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WILLIAM G. STRATTON, Governor

Wafer *and Land* Resources of *the Crab Orchard Lake Basin*

J. B. Stall, J. B. Fehrenbacher, L J. Bartelli, G. O. Walker,
E. L. Sauer and S. W. Melsted

A Cooperative Study by
Illinois State Water Survey Division; Agricultural Experiment Station,
University of Illinois; Soil Conservation Service,
United States Department of Agriculture; Southern Illinois University;
and Fish and Wildlife Service, United States Department of Interior.

DEPARTMENT OF REGISTRATION AND EDUCATION

VERA M. BINKS, Director

STATE WATER SURVEY DIVISION

A. M. BUSWELL, Chief

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SUMMARY

1. Crab Orchard Lake is located in southern Illinois in Williamson County. Construction was authorized in 1936 for the federal Resettlement Administration as part of the Crab Orchard Project for Land Utilization. The lake was completed in 1940 and was constructed by the Works Progress Administration and the Soil Conservation Service for: (1) work relief (2) recreational purposes (3) a migratory waterfowl refuge and (4) conservation of water, soil and forestry.

2. The 1951 sedimentation survey of this lake showed a capacity loss of 0.43 per cent per year. In 11.2 years the lake had lost 4.84 per cent of the original capacity. The original storage capacity of 23,054. million gallons had been reduced to 21,938 million gallons by 1951.

3. The lake has a contributing drainage area of 171 square miles exclusive of smaller lakes and their watersheds located within the basin. The sedimentation survey showed that the sediment deposited in the lake amounted to 2.8 tons per acre per year from the watershed.

4. The sediment has been deposited rather evenly in all parts of the lake; no significant deltas have formed at the two major inlets. The average specif ic weight of sediment deposited in the lake is 47.5 pounds per cubic foot.

5. Erosion from the lake banks has contributed 8.6 per cent of the total sediment in the lake. The remaining 91.4 per cent of the sediment has entered the lake from watershed sources upstream.

6. Physical and chemical characteristics of the lake sediment indicate that sheet erosion in the watershed is the main source of sediment. Gully erosion is a secondary source. The lake sediment ran as high in pH as 6.1. The reaction of the upland soils of the watershed in their natural state is medium to strongly acid, pH 5.0 to 5.5.

7. Little Grassy Lake was constructed on a tributary to Crab Orchard Lake and was completed in March 1942. A reconnaissance sedimentation survey of this lake in 1951 showed that the storage capacity of the reservoir had been reduced from 8,540 million gallons to 8,417 million gallons or 1.44 per cent in 9.3 years.

8. Reconnaissance sedimentation surveys of six smaller tributary reservoirs in the Crab Orchard Lake basin showed annual losses due to silting varying from 0.28 per cent per year to 1.3 per cent per year.

9. A water treatment plant having a capacity of two million gallons per day was constructed at Crab Orchard Lake during World War II to serve the needs of the Illinois Ordnance Plant which was developed in this area. This treatment plant now serves industries in the former ordnance plant buildings.

10. The total average annual evaporation in the Crab Orchard Lake area is estimated to be 40 inches. This average evaporation is expected to vary from 0.9 inches in January to 6.3 inches in July.

11. Mineral analysis of monthly water samples obtained from Crab Orchard Lake in 1952 show median values in parts per million for the following constituents: Iron, 1.6; manganese, 1.0; alkalinity, 34; sulfate, 112; hardness, 120 and total mineral content, 200.

(12/ Since the completion of Crab Orchard Lake the cities of Carbondale, Herrin and Marion have found it necessary to construct pipe lines from their respective municipal treatment facilities to Crab Orchard Lake. In 1953 these cities were using a total of 42 million gallons per day of water from Crab Orchard Lake in addition to supplies from their municipal reservoirs.

13. A study of stream flow variability indicates that Crab Orchard Lake could furnish a total continuous draft of 43 million gallons per day if it were permissible to draw the water level down 22 feet below the spillway crest, which would virtually empty the lake. The water level may be drawn down two feet by evaporation losses alone. The study indicates further that if it were permissible to draw the water level in the lake down 10 feet below spillway crest the lake could furnish a continuous draft of 26 million gallons per day.

14. Little Grassy Lake could furnish a total continuous draft of about 8.5 million gallons per day if it were permissible to draw the water level down 50 feet below the spillway crest elevation. The proposed Devils Kitchen Lake could furnish a total draft of about 11 million gallons per day if it were permissible to empty this lake at the end of an extreme dry period.

15. If the present and future maximum drawdowns of Crab Orchard Lake were limited to 8 feet, the lake could furnish approximately 20 million gallons per day under continuous draft at the present time. This possible draft will be reduced to 14 million gallons by the year 2000 A. D. under the present rate of silting.

16. The land area in the Crab Orchard Lake basin amounts to 185 square miles. Two distinctive types

of topography are present. The southern portion in general has greater elevation and rougher topography than the northern portion. Nearly half of the watershed area has a slope of less than four per cent while nearly 20 per cent of the land in the watershed has a slope greater than 12 per cent.

17. A detailed soil survey of Crab Orchard Lake watershed was made in 1951 and 1952. The predominant soils of the area have limited productivity potential as compared to other soils of the state.

18. A detailed soil association map is presented for this watershed. The soils of the basin have been grouped into eight soil association areas based on the parent materials from which the soils developed, the major type of vegetation influencing their development, and the slopes on which they occur.

19. The A2 Association, Manitou and related soils underlain by bedrock occupy 20.1 per cent of the watershed area. The C1 Association, Bluford and related soils underlain by glacial till occupy 18.2 per cent of the watershed area.

20. The land use survey of the watershed showed that approximately 50 per cent of the cropland was planted in clean tilled crops, a practice which is highly inducive to erosion. The survey showed that nearly 30 per cent of the watershed land was idle.

21. About 50 per cent of the 34,787 acres of idle land in the watershed is suited for cropland. About 16 per cent of the 39,469 acres now in cropland is rated Class VI or VII land and is better suited for pasture land or woodland.

22. Severe erosion in the watershed is most pronounced in the hilly soil association areas A2, B2 and C2 found in the southern part of the watershed. About 30 per cent of the watershed has no apparent erosion.

23. The proposed watershed treatment program will materially reduce the rate of sedimentation in Crab Orchard Lake. The needed program is based on the capability and adaptability of the land. The conservation measures would keep the soil loss to less than two tons per acre per year. It is calculated that soil loss under the conservation program would be reduced from 634,241 tons per year to 60,372 tons per year. This represents a 90 per cent reduction in soil leaving the fields. It will result in smaller amounts of sediment reaching the lake.

24. The calculated average soil loss for the upland soils in the watershed is 5.3 tons per acre per year under the present management. The measured rate of sedimentation in the Crab Orchard Lake is 2.8 tons per acre per year. The greatest soil loss occurs in the 9,485 acres of soil association area C2. Here it is estimated that the soil loss averages 15 tons per acre per year.

25. The Little Grassy Lake watershed of 15 square miles in soil associations Al and A2 has a calculated average soil loss of 5.4 tons per acre per year. The sediment deposited in this lake amounts to 3.7 tons per acre per year.

26. The sediment in Crab Orchard Lake represents about 48 per cent of the soil removed from the upland by erosion. The other 52 per cent is deposited en route to the lake to form the bottomland soils. Under the proposed conservation treatment program the sedimentation in the lake would be reduced from the present 2.8 tons per acre per year to from 0.3 to 0.5 tons per acre per year.

27. A land inventory of the watershed has been prepared. This inventory was used as a basis in developing a conservation treatment program. Since the soils in the watershed are inherently low in fertility, an integral part of the treatment program is a well-planned soil management program. This is dependent upon the soils being treated according to soil tests.

28. The treatment program requires that approximately 67 per cent of the cropland should be contoured with a 1-1-2 rotation for Class II land, 1-1-3 rotation for Class III land, and a 0-1-4 rotation for Class IV land. (The arabic numbers represent the years of row crops, small grain, and meadow, respectively.) Approximately seven per cent of the cropland should be in grassland farming using an average rotation of 0-1-4.

29. Approximately 16 per cent of the cropland needs farm drainage of the surface ditch type. This includes the poorly and imperfectly drained soils on level to nearly level slopes. Approximately 10 per cent of the cropland needs to be terraced. There is also a need to sod 97 miles of waterways and establish 179 miles of field diversions. About 2,725 acres need to be cleared of brush and trees.

30. Cropland acreage can be increased from 39,469 acres to 58,449 acres. This increase is a result of converting land now idle or in pasture or woods. The proposed pasture land acreage represents an increase from 14,377 acres to 27,887 acres. It is recommended that 18,232 acres be converted to pasture land from present cropland, idle land and woodland. About 25,527 acres are proposed for woodland and wildlife use. Of this acreage, 5,928 acres would be reforestation of land which, at the present time, is cropland, idle land, or pasture land.

31. Data from the Assessors Agricultural Census for Williamson County show that the average size of farms in the county is approximately 80 acres with approximately 40 acres in cropland.

32. A farm business survey in East and West Marion Townships, Williamson County, in 1935-1937 showed that a high proportion of the cropland was idle and that production was extremely low. The average net income per acre for the three years included in the survey was a minus $3.00 when an allowance was made of approximately $540 per farm for operator and family labor.

33. On the basis of 1945-1949 production figures for Williamson County, it is estimated that the average annual total value of crops for this watershed amounted to $10.88 per acre. This total value of all crops could be boosted to an estimated $21.47 per acre by applying the recommended conservation program which is based on using land within its capability and treating it according to its needs for conservation. Such an increase is based on average yields from farm-account-keeping farms on similar soils in the area.

34. It is estimated that the total cost of establishing the conservation program recommended would amount to an average of $38.47 per acre. On the basis of this cost, only four years of increased production resulting from such a program would pay for the cost of establishing it.

WATER AND LAND RESOURCES OF THE CRAB ORCHARD LAKE BASIN

by

J. B. Stall, Assistant Engineer, Illinois State Water Survey Division, Urbana, Illinois

J. B. Fehrenbacher, Assistant Professor of Soil Physics, Agronomy Department, Agricultural Experiment Station, University of Illinois, Urbana, Illinois

L. J. Bartelli, State Soil Scientist, Soil Conservation Service, U. S. D. A., Urbana, Illinois

G. O. Walker, Survey Supervisor, Soil Conservation Service, U. S. D. A., Anna, Illinois

E. L. Sauer, Research Project Supervisor, Economics of Soil Conservation, Soil Conservation Service, U. S. D. A., and Agricultural Experiment Station, University of Illinois Cooperating, Urbana, Illinois

S. W. Melsted, Associate Professor of Soil Analysis Research, Agronomy Department, Agricultural Experiment Station, University of Illinois, Urbana, Illinois

GENERAL

INTRODUCTION

Need for Data. Water supply follows the law of supply and demand. At a particular place and time an excess supply may go unused and at another place and time the successful development of a project may be prohibited by the lack of sufficient water. In southern Illinois, which is chiefly dependent on surface water, mean annual rainfall is about 40 inches. In various years, from 2 to 20 inches of this flows off the land through the stream system. This runoff, however, is distributed very unevenly in time and place as well as in amount. This extreme variability of stream flow makes it necessary to construct a dam across the stream to impound its waters so as to create a storage basin into which the stream can flow and from which water can be pumped for use when it is needed. However, when a dam is built to store the waters of a muddy flowing stream, the particles of mud or sediment carried by the water immediately begin to settle to the bottom of the lake that is formed and come to rest there, thereby decreasing the storage capacity of that lake. And so, immediately upon construction of a lake its destruction begins.

Some erosion occurs on practically all farmland. In Illinois, a yearly loss of three or more tons of soil per acre may occur if land subject to erosion is farmed. The cutting of a gully into afield is quickly noticeable. Sheet erosion on the other hand, removes a thin layer of soil every time rainfall occurs. The magnitude of sheet erosion is not easily noticed and such erosion can continue to remove great amounts of soil without being recognized.

The transport of soil particles from the farmer's field through ditch and stream into a storage reservoir affects the use of the water in many ways. A study, such as the one reported herein on the Crab Orchard Lake area, serves to emphasize to farmers the great amounts of soil being carried away from their land. Impoverishment of farm land has been illustrated in many ways, but here, since soil movement is destroying a lake, it is quite obvious. A study such as this also serves to bring to the public attention the great stake which reservoir owners have in the proper management of the watershed farmland.

The tragic effect of soil loss and transport by water is vividly expressed by Channing Cope from his observations in Georgia:

> "A little later we stood on the bridge overlooking the swirling waters of the same Yellow River. We saw tons and tons of topsoil hurrying away to the sea. Again we were thinking of the same thing when Veatch said, 'It isn't just topsoil that is rushing along here under the bridge; it's children's shoes and clothes and school books; it's the washing machine and the refrigerator that the family was planning to buy; it's the labor of the past and the hopes of the future.'
>
> "It does not matter that Veatch and I said these things. What matters is that they are tragically true. Soil erosion is not merely topsoil being moved off the land. It is school erosion, church erosion, and family erosion. Everyone is affected.
>
> "Erosion strikes first and most directly at the farmer. His crop yields are reduced; it makes the livestock in his fields and barns thin and gaunt. And through the losses of the farmer, erosion strikes at everyone; the tax gatherer, the school teacher, the preacher, the merchant, the banker,

the fertilizer man - these and others are the victims of erosion. The industrialist, seeking water for his plant, cannot locate or live in an eroded area. The development of a watershed is limited by erosion, the purchasing power of all the people who live on eroded farms or in eroded sections is less than it should be, and all victims are deprived of services they need and want.

"Erosion is stopped only by holding water where it falls. When a drop of rain falls on absorptive soil, its potential powers for evil are transformed into potential power for good. It seeps into the soil and later into the stream channels instead of rushing off the land carrying the topsoil with it and thus causing flood, destruction, and death.

"There is nothing more important to the nation and to you and me than holding soil and water on lands where rain falls. All else is secondary." [1]

Illinois Program. The need for information and quantitative data on the rates of siltation and their effects on surface water supplies began to be recognized in Illinois as early as 1930. A more comprehensive study of sedimentation problems was made possible when the Soil Conservation Service was created in 1935 as a permanent agency of the United States Department of Agriculture for the control of soil erosion. At this time a nationwide study was undertaken to determine the effects of accelerated soil erosion on rates of reservoir sedimentation.

Because of the seriousness of erosion and the subsequent rapid reservoir sedimentation, together with a lack of any suitable quantitative data relative to the problem, the Illinois Water Survey Division, the Illinois Agricultural Experiment Station and Soil Conservation Service joined in 1936 in a cooperative study of sedimentation in Illinois. The purpose was to determine the effects of the various watershed characteristics and climatic factors on the rate of sediment production and the rate of sedimentation of reservoirs. Under this cooperative agreement, four reservoirs were surveyed in 1936 to measure sediment deposition. These were Lake Decatur, West Frankfort Reservoir, Lake Bracken near Galesburg, and Lake Calhoun near Galva. Up to the present time, surveys have been made for 69 Illinois lakes under this program.

After an elapsed period of ten years a re-survey was made on Lake Decatur in May and June 1946. This second survey revealed a 20 per cent increase in silting rate over the earlier period. Analysis also showed that Decatur had only nine years in which to provide itself with a more adequate water supply. [2]

The specific objectives of the state-wide program as well as the survey outlined herein are: (1) to establish information on factors affecting sedimentation; (2) to furnish factual data for future reservoir development; (3) to provide data for estimating sediment damages to existing and proposed reservoirs; and (4) to develop methods of sedimentation control.

Need for this Report. Crab Orchard Lake is the largest man-made lake in Illinois. It was constructed during the late 1930's for recreational and water supply uses. During World War II it furnished water to the federal munitions plant located in the lake area. Crab Orchard Lake represents a major water supply source in the midst of an area where such supplies are generally scarce. As shown in Figure 1, Crab Orchard Lake is located near the center of the southernmost 16 counties of the state.

Because of its sheer size and its major importance in the water supply picture of Illinois, particularly Southern Illinois, Crab Orchard Lake drew the attention of the agencies carrying out the cooperative program of study of sedimentation in Illinois reservoirs.

After the conclusion of World War II, an intensive program was undertaken to promote the development of Southern Illinois. In 1949, the Executive Committee on Southern Illinois published a comprehensive regional inventory of the southernmost 16 counties in the state entitled, "Southern Illinois." [3] This report sums up the general situation.

"The 16 southernmost counties of Illinois are an area whose economic development has not supported the residents at a level of well-being equal to that of the rest of the state. Average annual incomes pier capita and average retail sales per capita are lower there than the average for the rest of the state. Unemployment, work relief,- old age assistance, aid to dependent children, blind relief and other forms of public aid are all higher than the average for the rest of the state.

"In large part this has been so because the economy of these 16 counties has not been balanced. Early in this century the population grew rapidly because of an increasing need for labor in the development of the coal resources and fluorspar deposits. Later advances in mining technology and changing markets brought about a displacement of labor in the mineral industry without the development of an alternative op-

[1] Cope, Channing, Front Porch Farmer. 171 p., Turner E. Smith & Company, Atlanta, Georgia, 1949.

[2] Brown, Carl B., Stall, J.B., and De Turk, E.E., The Causes and Effects of Sedimentation in Lake Decatur, Bulletin No. 37, Illinois State Water Survey Division, 62 pages illustrated, Urbana, Illinois. 1947.

[3] Southern Illinois. Executive Committee on Southern Illinois. 193 pages illustrated. University of Illinois Press, Urbana, Illinois. 1949.

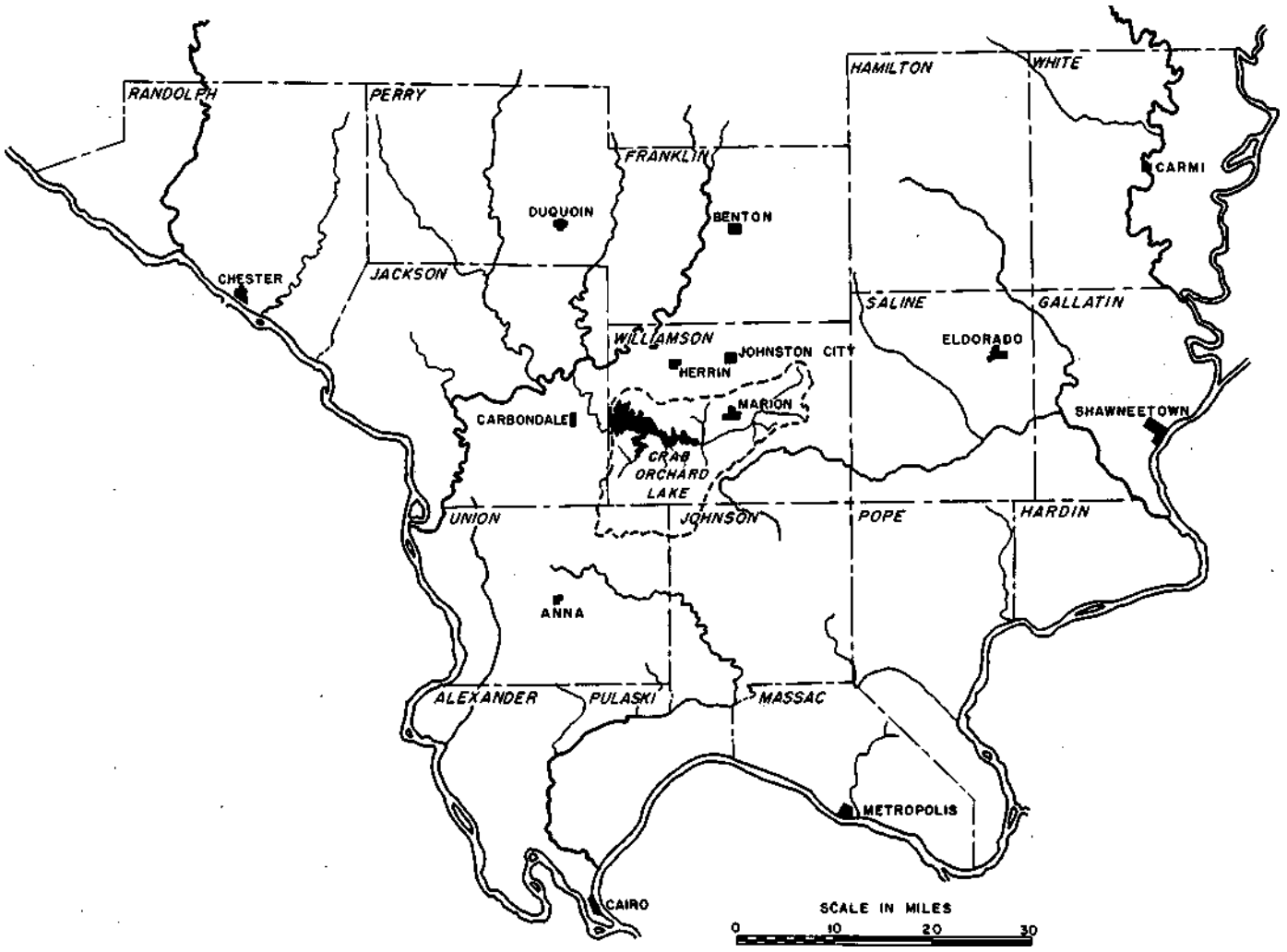

FIG. 1. LOCATION OF CRAB ORCHARD LAKE IN SOUTHERN ILLINOIS

portunity for employment. Agricultural problems have also been more difficult in this section because of a lower level of soil fertility, marked tendencies toward soil erosion and depletion of soil chemicals. The agricultural situation was further aggravated by farms too small to be effective in producing income and by the use of land in ways not well adapted to its characteristics." [3]

This report on the economy of Southern Illinois discusses agriculture, forests, mines, industries, people, land and playgrounds, each as a separate entity. In conclusion, the report states:

"The objective of the proposed new developments - whether the introduction of manufacturing industries, the restoration of idle land to tree planting, the modification of farming practices or the building of recreational facilities - is to diversify employment opportunity as well as to create more productive jobs so that the future of the 16 southern counties will be better than the past or the present." [3]

In 1950, Richardson Wood & Company, Economic Consultants, prepared a report for the State Department of Finance which discussed the economic prospects of the southern counties of Illinois and recommended ways in which state aid might be offered to help in developing this area. The findings of this report are enumerated as follows:

"1. There are no outstanding natural advantages in the area other than coal which has for the time being passed its peak ability to provide employment; but there are at least two notable disadvantages - poor soil and scarce water.

"2. (a) The major economic resource of the area is its people with their homes, highways and towns and this resource is attractive to certain types of manufacturing enterprises.

(b) There are minor resources in fruit farms in bottomlands suitable for truck farms and row crop cultivation, in pasture lands which can be economically rehabilitated and expanded, and in timber logs and forest; all of which are capable

of further development." [4]

The lake and watershed study of Crab Orchard was made at the request of the lake administrators and local persons interested in lake development. The study was justified by the importance of the lake to the area and the significant role that the Crab Orchard Lake may be expected to play in the future development of the area.

SCOPE OF INVESTIGATIONS

Lake Survey. In June 1950, the United States Fish and Wildlife Service, administrators of the lake, Southern Illinois University and Southern Illinois Incorporated requested that a study be made of the sedimentation of Crab Orchard Lake. At the request of this group, a reconnaissance survey was made, This investigative survey was carried out by the State Water Survey during July and August 1950, with the cooperation of the lake administrators. The purpose of the survey was to obtain an estimate of the rate of silting in the lake and to determine whether or not a detailed survey would be necessary. Along these 16 ranges, a total of 140 measurements of water depth and sediment thickness were made by means of a sounding pole. The results of this reconnaissance survey were reported to the lake owners and all interested persons. [5] Several significant facts were noted from the reconnaissance survey. First it was found that the sediment was rather evenly distributed over the entire lake bottom, that is, that the average depth of sediment did not vary greatly between the lower end and the upper end of the lake. Secondly, evidence of shore erosion and erosion of islands was observed but the magnitude of this erosion was not measured.

On the basis of the reconnaissance survey, it was estimated that the Crab Orchard Lake had lost 7.5 per cent of its original capacity during the 10 years since its creation. The estimated annual sediment deposition in the lake amounted to 2.4 acre-feet per square mile of drainage area.

A conference regarding the sedimentation of Crab Orchard Lake was held at Carterville in March 1951 with representatives of the cooperative sedimentation survey program and other interested groups present. From this discussion it was decided that a detailed survey should be conducted, and during the summer of 1951 the survey was made. Forty-nine cross-sections of water depth and sediment thickness were taken. In this manner, the original storage volume and the volume of sediment deposited in the lake were measured. In addition, the volume of shoreline erosion was measured by a series of cross-sections of the banks.

Surveys of Tributary Lakes. As a part of the study of sediment deposition in Crab Orchard Lake and as an aid to understanding the movement of sediment through the Crab Orchard Lake watershed into the lake proper, several surveys were made on smaller lakes in the area. A reconnaissance survey was made on Little Grassy Lake which is tributary to Crab Orchard Lake and which was built at about the same time.

Watershed Survey. To understand the movement of soil from the land to the stream system and into the lake, data on the soil types, slopes, land use and erosion in the watershed are necessary. The Soil Survey of the Illinois Agricultural Experiment Station carries on such a program of study of the characteristics of Illinois soils. The study of soils involves field inspection work plus laboratory analysis to determine soil characteristics. The Soil Survey uses these data to prepare a county-wide map and a bulletin outlining the soil areas and describing the characteristics of the soil in a particular county.

In Williamson County, the county in which most of the Crab Orchard Lake drainage area lies, a group of soils are present which had not been thoroughly studied to date. For this reason and the fact that several agencies in the Crab Orchard Lake drainage area were vitally interested, the Soil Survey gave Williamson County and this watershed priority within their mapping program. A complete detailed field survey was made during the field season of 1951 and 1952 by the soils specialists of the Soil Survey. From these data, a map of the watershed was prepared and is presented in this report along with a discussion of the soils of the watershed.

Watershed Treatment Program. On the basis of the comprehensive soil survey of this watershed, the Soil Conservation Service made a detailed study of the land capabilities. By the inspection of the physical conditions of the land in the light of experimental results on soil and water losses under various conditions, an estimate was made of the annual gross sheet erosion from this watershed. To reduce the sedimentation in the lake and to improve the productivity of the farm land in this area, a complete conservation program was outlined for this watershed. The specific conservation measures recommended have been tabulated and are presented in this report. The conservation measures recommended are based on the capabilities of the land.

Sediment Samples. During the course of the 1951 lake survey, a series of 11 sediment samples were taken from various parts of the lake by means of a special sampler. Sediment samples were also obtained from the five other lakes and ponds in the Crab Orchard Lake area which were surveyed as part of this study. Chemical and physical analyses of all of

[4] A Report on the Economic Prospects of Southern Illinois, Richardson, Wood & Company, New York-Chicago, October 1950.

[5] Larson, Bernt O., Reconnaissance Sedimentation Survey of Crab Orchard Lake, Carbondale, Illinois, August 1950. Illinois State Water Survey Division, Urbana, Illinois, 1950.

these samples were made by the Illinois Agricultural Experiment Station. These analyses reveal the texture, size distribution, density and presence of plant food constituents in the sediment of the lakes.

Water Samples. At the conclusion of the 1951 lake survey, a routine sampling of the Crab Orchard Lake water was initiated. Since August 1951, monthly samples of water have been obtained at two locations in Crab Orchard Lake. These samples have been analyzed by the State Water Survey and the results are summarized in this report.

ACKNOWLEDGMENT

Many individuals contributed materially to the investigations reported in this publication. Credit is due in particular to the following private, state and federal officials and other persons who supplied data or cooperated in making possible the several surveys and investigations reported herein.

Fish and Wildlife Service. The Fish and Wildlife Service of the U. S. Department of the Interior contributed materially to this study. As administrators of the Crab Orchard National Wildlife Refuge, within whose administrative bounds lie the Crab Orchard, Little Grassy and Devil's Kitchen impoundments, the Service is committed to the management of the federal lands as a multiple use project for the furtherance of industrial development and expansion, land management to its capability in the best interest of sound land use and harboring wildlife, especially a wintering population of migratory waterfowl, and the fullest development of the recreational potential of the lands. The refuge staff cooperated in this study in providing living quarters for field survey personnel during the summer field seasons of 1951 and 1952 and made available personnel to assist in the lake survey.

The Illinois Natural History Survey cooperated in providing utility services and furnishings in the living quarters.

Southern Illinois University. Dr. William E. Lewis, Fish Management Specialist in the Department of Zoology at Southern Illinois University, did much to make these lake and watershed studies possible. The Department of Zoology furnished two full-time helpers who worked with the field party carrying out the lake survey during the three-month period in 1951. John Parsons and Walter Welch aided in the field survey. Dr. William Freeburg, Director of the S.I.U. summer camp located on the banks of Little Grassy Lake, furnished living quarters for the lake survey field party during the three-week period of the survey of Little Grassy Lake.

The seven photographs used in this report to illustrate watershed land conditions were furnished by the Southern Illinois University Photographic Service.

State Water Survey Division. The 1950 reconnaissance survey of Crab Orchard Lake was conducted by B. O. Larson, Associate Engineer; L. E. Roberts and B. J. Sayers, Engineering Assistants. The 1951 detailed lake survey was carried out by J. B. Stall, Assistant Engineer, assisted by Paul Gordon and Jack Kennedy, Engineering Assistants. The lake survey portion of the present report was compiled by Mr. Stall. The work was done under the general supervision of H. E. Hudson, Jr., Head of the Engineering Sub-division.

The routine mineral analyses of the water samples obtained in duplicate from Crab Orchard Lake were done in the laboratories of the State Water Survey Division under the supervision of Dr. T. E. Larson, Head of the Chemistry Sub-division.

Evaporation data presented in this report were obtained from a research program on evaporation in Illinois carried out by W. J. Roberts, Associate Engineer.

Soil Conservation Service. The Soil Conservation Service of the United States Department of Agriculture has participated in the Illinois sedimentation program and in the present project in many ways. Mr. L. C. Gottschalk, Head of the Sedimentation Section, gave technical assistance during a week spent with the survey party during the 1951 detailed lake survey and, in addition, reviewed the present report. Mr. Gottschalk arranged for specialized survey equipment and the enlarged aerial photographs used in making the lake survey.

