been or is being used for energy production. New surface mining legislation has put the burden on the coal companies of reclaiming land that has been currently mined, but the so-called "pre-law" lands (lands that were mined before the 1971 Surface-mined Land Conservation and Reclamation Act) have been largely ignored. The Grundy County demonstration project has grown out of the desire to mend this omission.

The Grundy County demonstration site is located in the northeast corner of Grundy County near Morris, Illinois. The site is approximately 110 acres, about 50 acres of which have been affected by mining and regrading. Due to its proximity to Goose Lake Prairie State Park, the Illinois Department of Conservation purchased the property in an effort to provide additional public lands for the state park.

Original reclamation operations were begun in the fall of 1972 and continued through the first half of 1973. The emphasis was regrading the spoils and filling in some of the lakes on site. Topsoiling, seeding, and liming were done, but much of this effort was lost due to heavy rains and inadequate stabilization. Today, large parts of the regraded spoils are bare, and there is a severe acid runoff problem.

The Grundy County demonstration site is adjacent to the Goose Lake Prairie State Park (Fig. 1) and is intended to be used as a park overlook with picnicking facilities; however, at this point, the area cannot be used for this purpose. Therefore, this proposal is in answer to a request by the State Department of Conservation and the Illinois Institute for Environmental Quality that Argonne National Laboratory 1) determine the present problems on the site and 2) determine what will be necessary to achieve full use of the site.

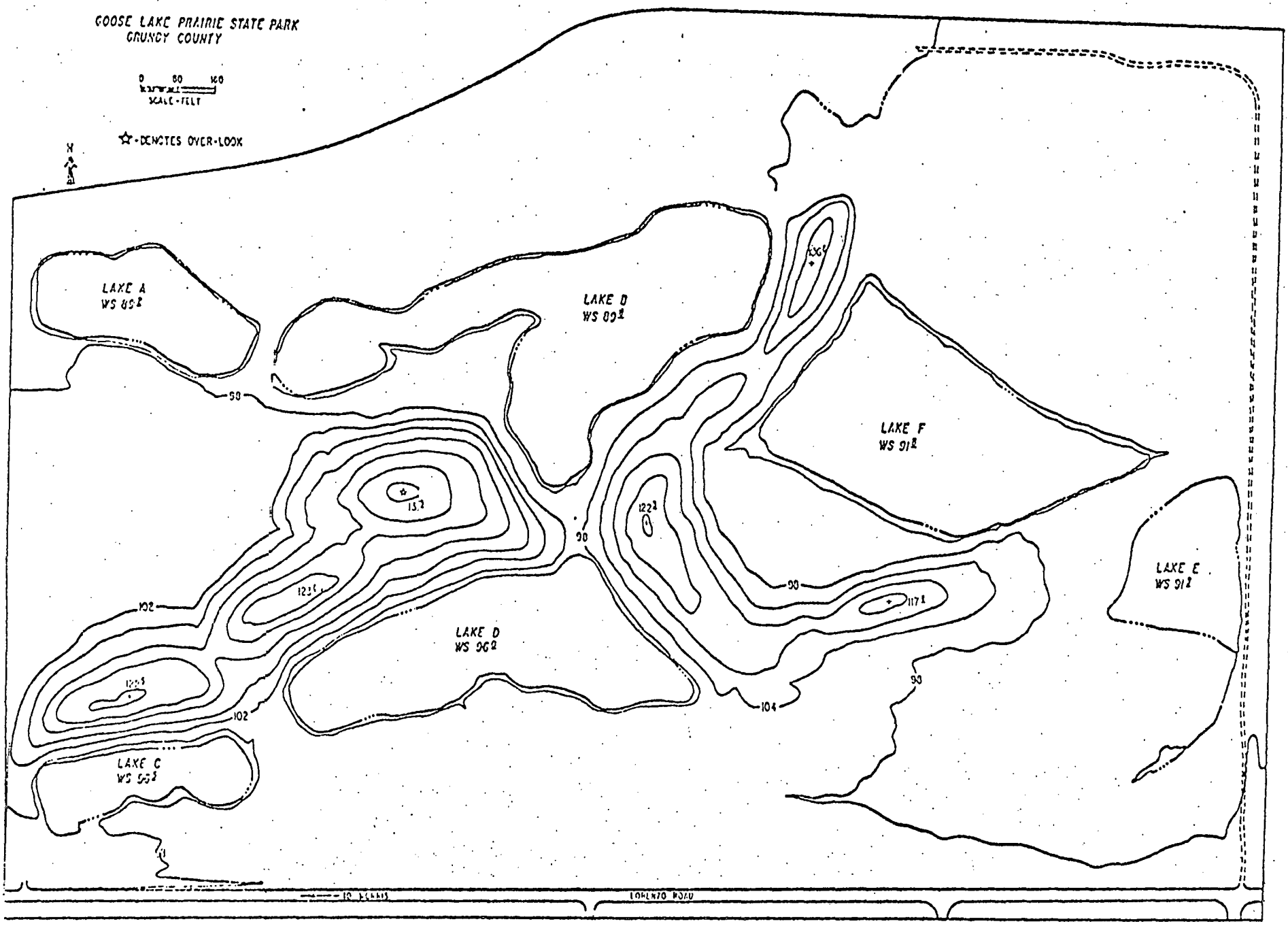

Fig. 1. Map of the Grundy County Demonstration Site Showing its Relationship to Goose Lake Prairie State Park

Many of the problems that occur throughout Illinois (e.g., acid formation, severe erosion, and sterile terrestrial and aquatic environments) occur on the Grundy County site. Thus, a unique opportunity to provide both a public recreation area and gain valuable information about the reclamation of other "pre-law" lands is available at the Grundy County site.

B. EVALUATION OF THE PRESENT STATE OF THE SITE

After reviewing both physical and biological parameters, the following factors were selected as valuable indicators of site condition: 1) a vegetation survey, 2) soil and erosion analyses, 3) an aerial survey, and 4) a water analysis.

1. Vegetation analysis

Distribution and species composition were analyzed by the line transect method with the aid of an aerial photograph. This analysis indicated that the major species are alfalfa (Medicago sativa) and various prairie weeds, among which goldenrod (Solidago spp.), Hymenopappus scabiosaeus spp. and timothy (Phleum pratense) are dominants (Table 1). It is apparent from the analysis that the vegetation is patchily distributed over most of the area with many areas being completely bare (Fig. 2). Alfalfa is the dominant species over most of the reworked area, particularly on the hillsides. The roots are generally stunted and more fibrous than normal, indicating unfavorable growing conditions in the regraded spoils (Fig. 3). The flat areas to the south and west of the hills are primarily in a mixed community of grasses and forbs, which is the weedy stage of old field succession. None of the vegetation on the site is desirable for recreational use, and the site would benefit from a reasonable management program.

2. Soil and erosion analyses

The site was divided into a number of sectors (Fig. 4) for the soil analyses. Limits for each sector were established using slope brakes and/or vegetation type. A minimum of four subsamples was taken at random for each sector. The subsamples were mixed, and a composite sample was made that represented the soil of each sector. Both the surface soil (0-3 in) and subsurface soil (3-6 in) were sampled and analyzed. The results of the chemical determinations done by Suburban Laboratories, Inc. appear in Table 2. The overriding problem with the soil is pH. At levels below pH 4, soil nutrients, even if they are present, are not available to the vegetation. When the pH is corrected, the correction of low fertility problems can be effected.

Physical analyses indicate that the soil is composed of a conglomerate of materials. A majority of the soil is sandstone with large pockets

of clay. Coal finds also occur in pockets under the surface of the soil. Infiltration is slow, a condition that encourages erosion.

It is apparent (Fig. 5) that erosion is not limited to the slopes alone; there are also serious problems on the flat areas in the drainage pattern. The gullies prohibit safe recreational use and will have to be ameliorated before the site is opened to the public.

TABLE 1. List of Species and Their Most Common Location at the Grundy County Demonstration Site in October, 1974

Species	Common Name	Location[a]
Medicago sativa L.	Alfalfa	slopes, south old field
Solidago missouriensis Nutt. var. fasciculata Holzinger	Missouri Goldenrod	old field, mixed forbs
Hymenopappus scabiosaeus L' Hér.		old field, mixed forbs
Phleum pratense L.	Timothy	old field
Bromus sp.	Bromegrass	slopes
Andropogon gerardi Vitman	Big Bluestem	slopes, around lakes
Populus deltoides Jones	Cottonwood	slopes
Melilotus alba Desr.	Sweet Clover	slopes, old field, forbs
Trifoluim pratense L.	Red Clover	old field, forbs
Aster spp.	Aster	old field, forbs

[a]Refer to Fig. 2.

