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Iowa Lake, Emmet County, Iowa. Lake is a beautiful clear body of water one and one-half square miles in extent. It lies on the border between Iowa and Minnesota, one-half of it being in each state. It has high, wooded banks. It is a fine boating lake and fishing is good. It has great possibilities as a summer resort.

STATE OF IOWA

1916

17-27391
REPORT OF THE

STATE HIGHWAY COMMISSION

ON THE

Iowa Lakes and Lake Beds

J. W. HOLDEN, Chairman

A. MARSTON,

H. C. BEARD,

State Highway Commission

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Ames, Iowa, December 30, 1916.

HON. GEORGE W. CLARKE, Governor:

Pursuant to the provisions of Title XIV, Chapter 2-B, Supplemental Supplement, 1915, the State Highway Commission presents this report on the meandered lakes and the lake beds of the state. Special phases of the general subject have been studied by expert investigators and their conclusions are embodied herein under the following titles:

Report of Crop Surveys in the vicinity of various lakes to ascertain damages resulting from black birds. Prepared by Agricultural Experiment Station under direction of Prof. H. D. Hughes.

Report on the Vegetation of Iowa Lakes. Prepared by Department of Botany under direction of Prof. L. H. Pammel.

Report on Possibilities of Improving Iowa's lake shores by Forestation. Prepared by Prof. G. B. MacDonald, Department of Forestry, Iowa State College.

Topographic maps of seventy lakes, prepared by the Commission, accompany and are made a part of this report.

J. W. HOLDEN, Chairman.

H. C. BEARD.

A. MARSTON.

State Highway Commission.

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PART ONE

REPORT OF

STATE HIGHWAY COMMISSION

CHAPTER ONE---COMMISSIONERS' SUMMARY

TITLE XIV, CHAPTER 2-B, SUPPLEMENTAL SUPPLEMENT, 1915, DIRECTS THE STATE HIGHWAY COMMISSION TO MAKE AN EXAMINATION OF, AND A REPORT ON THE LAKES AND LAKEBEDS OF IOWA WHICH, UNDER AUTHORITY OF THE EXECUTIVE COUNCIL HAVE NOT BEEN DRAINED, OR IN THE DRAINAGE OF WHICH FIVE HUNDRED DOLLARS HAS NOT BEEN, IN GOOD FAITH, EXPENDED.

It further directs that the report shall divide these lakes into three classes, as follows:

1. Lakes that should be preserved, with an estimate of the cost of improvement.
2. Lakes that should be drained, the state retaining title to the land, together with reasons for drainage and an estimate of the cost, and of their value.
3. Lakes that should be drained and the land sold, with reasons for drainage and for sale, together with an estimate of the cost of drainage and of the value of the land when reclaimed.

The law authorizes the Highway Commission to use any employees of the engineering departments of the State College or of the State University of Iowa in making the required surveys and investigations and in the preparation of the report. Students of the above named institutions are to be allowed to assist in the work, without compensation.

Extent of Investigation Required.

The specific information which the Commission was directed to obtain for every one of Iowa's lakes has required two years of extensive field engineering, which has included the topographical survey of approximately 90,000 acres; the gathering of soil samples and taking of soundings; the inspection and classification of seventy lakes; the holding of numerous conferences with property owners, citizens and county officials; the preparation of seventy separate topographical maps; the making of estimates of cost for the proposed improvements and studies of special problems such as dredging, reforestation of lake shores, and farm crops in the vicinity of the lakes.

To gather this information within the time limit has tested every resource of the Commission. It has been necessary, at the cost of efficiency, to carry on the field engineering regardless of weather conditions.

The policy of the Commission has been to make all of the field work of permanent utility. Permanent bench marks and monuments have been established at each lake. Each map is so complete in detail that it may be used as the foundation plan for future action—and some action must be immediate if Iowa's lakes are to be conserved to her own uses.

For the most part they are surrounded by privately owned property and are inaccessible to the public except as trespassers. Volunteer efforts alone this year prevented Eagle Lake from breaking down the narrow earth dam between its waters and a nearby drainage ditch. Daily, sand gravel and boulders necessary for the protection of the lake shores are being taken away for private use. At Storm Lake this despoliation has been extensive. The community is endeavoring now to

FIG. 1—Tuttle Lake, Emmet County. This photograph shows the source of the east branch of the Des Moines River. The outlet here is cutting rapidly. Two dams placed here in the past, to protect the lake have been blown out by parties interested in lowering the level of the lake. A permanent dam should be erected by the state to prevent any further cutting.

restore along part of the shore the protection that nature once provided.

Iowa's lakes are, in general, rapidly losing their natural charms. They are becoming less attractive and less useful. Iowa's lake problem is acute. Iowa realized the value of her school lands after they were gone. Iowa should recognize the value of her lakes before it is too late.

Co-operation of State Departments.

This report has been made possible largely through the co-operation of a number of state departments because of the great interest held by these departments in the conservation of Iowa's lakes.

The State Fish and Game Department, under Warden E. C. Hinshaw, has maintained one field party on the surveys, under the direction of Mr. L. A. Wilson, who formerly made the lake surveys authorized by the Executive Council. This party has made surveys of eighteen lakes, taking a total of 12,061 acres of topography.

The Iowa State College through its Division of Engineering assigned Professors H. C. Ford, M. F. Costelloe and F. A. Dragoun

with a party of engineering students to make lake surveys during the summer vacation of 1915. This party surveyed seven lakes. During the summer vacation of 1916, a similar party of students in charge of Professors H. C. Ford and P. F. Hopkins made the surveys for three lakes. The surveys for these ten lakes required the taking of the topography of 13,175 acres.

The Agricultural Experiment Station detailed Clyde McKee, F. S. Wilkins, D. H. Zentmire, W. R. Hechler and J. A. Krall, who, under the direction of Professor H. D. Hughes, have made a thorough investigation of the damage done to farm crops by black birds in the neighborhoods of four typical marshy lakes.

Professor H. A. Scullen of the Department of Zoology has contributed an article on the food and nesting habits of black birds.

The Department of Botany assigned Instructors J. L. Seal and L. W. Durrell to the lake examination. These studies were made under the direction of Professor L. H. Pammel, who has prepared the report on lake vegetation.

The Department of Forestry, under the direction of Professor G. B. MacDonald has studied forestry conditions around the lakes. A thoroughly practical discussion of lake improvement through tree planting, together with estimates of the cost of the work as applied to certain representative cases, is included.

All of the above employees of the State and of the departments of the Iowa State College have served on this work without extra pay, their actual expenses in the field being audited from the general fund, as provided by law.

As authorized under the statute, the Commission requested the State University in May, 1915, to assign such employees as the University considered could be employed on the lake surveys without detriment to the work of the institution. At that time, no such employees were available. In July, 1916, the Commission was advised that an engineer would be available to survey the two lakes in Johnson county, but as this information was received after one of the field parties of the Commission had been sent to this work, it was not considered advisable to equip a new party to survey this small acreage.

Work of the Highway Commission.

The Highway Commission has, through its Department of Drainage, coordinated the work of the other departments, made surveys of twenty-four lakes, including 63,926 acres of topography, prepared maps of all the lakes, estimated the cost of drainage or of improvement, as the case demanded and compiled this report. During the summer of 1916, as fast as the maps and other engineering data were available, the Commissioners personally inspected each one of the lakes; conferred with property owners, citizens and public officials; investigated the special problems in connection with each lake and on the basis of all the information available, classified the lakes into the three classes provided in the statute.

Present Status of Lakes

In the report of the Land Department for 1899, Mr. G. L. Dobson, then Secretary of State, reported that the original plats of the U. S. Land Survey showed one hundred and nine meandered lakes with a total area of about 61,000 acres, belonging to the state. This lake report did not include a few meandered ponds and lagoons along the Mississippi and Missouri Rivers.

Some of these tracts have been re-classified as swamp land under the federal act of 1850 by the Department of the Interior, patented as such to the state, and by the state, to the county in which they are situated.

A few of the lakes have been sold by the county. Such sales were recognized by the state and provision made for issuing patents under Section 2900-A25 Supplement to the Code, 1907. This provision was later repealed.

Section 2900-A1, Supplement to the Code, 1913, authorized the sale of abandoned river channels and prescribed the method of procedures. This law affected only a few of the lakes along the boundary rivers.

Section 2900-A19, Supplement to the Code, 1913, authorized the Executive Council to survey the lakes of the state and to determine which should be maintained, and which drained, demised, or sold. Under this authority the Executive Council caused surveys of certain lakes to be made, part of which have been ordered maintained, and part of which have been drained and sold. There still remains a considerable acreage of these drained lake beds which has not been sold.

Under these various acts, the number of meandered areas belonging to the state has been reduced to the seventy separate lakes and lake beds which have been included in this report by the Commission.

General Findings of the Commission.

The Commission has endeavored to get a general view of the questions involved. The situation has been studied from many different angles. The relation which the lakes bear to the sanitation and to the reclamation of adjoining lands, and to crops in their vicinity have been examined. The value of the lakes as places of recreation and their probable value as farm land have been compared.

Private interests as well as those of the commonwealth have been duly considered in all cases where the two appear to conflict. The future development of the state, in so far as it can be foreseen, has influenced the conclusions reached in no small degree.

The Commission is strongly impressed with the growing importance of the lakes and the necessity for their preservation and improvement. The lakes are Iowa's birthright. Their ownership came to her when she became a sovereign state. Iowa holds her lakes as a trust for the public. The responsibility for the preservation and improvement of the lakes is hers, whether she will it or not. Except for a few isolated cases in which peculiar conditions govern, this investigation has led the Highway Commission to believe and to recommend that the state of Iowa should retain her lakes. Further the Commission is of the opinion that the state should adopt an intelligent policy of betterment.

In cases where drainage is advised, it is recommended that the state retain title to the land until such time as its reclamation is complete, its value as agricultural land fully established, and its sale value the same as the surrounding land. Where the lake bed is well located, and of sufficient size, it is recommended that the state retain the property for state purposes. A description of each lake with the Commissioner's recommendations and an estimate of the cost of carrying out these recommendations is included in this report.

Improvements Recommended.

Improvements recommended by the Commission are classified under the following heads: Regulating works, parks, roads, tree planting, water supply and deepening.

At many of the lakes it has been found that the outlets are cutting badly under the action of floods. In a few cases this natural action has been encouraged and expedited by selfish agencies. In all these instances

FIG. 2—North Twin Lake, Calhoun County. The illustration shows the best portion of the shore on this lake. This locality is now used as a private summer resort. By widening the belt of trees and extending the planting around the lake, a fine recreation ground could be provided. This is the north one of the pair of lakes, which the people of the county always refer to as Twin Lakes.

the construction of concrete dams at the outlets is urged as the first step to be taken for the preservation of the lakes.

An annoying and unnecessary condition exists at nearly all of the lakes. The lakes are public property, but except for the few places where highways touch the shores, they are surrounded by private land. The ordinary citizen, desiring to avail himself of the opportunities the lake offers for enjoyment, finds himself obliged to ask permission to use some stranger's land or to go upon it as a trespasser. Recreation grounds have been established at some of the lakes by owners of adjoining lands and the public may use these grounds as long as their expenditures make

the maintenance of such grounds profitable. That is, the public pays a tax for the right to enjoy its own property. The eagerness with which large numbers use these privately owned recreation grounds indicates the extensive use that would be made of public parks along the lake shores. The Commission recommends as a general policy, the purchase of suitable acreage along the lake shores and the opening of roads to connect with established highways. Where suitable natural groves are not to be found and where the natural timber has been cut off, the Commission recommends that areas be planted with trees. The cost and methods for these improvements are discussed fully in this report.

In a few instances at the largest lakes, the question of the advisability of building parkways around the shores has been considered. It is thought, however, that local people will make even more use of these driveways than will the state.

A co-operative arrangement between the City of Emmetsburg and the State has already demonstrated the value of this principal in improving and making publicly useful the lakes. The Commission recommends, therefor, the extension of this principle of co-operation to cities, counties or other municipalities in the making and paying for public parks, for opening and improving roads and for planting groves.

The water supply at many of the lakes is far from satisfactory, and the water levels fluctuate more than could be wished. In some localities the supply may be increased at a reasonable expense, by diverting the drainage of outlying tracts of land. In the reports on Rush Lake in Osceola County, and on Clear Lake in Cerro Gordo County, attention is called to such supplies, and it is urged that steps be taken by the proper authorities to secure such additional supplies.

Costs of Lake Improvement.

Heretofore, the state has not profited, as a state, from the sale of the lake beds which have been drained. The law provided that after the attendant expenses of surveying, drainage and incidental expenditures have been paid, the balance accruing should be paid into the county road funds of the particular county in which the lake was located. The Commission believes that any funds of this character should go for the improvement of the lakes which are retained.

Also, the law has heretofore made no provision for the complete drainage of these lake beds, and the sale prices have, as a general rule, been low.

The Commission has estimated that the beds of Birge and Grass Lakes in Emmet County, Swan Lake in Johnson County, and Tow Head Lake in Calhoun County, when properly drained and subdued for agricultural purposes, should be sold for approximately \$60,000. The estimated cost of draining these lakes, and in addition, Goose Lake in Greene County, is approximately \$55,100.00. That is, the sale of the lake beds which the Commission is recommending to be sold, should more than equal the cost of the thorough drainage of these lake beds, as well as the reclamation of Goose Lake. The Commission has recommended the retention of the

bed of Goose Lake for state purposes, which, when thoroughly drained and subdued will be a valuable farm of approximately 411 acres.

The estimated cost of necessary dams and regulating works is approximately \$72,000. In this amount is included an estimate of \$15,000 for a lock between Spirit Lake and East Okoboji.

The building of the outlet dams which is the most immediate improvement necessary at the lakes, excluding the estimated cost of the lock, would total approximately \$57,000.

The purchasing of parks and the building of connecting roadways, the Commission estimates, would cost approximately \$183,000. In meeting this expense, the state will receive assistance from both private and public sources. Approximately \$2,000 would be necessary to cover the cost of land which will be covered by the raising of the lake elevations. In some communities there is a strong demand for an increased depth of water in the lakes over that recommended by the Commission. It is quite pos-

FIG. 3—Cass Lake, Minnesota. The timbered shore line of this lake is controlled by the United States Forestry service. Hundreds of campers from Iowa as well as from Minnesota take advantage of the free camp sites offered here. Special permits are issued for the erection of summer cottages at an annual fee of \$5.00. The proceeds of these fees are used to pay the expense of foresters and caretakers for the lake.

sible that such communities would acquire without cost to the state, title to all of the land thus submerged.

The bank protection and miscellaneous expenditures are estimated by the Commission at approximately \$16,500. In such work, some of the local communities are already active and this sum does not represent the outlay that will be necessary to protect all of the banks on which such protection will be necessary.

Dredging is the most expensive improvement that can be made at any of the lakes, and yet, at the rate at which some of the lakes are filling, it will be necessary to carry on more or less extensive dredging as the years pass, in order to hold the lakes at a sufficient depth. The cost of dredging is discussed in the reports on the individual lakes.

The Commission is of the opinion that the less costly improvements should be carried out promptly, regardless of whether any extensive dredging is undertaken. In this manner the elevation of the lakes will be preserved, the parks and roadways will be rendering service, and the planting that is done will be developing and adding to the beauty as well as the utility of the lakes.

Dredging might well be carried on comparatively slowly, using only two or three dredging plants, and restricting the work to a reasonable annual expenditure on a limited number of lakes at first, especially those where local co-operation can be secured.

The rate at which such improvements can be carried on will depend partly upon the revenues which the General Assembly provides for the purpose and partly upon the co-operation extended by the various interested communities. The development of public parks is so firmly established as a policy in the larger cities and towns, that the Commission foresees the adoption of this principle in the townships, the counties and smaller municipalities. It is entirely practicable to make, near some of these lakes, community centers, which, with the development of agricultural Iowa, will become increasingly popular and profitable.