Mr. G. R. Hall, Sedimentation Specialist of the Upper Mississippi Region 3, gave technical assistance to the lake survey party during a week spent with the party in 1951 and reviewed the present report.

Mr. B. B. Clark, State Conservationist arranged for cooperation of Soil Conservation Service personnel. H. R. McCulloch, Soil Scientist, aided the soil survey work on the watershed. Mr. L. J. Bartelli, State Soil Scientist, and H. M. Smith and George Walker, Spil Scientists, assisted with the preparation of the detailed conservation program needed for the watershed, including the estimates of probable annual soil losses.

Data presented in this report regarding sedimentation in Herrin Reservoir No. 2 are based on a study made May 12 and 13, 1936, by Dr. V. H. Jones, Sedimentation Specialist.

Illinois Agricultural Experiment Station. Dr. Russell T. Odell, who is in charge of the State Soil Survey, aided by authorizing the Williamson County soils survey work and by giving high priority to the work within the Crab Orchard Lake watershed. Joe B. Fehrenbacher, Soil Survey Party Chief, supervised the field work of the soil survey. J. D. Alexander, R. H. Rust, R. A. Bohannon, and W. R. Oschwald assisted in the field work of the soil survey. Mr. Fehrenbacher prepared the section of this report dealing with the soil association map.

The chemical and physical analyses of sediment samples were made in the laboratory of the Agricul-

tural Experiment Station under the direction of Dr. S. W. Melsted, Associate Professor of Soil Analysis, who also compiled the section of this report interpreting the analytical results.

Dr. E. L. Sauer, Research Project Supervisor of the Soil Conservation Service and Illinois Agricultural Experiment Station, carried out the study of land use history, land-ownership, and economics of conservation in the watershed.

Dr. D. M. Hall, Assistant Professor of Agricultural Extension at the University of Illinois, aided in the tabulation of the soil survey map data by means of IBM punchcards.

Others. Mr. M. J. Bozarth and Mr. N. G. Bitterman, President and Executive Director respectively, of Southern Illinois, Incorporated, aided considerably in the bringing together of the many groups interested in the sedimentation survey. The Williamson County Farm Bureau and the Williamson County Soil Conservation District furnished information on the agriculture of the area and expressed much interest in the present survey and study.

Mr. Ernest Brown, Superintendent of Waterworks at Marion, authorized the sedimentation survey of the Marion City Reservoir. Mr. Dan Williams, Waterworks Superintendent at Herrin, authorized the survey of Herrin Reservoir No. 1. Mr. Alfred Fluck, Dr. A. N. Baker and the Knights of Pythias Lodge, of Marion, Illinois, authorized the surveys of small lakes owned by them.

Mr. J. N. Harms, Photogrammetrist, Production and Marketing Administration, United States Department of Agriculture, Decatur, Illinois, aided in obtaining 1952 aerial photographs for Williamson County. This new aerial photography materially speeded the soil survey work. Mr. Harms also aided in photogrammetric checking of enlarged aerial photographs used to determine the surface areas of several of the lakes surveyed.

CRAB ORCHARD LAKE

HISTORY

Early Discussions. Many interests have been influential over the years in promoting the establishment of this lake and since no summary statement of its purpose is available, the authors have presented here a resume of the development history of the lake.

One of the earliest published statements discussing the possibility of a major water resource development in Southern Illinois appeared in February, 1935. At that time the Illinois Emergency Relief Commission requested the University of Illinois, State Geological Survey, State Water Survey and the State Natural History Survey to prepare jointly a preliminary report on certain engineering and economic features of the Big Muddy River Basin in Southern Illinois. The Relief Commission was interested in that area because of the heavy relief load caused primarily by the curtailment of coal production which was serious even before the depression set in. The object of the study was to locate sites upon which earthen dams could be advantageously constructed by relief labor to form reservoirs for the storage of water.

The report was titled "Reconnaissance Report on Proposed Reservoir Sites in the Basin of the Big Muddy River in Southern Illinois." [6] In outlining the relief problem, Dr. Frank C. Murrah of the Williamson County Committee of the Illinois Emergency Relief Commission stated that at one time there were 6400 families of the total population of 53,000 in Williamson County "on relief." Considering the average family to be four persons, nearly half of the population was on relief. Conditions were similar in other nearby counties. The advent of the mechanical coal-loading machine for use in the mines had greatly reduced the manpower requirements of the mining industry. In addition, the entire nation was in the depths of an economic depression. Dr. Murrah discussed hopes for rehabilitation as follows:

> "Rehabilitation through Work Relief. - When it became possible to provide work for people with the help of Government agencies several of us looked about for a project big enough to employ our dependent people and also a project that would eventually give permanent relief to our stranded population getting them back into private industry. Since it is apparent that even though we regained a large part of our coal business the loading machines are here to stay and there will never be any necessity of employing the number of men in the coal mines there once was. There remains then the problem of getting some other industries into the community where these men may be employed.
>
> "We are at about the center of population of the United States. We have excellent railroad transportation, good hardroad transportation, plenty of labor, and very cheap fuel. It has long been apparent that we did not have water which is very necessary in practically all industries. Its lack is even a handicap to the coal mining industry. Many coal mines in dry seasons are forced to have water hauled with great expense in order to operate their machinery. The only project that we could find that would meet all these requirements is the Big Muddy River Basin project. The cleaning out of the channel, deepening it in places and in other places straightening it and the building of eleven or more reservoirs along its

[6] University of Illinois, State Geological Survey, State Water Survey, and State Natural History Survey, Reconnaissance Report on Proposed Reservoirs Sites in the Basin of the Big Muddy River in Southern Illinois, for the Illinois Emergency Relief Commission, pages 78-85, Urbana, Illinois, February 1, 1935.

chief tributaries would provide work for all our unemployed for a period of two or three years. When the work was finished we would have an ample all the year water supply. With it and our other inducements we would be in a position to invite other industries into the area." [6]

Professor W. C. Huntington, Head of the Civil Engineering Department, University of Illinois presented the principal ideas of the entire report in an itemized summary. This summary is reproduced in part as follows:

"The relief problem is particularly acute in the Big Muddy Basin because of the great decrease in the amount of coal mined during recent years. The situation is only partially due to the present economic disturbance. After prosperity returns to the rest of the country there will still be economic distress in this area. The problem of rehabilitation must be considered along with that of relief. By utilizing relief labor on projects which will increase the resources of this area some progress can be made toward rehabilitation.

"The proposal which is now under consideration is to build earth dams with relief labor. These dams may be advantageous from many points of view but cannot in any way be considered as self-liquidating. They would create reservoirs which would improve the water supply of several towns whose supply is now inadequate; they might improve sanitary conditions by increasing the water available during dry seasons for sewage dilution; if used for flood control purposes they would be very effective, in proportion to their cost and the size of the area involved, in decreasing the flood flow in the Mississippi River; they would raise the surrounding ground-water level and thereby benefit wells in their vicinity; they might provide water for use as feed water for boilers of steam power plants and for condensation purposes; they would provide water which might be used for the irrigation of orchards during dry seasons; and they would increase the attractiveness of the area from the point of view of recreation. Some of these uses conflict with each other so all of them will not enter into a single project.

* * *

"The underground waters of this area are, on the whole, inadequate in quantity and are of high mineral content. The surface waters are a much more important and satisfactory resource than the underground waters and they have had but a limited development.

"Several desirable dam and reservoir sites are available near the centers of relief loads. As compared with many dams built and being built for flood control and other purposes in the United States, the cost of these projects per acre foot of storage capacity would be very low. Most of the reservoirs would be relatively small but one of the sites on Crab Orchard Creek would provide a storage of 120,000 acre-feet which is a comparatively large reservoir.

"All of the towns in the basin are well supplied with water except Marion, Carbondale and Du-Quoin. Some of the proposed reservoir sites are near these towns and could be used to augment their water supplies.

* * *

"One of the chief limiting factors in the production of apples, small fruits and vegetables in many southern Illinois sections is water supply. Three years out of ten there is a very great scarcity of rainfall which makes it difficult, or in some sections impossible, for orchard fruits, especially peaches and apples, to mature their crop. Additional reservoirs in the Big Muddy Valley would be a potential factor in raising of the level of marketable fruit and also lead to a logical expansion of the industry. Notwithstanding its large fruit and vegetable producing areas, not one-tenth of the requirements of the population of Illinois are met from within the state. Other areas, aside from the Big Muddy section, might also be used, especially for experimental purposes to determine the feasibility of irrigation for sections adapted to fruit and vegetable growing.

* * *

"The utilization of water impounded in the proposed dams for steam raising purposes does not present an attractive possibility. This is due to the fact that the region is already served by nearby plants at relatively low prices and that there are very few mines with local generating plants that would be interested in getting power from a central station. However, the possibilities are sufficient to warrant a careful survey with analyses of waters to determine their suitability. The matter of adequate water supply, chemically suitable, is usually the determining factor in an electric power plant location. Coal cost, including freight, is only a small part of the total money paid by the public for electric power.

* * *

"In the large scale planning projects now being studied by governmental agencies, parks and other recreational facilities are, quite properly, being given major consideration and are ranked on a par with other resources of an area.

"When reservoirs are created through the expenditure of public funds, it is very essential to obtain public ownership and control of their marginal lands and such marginal lands should be

more than a strip wide enough to provide public access, but there should be ample areas to safeguard the rights of the people in the use and enjoyment of such water.

"Southern Illinois is, in many ways peculiarly well adapted to contain numerous large scale areas devoted to parks; recreational forests; hunting, fishing and camping resorts. There is now a real opportunity to begin a program of park and other recreational development in this part of the state.

"If the sites of the proposed reservoirs were selected purely from the standpoint of increasing game and fish resources and not considering other uses for the stored water, changes could be made in the specifications to reduce costs considerably and without making the bodies of water impounded less productive of fish per acre or less useful as waterfowl resources.

"The geographical location of the proposed reservoir sites precludes their rendering much service in actual production of migrating waterfowl. The proposed reservoirs could serve as resting and feeding grounds for migratory waterfowl and if set aside as sanctuaries, with hunting prohibited or very carefully supervised, they would be an aid in helping preserve a resource which is in danger of disappearing.

"In conclusion it may be said that the construction of dams to provide reservoirs in the Big Muddy Basin would increase the resources of this region, and would be advantageous from many points of view with few, if any, disadvantages. However, no direct and immediate financial return should be expected from dam construction. Serious study should be given to the improvement of farming conditions in parts of the area by soil treatment. A soil erosion control program gives promise of valuable results. Reforestation and the development of timber crops should be given consideration and the opportunity for providing desirable parks and recreational areas should be recognized. "[6]

Project Proposal and Authorization. In June 1935 a report, "Preliminary Statement Regarding Reservoirs on Crab Orchard Creek and Grassy Creek" was prepared by the Illinois State Planning Commission. This was submitted to the Washington Office of the Resettlement Administration but it was reported[7] that budgetary limits at that time prevented further consideration of the project. In May 1936 a further report by the Illinois State Planning Commission in the nature of "A Water Resources Study" was prepared on this area and submitted to the Resettlement Administration.

At this time the President of the United States approved the expenditure of $426,000 for land and $1,375,000 for development of the Crab Orchard Project. This was disclosed in a letter dated May 11, 1936 from L. C. Gray, Assistant Administrator of the Resettlement Administration to Mr. C. F. Clayton, Chief of the Project Planning Section.

A report "Preliminary Plan for Land Acquisition, Crab Orchard Creek Project"[8] was prepared under the date July 25, 1936. This was submitted on July 31, 1936 to R. G. Tugwell, Administrator of the Resettlement Administration in Washington, D. C. for approval. This plan was accompanied by letters from the following local groups and persons endorsing the Crab Orchard Creek project: Southern Illinois State Normal University, Carbondale, Illinois, Carbondale Business Men's Association, Carbondale National Bank, Carterville Lions Club, Herrin Home Loan Association, Rotary Club of Herrin, Herrin Lions Club, Herrin Postmaster, District Manager of the National Reemployment Service, U.S. Department of Labor, Herrin Hospital, Marion Chamber of Commerce, Marion Merchants Association, Marion Lions Club, The Business and Professional Women's Club of Marion, Law Offices of Ferrel and Hay.

This report[8] contained the following section under the heading "Purpose of the Project and Development Proposed":

"The Crab Orchard Creek Project is proposed largely as a recreational and conservation program for water, soil and forestry conservation.

"Occupants of the land who are able to qualify for resettlement will be care for by the Gallatin Farms Resettlement Project in Gallatin County, Illinois, which is two counties east of the proposed purchase area.

"The development features contemplated in this project include timber stand improvement on the forested areas, reforestation on the steep slopes, construction of a reservoir with a surface of approximately 8000 acres around which will be centered recreational features, to provide camping, picnic grounds, fishing, boating, and migratory water fowl refuges.

"On some of the steeper slopes where serious erosion now occurs check dams will be constructed to supplement the reforestation work designed to control this erosion."[8]

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[7] Perfect, D.E. and Signell, L.O., Reconnaissance Survey Report of the Crab Orchard Creek Watershed, Williamson County. Illinois Project LU-IL-11. U.S. Department of Agriculture, Soil Conservation Service, Region 5, Des Moines, Iowa, March 1939.

[8] Preliminary Plan for Land Acquisition, Crab Orchard Creek Project LO-OL-11 Multiple Use Project, Williamson County, Illinois, Region 3, Land Utilization Division, Resettlement Administration, Washington, D.C., July 25, 1936.

During the summer of 1936 preliminary work for land acquisition was begun. Appraisal of land was begun and work was carried out in obtaining options for the purchase of land in the area.[8] No final plan was prepared on this project and the "Preliminary Plan" 8 constituted the first formal request for approval on the actual project that was filed.

The development of the lake was strongly supported by Congressman Kent B. Keller. A report[9] to the people published in October 1936 describing the activities of Congressman Keller contained the following discussion:

> "In the fall of 1933 there developed in Southern Illinois particularly in Williamson County and the three neighboring counties of Franklin, Perry and Jackson, each of them coal-producing counties, the feeling for the need of a constructive plan to be followed in formulating projects upon which the unemployed men of those counties could be placed to work.... Investigations were made and information compiled. Agencies of both the state and federal government were contacted and enlisted in this problem. Out of the discussion had grown the feeling that the storage of water in great reservoirs in Southern Illinois would not only prevent floods but would in itself be greatly desirable as a source of municipal water, recreation and conservation sites and especially as a source of water for industries requiring the use of large amounts of water. It was pointed out that Southern Illinois with its best developed soft coal field in the world, its strategic location, its excellent transportation facilities, its abundant and excessive markets, its wonderful diversity of. agricultural commodities and splendid climatic conditions, with an unlimited supply of water would offer an ideal location to industry in its present move out of the large centers. It was also apparent that water conservation projects would dovetail in splendidly with the forestry program already secured and underway in Southern Illinois.
>
> * * *
>
> "With the plans and surveys completed Congressman Keller presented this program to the federal government in the spring of 1935 but because of the necessity of buying land very little headway was made until the first of 1936. After explaining it carefully to President Roosevelt and emphasizing the great need of the program especially in the coal belt, the first of the projects, that known as Crab Orchard was approved by the federal government and money made available for the immediate beginning. Crab Orchard, being; the largest of the reservoir sites was chosen for this reason, as well as the fact that it is located in the center of the unemployment of Southern Illinois would therefore lend itself conveniently to the employment of men."[9]

On September 1, 1936 Mr. Will W. Alexander, Administrator of the Resettlement Administration signed an authorization for the preparation of a project plan for the Crab Orchard Creek project. Total funds allotted were those for the acquisition of land in the amount of $426,600 from federal appropriation No. FERA 03-7397. This authorization contained the following statement: "This project is justifiable because (1) it will materially aid in eliminating economic and social distress, (2) create the largest recreational area in the State of Illinois, (3) conserve a large water supply and eliminate flooding of privately-owned lands, (4) conserve existing forests, (5) control soil erosion.

Auxiliary Lakes. On June 30, 1936 Mr. R. C. Smith, Region Director, Region 3 of the Resettlement Administration with offices in Champaign, Illinois wrote to Dr. R. G. Tugwell, Administrator in Washington, D. C. In this letter Mr. Smith stated: "Our engineering studies disclose that it will be highly desirable to construct at least two additional reservoirs, which are indicated in the additional amount requested, if the area is; to be expanded. These reservoirs; would give flood control, maintain the level of the large lake during dry periods, which would insure an ample supply of water for the towns in the immediate vicinity and increase the recreational value of the area. The additional development will also preserve valuable timber and control gulley erosion which is much in evidence."

These auxiliary reservoirs are Little Grassy Lake and Devil's Kitchen Lake. Construction of these lakes was suspended during World War II. Little Grassy was later completed but Devil's Kitchen now (1954) is only about 50 percent complete. These two auxiliary lakes were discussed in. detail in an article by Mr. R. J. Brown: [10]

> "The three reservoir sites recommended were considered for multiple-purpose: use but were to be of particular value for their combined storage capacity of approximately 128,000 acre-feet of water in an area containing an abundance of coal, labor, transportation facilities-,, and other requirements for industrialization,, but: notably deficient in water supply.,
>
> "The Crab Orchard project, which is located principally in Williamson County, Illinois, was started under the land utilization program of the Resettlement Administration Service of the De-

[9] "The Development of the Big Muddy Basin, 4 pages, Carbondale,, Illinois, October 15, 1936.

[10] Brown, R.J., "Little Grassy and Devil's Kitchen Dams, Crab Orchard Project", The Illinois Engineer,, page 9, Vol. XIX, No. 1, January 1943 Illinois Society of Engineers, Urbana, Illinois, 1943.

partment of Agriculture, November 1, 1938. The overall plan for the project provided for the construction of dams across Grassy and Little Grassy Creeks, known as Devil's Kitchen and Little Grassy dams, in addition to Crab Orchard dam.

"The Federal Government has purchased approximately 32,000 acres of land needed for the construction and protection of the three lakes and appurtenances.

* * *

"In the fall of 1940 funds were made available to the Soil Conservation Service to sponsor a Work Projects Administration project for the construction of Little Grassy and Devil's Kitchen dams and appurtenances. On December 13, 1940, presidential approval was received authorizing the work as a State-operated Work Projects Administration project.

"The Soil Conservation is responsible for the preparation of general and detailed plans and specifications and for inspecting and testing the work as performed by the construction crews. The Work Projects Administration's approval was granted subject to securing War Department approval of the plans of the two dams. Consequently all of the plans and specifications of the two structures are submitted to the district engineer of Corps of Engineers, War Department, St. Louis, Mo., for review of the engineering designs."[10]

Reservoir Construction. The Work Progress Administration participated in the construction of all three reservoirs in the Crab Orchard Project as outlined in the final report of W. P. A. activities in Illinois.[11]

"The largest and most prominent dam construction involved projects in The Crab Orchard Area under sponsorship of the U. S. Department of Agriculture, Soil Conservation Service. WPA assisted in the completion of the main Crab Orchard Dam on Crab Orchard Creek near Carbondale, WPA work involved placing of rip-rap on the dam, clearing a large part of the reservoir area, and construction of roads, trails and recreational facilities. WPA also constructed to a point of near completion an earth fill dam, 85 feet high and 3500 feet long, on the Little Grassy Creek, a tributary to Crab Orchard Creek, above the Crab Orchard dam, and partially completed a monolithic concrete dam, which when completed will be 116 feet high and 670 feet long, known as the Devil's Kitchen dam on Grassy Creek, also a tributary of Crab Orchard Creek, above the Crab Orchard Dam. These dams were not completed due to the liquidation of the WPA Program."[11]

The status of construction on the project was reported in 1939 by the Illinois State Planning Commission:[12]

"The Bureau of Soil Conservation of the U. S. Department of Agriculture has recently taken over control of the Crab Orchard Creek Project which was originally authorized as a Resettlement Administration project.

"The present project as expanded, includes the acquisition of 60,000 acres in Williamson County, part of which has been purchased, and the construction of a dam on Crab Orchard Creek, east of Carbondale, for industrial water supply and other purposes."[12]

Impoundment of water began in Crab Orchard Lake in May of 1940. As late as May, 1941, however the water level in the reservoir was still eight feet below spillway crest elevation. In 1942 a major federal munitions plant, the Illinois Ordnance Plant was constructed at Crab Orchard Lake. This plant utilized water from the lake.

Administration of the Crab Orchard Project. The organization which initiated the project, the Resettlement Administration, was a Federal agency created by Executive Order on April 30, 1935 pursuant to the Emergency Relief Appropriation Act of April 8, 1935. The work of the Resettlement Administration was carried on by three administrative units, of which the Land UtilizationTMvision had authority over the Crab Orchard Project. The disposition of this federal agency is reported as follows:

"The Resettlement Administration was transferred to the Department of Agriculture by an Executive order of December 31, 1936; and on September 1, 1937, it was reorganized and renamed the Farm Security Administration. At that time the Land Utilization Division with related records, was transferred to the Bureau of Agricultural Economics, where it remained only a short time before being transferred to the Soil Conservation Service.***"[13]

The Soil Conservation Service operated the Crab Orchard Project until August 1947 when it was transferred to the Fish and Wildlife Service. The federal

[11] Casey, Charles P. Final Report of the Illinois Work Progress Administration. Federal Works Agency, Work Projects Administration of Illinois, April 30, 1943. pp. 103-104.

[12] Illinois State Planning Commission, Report on the Big Muddy River Basin, Department of Public Works and Buildings, Division of Waterways, Springfield, Illinois, March 1939, pages 21 and 22.

[13] Guide to the Records in the National Archives. U.S. Gov't Printing Office, Washington, D.C., 1948, page 367.

law 14 providing for this transfer outlines the purposes for which the project is to be operated. This law is reproduced in part as follows:

"Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled, that in order to promote the orderly development and use of the lands and interests therein acquired by the United States in connection with the Crab Orchard Creek project and the Illinois Ordinance Plant in William on, Jackson and Union Counties, Illinois, consisten with the needs of agriculture industry recreation, and wild life conservation, all of the interests of the United States in and to such lands are hereby transferred to the Secretary of the Interior for administration, development, and disposition, in accordance with the provisions of this Act.

"Sec. 2. All of the lands transferred to the Secretary of the Interior, pursuant to the provisions of this Act, first shall be classified by him with a view to determining, in cooperation with Federal, State, and public or private agencies and organizations, the most beneficial use that may be made thereof to carry out the purposes of this Act, including the development of wildlife conservation, agricultural, recreational, industrial, and related purposes.

"Except to the extent otherwise provided in this Act, all lands herein transferred shall be administered by the Secretary of the Interior through the Fish and Wildlife Service in accordance with the provisions of the Act of August 14, 1946 (Public Law 732, Seventy-ninth Congress), and Acts supplementary thereto and amendatory thereof for the conservation of Wildlife, and for the development of the agricultural, recreational, industrial and related purposes specified in this Act***".[14]

GENERAL INFORMATION

Dam. The dam which impounds the waters of Crab Orchard Creek extends in a general north-south direction. It is located in the southwest 1/4 of Section 19, and extends southward into the northwest 1/4 of Section 30, Township 9 South, Range 1 East in Williamson County, Illinois. The dam is of earth-fill construction with rock riprap on the upstream face. It is 3,000 feet in length and has a maximum height of 50 feet above the elevation of the stream bed of the former Crab Orchard Creek. The top of the dam is at elevation 415 feet above mean sea level and is 12 feet in width. The dam has a 3:1 and 2 1/2:1 slope on the upstream face and a 2:1 slope on the downstream face.

A general view of the dam is shown in Figure 2. The spillway is located at the south end of the dam where the bedrock outcrops. The concrete spillway has a width of 450 feet and has a crest elevation of 405.0 feet above mean sea level.

FIG. 2. CRAB ORCHARD LAKE DAM.

Crab Orchard Lake. The lake is approximately nine miles long extending in an easterly direction from the dam. It varies in width from about 1½ miles in the westerly part of the lake to about ½ miles width in the easternmost end. About two miles upstream from the dam, two major sidearms with widths of ½ to ¾ of a mile extend northward from the lake for about two miles. About six miles upstream from the main dam, another major arm about ¾ of a mile wide extend about four miles directly southward. This arm of the lake is fed by two major streams, Little Grassy Creek and Big Grassy Creek About six miles upstream from the dam a major tributary, Wolf Creek, enters the lake from the sou h. The main drainage area above the lake is to the east and is drained by Crab Orchard Creek proper.

METHODS OF SURVEY

Range System. The original and present volumes of water and the amount of sediment deposited in the reservoir were determined by the "range method" of survey developed by the Soil Conservation Service and described in their bulletin, Silting of Reservoirs.[15]

Figure 3 is a base map of Crab Orchard Lake showing the layout of the sediment ranges. For the major portion of the lake, aerial photographs enlarged to a scale of 1 inch equal to 500 feet were used as a base for the survey. Aerial photographs were available from a 1938 flight for that portion of the lake east of Range R29-R30. Thus about three-quarters of the lake was surveyed using these photographs as a base map. In the field, the survey stations were located on the aerial photographs by field inspection with reference to topographic and cultural features and by chaining from

[14] "Public Law 361 of the 80th Congress, Approved August 5, 1947" Statutes at Large, Volume 61, Part 1, Page 770, United States Government Printing Office, Washington 25, D.C.

[15] Eakin, H.M., Silting of Reservoirs. U.S. Department of Agriculture Technical Bulletin No. 524. Revised by C.B. Brown. 169 pages, illustrated. U.S. Government Printing Office, Washington, D.C, 1939.

FIG. 3. BASE MAP OF CRAB ORCHARD LAKE SEDIMENTATION SURVEY

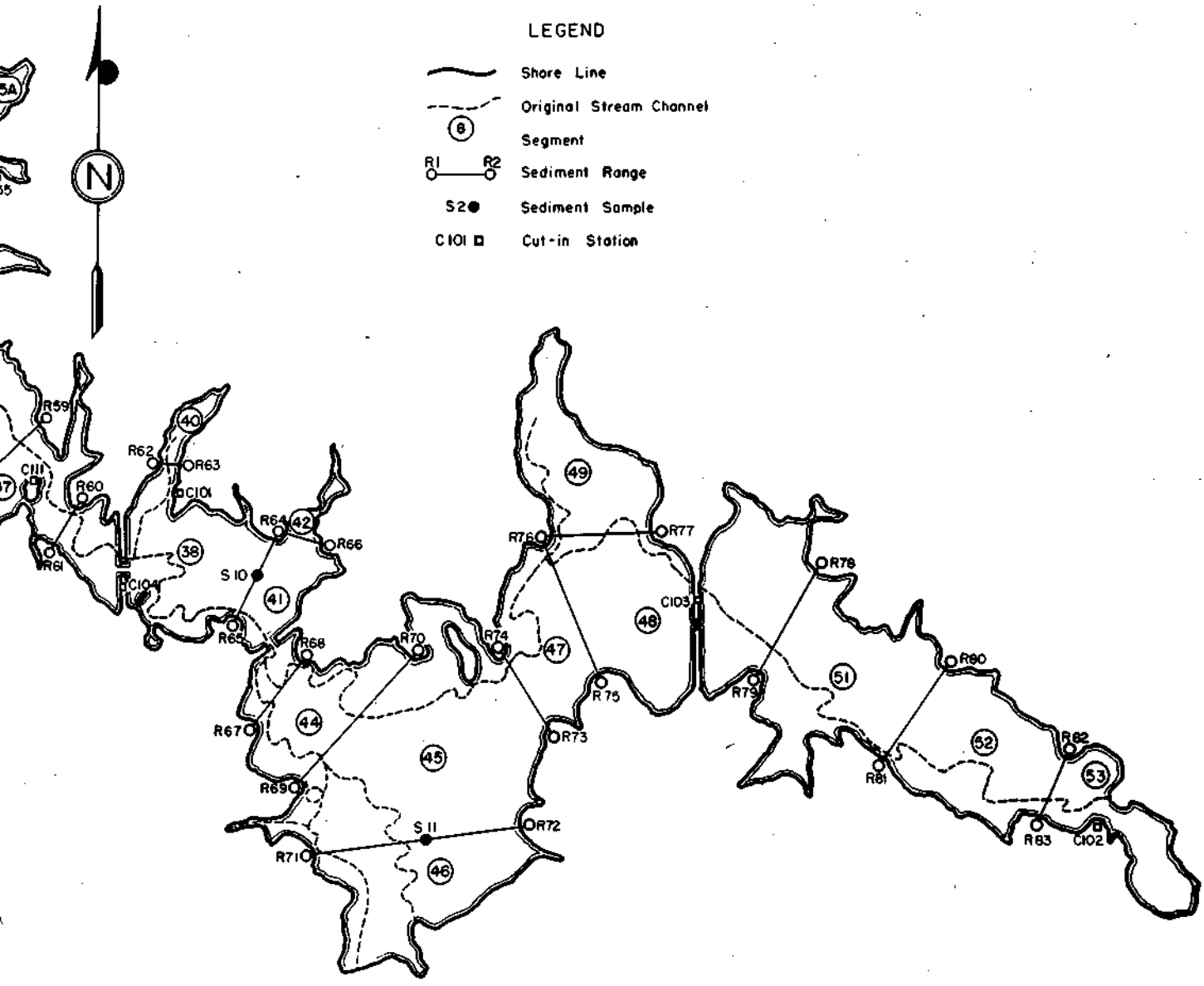
CRAB ORCHARD LAKE

Williamson County , Illinois

Sedimentation Survey of 1951

0 .25 .5 1 2

Scale in Miles



recognizable objects on the shore. The locations of all stations were checked by triangulation with a planetable and telescopic alidade during the course of the sounding work. For the westernmost one-quarter of the lake, for which aerial photographs were not available, a triangulation network was expanded from a baseline chained along the dam. All the range ends in this part of the lake were located by triangulation and the planetable sheets were used in sounding these ranges.

New aerial photographs of Williamson County, made by the federal Production and Marketing Administration in July became available for use in the fall of 1951. The aerial photographs of Crab Orchard Lake were obtained and enlarged to a scale of 1 inch equal to 500 feet. All survey stations and cross-sections were transferred from the older photographs and from the planetable sheets to the new photographs. The surface area of each segment was planimetered from these photographs. Figure 3 shows the detailed range system as laid out and surveyed on Crab Orchard Lake.