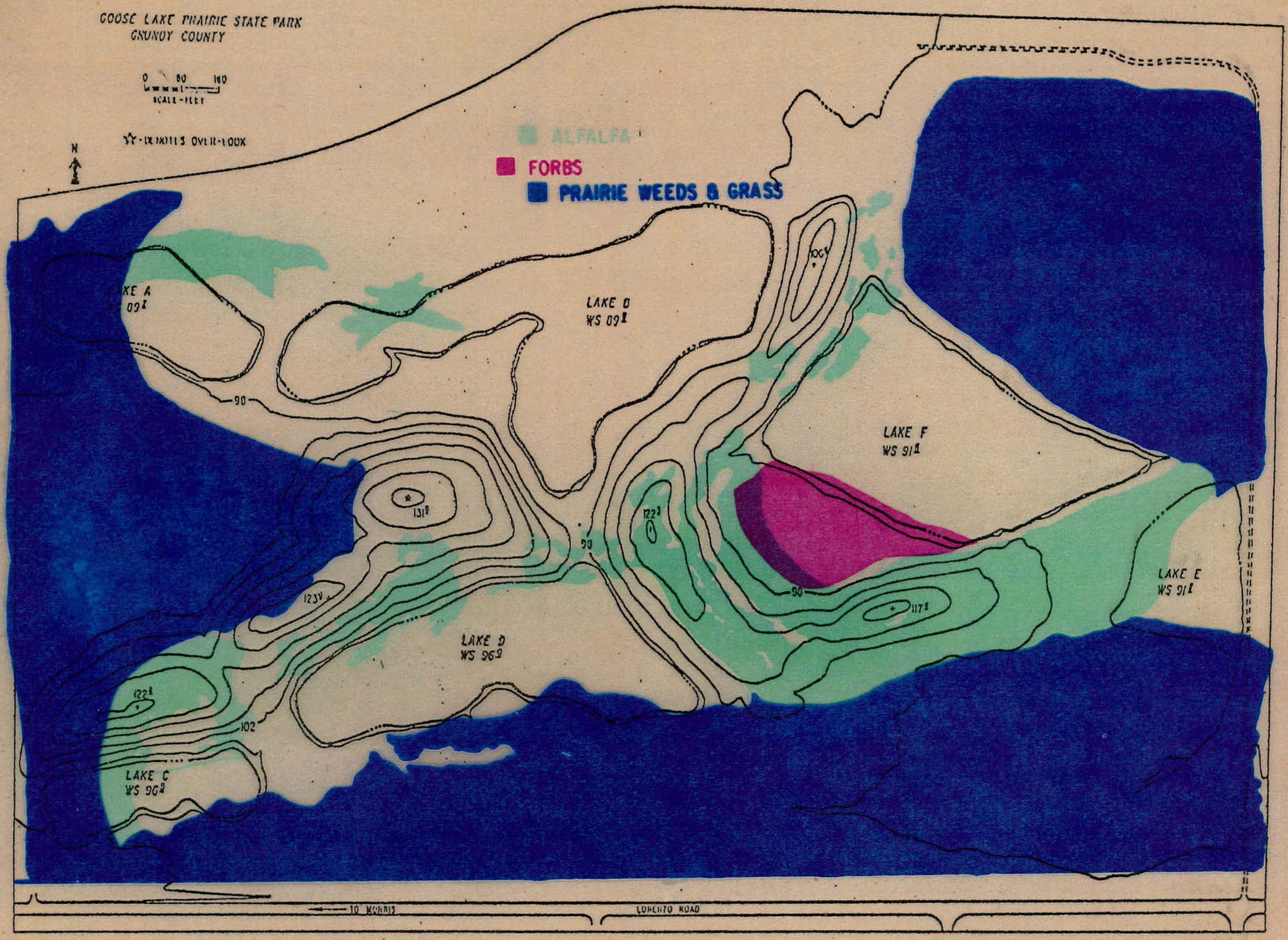

Fig. 2. Vegetation Distribution at the Grundy County Demonstration Site in October, 1974

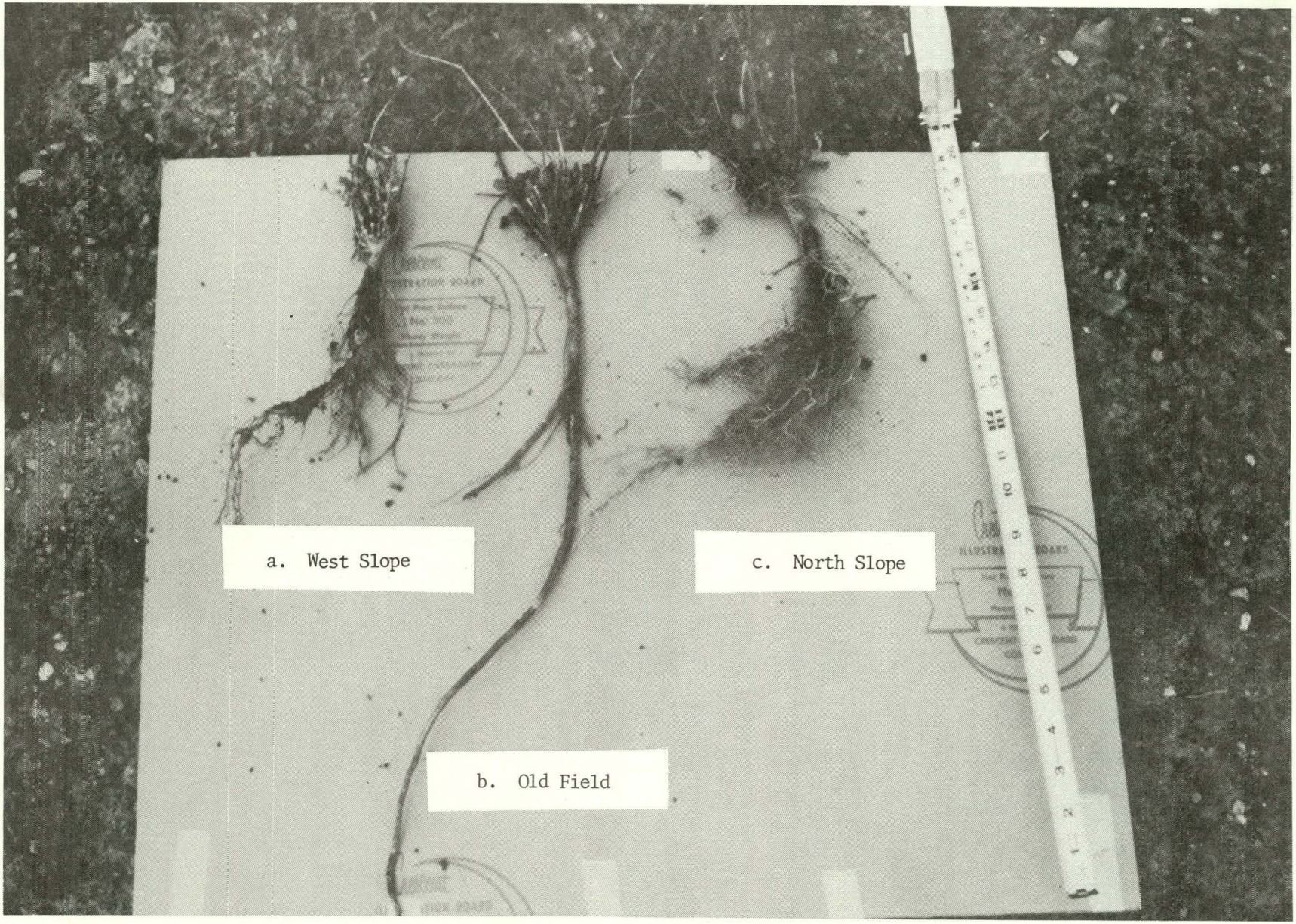

Fig. 3. Root Growth of Alfalfa in the Soil at the Grundy County Demonstration Site in April, 1975.

GOOSE LAKE PRAIRIE STATE PARK

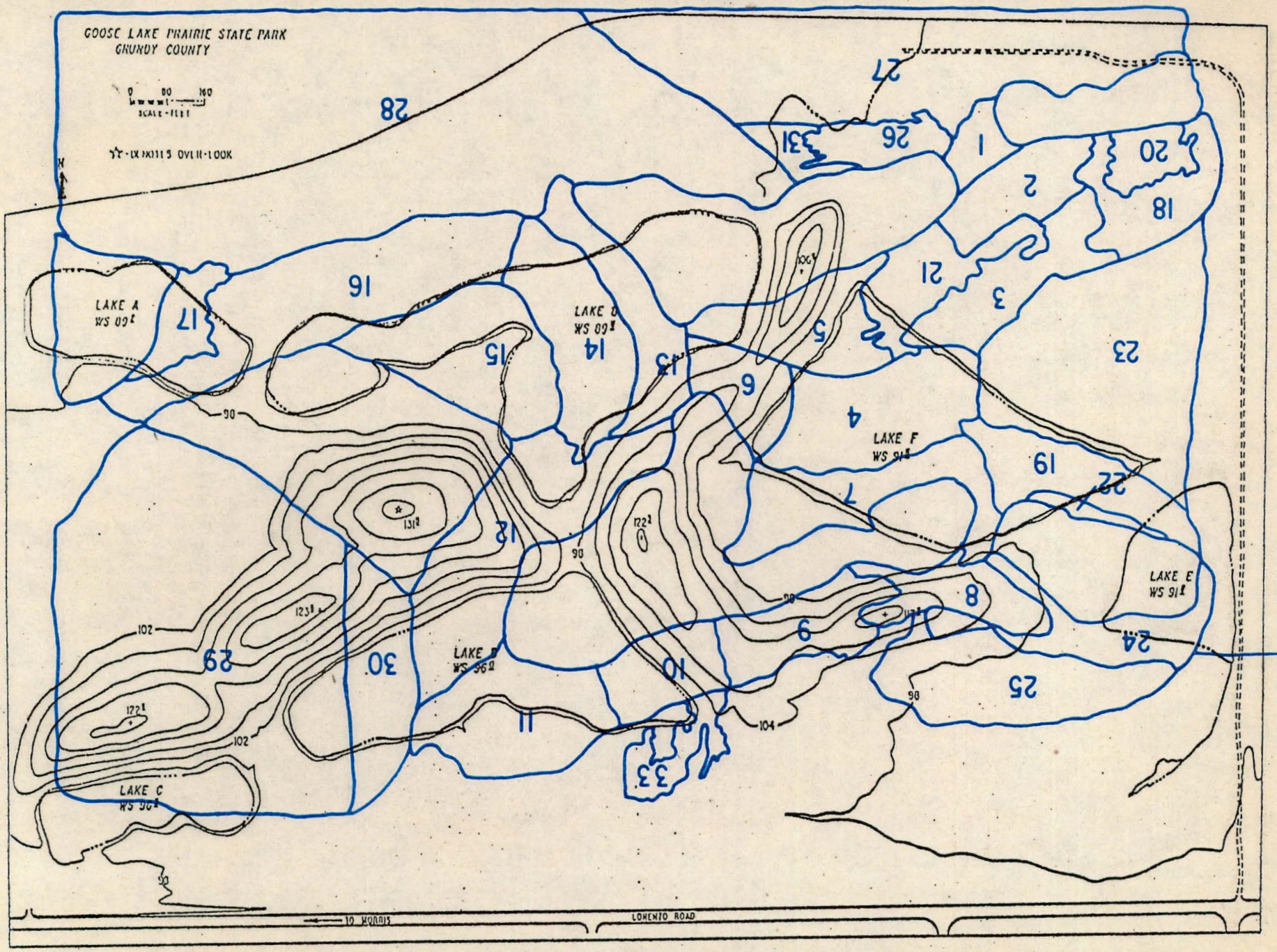

Fig. 4. 1975 Soil Sample Sectors at the Grundy County Demonstration Site in April, 1975

TABLE 2. Soil Analysis Performed on Samples Taken from the Grundy County Demonstration Site in April, 1975