The State Game Warden, Mr. E. C. Hinshaw, has suggested a combination hunting and fishing license which he estimates will return sufficient revenues to properly develop the lake properties and keep them well stocked with fish.

The Commission does not feel qualified to discuss the propriety of such a license, but is of the opinion that should such a license be established, it will result in more rapid development of the lake properties than is likely to be possible without such revenues.

The surprising increase in the use of motor cars in the state, leads to the conviction that a large proportion of the population will soon be able to take advantage of the lakes much more frequently than has been true in the past. Iowa has occupied a backward position with reference to public parks of any character. Both the neighboring state of Wisconsin and Minnesota have state parks which are visited annually by thousands of people. The Itasca State Park in Minnesota, and the joint park along the Dells of the St. Croix River between Wisconsin and Minnesota are indicative of the spirit actuating Iowa's sister states.

The Commission submits that a program of lake improvement, even though calling for no greater expenditure than \$25,000 to \$50,000 per year, when used to encourage and to co-operate with local communities and municipalities will render large returns to the people of the state in the years to come.

Administration.

The management of the lakes in the future is an important consideration. It should be recognized that primarily this is a business proposition and should be handled as such. The property is large and scattered. Varied interests, both public and private are involved. As has been indicated, the cost of lake improvement to the state will be greatly decreased as the local communities become interested to the point of shar-

ing in the financial burden. The Commission is of the opinion that no new board or administrative unit is necessary. The state has already in its employ, men who are keenly interested in the development of the lakes and whose technical qualifications are of the highest. The improvement of the lakes can well be administered by the State Executive Council, who should be authorized to call on any of the state departments qualified to render the service which the Council desires.

The administration of the fish and game laws is centered in the office of the Fish and Game Warden. The work of this department is now devoted to the protection and propagation of fish and game. All matters connected with the fish and game in or around the lakes would be administered by this department. The authority of this department could be extended to include the policing of the lake properties to insure their proper use by the public.

Expert service on all technical questions relating to tree planting, as well as definite plans for each lake, can be furnished by the Forestry Department of the Iowa State College at slight expense to the state. Since a forest nursery is now maintained by the Forestry Department of the Iowa State College for experimental reforestation work, it is practical to develop this nursery sufficiently to supply the necessary trees and other planting material for forestation work.

Plans for road building and the superintendence of this work can be supplied by the Highway Commission in the same manner as for the state institution roads. In fact, the Highway Commission can readily supply all the engineering service needed in connection with lake improvement and maintenance. The lakes act as storage reservoirs to regulate floods and hence have a direct connection with highway bridges.

The problems relating to lake vegetation can be satisfactorily handled by the Departments of Botany at both the University and the State College.

The legal questions which arise would be handled by the Attorney General's Department.

The Commission is thoroughly of the opinion that the principle of co-operation urged between the state and the local communities in the improvement of the lakes can well be extended to provide all necessary technical advice and plans from the various state departments.

Financial Management.

The duties relating to the financial and construction details are involved and demand business training and executive ability.

There is considerable land drained under the former law which remains to be disposed of. The tiling, reclamation and renting of the lakes to be drained in the future are to be handled. On lakes to be improved, final plans are to be prepared, contracts let, and construction work supervised and paid for. Negotiations will have to be carried on for the purchase or condemnation of land. Claims for damages will have to be investigated and settled. The management will often find it important to get in personal touch with public officials, private landowners, clubs and

improvement associations to gain their co-operation, and at times their financial assistance in carrying on desirable improvements.

Legislation Required.

That Iowa's lakes may be preserved and maintained for her use and future enjoyment, the whole policy must be provided for and defined through legislative enactment.

The Commission submits for the consideration of the General Assembly, the following general principles:

1. The adoption of the general policy of lake preservation and improvement for the benefit of the people of the state and for useful purposes, such as providing recreation places for summer resorts, camping, boating, bathing, fishing and hunting; for furnishing ice supplies; for flood protection by acting as storage reservoirs and for possible climatic and agricultural benefits.

2. A provision for placing the administration of the lakes, including their preservation, improvement, and management in the hands of the proper state officials and employees, without creating any new board or administrative unit.

3. A provision under which cities, towns or other administrative units located contiguous to the lakes may, in co-operation with the state, condemn land for parks and for roads, which are needed to afford the public free access to the lakes.

4. A provision under which the state and counties, towns, townships and other public or private organizations may co-operate to improve the lakes and to share the costs on an equitable basis.

5. A provision for effectively controlling the use of the lakes and the public properties and for providing proper police regulations. This protection must include the shores, the trees, the roads and materials found in or on the shores, such as sand, gravel and boulders.

6. A provision regulating the construction of private improvements on the lake shores such as boat houses and piers. Also the use of motor and sail boats on the lakes.

7. A provision authorizing the management to regulate and, if thought advisable, to license concessions which are installed at the lakes for revenue purposes.

8. A provision authorizing the management to enter on private land and regulate its use when necessary to protect the lakes, such as may be necessary in shore protection; to advertise and let contracts; to alter channels of inlets and outlets; to divert streams, drainage ditches and tile drains; to fill water courses; to construct regulating works; to build roads, bridges and fences.

9. A provision authorizing the raising of lake levels and the appraisal and payment of damages.

10. A provision for changing the names of the lakes and granting general authority to prescribe proper rules and regulations for the use and protection of the lakes and all other properties connected therewith in which the state is interested.

11. A provision authorizing co-operation with the authorities of contiguous states or their sub-divisions or private property owners for the purpose of lake improvement. A number of Iowa's lakes are on the Minnesota-Iowa state line.

12. A provision for condemning, appraising and paying for land taken for lake purposes.

13. A provision defining and providing the revenues that may be used for purposes of lake improvement.

14. A provision providing for the disposal of land in lake beds which have been drained and for the drainage and administration of the lake beds which are to be drained and sold or drained and retained by the state.

15. A provision authorizing the management to make co-operative arrangements with the state departments and institutions to supply technical service and advice to develop state nurseries for lake shore forestation and to make use of available employees and equipment to assist in carrying into effect the general policy of lake improvement.

CHAPTER TWO---THE LAKES AND LAKE BEDS OF IOWA

Since many of the characteristics of Iowa's lakes date back to the time of their formation, a brief review of their origin will help to a better understanding of their nature. For the purposes of this report, they may be divided into two classes.

The first, and by far the larger class, comprises those lakes in the north and central parts of the state which owe their existence to glacial action. At three times during its geological history, Iowa has been invaded by glaciers. First the Kansan, later the Iowan and finally the Wisconsin ice sheets pushed down from the north, wiping out the then existing drainage lines, overriding the hills, filling up the valleys, and converting the State into a region somewhat resembling Greenland as it is today.

Each of these glaciers has in its turn retreated northward dropping as it went, the loads of debris which it had pushed and carried down from

FIG. 4—Little Wall Lake, Hamilton County. The shore line of Little Wall Lake is typical of the lakes which have formed by glacial action. This type of lake forms the largest class of lakes in the state. This is a famous hunting resort for central Iowa. There are no other lakes or marshes in many miles. These shores are barren and unattractive at present. The shore lines are high around a good portion of the lake and by forestation, beautiful camp grounds could be provided here. Tree growth would also prevent the soil erosion which is both destroying the shores and the lake itself.

the districts to the north and east. During these retreats, the waters from the melting fronts poured away to the southward, distributing the sands, gravels and clays which form our present prairies.

The last of these (the Wisconsin ice sheet) is the only one in which we are interested. This sheet entered from Minnesota and pushed southward in the form of a great triangle, its base reaching from Worth to Osceola counties along the Iowa-Minnesota line, and its apex reaching to the present City of Des Moines. Its outline may be traced today by low irregular chains of morainic hills or knobs which were heaped up along the edges of the ice. The area within these boundaries while compara-

tively flat is made up of low hills and shallow depressions. The natural drainage is very incomplete, and it is difficult to determine the exact limits of the water sheds. Many shallow ponds and undrained sloughs are encountered. Only the largest streams have real channels and even these have not as yet developed any system of tributaries.

During this glacial period, the first class of Iowa's lakes were formed. The lakes are generally small, nearly all of them are comparatively shallow and for the most part, the drainage areas tributary to them are too small to maintain a constant water level during dry years.

The second class comprises those lakes which lie near the two great rivers that form the eastern and western boundaries of the State. As all who are at all familiar with these streams know, they have not always occupied their present channels. During the ages in which they have been busy eroding the valleys which they occupy today, they have constantly been at work cutting away the banks and beds in some places, piling up

FIG. 5—Noble's Lake, Harrison and Pottawattamie Counties. The shore line of Noble's Lake is typical of the type of lake formed by the cutting off of a bend in a river. This type is the second and smaller class of Iowa lakes. This lake was formed by cutting off of a large bend in the Missouri River.

bars of sand and gravel in others, and so working back and forth across their flood plains in great bends and curves.

During the course of these wanderings parts of the old channels have been abandoned, their mouths filled in by later activities of the rivers and the old channel filled with the drainage from the country immediately surrounding them.

In this way our second class of lakes were formed. They lie low in the alluvial valleys of their parent stream only a few feet at best above the present water level and often subject to back water in times of flood. Their beds are shallow, their water sheds as a rule are very limited, and their banks low and rather unattractive. The Missouri River, because of the easily eroded nature of the material through which it flows, has been especially active in forming this class of lakes. It appears not unlikely that this same erratic river may later return and in a week undo its former work.

The streams which drain the lakes are slowly but surely cutting their valleys deeper, tending thus to lower the water surface. The streams which enter the lakes are constantly bringing down soil from the surrounding lands. This soil is dropped in the comparatively quiet waters of the lakes, and so the bottom is built up. Dust blown from the neighboring fields aids in the process. At last during some more than usually dry season rushes and other water plants begin to grow, adding their contribution of decaying vegetable matter. Thus if nature continues her work undisturbed, the shallow lake becomes a slough. The slough in its turn becomes a peat bog and finally emerges as dry ground, with the creek winding its way through a channel low enough to afford drainage to the tract. Among the lakes under consideration are found examples of each step in this process.

West Okoboji in Dickinson County is over one hundred and twenty (120) feet in depth. Duck Lake in Winnebago County is scarcely three feet deep. Depth alone, however, does not form a criterion by which the value of a lake may be judged.

Previous Administration.

During the earlier years of the state's history, as was but natural, very little attention was paid to her lakes. The country was new and sparsely settled, and plenty of cheap land was to be had. At that time also the reclamation of wet lands by means of drainage was neither understood nor practiced as is the case today. The country was dotted with undrained sloughs. Water fowl as well as other wild game was plentiful.

A few of the more shallow lakes were patented to various counties under the Swamp Land Act of 1850.

With the rising price of land, and the development of land drainage, a demand arose for the reclamation of the beds of certain of the meandered lakes, and in 1904 a law looking toward the accomplishment of this end was passed by the state legislature. This act (Chapter 2-E, Title 14, Supplement to the Code, 1913), under which a number of the lakes have been drained, authorized the Executive Council to survey the lakes and to determine which should be retained and which sold.

Proceedings were started by a petition to the State Executive Council for drainage, signed by fifty property owners, at least twenty of whom were residents of the township in which the lake was situated.

A survey of the lake was ordered and after a hearing, the Council determined what was to be done with the lake. In case drainage was determined upon, the actual work was carried out by the County Board of Supervisors, the State paying drainage assessments upon the lake bed in the same manner as did other property owners in the district. The net proceeds from the sale of the land, after the deduction of the cost of survey appraisement, drainage and sale, were returned to the county road fund.

Schedule No. 1 gives a list of the lakes disposed of, their location and size.

Schedule No. 2 gives a list of lakes, upon which the Highway Commission is directed to report, together with their location and size.

LAKES AND LAKE BEDS OF IOWA

SCHEDULE NO. 1—LAKES UNAFFECTED BY LAW OF 1915.

Lake	Sections	Township	Range	County	How Disposed Of
Bancroft	10-14-15	100	29	Kossuth.....	Act of 1904
Pass Lake No. 2.....	3-4	90-91	29	Webster.....	Sold by county, 1904
Pass Lake	33-34			Humboldt.....	
Big	13-18-19-24	91	29-30	Humboldt.....	Act of 1904
Boyer	11-14-15	75	44	Pottawattamie.....	Chapter 216 of 31st General Assembly
	22-23				
	21-22-27-28	76	44	Pottawattamie.....	Selected as swamp land under Act of 1850. 165 acres for right of way sold to John C. Welling, Ch. 185, 30th General Assembly
Brights	7-8-17				
Carr	29-32	100	22	Worth.....	Act of 1904
Cairo	13-12-24	74	43	Pottawattamie.....	Chapter 216 of 31st General Assembly
	18-19	87	24-25	Hamilton.....	Drained and patented to county as swamp land in 1895
Cheevers	20-21-29	99	34	Emmet.....	Act of 1904
Dry	14-15-22-27	80	45	Harrison.....	Drained and patented to county as Swamp land. Sold by county in 1881
Eagle	2-11-21	100	30	Kossuth.....	Act of 1904
Elbow	16-17-19	96	34	Palo Alto.....	Act of 1904
Goose	20-21				
	28-29-32-33	83	5	Clinton.....	Drained and patented to county as swamp land in 1886
Honey Creek.....	2-3-10-11	76	44	Pottawattamie.....	Drained by District No. 6, all land taxed
Impassable Marsh.....		91-92	27	Humboldt.....	Drained and patented to county as swamp land
Iowa	24-25-26	88	23	Hamilton.....	Declared swamp land by Department of Interior
	14-15-22-23				
Island	8-17	87	24	Hamilton.....	Act 1904. Previously sold by county
Lard	7-18	89	35	Sac.....	Act of 1904
Lily	22-23-26	99	35	Dickinson.....	Act of 1904
Minnewashta or Soldier.....		78	45	Harrison.....	Selected as swamp land under Act of 1850. Sold by county, 1899
Mud	25-26	94	35	Clay.....	Act of 1904
Muscatine Slough.....	7-17-18-20	74	2	Louisa.....	Act of 1904
	21-28-29				
Odesa and Keokuk Lakes..	26-27	76	3	Muscatine.....	Act of 1904
	13-22-23-24				
Owl	21-22-27-28	92	27	Humboldt.....	Drained and patented to county as swamp land in 1895

Pond Grove.....	10	86	33	Calhoun.....	Act of 1904
Rice	13-14-24	99	22-23	Worth and	
Pratt	18-19-20			Winnebago.....	Act of 1904
Round	31-32	99	37	Dickinson.....	Act of 1904
	13-14-23-24	86	45	Harrison.....	Selected as swamp land under Act of 1850.
					Sold by county, 1899
Rush	4-5-8-9	89	35	Sac.....	Act of 1904
Ryan	27-28-33-34	99	33	Emmet.....	Act of 1904
Sand Hill.....	10-11-12-13-14	86	47	Woodbury.....	Act of 1904
	23-24-27-34				
Swan (East).....	20-21-22	99	32-33	Emmet.....	Act of 1904
Swan and Rat.....	9-15-16-17	93	34	Pocahontas.....	Act of 1904
Sylvan	30-31	99	37	Dickinson.....	Act of 1904
1 and 2.....	31-32-6	99-100	36-37	Dickinson.....	Act of 1904
Wapello	30-31-25-36	75	2 and 3	Louisa.....	Act of 1904
Wabonsie	2 and 3	70	43	Fremont.....	34th General Assembly, Ch. 234

SCHEDULE NO. 2—LAKES REPORTED UPON UNDER THE
PRESENT LAW.