Along each of the 49 ranges shown in Figure 3, a cross-section was obtained of water depth and sediment thickness. The surface area of the lake in each segment bounded by two or more cross-sections was determined by planimeter from the corrected aerial photographs of the lake surface. The original and present water volumes and the consequent sediment deposition were calculated for each of the 50 segments shown in Figure 3. This volume calculation was based on a pyramidical formula 15 involving the cross-sectional area of the bounding ranges and the surface area of the particular segment.

Measurement of Sediment. On each of the sediment ranges shown in Figure 3 measurements were made of sediment thickness. Along the deeper ranges in the lower part of the lake near the dam, the sediment was measured with a spud. This is a specially designed instrument developed for this work by the Soil Conservation Service. The spud consists of a 1-inch diameter case-hardened steel rod in which cup-shaped grooves have been machined every one-tenth of a foot. The spud is thrown downward with enough force to pass completely through the sediment and penetrate the original bottomsoil for the pre-reservoir deposit. The total depth of penetration is determined by means of a calibrated line attached to the spud. After the spud is retrieved the actual thickness of the sediment is measured by inspecting the small soil or sediment samples retained in the cups. The use of the spud is shown in Figure 4.

The spud was operated from a small boat rowed along the range line. The locations of the spud readings along the range line were determined by single-angle triangulation with the telescopic alidade and planetable. At intervals varying from 25 to 200 feet, the thickness of the sediment was measured with the spud.

For the majority of the ranges in Crab Orchard Lake the sediment was measuredwithasoundingpole. This consists of a 1½ inch diameter calibrated aluminum pole as shown in Figure 5. The pole is lowered in the water until it rests lightly on the top of the sediment deposit and the present water depth is measured. The pole is then thrust on down through the soft sediment until it strikes the more resistant soil of the original reservoir bottom. As the boat is rowed across the range and measurements are made, a cross-section is obtained of water depth and sediment thickness. This method of measuring the sediment can be utilized only in cases where the original reservoir bottom is relatively firm and where the sediment deposit is relatively thin and soft and has not been exposed to air and consequent drying and hardening. Fortunately, this was true for a considerable portion of Crab Orchard Lake. In each portion of the lake where the sounding pole was utilized its accuracy was checked beforehand by measurements With the spud. The use of the sounding pole greatly speeded the survey.

FIG. 4. USE OF SPUD IN MEASURING SEDIMENT THICKNESS.

FIG. 5. USE OF SOUNDING POLE IN MEASURING SEDIMENT THICKNESS

Bank Erosion Profiles. Because considerable bank erosion had occurred on Crab Orchard Lake, a special study was made of the severity and extent of such erosion. At 98 survey stations which marked the ends of

the sediment ranges, detailed profiles were taken of the lake bank. These bank profiles extended from 100 to 200 feet landward from the shoreline at each position and an equal distance out into the water. From the general shape of the topography above the present lake bank, the original shape of the lake bank was determined and sketched in on each profile. The area of removal on each cross-section was shown by the difference between the original and present profiles of the bank.

Survey Markers. As a part of this survey, 106 survey stations were located in the field; this total includes all range ends and cut-in stations. All survey stations were marked permanently with concrete posts 4½ inches square and 4½. feet long. These posts were set into the ground with about 1-foot exposed. Identification numbers were stamped on the brass plate on top of each post, so that it might be possible to return to Crab Orchard Lake in future years and relocate the 1951 cross-sections for a resurvey.

SEDIMENTATION IN THE RESERVOIR

Summary of Data. Table 1 summarizes the data obtained from this survey together with derived data pertinent to the sedimentation problem in this lake. Several of the significant findings shown in this summary are:

1. The storage capacity of the reservoir has been reduced by sediment accumulation from 23,054 million gallons to 21,938 million gallons, or 4.84 percent in 11.2 years.
2. This sediment accumulation in the lake represents an average annual soil loss of 2.8 tons of soil per acre from the watershed.
3. Of the 3,426 acre-feet of sediment deposited in the lake, only 296 acre-feet came from bank erosion.
4. At the present rate of sedimentation, the expected ultimate life of the reservoir is approximately 230 years.

Typical Cross-Sections. The survey showed the sediment deposition to be rather uniform in all portions of Crab Orchard Lake. The thickness of sediment deposits varied only slightly from the shallower portions near the two major inlets to the deeper central and western portions of the lake.

Figures 6 to 13 illustrate typical water and sediment cross-sections in various parts of Crab Orchard Lake. The location of these cross-sections can be seen on the base map of the reservoir, Figure 3.,

Table 1
Summary of Sedimentation Data
Crab Orchard Lake

	Quantity	Units
AGE	11.2	Years
Storage began in May 1940		
Date of this survey July 1951		
WATERSHED		
Total land and water area of basin	196	Square Miles
Land area	185	Square Miles
	or 118, 137	Acres
Sediment-contributing area (Excludes smaller lake drainage areas within the basin)		
Including Crab Orchard Lake Surface area	171	Square Miles
	or 109, 261	Acres
Excluding Crab Orchard Lake Surface area	160	Square Miles
	or 102, 296	Acres
RESERVOIR		
Area at spillway level		
Total	11.0	Square Miles
	or 7,013	Acres
Area of islands	48	Acres
Area of water surface	10.9	Square Miles
	or 6,965	Acres
Length of shoreline	103.5	Miles
Storage capacity at spillway level		
1940	70,746	Acre-feet
	or 23,054	Mil. Gal.
1951	67,320	Acre-feet
	or 21,938	Mil. Gal.
Capacity per square miles of drainage area		
1940	414	Acre-feet
1951	394	Acre-feet
SEDIMENTATION		
Total sediment volume	3,426	Acre-feet
	or 1,116	Mil. Gal.
Average specific weight of sediment	47.5	Lbs./Cu.Ft.
Bank erosion		
Above spillway level	296	Acre-feet
Below spillway level	155	Acre-feet
From watershed sources	3,130	Acre-feet
Average annual accumulation		
From all sources	307	Acre-feet
From bank erosion	27	Acre-feet
From watershed sources	280	Acre-feet
Per square miles	1.8	Acre-feet
Per acre	119	Cubic feet
Tons per acre	2.8	Tons
DEPLETION OF STORAGE		
Loss of original capacity per year	0.43	Per cent
Loss of original capacity – total	4.84	Per cent

Figure 6 is a cross-section of Range R3-R4 (looking upstream). This range is about one mile long and extends across the main body of the lake near the dam. Along this range the general depth of the water varies from 17 to 24 feet over the flood plain of the former creek. Notice near the center of the cross-section the channel of the former Crab Orchard creek which has a water depth at present of about 35 feet. The sediment deposited along the former flood plain is about 0.7 to 0.8 feet. Slightly thicker deposits of from 1 to 1.5 feet are found in the slightly deeper water adjacent to the former stream channel. Sediment is deposited to a depth of about 1.5 feet in the bottom of the former Crab Orchard Creek channel.

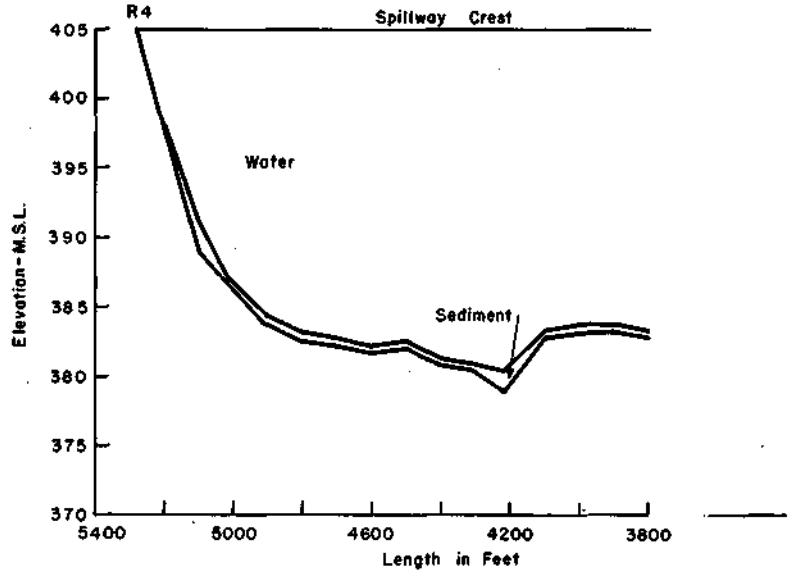


FIG. 6. CROSS SECTION OF RANGE R3-R4. (PART)

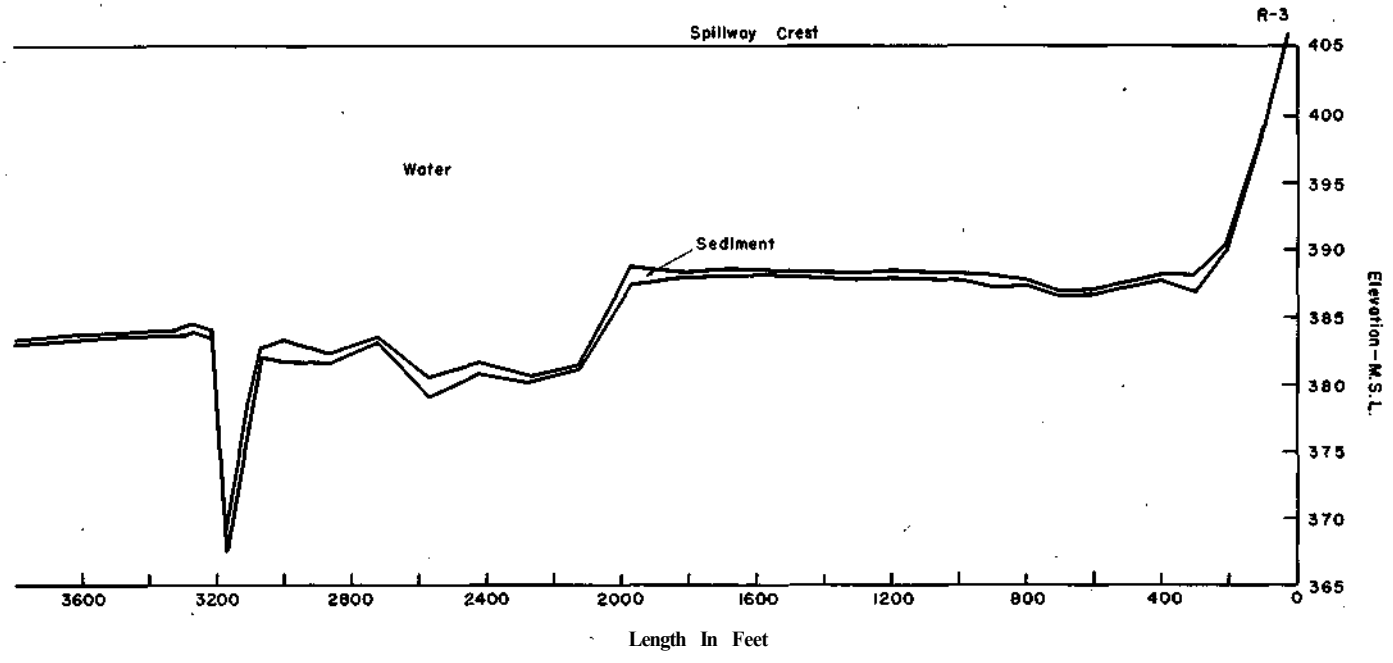


FIG. 6. CROSS SECTION OF RANGE R3-R4. (PART)

Figure 7 is a cross-section of Range R26-R27 which extends across the main body of the lake about 2 miles east of the dam. This range is about 3800 feet long and the average water depth along the major portion of the cross-section is about 19 feet. Sediment thickness along the range varies from zero near the center to about one-foot along parts of the submerged flood plain. The former channel of Crab Orchard creek is located near station R27 on the extreme right end of cross-section. The depth here is about 30 feet as contrasted with its original depth of about 33 feet.

Figure 8 is a cross-section of Range R11-R10. This range extends across one of the major side arms entering the lake from the north about two miles from the dam. This cross-section is considered typical of the sediment deposition in these arms of the lake. This range is about 1200 feet long. The cross-section of the lake bed at this point is generally U-shaped and the valley of the former stream is not incised into the lake bed to any great degree. Sediment along this range varies from about 0.5 feet to slightly more than one foot in the old stream channel.

Figure 9 shows a cross-section of Range R41-R40. This range extends across the major side arm entering Crab Orchard Lake from the south along the course of the former Grassy Creek. Along the major portion of this cross-section the water depth over the former flood plain is 8 to 10 feet deep. Sediment thickness along this flood plain varies from about 0.5 to 0.8 feet. The channel of the former Grassy Creek is definitely incised in the flood plain. The depth in this channel was formerly about 23 feet; this has been reduced by a

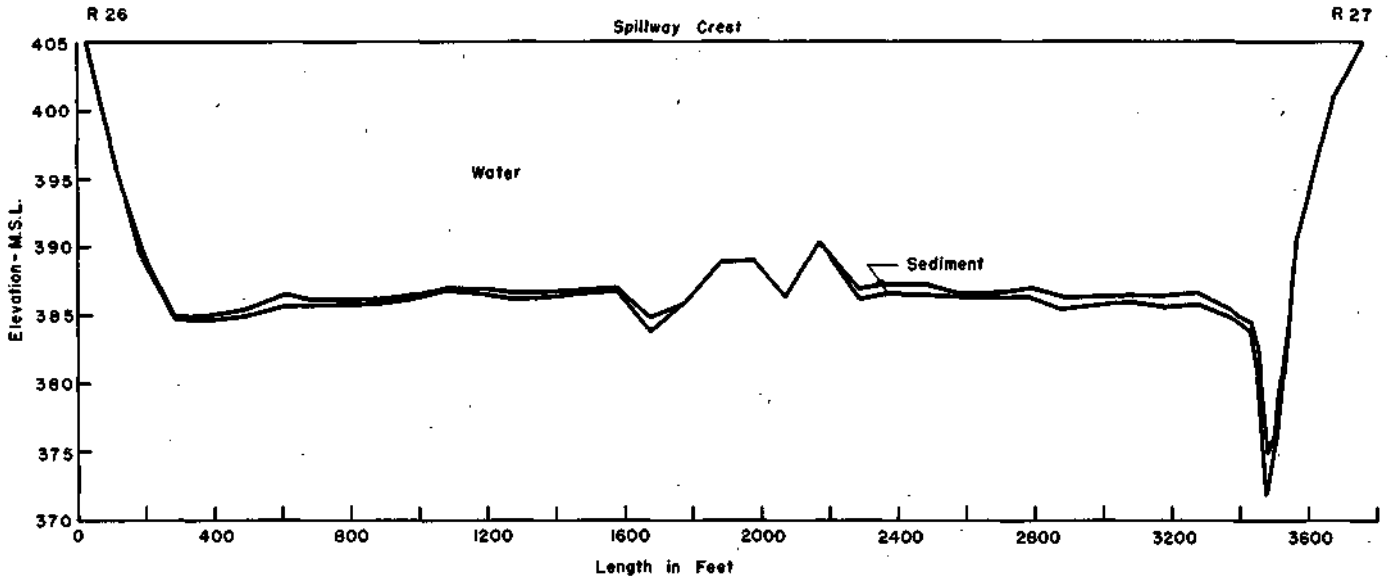


FIG. 7. CROSS SECTION OF RANGE R26-R27.

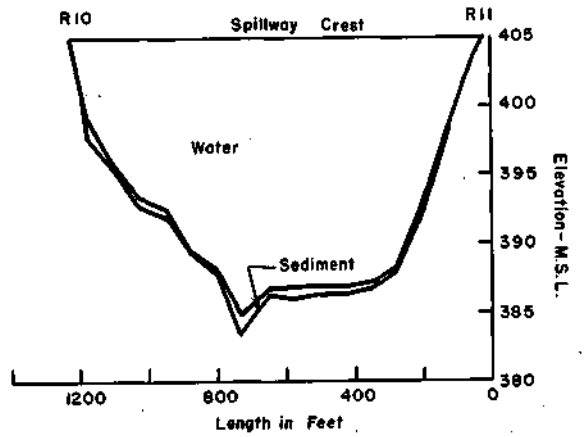


FIG. 8. CROSS SECTION OF RANGE R11-R 10.

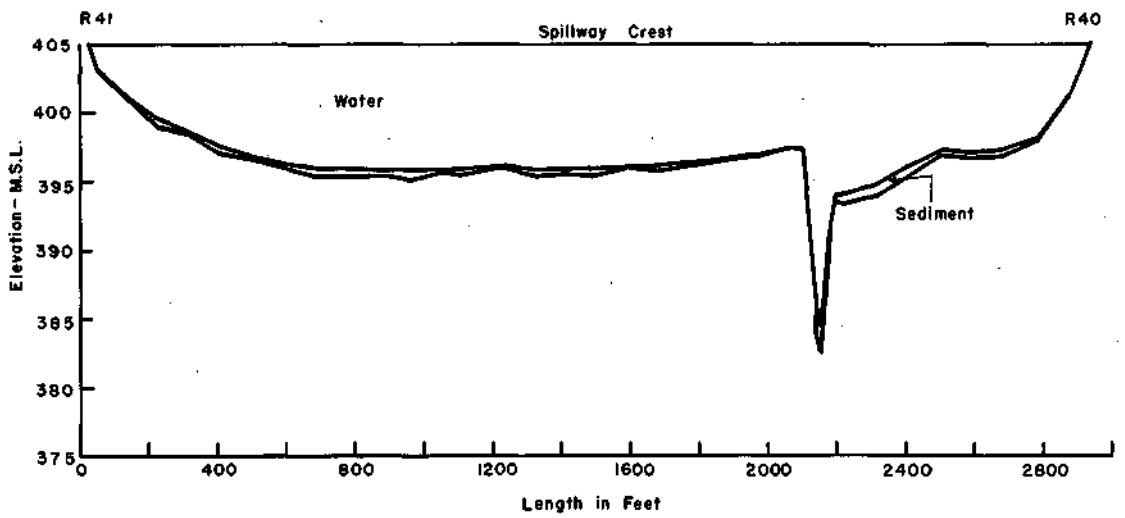


FIG. 9. CROSS SECTION OF RANGE R41-R40

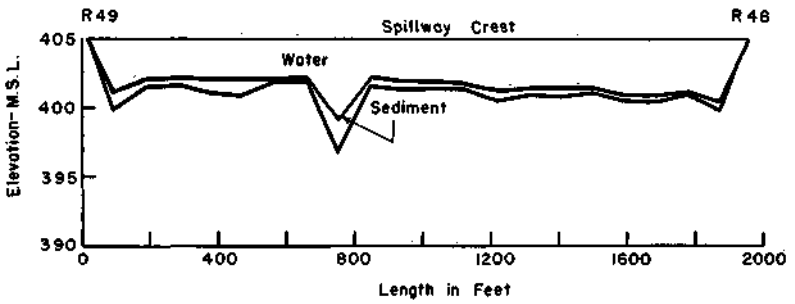


FIG. 10. CROSS SECTION OF RANGE R49-R48

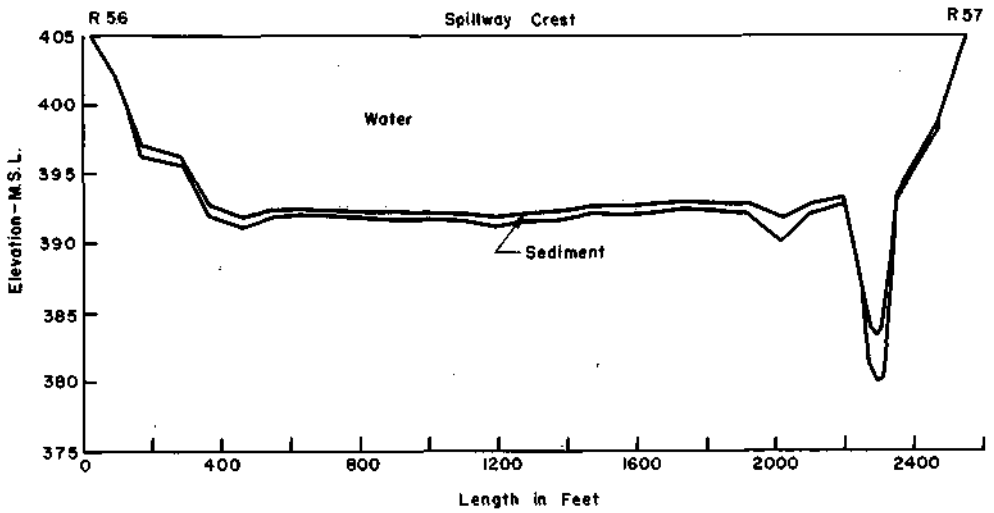


FIG. 11. CROSS SECTION OF RANGE R56-R57

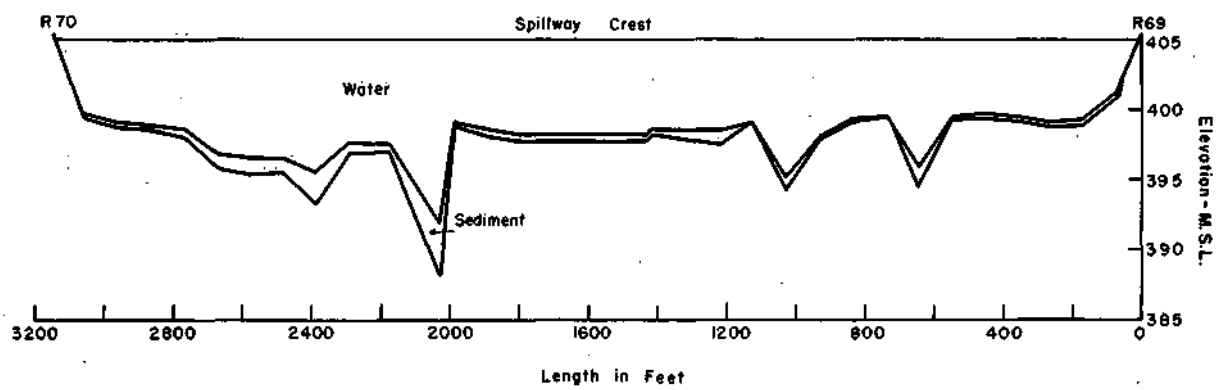


FIG. 12. CROSS SECTION OF RANGE R69-R70

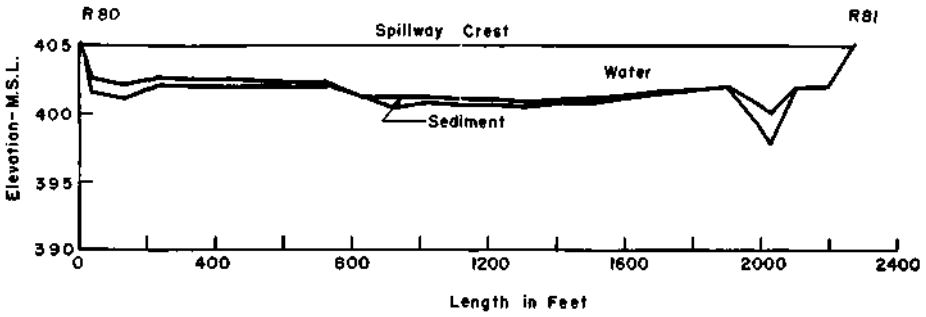


FIG. 13. CROSS SECTION OF RANGE R80-R81.

sediment deposit about 2 feet in thickness.

Figure 10 shows a cross-section of Range R49-R48 which is located near the inlet of Grassy Creek. Along the major portion of this 2,000-foot range, the water depth was originally 3 to 4 feet. Sediment deposition in this area averages from 0.7 of a foot to about 1.5 feet.

Figure 11 shows a cross-section of Range R56-R57. This range is about 2500 feet in length and extends across the main body of the lake. Water depth above the former flood plain averages about 13 feet. Sediment thickness along this range varies from about 0.7 to 1.0 feet. The water depth in the former Crab Orchard Creek channel was originally 25 feet but this has been reduced by a sediment deposit about 4 feet in thickness.

Figure 12 shows a cross-section of Range R70-R69. This range is about 3200 feet in length. It extends across the main body of the lake near the point where Wolf Creek enters the lake from the south. Three creek channels which are cut into the flood plain by former creeks are clearly evident on this cross-section. Water depth above the flood plain originally varied from 5 to 7 feet. Sediment thicknesses on the flood plain vary from about 0.5 feet to about 2.0 feet.

In Figure 13 is shown a cross-section of Range R80-R81 which is located across the main body of the lake at the extreme east end near the point where the major inflow to the lake enters from the Crab Orchard Creek drainage area. Water depth in this portion of the lake originally varied from 3 to about 4.5 feet with the exception of the creek channel which had a depth of about 6 feet. Sediment thickness along the major portion of the range varies from 0.5 foot to about one foot. About two feet of sediment have been deposited in the former stream channel.

Table 2
Bank Erosion Calculations

1940 original capacity as calculated from 1951 cross-sections of lake	23,104 Mil. Gal.
Volume added 1940-1951 by bank erosion below spillway crest elevation	50 Mil. Gal.
Actual 1940 original storage capacity	23,054 Mil. Gal.
1951 storage capacity as calculated from cross-sections	21,938 Mil. Gal.
1951 total sediment measured in lake	1,167 Mil. Gal.
Volume moved laterally into sediment deposit during 1940-51 from lake bed near bank	50 Mil. Gal.
Sediment entering lake during 1940-51	1,117 Mil. Gal.
Sediment entering lake from banks above the crest elevation	96 Mil. Gal.
Sediment entering reservoir from watershed above the reservoir	1,021 Mil. Gal.
Per cent of sediment coming from bank erosion $\frac{96 \text{ MG.}}{1,117 \text{ MG.}} \times 100\%$	8.6 Per cent

Bank Erosion. Because of the seriousness of bank erosion at Crab Orchard Lake, a special study of this phenomenon was made by the field party. At each end of the sediment ranges shown in Figure 3, a permanent station was established. A detailed profile of the bank was taken at each of these stations to determine the sediment removed by bank erosion.

No effort was made in the field to determine the lateral extent along the lake bank represented by each particular bank profile. On several of the cross-sections, the volume of soil removed by this wave erosion seemed great; in other parts of the lake, it seemed rather small; and in some cases, there was no removal at all. In order to obtain an over-all estimate of the total volume of sediment removed from the bank of the lake, all 98 of the bank profiles were plotted and the average removal in square feet was calculated. The average of the total 98 was considered to represent the condition for the total shoreline of the entire lake. A picture of the eroded bank on the northern part of Crab Orchard Lake near Station R52 is shown in Figure 14. This is typical of much of the north shoreline of Crab Orchard Lake.

FIG. 14. BANK EROSION NEAR STATION R52

Figure 15 presents a composite bank erosion profile for the Crab Orchard Lake showing the total removal by bank erosion for the entire lake. From this profile it can be seen that a quantity of sediment occupying a volume equivalent to 146 million gallons has been removed from the lake banks by wave erosion. A quantity equal to fifty million gallons of this sediment has been removed from the lake bank below the present spillway crest elevation. This sediment has been removed from the bank area of the lake and carried laterally toward the center of the lake in suspension and has been deposited in the main bed of the lake. This 50 million gallons does not represent a loss of lake capacity since the sediment has been transported from one location in the lake near the bank to another in the center of the lake. From Figure 15 it is also seen that sediment equivalent to 96 million gallons has

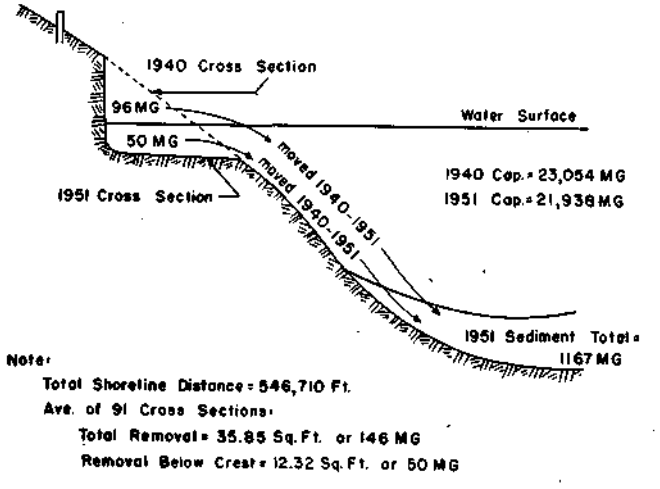
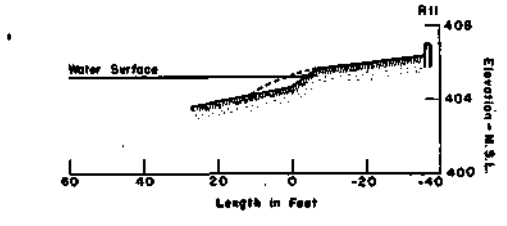


FIG. 15. COMPOSITE BANK EROSION PROFILE

been eroded from the banks of the lake above spillway crest elevation. This sediment has been transported into the lake and deposited. This does represent a loss in lake capacity. As shown in Table 2, this 96 million gallons of sediment originating from bank erosion above the crest line amounts to 8.59 per cent of the total sediment deposited in the lake.

Bank Erosion Profiles. In Figures 16 to 21 bank erosion profiles at selected stations on Crab Orchard Lake



. FIG. 16. BANK EROSION PROFILE AT STATION R11

are shown. These profiles illustrate the severity of shoreline erosion in various parts of the lake. In each profile the heavy solid line shows the shape of the eroded bank at the time the prof ile was taken in 1951.