Sample #	Org. Matter (%)	pH	Avail. Phosphorous (ppm)	Nitrate (ppm)	Cation Exchange Capacity (MEQ/100g)	Exchangeable (MEQ/100g)			
						K	Ca	Mg	Al
1A[a]	0.005	3.9	28.0	0.96	10.83	.04	5.63	5.20	1.85
1B[b]	0.004	3.3	14.0	0.00	10.75	.02	5.13	5.63	2.08
2A	0.008	3.5	28.0	0.96	10.13	.09	5.13	5.00	2.05
2B	0.006	3.3	10.5	0.96	10.70	.06	5.50	5.20	1.69
3A	0.006	4.3	70.0	1.44	12.05	.08	6.63	5.43	0.99
3B	0.008	4.0	101.5	0.32	12.08	.08	6.88	5.20	1.98
4A	0.011	2.8	56.0	0.32	7.38	.03	4.88	2.50	1.59
4B	0.007	2.8	17.5	0.64	8.70	.03	5.38	3.33	1.98
5A	0.009	6.0	3.5	1.60	12.95	.10	7.75	5.20	0.03
5B	0.008	6.5	112.0	1.28	15.50	.11	7.38	8.13	0.03
6A	0.008	3.7	45.5	0.96	5.55	.06	4.50	1.05	0.73
6B	0.006	5.3	56.0	1.76	11.18	.08	7.63	3.55	0.03
7A	0.005	3.4	35.0	0.80	10.88	.02	6.50	4.38	2.74
7B	0.007	3.2	3.5	0.64	10.70	.03	6.13	4.58	2.65
8A	0.010	4.2	10.5	3.20	11.58	.14	7.00	4.58	0.46
8B	0.009	4.0	3.5	2.88	8.93	.14	4.13	4.80	1.26
9A	0.007	3.5	3.5	1.28	6.95	.03	4.25	2.70	1.29
9B	0.013	3.9	24.5	1.44	6.93	.04	4.63	2.30	1.03
10A	0.012	3.0	112.0	1.76	3.58	.02	2.13	1.45	1.72
10B	0.008	3.1	7.0	2.24	5.55	.03	3.25	2.30	2.91
11A	0.013	3.5	70.0	2.08	10.38	.03	3.50	6.88	1.92
11B	0.010	3.4	24.5	3.04	7.50	.02	3.75	3.75	0.56
12A	0.007	3.3	21.0	0.96	8.58	.06	4.63	3.95	1.79
12B	0.006	3.3	45.5	0.80	7.50	.04	5.00	2.50	2.48

TABLE 2. (Contd.)

Sample #	Org. Matter (%)	pH	Avail. Phosphorous (ppm)	Nitrate (ppm)	Cation Exchange Capacity (MEQ/100g)	Exchangeable (MEQ/100g)			
						K	Ca	Mg	Al
13A	0.008	6.3	14.0	2.24	12.45	.10	8.50	3.95	0.03
13B	0.008	6.3	38.5	1.92	15.83	.10	9.38	6.45	0.01
14A	0.004	3.3	38.5	1.28	3.53	.04	3.00	0.53	0.83
14B	0.009	3.1	35.0	0.96	4.35	.04	3.63	0.73	0.99
15A	0.016	5.9	17.5	1.12	13.70	.15	9.13	4.58	0.03
15B	0.024	5.9	108.5	1.28	18.55	.24	11.88	6.68	0.03
16A	0.016	6.1	213.5	4.16	14.58	.18	8.75	5.83	0.03
16B	0.017	6.3	3.5	1.60	15.68	.12	8.38	7.30	0.03
17A	0.008	6.1	70.0	3.68	13.95	.31	5.63	8.33	0.03
17B	0.013	5.9	28.0	2.08	16.88	.15	6.88	10.00	0.03
18A	0.005	6.4	676.0	4.64	11.98	.20	8.25	3.73	0.03
18B	0.006	6.1	77.0	1.12	12.30	.11	6.88	5.43	0.03
19A	0.015	3.7	448.0	3.84	9.43	.10	4.00	5.43	1.79
19B	0.017	3.6	123.0	1.92	9.18	.10	3.75	5.43	1.79
20A	0.010	3.7	70.0	0.96	6.50	.06	4.25	2.25	1.55
20B	0.009	3.5	144.0	0.80	9.13	.06	4.38	4.75	1.98
21A	0.019	6.2	56.0	2.56	19.95	.17	10.38	9.58	0.03
21B	0.014	6.1	228.0	1.60	15.83	.13	6.25	9.58	0.03
22A	0.024	6.2	49.0	1.60	12.20	.36	8.25	3.95	0.03
22B	0.016	6.3	228.0	0.80	11.93	.21	8.38	3.55	0.03
23A	0.018	6.1	70.0	10.24	15.68	.64	10.25	5.43	0.03
23B	0.018	5.6	31.5	7.52	13.95	.22	9.38	4.58	0.03
24A	0.022	6.6	73.5	9.92	21.43	.20	12.88	8.55	0.07
24B	0.015	6.9	24.5	6.56	20.83	.16	12.50	8.33	0.03

TABLE 2. (Contd.)

Sample #	Org. Matter (%)	pH	Avail. Phosphorous (ppm)	Nitrate (ppm)	Cation Exchange Capacity (MEQ/100g)	Exchangeable (MEQ/100g)			
						K	Ca	Mg	Al
25A	0.014	4.8	24.5	2.24	11.13	.01	6.38	4.75	0.46
25B	0.025	4.8	91.0	0.96	11.50	.38	6.75	4.75	0.50
26A	0.009	3.6	49.0	1.28	7.88	.13	4.13	3.75	2.71
26B	0.012	3.2	91.0	0.32	8.20	.09	4.25	3.95	2.48
27A	0.018	4.3	38.5	2.56	6.13	.29	3.00	3.13	0.50
27B	0.016	3.8	199.5	1.60	5.45	.15	2.75	2.70	1.12
28A	0.017	5.8	45.5	2.08	13.20	.15	5.50	7.70	0.03
28B	0.018	5.6	140.0	1.76	12.45	.23	6.00	6.45	0.03
29A	0.021	6.5	87.5	1.76	23.08	.96	16.00	7.08	0.03
29B	0.016	6.4	63.0	0.96	24.00	.58	16.50	7.50	0.03
30A	0.015	6.2	126.0	1.28	22.30	.70	15.63	6.68	0.03
30B	0.016	6.4	137.0	1.12	23.00	.38	16.13	6.88	0.03
31A	0.017	6.0	42.0	1.12	15.05	.70	9.63	5.43	0.03
31B	0.019	5.3	273.0	0.96	12.45	.38	7.88	4.58	0.10
32A	0.018	5.7	35.0	3.68	12.18	.77	8.00	4.18	0.03
32B	0.021	5.6	35.0	3.20	10.58	.30	7.25	3.33	0.07
33A	0.022	3.4	7.0	1.92	10.23	.04	0.25	9.98	4.10
33B	0.018	3.4	7.0	2.72	7.30	.03	0.63	6.68	3.08

[a]A = surface sample (0" - 3")

[b]B = subsurface sample (3" - 6")

3. Aerial survey

An aerial survey was flown over the Grundy County site in April, 1975, which aided in the preparation of an accurate topographical map. This map has a scale of 1 in = 80 ft with 2-ft contours. When the aerial survey map was compared with the proposed contour map, it became apparent that the proposed contours were not met by the grading activities (Fig. 6). The slope from the overlook to the west is a good example. The proposed contour map showed a gentle slope with a drop of not more than 9 ft or a 3% slope, but the aerial survey map indicated a 34-ft drop in elevation or a 10% slope. Another problem was found with the slope on the northwest of the overlook down to Lake B where the proposed contour map called for a 12% slope, while the aerial survey map showed a 16% slope. Both of these slopes, and others on the site as well, are highly eroded and acidic, which presents a serious deterrent to revegetation.

4. Water Analyses

Water analyses taken in May 1975 indicate very poor aquatic habitats in all but one lake (Table 3). The pH in lakes D and F is good, but it is the limiting factor in lakes A, B, C, and E. Dissolved oxygen is low in all lakes except E and F, and it is unlikely that any aquatic vertebrae, except perhaps carp, could tolerate less than 6 ppm dissolved oxygen. The water is extremely hard as indicated by the high calcium, which may be a limiting factor to many aquatic plants. The high carbon dioxide levels reflect the low pH. Although lake F does not appear to be limited by pH or oxygen and is marginally good in hardness for aquatic biota, it will probably require the addition of nitrogen and phosphate to establish aquatic plants.