Lake	Sections	Twp. N.	Range W.	County
Babcocks.....	30 and 31	81	7	Johnson
Big.....	4-5-8-9	99	3	Allamakee
	16-17			
Big & Kains.....	13-24	100	4	Allamakee
Birge.....	12-13-18	190	32-33	Emmet
Blue.....	34-35-1-2-3-10	83-84	45-46	Monona
	11-12-13-18-14			
Brown's.....	28-29-32-33	87	47	Woodbury
Center.....	5-6-7 and 8	99	36	Dickinson
Clear.....	5-6-31 and 32	91-92	34	Pocahontas
Clear.....	21-22-23-24-26	96	22	Cerro Gordo
	13-14-15-16-20			
Little Wall or Cornelia.....	9-16	92	24	Wright
Crystal.....	9-10-15-16	97	25	Hancock
Dan Green's Slough.....	8-9-16-17-20	97	35	Clay
Diamond.....	10-11-14-15	100	37	Dickinson
Duck.....	20-21	100	24	Winnebago
Eagle.....	18-19-30	96	24 & 25	Hancock
	13-24			
Elk.....	36-1	95-96	35	Clay
Elm.....	21-22-27-28	92	24	Wright
Four Mile.....	18-13	99	34-35	Emmet and Dickinson
Gar.....	29-30-32	99	36	Dickinson
Goose.....	17	100	30	Kossuth
Goose.....	1-6-7-12	84	30-31	Greene
Grass.....	16-17	100	33	Emmet
Green Bay.....	26-27-28-29	68	3	Lee
	31-32-33			
High.....	14-15 and 23	98	33	Emmet
Hottes.....	7-8-17-18-19	100	36	Dickinson
Iowa.....	11-12-14	100	31	Emmet
Iowa.....	9	100	39	Osceola
Jefferson Slough.....	31-32	99-100	36	Dickinson
	5-6			
Little Spirit.....	7-8	100	36	Dickinson
Little Wall.....	9-10-15-16	86	24	Hamilton
Lizard.....	22-27	91	31	Pocahontas
Lost Island.....	31-32-5-6	96-97	34 & 35	Clay and Palo Alto
	36 and 1			
Marble.....	17-18-19-20	100	36	Dickinson
Medium.....	32-5-7-8-18	96-97	32-33	Palo Alto
	19-24			
Mud.....	11-12-13	98	33	Emmet
Mud Hen.....	1 and 2	96	3	Allamakee
Nobles.....	2-35	77-78	45	Pottawattamie and Harrison
Okoboji (East).....	32-34-3-4-10	99-100	36	Dickinson
	11-14-15-16-17			
	20-21			
Okoboji (West).....	1-2-11-12-13	99	36-37	Dickinson
	23-24-25-26-35			
	36-19-30-31			
Pickereel.....	1-36	93-94	35	Buena Vista and Clay
Pleasant.....	7	99	35	Dickinson
Prairie.....	23	99	36	Dickinson
*Round.....	13-14-23-24	80	45	Harrison
Rush.....	30 and 31			
	25 and 36	100	39-40	Osceola
Rush.....	20-21	94	34	Palo Alto
Silver.....	16-20-21	88	4	Delaware
Silver.....	33 and 34			
	27-28-29-32	100	38	Dickinson
Silver.....	14-15	100	22	Worth
Silver.....	28-29	95	34	Palo Alto
	18-19-20-21			
Spirit.....	8-9-10-11-14-15	100	36	Dickinson
	16-17-20-21-22-27			
	28-29			

SCHEDULE NO. 2—LAKES REPORTED UPON UNDER THE
PRESENT LAW.—Continued.

Lake	Sections	Twp. N.	Range W.	County
Storm.....	4-5-8-9-10-11 14-15 and 16	90	37	Buena Vista
Swag.....	9 and 10	100	30	Kossuth
Swan.....	22-23-26-27	100	35	Dickinson
Swan—West.....	25-36 29-30-31	99	32-33	Emmet
Swan.....	32-33-4 and 5	80-81	7	Johnson
Tow Head.....	23-24	89	34	Calhoun
Trumbull and Round.....	34-3 22-23-26-27-35	96-97	35	Clay
Tuttle.....	10-11-12	100	32	Emmet
Twelve Mile.....	20-21-29	98	34	Emmet
Twin Lakes—East.....	19-20-29-30	94	24	Hancock
Twin Lakes—West.....	24-19-25-30	94	24-25	Hancock
Twin Lakes—North.....	1-32-33 23-27	88-89	32-33	Calhoun
Twin Lakes—South.....	1-2-11-12	88	33	Calhoun
Twin Sisters.....	28-29	93	24	Wright
Virgin.....	29-30	96	34	Palo Alto
Wall.....	33-34-35 2-3-4	86-87	36	Sac
Wall.....	2-3-10-11-14-15	90	24	Wright
Welch.....	23-24-25-26	100	37	Dickinson
Wood Lake.....	24	96	25	Hancock

*Nothing was found in the state records to show that this lake had been disposed of. After its survey a record of its sale by the county was found at the county seat.

Legal Status.

The question as to whether the federal or the state government holds title to these lands is frequently raised. This matter was thoroughly discussed by Milton Remley, Attorney General for the state in an opinion rendered to Governor F. D. Jackson. (Iowa Documents 1900, Vol. 2, Land Dept., page 94). His conclusion was that the state by virtue of its rights as sovereign, holds title to all lakes.

The term meandered lake is used in describing those bodies of water, which at the time of the division and sale of the public lands surrounding were set apart and retained as government property. Meander posts were set at each point where a section line intersected the shore. A meander line was then run, following the shore line, from one of these posts to another until the whole lake had been encircled. The instructions for the survey, directed that these meander lines, wherever possible, be run along the high water line.

The courts have held that this line was surveyed, not as a boundary between the land retained by the state and that sold to private owners, but to permit of the lake being outlined on the map and that the areas of the fractional pieces of land might be computed. Private property abutting on meandered lakes is bounded by the ordinary highwater line, and the boundary moves with that line when it changes slowly, through the processes of nature. If a change takes place in a sudden, violent, or artificial manner, the boundary of such property remains as before.

The Examination.

In undertaking an examination of the scope required under the present law, the need of reliable maps upon which the information collected regarding each lake could be recorded, and which could be used as the basis for making estimates of the cost of drainage or of improvement, at once become apparent. The maps of certain lakes, surveyed by the Executive Council were available, and after having been reduced to a uniform scale, were used. A map of West Okoboji had been made by the Civil Engineering Department of the State College and this also has been used. Aside from these mentioned, no maps were to be had. Surveys of the remaining lakes were at once begun and because of the limited time, carried forward regardless of weather conditions.

Following a provision of the law, a party of engineering students in charge of Professor Ford began the work of survey in June, 1915. Weather conditions were unfavorable for field work throughout the summer. On the first of September when they returned to their school work, seven lakes covering an area of 7,135 acres had been completed.

FIG. 6—Group of three lake bed survey parties at Lost Island Lake, Palo Alto County. These parties were in charge of S. A. Schackle, H. S. Leicht and W. M. MacGibbon.

At this time, it was apparent that the work could not be completed with the aid of students only. Two surveying parties under H. S. Leicht and S. A. Schackle were placed in the field by the Commission during the fall of 1915 and a third party under W. M. MacGibbon, in the spring of 1916. The weather during the winter of 1915 continued very unfavorable for field work, with deep snow and extremely cold weather. These three parties have made surveys of twenty four lakes, covering 63,926 acres of topography.

In October 1915, the Fish and Game Department put a party in the field under the direction of Mr. Reeves. This party surveyed eighteen lakes, taking a total of 12,061 acres of topography.

In June, 1916, a party of engineering students from Ames, took up the lake survey under the direction of Professor Ford. During the summer they completed the survey of three lakes, taking topography of 6,040 acres.

In all fifty-two lakes have been surveyed. The topography of 89,162 acres has been taken.

It was realized at the start that the area to be covered was large and the work however done, would be expensive. In view of these facts it seemed best to make the surveys reasonably complete, so that the same ground would not have to be gone over in the future. Carrying out this idea, permanent concrete monuments were set in protected locations near each lake. These will prove useful as the work of lake improvement is undertaken.

The question of the advisability of running levels from lake to lake so that all the surveys might be referred to a uniform base level (sea level) was considered. Keeping in mind the various uses to which such maps would be put, the expense of so doing did not seem warranted. Each survey was based on a datum plane assumed one hundred feet below the water surface in the lake except where two or more lakes were connected. In that case the levels were carried from the lowest lake.

A uniform scale of five hundred feet to the inch was determined upon for the field maps. The details of field work varied in the different parties. In general, transit and stadia or plane table methods have been used, and the maps drawn on the ground.

The first step consisted in running a control traverse by chaining or by stadia. Latitudes and departures were computed, the survey closed, and the transit points plotted on the field sheets by co-ordinates. Topography sufficient to locate the shore line, and lines five feet and ten feet above the shore line was then taken and plotted up. All buildings, fence lines, section corners, roads, tile drains, ditches and other natural and artificial objects that might have a bearing on the disposition of the lake were carefully located. The lakes were sounded to obtain the depth of water. Borings were made to determine the character of the bottom and in many cases lines were run down the outlets till fall enough to give good drainage was found.

Watershed lines have been mapped to show the area of land which drains into each lake. Some of them were obtained from county drainage maps, others were traced out on the ground. All computations have been independently checked before the work was turned into the office.

Engineer's Examination.

While the survey was in progress a careful examination of the conditions surrounding each lake was made by the engineer in charge, R. W. Clyde. While conditions at the various lakes differ somewhat, in general the problems encountered are very much the same, and may be discussed under the following heads:

Drainage of Surrounding Lands.

Attention has before been called to the fact that the region in which the lakes are situated is of very recent origin and that its natural drainage systems have not yet developed. Thus it is, that in many instances there are shallow sloughs in the vicinity of many of the lakes whose natural outlet is through the lake but which are so little above the lake surface that they cannot be tiled successfully. The owners of the land desire to drain it. It is recognized that this desire is a laudable one, but it should be remembered that the land was purchased with an understanding of conditions, often as a speculation, and never with any assurance that the rest of the commonwealth would waive its rights to the enjoyments of the lake, so that the individual might benefit.

In some few instances these low lands may be drained in some other direction, without decreasing the water supply of the lake enough to be

FIG. 7—Noble's Lake, Harrison and Pottawattamie Counties. This photograph shows the damage done to the shore line of the lake by erosion. It also shows the unsuccessful efforts made by private parties to protect the shore line and save the grove on the lake bank in which their home is located.

objectionable. In a few instances the area to be drained is large enough to warrant the installation of a pumping plant which will lift the water into the lake. Attention has been called to these possibilities in the reports on individual lakes.

At many of the lakes investigated tile has been laid from surrounding land which outlets at the present lake level. In such cases, where the lake is of a character to warrant improvement, it has been considered best to recommend deepening of the lake rather than raising its level. The question as to whether the placing and maintaining of such an outlet, without objection from the State, has established a right to such an outlet is purely a legal one.

Sanitation.

A plea for the drainage of many of our lakes has been made on the ground that they were detrimental to the public health and welfare, leaving it to be implied that drainage would improve such conditions.

The inspection shows that the plea has been very much exaggerated. Viewing the matter from a practical standpoint, it is interesting to note that because of a water supply, the first settlements in the lake region were made on the lake shores. Many of these people are fine, hearty old men and women and so far as can be seen have never suffered from their proximity to the lakes.

From the point of view of the modern sanitary inspector, the chief danger to be feared in swampy localities, is malaria fever. It is well understood now that this disease is transferred from one person to another by the mosquito. Only one of all the different varieties of mosquitoes, the Anophelines, carries malaria and only the female of this variety. They dislike foul water and choose clean, shallow water for breeding places preferably little pools of rain water. Moreover, experience has demonstrated that under ordinary conditions they seldom travel over a thousand feet from their hatching place. A tin carelessly thrown out or a sagging eavestrough has often proved to be a serious point of infection for a construction camp. When the condition of the average farm yard is considered, it is apparent that the first fight on malaria should be made near home.

Natural Water Supply.

The drainage areas tributary to Iowa's lakes are nearly all small. This fact should be recognized from the start. It is not possible to maintain an absolutely uniform water level in the lakes, for which a desire is frequently expressed. Nature has not made the lakes that way. The rainfall varies in quantity from year to year, and in distribution throughout the months of the year, and this variation cannot be foreseen. The lakes will inevitably be higher some years than they are during others, but this will not prevent their use as pleasant outing places.

Improvements can be carried out in such a way as to practically control these variations. In the case of lakes which become too shallow to be used during the summer, a properly arranged dam at the outlet will store a foot or more of the spring flood water. This extra depth of water will in a large measure take care of the summer's evaporation and make the lake usable throughout the year.

In the case of lakes to be deepened it is advisable to use the spoil in building up land for park purposes in the former lake bed. This will decrease the lake area, materially reduce the losses by evaporation, and so conserve the water supply. It is a well known fact that the evaporation from plants may be as much as three times that which takes place from open water. From this it is seen that killing off the water plants will aid in conserving the available water.

Nearly all our lakes receive some part of their water supply from underground flows and with some of them this constitutes the most important source of supply. Considerable quantities of water from the sloughs and undrained portions of the country find their way into the sands and gravel of the glacial deposits. Some of these gravels may be in prehistoric stream beds, along which the water travels with comparative ease until it outflows in the form of spring in one of the lake beds. Clear

Lake in Cerro Gordo County affords a good example of a large lake with a limited watershed, which is maintained in this way. It is well to note in this connection that the drainage of surrounding lands will decrease and may entirely shut off such flows.

In a few instances, it will be practical to divert drainage from outlying lands toward the lake. Where this is practicable attention has been called to the fact in the reports on individual lakes. In a large number of cases, however, the lakes occupy relatively high ground and no supply of this kind is to be had.

Artificial Water Supplies.

An examination of data published by the Iowa Geological Survey shows that artesian water can probably be found under the entire lake region.

FIG. 8—Douglas Lodge, Itasca State Park, Minnesota. This is the largest state park in Minnesota. Part of the park was granted by Congress but thousands of acres of private holdings were bought by the state to create this famous resort. The state has built and maintains Douglas Lodge, the hotel, and a number of cottages for the accommodation of visitors. The state regulates the rates and the service in the hotel.

The St. Peter sandstone, best known of Iowa's artesian water supplies, underlies the entire area, at elevations ranging from 800 feet above sea level in the northern part to 500 feet below sea level in the southern part. The artesian head varies from 1200 feet above sea level in the northern part of the state to perhaps 1,000 feet above sea level in the southern. As the ground surface varies from 1265 feet above sea level at Lake Mills, 1413 feet at Spirit Lake and 1500 feet at Sibley to 1100 feet above sea at Jefferson and 1,000 feet at Ames it is evident that water obtained from this source would have to be raised with pumps.

There are other artesian supplies, notably those in the vicinity of Webster City, which come from gravel deposits just below the Kansan drift. Eagle Grove also draws her city supply from flowing wells part of which comes from the gravels and part from underlying limestone. It is not probable that flowing wells will be found near the lakes, a large number of which occupy relatively high ground.

Throughout the lake regions good water supplies are to be found in the general deposits at depths ranging from fifty to three hundred feet. It is from this source that the railroads which traverse the district most frequently draw water for their locomotives. The water in most cases is of good quality and the quantity sufficient for their needs. While it is not probable that pumping will prove a practicable means of providing a water supply for Iowa lakes, it is often suggested and deserves some discussion.

The rainfall and evaporation records for the State show that for one month the evaporation may exceed the rainfall by five inches. During two consecutive months it may exceed the rainfall by eight inches. During three consecutive months it may exceed the rainfall by about nine inches. This last figure appears to be a reasonable one to adopt for a pumping plant. At this rate, one 8" well will furnish water for twenty-six acres, if pumping is carried on twenty-four hours a day.

The following table shows the theoretical horse power, the brake horse power and its equivalent in kilowatts necessary to supply water for one hundred acres of lake when pumping against different heads. The friction head loss in pipe has been assumed as twenty feet.

Power Required to Raise Water for 100 Acres.