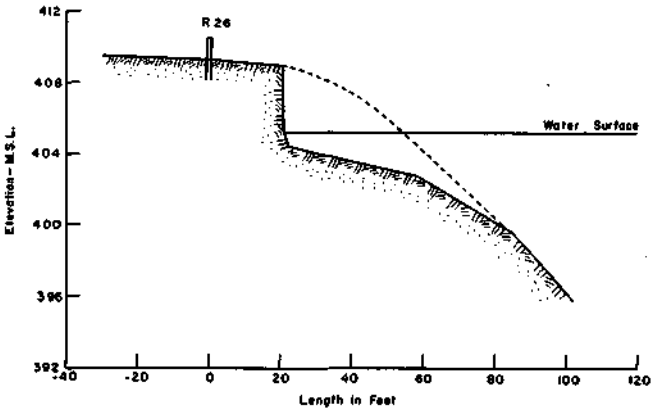


FIG. 17. BANK EROSION PROFILE AT STATION R26

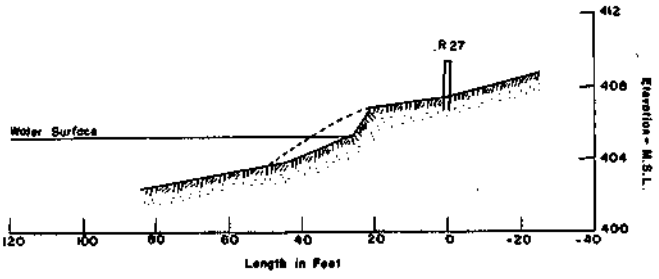


FIG. 18. BANK EROSION PROFILE AT STATION R27

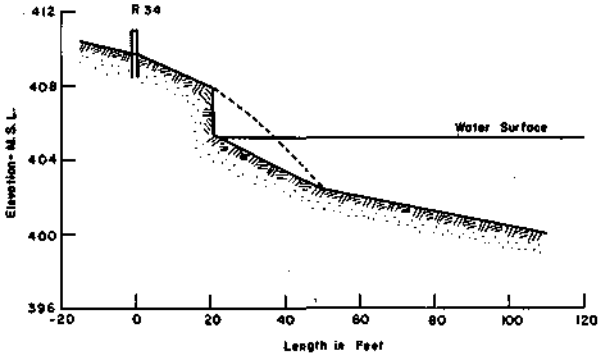


FIG. 19. BANK EROSION PROFILE AT STATION R34

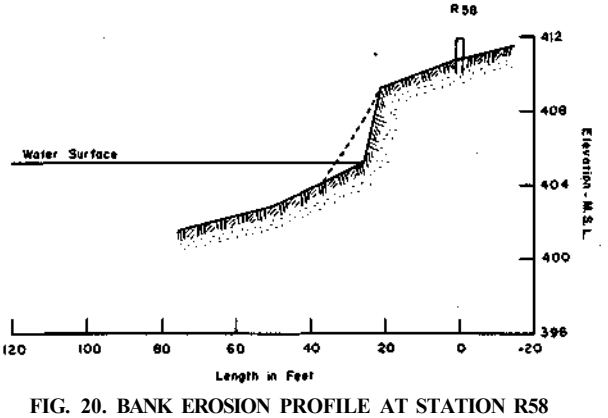


FIG. 20. BANK EROSION PROFILE AT STATION R58

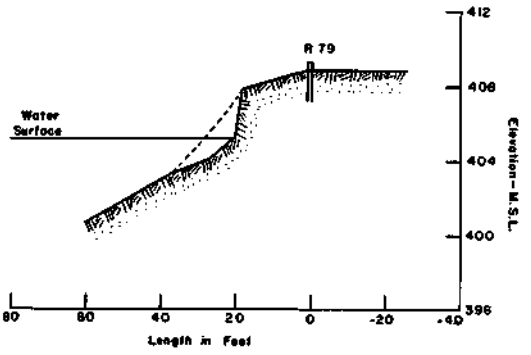


FIG. 21. BANK EROSION PROFILE AT STATION R79

Shown as a dotted line on each of these profiles is the estimated shape of the lake bank prior to the lake construction. The area between these lines represents the volume of soil removed during the life of the lake prior to this survey. The locations of all the bank erosion profiles shown in Figures 16 to 21 are shown in Figure 3, the base map of Crab Orchard Lake.

Figure 16 shows the bank erosion profile at Station R11 which is located on one of the smaller arms of the lake extending to the north. As seen from this figure, the bank erosion in this part of the lake has not been great.

In Figures 17 and 18 are shown the bank erosion profiles at Stations R26 and R27 located on the north and south sides of the lake respectively on the main body of the lake. In comparing the bank erosion at Stations R26 and R27, it is noticeable that erosion has been considerably greater at Station R26 located on the north side of the lake than at Station R27 located on the south side. Inspection shows that bank erosion has been more serious along the entire north shore of the lake. This is understandable due to the fact that the prevailing winds come from the southeast and the waves tend naturally to attack the northern banks of the lake more than the southern banks.

Figure 19 shows the bank erosion profile at Station R34 located on the main body of the lake on the north side (see Figure 3). In Figure 20 is shown the bank erosion profile at Station R58 which is located on the main body of the lake on the south side as shown in Figure 3. Figure 21 shows the bank erosion profile at Station R79 which is located on the south side of the main body of the lake near the inlet from Crab Orchard Creek. As can be seen from this profile, bank erosion is noticeable even in this easternmost end of the lake where the water is relatively shallow and the lake fairly well protected.

Distribution of Sediment. In Table 3 is a tabulation of the capacity losses in Crab Orchard Lake by various segments. The location of the segments are shown on the base map in Figure 3 of this report. Table 3 reveals that the greatest percentage capacity loss in the lake has occurred in segment 53 where a loss of 32 percent has occurred. This segment is located at the extreme east end of the lake where Crab Orchard creek enters the lake. The adjoining segment 52 has suffered a capacity loss of 22 per cent.

Table 3
Crab Orchard Lake Capacity Loss by Segments
(See Figure 3 for Segment Locations)

Segment	Volume in Million Gallons Original Capacity	Sediment	Loss of Storage Capacity Percent
1	346	14	4.1
2	1617	59	3.7
3	2919	88	3.0
4	45	3.5	7.8
5	157	9.7	6.2
6	190	4.0	2.1
7	429	11	2.4
8	203	13	6.3
10	38	2.2	5.9
11	64	2.5	3.9
12	22	1.1	5.0
13	232	9.5	4.1
14	208	7.2	3.5
16	73	3.3	4.6
17	92	4.5	4.8
18	1520	14	0.90
19	299	19	6.5
20	13	0.9	6.6
21	588	37	6.3
22	113	6.3	5.6
23	2227	114	5.1
24	1951	84	4.3
25	337	22	6.4
25A	57	3.5	6.0
26	290	19	6.4
27	239	12.5	5.2
28	197	15	7.9
29	551	56	10.2
30	140	12	8.9
31	55	6.7	12.2
32	27	3.0	11.3
33	2228	93	4.2
34	1102	50	4.6
35	154	9.9	6.4
35A	7.2	0.8	11.0
36	832	48	5.8
37	351	18	5.3
38	464	26	5.6
40	10	0.9	8.6
41	234	16	6.7
42	70	3.4	4.8
44	224	18	8.2
45	725	68	9.3
46	132	14	10.6
47	174	14	7.9
48	536	36	6.7
49	179	13	7.2
51	252	24	9.4
52	99	22	22.0
53	95	31	32.0
Total	23,104	1167	---

(See Table 2 for total loss of capacity)

Segments 31 and 32 located at the head end of the Grassy Creek arm of the lake have suffered percentage reductions in capacity of 12.2 and 11.3 per cent. These losses are slightly higher than those experienced in the majority of the lake segments. It is also to be noted

from Table 3 that the capacity losses in segments 1, 2, and 3, located just above the dam, have varied from about 3 to 4 per cent. Segments 33 and 34, which are located near the center of the lake and have large total capacities, have suffered losses due to sediment of 4.2 and 4.6 per cent respectively.

SEDIMENT CHARACTERISTICS

Sediment samples were taken at various locations within the lake and analyzed to determine their physical and chemical characteristics. Chemical analysis included total carbon and nitrogen, total bases, base-exchange capacity, and pH. Mechanical analyses for particle size distribution and volume weight were also carried out. The data are given in Table 4.

There is no general indication of the sorting out of the sediments entering the lake with the possible exception of the areas represented by samples 6 and 11. The sediments are quite uniform in both chemical and physical characteristics. Sediments in areas corresponding to samples 6 and 11 are somewhat lower in clay content and higher in silt and sand, indicating some settling out of the coarser sediments as the incoming load is deposited in the lake.

The general characteristics of the sediments seem to indicate that the source material is largely a combination of surface and subsoil materials from the soils of the watershed area. Chemical and physical analyses of some major soil types in the watershed area, Table 5, show that the soils are quite similar in character. Therefore no significant differences in sediment char-

Table 4
Crab Orchard Lake Sediment Analysis

Laboratory S-Number	Sample Number	Range	Vol. Wt.	Organic Carbon percent	Total Nitrogen percent	Base Capacity me/ 100 gm	Total Bases me/100 gm	pH	Sand 50 u percent	Silt 50-2 u percent	Clay 2 u percent
S-17823	1	R-19 R-20	0.6*	1.43	0.11	20.6	10.4	4.9	3.1	50.8	46.1
S-17824	2	R-29 R-30	0.8*	1.08	0.14	26.0	14.9	4.9	–	–	–
S-17825	3	R-31 R-32	0.6*	1.36	0.15	26.4	14.9	5.4	–	–	–
S-17826	4	R-34 R-38	0.7*	1.20	–	26.4	15.5	5.6	0.7	47.6	51.7
S-17827	5	R-34 R-37	0.74	0.93	0.12	20.7	12.6	6.0	3.3	63.0	33.7
S-17828	6	R-14 R-15	0.88	0.90	0.10	18.8	8.5	5.6	3.3	69.0	27.7
S-17829	7	R-48 R-49	0.9*	0.99	–	18.3	10.0	5.1	0.6	63.8	35.6
S-17830	8	R-40 R-41	0.8*	1.06	–	23.6	11.2	5.0	1.5	53.0	45.5
S-17831	9	R-57 R-56	0.8*	1.06	–	25.2	11.3	4.8	2.8	54.3	42.9
S-17832	10	R-64 R-65	0.8*	0.97	0.12	19.4	10.6	4.9	–	–	–
S-17833	11	R-71 R-72	0.82	0.99	0.11	16.0	8.6	6.1	9.7	65.2	25.1

*Extrapolated values

Table 5
Analysis of Soils of the Watershed Area

Soil Type	Horizon	Depth inches	Organic Carbon percent	Base Capacity me/100 gm	Total Bases me/100 gm	pH	Sand 50 u percent	Silt 50-2 u percent	Clay 2 u percent
Ava silt loam (Virgin sample)	A_1	0-4	1.20	13.2	2.4	4.6	2.5	82.8	14.7
	B	14-41	0.03	22.3	7.0	4.4	1.7	68.6	29.8
Bluford silt loam (Virgin sample)	A_1	0-3	1.85	15.4	2.6	4.5	7.4	79.3	13.3
	B	19-42	0.17	31.2	11.5	4.4	3.5	57.9	38.6
Hosmer silt loam (Virgin sample)	A_1	0-5	0.62	10.9	2.6	4.8	2.8	80.3	16.9
	B	11-48	0.05	18.8	8.3	4.6	2.5	72.9	24.7
Hosmer silt loam (Farmed)	Plow	0-8	0.71	13.2	8.7	6.5	4.5	80.7	14.8
	B	15-48	0.04	19.4	6.8	4.6	1.4	70.9	27.8

acteristics can be expected from the materials being deposited in the lake by the various streams. The uncultivated soils of the watershed area are naturally quite acid, pH of 4.7 or less, whilesome of the sediment samples have pH values as high as 6.1. This would seem to indicate that surface soil that has been limed for agricultural purposes forms a significant proportion of the sediments accumulating in the lake.

The two smaller reservoirs, Little Grassy Lake and Marion Reservoir, located within the general watershed area of Crab Orchard Lake, appear to be quite similar with respect to sediment characteristics. The sediments in both reservoirs, Table 6, appear to contain more subsoil material than surface material with some indications of the sorting of sediments within the lakes due to water transport. The sediment characteristics indicate that the source of much of this material is probably sheet erosion of exposed "A 2" or "B 1" horizon soil material rather than deep gully formation. The sediments in the Marion Reservoir are much

Table 6

Sediment Analysis of Little Grassy Lake and Marion Reservoir

Lake	Sample Number	Range	Vol. Wt.	Organic Carbon percent	Total Nitrogen percent	Base Capacity me/100 gpm	Total Bases me/100 gm	pH	Sand 50 u percent	Silt 50-2 u percent	Clay 2 u percent
Little Grassy	1	R-9 R-10	0.76	1.10	0.12	16.6	11.4	4.4	3.9	58.2	37.9
	2	R-5 R-6	0.53	1.56	–	22.7	12.6	4.6	5.2	38.1	56.7
	3	R-1 R-2	–	0.96	–	18.2	12.2	4.3	1.6	51.5	46.9
Marion	1	R-1 R-2	0.78	1.36	0.11	16.4	9.7	4.2	13.1	47.3	39.6
	2	R-1 R-2	0.61	1.38	0.14	22.9	10.5	3.7	6.8	44.0	47.6
	3	R-3 R-4	0.52	1.58	–	28.0	11.2	3.6	6.2	82.0	11.9
	4	R-5 R-6	0.55	1.85	0.16	25.0	10.8	3.8	6.5	46.5	47.0
	5	R-7 R-8	0.42	2.82	–	24.6	7.6	3.2	4.5	87.8	7.7

higher in organic carbon and lower in pH than can possibly be accounted for on the basis of soil erosion from areas of the watershed. These values, however, suggest organic growth of some sort in the Marion reservoir which is more extensive in the upper region, the area represented by sample number 5.

The physical and chemical characteristics of the sediments of all three lakes and reservoirs seem to indicate that sheet-erosion control is the major problem in reducing the silting rates in these lakes. While some gully erosion is occurring, it appears to be secondary to sheet erosion as a source of sediments.

LITTLE GRASSY LAKE

Description. The dam which forms Little Grassy Lake extends in a generally northwest southeast direction and is located in the southeast ¼ of Sec. 18, T.10 S., R.1 E. The dam has a total length of about 1500 feet. The slopes of the upstream face are 4 to 1 and 3 to 1, and the slope of the downstream face is 3 to 1. The concrete spillway is located in the west central portion of the dam and has an elevation of 500.0 feet above mean sea level. The lake is approximately four miles long extending generally south from the dam. About 1½. miles south of the dam, the lake divides into two major side arms which extend further. The lake is impounded on Little Grassy Creek as shown in Figure 22.

METHODS OF SURVEY

Range System. The volume of sediment accumulated in Little Grassy Lake was determined by cross-sections taken along six ranges laid out during the survey and located as shown in Figure 23. For horizontal control in the location of the sediment ranges a triangulation system was laid out coveringthe lake area. This network was expanded from a base line 1,165 feet in length which was chained along the main dam. This survey work was done with a planetable and telescopic alidade to the scale of 1 inch equals 500 feet. All survey stations were permanently marked in the field with concrete posts 4½ feet in length and 4½ inches square. Identification numbers were stamped into the metal plates contained in the top of these posts.

Measurement of Sediment. On each of the six ranges shown in Figure 23, a cross-section was made of water depth and sediment thickness. All sediment measurements were made with the spud bar as described earlier in this report and shown in Figure 4. The location of the spud readings along the range lines were determined by single angle triangulation with a planetable and alidade. The total volume of sediment in the lake was calculated on the basis of these six cross sections.[16]

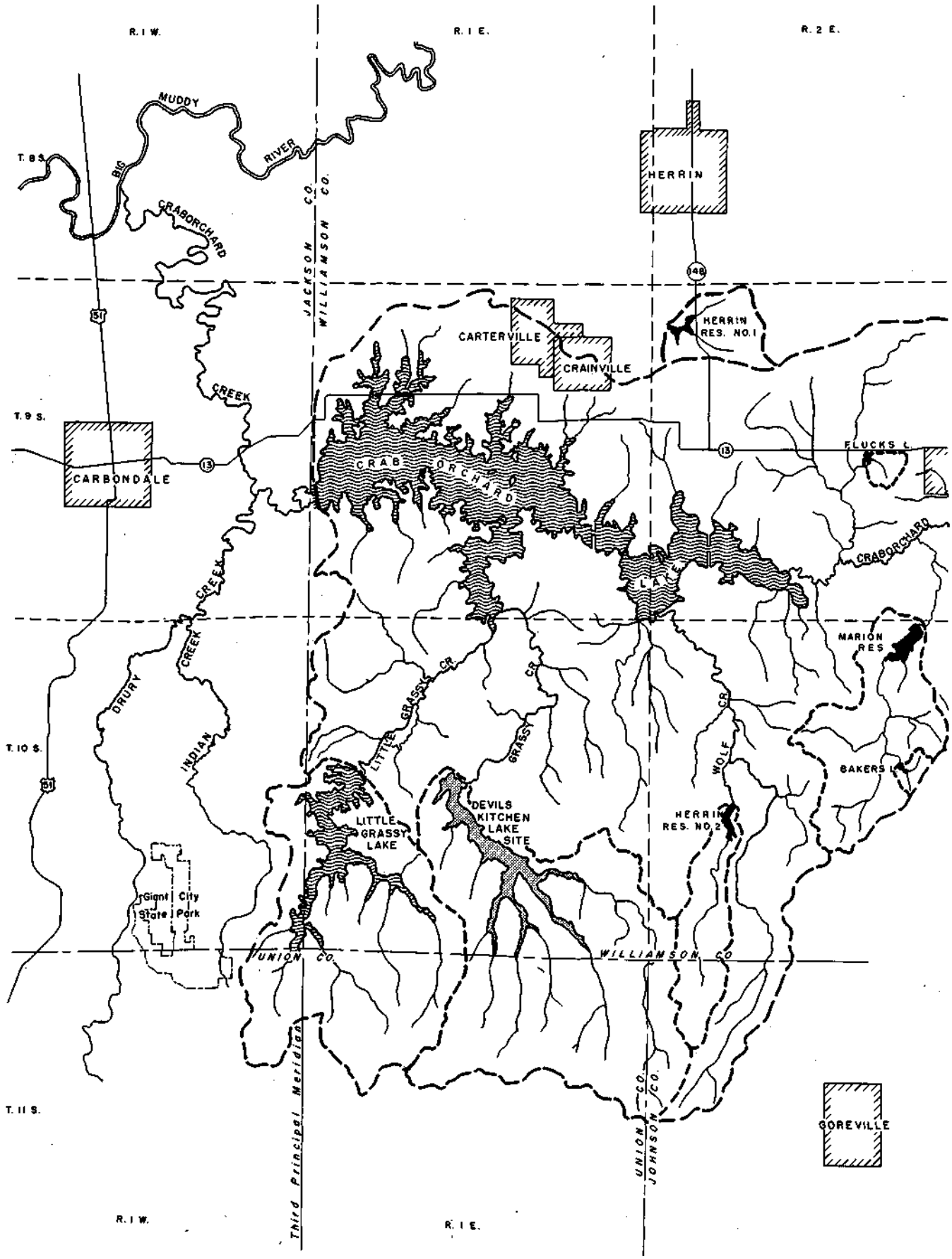
Sedimentation in the Reservoir. The summary of sedimentation data obtained from this survey of Little Grassy Lake together with derived data pertinent to the problems of this lake is shown in Table 7. Several of the significant findings shown in this summary are:

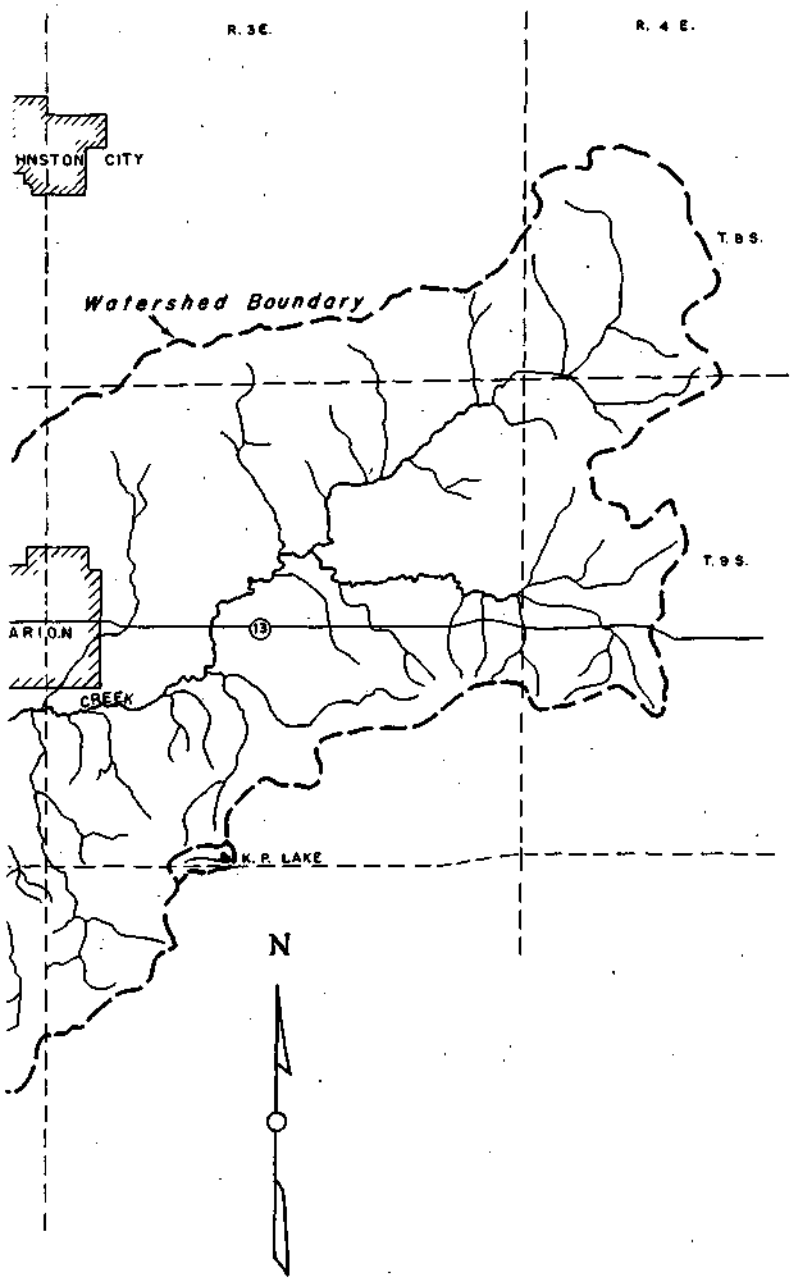
1. The storage capacity of the reservoir was reduced from 8,540 million to 8,417 million gallons or 1.44 per cent in 9.3 years.
2. The sediment accumulation in the lake is equivalent to an average of 3.7 tons of soil per acre from the watershed.

In Figure 24 is shown a cross-section of range R6-R5 on Little Grassy Lake. This cross-section is considered typical of the lake. It will be noted that, in this part of the lake, the water depth varies from 50 to 65 feet in total depth. The sediment deposited along the lower part of the cross-section varies from 9.5 feet to 2.0 feet.

OTHER LAKE SURVEYS IN THE REGION

As a part of the study of soil loss in Crab Orchard Lake watershed and the movement of the suspended material to the stream systems and into Crab Orchard Lake, several reconnaissance surveys were made on smaller lakes located in the Crab Orchard region and located on smaller streams. The locations of these reservoirs can be noted in Figure 22. The reservoirs surveyed were as follows: 1. Marion City Reservoir, 2. Herrin City Reservoir, 3. Fluck's Lake, 4. Baker's Lake, and 5. Knights of Pythias Lake. In addition to


R. 1 W.
R. 1 E.
R. 2 E.
MUDDY
BIG
RIVER
CRABORCHARD
CREEK
T. 8 S.
T. 9 S.
T. 10 S.
T. 11 S.
JACKSON CO.
WILLIAMSON CO.
51
13
148
CARBONDALE
HERRIN
CARTERVILLE
CRAINVILLE
HERRIN RES. NO. 1
CRAB ORCHARD
CRAB ORCHARD L.
FLUCKS L.
MARION RES.
BAKERS L.
DRURY
INDIAN
LITTLE GRASSY CR.
GRASSY CR.
WOLF CR.
LITTLE GRASSY LAKE
DEVILS KITCHEN LAKE SITE
HERRIN RES. NO. 2
Giant City State Park
UNION CO.
WILLIAMSON CO.
JOHNSON CO.
GOREVILLE
Third Principal Meridian



CRAB ORCHARD LAKE REGION

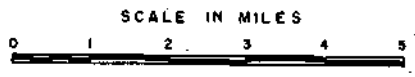


FIG. 22. CRAB ORCHARD LAKE REGION

the above surveys, data were available on Herrin City Reservoir No. 2 from a survey of that lake made by the Soil Conservation Service in 1936.

On all five surveys made during the 1951 field season, reconnaissance data were obtained. Thesedimentation records in these lakes are based on a series of cross-sections located in the field on aerial photographs to a scale of 1 inch equals 200 feet. From the cross-section data on each lake, the average original depth and average present depth of water and sediment in the lake were calculated. The total sediment volume in the lake was obtained in this manner.[16] The summary of sedimentation data on the six smaller reservoirs located in the Crab Orchard Lake region is shown in Table 7.

WATER SUPPLY POTENTIALITIES OF THE CRAB ORCHARD LAKE SYSTEM

PRESENT WATER USE

Desirability of Further Water Supply Development. At the time the Crab Orchard Lake project was being planned discussions included the recreation, wildlife, work relief, and water supply possibilities of the project. (See "History," page 10.) Since the completion of the lake the recreational and wildlife uses of the lake have predominated. The reservoirs have been used for industrial-water supply to some extent. The potential supply of water available from the three reservoirs in this project (two of which have, been constructed), is believed considerably in excess of that being utilized at the present time.

A major increase in the supply of water taken from Crab Orchard Lake would necessitate the drawdown of the water level in the reservoir during a drouth. The occurrence of such a drawdown of the water level over a considerable time might impair the usefulness of the lake as a recreation area, a migratory water fowl refuge and a means of propagating fish. Because of the conflict of these uses it is believed that considerable attention should be given to the policy regarding further major water supply developments on this reservoir.

It will be noted that present use of water in the former ordnance plant area is considerably less than the nominal capacity of the water treatment plant of 2 million gallons per day. Water use could be increased to 2 million gallons per day without serious water level drawdowns, however developments which would require water in quantities from 10 to 30 million gallons per day would seriously hamper the use of the lake for other purposes. The use of the reservoir for water supply consequently will not affect its recreational and wildlife conservation uses unless a greatly expanded water supply development is considered.

[16] **Reconnaissance Investigations of Reservoir Silting in Connection with Flood Control Surveys, U.S. Department of Agriculture, Soil Conservation Service, Sedimentation Division, Technical Letter SED-2A, July 1, 1941, Washington, D.C.**

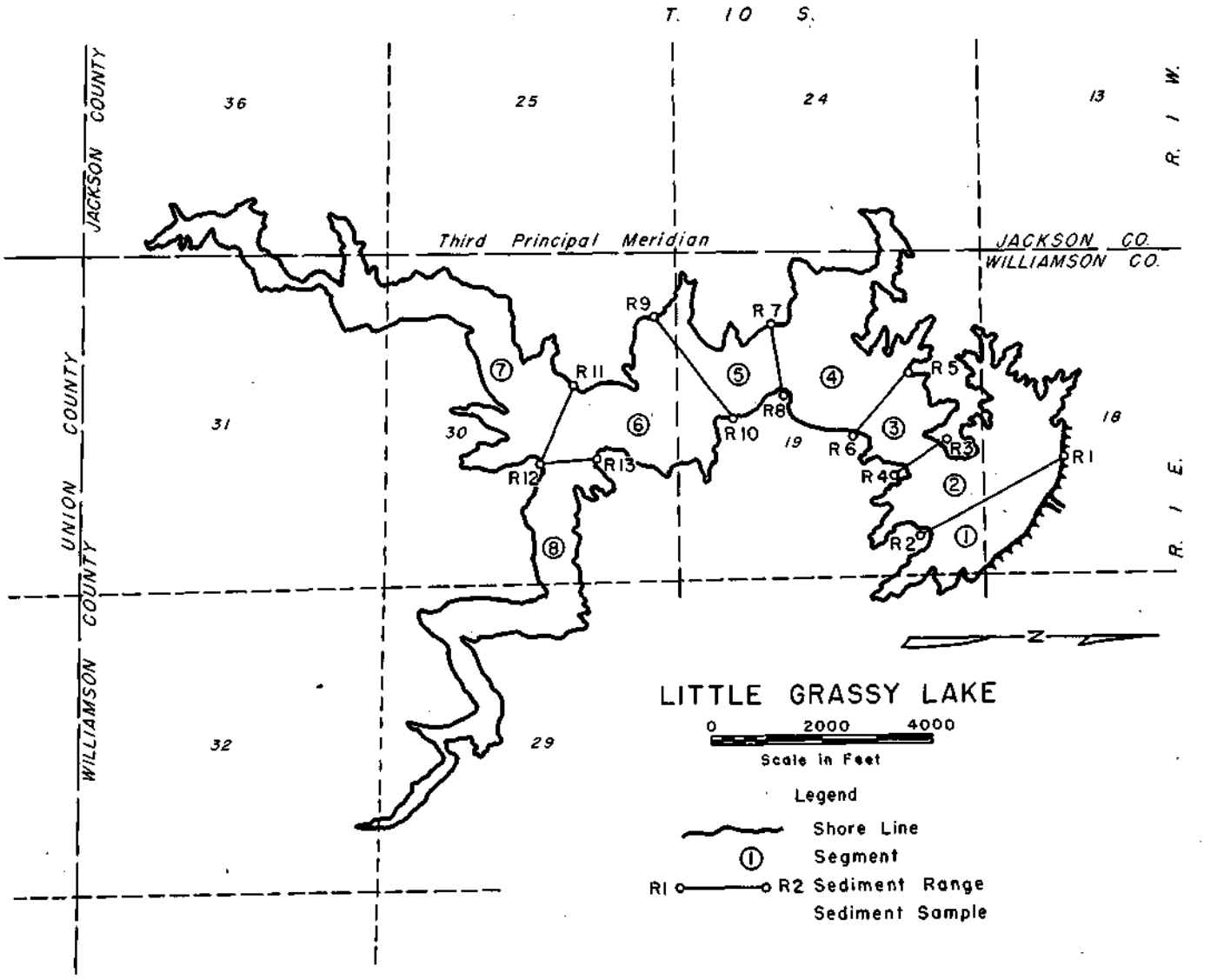


FIG. 23. BASE MAP OF LITTLE GRASSY LAKE SEDIMENTATION SURVEY.