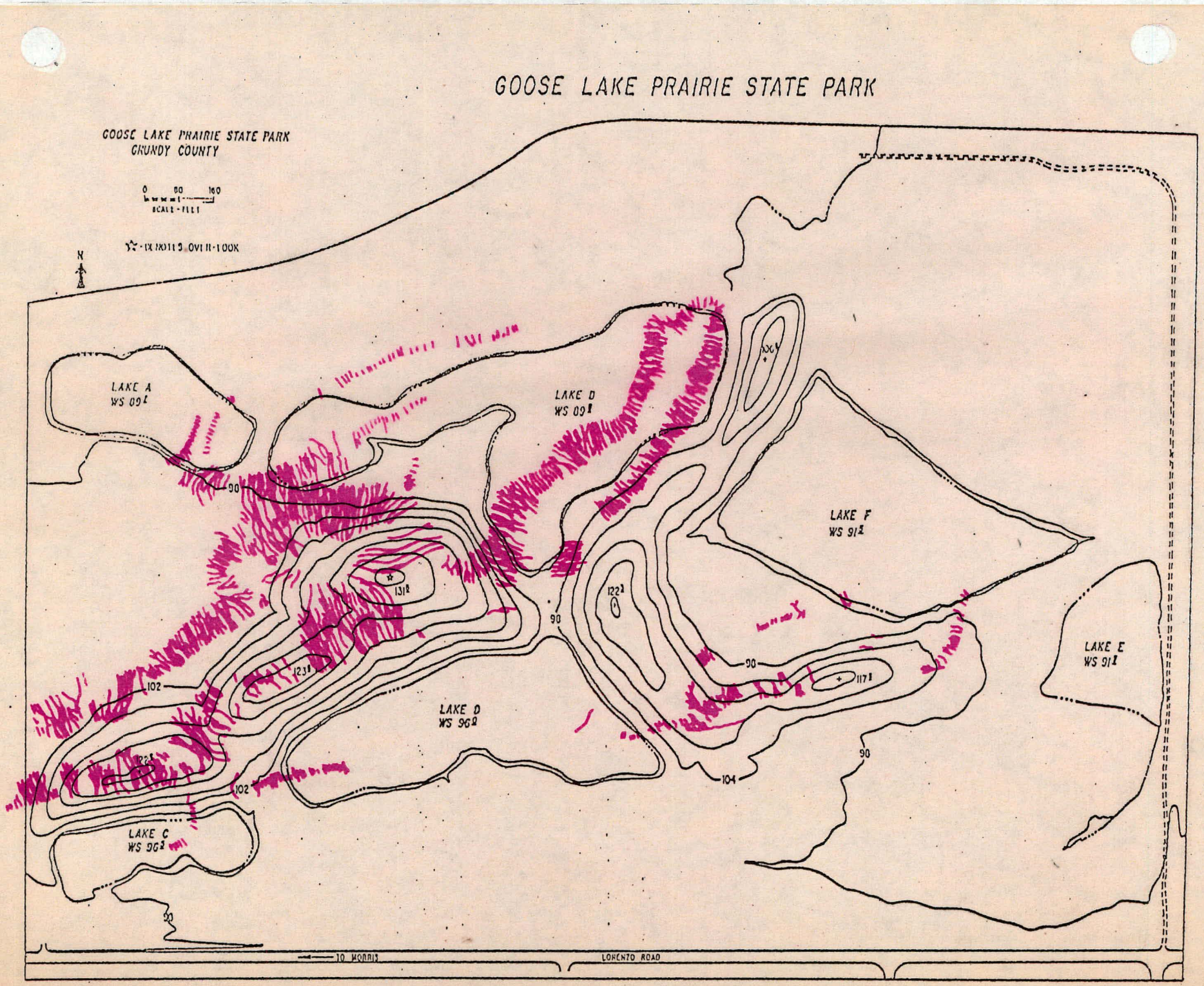

Fig. 5 Location of Erosion Gullies at the Grundy County Demonstration Site in April, 1975

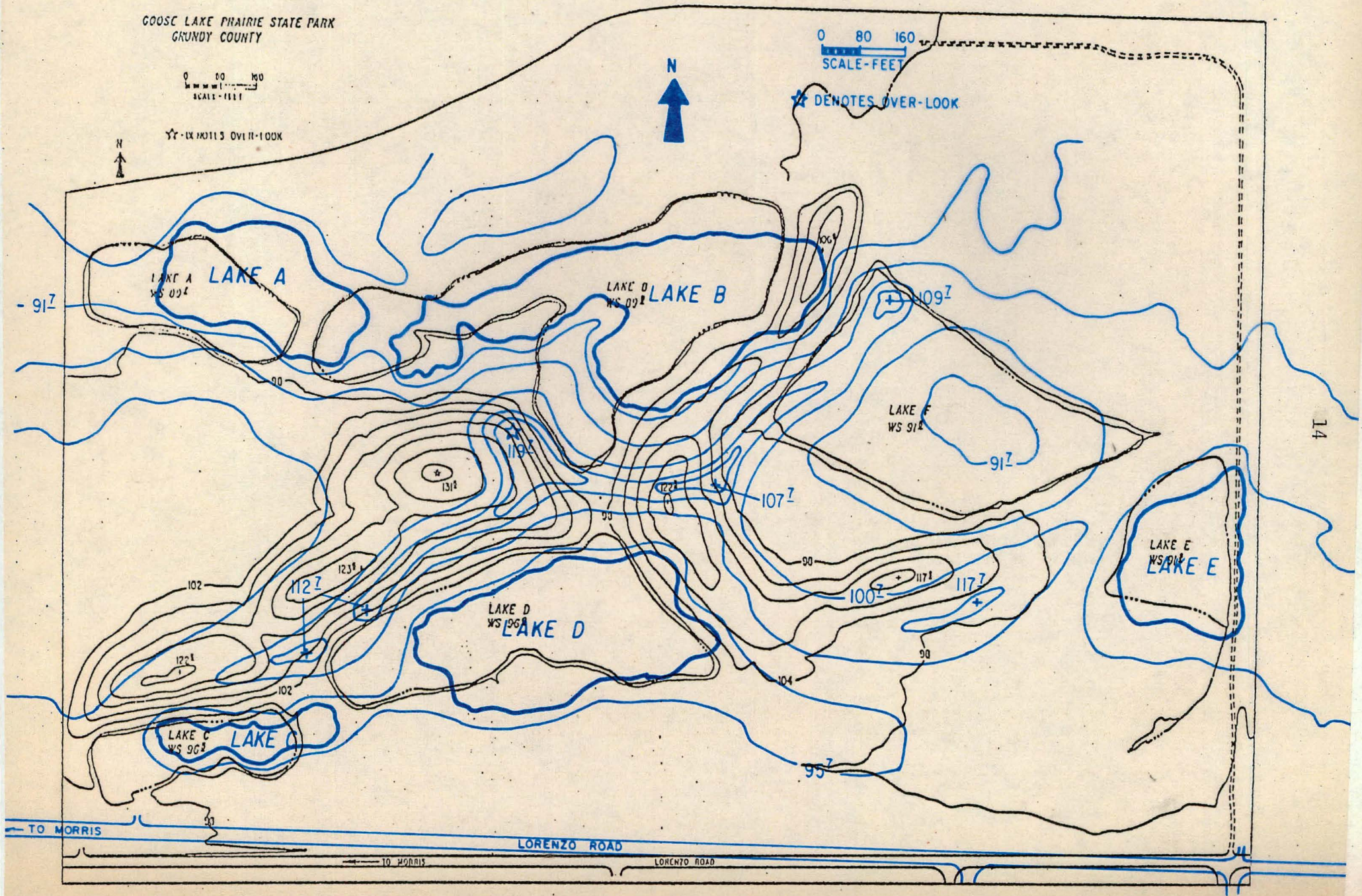

Fig. 6. Proposed Contour Map Drawn by the Illinois Department of Conservation Compared with the Actual Contour Map Drawn from the April, 1975 Aerial Survey

TABLE 3. Water Analyses from the Lakes at the Grundy County Demonstration Site in May, 1975

Analysis	Lake					
	A	B	C	D	E	F
Calcium (ppm)	500	775	625	700	425	262
Carbon Dioxide (ppm)	79	375	226	33	196.5	4.5
Dissolved Oxygen (ppm)	4.72	4.88	4.92	4.72	6.6	6.8
Nitrate (ppm)	0	0	0	0	0	0
Nitrite (ppm)	0	0	0	0	0	0
pH	3.5	3.5	4	5.4	3.3	6.5
Phosphate (ppm)	0	0	0	0	0	0
Silica (ppm)	2.6	10	10	2.5	7	0.5

C. COMPARISON OF THE SITE WITH ITS PAST HISTORY

The Grundy County site was mined by the Peabody Coal Company as a part of their 1943 operations. At that time, mines were not being reclaimed, and the area was abandoned. It resembled other unreclaimed surface mines in that there were many steep-sided round hills (old spoils) intermingled with small lakes (final cuts). Figure 7 shows the site in 1972, 29 years after mining.

In 1972, the Illinois Department of Conservation appropriated the funds to reclaim the Grundy County site as a demonstration area for other "pre-law" lands. Mr. James R. Johnson was the resident engineer on the project; Charles O'Brien & Son was the contractor.

Before the area was regraded, a cursory environmental survey was performed. No soil samples were taken, but the affected area (approximately 50 acres) was described as being 75% bare with erosion problems. The vegetation was largely European herbaceous species and volunteer woody species, primarily cottonwoods. Water conditions were listed as extremely acid with a pH range of 3.3 to 3.6.

Regrading operations were primarily concerned with reshaping the spoils into an "esker" formation and filling in or reforming the lakes. Trees were cut down and removed as were shrubs and other vegetation. Topsoil was taken from the unaffected areas on the site as well as from the base of the spoil piles where it had been placed when the overburden was removed during mining. This soil, lime, and seed (Table 4) were placed on the regraded spoils. Lakes A, B, C, D, and E were neutralized by liming; lake F had not yet formed.

TABLE 4. Species Seeded in 1973 on 35 Acres of Regraded Spoils at the Grundy County Site

Species	Common Name	Amount (Lbs.)
Andropogon gerardi Vitman	Big Bluestem	546
Avena sativa L.	Oat	600
Sorghastrum nutans (L.) Nash.	Indiangrass	222.75
Secale cereale L.	Rye	600
Medicago sativa L.	Alfalfa	300

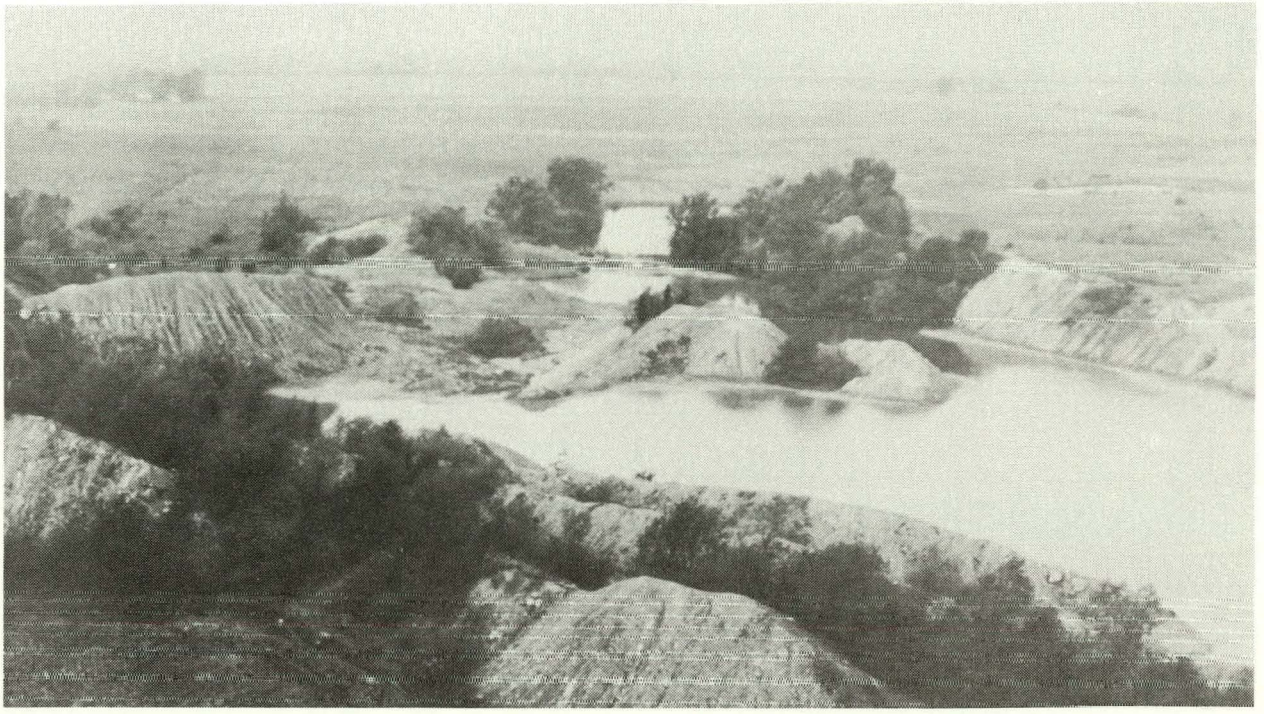

Fig. 7. Grundy County Demonstration Site In Early 1972 Before Reclamation Activities Began.