Height in Feet	Theoretical H. P.	Brake H. P.	K. W.
5	1.19	2.38	1.78
10	1.43	2.86	2.13
15	1.67	3.34	2.49
20	1.91	3.82	2.85
25	2.14	4.28	3.19
30	2.38	4.76	3.55
35	2.62	5.24	3.91

It is estimated that the pumping plant including, pump, motor, building and grounds will cost \$5,400 for a lake of 100 acres, \$8,700 for a lake having an area of 200 acres, and \$12,000 for a lake having an area of 300 acres, or roughly from \$40 to \$54 per acre of lake surface. No estimate can be given of the cost of the power line to the pumping plant as this will vary with the location.

Fixed charges, which include interest, depreciation and insurance may be taken at 13 per cent that is to say from \$5.20 to \$7.02 per acre of lake. Electric power for pumping water costs from 1½ to 10 cents per kilowatt hour. Assuming that we are to pump against a thirty-five foot head, that we pay 5 cents per K. W. H. and that an attendant is paid ninety dollars a month, the cost of operation varies from \$2.78 an acre per month for

a lake of one hundred acres to \$2.17 per acre per month for a lake of three hundred acres.

As an example Cornelia Lake in Wright County has an area of 262 acres. The cost of the plant may be estimated as $262 \times \$41.26$ equals \$10,810. Fixed charges will be $\$10,810 \times .13$ equals \$1,405. Operating expenses during dry years may be as high as $262 \times \$2.23 \times 3$ equals \$1,753 per year. These operating expenses while somewhat high, seem reasonable when the small size of the plant, its isolation, and the small percentage of the time it will be in operation is considered. This same plant with slight additions can be used for the drainage of lowlands lying near the lake. The two uses would in no way conflict one with the other. For each acre of lake supplied, nearly $\frac{1}{2}$ acre of land could be reclaimed. By so doing the initial cost chargeable to lake improvements will be considerably reduced.

A discussion of the question of water supply will not be complete without attention being drawn to the possibility of damming some of the rivers of the State and thus forming artificial lakes with an abundant and never failing natural water supply. In some instances this would seem to be the logical and economical method to adopt.

Silt Deposits.

The questions of the depth of water which should be maintained and of the silt deposits are very intimately related in lakes of moderate depth. A great variety of opinions are expressed relative to the rate at which such deposits accumulate. The present survey shows depths of almost liquid mud ranging all the way from a few inches to several feet in different lakes.

A large number of the lakes of the State range from six to ten feet in depth under present high water conditions. With water four feet deep, rushes and other water plants gain a foothold and may persist through two or three years of higher water. It seems evident then that the extensive silt deposits which are forming are a serious menace to the beauty and utility of a large proportion of our lakes.

That this same condition is found in other reservoirs and in drainage districts is shown by the following instances:

In 1908 the Hill View drainage district of Illinois, which has a drainage area of some 18,500 acres, was established. In 1914, after six years of operation, they let contracts for the removal of 90,000 cu. yds. of silt from their ditches at a total cost of over \$16,000.00.

The Indian Grave drainage district established in 1914 in the same state has recently been put to an expense of between \$30,000.00 and \$40,000.00 for the removal of silt.

At the lower Otay dam in California, which recently failed, it was found that between five and six feet of silt has accumulated in the reservoir during the nineteen years of use. A large part of the water which filled this reservoir came from conduits and was considered very clean.

Unquestionably the breaking up of the prairie sod which has left the soil exposed to the action of both wind and water, has greatly accelerated the rate at which these deposits are made. As Iowa's land rise in value, the farmer will not sit calmly by and see his best soil carried away. Some inexpensive precautions in the way of check dams and terracing will pre-

vent an appreciable part of this erosion. The State might well set an example in undertaking this work.

At some of the lakes it will be found cheaper to catch this sediment, before it enters the lakes, than to remove it after it is once deposited. In some instances (as has been done in drainage districts) it will be possible to provide settling basins located in the low lands near the inlet. A shallow portion of the lake itself may sometimes be utilized for this purpose by a dividing dyke.

Dredging.

The soft black slit deposits as well as the sand and gravel which form the beds of Iowa lakes, can all be moved with suction dredges. The soil so removed can nearly always be used to advantage in building up low lands around the lake. It would appear that in reclamation work of this nature the state should be in a position to profit from the land so reclaimed, either through a contract with the owners or by purchase and resale.

A depth of fifteen feet of water is required to insure safe winter quarters for fish. With a depth of less than this, fish may winter safely for several years in succession, but a sudden cold snap followed by snow, will seal the lake tightly and result in their death by suffocation. With a hard bottom a contingency of this kind may be provided for by the excavation of holes of limited area. Where any considerable amount of semi-liquid mud occurs, such a plan will not prove practicable, as the first wind storm will stir up the mud and it will settle again in the deepest water.

A modern suction dredge having a twelve inch discharge pipe, and engines powerful enough to pump against the heads required, will cost from \$15,000.00 to \$20,000.00, depending on the length of the discharge pipe and the number of pontoons required.

It is suggested that a combination of suction and dipper dredge can be developed which will avoid the necessity of moving more than one hull to the lake where work is to be undertaken.

Before this work is undertaken a competent consulting engineer should be employed to go over the ground and advise as to methods of handling the work and the type of machines to be used. Such advice should save the State many times its cost.

Bank Protection.

The question as to what the state should undertake in the way of bank protection will be raised. It will be argued on the one hand that the State has never done such work before, that it will lead to a never-ending source of expense, that it is the private property owner who suffers from the encroachment of the lake and hence, that he should foot the bills for protection. It will be urged that the courts have held that where the shore line of land bordering on a meandered lake changes slowly and imperceptibly either by adding to the land or by perceptibly washing the soil away, the boundary line follows the new shore line thus made.

On the other hand, where wave action on the lake is undermining vertical banks, large quantities of earth fall into the lake. This earth is broken up and carried into the lake by shifting winds, and eventually deposited on the lake bottom. Our lakes are too shallow as it is, and the State as well as the land owner will find their best interests served by some kind of protection which will maintain the banks approximately in their present location.

Office Work.

The office work has consisted in inking the field sheets and making tracings for each lake. Areas of lakes and water sheds have been found with a planimeter. Meander lines were plotted from the government notes. No attempt was made to retrace the old meanders in the field. They have been fitted onto the maps in what, everything considered, seems to have been their most probable position. In the majority of cases these meanders have followed the lake shores better than was expected. In a few instances large discrepancies, probably due to some error in the original surveys have been found. Preliminary and final reports have been prepared for each lake examined.

Inspection.

With all the information obtained, the Highway Commission has, during the Summer of 1916, visited each of the lakes in turn, and looked over conditions on the ground. During these trips an effort has been made to meet the local people who were interested in the situation and to get from them any additional data which they might have to offer, as well as to get their point of view. These conferences have proved very valuable and have given the Commission a grasp of the numerous problems which are to be solved that they could have obtained in no other way. The results of each inspection together with recommendations as to the disposition of the lake are embodied in separate reports in Chapter Two.

Estimates.

Estimates, as required by law have been prepared covering the cost of drainage and of improvements. Where drainage has been recommended a very thorough reclamation of the lake bed has been provided for. Main ditches are to go deep enough to provide efficient tile outlets for the entire area, after the shrinking of the soft mud in the lake bottom. The cost of the tile and of labor has been figured at current prices.

In estimating the cost of outlet dams permanent construction has been contemplated. The overflow section is to be of concrete with only sloping surfaces where there is danger of ice pressure. The foundation is of piling. A cut-off of steel piling has been provided at the up stream face as a protection against the danger of undermining and the action of burrowing animals. An ample apron on the down stream side and wing walls at the ends have been included in the estimates. Their length has in most cases been computed so that with a two foot head they will discharge an amount of water per day equal to a half inch of runoff from the drainage area. In a few cases where it has been thought wise to prevent any marked change in the lake level a much larger capacity has been provided.

The prices used in estimating the value of lands for park purposes have been largely a matter of judgment. No particular tracts of land have been selected at the different lakes. After making certain that a desirable location for a park exists the price has been estimated from the value of surrounding lands. Prices used in the estimate have varied from \$150 to \$300 an acre.

Meadow land which will be overflowed by raising the level of a lake has been estimated at from \$30 to \$100 per acre.

The cost of dredging is difficult to determine without knowing the condition under which the work is to be done. The size of the dredges used, the amount of work to be done in each locality and the disposition to be made of the spoil, as well as the nature of material to be excavated all are factors which will affect the cost. A price of fifteen cents per cubic yard has been used in the estimates. This is thought to be safe. In some instances the work can be done for less.

Conclusions.

The lakes are deteriorating under the action of natural forces and if the present plan is pursued it will only be a matter of a few years until they have nearly all passed from public to private ownership. Contrasted to a short sighted public policy of this sort, it is possible for the state, with very reasonable expenditures, to hand down to the coming generations a system of publicly owned parks and play grounds whose value can hardly be estimated.

There is at present a demand for outing places, due largely to the larger radius of travel made possible by the automobile, which the private resort owners have failed to meet in an adequate manner.

That this demand is a growing one the Commission is convinced. There are hundreds of men who do not care to spend a vacation at a big resort where a carnival spirit prevails. These same people would welcome an opportunity to spend a week with their family in some quiet camp or cottage where they could watch the children grow brown and strong, even if the fishing and boating were not of the best.

It is often argued, in speaking of a lake, that it is all grown up to rushes and water plants, thus assuming in the first place that such a lake is of no use, and in the second place that it must always remain worthless unless drained. Both these assumptions are wrong. A lake in which the water is all deep and open is by no means an ideal one except as it is pleasing to the eye. Fish require shallow quiet water for spawning grounds. Wild game shuns the open water and seeks localities where shelter and food are to be had.

One class of people find rest and recreation mingling with the crowds of a popular resort. A second class prefer a day's tramp with only a dog and gun for company. A third find their pleasure in the quiet hours spent with a rod and line. Are the needs of one class greater than of the other two?

If we are to make good our American boast, that a million men who can shoot and who know life in the open stand ready to respond to the

president's call, it will not be out of place for the State to retain a few of the shallow lakes where these men may get their training in a way which is pleasant and which harms no one.

Such a course of action will be entirely in keeping with the policy of the State in passing laws for the protection of fish and game and in collecting a hunting license.

During the progress of the investigation the Commission has taken opportunities, when offered, to inspect the beds of lakes already drained to determine their actual value as farm lands. Several of these lake beds were found supporting a crop of weeds, shoulder high. The ground under foot was soggy and good for nothing else. A few were used in whole or in part for pasture land. On only two were farm crops actually found growing.

These conditions are due to several reasons. In the first place the plans for drainage have often been entirely inadequate. The ditches have been too shallow to drain the water from the deep soft mud of the lake bottoms. Rice Lake in Winnebago County is an example. The lake was drained in 1906. In 1916 a stagnant pool of water covers several acres in the south central part of the lake bed. The remainder is a marsh, too wet to afford safe footing and covered with a rank plant growth. Plans on file in the county auditor's office show that the bottom of the ditch was to be four feet above the bottom of the deepest part of the lake. The outlet ditch is eight miles in length and it will cost a large sum of money to deepen it enough to afford good drainage to the lake bed. The people in the vicinity are dissatisfied and wish the lake restored. The fact that some thirteen thousand dollars have been legally collected as assessments on the district above the lake, complicates the situation.

A second reason is that the purchasers of the beds have often lacked capital to properly tile the land and to plant and subdue it. Such land is heavy and requires considerable time and work before it can be expected to produce common farm crops. Making allowance, however, for these conditions it must be admitted that the development of the land has been distressingly slow.

This brings us to the third, and what appears to the Commission to be the principal cause of the conditions found to exist in the drained lake beds. In a large number of instances there has been no real demand for the drainage of the lake bed itself except as it offered the cheapest outlet for the drainage of surrounding lands. The prices at which much of this land has been sold bears out this conclusion. Taken as a whole the results obtained by lake drainage are discouraging from the State's standpoint.

The work of preserving and improving the lakes and of making them accessible to the public, their owners, is a legitimate function of the State, and directly in line with similar undertakings which are being carried on by the federal and other State governments. The United States owns and manages several national parks. It exercises a very strict supervision over their use by the public and over private enterprises such as hotels and transportation lines which depend for their patronage upon tourists drawn there by the parks.

Minnesota has in all about 43,500 acres in state parks. The largest of these, Itasca State Park, includes some 20,000 acres part of which was donated to the State by Congress. The State has expended approximately \$175,000 acquiring private holdings. Here the State has built a hotel called Douglas Lodge, and several cottages for the accommodation of the public. They prescribe the rates which may be charged for board, for rooms and for saddle horses and teams, and exercise a supervision over the kind of meals that are served.

Persons desiring to camp in the park are issued a permit for the nominal sum of fifty cents. A deposit of five dollars is required to insure compliance with the regulations. This park as well as the Burntside State Forest is under the jurisdiction of the Minnesota Forest Service.

CHAPTER THREE---REPORT ON INDIVIDUAL LAKES

LAKES IN ALLAMAKEE COUNTY.

Lake No. 1, Big Lake; No. 2, Big Lake; No. 3, Kain's Lake; No. 4, Mud Hen Lake. Survey made by the Mississippi River Commission. Inspection made September 22-23, 1916.

The four lakes covered by this report are, Mud Hen Lake, in Sections 1 and 2-96-3, which lies just to the east of Waukon Junction; Big Lake, Sections 4-5-8-9-16 and 17-99-3, which is located to the north and east of Lansing; Kain's Lake, Sections 24 and 25-100-4, just east of Kain's siding, and Big Lake, Sections 13 and 24-100-3, which lies south and east of New Albin. The first two are most easily reached by motor boat from Waukon Junction and Lansing. The last two are easily reached on foot from New Albin during low water, or by boat from the same place when the river is high.

If reference is made to a county map, it will be seen that the Mississippi River, near Waukon Junction, and from Lansing north to the state line, lies well over to the eastern part of its valley. The land between the main channel of the river and the Iowa bluffs (which are followed by the railroad) is cut up by a network of auxiliary channels, bays and ponds. The four lakes in question are simply four of the largest of these ponds.

Big Lake near New Albin is partly grown up to water plants; Kain's Lake is almost entirely overgrown; the lower two are open water. At the time of our inspection, in September, the water in these lakes ran from four to six feet deep. The gauge at McGregor stood at 5.1. Low water on this gauge is 0.0. High water is 21.5. The banks stood from four to six feet above the water level and were covered with a thick growth of scrub timber and brush.

No attempt was made to make a survey. The Mississippi River Charts of this section, are complete and accurate.

The areas, as taken from the meanders are Big and Kain's 200 acres, Big Lake near Lansing 679 acres, Mud Hen 164 acres.

The entire valley is subject to overflow when the river is high. The upper Iowa River empties into the Mississippi just to the south of New Albin. In times of flood its waters come nearly into the town and spread out over all of the flat country to the south and east. Very little effort is made by land owners to bring the bottom land near these lakes under cultivation. It is undoubtedly true that during some seasons an abundant crop might be harvested, but experience from year to year with the attendant loss of seed and labor has made them regard an occasional crop as hardly worth the risk. Hogs and stock are allowed to find pasture as they can.

The lakes themselves serve as valuable breeding places for fish. Constant watching is necessary to prevent them from being seined out by parties of fishermen who come in for that purpose.

There are many acres of land in this vicinity that may ultimately be diked off from the river, and reclaimed by pumping. This will be a scheme for private capital. It will be expensive and will not be undertaken for years to come.

Recommendations.

The Commission recommends that these lakes be retained in their present condition. Only one improvement can be suggested. At times of low water the fish which hatch here sometimes perish from lack of air during the winter. It is suggested that at Big Lake near Lansing and at Mud Hen Lake opposite Waukon Junction, artesian wells might be bored, which would keep some open water during the winter months and thus save the fish.

Artesian water should be found at a depth of from two hundred to two hundred fifty feet. Such wells as are desired can be bored for about three dollars a foot, making the whole expenditure not to exceed fifteen hundred dollars.

STORM LAKE, BUENA VISTA COUNTY.