Treatment Facilities. During World War II the Illinois Ordnance Plant was located and developed in this area. A complete water system was developed from Crab Orchard Lake to serve the ordnance plant. The water treatment plant was located on the northern side of the lake east of Wolf Creek Road. This is located near station R62 (see Figure 3). The water treatment plant has a designed capacity of two million gallons per day and can produce three million gallons per day under a 50 per cent overload. The raw water flows 550 feet from the intake in the lake to the plant. Four chemical feeders supply lime, soda ash, and carbon for two treatment basins in which both flocculation and sedimentation are performed. Each has a capacity of from 650 to 725 gallons per minute. The water is then filtered through four rapid sand filters each having a capacity of 500,000 gallons per day.

A complete water distribution system covers the ordnance area. The system includes four elevated tanks each having a capacity of 250,000 gallons and a five-million-gallon storage reservoir with chlorinator. During the year 1951, the treatment plant was operating under a load of 700,000 to 900,000 gallons per day.

The raw water intake serving the water treatment plant is located in the lake and has an elevation of 397 m.s.l. Spillway crest elevation is 405 m.s.l. Thus, this treatment plant can continue to operate successfully unless the water level in the lake were drawn down more than 8 feet below spillway crest elevation.

Table 7
Results of Reconnaissance Lake Surveys in Crab Orchard Lake Region

	Units	Little Grassy Lake	Marion Reservoir	Herrin Reservoir No. 2	Herrin Reservoir No. 1	Fluck's Lake	Baker's Lake	Knights of Pythias
AGE	Years	9.3	30.0	9.3[3]	38	32	14	25.7
Date storage began		Mar., 1942	1921	Feb., 1926	1913	1919	1937	Dec., 1925
Date of survey		July, 1951	July, 1951	May, 1936	Aug., 1951	Aug., 1951	Aug., 1951	Aug., 1951
WATERSHED								
Total area[1]	Sq. Miles	15.1	6.5	3.1	1.8	0.34	0.26	0.26
	Acres	9664.	4150.	2000.	1140.	215.	166.	168.
RESERVOIR								
Area at spillway level	Acres	1000	110	56	37	15	6.3	8.1
Storage capacity at spillway level								
Original	Acre-Feet	26,116	705	804	199	58.1	24.0	74.6
	Mil. Gal.	8,540	231	263	65.0	19.0	7.9	24.3
1951	Acre-Feet	25,740	590	704	178	46.8	21.7	64.7
	Mil. Gal.	8,417	193	230	58.2	15.3	7.1	21.1
Capacity per Sq. Mi. of Drainage area[2]								
Original	Acre-Feet	1,730	109	257	112	171	92	284
1951	Mil. Gal.	1,705	91	225	100	138	84	247
SEDIMENTATION								
Total sediment	Acre-Feet	376	115	100	21	11.3	2.3	9.9
	Mil. Gal.	123	38	33	6.8	3.7	0.8	3.2
Ave. Specific Wt.	Lbs./Cu.Ft.	38.7	34.5	60[4]	27.5	56.6	36.8	62.9
Ave. Annual Accumulation								
From entire watershed	Acre-Feet	40.3	3.8	10.8	0.55	0.35	0.16	0.39
Per square mile	Acre-Feet	3.0	0.59	3.4	0.32	1.1	0.66	1.5
Per acre	Cu.Ft.	202	40.	233	22.	75.	45.	105.
Tons per acre	Tons	3.7	0.72	7.0	0.30	2.2	0.8	3.3
DEPLETION OF STORAGE								
Loss of original capacity								
Total	Percent	1.44	16.4	12.4	10.5	19.5	9.6	13.3
Per year	Percent	0.15	0.55	1.3	0.28	0.61	0.68	0.52

Mineral Quality. Since October 1951, samples of Crab Orchard Lake water have been obtained monthly at two locations within the lake for mineral analysis. These samples were obtained from the lake near station R5 and near station C104 (see Figure 3). The results of these analyses are shown in Table 8. To permit a comparison of the general mineral character of the Crab Orchard Lake water for the two locations sampled, one near the east end of the lake and the other near the west end of the lake, the analyses of samples taken from the two stations are presented in Table 9.

Evaporation. In any determination of water availability and use, the factor of evaporation must be studied carefully. Direct measurement of actual evaporation from a free water surface is difficult to obtain and no reliable method is now available for a large area.

One authoritative study in the field of evaporation was completed in 1942 by Adolph F. Meyer. This study was based on 50 years' records of the U.S. Weather Bureau.[17] Table 10 presents the expected monthly evaporation from a free water surface in the Crab Orchard Lake area as determined from the Meyer data. It shows that average monthly evaporation may vary from 0.9 inch in January to 6.3 inches in July. Average annual evaporation is 40 inches.

Since 1947 the State Water Survey has maintained a U.S. Weather Bureau, Type A evaporation pan at Carbondale. This metal pan is 48 inches in diameter, 12 inches deep and filled to a depth of approximately 10 inches. The evaporation is measured daily. Table 10 also shows the measurements recorded from this pan during the years 1947 to 1953. It will be noted that the measured pan evaporation is generally somewhat higher than that estimated by Meyer. This generally has been found to be true in other locations throughout the country. However, no reliable method

[17] Meyer, Adolph, F., Evaporation from Lakes and Reservoirs, Minnesota Resources Commission, St. Paul, Minnesota, June, 1942.

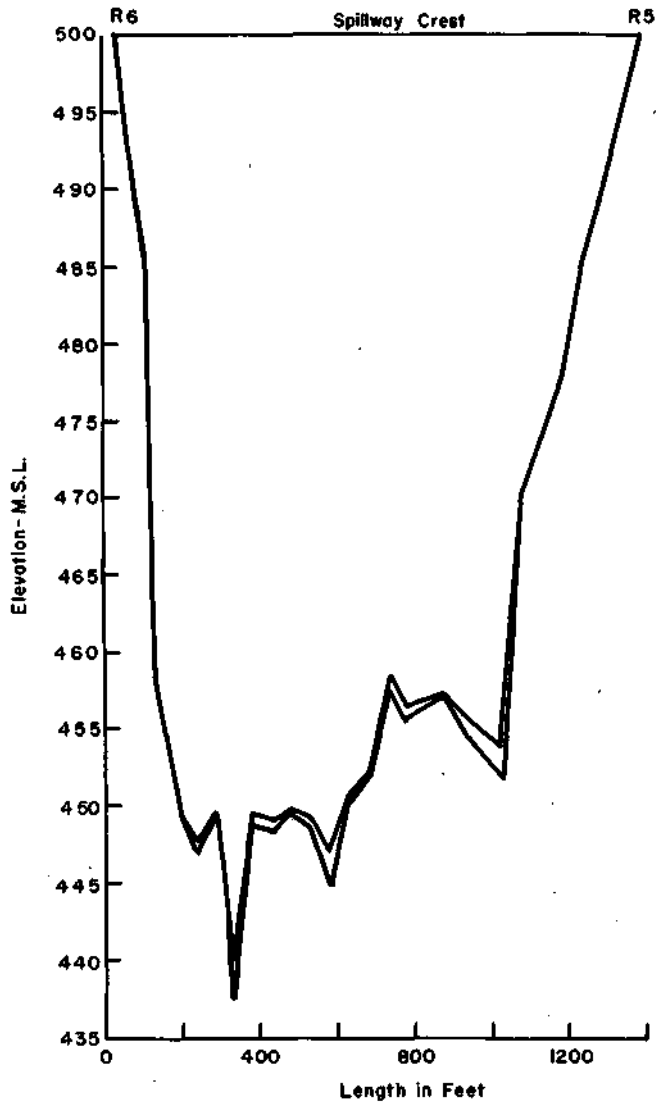


FIG. 24. CROSS SECTION OF RANGE R6-R5, LITTLE GRASSY LAKE

has been developed for correlating pan evaporation with evaporation expected from a free water surface as measured in other ways. In the water supply analyses made later in this report the Meyer data, have been used. It is believed these data are more representative of the Crab Orchard Lake situation than the pan results.

Water Use by Cities. Since the construction of Crab Orchard Lake, four cities in the immediate area have built pipelines from their municipal systems. Use of Lake water as a source of municipal supplies was occasioned by insufficient municipal storage facilities compounded by periods of drouth. In 1954 the total withdrawal by municipalities was about 5 million gallons per day.

The City of Carbondale constructed a pipeline to Crab Orchard Lake following a drouth period in 1941. A 14-inch diameter pipeline was laid from the Crab Orchard dam to a point about one mile west. A pump was located there and the water can be pumped through a 12-inch pipe to the city filter plant in Carbondale. The cost to the city of the water pumped from Crab Orchard Lake is two cents per thousand gallons.

Table 8
Mineral Quality of Water Samples
Crab Orchard Lake

Year	Date	Temperature	Turbidity	Iron	Manganese	Chloride	Sulphate	Alkalinity (bicarbonates)	Hardness	Total Dissolved Solids
				Fe	Mn	Cl	SO_4	(as $CaCO_3$)		
		°F		parts per million						
		Samples taken near station C104								
1951	Oct. 12	63	30	1.4	1.0	13	111	36	119	197
	Nov. 27	41.5	47	3.1	1.8	8	111	8	115	188
	Dec. 10	44	43	2.1	1.6	8	111	24	115	187
1952	Jan. 9	38	21	1.8	1.2	8	118	8	129	201
	Feb. 13	43	36	4.0	1.0	9	125	16	119	199
	Mar. 19	49	91	4.2	0.9	5	74	12	88	132
	Apr. 18	58	43	1.9	0.6	6	109	20	101	173
	June 5	79.5	13	0.8	0.6	8	111	32	113	193
	July 16	79	42	2.0	10.0	0	100	36	118	195
	Sept. 11	80	6	1.2	0.5	10	113	44	122	217
	Oct. 9	64	27	1.4	1.4	10	112	48	132	215
	Nov. 14	50	30	1.4	1.0	14	121	48	136	243
	Dec. 9	50	15	1.0	0.9	13	118	40	126	221
1953	Jan. 12	34	22	0.9	0.7	13	114	36	132	209
	Feb. 10	43	30	1.2	0.7	13	113	32	120	204
	Mar. 6	50	68	1.7	1.6	14	122	28	124	220
	Apr. 8	–	48	1.4	1.7	9	131	24	136	219
	May 8	67	16	0.9	1.2	11	138	20	136	225
	June 8	82	30	1.1	1.2	10	110	32	112	192
	July 9	84	25	2.4	1.2	9	108	44	128	209
	Aug. 6	84	38	3.5	1.5	11	103	76	118	235
	Sept. 14	71	40	1.3	1.7	14	106	60	128	244
	Oct. 15	66	27	1.0	0.9	14	111	56	122	242
	Nov. 6	52	18	1.0	0.5	12	118	72	144	223
	Dec. 9	49	16	0.6	0.3	13	119	56	140	224
1954	Jan. 8	40	8	0.5	0.2	13	115	56	124	240
		Samples taken near Station R5								
1951	Oct. 12	65	5	0.4	0.1	9	83	28	94	174
	Nov. 27	42	8	0.6	0.9	5	80	32	88	159
	Dec. 10	44	8	0.5	0.5	7	86	8	89	162
1952	Jan. 9	38	9	0.7	0.8	5	87	20	91	163
	Feb. 13	42.5	22	1.5	0.6	7	91	24	82	168
	Mar. 19	47	26	2.0	0.6	8	89	12	79	158
	Apr. 18	56.5	18	0.8	0.2	5	80	16	66	140
	June 5	80.5	7	0.5	0.2	6	81	20	67	140
	July 16	77.3	5	0.4	0.2	6	76	28	78	146
	Sept. 11	82	10	0.8	0.4	7	83	24	92	153
	Oct. 9	65	36	0.9	2.0	8	83	28	93	161
	Nov. 14	50.5	15	0.6	1.6	8	88	24	94	160
	Dec. 9	50	19	0.5	0.8	7	87	24	92	174
1953	Jan. 12	35	9	0.4	0.5	7	82	28	88	155
	Feb. 10	42.5	5	0.3	0.2	8	86	24	86	165
	Mar. 6	47	9	0.6	0.1	8	83	20	87	151
	Apr. 8	–	16	1.1	0.4	6	86	12	90	153
	May 8	66	15	0.7	0.2	7	90	24	94	160
	June 8	83	10	0.9	0.4	12	93	12	98	198
	July 9	83.5	8	0.5	0.5	9	97	32	104	217
	Aug. 6	83	16	0.5	0.4	10	94	40	107	215
	Sept. 14	73	26	0.5	1.4	13	97	52	114	209
	Oct. 15	65	12	0.4	0.8	12	101	44	111	210
	Nov. 6	54	14	0.4	0.4	9	98	40	116	192
	Dec. 9	48	7	0.5	0.2	10	104	44	121	215
1954	Jan. 8	40	4	0.3	0	11	101	44	119	204

Table 9
Comparative Mineral Quality of Water at Two Locations in Crab Orchard Lake
(see Figure 3)
Median Value for Calendar Years Shown

		parts per million			
		Samples taken near station C104		Samples taken near station R5	
		1952	1953	1952	1953
Iron	Fe	1.6	1.2	0.8	0.5
Manganese	Mn	1.0	1.2	0.6	0.4
Sulfate	SO_4	112	113	85	93
Alkalinity (as $CaCO_3$)		34	40	24	30
Hardness (as $CaCO_3$)		120	128	87	101
Total Dissolved Solids		200	221	159	195

Table 10
Evaporation From a Free Water Surface in Crab Orchard Lake Area
All values in inches

Month	Meyer Data (see text)	Observed at Carbondale						
		1947	1948	1949	1950	1951	1952	1953
January	0.9							
February	1.1							
March	1.6			2.91	3.62			
April	3.1	5.09	7.01	4.51	....	3.47	4.55	4.30
May	4.0	6.85	6.05	6.89	6.19	6.61	5.36	4.93
June	5.2	6.36	6.24	7.55	6.89	5.37	7.65	8.21
July	6.3	7.52	7.29	6.64	7.43	5.71	6.79	7.61
August	5.7	5.79	5.98	7.23	5.82	4.97	6.14	7.01
September	5.0	5.36	....	4.75	3.64	4.18	5.11	6.29
October	3.7	3.65	....	3.47	2.84	....	5.86	3.09
November	2.3							
December	1.1							
Total	40.0							

The City of Herrin found it necessary during the drouth of 1952 to obtain water from Crab Orchard Lake. A pumping station was established on Crab Orchard Lake and water is pumped through the city's permanent pipeline into Herrin Reservoir No. 1, the location of which is shown in Figure 22.

The City of Marion also found it necessary to construct an 8-inch permanent pipeline from Crab Orchard Lake to the Marion Reservoir following the drouth of 1952. This pipeline is about 4 miles in length and water is pumped from Crab Orchard Lake into the Marion City Reservoir located east of the lake.

The City of Carterville constructed a pipeline to Crab Orchard Lake in 1954.

MAXIMUM SUPPLY AVAILABLE

Operating Principles of a Reservoir. The function of any water supply impounding reservoir is to store run-off from the watershed during wet periods when the stream flow exceeds the consumption. The water thus stored is available for use during dry periods. Consequently, to obtain the full value from the reservoir it must be designed so that the runoff coming into the reservoir is large enough to overbalance the consumption plus the losses from evaporation and seepage. The storage volume of the reservoir should be large enough to fulfill all needs during the driest season for which the lake is designed.

The best indication of the usefulness of a water supply reservoir is the fluctuation of the water level in the lake. Every time the water level is drawn down in the reservoir, demand is exceeding the inflow. This means that there would be a water shortage if the lake were not present. Likewise the best indication of the inadequacy of a reservoir is the occurrence of serious drawdowns during dry periods when inflow is small and consumption is large. Sediment deposits reduce water storage capacity causing progressively heavier drawdowns during dry periods.

Under limiting conditions of precipitation, runoff, evaporation, seepage, availability of land, and prevailing rate of sediment production, the problem of developing a dependable water supply is not a simple one. If the reservoir capacity is too large in relation to the size of the drainage area, it may never fill to capacity, thus representing an economic loss to the owners. If the reservoir capacity is too small, loss of capacity due to sedimentation will probably be high and the reservoir will soon become inadequate.

The total quantity of water that can be pumped from a particular lake is dependent upon: (1) the total precipitation expected on the watershed, (2) the runoff characteristics of the watershed, (3) the consequent flow characteristics of the streams which feed the lake, and (4) losses from evaporation and seepage.

Stream Flow Variability. At the present time there are in existence approximately 170 gaging stations on Illinois streams. After records at a particular station have accumulated for a number of years, an analysis is made of the flow characteristics of the stream at that point. Because such data show how much water flows in a stream at a given point, they are necessary in the designing of a reservoir. This stream gaging work is carried out by the United States Geological Survey in cooperation with state and local agencies. The primary sponsor for stream gaging stations in Illinois is the State Water Survey. In a recent publication of the State of Illinois, a detailed analysis was made of the flow characteristics of 28 Illinois streams.[18] The method devised by Mitchell in the above-mentioned publication was used to determine the probable flow characteristics of the watersheds of Crab Orchard Lake, Little Grassy Lake and the proposed Devil's Kitchen Lake. The Cache River at Forman was used as an index station in this stream flow analysis. This 23-year record covered the years 1922 through 1945. The total watershed area of the Cache River station at Forman is 242 square miles.

Draft Studies. Utilizing the above flow records, a study was made of the maximum water demands

which could be met by Crab Orchard Lake under conditions similar to those of past drouth periods. Similar studies were made for Little Grassy Lake and the proposed Devil's Kitchen Lake. In these studies, the quantity of evaporation was considered to be that published by Meyer[18] as shown in Table 10. The relationships between draft rate and drawdown shown in Figure 25, are based upon droughts which occurred during the period 1922 through 1945. These relationships could be expected to change if a more severe drought is experienced in the future.

Supply Available. The results of the draft-drawdown analysis described above are shown in Figure 25. Inspection of the Crab Orchard Lake curve in Figure 25 reveals that the water level in the lake may be drawn down two feet by evaporation losses alone. The curve indicates further that, if it were permissible to draw the water level in the lake down 10 feet below spillway crest, the lake could furnish a continuous draft of 26 million gallons per day. From the endpoint of the Crab Orchard Lake curve shown in Figure 25, it can be seen that this lake might furnish a total continuous draft of 43 million gallons per day if it were permissible to draw the water level down 22 feet below the spillway crest which would virtually empty the lake.

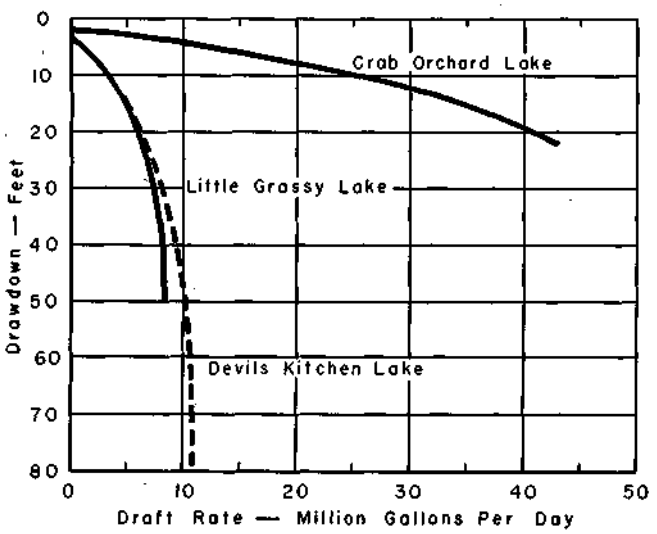


FIG. 25. MAXIMUM EXPECTED DRAWDOWN UNDER VARIOUS DRAFT RATES

The draft rate which can be furnished by Little Grassy Lake is also shown in Figure 25. From this curve it is seen that this lake could furnish a total draft of about 8.5 million gallons per day if it were permissible to draw the water level down 50 feet below the spillway crest elevation.

The draft rate available from the proposed Devil's Kitchen Lake is shown also in Figure 25. The analysis of the water supply which would be available from this lake is based on the total capacity of the lake, as originally designed 28,000 acre-feet. From the dashed line in Figure 25 it is noted that the Devil's Kitchen Lake, if completed, could furnish a total draft of about 11 million gallons per day if it were permissible to draw the water level of the lake down 80 feet below the spillway crest, a drawdown which would virtually empty the lake.

Future Use of the Lake. The storage capacity of Crab Orchard Lake is now being reduced by 0.43 per cent per year as shown in Table 1. As the storage capacity of the lake further decreases in the future, the maximum draft rates which the lake could furnish would be lowered. The draft rates which will be available from Crab Orchard Lake in future years are shown in Figure 26. For the purposes of this analysis it is assumed that it is desirable to limit the maximum drawdown to 8 feet at the present time as well as in future years. If this drawdown were tolerable, it is noted from Figure 26 that Crab Orchard Lake could furnish approximately 20 million gallons per day under continuous draft at the present time. Assuming that the present rate of sedimentation will continue into the distant future, the draft rate available will decrease as shown by the solid line in Figure 26.

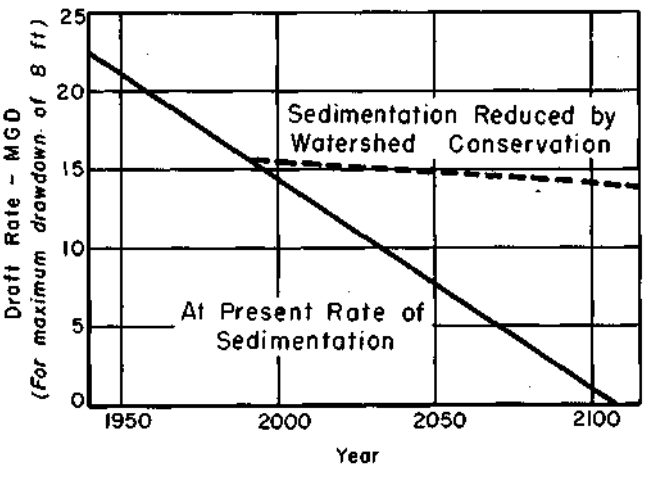


FIG. 26. FUTURE DRAFT RATES AVAILABLE FROM CRAB ORCHARD LAKE

In a later portion of this report, dealing with the Watershed Conservation Program, it will be shown that the sedimentation in Crab Orchard Lake could be reduced by approximately 90 per cent by soil conservation work on the watershed. The dashed line in Figure 26 shows the draft rates which would be available in future years if sedimentation were reduced by such a watershed conservation program. It is noted that a higher draft rate could be sustained if the lake sedimentation were reduced by such work.

[18] Mitchell, William D., Water Supply Characteristics of Illinois Streams. State of Illinois, Department of Public Works and Buildings, Springfield, Illinois. 1950.

WATERSHED

PHYSICAL ASPECTS

Introduction. Many watershed characteristics - such as topography, physiography, size of drainage area, soil types, erosion, and use of the land-affect the rate of sedimentation of reservoirs and lakes. These various factors must be examined carefully to determine the source of the sediment and to evaluate their relative influence on the rate of sedimentation before an effective sediment control program can be developed in a watershed.

To obtain information on these factors in the Crab Orchard Lake Watershed a basic soil survey was made by the Illinois Agricultural Experiment Station and the Soil Conservation Service in Williamson County, and by the Soil Conservation Service in Union, Johnson, and Jackson counties. The survey work in Williamson County was a part of a detailed soil survey of the entire county, the results of which will be published by the Illinois Agricultural Experiment Station.

The survey consisted of detailed mapping of the entire area showing soil type, slope, and degree of erosion on aerial photographs having a scale of 4 inches to a mile. In addition, detailed land use was mapped on the northeast quarter (160 acres) of each odd numbered section or square mile.

Physiography. The major portion of Crab Orchard Lake Watershed is in Williamson County, Illinois, but it extends on the south into Union and Johnson counties and on the west into Jackson County (see Figure 22). The total land area of the watershed (excluding lakes) is 118,137 acres or 184.59 square miles.

The northern portion of the watershed is in the glaciated Mt. Vernon hill county[19] and the southern portion is in the unglaciated Shawnee Hills Section. In general, the southern portion has greater elevation and rougher topography than the northern part.

Slopes. The steepest and longest slopes in the Crab Orchard Lake Watershed occur in the southern and southwestern part. In the central part the slopes are more gentle and shorter. In the northeastern section of the watershed the slopes are moderately steep to steep but in general are not as long as in the southwestern portion.

Seven slope groups were mapped. They include very gently sloping, (A) 0 to 1.5 per cent; gently sloping, (B) 1.5 to 4 per cent; moderately sloping, (C) 4 to 7 per cent; strongly sloping, subdivided into two groups of (D) 7 to 12 per cent and (E) 12 to 18 per cent; and steeply sloping, subdivided into (F) 18 to 30 per Cent and (G) over 30 per cent slope groups. The total number of acres in each slope group is given in Table 11 by erosion class for each soil association and for the entire watershed.

Erosion. Two kinds of erosion occur in the watershed, sheet erosion and gully or channel erosion. By measuring the amount of topsoil left in place, and, from this, estimating the amount that has been eroded, the main sources of sediment entering the lake can be determined.

On the original field maps five erosion groups were mapped. However, for this report two of them were combined and the results were summarized for four erosion groups. Those four groups were as follows:

None: No apparent erosion, over fourteen inches of topsoil remaining (0 erosion).

Slight: Seven to fourteen inches of topsoil remaining (1 erosion).

Moderate: Three to seven inches of topsoil remaining, occasional to frequent exposure of subsoil by plow (2 erosion).

Severe: Less than three inches of topsoil remaining, subsoil eroding and frequently gullied (3 erosion).

The distribution of erosion in relation to slopes is shown in Table 11 for the various soil associations and for the entire watershed. The relationships of the slop and erosion groups to soil types are given in Table 12.

SOIL ASSOCIATIONS

Map. Figure 27 is a soil association map made from the detailed field maps. Eight soil associations were separated on the basis of soil types and such factors as thickness of loess (a silty wind-blown deposit), material underlying the loess, topography or slope, and degree of erosion of the soils.

The loess cover from which most of the upland soils developed (except those on very steep slopes) is thickest in the southwest part of the watershed and thinnest in the northeast part. Actual loess thicknesses on gently sloping, uneroded areas vary from about 150 Inches in the southwest to about 40 inches in the northeast part of the watershed. The northern portion of the watershed (soil associations B_1, B_2, C_1, C_2, and D) was glaciated and in these five areas the loess is underlain by leached glacial till of Illinoian age. Soil associations A_1 and A_2 in the southwestern part of the watershed, in general, were not glaciated although it is evident in many places, especially near the northern boundary of these two areas, that the glacier extended up many of the major valleys and in some cases overrode the lower-lying portion of soil association A_1 and A_2. In general, the loess in soil associations A_1 and A_2 is underlain either by a residual soil, developed from the weathering of sandstone bedrock, or by sandstone bedrock itself.

A key to the soils of the Crab Orchard Lake water-

[19] Leighton, M.M., Eckblaw, G.E., and Hotberg, L. Physiographic Divisions of Illinois. Illinois Geological Survey, Report of investigations No. 129, Urbana, Illinois, 1948.

Table 11
Acreages of Various Soil Associations By Slope and Erosion Groups

Soil [b] Assoc.	Erosion Group [a]	Acres of Various Slope and Erosion Groups							Total	Percent of Total Watershed
		Very Gently Sloping 0-1.5% (A)	Gently Sloping 1.5-4% (B)	Moderately Sloping 4-7% (C)	Strongly Sloping 7-12% (D)	Strongly Sloping 12-18% (E)	Steeply Sloping 18-30% (F)	Steeply Sloping over 30% (G)		
A1	None (0)	68	44							
	Slight (1)		3506	2837						
	Moderate (2)		84	4617						
	Severe (3)			492						
	Total	68	3634	7946					11648	9.86
A2	None (0)									
	Slight (1)					267				
	Moderate (2)				1542	834	4064	2544		
	Severe (3)				4038	9622	859			
	Total				5580	10723	4923	2544	23770	20.12
B1	None (0)	2248	2430							
	Slight (1)		6169	1670						
	Moderate (2)		263	2458						
	Severe (3)									
	Total	2248	8862	4128					15238	12.90
B2	None (0)									
	Slight (1)					15				
	Moderate (2)				503	432	240	40		
	Severe (3)			2418	7568	1998	165	35		
	Total			2418	8071	2445	405	75	13414	11.35
C1	None (0)	1507	4423							
	Slight (1)		7993	1330						
	Moderate (2)		122	6135						
	Severe (3)									
	Total	1507	12538	7465					21510	18.21
C2	None (0)									
	Slight (1)				122	48				
	Moderate (2)				994	99	55			
	Severe (3)			2355	5209	496	44	63		
	Total			2355	6325	643	99	63	9485	8.03
D	None (0)	1915	988							
	Slight (1)		344	213						
	Moderate (2)			220						
	Severe (3)									
	Total	1915	1332	433					3680	3.12
E	None (0)	18950								
	Total	18950							18950	16.04
SM [c]									442	.37
Entire Watershed Excluding Lakes	None (0)	24688	7885							
	Slight (1)		18012	6050	122	330				
	Moderate (2)		469	13430	3039	1365	4359	2584		
	Severe (3)			5265	16815	12116	1068	98		
	Total	24688	26366	24745	19976	13811	5427	2682	118137	100.0

[a] None — over 14 inches of copsoil remaining (0); Slight — 7 to 14 inches of topsoil remaining (1); Moderate — 3 to 7 inches of topsoil remaining (2); Severe — Less than 3 inches of topsoil remaining (3).

[b] Soil Associations are discussed on page 31 and a map is presented in Figure 27, page 34.

[c] Strip coal mines

shed is given in Table 13. The relationship of the various soil types to the parent material from which they developed, the major type of vegetation influencing their development, and the slopes on which they occur are given for each soil association.