Soil samples were taken in the fall after reclamation activities had been completed. They showed that the pH was still quite low. The location of these samples corresponds with ANL sample areas 19 (1973 sample #9622) and 10 (1973 sample #9623) (Fig. 4). A comparison between 1975 and 1972 pH readings indicate that there has been little improvement (Table 5).

TABLE 5. Comparison of the Soil Samples Taken in September, 1973, with Those Taken in April, 1975, at the Grundy County Demonstration Site

	1973 #9622	1975 #19	1973 #9622	1975 #10
pH	3.1	3.6	2.7	3.0
SO_4 = (ppm)	40,000	-	28,000	-
$CaCO_3$ (ppm)	13.6	80.2	14.0	42.7
Iron (ppm)	4,600	-	5,000	-

Reports issued at the termination of reclamation efforts indicated that the water in the lakes had been neutralized. Current analyses (Table 3) indicate that the pH in all the lakes, except lake D (lake F did not exist initially), has returned to former levels. The pH's listed by Mr. Johnson for lakes B, C, D, and E before the initial reclamation are 3.3, 3.6, 3.6, and 3.4, respectively.

Only the regraded "eskers" seeded, and vegetation is not distributed evenly over the site (Fig. 2). Of the seed that was planted during the reclamation effort, alfalfa is unquestionably the most successful species. The oats and rye were probably designed as a nurse crop so their absence in the current community is not remarkable. Neither indiangrass nor big bluestem is very acid tolerant (Heath, Metcalf and Barnes, 1974), and big bluestem only occurs on the site in scattered clumps. Indiangrass is not present at all. Revegetation was apparently successful on the east side of the site where there was not as much disturbance, i.e. regrading, and where the slopes are not so steep. Here the vegetation is about 80% alfalfa with 80-90% cover. The remainder of the site is bare with only patchy occurrences of vegetation.

D. IDENTIFICATION OF CRITICAL SITE PROBLEMS

There are three major problems associated with the Grundy County site that will hinder vegetation establishment: 1) acid formation, 2) sedimentation, and 3) erosion gullies. All three are serious and are interrelated.

1. Acid Formation

The most critical problem at the Grundy County site is acid formation. The acid reaction results when pyritic materials (iron disulfide) are exposed to the air and water. The oxidation of this material results in the production of ferrous iron and sulfuric acid. The reaction proceeds from there to form ferric hydroxide and more acid. The equations are shown below.

$$2\ FeS_2 + 2\ H_2O + 7O_2 \rightarrow 2\ FeSO_4 + 2\ H_2SO_4$$
(Pyrite) (Ferrous Iron) (Sulfuric Acid)

$$FeS_2 + 14\ Fe^{+++} + 8\ H_2O \rightarrow 15\ Fe^{++} + 2\ SO_4^{=} + 16H^{+}$$
(Ferric Iron) (Sulfate) (Acid)

$$4\ FeSO_4 + 2O_2 + 2\ H_2SO_4 \rightarrow 2\ Fe_2\ (SO_4)_3 + 2\ H_2O$$

$$Fe_2\ (SO_4)_3 + 6\ H_2O \rightarrow 2\ Fe(OH)_3 + 3\ H_2SO_4$$
(Grim and Hill, 1974)

Water that runs off of acid-forming material usually has a pH of 2-4.5.

If the acid-producing materials are not disturbed, acid formation will eventually cease. When the spoils at the Grundy County site were regraded, new acid-forming material was exposed, and acid production became a problem. If the spoils were covered with topsoil, lime, sludge, or flyash, the acid reaction would be slowed due to lack of exposure to oxygen.

Highly acid areas are shown in Fig. 8. The hills are undoubtedly acid runoff sources due to constant exposure of new materials (see "sedimentation"). The flat area north of lakes B and A where old spoils were scraped off are also acid-producing areas.

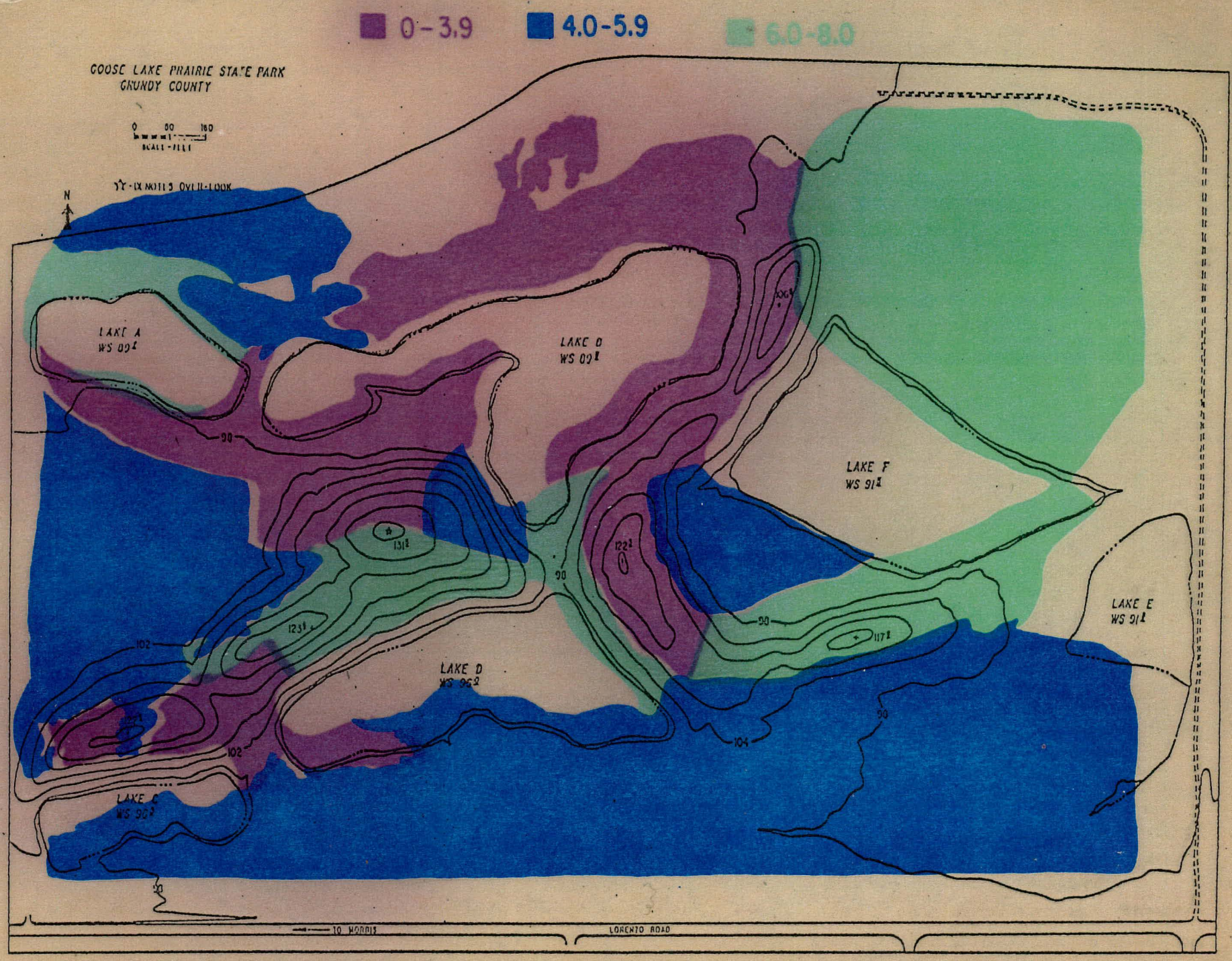

Fig. 8. Distribution of Acidity at the Grundy County Demonstration Site in April, 1975

Runoff from both of these areas is entering Goose Lake Prairie State Park at the drainages marked A and B in Fig. 8. It is particularly damaging to the prairie cordgrass (Spartina pectinata Link.) community along the drainages. There is a possibility that this could become a serious problem if it is not controlled.

Acid problems are not limited to runoff, however. As stated in Sec. B, nutrients are not available to plants in soil with a pH of 4 or below. The low pH alters the state of the nutrients, making translocation through root tissue difficult.

2. Sedimentation

Sedimentation or the loss of soil due to runoff (also called erosion) is also a problem at the Grundy County site since much of the soil is sandstone, which breaks down readily and is susceptible to being washed off or blown away. The amount of soil lost from the site in this manner is not known at this time, but it will be monitored in the experimental phase of this project (see Sec. H).

Loss of soil in this manner creates two major problems at the site. First, the constant removal of surface materials, particularly on the steeper slopes, causes new acid-producing materials to be exposed. Second, it dictates that a stabilizing material such as a straw mulch will be necessary to keep seeds and soil amendments in place on the bare slopes. Vegetation is the best soil stabilizer, and areas where it is established have a higher pH and probably less sedimentation.