Lake No. 5. Survey made by the State Highway Commission. Inspection made August 10, 1916.

Storm Lake occupies parts of sections 4, 5, 8, 9, 10, 11, 14, 15, and 16, of township 90 north, range 37 west. The City of Storm Lake, a town of twenty-five hundred people, lies on the north shore of the lake. The Illinois Central, Minneapolis and St. Louis, and the Chicago, Milwaukee and St. Paul Railroads, render the lake accessible from every direction. Public highways skirt the north, west and east shores of the lake.

Storm Lake is the natural playground for a considerable area of country. Spirit Lake and the Okobojis are about fifty miles to the north; the Twin Lakes in Calhoun County are about forty miles to the east; Wall Lake in Sac County is about thirty miles to the southeast.

The lake is a nice open sheet of water from seven to nine feet in depth. The banks are high except for a short distance on the east, and

where the inlet enters from the northwest. A large slough at the inlet and a smaller one a little to the south, are the only areas of low land in the vicinity.

On the west shore of the lake, at what is known as Casino Park, a good sized summer resort is established. All the usual amusements are provided, and large crowds are attracted. During the summer, a launch makes regular trips to and from the town.

The lake has been stocked with fish and fair catches are made during the open season. Due largely to the lack of shelter, no great amount of hunting is done in the immediate neighborhood of the lake.

The park board of the city has established a public park which extends for over half a mile along the north shore of the lake, and has just gone to considerable expense, gathering and planting the various kinds of trees that are natives of the state, and in grading and protecting the lake bank along the park front.

The city of Storm Lake draws water for municipal use from the lake. The effluent from the city sewage disposal plant east of town, is discharged into the lake. Some complaint has been made of the odor which arises from a minute green plant-like growth that appears in water during the month of August. This seems to be a condition that is common to all of Iowa's lakes and which does not usually prove objectionable except in years of low water.

Several tile enter the lake at various places around the shore, but as far as could be determined, all of them have been placed so as to have satisfactory outlets. The lake has an area of 3,080 acres. The meander encloses 3,060 acres. The water shed consists of 20,230 acres.

Although the lake varies somewhat in level from year to year, the water supply may be said to be fairly satisfactory. The main inlet is a ditch from the northwest that drains a considerable area of country.

The outlet to the lake is to the southeast into the Raccoon River, but the lake is exactly on the divide, and within the memory of early settlers, flood waters have gone to the Boyer. The county board of supervisors, co-operating with the Commercial Club of the City of Storm Lake, have installed and kept in repair a concrete dam, some seventy-two feet long at the outlet of the lake. Sand, gravel and clay, form the lake bottom, although in places, this is covered with deposits of silt.

Legal Status.

The ordinary high water level has been fixed by the courts in the case of the State of Iowa vs. Terrence Thomas, et al., which was tried in the November term, 1912. This suit was brought to prevent the hauling away of sand from along the lake's edge. The court decree made permanent a temporary injunction which had been issued as to the defendants in default, to-wit, G. H. Edwards, W. J. Schoner, and the Lake Side Stock Farm Company. The case was appealed to the Supreme Court, and affirmed.

At the time of this inspection, wagons were being loaded with sand taken from the lake bed at the east end of the lake. This deliberate

spoliation has been going on for years. First, the rock which protected the lake shores and now the sands also are being taken for private use. If the lake is to be preserved, an equal quantity of hard materials will have to be shipped in and deposited around the lake shores. Naturally, the state will be expected to foot the bill. Immediate steps should be taken not only to remedy the laws if they are inadequate, but what seems more important, to see that they are rigidly enforced.

Members of the Storm Lake Commercial Club have offered to co-operate in the prosecution of offenders, but suggest that the high water marks as established by the courts, be marked out on the ground to aid in the ready determination of the facts in any given case. This could easily be done if the high water line were a fixed line. Unfortunately, this is not the case, for the courts have held that where the shore line changes slowly from year to year, the ownership of property changes with the shore line.

Special Problem.

The question of bank protection is by far the most important which should be considered in connection with this lake. For the preservation of natural banks, or where bank protection is undertaken by the state, it is not sufficient that the states have jurisdiction up to high water mark alone. The action of both waves and ice which tear down the banks, extends beyond this line. Unless means can be provided whereby the state can protect the natural rock along the lake shores, and the material she may see fit to deposit for bank protection, no money should be spent for such works.

There is in all, a mile and a half of bank where the lake is cutting badly. At some places, this is at the rate of about fifteen feet a year. The banks vary in height from ten to twenty-five feet. In other locations, where the rock is in its original place, the banks stand perfectly.

Just to the west of the city, is one of the worst examples of this bank damage. Large trees are cut out and have fallen into the water. The quantity of dirt washed down, is large and is of course, carried out into the lake.

The highway on the south is some distance from the lake shores. A drive, four miles long, could be built which would follow the shore very closely, and add materially to the attractiveness of the lake. Such a plan, however, would meet with strong opposition from the property owners on the south shore.

Recommendations.

The Commission recommends that here, as at Clear Lake, authority be granted for co-operation with the local authorities in obtaining options and making arrangements for the future construction of a road to follow the south lake shore; also that \$10,000 be expended in bank protection work, and that land for a public park be purchased fronting on the south or west side of the lake; the estimated cost of which is \$8,000.00.

PICKEREL LAKE, CLAY AND BUENA VISTA COUNTIES.

Lake No. 6. Survey made by the State Highway Commission. Inspection made August 9, 1916.

Pickereel Lake occupies parts of section 1, township 93 north, range 35 west, and section 36, township 94 north, range 35 west. The town of Marathon on the C., M. & St. P. Ry. is six miles southwest of the lake. Laurens, in Pocahontas County, at the junction of the C. & N. W. and C., R. I. & P. Ry., is six miles southeast of the lake. Storm Lake is thirty-two miles southwest of Pickereel Lake. Clear Lake is eleven miles to the southeast. To the northeast, Rush Lake lies four miles away, Silver Lake ten miles, and Lost Island eighteen miles. Two township roads touch the lake, one on the east and the other on the west.

The banks are high, and good groves of natural timber cover the eastern and northern shore. The water is from four to six feet deep, and while there are few rushes to be seen, other water plants destroy the pleasure of boating.

The area of this lake is 171 acres. The area enclosed by the government meander is 176 acres. Eight hundred forty acres of land drain

FIG. 9—Pickereel Lake, Buena Vista County. Pickereel Lake covers about one quarter section. It is an open water lake. To keep up the water level, private parties have built a dam at the outlet. Fishing is good and the resort is a popular place for people of the community.

into the lake. One slough drains into the lake from the northwest. This cannot be drained out unless the lake is drained.

Parties living in Laurens have built a small resort on the east side, which at present is kept open on Sundays. There is a base ball park, boats to rent, and considerable crowds from the nearby towns and the surrounding country gather here for their outings.

Bullheads and carp are to be caught. The depth of water does not warrant its being stocked with game fish. The hunting is considered good. There is enough cover to permit ducks to nest here and raise their young.

As is the case with many of the lakes of the state, the water shed is small. No streams enter the lake. During dry seasons it is to be expected that there will be a shortage of water. During average years the lake is used and appreciated by a great many people.

The outlet is to the southeast to Cedar Creek. A rough concrete dam has been built by local people, which holds the water at a fair level. If this were raised, two sloughs to the northwest would be flooded and would probably have to be purchased by the state.

The bottom is of a black silt underlaid by sand and clay.

Blackbirds and mosquitoes are found in about the same numbers as at other lakes, but scarcely any complaint is made of them by people residing in the vicinity.

Recommendations.

There is not as pressing a need of improvement at this lake as at many of the other small lakes. The Commission recommends that a

FIG. 10—Pickerel Lake, Buena Vista County. Pickerel Lake could be greatly improved at comparatively slight expense by building a permanent dam at the outlet. Raising the water level would necessitate the purchasing of a couple of marshes which are at present valueless.

permanent dam be built which will raise the water level two feet. That the slough northwest of the lake be purchased and made a part of the lake and that land be purchased for a public park fronting on the water. The estimated costs are seven hundred dollars for the dam, one thousand dollars for damages including the price of the slough, and thirty-five hundred dollars for the park.

TOW HEAD LAKE, CALHOUN COUNTY.

Lake No. 7. Survey made by the State Highway Commission. Inspection made September 29, 1916.

This so-called lake is located in sections 23 and 24, township 89 north, range 34 west. The village of Knoke on the C., M. & St. P. R. R., lies

three miles to the east and Fonda on the I. C. R. R., is six miles to the north. The Twin Lakes, where a small summer resort is located, are in the same county, about eleven miles to the southeast.

The lake may be easily reached from either of the above named towns. A county road passes it on the north. The township road north and south is interrupted by the lake.

Judged from its appearance, it should be called a marsh. With the exception of perhaps two acres south of the island, it is entirely grown up to rushes and marsh grass. The deepest water found, was three and a half feet.

The banks are low and bare. In fact, except for some differences in the vegetation, it is difficult to tell where the lake leaves off, and the numerous sloughs surrounding it begin.

The area at the time of the survey was 151½ acres. The area within the meander line is 192 acres. The area of the water shed is 500 acres and is largely composed of slough land.

So far as can be learned from inquiry, the place is used only occasionally as a hunting resort. A few of the smaller species of ducks were seen during the survey, but it did not appear that the lake was used to any extent as a hatching place.

There were no fish to be seen. The shallow water, the absence of any stream at the outlet, and the fact that the lake goes dry at times, account for this condition, and would render any attempt toward stocking it, a failure.

The natural water supply is very limited. The lake is situated on high ground, and the drainage leads away from it in all directions. The only artificial source of supply would be from wells. The cost of the wells and of pumping would prove almost prohibitive.

The outlet leads away to the northwest to a county drainage ditch. A fall of twenty-six feet was found in the mile and a half between the lake and the ditch. There are other possible outlets to the east and to the south.

The bottom of the lake is made up very largely of peat with a mixture of black silt. Under the open water, just south of the island, borings showed the bottom to be of clay. No sand was to be found, even along the shore.

Swamp blackbirds were fairly numerous in the neighborhood, and the farmers complain of the damage to crops which they cause. Muskrats are found in small numbers and complaint is made of their undermining the road embankments.

Local sentiment seems all to be in favor of drainage. A small island in the lake has been pre-empted by an old soldier who lives there by himself. This is the only spot where timber is found near the lake.

Recommendations.

In the opinion of the Commission, this lake should be drained. It is recommended that when a district is formed for the drainage of surrounding land, the state co-operate and pay their proper proportion of the cost. The land should be retained by the state, until such time as

its character as farm land is established. When thoroughly tiled, and subdued, it should have a value of not less than a hundred and twenty-five dollars an acre.

Drainage is recommended because the conditions which surround this marsh, are such as to render the cost of improving it prohibitive.

The total cost of an outlet, including the work of replacing the 18-inch tile now in place in sections 14 and 15, with one large enough to carry the additional water, is estimated at twenty-one thousand dollars. The area of the lake, and its water shed is 500 acres. Fifty dollars an acre is estimated as a fair assessment against the lake bed, to which should be added thirty dollars an acre for tiling and a reasonable amount to cover interest charges and the work of subduing the land. Without other improvements, this land should at first rent at from four to five dollars an acre. Later, it may be worth from six to eight dollars.

NORTH AND SOUTH TWIN LAKES, CALHOUN COUNTY.

Lake Nos. 8 and 9. Survey made by the Civil Engineering Department, Ames, Iowa. Inspection made September 7, 1916.

North Twin Lake is located in section 1 of township 88 north, range 33 west, and sections 27, 28, 32 and 33 of township 89 north, range 32 west. South Twin is in sections 1, 2, 11 and 12 of township 88 north, range 33 west. They are four miles north of Rockwell City and twenty-four miles west of Fort Dodge. Wall Lake is twenty-eight miles southwest. Storm Lake is twenty-six miles northwest. A county road skirts the west side of the south lake and township roads follow the east bank of the south lake, pass between the lakes, and follow the west bank of the north lake.

Both lakes are nice open sheets of water. North Twin Lake is slightly the larger of the two, being possibly $2\frac{1}{2}$ or 3 miles long and varying from one-quarter to three quarters of a mile in width, with the length of the lake running in a general northeast and southwest direction. South Twin Lake lies immediately southwest of North Twin Lake and is separated from it by a narrow strip of land, five hundred to one thousand feet wide. The south lake is something less than two miles long and approximately a mile wide at the widest place. The North Lake is at a little higher elevation than the South Lake, and empties into it through a ditch some five hundred feet long, at the north end of which the State Fish and Game Commissioner has built a concrete dam to keep the level of the lake. A similar dam has been built at the South Lake over which the water will pass into Lake Creek, the outlet of the two lakes.

South Lake averages five feet in depth and North Lake a little more than six feet. At the north and northwest shores of North Twin Lake, the land is very low and flat. This is also true at the east and southeast of South Twin Lake; at other points, the shore varies from five feet to fifteen feet in height. At the time that these lakes were surveyed, that is in June, 1916, there was no considerable growth of vegetation in either lake.

The North Lake has an area of 509 acres. The meander encloses 569 acres. The South Lake has an area of 596 acres, its meander encloses 600 acres, and 4,310 acres of land including the north lake, are tributary to it.

Between the two lakes, lies the Twin Lakes Hotel Summer Resort which draws good crowds of people on Sundays and holidays. Here are located facilities for bathing, and boating and the usual run of summer resort amusements. There are a few cottages near the south end of North Twin Lake and another group of some one-half dozen or more near the north end. The scenery, especially around North Twin Lake, is pleasing. The

FIG. 11—North Twin Lake, Calhoun County. This view shows the best timbered portion of the shore line on Twin Lakes. The shore line is good entirely around the lakes, but barren. The wooded portion suitable for camp sites is utterly inadequate to accommodate the thousands of people who throng these lakes during the summer months. The Fish and Game Department has built a small dam to maintain the present water level.

scenery around South Twin Lake is not so attractive and that lake will probably never be quite so popular as the north one.

The water supply is limited and it is to be expected that there will be occasional dry years when the lakes will be low. This in no way detracts from the pleasure which the public will obtain from them during most seasons.

Flood waters escape to the south through Lake Creek to the Coon River. The lake bottom is quite uniformly black slit underlain by a black clay soil.

Legal Status.

A petition for the drainage of South Twin Lake in which the customary allegations were made, was filed with the Executive Council. At a meeting in November, 1906, drainage was denied, and it was ordered maintained as a lake.

Local sentiment now is practically agreed that this order was wise. The people value the lakes and are making more and more use of them as time goes on.

Recommendations.

The Commission recommends that the lakes be retained. The state should purchase tracts of land fronting on each one, which should be thrown open to the public as parks. The estimated cost is \$8,000. It is also recommended that the state co-operate with local authorities in the construction of roads on the east side of the North Lake, at an estimated cost of \$4,000.00.

CLEAR LAKE, CERRO GORDO COUNTY.

Lake No. 10. Survey made by the State Highway Commission. Inspection made June 12th, 1916.

Clear Lake occupies parts of Sections 13, 14, 15, 16, 20, 21, 22, 23, 24 and 26 in township 96 north, range 22 west. It is one of the very few beautiful lakes of the state which is large enough to be justly popular as a summer resort for a large number of people. In point of size, it ranks third, its area being only exceeded by Spirit Lake and by West Okoboji.

The town of Clear Lake, which has a population of 2,500, lies just to the east of the lake. Ventura, which has a population of 100, lies on the west shore.

Both these towns are on the North McGregor-Mason City branch of the Milwaukee railroad. An electric line connects the town of Clear Lake with Mason City, twelve miles to the east. Good roads circle the lake and render it easy of access from all sides.

Geologically speaking, the lake lies right in the edge of the terminal moraine of the Wisconsin drift. Surrounding the lake on the north, west and south, are the low hills and poorly drained hollows which characterize the Wisconsin drift. On the east, the land drops away rapidly to the level prairies of the older Iowan sheet.