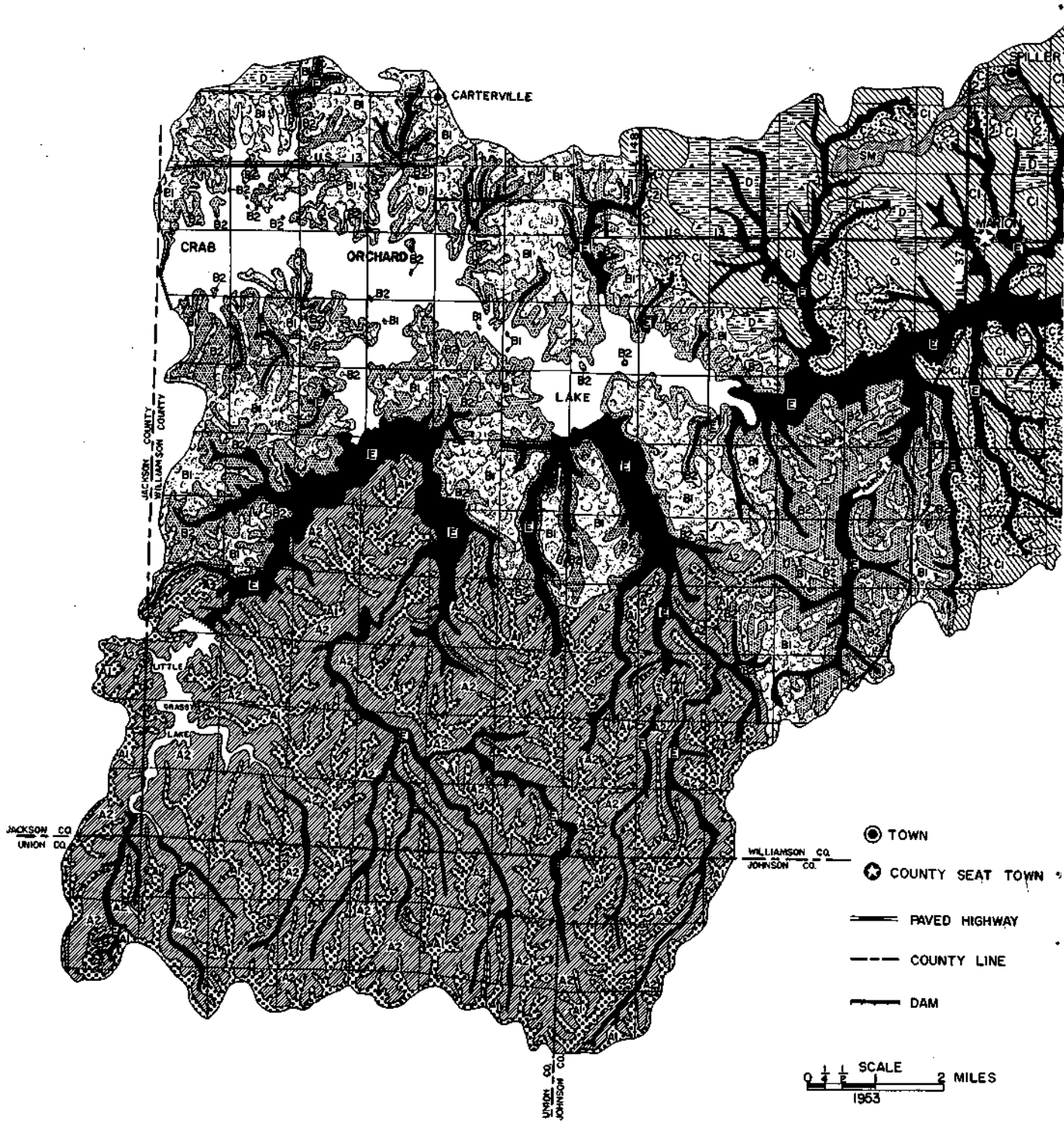
Internal drainage classes or degree of oxidation for the various soils are also given in Table 13. Poor internal drainage for a soil indicates that water movement is very restricted. Soils of this class in the Crab Orchard Lake watershed have rusty iron stains throughout their profiles, and numerous iron-manganese concretions or "buckshot" can be found on and in their surface horizons. Their subsoils are gray with a few faint yellowish mottlings. Soils having imperfect in-

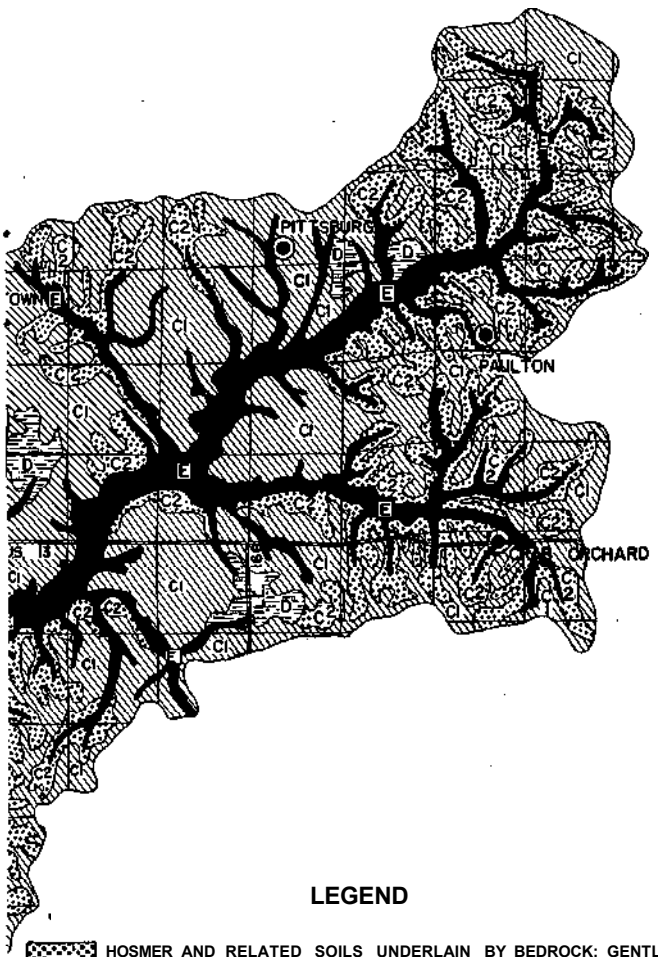
Table 12
Acreages and Percentages of Various Soil Types in Each Soil Association,
Crab Orchard Lake Watershed, Illinois

Soil Type No.	Soil Type Name	Erosion Group	Acres of Various Slope and Erosion Groups: Very Gently Sloping 0-1.5% (A)	Gently Sloping 1.5-4% (B)	Moderately Sloping 4-7% (C)	Strongly Sloping 7-12% (D)	Strongly Sloping 12-18% (E)	Steeply Sloping 18-30% (F)	Steeply Sloping over 30% (G)	Total	Percent of each soil Association
		A1 Association – Hosmer and Related Soils Underlain by Bedrock									
164	Stoy silt loam	None (0)	68	44							
		Slight (1)		44						156	1.3
214	Hosmer silt loam	Slight (1)		3462	2837						
		Moderate (2)		84	4617						
		Severe (3)			492					11,492	98.7
										11,648	100.0
		A2 Association – Manitou and Related Soils Underlain by Bedrock									
9	Steep rocky land, sandstone material	Moderate (2)					218	1905	855	2,978	12.5
214	Hosmer silt loam	Slight (1)					267				
		Moderate (2)				1542	224				
		Severe (3)				3760	2457			8,250	34.7
339	Wellston silt loam	Moderate (2)					102	1867	1688		
		Severe (3)					1364	437		5,458	23.0
340	Manitou silt loam	Moderate (2)					289	291			
		Severe (3)				279	5803	422		7,084	29.8
										23,770	100.0
		B1 Association – Stoy and Related Soils Underlain by Glacial Till									
164	Stoy silt loam	None (0)	107	2430							
		Slight (1)		2828							
		Moderate (2)			453					5,818	38.2
165	Weir silt loam	None (0)	2141							2,141	14.0
214	Hosmer silt loam	Slight (1)		3342	1670						
		Moderate (2)		263	2004					7,279	47.8
										15,238	100.0
		B2 Association – Hosmer and Related Soils Underlain by Glacial Till									
8	Hickory loam	Moderate (2)						44	40	84	0.6
8-214	Hickory loam-Hosmer silt loam complex	Moderate (2)					124	196			
		Severe (3)				26	1735	165	35	2,281	17.0
164	Stoy silt loam	Severe (3)			80					80	0.6
214	Hosmer silt loam	Slight (1)					15				
		Moderate (2)				503	309				
		Severe (3)			2339	7540	263			10,969	81.8
										13,414	100.0
		C1 Association – Bluford and Related Soils Underlain by Glacial Till									
5	Blair silt loam	Slight (1)			63						
		Moderate (2)			1296					1,359	6.3
12	Wynoose silt loam	None (0)	1430							1,430	6.7
13	Bluford silt loam	None (0)	76	4425							
		Slight (1)		3694							
		Moderate (2)		84						8,279	38.5
14	Ava silt loam	Slight (1)		4298	1267						
		Moderate (2)		38	4839					10,442	48.5
										21,510	100.0
		C2 Association – Ava and Related Soils Underlain by Glacial Till									
5	Blair silt loam	Severe (3)			220	75				295	3.1
8	Hickory loam	Moderate (2)						55			
		Severe (3)						11		66	0.7
8-14	Hickory loam-Ava silt loam complex	Moderate (2)				31					
		Severe (3)				1792	326	33	63	2,245	23.7
14	Ava silt loam	Slight (1)				122	48				
		Moderate (2)				963	99				
		Severe (3)			2134	3343	170			6,879	72.5
										9,485	100.0
		D Association – Hoyleton and Related Soils Underlain by Glacial Till									
2	Cisne silt loam	None (0)	1176							1,176	31.9
3	Hoyleton silt loam	None (0)	739	988							
		Slight (1)		344						2,071	56.3
4	Richview silt loam	Slight (1)			213						
		Moderate (2)			220					433	11.8
										3,680	100.0
		E Association – Belknap and Related Alluvial Soils									
72	Sharon silt loam	None (0)	3553							3,553	18.7
108	Bonnie silt loam	None (0)	3157							3,157	16.7
382	Belknap silt loam	None (0)	12240							12,240	64.6
										18,950	100.0

FIGURE 27.

SOIL ASSOCIATION MAP OF CRAB ORCHARD LAKE WATERSHED, ILLINOIS





LEGEND

A1 HOSMER AND RELATED SOILS UNDERLAIN BY BEDROCK; GENTLY TO MODERATELY SLOPING; SLIGHTLY TO MODERATELY ERODED.

A2 MANITOU AND RELATED SOILS UNDERLAIN BY BEDROCK; STRONGLY TO STEEPLY SLOPING; SLIGHTLY TO SEVERELY ERODED.

B1 STOY AND RELATED SOILS UNDERLAIN BY GLACIAL TILL; VERY GENTLY TO MODERATELY SLOPING; UNERODED TO MODERATELY ERODED.

B2 HOSMER AND RELATED SOILS UNDERLAIN BY GLACIAL TILL; MODERATELY TO STEEPLY SLOPING; SLIGHTLY TO SEVERELY ERODED.

C1 BLUFORD AND RELATED SOILS UNDERLAIN BY GLACIAL TILL; VERY GENTLY TO MODERATELY SLOPING; UNERODED TO MODERATELY ERODED.

C2 AVA AND RELATED SOILS UNDERLAIN BY GLACIAL TILL; MODERATELY TO STEEPLY SLOPING; SLIGHTLY TO SEVERELY ERODED.

D HOYLETON AND RELATED SOILS UNDERLAIN BY GLACIAL TILL;" VERY GENTLY TO MODERATELY SLOPING; UNERODED TO MODERATELY ERODED.

E BELKNAP AND RELATED ALLUVIAL SOILS; VERY GENTLY SLOPING ; UNERODED.

SM STRIP MINE.

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION
IN COOPERATION WITH
UNITED STATES DEPARTMENT OF AGRICULTURE

ternal drainage and oxidation contain less iron-manganese concretions than poorly drained soils and have brighter, more yellowish, mottled subsoils. Moderately drained soils have a brownish cast in their surface horizons and a strong brown color in the upper part of their subsoils with yellowish and grayish mottles in the lower part. Moderate to good internal drainage indicates that the soils are wet only long enough to cause yellowish and grayish mottling in the very lowest portion of the subsoil. Also, in moderate to good internally drained soils, the mottlings are much fainter, ordinarily, than they are in moderately drained soils. Good internal drainage indicates that water is removed readily but not rapidly. Soils having this drainage class have a brownish cast throughout and are not mottled. Good to very good internal drainage signifies that water is removed from the soil rapidly. Soils of this class are porous, sometimes drouthy, and are not mottled.

Detailed descriptions of most of the soil series given in the key Table 13 may be found by name or number in Illinois Soil Type Descriptions, University of Illinois, Agricultural Experiment Station, Publication AG 1443, 1950.

Soil Association A_1. Soil association A_1, Hosmer and related soils underlain by bedrock, represents the gently to moderately sloping, slightly to moderately eroded ridgetops in the unglaciated, southwestern section of the watershed. Stoy silt loam and Hosmer silt loam are the two soil types occurring in this association. They are light colored soils developed under the influence of hardwood forest vegetation from moderately thick to thin loess. Stoy occurs on more poorly drained areas than Hosmer and has more gray mottling in the subsoil. It is slowly permeable to water whereas Hosmer is moderately permeable. Both soils are low in organic matter, medium to strongly acid, low in available phosphorus, and medium to high in available potassium. These soils are adapted to cultivation if treated according to needs as indicated by soil tests and if erosion control practices such as contouring and grass waterways are used on the more sloping areas.

Soil association Al comprises 11,648 acres which is 9.86 per cent of the total land area of the watershed (Table 11 and Table 12).

Soil Association A2. Soil association A2,Manitou and related soils underlain by bedrock, occurs on the strongly to steeply sloping, slightly to severely eroded areas in the unglaciated southwestern part of the watershed. This association consists of Hosmer silt loam, Manitou silt loam, Wellston silt loam and steep rocky land derived from sandstone material. Some rock outcrop occurs on many of the steeper slopes. These soils are all light colored and have developed from thin loess or from sandstone bedrock under the influence of forest vegetation. Probably because of the high gradient the loess was eroded from the very steep slopes long ago and as a result

Table 13
Key to Soils of Crab Orchard Lake Watershed, Illinois*

Soil Assoc.	Parent Material	Native Vegetation	Internal Drainage & Oxidation	Soil Series Listed According to Slope						
				Very gently sloping 0-1.5% (A)	Gently sloping 1.5-4% (B)	Moderately sloping 4-7% (C)	Strongly Sloping 7-12% (D)	Strongly Sloping 12-18%(E)	Steeply Sloping 18-30%(F)	Steeply Sloping over 30% (G)
A1	Moderately thick to thin loess (150-50 inches) on residuum or bedrock	Timber	Imperfect Moderate		Stoy (164) Hosmer (214)	Hosmer (214)				
A2	Thin to very thin loess (50-0 inches) on residuum or bedrock	Timber	Moderate Moderate to good Good Good to very good				Hosmer (214) Manitou (340)	Manitou (340) Wellston (339) Steep rocky land, sandstone material(9)	Wellston (339) Steep rocky land, sandstone material(9)	Wellston (339) Steep rocky land, sandstone material(9)
B1	Moderately thick loess (100-65 inches) on leached till	Timber	Poor Imperfect Moderate	Weir(165) Stoy (164)	Stoy (164) Hosmer (214)	Stoy (164) Hosmer (214)				
B2	Moderately thick to very thin loess (70-9 inches) on leached till	Timber	Imperfect Moderate Moderate to good			Stoy (164) Hosmer (214)	Hosmer (214) Hickory-Hosmer (8-214)	Hosmer (214) Hickory-Hosmer 8-214)	Hickory-Hosmer (8-214) Hickory (8)	Hickory-Hosmer (8-214) Hickory (8)
C1	Thin loess (65-40 inches) on leached till	Timber	Poor Imperfect Moderate	Wynoose (12) Bluford(13)	Bluford(13) Ava (14)	Blair (5) Ava (14)				
C2	Thin to very thin loess (50-0 inches) on leached till	Timber	Imperfect Moderate Moderate to good			Blair(5) Ava(14)	Blair(5) Ava(14) Hickory-Ava(8-14) Hickory(8)	Ava(14) Hickory-Ava(8-14) Hickory(8)	Hickory-Ava(8-14) Hickory(8)	Hickory-Ava(8-14) Hickory(8)
D	Thin loess (65-40 inches) on leached till	Prairie	Poor Imperfect Moderate	Cisne(2) Hoyleton (3)	Hoyleton (3) Richview (4)	Hoyleton (3) Richview (4)				
E	Bottomland, alluvial wash from acid upland soils	Timber	Poor Imperfect Moderate to good	Bonnie (108) Belknap (382) Sharon (72)						

• Detailed descriptions of most of the soil series in this key are included in "Illinois Soil Type Descriptions," University of Illinois, Pub. AG 1443, Agr. Exp. Sta., 1950.

the steep rocky land shows little evidence of ever having a loess cover. It is largely residual material developed from sandstone bedrock. Wellston silt loam occurs on slopes where the loess is generally less than 24 inches thick. Manitou silt loam has developed in loess varying from about 24 to 40 inches thick and Hosmer silt loam iri loess over 40 inches thick.

The soils of this association are not adapted to cultivation, largely because of their steep slopes. In the case of steep rocky land, its shallow and rocky nature also precludes cultivation. However, the lesser sloping portion of this association on which the Hosmer and Manitou soils are found can be used for pasture and hay production if they are managed properly.

The Hosmer and Manitou soils have moderately developed subsoils and are moderately permeable to water. The Hosmer has a more highly mottled subsoil and a somewhat more brittle siltpan below the subsoil than Manitou. Wellston does not have any mottling

in the subsoil not does it have a siltpan. Wellston silt loam and steep rocky land are probably better adapted for tree growth than they are for the production of pasture or hay. These soils are medium to strongly acid and low in available phosphorus. They are medium to high in available potassium. Unless the soils of this association are protected by a good vegetative growth of grass or tress, they are subject to serious erosion and contribute large quantities of sediment to their runoff waters which enter Little Grassy Lake and Crab Orchard Lake.

This association includes a total of 23,770 acres and is 20.12 per cent of the total watershed land area (Tables 11 and 12).

Figure 28 shows a panoramic view of soil association areas Al and A2.

FIG. 28. PANORAMIC VIEW OF SOIL ASSOCIATION AREAS Al A2. Some of the steeply rolling land in soil association A2 have been planted to trees and the more level lands in soil association area Al are being used as cropland.

Soil Association B1. Soil association B1, Stoy and related soils underlain by glacial till, occurs in a belt from the northwestern to the south-central part of the watershed. In general it is found to the north and east of soil association areas A1 and A2.

The soils of the Bl association-Weir silt loam, Stoy silt loam, and Hosmer silt loam-are found on the very gently to moderately sloping areas between draws and small creek bottoms. They vary from uneroded to moderately eroded and, in general, are not a major source of sediment for Crab Orchard Lake.

All of these soils have developed from moderately thick loess under the influence of forest vegetation. They have light colored surfaces and differ principally in the degree of internal drainage or the amount of oxidation that has taken place within their profiles. Weir occurs on areas having slopes of less than 1.5 per cent. It is a gray, poorly drained soil that has a claypan horizon beginning at a depth of about 18 inches. Artificial drainage is needed on this soil before it can be cropped satisfactorily but because of its very slow permeability to water, open ditches rather than tile are commonly used to remove excess water. Stoy silt loam occurs mainly on gentle slopes and usually excess water can be removed readily by a few well placed furrows. It is less gray than Weir, having a yellowish cast in the surface horizons and more yellowish mottlings in the subsoil. Hosmer silt loam occurs mainly on moderately sloping areas and has a brownish cast in its surface horizon. The upper part of the subsoil is a strong brown color free of gray mottles whereas the lower portion of the subsoil is mottled with gray and yellow. Artificial drainage is not needed on this soil. On the other hand, most areas of Hosmer are subject to erosion unless they are properly managed.

The soils of this association are low in organic matter, medium to strongly acid, low in available phosphorous and about medium in available potassium. These soils are adapted to cultivation but for good crop yields they require soil treatments based on soil tests, the adoption of good crop rotations, adequate drainage on nearly level areas, and the use of suitable erosion control practices on the moderately sloping areas.

There are 15,238 acres in soil association B1. This is 12.90 per cent of the total land area of the watershed, (Tables 11 and 12).

Soil Association B2. Soil association B2, Hosmer and related soils underlain by glacial till, lies adjacent to the Bl association. The B2 association includes Stoy silt loam, Hosmer silt loam, and Hickory loam on moderately to steeply sloping, slightly to severely eroded areas. The B2 association includes the soils on the more sloping breaks from the tablelands of soil association Bl into the draws or small bottomlands.

Stoy and Hosmer are described in the discussion of soil association Bl. Where these two soils fall into association B2 they are either more sloping or more eroded or both than where they are included in association Bl. It is, therefore, evident that in B2 they are less well adapted to cultivated crops. Longer rotations including less row crops such as corn or soybeans and more sod crops are needed on these soils in B2, and in many cases, they should be seeded to permanent pasture.

Hickory loam, like Stoy and Hosmer, is a light colored soil developed under hardwood forest, but unlike Stoy and Hosmer, it has not developed from loess. It is a moderately well-drained soil developed from glacial till on slopes from which the loess cover has been eroded. In a sense it represents an outcropping of the till underlying the loess from which Stoy and Hosmer developed. Hickory usually is medium to strongly acid, slowly permeable, and subject to severe erosion where unprotected by good vegetative cover. Where it is mapped as a complex with Hosmer (Hickory-Hosmer areas) it means that the two soils are intimately intermingled and could not be separated conveniently on the scale used in mapping. In these

complex areas usually Hosmer occupies the upper portion and Hickory the lower portion of the same slope.

Most areas of Hickory-Hosmer complex and of Hickory mapped alone are best suited to permanent pasture. Most of the very steep, severely eroded areas of these two units should be reforested.

Like soil association A2, soil association B2 is one of the main sources of sediment for Crab Orchard Lake unless it is protected from erosion by good vegetative cover most of the time. Figure 29 shows eroded cropland in this soil association.

FIG. 29. ERODED CROPLAND IN WATERSHED. Due to past treatment, this rolling field in soil association B2 is so badly eroded that it should be converted to pasture or woodland.

Soil association B2 contains 13,414 acres which is 11.35 per cent of the total land area of the watershed, (Tables 11 and 12).

Soil Association C1. Soil association C1, Bluford and related soils underlain by glacial till, occurs in the eastern part of the watershed. In general, it is north and east of soil associations B1 and B2. It includes Wynoose silt loam, Bluford silt loam, Blair silt loam, and Ava silt loam on very gently to moderately sloping, uneroded to moderately eroded areas. This association occupies ridgetops and broad tablelands between draws and small stream bottomlands.

These soils have developed from thin loess on leached glacial till under the influence of hardwood forest vegetation. They resemble the soils of the Bl association but are more strongly leached and weathered and are somewhat less permeable to water.

Wynoose is a gray claypan soil that contains numerous iron-manganese concretions or "buckshot" throughout the profile. It will not tile satisfactorily so that excess water must be removed by open ditches and furrows. Bluford silt loam occurs mainly on gentle slopes and, therefore, has better surface drainage than Wynoose. It has a yellowish cast in the surface and subsurface horizons and the subsoil is highly mottled with yellow and rusty brown. Blair silt loam is similar in color to Bluford but has developed from thinner loess so that the lower portion of the subsoil (below a depth of 20 to 24 inches) has developed in leached glacial till. Ava silt loam is a moderately drained soil with a brownish cast in its surface horizons, a strong brown upper subsoil, free of mottlings, and a highly mottled lower subsoil.

All of these soils are suitable for cultivation but in addition to the needs for drainage on the flatter areas and erosion control measures on the moderately sloping areas, they require liberal use of limestone and fertilizers before satisfactory crop yields can be obtained. These soils are low in organic matter, strongly acid, very low in available phosphorus and low in available potassium.

This association is not a major source of sediment to runoff waters largely because slopes are not great enough to cause swift runoff.

Soil association area C1 contains 21,510 acres and makes up 18.21 per cent of the total land area of the watershed, (Tables 11 and 12).

Soil Association C2. Soil association C2, Ava and related soils underlain by glacial till, includes Blair silt loam, Ava silt loam, and Hickory loam on moderately to steeply sloping, slightly to severely eroded areas. This association ordinarily occurs on the breaks or steeper slopes from the tablelands of association C1 into draws and small creek bottomlands.

Blair and Ava are described in the discussion of soil association C1. Where they are included in C2, they are either more eroded or occur on steeper slopes or both than when grouped in association C1, and, therefore, need to be handled differently. In the C2 association they are less well adapted to cultivation and require more sod crops and other conservation practices to aid in reducing soil losses by erosion.

Hickory loam is discussed under association B2. It is an outcropping on slopes of the leached glacial till underlying the loess in which Blair and Ava have developed. In areas mapped Hickory-Ava complex, Ava usually occupies the upper and Hickory the lower portion of the same slope.

The soils of association C2 have developed under the influence of forest vegetation. They are light colored and low in organic matter. Usually they are strongly acid and low in available phosphorus. Blair and Ava are frequently low in available potassium whereas Hickory is medium or sometimes high in this plant nutrient.

The runoff waters from this association contain large amounts of sediment unless the land is protected by good vegetative growth of grasses or trees. Many areas can be profitably used for pasture or hay if these crops are established and handled with proper care. The very steep and severely eroded areas often can best be utilized by well planned reforestation and woodlot management.

This association has a total area of 9,485 acres and is 8.03 per cent of the total land area of the wa-

tershed, (Tables 11 and 12).

Soil Association D. Soil association D, Hoyleton and related soils underlain by glacial till, is scattered throughout the northern portion of the watershed. Included in this association are Cisne silt loam. Hoyleton silt loam and Richview silt loam. These soils have developed from thin loess under the influence of a prairie grass vegetation. They are closely related to the soils of association C1 but differ principally in having somewhat darker and somewhat thicker surface horizons because of the influence of the grass vegetation. Cisne is usually thought of as the prairie counterpart of Wynoose, Hoyleton as the prairie counterpart of Bluford, and Richview as prairie counterpart of Ava.

The soils of association D are adapted to cultivation. They occur on very gently to moderately sloping, uneroded to moderately eroded areas and do not contribute large amounts of sediment to runoff waters. They are low in organic matter, strongly acid, low in available phosphorus and available potassium, and, therefore, require large amounts of limestone and fertilizer for satisfactory crop yields.

Cisne silt loam is a claypan soil which occurs on very gently sloping topography. It cannot be tile drained because of its very slow permeability to water. However, adequate drainage can usually be provided by open ditches and furrows. Hoyleton occurs mainly on gentle slopes and is not as poorly drained as Cisne. It has a more yellowish cast in the subsurface and more bright red mottles in the upper portion of the subsoil than Cisne. The claypan in Cisne and Hoyleton on uneroded areas is usually encountered at a depth of about 18 inches. Richview is less of a claypan soil than Cisne or Hoyleton. The subsoil in Richview is not as pronounced nor quite as heavy textured. Richview has a more brownish cast throughout than Cisne or Hoyleton and less red mottling in the subsoil than Hoyleton.

Soil association D contains 3,680 acres which is 3.12 per cent of the total land area of the watershed (Tables 11 and 12).

Soil Association E. Soil association E, Belknap and related alluvial soils occupies the very gently sloping, uneroded bottomlands of the entire Crab Orchard lake watershed. Included in this association are Bonnie silt loam, Belknap silt loam, and Sharon silt loam.

Bonnie silt loam is a light gray soil but may have a dark gray surface horizon as much as 8 inches thick. It is a poorly drained soil and many areas tend to be wet late in the spring. It is strongly acid, low in available phosphorus, and low to medium in available potassium. Tiling is questionable and unless adequate drainage can be provided by means of furrows it is not well adapted to cropping.

Belknap is somewhat better drained than Bonnie. It has a dark gray surface layer that may vary from 8 to 24 inches in thickness. Below the surf ace layer it is gray, mottled with rusty brown and faint yellow. Because of slightly better drainage and the thicker surface layer, it is a better soil than Bonnie although like Bonnie it requires a great deal of fertilization for good crop growth.

Sharon silt loam has moderate to good internal drainage. It may be either a uniform brown or yellowish brown color throughout its profile or may have some faint rusty brown mottles below a depth of 24 inches. Most of the Sharon occurs in small stream bottoms in the southwestern part of the watershed adjacent to the Al and A2 soil associations. Sharon is well adapted to cultivation and is one of the better soils in the watershed. It is medium acid, often low in available phosphorus, and about medium in available potassium. None of the three bottomland soils discussed above have subsoils or clay accumulation layers as do the upland soils. The bottomland soils are derived from sediment of too recent age to have had time for much soil development to have taken place.

The total area of soil association E is 18,950 acres. This is 16.04 per cent of the total land area of the watershed, (Tables 11 and 12).

There were 442 acres in strip mine (SM), shown separately on the soil association map. This is .37 per cent of the total land area of the watershed.

LAND USE

Present. One of the more important factors affecting the rate of sediment production is land use. Five major classes of land use were mapped in the soil survey: cropland, pasture, idleland, woodland, and miscellaneous.

Cropland includes all intertilled crops, small grains, orchards, hay, and pasture meadows. In order to arrive at a reasonably accurate average of the rotation being used at the present time, it was necessary to make a very detailed survey of present land use. The following nine subclasses of cropland were mapped: (L1) clean tilled crops, (L2) small grain without legumes, (L3) small grain with legumes, (L4) fall plowed or fall seeding, (M1) rotation meadow with good cover of legumes or mixture of legumes and grasses, (M2) rotation meadow with good cover of grasses, (M3) rotation meadow with poor cover or severely grazed, (01) clean tilled orchards, and (02) orchards with good cover crops. Pasture includes land in grasses or legumes that is devoted umes and grasses, (P2) good cover of grasses, (P3) poor cover or severely grazed and (P4) good cover of grasses with 25 to 75 per cent coverage of brush. Idle land includes land formerly used for crops and pasture now abandoned. The four conditions shown on the soil survey consisted of: (X1) nonbrushy, good cover with less than 40 per cent canopy, (X2) brushy, fair to good cover with over 40 per cent canopy, (X3) sparse cover, often severely eroded, brushy, or nonbrushy, and (X1) swampy-cattails, reeds, sedges, etc. Woodland includes areas of land covered with a closed or nearly

closed canopy of trees or areas devoted to forest plantations. The two conditions mapped consisted of: (F1) woodland with good ground cover, usually not grazed with a tree coverage of over 40 percent canopy, and (F2) poor ground cover, usually grazed, with a tree coverage of over 40 per cent canopy. Miscellaneous land consists of farmsteads, roads, golf courses, and other areas not otherwise classified.