3. Erosion Gullies

Erosion gullies are a product of sedimentation, and they are a serious problem at the Grundy County site (Fig. 9). They present a hazard to safe recreational use in that some of the gullies are as much as 2 feet deep. Erosion gullies also pose a problem for site rehabilitation activities. The use of spreading, discing, and drilling equipment may require that some of the gullies be filled in before the equipment will operate properly. As can be seen in Fig. 5, the location of erosion gullies is not limited to the slopes, although there are a greater number there. Vegetation will also be effective in slowing the formation of erosion gullies.

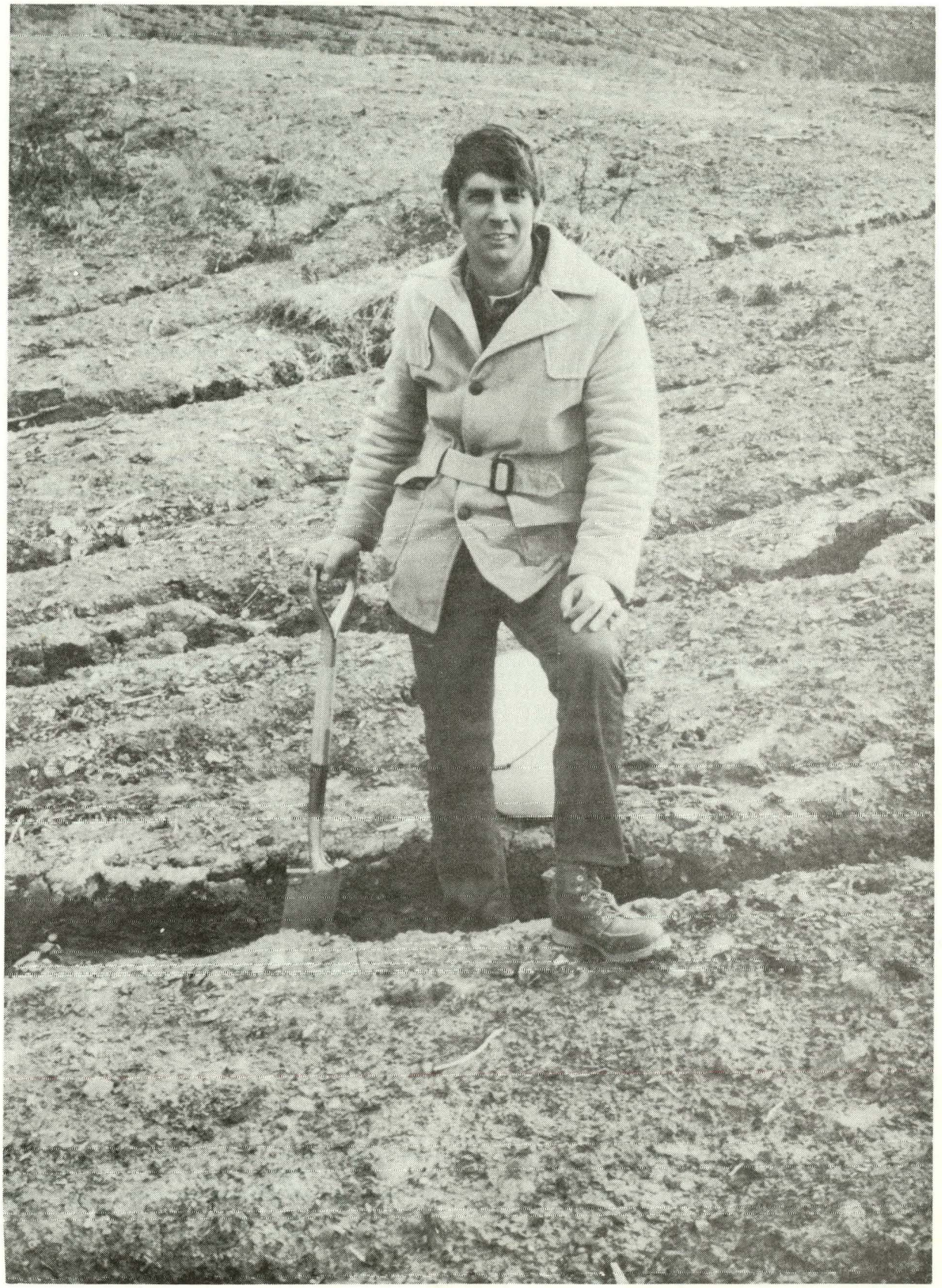

Fig. 9. Erosion Gully at the Grundy County Demonstration Site in April, 1975.

E. PLANNED DEVELOPMENT BY THE ILLINOIS DEPARTMENT OF CONSERVATION

The proposed usage for the reclamation site consists primarily of a trail system including bridging, signage, and stairs (when appropriate) and an observation area. Support facilities will include car and bus parking areas, drinking water and sanitary facilities. The trail construction will be gravel with wood bridging, signage, and stairs. The interpretive effort will be threefold:

1. Explanation of strip mine reclamation, including prairie restoration.
2. Interpretation of mesic prairie (on the slopes) and aquatic conditions (along the lake edges).
3. Large-scale prairie interpretation (afforded by views from observation area).

Peter J. Weher, Landscape Architect
Site Planning Division
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Department of Conservation

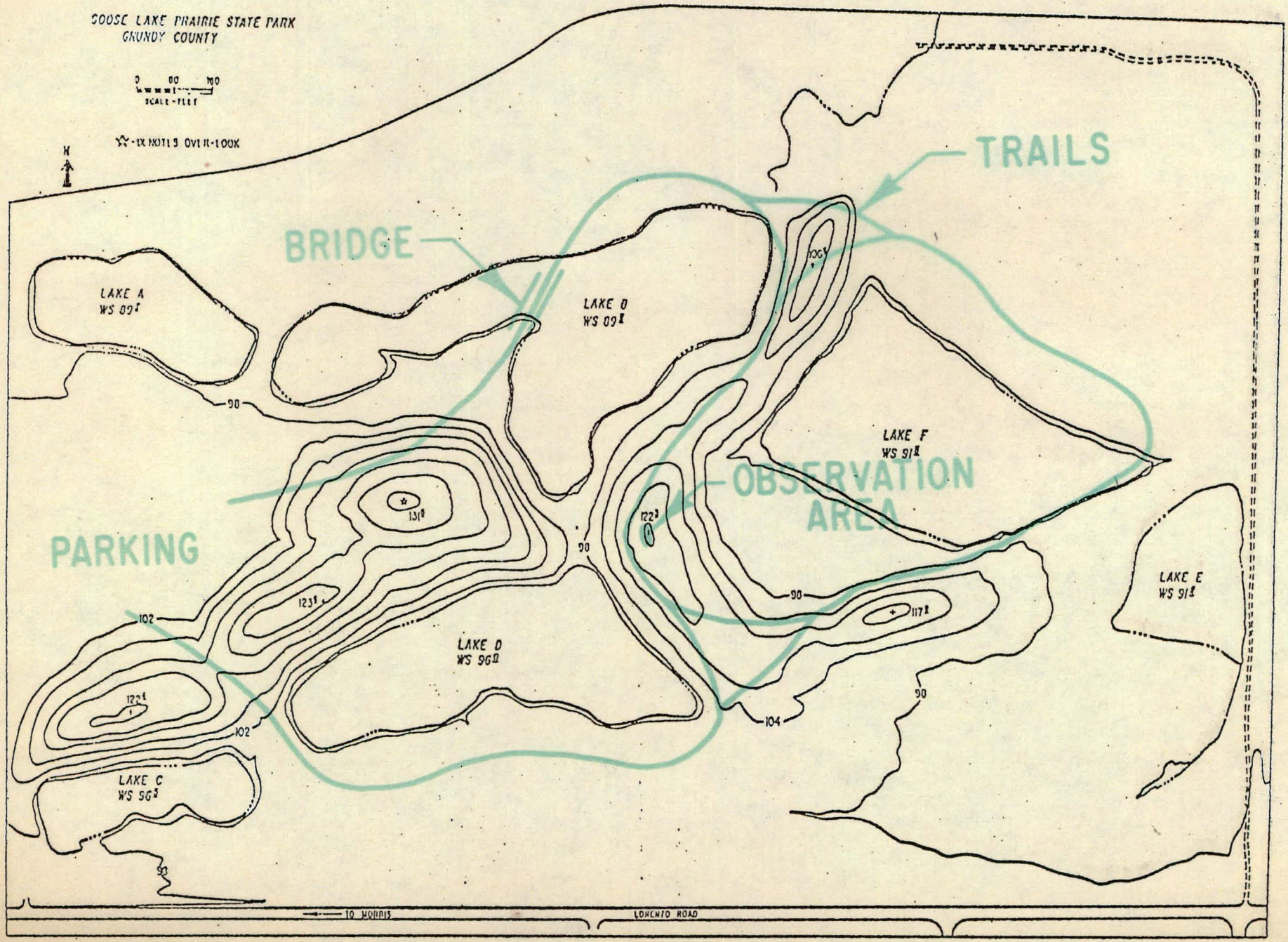


Fig. 10. Planned Development of the Grundy County Demonstration Site by the Illinois State Department of Conservation

F. ASSESSMENT OF AVAILABLE INFORMATION

There has been a minimum of reclamation research in Illinois, so this work will be, in a sense, a pilot project. Information relating to the various factors included in the experimental design was made available to us by individuals at the University of Illinois' Champaign-Urbana campus and at Knox College in central Illinois.

Drs. William Osterwald, J. C. Siemens, and J. Kent Mitchell, University of Illinois, were able to provide valuable information on the design and construction of the runoff plots. Dr. Peter Schramm, Knox College, was consulted about restoring prairie vegetation on the Grundy County site. The conference held at Northern Illinois University on restoring roadside prairies was also of great help. Both Dr. Schramm and individuals at the conference were concerned that the soil pH was too low, but thought that if the pH problem was remedied, it would be possible to introduce prairie vegetation.

G. ADVANTAGES DERIVED FROM PAST RECLAMATION EFFORTS

Although the area is not usable at this point in time, there were a number of advantages in the strict economic sense gained from the original (1972-1973) reclamation work at the Grundy County demonstration site (Table 5). Tree removal, pumping, and the alteration of water features, inasmuch as they do conform to the original plan and do not have to be redone, were 100% successful. In fact, with the 20% inflation adjustment, they would cost more if they were done at this time.