Along the shores, sandy beaches and steeper rocky banks are found. Only on the extreme western end, and to the southeast, near the outlet, are any considerable areas of slough land encountered. A large part of the land which fronts on the lake is divided into small lots and held as summer homes. Cottages, club houses and summer hotels offer shelter to the tourists who frequent this resort during the warmer months of the year.

The water in the lake is clear and cold; deep enough to permit of the use of motor boats and sailing crafts and to offer safe winter quarters for fish. The surface level varies greatly from year to year. At present,

with the lake bank full, from eighteen to twenty feet of water is to be found in the deepest places.

The area of the lake is about 3,643 acres. The meander encloses the same number of acres. About 8,400 acres of farm land make up the drainage area tributary to the lake.

Aside from Spirit Lake and the Okobojis, there are no lakes in the state that can at all compete in popularity with this as a summer resort. The facility with which Clear Lake is reached by railroad, largely augment the crowds which gather here for the summer season.

The outlet is to the east, through Willow Creek, to Lime Creek and ultimately to the Cedar River. For months at a time, during the dry seasons, no water passes out this way. This spring, water has cut around the outlet, forming a channel twelve or fourteen feet wide. South of the natural outlet, on the Grimm farm, a ditch was dug forty years ago to permit certain swamp lands to drain into the lake. With the present lake level, water is flowing out of the lake through this ditch and flooding lands farther to the south. The total discharge, as estimated by rough measurements being some sixty second feet at the natural outlet and perhaps twelve second feet through the Grimm ditch.

The drainage area tributary to the lake is extremely limited. Without doubt, a large part of the water supply must come from underground sources, and it follows that this supply will be diminished as the country to the north and west is drained.

Mr. H. Keerl, a drainage engineer of Clear Lake, is authority for the statement that some 3,300 acres of land, lying south of the lake, and which form the upper part of a drainage district now under consideration, lie above the lake level and can be given an outlet into the lake. This land is outside of the drainage area as shown on the accompanying map, and would naturally find its outlet to the southeast. Such a diversion of this water from its natural course, would prove of benefit both to the lake and to the rest of the drainage district.

The outlet into the lake would cost more than one in the other direction. If this difference is within reason, it would seem best that the State should pay the difference and secure this water supply.

In 1903, the county board of supervisors constructed a concrete outlet for the lake. This was placed a few rods south of the older outlet which which had been closed in 1887. It consisted of a concrete floor some 14 feet 8 inches wide and two side walls reaching about 3 feet, above the floor, and extending some 22 feet along the direction flow.

Legal Status.

In the September term of the District Court, 1905, H. A. Merrill, The Mason City & Clear Lake R. R. Co., and the Outing Club, brought an action asking an injunction and an order of Mandamus against the Board of Supervisors, C. M. Grimm and others.

Grimm owned land in the east $\frac{1}{2}$ of the 26 and west $\frac{1}{2}$ of 25-96-22. The Board of supervisors and Grimm constructed a canal across Grimm's land to turn drainage into Clear Lake.

In 1906, the state entered, through its Attorney General, a petition of Intervention. They aver that the state owns the lake, that it is her duty to preserve it in its original condition, that the board of supervisors acted without authority of law and were trespassers and intermeddlers. They ask that the court ascertain the original high water level and shore line and authorize the state to erect and maintain such sluice ways, gates and embankments as are necessary.

The District Court established the high water level as the eastern end of the bottom of the spillway. Nothing was said in regard to the Grimm ditch.

The case was appealed. The Supreme Court modified and affirmed the verdict of the lower court. Ordinary high water level was fixed one foot above the level decided upon by the District Court. A concrete wall one foot in height was then built across the sluice way.

While the courts have thus established the ordinary lake level, they have in no way, determined the size of outlet necessary. The spillway at Storm Lake, which has a watershed but little larger than that of Clear Lake, is seventy-two feet long. That of Clear Lake is fifteen feet long.

It appears reasonable that a spillway should be made large enough so that it will neither back the water up to a level higher than that reached by occasional floods before its installation nor retard the escape of the water long enough to kill crops on land that is flooded.

In the case at Clear Lake, the storage capacity on the lake and the slough to the west is large as compared to the drainage area, and will take care of any ordinary rain. The small spillway will discharge this stored water very slowly. The land covered by such storage will be under water so long as to be badly damaged. There is also the danger that a heavy rain may come at a time when the lake is high and no storage space available. In that case, not only the spillway but the highway culvert just below, which has a carrying capacity about equal to the spillway, will be washed out.

The Commercial Club of Clear Lake is anxious that a driveway be furnished around the lake, skirting the shore line. As will be seen from the map accompanying this report, this will necessitate the construction of about two miles of new road along the south shore, and extensive repairs to parts of the existing roads which have been damaged by water. Considerable opposition to this plan has developed among the property owners, who will be affected.

The plan for the road is entirely practical. It does not appear, however, that the state will be the party most benefited by its construction. If the state, the property owners, and the county can reach some equitable plan of dividing the costs, the plan is to be commended as one which will add greatly to the value of the lake to the state.

Recommendations.

The Commission recommends that a suitable spillway be built at the outlet, the estimated cost to be \$3,000; and that the proper authority be granted to secure the additional water supply before mentioned, and to co-operate with the Clear Lake Commercial Club in obtaining options on a

right of way for the south road. The cost of the additional water supply should not exceed \$5,000.00. Land for a state park fronting on the lake should be purchased at an estimated cost of \$8,000.00.

TRUMBULL AND ROUND LAKES, CLAY COUNTY.

Lakes Nos. 11 and 12. Survey made by order of the Executive Council. Inspection made August 9th, 1916.

Trumbull and Round Lakes occupy parts of section 3, township 96 north, range 35 west, and sections 22, 23, 26, 27, 34 and 35 of township 97 north, range 35 west. They are situated ten miles northeast of Spencer and six miles northwest of Ruthven; both towns on the C. M. & St. P. Ry. One township road passes between the two lakes, and a second one leads in to the lake shore from the east. Lost Island Lake is two miles to the east, and Okoboji, twenty-two miles to the northwest of these two lakes.

Trumbull Lake is a clear open body of water, five feet in depth, which extends for more than two miles north and south, and varies from a half to nearly a mile in width. The beaches are covered with gravel; the banks are well defined, and in many places covered with native timber. On the east side is a long slough which has about the same elevation of water surface, is perhaps two feet in depth and drains into the lake. On the southwest, there is a small area of slough. With these two exceptions, the land around the lake is high and fairly well drained.

Round Lake formerly was a part of Trumbull Lake, but now is considered a separate lake. It is connected to Trumbull Lake by a small creek which passes through the slough southwest of Trumbull. The banks are sharp and fringed with timber.

The lake itself is shallow and three-quarters of its surface is covered with rushes.

Trumbull Lake has an area of 1,190 acres; Round Lake an area of 450 acres.

No pleasure resorts are located on these lakes. In fact, the lakes are not particularly attractive to the class of people usually found at such places. They make their appeal to the sportsmen. The shooting is good; the outlying sloughs and sheltered bays afford both shelter and feeding places for wild fowl. Several hunting shacks, and boats are found along the shores, and hundreds of hunters visit the vicinity every year.

Fishing has always been considered good, and many big pickerel as well as quantities of smaller fish are taken, during the season.

In the matter of a natural water supply, these two lakes are more fortunate than most of the lakes examined. A total of some 48,000 acres of territory is tributary to them. The largest source of supply is from a large drainage ditch which enters the lake from the north. This brings the water from some 30,000 acres of land. People living in this district are satisfied with their outlet as it is.

The second largest source of supply is from the east from what is known as Mud Lake. This lake which has an area of 560 acres, is in reality, a slough about two feet in depth, and almost entirely grown up

to rushes. The water shed has an area of 15,800 acres. The remainder of the drainage area is a rather narrow strip of land around the two lakes which drains directly into them.

The outlet for the two lakes is on the west side of Trumbull Lake in section 27. From here a creek leads away to the southwest and at a distance of perhaps seven miles, unites with the outlet of Lost Island Lake. What at one time was an outlet to Round Lake is found on its west shore. This low point is above the present water level of the lake. There is no channel leading away but two low sloughs mark the path that flood waters must have taken in former times.

The bottom of Trumbull Lake is hard, in the main body of the lake, and considering the depth of water, it seems remarkable that rushes have never gained a foothold. In the bays, there are deposits of silt and rushes and other water plants grow luxuriantly. Round Lake has a bottom of silt and decayed vegetable matter.

The question of the damage caused by black birds in this vicinity is discussed in detail in the report of the Farm Crops Department.

Legal Status.

Originally, these two lakes were meandered as one. In 1900, the Department of the Interior meandered the two bodies of water as separate lakes, and declared the first survey fraudulent. At about the same time, they cut off large tracts of land on the north and south of Lost Island Lake, which before had been included in the meander. This land was disposed of. A large part of it was low, wet land.

In April, 1914, application was made to the Executive Council for permission to drain Trumbull and Round Lakes. A survey and report were made as required by law. A hearing was had in November of the same year. Various remonstrances were received and placed on file. The Governor then appointed Seth Dean of Glenwood as Engineer to report on the feasibility of adequately draining, at a reasonable cost, the low land to the east which drains through Trumbull Lake.

He reported on April 21st, 1915, that it is possible to locate a ditch from the bridge at the outlet of Mud Lake in Section 25, which will pass around the southern end of Trumbull and Round Lakes, through sections 35, 3, 4, 5, 8 and 17 to a junction with the present outlet about half a mile east of Dickens. In this distance, about six miles, there is a fall of about thirty-two feet. The deepest cut through the divide in Section 4 will be twenty feet, the average cut, fourteen feet.

Special Problem.

The outlet ditch proposed by Mr. Dean passes very close to both the lakes. The soil is sandy and precautions will have to be taken to guard against undue seepage from the lake to the ditch if it is constructed. With the idea of keeping away from the lakes, a trial line for an outlet ditch was run by the Commission, through Sections 35, 2, 1, 12, 11, 14, 15, 21 and 20. This line crosses the divide in the northwest quarter of section 2, and from there, follows down the outlet of Lost Island Lake. The divide is higher than on the other route and would necessitate a maximum cut of twenty-seven feet, but the average cut is only fourteen as on the other

route. It will be entirely practical to carry large tile through this divide and to construct the rest of the drain as an open ditch.

This plan has the advantage of draining a large amount of wet land along Lost Island outlet and so spreading the cost of construction over a large acreage.

The Commission is of the opinion that the low land east of Trumbull and Round Lake can be drained at a cost which is not prohibitive even if this has to be done by pumping. Much of the land is almost useless at present and if made into good farm lands by drainage, will be enormously increased in value.

Recommendations.

The Commission recommends that both lakes be retained and that a dam be built at the outlet which will prevent erosion and allow the land along the outlet to be drained. The estimated cost is \$2,000. It is recommended further that land for a state park be purchased on the shore of Trumbull Lake at an estimated cost of about \$3,500.00.

DAN GREEN'S SLOUGH, CLAY COUNTY.

Lake No. 13. Survey made by State Highway Commission. Inspection made August 9th, 1916.

Dan Green's Slough is a long narrow lake extending across Sections 8, 9, 16, 17 and 20 in township 97 north, range 35 west. It is situated about eleven miles northeast of Spencer and is most easily reached by driving from there or from Dickens on the C. M. & St. P. Ry. Trumbull Lake lies about two miles to the east, and the outlet of the slough, after following a tortuous course through low wet ground for a distance of perhaps three miles, joins the outlet to the lake and so drains away to the Sioux River.

The banks of the slough are rather well marked and high on the east side. On the west side, they are lower and open back to small areas of low lying ground. There is no natural timber to be seen in the vicinity and the shores are either under cultivation or in use as pasture land. Nearly the entire area of the slough is grown up to water grass and rushes, with here and there a muskrat house to break the monotony. The water is very shallow.

The area, as found from the survey, is 285 acres, 2,753 acres of farm land form the drainage area.

Such a lake as this has only one use, as a hunting reserve. If it were not for the fact that nearly all the land around it has good tile outlets, it would have been drained long ago. The bottom is of black silt and decaying vegetable matter, which should make as good agricultural land as any of the surrounding property.

Two east and west roads touch the lake. The southern road makes a detour to the south and crosses the outlet on an embankment. The northern road swings a half mile north and passes the upper end.

Recommendations.

In the opinion of the Commission, this lake should be retained. It is suggested that the highway embankment across the south end could be improved by widening it and raising the grade. Aside from this, nothing is recommended in the way of improvements.

ELK LAKE, CLAY COUNTY.

Lake No. 14. Survey made by State Highway Commission. Inspection made August 9, 1916.

Elk Lake is one of the smaller lakes which dot the north central part of the state. It occupies parts of section 1, township 95 north, range 35 west, and section 36, township 96 north, range 35 west. Lost Island Lake is six miles northeast, Silver Lake four miles southeast. It is easily reached by road from the towns Ruthven or Dickens which are located on the C. M. & St. P. Ry. Good roads skirt both the east and west shores.

This is one of the naturally, very attractive little lakes, which because of its location near the larger lakes is overshadowed by them, and is scarcely known outside of its immediate vicinity. The banks are gently sloping pasture land with occasional groves or scattered trees. The water is open, free from any excess of vegetation and from four to six feet deep. Two large sloughs drain into the lake from the south, and a smaller one drains in from the northeast. The land surrounding these sloughs has been pretty well tiled. Many of these tile outlet at about the present lake level. Any attempt to raise the water level would be opposed for this reason. Two hundred sixty-one acres are covered by the lake at its present level. The watershed is composed of 2,048 acres of farm land. So far as can be learned, the lake is used only by people residing in the immediate vicinity for either hunting or fishing purposes. There are no resorts or shooting lodges. The ordinary fish are to be caught, but the lake is scarcely deep enough to warrant its being stocked. As a whole the water supply is fairly satisfactory. During extremely dry periods the lake will get low, but under ordinary conditions, it will be maintained at a good stage of water.

The outlet is toward the north, through a narrow creek, to the ditch which drains Elbow Lake. The soil around the outlet is firm, and does not appear to be cutting at all.

Local sentiment is in favor of keeping this lake in its present condition. There are no serious complaints made of damage done by black-birds or of annoyance caused by mosquitoes. Old residents report the lake as formerly much deeper. This is borne out by borings in the lake bottom, which show deep deposits of soft black silt. In time to come it seems probable that this accumulation of silt will have to be removed.

Recommendations.

The Commission recommends that at present this lake be left as it is. A park fronting on the water should be purchased so as to make the lake available to the public and a grove set out. Thirty-five hundred dollars is the estimated cost of this improvement.

SILVER LAKE, DELAWARE COUNTY.

Lake No. 15. Survey made by State Highway Commission. Inspection made September 22, 1916.

Silver Lake occupies portions of sections 16, 20 and 21 of township 88 north, range 4 west. It is situated just southeast of Delhi, a town of perhaps five hundred population, on the C. M. & St. P. Ry. Except for the Mississippi River lakes in Allamakee County this is the only lake in north eastern Iowa.

A county road leading east from town passes just north of the lake, and a township road south crosses the outlet.

The banks are well defined, grass covered slopes. On both the east and west banks there are natural groves.

Part of the lake is open water from four to seven feet in depth. Perhaps one quarter of the surface is grown up to rushes. Near the outlet eighteen feet of water were found. No large tracts of low land are dependent on the lake for drainage.

The area at the time of survey was 32 acres. The area inside the government meander line is 45 acres. The water shed is composed of 410 acres.

As a fishing place and picnic grounds, the lake and its surroundings are valued by the local people. Nearly all the ice for the town supply is cut here during the winter months.

The water shed is small and during dry years the lake gets rather low. It is reported to have gone entirely dry fifteen years ago, so that even the springs which are purported to feed it, were not in evidence.