There was some general relationship between land use and soil association areas. A large portion of the idle land was located in the rough and rolling A2 areas, much of which is government-owned. Approximately 80 per cent of the cropland in the watershed is located in the less rolling to level soil association areas A1, B1, C1, D, and E. Approximately 50 per cent of the woodland is located in soil association areas A2 and B2.

A significant feature to note in Table 14, which summarizes the present land use by subclasses, is that approximately 50 per cent of the cropland is in clean tilled crops, a practice which is highly inducive to erosion unless adequate erosion-control practices are used. The table further shows that only a small acreage of the permanent pasture land has a good cover of legumes or a mixture of legumes and grasses. Of significance also is the high percentage (30 per cent) of the idle land which is sparsely covered and often severely eroded. The major portion of the woodland acreage has good ground cover, usually not grazed and with a tree coverage of over 40 per cent canopy.

land is good land that can be cultivated safely with easily applied practices. These include such measures as contouring, protective cover crops, and simple water management operations. Class III land is moderately good land that can be cultivated safely with intensive measures. These measures consist of practices such as terracing, strip-cropping, etc. where they can be applied. Where these practices will not apply, the use of the land is restricted to long rotations with grasses and legumes with simple or easily applied practices. Class IV land is fairly good land that is best suited to pasture or hay but can be cultivated occasionally, usually not more than 1 year in 6. When this land is plowed, careful erosion control prevention practices must be used. Class V land is land suited for grazing and forestry with no limitations; needs only good management. Class VI land is land suited for grazing or forestry with minor limitations; needs protective measures. Class VII land is land suited for grazing or forestry with major limitations; needs extreme care to prevent erosion or to overcome other hazards.

Table 15 shows the present use of land as compared to the rated capability of the land. Table 15A is a summary of the same data. This table shows that, out of the total 39,469 acres now in cropland, about 16 per cent is rated class VI or VII and is better suited for pastureland or woodland. It also shows that about 50 per cent of the 34,787 acres of idleland is suited for cropland (class I, II, III, and IV land). About 20 per cent of the 23,230 acres now in woods is suited for cropland.

Figure 30 shows good cropland on class II land in the watershed. Figure 31 shows class V land in the watershed.

Table 14
Acreage of Present Land Use in Each Soil Association Area

Soil*	Cropland							Pasture				Idle				Woodland		Misc.	Total
Assoc.	01					02													
Area	L1	L2	L3	L4	M1	M2	M3	P1	P2	P3	P4	X1	X2	X3	X4	F1	F2		
A1			465			547	219	1736		4334	670			3377			27	273	11,648
A2	723		59		426	229	88	521	634	901	50	538	2427	3975		9777	3267	155	23,770
B1	3972	35	437	363	1479	437	146	68	988	291	4	1987	1224	1204		1544	225	834	15,238
B2	478	76	102	263	729	401	190	36	1498	919	46	1267	1591	3217		1848	610	143	13,414
C1	5701	226	694	509	2378	534	18	446	1433	242	222	3649	1152	89		616	179	3422	21,510
C2	1598	207	60	350	288	467	40	132	1415	378	207	1441	1306	196		795	233	372	9,485
D	2011	80	182	18	382			135	222			171				182		297	3,680
E	4679	186	119	153	848	229	14	229	852	313	27	2912	917	1870	58	4531	683	330	18,950
Total	19162	810	2118	1656	6530	2844	715	3303	7042	7378	1226	11965	8617	13928	58	19293	5224	5826	117,695

* Soil associations are discussed on page 31. See also soil association map, Figure 27, page 34.

Capabilities. The soil map serves as a means of developing an intimate understanding of the land which is basic to adopting proper land use. The land-capability classification system serves as a method of interpreting the significant characters of the land delineated on the soil map and arranging these properties in a systematic manner[20]. There are seven different capability classes of land in Crab Orchard Lake Watershed. Class I land is very good land found on level to nearly level slopes that can be cultivated safely with ordinary good farming methods. Class II

[20] Hockensmith, Roy D., Classification of Land According to Its Capability as a Basis for a Soil Conservation Program, U.S. Dept. of Agriculture, Soil Conservation Service, Washington 25, D.C., 1949.

PROBABLE SOURCES OF SEDIMENT

General Indications. In developing a watershed treatment program for reservoir protection, it is of primary importance to determine the source of sediment. The chemical analysis of the sediment in Crab Orchard Lake presented before indicates that surface soil that has been limed for agricultural purposes forms a significant proportion of the sediment accu-

mulating in the lake.

Two kinds of water erosion occur in the watershed,

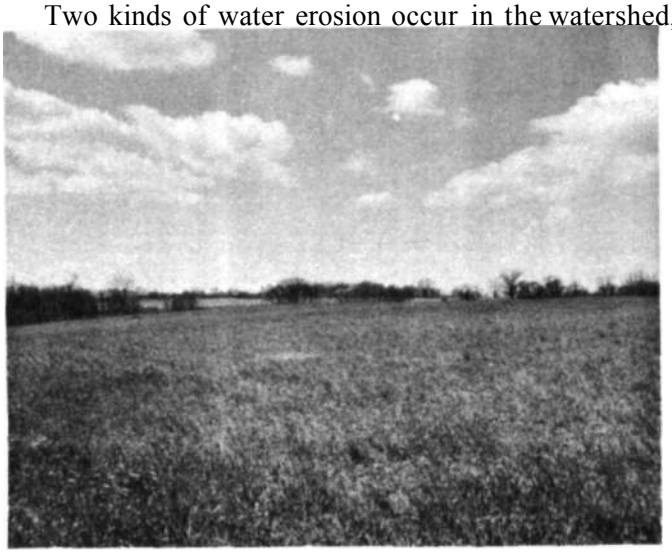


FIG. 30. CLASS II LAND IN SOIL ASSOCIATION AREA A1. Good cropland on slightly rolling ridgetop which is characteristic of soil association area A1.

sheet erosion and gully erosion. No attempt was made to measure and obtain volumetric data on the gully and streambank erosion taking place within the watershed. Table 16 shows the amount of land in the watershed in the different erosion classes by land use and soil association areas. Table 16A is a summary of the same data. Severe erosion is most pronounced in the hilly soil association areas A2, B2, and C2. Serious erosion is most common on the crop and idle lands found within these soil association areas. Table 16 further shows that 30 per cent of the watershed has no apparent erosion, 22 per cent is slightly eroded, 22 per cent is moderately eroded, and 30 per cent is severely eroded. Figure 32 shows gullied idle land in the watershed.

FIG. 31. CLASS V LAND IN THE WATERSHED. This land is too wet for cultivation, but can be developed into productive pastureland.

Gross Erosion. The volume of sediment that is produced at the present time by sheet erosion was computed directly from the physical land conditions and cropping patterns which exist in the watershed. Soil losses are caused by many factors, singly and in combination. Erosion-producing ratings based on available research data have been developed for the various factors involved.[21]

FIG. 32. GULLIED IDLE LAND IN WATERSHED. The badly eroded area in the background is only producing sediment, the area in the foreground has been planted to trees.

Studies carried on at the various erosion experiment stations definitely show that steepness of slope is one of the more important factors influencing soil loss. 22 In general, the soil losses will increase 2.5 times if the per cent of slope is doubled. The rating for the per cent of slope factor arrived at from data at the Dixon Springs, Illinois, run-off plots is 1.39 asdetermined by Van Doren and Klingebiel.[21]

Length of slope is another factor affecting the rate of soil loss. Van Doren and Klingebiel21 reported that the Dixon Springs data showed that soil losses varied as the 0.6 power of the slope length. In other words, doubling the length of slope will increase the soil loss 1.5 times.

Various crops and the sequence of crops also affect the rate of soil loss. Data at Dixon Springs showed that the soil loss from a corn, small grain, meadow rotation was 9 tons per acre per year while, on similar soil and slope condition, the soil loss from a corn, small grain, 2 years of meadow rotation was only 5.5 tons per year. 23 Estimated effectiveness of crop rotations based on plot data determined by Van Doren and Klingebie 21 were used in this study.

There is also research evidence to show that different soils erode at different rates. The relative rates for the particular soils found in this watershed were

[21] Van Doren, C.A. and Klingebiel, A.A., mimeographed material, U.S. Dept. of Agriculture, Soil Conservation Service, Urbana, Illinois, 1948.

[22] Van Doren, C.A. and Gard, L.E., Protecting Your Soil, Circular 667, 1950

[23] Van Doren, C.A., 1950 Annual Report, U.S. Dept. of Agriculture, Soil Conservation Service, Illinois Agricultural Experiment Station.

Table 15
Present Land Use and Recommended Land Use Adjustments by Land Use Capability for Each Soil Association Area

Soil* Assoc. Area	Land Use Capability Class	Present Land Use						Recommended Land Use				
		Cropland Acres	Pasture Acres	Woodland Acres	Idle Acres	Misc. Acres	Total	Cropland Acres	Pasture Acres	Woodland Acres	Misc. Acres	Total
A1	II	1739	314	289	1271	91	3704	3454	115	44	91	3704
	III	2696	1108	691	2798	159	7452	5902	700	691	159	7452
	IV	71	205	4	212		492	170	318	4		492
	Total.....	4506	1627	984	4281	250	11648	9526	1133	739	250	11,648
A2	IV	555	401	237	326	26	1545	705	576	238	26	1545
	VI	1481	595	1107	1924	33	5140		3999	1108	33	5140
	VII	865	1353	8822	5968	77	17085		4371	12637	77	17085
	Total.....	2901	2349	10166	8218	136	23770	705	8946	13983	136	23,770
B1	II	4242	763	1033	2220	711	8969	7455	340	463	711	8969
	III	2585	904	814	1623	343	6269	4790	448	688	343	6269
	Total.....	6827	1667	1847	3843	1054	15238	12245	788	1151	1054	15,238
B2	IV	847	502	661	909	3	2922	1234	1024	661	3	2922
	VI	2079	1192	1614	2977	152	8014		4832	3030	152	8014
	VII	111	744	641	970	12	2478		1414	1052	12	2478
	Total.....	3037	2438	2916	4856	167	13414	1234	7270	4743	167	13,414
C1	II	2107	529	228	914	634	4412	3342	266	170	634	4412
	III	8139	1837	718	3808	2596	17098	13039	924	538	2597	17097
	Total.....	10246	2366	946	4722	3230	21510	16381	1190	708	3231	21,510
C2	IV	1465	419	220	1128	225	3457	1468	1545	220	225	3458
	VI	1483	1711	630	1486	115	5425		4608	702	115	5425
	VII	101	22	124	325	31	603		322	250	31	603
	Total.....	3049	2152	974	2939	371	9485	1468	6475	1172	370	9,485
D	II	563	66	40	71		740	740				740
	III	2111	291	142	100	296	2940	2547	56	41	296	2940
	Total.....	2674	357	182	171	296	3680	3287	56	41	296	3,680
E	I	1580	389	836	363	22	3190	3168			22	3190
	II	2826	834	1302	2163	288	7413	6472		653	288	7413
	III	1517	72	1619	2127	7	5342	3963	493	879	7	5342
	V	306	126	1458	1104	11	3005		1536	1458	11	3005
	Total.....	6229	1421	5215	5757	328	18950	13603	2029	2990	328	18,950
Strip-mine	VII					442	442				442	442
Total Land Use		39,469	14,377	23,230	34,787	6,274	118,137	58,449	27,887	25,527	6,274	118,137

* Soil associations are discussed on page 31. See also soil association map, Figure 27, page 34.

Table 15A
Summary of Present and Recommended Land Use

Land Capability Class	Present Land Use					Recommended Land Use			
	Cropland (acres)	Pasture (acres)	Woodland (acres)	Idle (acres)	Misc. (acres)	Cropland (acres)	Pasture (acres)	Woodland (acres)	Misc. (acres)
I	1,580	389	836	363	22	3,168	.....	.....	22
II	11,477	2,506	2,892	6,639	1,724	21,463	721	1,330	1,724
III	17,048	4,212	3,984	10,456	3,401	30,241	2,621	2,837	3,401
IV	2,938	1,527	1,122	2,575	254	3,577	3,463	1,123	254
V	306	126	1,458	1,104	11	.....	1,536	1,458	11
VI	5,043	3,498	3,351	6,387	300	.....	13,439	4,840	300
VII	1,077	2,119	9,587	7,263	562	.....	6,107	13,939	562
Total	39,469	14,377	23,230	34,787	6,274	58,449	27,887	25,527	6,274

Table 16
Distribution of Land Use Classes in Each Erosion Group

Soil* Assoc.	Land Use	No Erosion Acres	Slight Acres	Moderate Acres	Severe Acres	Total
A1	Cropland	15	2341	2079	71	4506
	Pasture		892	530	205	1627
	Woodland	84	622	274	4	984
	Idle	13	2361	1695	212	4281
	Misc.		126	124		250
	Total....	112	6342	4702	492	11648
A2	Cropland			581	2320	2901
	Pasture			678	1671	2349
	Woodland		267	6936	2963	10166
	Idle			764	7454	8218
	Misc.			26	110	136
	Total....		267	8985	14518	23770
B1	Cropland	2118	3251	1458		6827
	Pasture	288	926	453		1667
	Woodland	454	1153	240		1847
	Idle	1261	2092	490		3843
	Misc.	558	419	77		1054
	Total....	4679	7841	2718		15238
B2	Cropland			91	2946	3037
	Pasture			336	2102	2438
	Woodland		15	484	2417	2916
	Idle			298	4558	4856
	Misc.			4	163	167
	Total....		15	1213	12186	13414
C1	Cropland	2428	5191	2627		10246
	Pasture	417	1037	912		2366
	Woodland	298	348	300		946
	Idle	813	1880	2029		4722
	Misc.	1972	868	390		3230
	Total....	5928	9324	6258		21510
C2	Cropland		52	148	2849	3049
	Pasture			82	2070	2152
	Woodland		118	176	680	974
	Idle			574	2365	2939
	Misc.			169	202	371
	Total....		170	1149	8166	9485
D	Cropland	2246	295	133		2674
	Pasture	282	75			357
	Woodland	94		87		181
	Idle	146	25			171
	Misc.	135	162			297
	Total....	2903	557	220		3680
E	Cropland	6229				6229
	Pasture	1421				1421
	Woodland	5215				5215
	Idle	5757				5757
	Misc.	328				328
	Total....	18950				18950
SM						442
	TOTAL	32572	24516	25245o	35362	118137

* Soil associations are discussed on page 31. See also soil association map, Figure 27, page 34.

determined by comparing them under the same crop, practices, length, and degree of slope.[21]

The extent of previous erosion also influences the soil loss. Factors were assigned the various erosion classes mapped in the watershed..21

Table 16A
Summary of Land Use and Erosion

	Acres in Each Erosion Group				
Land Use	No erosion	Slight	Moderate	Severe	Total
Cropland	13,036	11,130	7,117	8,186	39,469
Pasture	2,408	2,930	2,991	6,048	14,377
Woodland	6,145	2,523	8,497	6,064	23,229
Idle	7,990	6,358	5,850	14,589	34,787
Misc.	2,993	1,575	790	475	5,833
					+442
Total	32,572	24,516	25,245	35,362	118,137

The above considerations led to the development of the following equation which was used in determining the present rate of soil loss under the physical and cultural characteristics of the watershed at the time of the survey:

$$SR = CR \times S \times L \times SE \times E \times CP$$

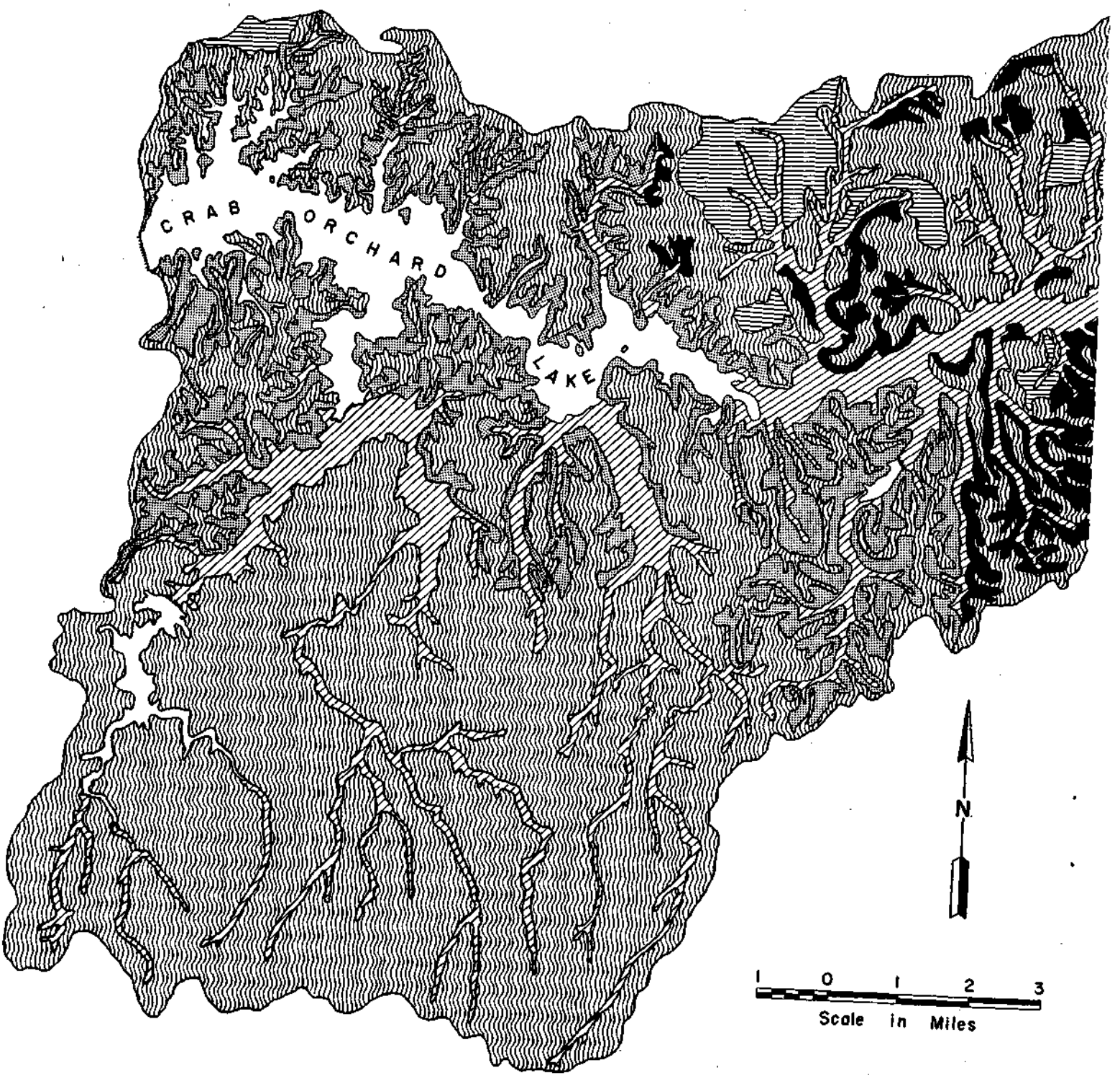
where SR = Soil loss in tons per acre per year
CR = Tons per acre per year loss measured from a standard rotation under known conditions
S = Degree of slope in per cent
L = Length of slope in feet
SE = Soil erodability factor
E = Present degree of erosion factor
CP = Cropping pattern factor

Table 17
Estimated Annual Tons of Soil Loss under Present Land Management

Slope & Erosion Groups[a]	Soil Association Areas[b]								
	A1	A2	B1	B2	C1	C2	D	E	Total
A0									
B0	13		647		747		432	–	1,839
B1	14,347		35,166		22,249		736	–	72,498
B2	830		1,621		814			–	3,265
C1	12,624		6,818		11,227		3,484	–	34,153
C2	29,703		26,252		54,043		2,674	–	112,672
C3	1,865			14,961		30,316			47,142
D1						1,914			1,914
D2		5,145		3,593		7,059			15,797
D3		71,672		101,847		88,924			262,443
E1		133		8		701			842
E2		1,155		858		1,879			3,892
E3		47,796		9,810		6,617			64,223
F1									
F2		3,368		213		28			3,609
F3		3,240		558		18			3,816
G2		845		20					865
G3				18		5,253			5,271
Total	59,382	133,354	70,504	131,886	89,080	142,709	7,326	–	634,241

[a] For definition of slope and erosion groups see pages 26 and 27.
[b] Soil associations are discussed on page;31. See also soil association map, Figure 27, page 34.

Table 17 presents a summary of the above computations which indicates that soil loss from sheet erosion under present management conditions is 634,240 tons per year. The greatest soil loss occurs in soil association area C2 and a considerable amount occurs in areas A2 and B2. This table shows further that the greatest soil losses occur on C, D, and E slopes with severe erosion.


CRAB ORCHARD LAKE
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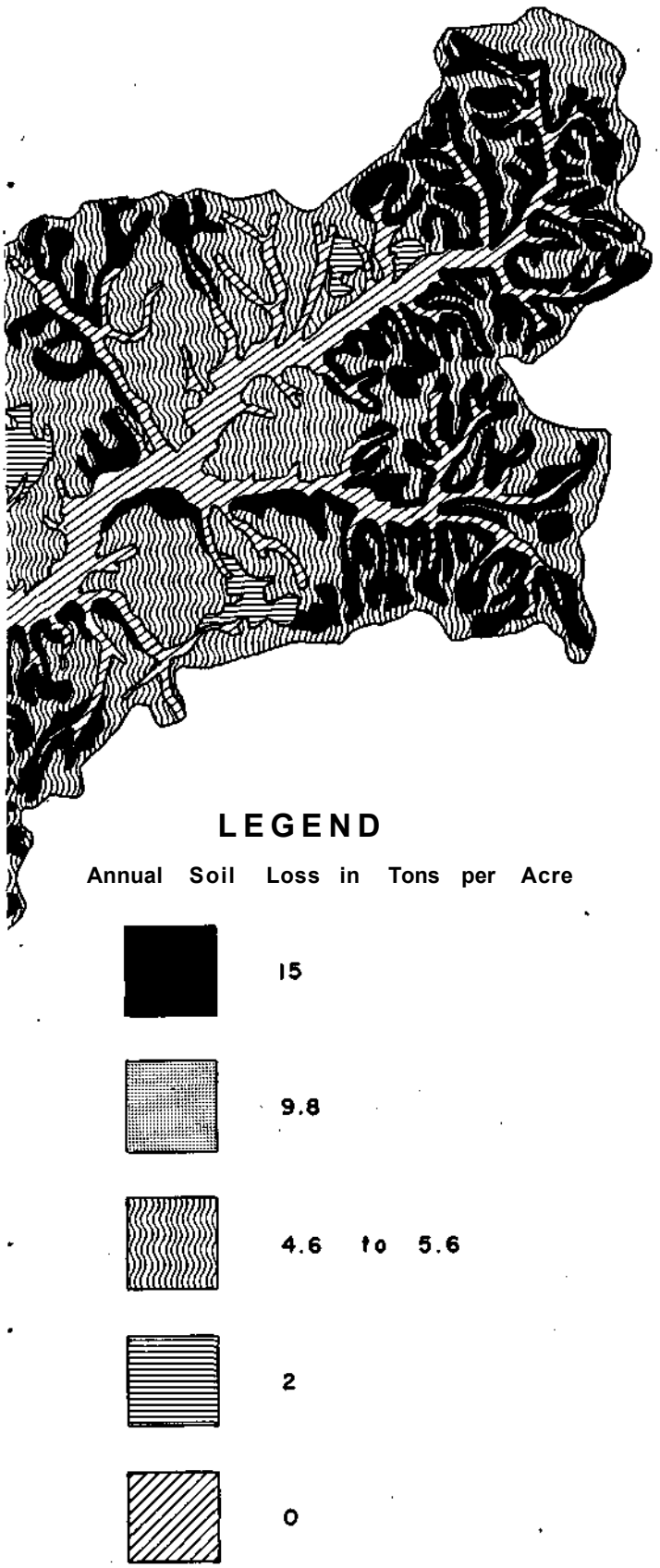

Figure 33 compares the relative soil losses from various areas of the watershed. On a ton-per-acre rate loss, the most critical erosion area is the steep eroded hillside area along Crab Orchard Creek and its tributaries. The present soil loss in this area is 15 tons per acre per year. The second critical area is the rolling land adjacent to the margins of the reservoir. The average rate of soil loss for the entire watershed is 5.4 tons per acre per year. Gottschalk and Brune[24] reported that there is a close relationship between the amount of gross erosion in a watershed and the amount of sediment deposited in the lake. Actual measured deposition (discussed in another section of this report) in the Crab Orchard Lake is 2.8 tons per acre per year. About 8.6 per cent of the sediment deposited in the lake originates from wave erosion of the lake banks, as has been shown earlier in this report. The remaining 91.4 per cent of the sediment, or 2.6 tons per acre per year, originates on the watershed. This 2.6 tons per acre per year is equivalent to 48 per cent of the average soil loss for the watershed of 5.4 tons per acre per year.

WATERSHED TREATMENT PROGRAM

SCOPE OF PROGRAM

Feasibility. Studies of reservoir sedimentation in agricultural areas in different parts of the country indicate that the sediment output from small watersheds can be reduced from 50 to 90 per cent by soil and water conservation measures. Because of the seeming feasibility of establishing such a conservation program on the Crab Orchard Lake Watershed, a detailed program and its possible benefits are presented in this section. The program, however, must meet the economic and social demands of the farmer. Since it is impossible to evaluate all of the essential economic and social factors in this case, the areas of usable land presented in this section may not represent precisely the most desirable over-all pattern of land use. They simply indicate how far it is possible to go and where changes might be made to improve use of land.

Changes in Land Use. The adoption of a good land use program is the first and most important step. However, in recommending land use changes and adjustments, it is necessary to have an accurate measurement and location of each soil type, slope class, and erosion class in each land use classification of the sample area. This land descriptive information is then converted into capability classes. From these capability classes the adjustments necessary for good land use are developed.

Generally, it is proposed that most of the Land Capability Classes V, VI, and VII now used for cropland be converted to either grassland or woodland use. There are minor exceptions to this general rule, where

[24] Gottschalk, L.C., and Brune, Gunnar M., Sediment Design Criteria For the Missouri Basin Loess Hills, U.S. Dept. of Agriculture, Soil Conservation Service, Milwaukee, Wisconsin, October, 1950.

some of the capability classes are distributed in such proximity to lands suitable for cultivation that it is not feasible to convert these lands to their proper use in accordance with capability. The same general rule applies to Class I, II, and III lands in woodland and grazing land use. These recommended land use conversions are also guided by type of farming and past experience in farm conservation planning in the area.

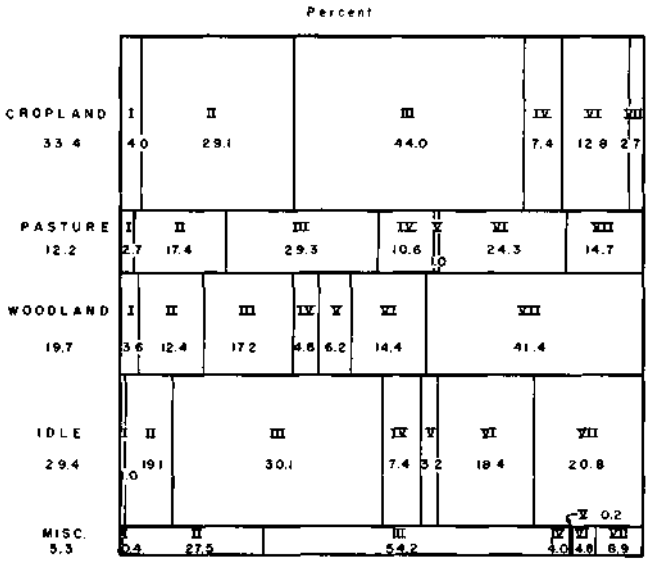

FIG. 34. PRESENT LAND USE.

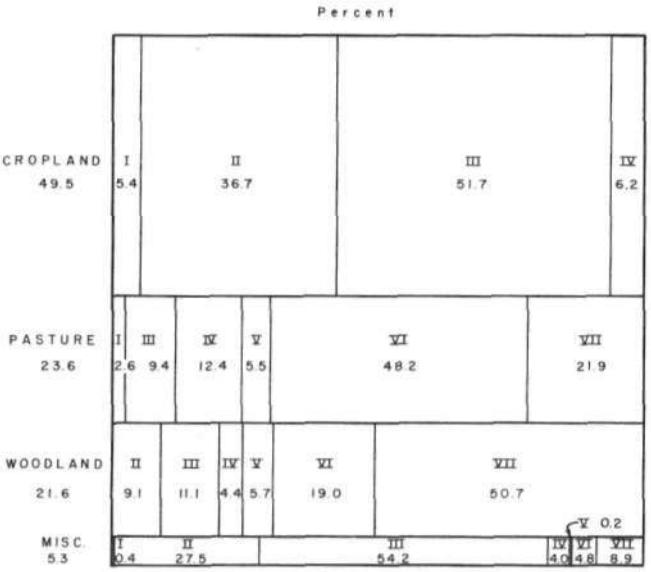

FIG. 35. RECOMMENDED LAND USE.

Figures 34 and 35 show the present and recommended land use patterns for this watershed. Figure 34 shows that out of 39,469 acres (33.4 per cent of total land area) now in cropland, 22.9 per cent is not suitable for continuous cultivation and should be managed under a permanent type of vegetation. Twenty-nine per cent of the land area (34,787 acres) in the watershed is idle and producing nothing of economic value to the owner. Slightly over 50 per cent of this idle acreage is suitable for cultivation. About 50 per cent now in pasture and about 30 percent of the land now in woodland are also suitable for cultivation.

Figure 35 is a graphic sketch of the recommended land use pattern and shows that the cropland can be increased to 49.5 per cent (58,449 acres) of the land area. Most of this cropland acreage is class I, II, and III land. An increase in the pasture land acreage is recommended by conversion of class VI and VII land now being used as cropland and idle land. The woodland acreage is slightly increased, the overall result of converting some of the class I, II, and III land to cropland and class VI, and VII land from idle and cultivation to woodland. The major increase in cropland is accomplished by the productive use of much suitable land which is now idle. Figure 36 shows level, idle land in the watershed which could be cropped.

FIG. 36. LEVEL, PARTLY BRUSHED IDLE LAND. This land could be converted Co productive cropland.