Spoil relocation was not considered completely satisfactory since the regraded spoils do not conform to the proposed contours. The acid water treatment, while it was initially successful, has been rendered ineffective due to acid runoff from the regraded spoils.

According to the records received from Mr. Johnson, seedbed preparation and seeding operations were limited to the "esker" formations. Forty-nine percent of the spoils is covered with vegetation, which is considered to constitute a successful effort. The estimated figure for the proposed treatment includes treatment of both the slopes and flat areas. This figure also includes the extensive use of stabilizers on the slopes that the original work did not attempt.

TABLE 6. A Comparison of Costs and Advantages of the 1972-1973 Reclamation Work at the Grundy County Demonstration Site

(A)	(B)	(C)	(D)	(E)	(F)
Item	Original $ Cost	Advantages ($)	Estimated Advantages ($)[a]	Effectiveness (D/B)[b]	Estimated $ Cost of Proposed Reclamation
Tree Removal	8,250.06	8,250.06	8,415.06	100	-
Spoil Relocation	127,339.15	101,871.32	122,245.58	96	-
Pumping	2,223.56	2,223.56	2,668.27	100	-
Alteration of Water Features	27,672.64	27,672.64	33,207.17	100	-
Acid Water Treatment	1,869.70	0.00	0.00	0	1,900.00
Seedbed Preparation and Seeding	5,111.83	2,095.85	2,515.02	49	127,100.00

[a] 20% inflation-of-costs figure incorporated.

[b] 100% is the maximum effectiveness.

H. DEVELOPMENT OF DEMONSTRATION SECTORS - EXPERIMENTAL DESIGN

1. Introduction

The Grundy County site is only one of many problem sites in Illinois. Although the site problems vary, the fact remains that they are eyesores and useless in a state where land is at a premium for farming or housing. Information gathered from Grundy County while it is being restored will be valuable to other areas of the state where restoration is not yet underway. The restoration of Grundy County will stress vegetation establishment. Current site evaluation data (see Sec. B of this report) indicate that there are severe acid and erosion problems, and until those are stopped, vegetation will be difficult -- if not impossible -- to establish naturally.

2. Scope

The proposed restoration would include implementing different vegetation establishment techniques using combinations of a chemical slope stabilizer, straw mulch, lime, new earth, topsoil, and flyash. The ultimate goal will be to establish shortgrass prairie (little bluestem) over most of the slopes and wet prairie (prairie cordgrass) around the lakes. The flat areas will be mesic or dry prairie (big or little bluestem) depending on microclimatic conditions. Each of the sectors will be monitored using runoff and sedimentation devices, soil moisture analyses, and chemical soil analyses. There will be a weather station for the entire site, which will contain a tipping bucket rain gage and an event recorder to measure precipitation, and a hygrothermograph to measure temperature and humidity. It is important to note that, should a particular treatment fail, a more successful treatment will be applied to prevent further erosion and acid development. The annual progress reports and the final report will contain cost effectiveness analyses and evaluations on each of the treatments applied. The final report will be a complete analysis of the entire project with suggestions for other areas in Illinois.

3. Implementation

Demonstration areas will be laid out over the site with the majority being larger than 1/4 acre. Treatments have been assigned to them by randomized design and are shown in Fig. 11. A summary of the proposed treatments

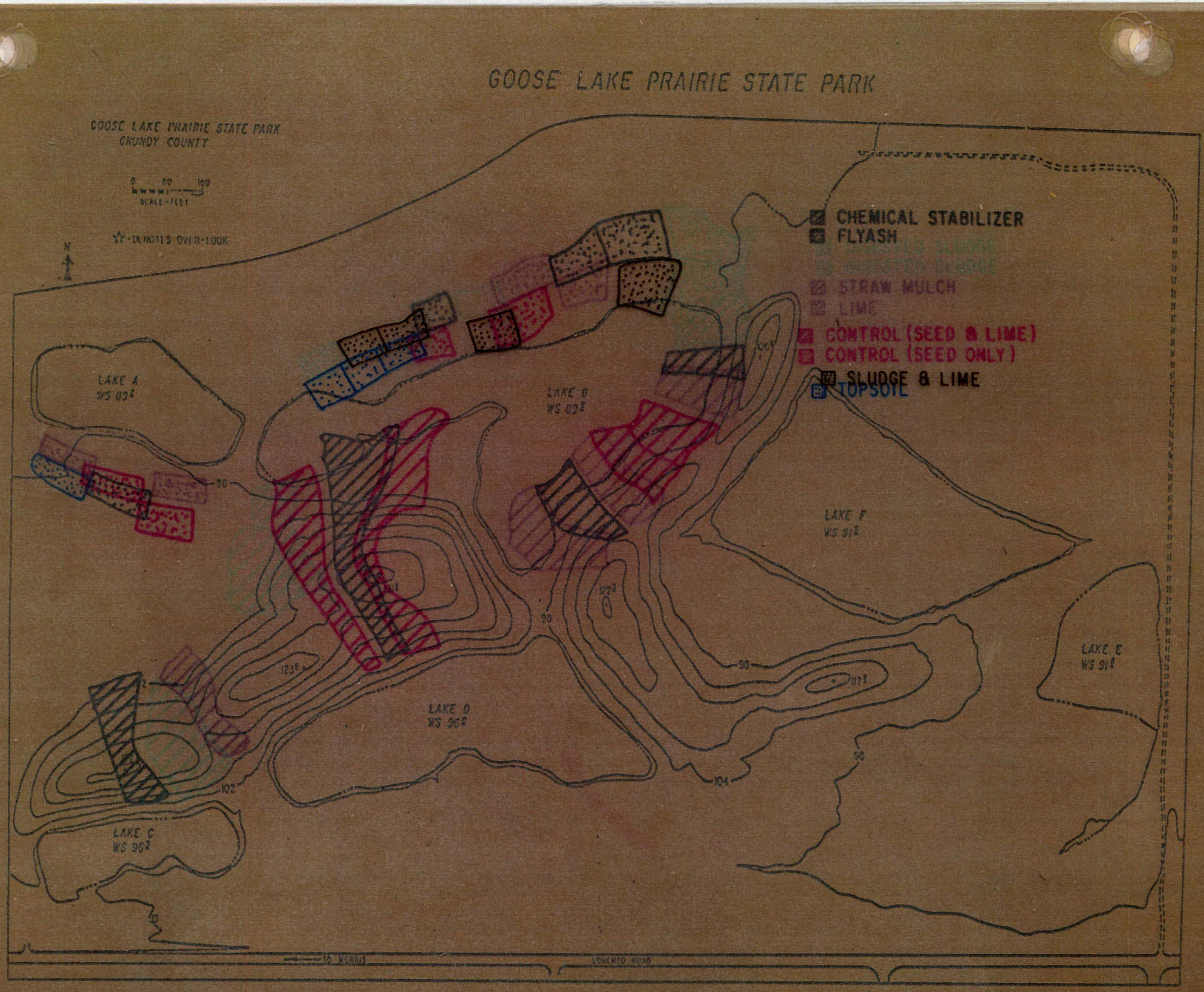


Fig. 11. Proposed Experimental Sector Design for the Grundy County Demonstration Site

appears in Table 7. The chemical stabilizer to be used will be Petroset SB, a rubberizing emulsion produced by the Phillips Petroleum Company. New earth is digested sludge soil builder from the Metropolitan Sanitary District of Greater Chicago, and the flyash originates from Commonwealth Edison's coal-fueled power plant.

Each sector will be monitored for cover, physical and chemical soil characteristics, and soil moisture. Cover will be analyzed along two permanent transects, each 1 chain long (66 ft). Due to the conglomerate nature of the "soil" conditions at the site (see Sec. B), soil sample sites for chemical, physical, and moisture analyses will have to be as fixed as possible so that a realistic analysis of changes may be made. Each sector will contain 6 fixed sample sites. In addition to the above, each hillside sector will include a 4 x 11-ft (.001 acre) runoff sampling device (Fig. 12a). The downhill end will empty runoff into a 55-gallon drum (Fig. 12b). Both the amount of runoff and the degree of sedimentation can be measured. The theory is that, as vegetation or cover increases and the slope becomes increasingly stable, there will be higher infiltration (less runoff) and a decreased sediment load. The runoff will also be tested for acidity.

The entire site will be monitored for precipitation, temperature, and humidity by a P501 Remote Recording Rain Gage with an attached P521 Event Recorder (both from Weathermeasure Corporation) and an H311 Hygrothermograph (also from Weathermeasure Corporation), respectively. The rain gage will be protected by a windscreen, and the other equipment will be housed in a standard U.S. Weather Bureau instrument shelter.

The species proposed for use in revegetation are tall fescue (Festuca arundinacea Schreb.), red fescue (F. rubra L.), white or ladino clover (Trifolium repens L.), medium red clover (T. pratense L.), and alsike clover (T. hybridum L.). Tall fescue, white clover, and particularly, red fescue are acid tolerant (Heath, Metcalf and Barnes, 1974). The mixture of alsike clover, tall fescue, and ladino clover has been recommended for poorly drained soils that occur on site, and the medium red clover, lanino clover, and tall fescue mixture is drought tolerant, a requirement for many places on site where most of the moisture runs off.

The critical factor in implementing the proposed research is weather. Most plantings are done in the spring and fall and are dependent on moisture

being received after the planting. It is proposed that the plots be set up by late September, 1975, and that seeding take place that fall. The plots will be seeded again in the spring of 1976.

The ultimate intention for the Grundy County site is to revegetate with prairie species as is being done in Goose Lake Prairie State Park. Although the pH is too low on the spoils to attempt this now (prairie vegetation requires a pH of at least 5), the old field areas provide an ideal location to begin. In the fall of 1976, a selected area, whose size depends on seed availability, will be plowed. Seeding will be done in late spring after the area has been disced a second time. As the restoration project develops, prairie plantings will be attempted in areas where the pH is in the acceptable range. It is imperative that alternate methods of seeding and management be examined since there has been little work on seeding prairie on slopes and none on acid strip mine spoils (P. Schramm, pers. comm.). A minimum of laboratory experimentation on root growth and species tolerance will be conducted in the Argonne facilities.