The outlet is through a deep ravine to the south west to the Maquoketa River. A highway embankment has been thrown across this ravine, but the foundations are not good. Water from the lake continually seeps through and trickles off down the ravine.

Just to the north of this embankment, the lake is nearly eighteen feet deep. Mr. Thomas Simpson, Sr., an old resident, is authority for the statement that many years ago this embankment was blown out and that the escaping water cut the ravine to its present dimensions. This would account for the deep hole to the north.

In the northern part the lake bottom is of silt and decaying vegetation which overlies a sandy clay. Near the highway embankment on the southwest sand predominates.

Local sentiment is very much in favor of retaining the lake. The time will undoubtedly come when the people of Delhi will co-operate with the State in some such way as have the citizens of Emmetsburg, to make this lake a city park.

Considerable water might be saved by driving a tight line of steel sheet piling across the ravine which is about two hundred feet wide at water level, or by blanketing the north side of the embankment and the adjacent lake bottom with a heavy clay.

Before such improvements are undertaken, more and deeper borings should be made than were possible with the apparatus carried by the survey parties.

An outlet culvert of ample size should be built that will care for flood water and prevent the cutting of a new outlet farther to the northwest.

Recommendations.

The Commission recommends that the lake be retained and that a tract of land fronting on the lake be purchased for a public park. The estimated cost is placed at \$4,000.

SPIRIT LAKE, DICKINSON COUNTY.

Lake No. 16. Survey made by the State Highway Commission. Inspection made August 7th, 1916.

Spirit Lake occupies parts of Sections 8, 9, 10, 11, 14, 15, 16, 17, 20, 21, 22, 27, 28 and 29 of township 100 north, range 36 west. It has something the shape of a great pear; the broad end extends for more than three miles along the Minnesota state line, the narrow end reaches down about four miles into Iowa. The City of Spirit Lake, on the C. M. & St. P. Ry., is more than a mile south of the lake. Orleans on the C. R. I. & P. Ry. is on the southern shore of the lake. The north end of East Okoboji nearly touches it on the south. West Okoboji is about six miles to the southwest.

Township roads parallel the banks on all sides, so that nearly all parts of its shores are easily reached by team.

The water is clear, open, and from twenty to twenty-five feet in depth. The banks are well defined but not so high as those of East and West Okoboji. Pleasant groves of native timber are scattered along its shores.

Around the southern half of the lake, there is very little low wet land. On the northeast, are two large sloughs, one of which is meandered as a part of the lake. On the north side two sloughs, one of which is the inlet from Loon Lake, are both enclosed by the meander line. To the northwest, three smaller lakes drain into Spirit Lake, but are meandered as separate bodies of water.

Spirit Lake has an area of 5,660 acres. The meander encloses 5,684 acres.

The Orleans, West Side, Crandall's Ledge and Templar Park are the largest and best known of the summer resorts at this lake. Innumerable private cottages offer shelter to those who prefer a more quiet outing and more privacy than is to be found at the large hotels.

Probably more fish are caught here than at any other lake in the state. Natural conditions are very favorable for their propagation and the place is a favorite one with fishermen from this and the surrounding states.

Hunting is also considered good, and the many outlying sloughs furnish feeding grounds and shelter for water fowls of all kinds.

The city of Spirit Lake draws its municipal water supply from this source. Doubts are often expressed as to the adequacy of the lake's water supply, but these fears do not seem to be well founded. The lake is subject to marked changes in level. No actual measurements

were to be had but people who are very familiar with conditions, report that some years the water level may be four feet higher than at other times. This difference is due to a peculiar condition which exists at the outlet.

Spirit Lake drains into East Okoboji, through a narrow creek at Orleans. At normal stage, there is a difference of about four feet in the levels of the two lakes. Gravel is pushed into the mouth of this creek by wind and by ice, and gradually seals it up. The lake rises, but keeps on piling in sand and gravel. Sometimes three or four years may elapse before a sudden freshet raises the lake enough to over-top and cut away the dam. Then the water drains out until weather conditions become right to repeat the process.

Such large changes in level as now occur, may be prevented by the periodic removal of the gravel deposits north of the outlet with or without the installation of some kind of regulating gates.

The question of locks to permit of the passage of boats between Spirit Lake and Okoboji, has often been brought up. The Rock Island railroad crosses the outlet at an elevation which will allow ordinary launches to pass underneath it. The highway which parallels the railroad will have to be raised to provide head room.

Estimates based on the number of boats which will pass through the locks, show that Spirit Lake will be lowered less than two inches in supplying all the water required for lockage during a season.

The outlets of the sloughs east of the lake, as well as that from Hottes Lake on the west, are shallow. In the spring when the water is high, fish go out into these sheltered waters to spawn. Later in the year, when the water is low, the fish cannot get out into the deeper waters of the lake. Thousands of young fish perish every winter in these places. This situation will be much improved if deep channels are cut from the lake into these sloughs so as to allow fish to pass in and out at all times.

Recommendations.

The Commission recommends that channels be cut into the two sloughs east of the lake, that regulating gates and a lock large enough to pass launches, be built between Spirit Lake and East Okoboji, and that sufficient land for a state park be purchased, fronting on the lake.

The estimated cost of the two channels including a highway bridge, is \$2,500.00. The estimated cost of the locks is \$15,000.00. The estimated cost of the park is \$8,000.00

EAST OKOBOJI LAKE, DICKINSON COUNTY.

Lake No. 17. Survey made by State Highway Commission. Inspection made August 7th, 1916.

East Okoboji is located in sections 3, 4, 10, 11, 15, 16, 17, 20, 21, 29 and 32 of township 99 north, range 36 west, and sections 33 and 34 of township 100 north, range 36 west.

Spirit Lake, Arnold's Park and Okoboji on the C. M. & St. P. Ry., each provide easy access to different parts of the lake. Township and private roads approach its shores at different points, and boat liveryes from the different resorts make it easy to reach and enjoy the whole of its long shore line. During the summer season, a line of steam boats traverse the lake from end to end.

The area as shown by the survey is 1,875 acres. The government meander, with one or two minor exceptions, follows its shores with striking fidelity. The water shed, including Spirit Lake, Little Spirit, Marble, Hottes and West Okoboji, is 84,500 acres.

In shape, the lake is long, narrow and irregular. Including the Gar Lakes, which were meandered as a part of this lake, it extends for seven miles in a north and south direction, and a trifle more than three miles east and west.

A maximum depth of twenty-four feet was found in the southern end and eight feet in the northern part. At two places, the Narrows

FIG. 12—East Okoboji, Dickinson County. This is one of the few well known lake resorts of Iowa. It is visited by thousands of people every season. A state fish and game hatchery is located here where fish are hatched and later distributed to the other lakes of the state.

and at Spirit Lake, the water shoals to four feet or less, and at low stages, a channel is only kept open by continual use.

The banks are uniformly high, in many places timbered, and rise from gravel beaches. Practically no low or wet land is found along its margin.

East Okoboji, together with the other lakes in its immediate vicinity, form the heart of the lake region of Iowa. There are not nearly so many summer cottages on its banks as on those of its neighbors; nevertheless, it forms an indispensable part of the whole. Its waters are well stocked with fish, and during the open season, good catches are made. During the winter large quantities of ice are cut and packed for home consumption.

This lake forms the outlet for Spirit Lake, Little Spirit, Marble, Hottes and Loon Lake, as well as West Okoboji. Its supply of water, therefore, is much more regular and satisfactory than is that of the other lakes. The water level varies perhaps three feet between dry years and those of heavy rainfall.

The outlet is from the southern end of the lower Gar Lake, to the Little Sioux River, of which these lakes are the source. A low dam has been built by the state at the outlet and aids in controlling the water level. It has suffered the usual vicissitudes to which such a structure is subjected, and has twice been dynamited by people who were dissatisfied with the level at which it held the lake.

Recommendations.

There is no question about the advisability of keeping this lake. The Commission recommends that the state excavate and maintain at the

FIG. 13—East Okoboji, Dickinson County. There is a popular demand for a lock connecting East Okoboji to Spirit Lake. This would render the entire shore line of the three lakes, East and West Okoboji and Spirit Lake, accessible to launches.

two shallow places before mentioned, channels which will provide six feet of water at low stage. The original cost of doing this work should not exceed \$10,000. There is no data upon which to base an estimate of the rate at which silt is being deposited in these places, neither is it possible to predict what effect these dredging operations may have upon this rate. It is safe to say, however, that these channels will have to be cleaned out from time to time.

The State should purchase land enough for a good sized park, somewhere along the shore, and open it for the use of the people. The estimated cost is placed at \$8,000.00.

WEST OKOBOJI LAKE, DICKINSON COUNTY.

Lake No. 18. Survey made by the Civil Engineering Department, Ames, Iowa. Inspection made August 7th, 1916.

West Okoboji is located in sections 19, 30, and 31 of township 99 north, range 36 west and sections 1, 2, 11, 12, 13, 23, 24, 25, 26, 35 and 36 of township 99 north, range 37 west. It is most easily reached from Arnold's Park, or Okoboji on the C. M. & St. P. Ry., or by driving from Spirit Lake. County roads touch it on the north, east and south; township roads approach it on the west.

The lake is nearly six miles in length, from north to south, and averages perhaps a mile in width. Three deep bays indent the east and west shores. The country around the lake is broken, and many smaller lakes and undrained ponds lie scattered among low hills. As a general thing, the banks of the lake are high, and in many places, wooded, though there are several exceptions. On the north, south and west sides, isolated areas of low, wet land extend back from the lake shores proper.

This is the deepest of the lakes. One hundred and thirty-two feet of water was the greatest depth measured. The bottom in the southern end is very irregular. The water is remarkably clear, and the most severe storms only ruffle its surface.

The area of the lake is 3,788 acres. The government meander, with one or two unimportant exceptions, fits the lake shore closely. It encloses 3,939 acres.

Summer colonies, too numerous to mention by name, are scattered all around the shores. Without question, this is rightly, the most popular of Iowa's lakes. Fishing is reported as good, and large strings of all varieties are taken.

No large streams feed West Okoboji. The drainage from Center Lake and the sloughs to the north of it, constitute the largest visible supply. The lake always maintains a satisfactory level, though this of course, varies somewhat with the rainfall. The outlet is from Smith's Bay on the east side, into East Okoboji.

There is no question as to the preservation of this lake; it can't be drained. In the interests of fish culture, it is suggested that the State would do well to purchase the sloughs both on the north and south, and connect them to the lake with deep channels. This would provide safe spawning grounds, which the lake lacks at present.

Recommendations.

The Commission recommends the purchase by the State of a public park, on the lake shore, and estimate the cost at \$12,000.00.

CENTER LAKE, DICKINSON COUNTY.

Lake No. 19. Survey made by the Fish and Game Department. Inspection made August 7, 1916.

Center Lake occupies portions of sections 5, 6, 7, and 8 in township 99 north, range 36 west. It lies about two miles west of the town of Spirit

Lake, and is nearly surrounded by East and West Okoboji. County roads approach it closely on the north and on the east. On the south and west, township roads are within half a mile of its borders.

This is an unusually attractive body of water. The central part is very deep and clear. There are very few rushes to be found, and these are all in a small bay on the north side. In most all respects, Center is a close rival to the other lakes around it.

The banks are well defined and in most cases, very abrupt. They are fringed with natural timber which, in many places, widens into large clean groves. One small slough to the south is connected to the lake. At the time of the survey, nearly a foot of water was standing over this area.

The lake has an area of 264 acres. The meander encloses 329 acres. The water shed has an area of 883 acres.

Center Lake affords good hunting and fishing. It is used for camping and is very favorably known as a pleasure resort. Fluctuations of the water level during wet and dry seasons are rather small, and it is always in the most excellent condition. The water has not flowed from the outlet in a number of years. It cannot be drained by ditching as the bottom is only four feet above the level of Lake Okoboji, its natural outlet.

As in most Iowa Lakes, the bed is filled to a considerable depth, with black alluvial soil. The beach, however, is generally covered with gravel or boulders.

Recommendations.

Unquestionably, this lake should be retained. The only expenditures which it seems advisable to make at present, should be made in the purchase of land for a park, and for a road leading in from the highway.

Land in this vicinity is worth \$150.00 to \$200.00. an acre. Five thousand dollars should purchase a tract such as is required to give the public entrance to the lake.

SILVER LAKE, DICKINSON COUNTY.

Lake No. 20. Survey made by the Fish and Game Department. Inspection made September 28, 1916.

Silver Lake occupies parts of sections 27, 28, 29, 32, 33 and 34, township 100 north, range 38 west. It is just south of the town of Lake Park on the C. R. I. & P. Ry. West Okoboji is nine miles east, Rush Lake in Osceola County, is seven miles west. A county road touches the lake on the south and a township road on the west end.

The banks on the north, west and east are high and fringed with oak timber which in places, widens out into thick groves. Several sandy beaches suitable for bathing places, are found along the shores.

Most of the water is open, free from rushes and suitable for boating. At the time of the survey, there was no sign of vegetation in the lake but local parties state that in the late summer, some portions are badly infested by sub-aquatic plants. A depth of water varying from five to seven feet was found.

The area of the lake is 1,096 acres. The meander encloses 1,058 acres. The water shed is composed of 16,550 acres, 480 of which are in Minnesota.

On the east shore near the outlet, the city of Lake Park has set apart

FIG. 14—Silver Lake, Dickinson County. Silver Lake is a very pretty body of open clear water, of good depth, almost two square miles in extent. The city of Lake View has bought and improved a city park on the lake front.

a place for a park and by trimming the trees and cutting away the under brush, have made a beautiful place for picnics and camping. Silver Lake itself is not regarded as particularly good from the hunters' standpoint, because of the lack of cover. In the small swamps to the south and west

FIG. 15—Silver Lake, Dickinson County. This photograph shows the concrete dam which has been put in at the outlet of the lake to raise the water level. Dams of this nature could be built to advantage at many of the state lakes.

however, ducks are found to be quite numerous and as a general thing a few nest there. The fishing in Silver Lake is not the best. In fact, it is only used for that purpose by a few of the local parties. It has never been stocked.

The only land that is deprived of drainage by retaining it in its present condition is that in the swamps to the south and west. The lake will have to be lowered a number of feet to afford these ponds proper drainage.

On the north side, a stream of fairly good size, and with a large drainage area, enters the lake. On the south side, back a short distance from the lake, there are several springs and a flowing well, all of considerable size. The variation of water level in the lake is about two to three feet.

The lake has been raised in the last year by means of a dam across the outlet. We have been informed that about seven inches have been taken off of the dam since the time of the survey. The reason for this was that the people owning land abutting the lake claimed the water was washing the banks away.

Drainage from Silver Lake goes to the west branch of the Sioux River.

A thick black silt was found spread out over most of the bottom. At places, there is sand and gravel.

Recommendations.

The Commission is of the opinion that this lake should be held at its present level. They recommend that the state purchase land, fronting on the lake, for a public park. The cost is estimated at \$4,000.00.

DIAMOND LAKE, DICKINSON COUNTY.

Lake No. 21. Survey made by Fish and Game Department. Inspection made September 28, 1916.

Diamond Lake occupies parts of sections 10, 11, 14 and 15, of township 100 north, range 37 west. It is eight miles northwest of the city of Spirit Lake.

Because of its location, so near to the large lakes, Diamond Lake is very little known or valued. It is a beautiful little body of water, from four to six feet deep, and almost entirely free from rushes. The shores are well defined, and on the south and east, fringed with natural timber. On the north, two grass covered sloughs are separated from the lake only by narrow ice formed ridges. One of these is enclosed by the meander; the other not.

The area of the main body of the lake was found to be 111 acres. The meander enclosed 166 acres. The water shed contains 1,949 acres of land.

Hunting has always been considered good here. The fishing has been injured to some extent by the carp and other fish of their nature that have entered it the last few years.

One small stream feeds it from the north, and a tile drain enters from the south. The water supply appears to be satisfactory. Residents of the neighborhood report a variation of a foot in level, due to wet or dry seasons.