Conservation Measures. Not only are these land use adjustments required, but, in addition, conservation measures are needed in the watershed both to develop a more permanent and profitable agriculture and to reduce the rate of sedimentation in the lakes. A conservation program based on the land inventory has been developed for each sample area and expanded to depict the conservation needs for the watershed. The conservation measures recommended for this area are similar to those needed and being applied by cooperators of Williamson, Johnson, Jackson, and Union Counties Soil Conservation Districts. The Crab Orchard Lake watershed is located within the boundaries of these districts. The needed conservation measures are shown in Table 18 and are based upon the capabilities and treatment needs of the land. These measures are designed to keep the soil loss below two tons per acre per year.

This study has shown that much of the land within the watershed has been farmed with little thought to. conservation. It has also been indicated that some of the land has been farmed without consideration of the

Table 18
Needed Conservation Program for Each Soil Association Area of Watershed

	Cropland									Pastureland		Woodland-Wildlife		
Soil* Assoc. Areas	Soil Management Acres	Grass land farming Acres	Waterways Miles	Contouring Acres	Farm drainage Acres	Terraces Acres	Field diversion Miles	St. Cropping Acres	Land Clearing Acres	Pasture Imp. Acres	Pasture Seeding Acres	Forest Planting Acres	Wildlife & Wood Mgt. Acres	Misc.
A1	9526	170	.7	9285	77	1125	58.9		245	1133	113	24	739	250
A2	705	705	64.8	705			6.3			8946	6995	3880	13983	136
B1	12245	736	.6	10390	1852		28.3		472	788			1151	1054
B2	1234	1235	12.1	1235						7270	4833	1828	4743	167
C1	16381		8.4	14449		4230			379	1190			708	3230
C2	1468	1479	9.3	1479						6475	4402	196	1172	371
D	3287		1.5	1522	1764	819			140	56			41	296
E	13603				6060		85.3		1489	2029	1889		2990	328
TOTAL	58,449	4,325	97.4	39,065	9,753	6,174	178.8		2,725	27,887	18,232	5,928	25,527	5,832

*Soil associations are discussed on page 31. See also soil association map, Figure 27, page 34.

steepness of slope or erosion that has taken place.

As indicated in Table 15, a total of 58,449 acres is recommended for cultivation, 27,887 acres for pasture land and 25,527 acres for woodland. Out of the 58,449 acres of recommended cropland, 4,325 acres are recommended for grassland farming with a rotation of 0-1-4. The remaining cropland should be farmed to a 1-1-2 or 1-1-3 rotation with the needed supporting conservation practices. (The numbers refer to years of intertilled crops, small grain, and meadow, respectively. The recommended 0-1-4 rotation would thus be small grain followed by four years of meadow.) These recommended supporting practices are: construction of 97.4 miles of waterways, establishment of 39,065 acres of contour cultivation, surface drainage of 9,753 acres, construction of 6,174 acres of terraces, and 178.8 miles of field diversions and clearing of 2,725 acres of trees and large brush for cropland use. Of the recommended 27,887 acres of pastureland, 18,232 acres should be converted from idle land and cropland by seeding proper grasses and legumes. The total pasture land should be renovated when needed according to pasture renovation standards. Of the 25,527 acres recommended for woodland and wildlife, 5,928 acres should be planted to trees. On the rest of this land, good woodland and wildlife management practices should be followed. Figure No. 37 shows a multiflora rose planting which provides highly desirable wildlife cover.

FIG. 37. IMPROVING THE WILDLIFE HABITAT. Four year old Multiflora Rose fence and Bicolor Lespedeza furnish food and cover for desirable wildlife.

Under this needed program, pastureland woodland should be managed according to sound conservation standards. Grazing should be confined to pastureland and rotation cropland; timberland should be protected from fire and grazing.

Since the soils in the watershed are normally low in fertility, all cropland and pasture land should be tested and plant food nutrients applied according to tests.

Reduction in Soil Loss Under This Program. Probable soil losses for the lands in the watershed have been determined under the recommended conservation program. Research data has shown that such practices as contouring, terracing, use of meadow crops, trashy mulch cultivation and soil improvement admendments reduce soil erosion.[25] The soil losses from land farmed under these practices have been calculated by applying a factor to measured up- and down-hill cultivation loss with a known crop sequence. Factors have been assigned to the various conservation practices and rotation recommended in the treatment program by Van Doren and Klingebiel.2i

Table 19 shows that the annual soil loss can be reduced 90 per cent (to 60,369 tons) under the recommended conservation program. The average rate of soil loss for the watershed can be reduced from 5.4 tons per acre per year to 0.6 tons per acre per year. The greatest soil loss under the conservation program would come from cultivated lands with slopes ranging from 1-1/2 to 7 per cent with slight and moderate erosion.

25 Hayes, O. E. and Clark, Noble, Cropping Systems That Help Control Erosion. Bulletin No, 452, Wisconsin State Soil Conservation Committee, Madison Wisconsin, 1941.

Table 19
Estimated Annual Tons of
Soil Loss under Recommended Land Management

Slope & Erosion Groups [a]	Soil Association Areas [b]								
	A1	A2	B1	B2	C1	C2	D	E	Total
A0									
B0	9		428		496		190	–	1,123
B1	4,188		6,107		7,025		215	–	17,535
B2	114		288		168			–	570
C1	4,175		2,357		1,747		339	–	8,618
C2	7,556		3,653		7,749		329		19,287
C3	204			1,627		1,750			3,581
D1						91			91
D2		1,288		241		407			1,936
D3		798		1,478		1,019			3,295
E1		53		3		10			66
E2		156		93		20			269
E3		1,901		407		94			2,402
F2		811		38		11			860
F3		169		33		96			208
G2		508							508
G3				7		13			20
Total	16,246	5,684	12,833	3,927	17,185	3,421	1,073		60,369

[a] For definition of slope and erosion see page 31.

[b] Soil associations are discussed on page 31.
See also soil association map, Figure 27, page 34.

ECONOMICS OF SOIL CONSERVATION

Land Use History. A picture of the land use in Williamson County is given in Table 20. This table, based on the assessor's census data, shows the land-use picture for the years 1939, 1944, 1949, and 1950, as well as a three-year average for 1939-41 and 1948-50 and a ten-year average for 1940-49. The land use in the Crab Orchard Lake Watershed is shown in Table 21. Data for the years 1939, 1944, 1949, and 1950, based on the assessor's census, show that more meadow is grown on the farms in the watershed than in Williamson County as a whole. Somewhat less land is in intertilled crops and also less land is idle in the watershed. The size of farms is small, averaging approximately 80 acres with some 40 acres in cropland per farm. A high portion of the land in the watershed is listed as "odd tracts" in the assessor's census data. This land is largely in government ownership. Approximately 35,000 acres of the 118,000 acres in the watershed are in government ownership. Proper use of this land in government ownership would go a long way toward solving some of the land-use and conservation problems in the watershed. The map in Figure 38 shows ownership in the region.

Of the 1,481 farms in the watershed, as shown by the 1949 assessor's census data, 839 are growing corn and 352 are growing soybeans. Compared with 1939, fewer farms are growing corn and more are growing soybeans (Table 22).

A farm business survey in East and West Marion Townships in Williamson County was conducted in 1935, 1936, and 1937 (see Table 23). This survey covered a considerable amount of the area in the Crab Orchard Lake Watershed. At that time, a high proportion of the cropland was idle and both production and farm earnings were extremely low. The average net income per acre for the three years included in the survey was a minus $3 when an allowance was made of approximately $540 per farm for

Table 20
Farms, Acreage, and Land Use, Williamson County
(Based on Assessor's Census Data)

Items	1939	1944	1949	1950	3-year average 1939-41	3-year average 1948-50	3-year average 1940-49
Number of farms	2,156	2,273	2,595	2,452	2,262	2,405	2,399
Total land in farms (acres)	158,984	170,225	173,478	159,635	162,710	164,314	165,348
Total cropland in farms (acres)	96,400	101,685	110,189	86,216	100,195	95,665	100,831
Per cent cropland is of total land in farms	57	60	63	54	61	58	61
Acres per farm	73.7	74.9	66.8	65.1	71.9	68.3	68.9
Acres cropland per farm	44.7	44.7	42.5	35.2	44.3	39.8	42.0
Acres nonagricultural land in county (odd tracts)	18,941	69,573	91,749	96,236	33,258	95,801	70,490
Cropland Use							
Per cent cropland in:							
Corn	22	21	23	27	22	25	21
Soybeans	5	6	9	9	5	9	6
Other intertilled	7	5	4	5	9	4	6
Total intertilled	34	32	36	41	36	38	33
Wheat	5	6	5	4	5	6	5
Oats	3	3	2	2	3	2	3
Other small grain	1	1	–	–	1	–	1
Total small grain	9	10	7	6	9	8	9
Hay	17	14	11	16	15	14	14
Rotation pasture	27	22	25	20	28	21	23
Other grass and legumes	–	–	1	1	–	1	1
Total meadow	44	36	37	37	43	36	38
Idle	13	22	20	16	12	18	20

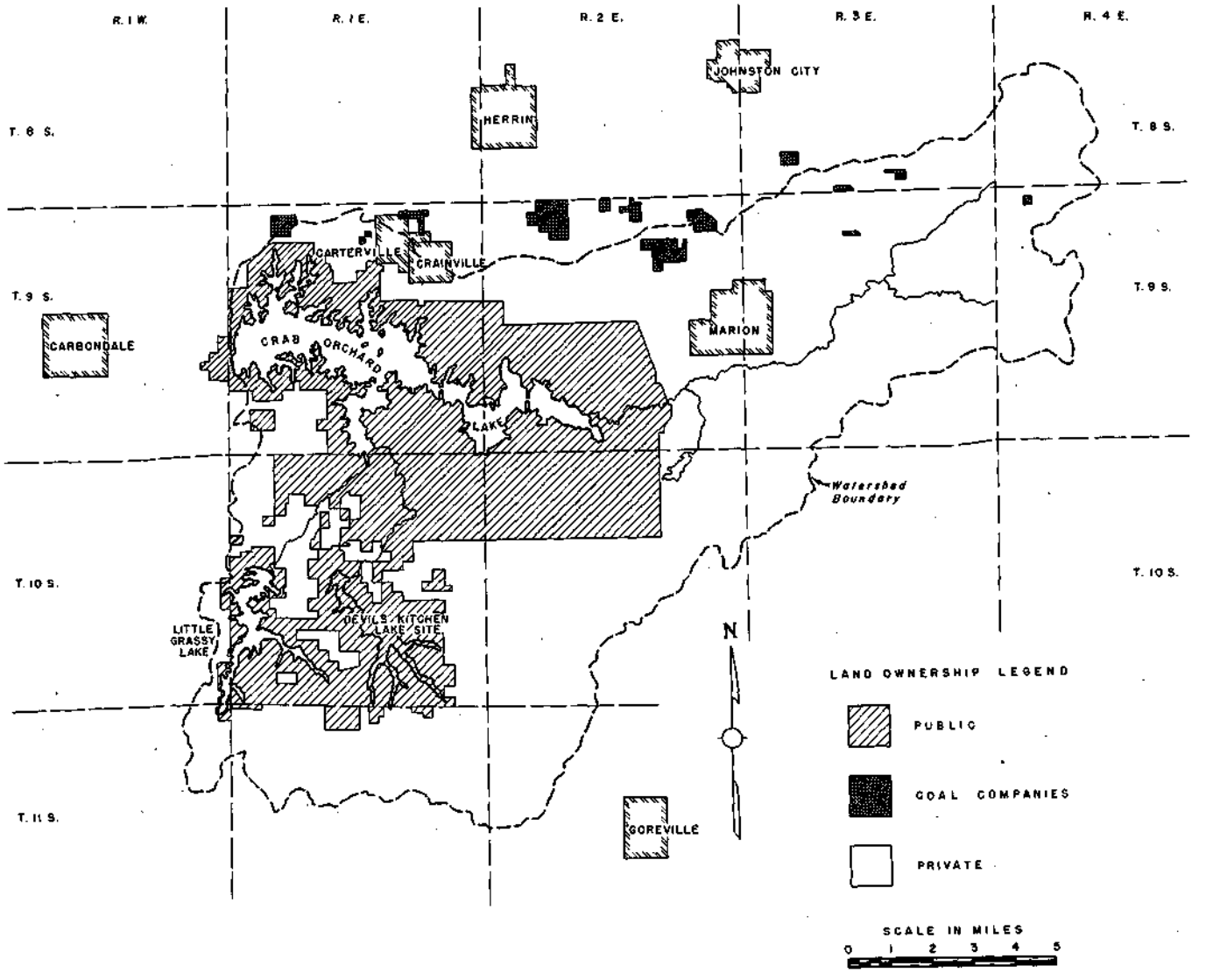

FIG. 38. LAND OWNERSHIP IN CRAB ORCHARD LAKE REGION

operator and family labor. The cash farm receipts above cash farm expenses averaged about $2.50 per acre for the 99 farms included in the survey. With improvements in land use and yields, together with higher farm prices, farm incomes in the area have been raised materially. However, they are still much below what they might be if good land-use and soil conservation practices were followed.

Present and Recommended Land Use. A picture of the present and recommended land use by land-use capability classes is given in Table 24. The present land use, as shown in Table 24, is based on the soil survey made for the watershed. The recommended land use takes into consideration the use of land in accordance with its capabilities so as to conserve and improve its productivity.

Yields, Production and Income

Before Conservation. The land use before conservation (1951), with estimated production of grain, hay, and pasture crops and their estimated value for the total watershed and per 100 acres in farms, is shown in Table 25. The yields used in estimating production are based on the five-year average (1945-1949) for Williamson County. The farm prices used are likewise a five-year average for 1945-49 and the pasture values are those which were estimated in a 1951-52 study of the production capacity of Illinois agriculture. The 1951 value of grain and hay production averaged $800 per 100 acres in farms, or $8 per acre. Adding the estimated value of pasture, the total value of crops (grain, hay," and pasture) was $10.88 per acre.

After Conservation. If the recommended land use pattern based on land capability data were followed in the watershed, there would be an increase in acres in cropland, pasture, and woodland, and approximately 35,000 acres of idle land would be put to productive use (compare Tables 25 and 26). In arriving at estimated production after applying a conservation plan, average yields from farm-account-keeping

Table 21
Farms, Acreage, and Land Use, Crab Orchard Lake Watershed (Based on Assessor's Census Data)

Items	1939	1944	1949	1950
Number of farms	1,475	1,478	1,481	1,386
Total land in farms (acres)	124,526	122,920	120,760	108,998
Total cropland in farms (acres)	69,979	66,446	65,431	45,961
Acres per farm	84.4	83.2	81.5	78.6
Acres cropland per farm	47.4	44.9	44.2	33.2
Acres odd tracts in watershed	15,776	46,724	54,574	60,982
Cropland use				
Per cent of cropland in:				
Corn	19	21	19	26
Soybeans	3	5	7	7
Other intertilled crops	4	4	4	4
Total intertilled crops	26	30	30	37
Wheat	4	7	5	4
Oats	3	3	2	2
Other small grain	2	1	0	0
Total small grain	9	11	7	6
Hay	21	11	13	26
Rotation pasture	30	25	37	22
Other grass and legumes	–	5	1	1
Total meadow	51	41	51	49
Idle	14	18	12	8

farms on similar soils were used. These farm-account-keeping farms in the area that had conservation plans were doing an average job. Some individual farms in the area, for instance, had corn yields of 70 to 85 bushels per acre after applying a recommended soil conservation program. Experimental field results on somewhat similar soils also show much higher yields

Table 22
Cropland Use Crab Orchard Lake Watershed (Based on Assessor's Census Data)

Items	1939	1949
Number of farms	1,475	1,481
Number of farms growing corn	1,051	839
Acres of corn per farm growing corn	12.6	15.0
Number of farms growing soybeans	167	352
Acres of soybeans per farm growing soybeans	10.8	13.6

than are used in the estimates in Table 26. Conservative estimates based on average yields possible of achievement by the average operator were made. Corn yields after conservation were estimated at 50 bushels, soybeans 22 bushels, wheat 22 bushels, oats 32 bushels, and hay 1.7 tons. The five year average (1945-49) farm prices were applied to the estimated production after conservation. The value of grain and hay crops were thus estimated at $1,497 per 100 acres in farms in the watershed or $14.97 per acre. The value of all crops-grain, hay, and pasture - amounts to $21.47 per acre.

Cost of Establishing Conservation. Table 27 contains a detailed estimate of all costs of establishing the recommended conservation program in the Crab Orchard Lake Watershed. Data are shown for the total watershed and per 100 acres in farms. The

Table 23
Comparison of Production, Earnings, and Investments Soil Conservation Service Farm Business Survey East Marion and West Marion Townships, Williamson County, 1935-1937

Items	1935	1936	1937
Number of farms	130	123	99
Average size of farm, acres	93.9	107.0	98.5
Gross income per acre*	$ 5.49	$ 5.83	$ 7.63
Operating cost per acre	9.95	8.39	9.53
Net income per acre	-4.46	-2.56	-1.90
Average value of land per acre	$ 21.00	$ 23.00	$ 22.00
Total investment per acre	40.00	43.00	42.00
Investment per farm in:			
Total livestock	$515.	$713.	$672.
Cattle	215.	295.	297.
Hogs	55.	87.	57.
Poultry	40.	58.	50.
Income per farm from:			
Crops	$-69.	$ 12.	$179.
Total livestock	431.	531.	516.
Cattle	100.	110.	121.
Dairy sales	157.	219.	211.
Hogs	79.	90.	103.
Poultry and eggs	88.	102.	76.
Cash income per farm	$598.	$914.	$859.
Cash expenses per farm	466.	700.	589.
Cash balance	132.	214.	270.
Average yield of corn, bu.	15	8	23
Average yield of oats, bu.	13	18	25
Average yield of wheat, bu.	7	10	18
Per cent of tillable land in:			
Corn	18	26	19
Oats	2	5	7
Wheat	14	12	11
Other cultivated crops	5	2	4
Legume hay and pasture	23	22	17
Non-legume hay and pasture	23	28	35
Idle	15	5	7

*Includes inventory changes.

largest items of expense are those for soil fertility improvements, including limestone, phosphate, potash, and nitrogen. The bases for estimating various items of cost are shown in the table. While many fields and some farms have been completely limed, other fields and farms have had no limestone applied, and it was estimated that an application of approximately three tons per acre for the watershed could correct the limestone needs. Similar estimates were used in arriving at the phosphate, potash and nitrogen needs.

The total cost of establishing a conservation program is estimated at $3,847 per 100 acres in farms in the watershed. This is an average cost of $38.47 per acres.

Increased Value of Crop Production. The value of the grain, hay, and pasture production before and after conservation for the total watershed, on a basis

Table 24
Present and Recommended Land Use by Land Use Capability Classes, Crab Orchard Lake Watershed

	Present Land Use	Recommended Land Use	
	Acres	Acres	Rotation
Cropland			
Class I	1,580	3,168	2-1-1
II	11,477	21,463	1-1-2
III	17,048	30,241	1-1-3
IV	2,938	3,577	0-1-4
V	306	- -	
VI	5,043	- -	
VII	1,077	- -	
Total cropland acres	39,469	58,449	
Pasture			
Class I	389	- -	
II	2,506	721	
III	4,212	2,620	
IV	1,527	3,463	
V	126	1,536	
VI	3,498	13,439	
VII	2,119	6,106	
Total pasture acres	14,377	27,885	
Woodland			
Class I	836	- -	
II	2,892	1,332	
III	3,984	2,837	
IV	1,122	1,123	
V	1,458	1,458	
VI	3,351	4,840	
VII	9,587	13,939	
Total woodland acres	23,230	25,529	
Idle			
Class I	363		
II	6,639		
III	10,456		
IV	2,575		
V	1,104		
VI	6,387		
VII	7,263		
Total idle acres	34,787		
Miscellaneous			
Class I	22	22	
II	1,724	1,724	
III	3,401	3,401	
IV	254	254	
V	11	11	
VI	300	300	
VII	562	562	
Total miscellaneous acres	6,274	6,274	

Table 25
Land Use, Yields, Production and Farm Income, Crab Orchard Lake Watershed Before Conservation (1951)

Items	Total Watershed		Per 100 acres in farms
Land Use			
Cropland, acres	39469		33
Pasture, acres	14377		12
Woodland, acres	23230		20
Idle, acres	34787		30
Miscellaneous, acres	6274		5
Total	118,137		100
		(per cent of cropland)	
Cropland Use			
Corn, acres	10657	27	8.9
Soybeans, acres	3552	9	3.0
Wheat, acres	2763	7	2.3
Oats, acres	1184	3	1.0
Hay, acres	7499	19	6.3
Pasture, (Rotation), acres	13814	35	11.5
Total	39,469	100	33.0
Production 1/			
Corn, bu.	341,024		289
Soybeans, bu.	56832		48
Wheat, bu.	46971		40
Oats, bu.	29600		25
Hay, tons	9299		8
Value of Crop Production 2/			
Corn	$504,715		$427
Soybeans	148,332		126
Wheat	94,412		80
Oats	23,680		20
Hay	173,798		147
Total crops	$944,937		$800
Pasture – value 3/			
Rotation ($17.37 per a.)	$239,949		$203
Permanent ($6.95 per a.)	99,920		85
Total pasture	$339,869		$288
Value of crops and estimated value of pasture	$1,284,806		$1088

1/ Using 5-year average (1945-49) yields for Williamson County—corn 32 bu., soybeans 16 bu., wheat 17 bu., oats 25 bu., and hay 1.24 tons per acre.

2/ Based on 5-year average yields (1945-49) and 5-year average (1945-49) Illinois farm prices - corn $1.48, soybeans $2.61, wheat $2.01, oats $0.80 and hay $18.69.

3/ Rotation pasture production per acre estimated at 75% of value of hay—permanent pasture at, 30% of hay value.

of 100 acres in farms, is given in Table 28. Using the conservative estimates of crop yields, grain and hay production would be worth an average of $6.97 more per acre per year on farms after applying conservation, and total crop production would be worth an estimated $10.59 more per acre per year for the total watershed. On the basis of a total cost of $38.47 per acre for applying the conservation program, four years of increased production resulting from such a program would pay for the cost of establishing it. These estimates do not show what is really possible with efficiently managed livestock, since rotation pasture is valued at $23.80 per acre and permanent pasture at $9.50 per acre. With comparable livestock prices, the annual gross value of pastures at Dixon Springs ranged from $50 to $100 per acre. Some farmers in the area of Crab Orchard Watershed are securing annual gross returns of $60 to $85 per acre from their improve legume-grass pastures. The pasture values as used in the estimates in Table 26 are based on the average returns secured on the lower half of the farm-account-keeping farms in counties adjacent to the Crab Orchard Lake Watershed. Figure 39 shows an example of a successfully renovated pasture in Illinois.

Observations indicate that it might take two to four years from the time a conservation program was

Table 26
Land Use, Yields, Production and Farm Income,
Crab Orchard Lake Watershed After Conservation

Items	Total Watershed		Per 100 acres in farms
Land Use			
Cropland, acres	58,449		49
Pasture, acres	27,885		24
Woodland, acres	25,529		22
Idle, acres	.....		..
Miscellaneous, acres	6,274		5
Total	118,137		100
		(Per cent of cropland)	
Cropland Use			
Corn, acres	9,749	17	8.2
Soybeans, acres	3,249	6	2.7
Wheat, acres	9,045	15	7.5
Oats, acres	3,876	7	3.1
Hay, acres	11,385	19	9.6
Pasture, (rotation) acres	21,145	36	17.9
Total	58,449	100	49.0
Production 1/			
Corn, bu.	487,450		413
Soybeans, bu.	71,478		61
Wheat, bu.	198,990		168
Oats, bu.	124,032		105
Hay, tons	19,355		16
Value of Crop Production 2/			
Corn	$721,426		$611
Soybeans	186,558		158
Wheat	399,970		338
Oats	99,226		84
Hay	361,745		306
Total crops	$1,768,925		$1497
Pasture - value 3/			
Rotation ($23.80 per a.)	$503,251		$426
Permanent ($9.50 per a.)	264,908		224
Total pasture	$768,159		$650
Value of crops and estimated value of pasture	$2,537,084		$2147

1/ Estimated yields per acre after conservation - corn 50 bus., soybeans 22 bu., wheat 22 bu., oats 32 bu., and hay 1.7 tons.

2/ Based on estimated yields after conservation and 5-year average (1945-49) Illinois farm prices - corn $1.48, soybeans *$2.61,* wheat $2.01, oats $0.80, and hay $18.69.

3/ Rotation pasture production per acre estimated at 75% of value of hay - permanent pasture at 30% of hay value.

started to achieve the increased production and income possible from such a program. The application of a high fertilization program would increase the costs somewhat but would materially speed up the results from the program. Based on the estimates in Table 25 to 28, the cost of establishing a complete conservation program could be paid out of increased crop production and earnings in a period of six to eight years. With the application of more fertilizer, the costs could be paid for in two to four years. In addition the capital resources of the farm would be not only maintained but materially built up and the farm would continue to produce at a profitable level.

Table 27
Estimated Cost of Establishing Conservation
Program in Crab Orchard Lake Watershed

Items	Total Watershed	Per 100 acres in farms
Limestone, 86,334 acres, 3 ton per a. at $3.75 ton. a/	$971,258	$823
Phosphate, 86,334 acres, 500 lb. Super per a. at $40 ton. a/	863,340	732
Potash, 86,334 acres, 250 lb. per a. at $70 ton. a/	755,440	639
Nitrogen, 86,334 acres, 200 lb. 20-0-0 per a. at $75 ton. a/	647,475	548
Waterways, 97.4 miles for watershed at $8.30 per mile. b/	80,842	68
Contouring, 39,065 acres in watershed. b/ (No cash outlay)		
Surface Drainage, 9753 acres in watershed at $4.50 per acre. b/	43,889	37
Terracing, 6174 acres in watershed at $3.70 per 100 linear feet for all terracing operations, including filling and wiring fences, and using 150 linear feet per acre. b/	34,266	29
Field diversions, 178.8 miles in watershed at $96 per mile. b/	17,165	15
Land clearing, 2725 acres in watershed at $40 per acre. b/	109,000	92
Pasture seeding and establishing, 18,232 acres in watershed at $24 per acre. b/ (fertilizer cost computed above)	437,568	370
Pasture improvement, 27,887 acres in watershed at $12 per acre. b/ (fertilizer cost computed above)	334,644	283
Forestry planting, 5928 acres in watershed at $25 per acre. c/ ($6.50 for 1200 trees, $14.00 for machine planting, plus $4.50 for tractor and driver)	148,200	125
Wildlife and woodland management, 25,527 acres in watershed at $4 per acre. b/	102,108	86
Total cost	$4,545,195	$3847

a/ Currently quoted (1953) costs of fertilizer materials spread on farm. Quantities based on soil tests and farmer data from farm account record and SCS cooperators on comparable land in area.

b/ Cost data adapted from regional study on economics of conservation practices and regional bulletin "Economics of Some Soil Conservation Practices".

c/ Forestry Department, University of Illinois, unpublished data (does not include fire protection, etc.).

The conservation needs in this area include fertility improvement, proper land use and rotations, and the application of erosion control practices. The productivity level and earnings of farms are very low unless a sound soil conservation and fertility improvement program is applied. Detailed studies in comparable areas show that the application of conservation plans make it possible to use the land more productively. The farms with conservation plans on

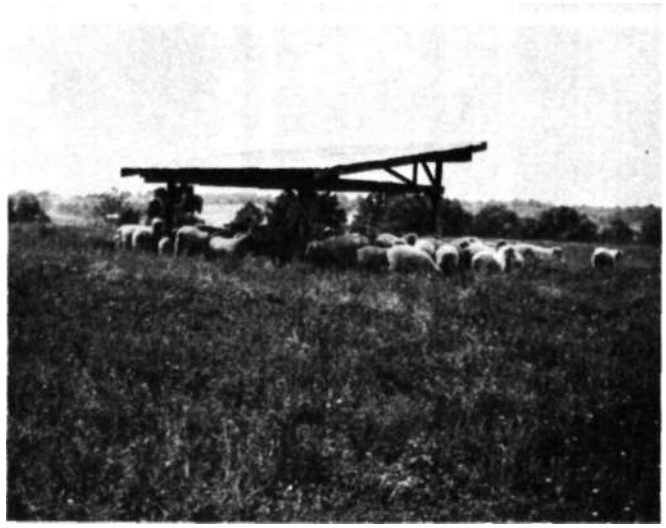

FIG. 39. ESTABLISHMENT OF IMPROVED HIGH-YIELDING PASTURES SUCH AS THIS PAYS HIGH DIVIDENDS. Costs may vary from $35 to $50 per acre plus annual maintenance costs of from $6 to $12 per acre. With efficient livestock these well managed pastures are producing from 250 to 400 pounds of sheep per acre per year.

comparable land usually have larger acreages in corn and soybeans, small grains, and improved hay and pasture, and much less cropland idle.

The lack of capital combined with current low earnings limit the application of conservation measures in this area. Studies of costs and benefits of soil conservation on individual farms in the area, as well as more complete studies in areas of similar soil resources, show that the application of conservation pays high dividends. Where the land is badly depleted and eroded, a considerable amount of money, effort, and time must be expended in order to build up productivity and earning power to high levels. A comparison of production and returns before and after adopting conservation on individual farms reveals that improvements varied with (1) the condition of the farm when the program started, (2) the speed at which the program was applied, (3) the amounts and kinds of fertilizer used, (4) the weather, and (5) the management of the owner and operator. Investments in conservation have paid dividends on most of the farms studied. The long-time average results clearly show that the key to increased production and farm income is the adoption of a combination of sound land use, soil and water erosion control practices, and more intensive use of adapted fertilizers.

Table 28
Comparison of Annual Gross Value of Crop Production Before and After Conservation, Crab Orchard Lake Watershed.

Items	Before Conservation	After Conservation	Difference
Total Watershed			
Value of grain and hay crops	$ 944,937	$1,768,925	$ 823,988
Value of pasture	339,869	768,159	428,290
Total grain, hay, and pasture	1,284,806	$2,537,084	$1,252,278
Per 100 Acres In Farms			
Value of grain and hay crops	$ 800	$1497	$ 697
Value of pasture	288	650	362
Total grain, hay, and pasture	$1088	$2147	$1059