TABLE 7. Proposed Treatments for the Demonstration Sectors at the Grundy County Demonstration Site

Slope Treatments	
Treatment 1	Treatment 2
Control	Chemical Stabilizer
a. Lime b. Seed	Control
Treatment 3	Treatment 4
Straw Mulch	Digested Sludge
Control	Control

Flat Treatments		
Treatment 1	Treatment 2	Treatment 3
2" Topsoil	Digested Sludge	Flyash
Seed	Seed	Seed
Treatment 4	Treatment 5	Treatment 6
Lime	Digested Sludge	Seed (Control)
Seed	Lime	
	Seed	

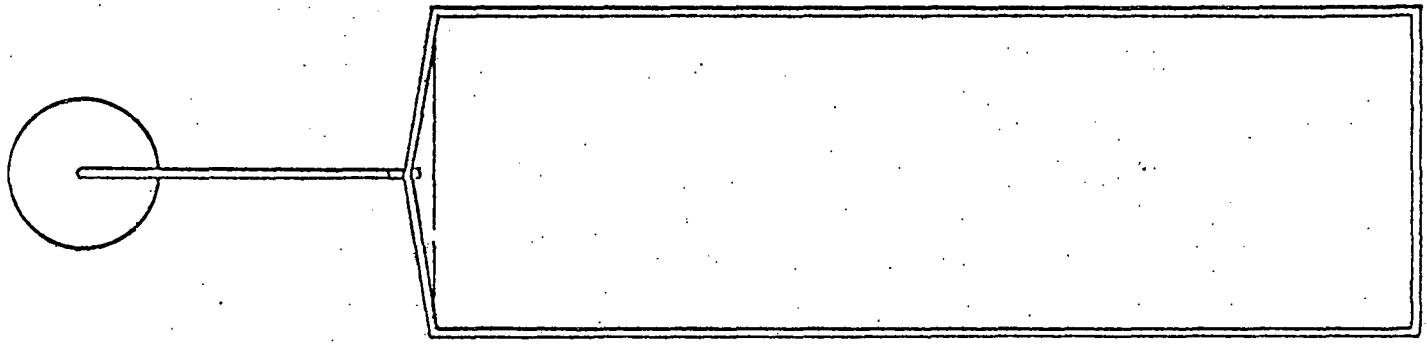


Fig. 12a. Top View of Runoff-Sedimentation Measurement Device

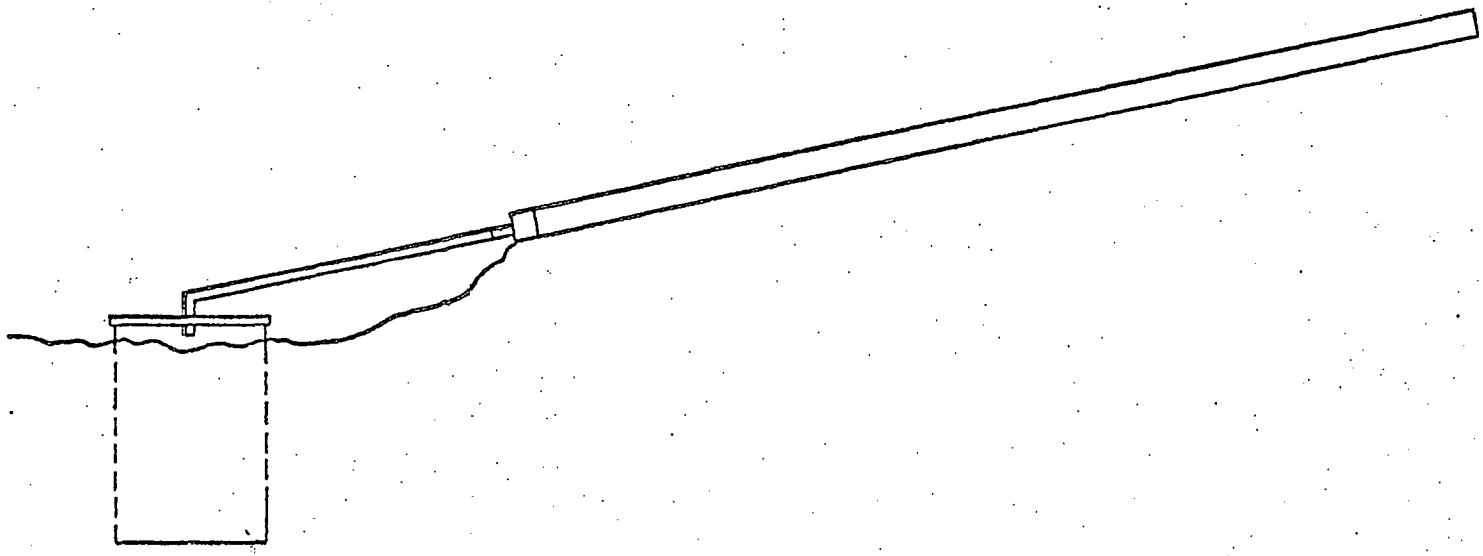
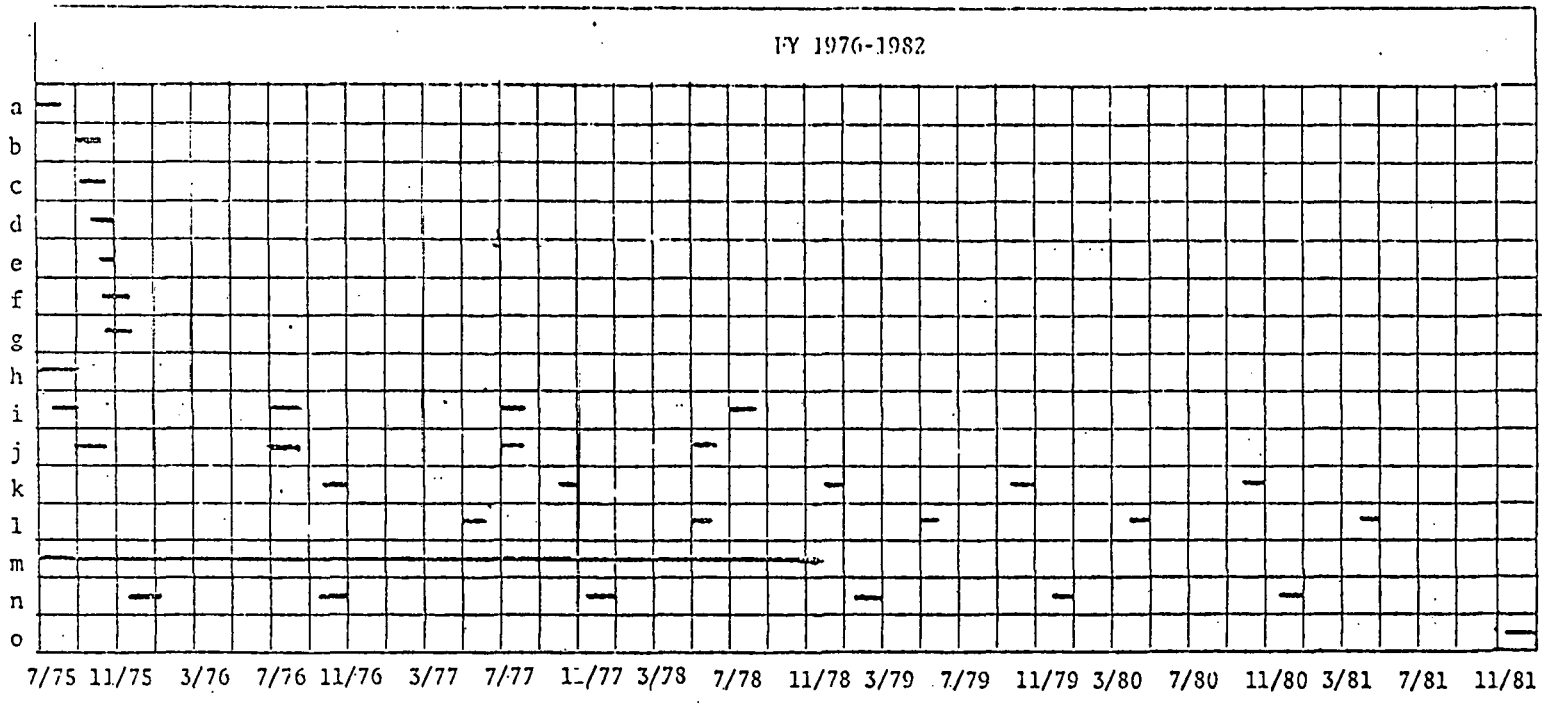


Fig. 12b. Cross-section of Placement of Runoff-Sedimentation Device



a Order equipment, place bids where necessary, etc.
b Delivery of flyash, sludge, lime, chemical stabilizer, straw.
c Spreading of flyash, sludge, lime, straw.
d Seedbed preparation.
e Drilling, seeding.
f Apply chemical stabilizer.
g Runoff plot set-up.
h Monitoring equipment delivered and set-up.
i Soil sample analysis.
j Cover analysis (include emergence data when appropriate).
k Fall plowing for prairie (new areas).
l Seedbed preparation for planting for prairie.
m Weekly monitoring check (weather station).
n Progress report.
o Final report.

I. BUDGET

The budget for the proposed reclamation project at the Ground County demonstration site follows. Only two years, FY 1976 and FY 1977, are shown. The project is scheduled to go through FY 1982 with the years FY 1978 through FY 1982 being funded at the FY 1977 level with allowances for inflation.

Grundy County Phase II
Budget Estimate
FY 1976-1982*

	FY 1976		FY 1977	
	Man Months	$x1000	Man Months	$x1000
Federal Rate				
Scientific Staff	6.0	12.7	4.0	9.1
Staff Assistance	2.0	2.0	3.0	3.3
Soil/Water Analysis		1.1		1.7
Contract Services		5.7		1.0
Other Materials & Services		9.6		4.8
Indirect Costs (clerical and overhead)		13.9		13.1
Total Federal Rate		$45.0		$33.0
Full Cost Recovery Rate				
Federal Rate		45.0		33.0
Depreciation		3.7		3.6
Subtotal		48.7		36.6
ERDA Factor		9.7		7.3
Total Full Cost Rate		$58.4		$43.9

*For a 5 year period following FY1977, it is anticipated that the spending will remain flat at a $30-40,000/year rate.

J. LITERATURE CITED

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Heath, M. E., D. S. Metcalfe, and R. F. Barnes. 1974. Forages. The Science of Grassland Agriculture. The Iowa State University Press, Ames, Iowa. 755 pp.