The outlet is to the south through an intermittent creek to the Sioux River. A project is now under way, looking toward the drainage of this creek bottom. This will necessitate the building of a dam at the outlet. There is no demand for the drainage of the lake itself.

The bottom was found to consist of silt. Considerable sand and gravel is visible along the shore.

All of the surrounding land is held by one man, and he would like to see the lake kept as it is or raised a foot or two higher.

Recommendations.

In the opinion of the Commission, this lake should be reserved. A dam

FIG. 16—Diamond Lake, Dickinson County. Diamond Lake is an open body of water covering about one-quarter square mile. The shore line is partly wooded. The land around the lake is all owned by private parties and there is no means of access except over private property. Private parties who own the outlet to this lake want to drain their land, which would necessitate the construction of a dam to maintain the water level.

costing \$700.00 should be built at the outlet. Enough land for a park should be purchased on the lake shore, and trees planted. A road should be built connecting this to the public highway. The estimated cost of these improvements is \$5,000.00.

WELCH LAKE, DICKINSON COUNTY.

Lake No. 22. Survey made by the State Fish and Game Department. Inspection made September 28, 1916.

Welch Lake is situated in sections 23, 24, 25 and 26, township 100 north, range 37 west. It is three miles west of Spirit Lake and about the same distance north of West Okoboji, into which it drains.

This is a beautiful little lake with high banks timbered on the east; gravel shores and clear open water from five to six feet deep. There is practically no low land around its shores.

The area is 57 acres. The meander encloses 75 acres. The water shed has an area of 375 acres. Very little hunting is done in this neighborhood because of the lack of cover. The fishing is only fair.

The water shed is small and it seems possible that a part of the water supply comes from springs. The outlet is through a 16-inch pipe under the road on the south side of the lake. No water was running out at the time of the examination. There is a fall of seventeen feet from the lake to the Rock Island Railroad, in a distance of a mile and three-tenths.

The bottom is of silt, beneath which is blue clay. No demand was

FIG. 17—Welch Lake, Dickinson County. This is a very beautiful little body of open clear water, fifty-seven acres in extent. The shores are wooded. The highway skirts the south shore of the lake. The wooded shore lines are not available to picnickers except on private property.

found for drainage, and few, if any, complaints were heard regarding any nuisance arising from the lake.

Recommendations.

The Commission recommends that the lake be retained in its present condition.

HOTTES AND MARBLE (MARRIE) LAKES, DICKINSON CO.

Lake Nos. 23 and 24. Survey made by the State Fish and Game Department. Inspection made August 7, 1916.

These two lakes, which are in reality, outlying parts of Spirit Lake, although meandered separately, occupy parts of sections 7, 8, 17, 18 and 19 in township 100 north, range 36 west. They are located just west of the big lake, separated from it only by the width of a roadway, and drains into it.

Around them, are timbered hills, and they have high, well defined banks. The water varies from five to seven feet in depth, and is open and clear in the main bodies. Several shallow bays are grown up to rushes and other water plants.

The area of Marble Lake is 175 acres; that of Hottes, 312 acres. The meander of Marble Lake seems to be somewhat in error. A total of 4,936 acres of land, of which 4,472 are in Iowa, drain into the two lakes.

These bodies of water should be considered in connection with the

big lake. They are a little more secluded, and for that reason, furnish better hunting than is to be found on its more open water.

Their drainage area is relatively large, and there is no record of their ever having gone dry. The bottoms are of sand and gravel, over which in places, layers of silt are found. The outlet which passes under the road is shallow, and when the lakes are low, goes dry. It is desirable that this channel be deepened so that boats may pass back and forth, and so that at all seasons of the year, fish may go in and out. These lakes, as well as the sloughs on the east side of Spirit Lake, may be made into natural fish hatcheries at very little expense.

Recommendations

The Commission recommends that these lakes be retained and that the outlet be deepened. The estimated cost of this work, including a highway bridge, is \$2,400.00.

LITTLE SPIRIT LAKE, DICKINSON COUNTY.

Lake No. 25. Survey made by the State Fish and Game Department. Inspection made August 7, 1916.

Little Spirit occupies parts of sections 7 and 8, township 100 north, range 36 west, in Iowa, and 27, 28, 33 and 34 in township 101 north, range 36 west in Minnesota. It is most easily reached by driving north from Spirit Lake. The road passes along a narrow causeway between Big and Little Spirit Lakes.

This is a very irregular sheet of clear open water from eight to twelve feet deep. The banks for the greatest part of their length are high and in many places, covered with timber. There are several gravel covered beaches along the shores.

One large pond on the Minnesota side of the line is at the same level as the lake and cannot be drained without lowering the lake.

The area as found by our survey, is 724 acres of which 214 acres are in Iowa. The water shed has an area of 2,462 acres. As will be seen by referring to the map, the meander line does not follow the shore line very closely on the Iowa side.

While Little Spirit is used only for hunting and fishing at present, there seems to be no reason why it may not become just as popular as the other lakes in this region. The lake itself does not offer very much cover for wild fowl, but the pond to the northeast affords excellent shelter and feeding grounds, and many ducks nest there.

Fishing is considered as very good, and some very nice catches are made here every season. The Minnesota fish laws do not afford the same protection to fish as do those of Iowa. This lake is directly connected with Spirit Lake and receives the benefit of all the work which this state does in restocking.

Most of the lake bottom is of sand, but in some places, a mud bottom is found supporting a growth of wild celery and other aquatic plants.

No streams of any size supply water to Little Spirit. One line of sixteen-inch tile enters it from the northwest. Residents in this vicin-

ity report variation of the water level of three feet between wet years and dry.

The outlet is about half a mile south of the Iowa-Minnesota line. The highway at this point follows the very narrow dividing ridge between Big and Little Spirit Lakes. A sixteen-foot wooden bridge spans the outlet.

People who have lived here for years, say that they have no reason to complain either of the blackbirds or mosquitoes.

Recommendations

The Commission recommends that a permanent concrete culvert should be built at the outlet. The cost is estimated at \$1,900.00. They also recommend that land be purchased for a public park fronting on the lake. The cost of this is estimated at \$3,000.00.

SWAN LAKE, DICKINSON COUNTY.

Lake No. 26. Survey made by the State Fish and Game Department. Inspection made August 5, 1916.

Swan Lake is located in Sections 22, 23, 26 and 27, township 100 north, range 35 west. It is nine miles northeast of Spirit Lake and ten miles northwest of Estherville. Superior is the nearest railroad point. A county road crosses the middle of the lake on a fifty foot concrete bridge, and divides it into two parts which are quite different.

West of the road is a circular depression overgrown with rushes and other forms of water plants. The banks are low and bare. One thirty-six inch tile and two or three small ditches outlet into this basin which at times is entirely dry, and at times is covered with a foot or so of water.

East of the road is an attractive little lake. The bank is high throughout most of its length, and covered with timber. Nearly half the lake surface is open water from two to three feet deep. The remainder is covered with different water plants. There are no sloughs and scarcely any low land near this part of the lake.

The area at the time of the survey was 298 acres. The meander encloses 371 acres. 9,888 acres of land are tributary to the lake.

This is an ideal place for game birds, and considerable hunting is done here. People living near the lake say that ducks never nest there. Fishing is good during the season although the lake has never been stocked.

The water supply is better than at many of the other lakes. The drainage area is relatively large. Several tile outlet along the shores and two or three small springs were found along the banks.

From the northeast, the outlet leads away to the west fork of the Des Moines. There is enough fall so that the bed could be drained.

Some complaint is made about the number of mosquitoes that breed in the vicinity.

People owning land near the lake would like to see it drained. The sportsmen all wish to see it kept and improved if possible.

Recommendations.

The Commission recommends that it be kept, and that a dam which will raise the water level two feet, be put in at the outlet. The estimated cost is \$2,000.00. The state should purchase land for a park fronting on the water so that the public may use the lake without trespassing. The estimated cost is \$3,500.00.

PRAIRIE LAKE, DICKINSON COUNTY.

Lake No. 27. Survey made by the State Fish and Game Department. Inspection made August 7, 1916.

Prairie Lake is a small body of water which covers a part of section 23, township 99 north, range 36 west. It is five miles southeast of the town of Spirit Lake. Pleasant Lake is four miles northeast, East Okoboji about a mile west. A township road on the north passes very close to the lake.

The lake is practically divided by two narrow timbered ridges which nearly meet at the center of the lake. That portion lying west of the ridges is shallow and muddy. It is thickly overgrown with rushes and has muddy shores. The eastern portion is generally shallow, but clear of rushes. Probably 30 per cent of the entire surface of the lake is covered with aquatic plants. The shore of the east portion of Prairie Lake is well defined and inclined to be gravelly in places. The banks are steep and can be made attractive by the judicious planting of trees.

There is no low ground near the lake except at the outlet. The area of the lake is 105 acres. The meander line which does not follow the shore line very closely, encloses 136 acres. The water shed is made up of 514 acres of farm land.

The lake has no present value for fishing but is an excellent hunting resort. A few birds nest there. There are several undrained sloughs in the vicinity that offer cover and feeding places. The outlet is from the northeast end, through a small ditch which drains considerable slough land along its source and empties into the lower Gar Lake.

This lake is often very low in dry times and sometimes goes entirely dry. The water can be raised to any desired height by means of a dam and spillway across the outlet. This dam should consist of two parts—one across the northern outlet and the other across the southern main outlet. The spillway should be through the southern dam.

The bottom is of black silt which rests on typical glacial drift.

Local sentiment is in favor of the retention of the lake. Little, if any complaint is made either of blackbirds or mosquitoes.

Recommendations

The Commission is of the opinion that this lake should be retained and that a dam should be built at the outlet which will raise the water two feet. The estimated cost of such a structure is \$750.00.

PLEASANT LAKE, DICKINSON COUNTY.

Lake No. 28. Survey made by the State Fish and Game Department. Inspection made August 7, 1916.

Pleasant Lake occupies parts of section 7 township 99 north, range 35 west, and of section 12, township 99 north, range 36 west. It is situated five miles southeast of the city of Spirit Lake. It is only two miles east of East Okoboji and a little more than two miles northeast of Prairie Lake. A township road makes a detour around the west side of the lake.

The lake is a small irregularly shaped body of clear water from five to six feet deep. The banks are high on the north, east and south sides, and in a few places, there are scattered trees. On the west of the lake is a small amount of slough land but little above the lake level. The survey shows the lake as having an area of 82 acres. The meander line, which does not at all conform to the lake shore, encloses 117 acres. The water shed consists of 448 acres.

Pleasant Lake is used but little, either for hunting or fishing purposes. There is no cover for game birds and only occasional flocks stop at the times of the spring and fall migrations. The drainage area is very small and the lake varies in level as do all the other small lakes. So far as could be learned from inquiry, it has never gone dry. The outlet is to the southeast into the old bed of Lily Lake, which was sold in 1913. The bottom is of black silt for a depth of at least six feet.

Farmers living in the vicinity make no complaint of any nuisance arising from the lake and express themselves as anxious that it be retained.

Recommendations.

The Commission is of the opinion that this lake should be kept just as it is. It is recommended that no improvements be provided for the present.

JEFFERSON SLOUGH, DICKINSON COUNTY.

Lake No. 29. Survey made by the State Fish and Game Department. Inspection made August 7, 1916.

This lake is located in sections 5 and 6, township 99 north, and sections 31 and 32, township 100 north, range 36 west. It is about a mile west of the town of Spirit Lake, and is easily reached from the county road.

This so-called lake is the east one of three marshes which lie just north of the railroad. The two west ones were sold by the state without being drained. A depth of two and a half feet of water is almost entirely filled with water plants of every variety. Its banks are rather high and partly timbered. The rest of the surrounding land is used as pasture and is too wet for cultivation. In fact, during wet seasons, this slough is nearly surrounded with other sloughs.

An area of 80 acres was covered with water in the fall of 1916. The meandered area is 100 acres. The water shed consists of 397 acres.

Considerable hunting and trapping is done around the shores. This slough and the other two which lie just west of it, furnish ideal cover and feeding ground for ducks.

There are no streams, tile or springs, which feed the lake and the water seldom overflows at the outlet which leads into lake No. 2. The bottom is of mud from two to three feet deep.

Recommendations.

The Commission is of the opinion that this lake should be preserved as it is for the present. When a drainage plan for the other two ponds on the west is proposed, the state may well co-operate and secure drainage for this lake as well, retaining title to the land.

FOUR MILE LAKE, EMMET AND DICKINSON COUNTIES.

Lake No. 30. Survey made by order of the Executive Council. Inspection made August 5, 1916.

Four Mile Lake occupies part of section 18, township 99 north, range 34 west, and section 13, township 99 north, range 35 west. Estherville is about four miles to the east, Spirit Lake eleven miles to the northwest. It is most easily reached by driving from Estherville. No roads touch the lake.

The banks are well defined, and on the north, fringed with timber. The water is from two to four feet deep, and almost entirely grown up to rushes. Occasional patches of open water can be seen from the shores. Surrounding the lake, lies a rather rolling, but well drained country. On the north, there is a small area of wet land. Aside from this, there is no large amount of land dependent on the drainage of the lake for its improvement.

The area is 185 acres as against the meandered area of 219 acres.

The lake has a distinct value as a breeding place for game birds, and as a hunting resort during the shooting season. The water is not deep enough to provide safe winter quarters for fish, and so far as could be learned, no fishing is done there.

Extending south and east from the lake are a succession of sloughs which drain into a county ditch and act as the outlet for the lake. The country south of the lake is fairly well drained.

Silt and decaying vegetable matter form the bottom. The information gained from previous examinations, indicate that the lake is deteriorating.

Legal Status.

In October of 1904, petition was made to the Executive Council for the drainage of this lake. A survey and report were made by Mr. L. E. Ashbaugh, but as no one appeared at the time set for the hearing, drainage was denied.

Again in September of 1913, a petition asking for its drainage was submitted. Mr. L. A. Wilson made a second examination and report on the lake. This petition stirred up considerable feeling and both sides were represented at the hearing. The petition for drainage was again denied.

Opposition to drainage seems to have arisen from the value of the lake as a hunting resort, and from fear of damage to land that would be caused by the outlet ditch.

Recommendations.

It is the opinion of the Commission that this lake should be kept in its present status because of its value as a shooting resort. Spirit Lake with all the advantages it offers in the way of boating and bathing, is only a short hour's drive farther west. People from the vicinity of Four Mile Lake, when in search of an outing, go there. For this reason, also, it is not considered wise to expend any considerable amount of money in the improvement of Four Mile Lake. It is recommended that a road be built from the highway to the lake so that the public may reach it without trespassing. \$600.00 is estimated as the cost of such a road.

GRASS LAKE, EMMET COUNTY.

Lake No. 31. Survey made by the State Fish and Game Department. Inspection made August 8, 1916.

Grass Lake is located in sections 16 and 17, township 100 north, range 33 west. Huntington, on the C., R. I. & P. Railway, is the nearest railroad point. The lake is two miles east of the town. Estherville is ten miles to the southwest. Tuttle Lake is seven miles to the east.

This is a small lake from two to three feet deep, and almost covered with a growth of water plants. Its banks are very flat except for a short distance on the north, and are too wet for cultivation. There is scarcely any natural timber in the vicinity. Aside from these shores, two small ponds northwest of the lake are the only lands which cannot be drained with the lake as it is.

A survey shows the area to be 152 acres. The meander encloses 179 acres. 8,298 acres in Minnesota and 2,256 acres of land in Iowa, make up the water shed of the lake.

Some hunting is done around the shores, but no lodges are maintained. So far as could be learned, there is no fishing and this is what would be expected when the depth of water is considered. The main source of water supply is from a drainage ditch which comes down from Minnesota. Four tile from the surrounding farms also outlet a little above the present level. The outlet is through a creek, which flows into the west fork of the Des Moines. The creek has a fall of 28 feet in five and seven-tenths miles. A bull ditch was run down this years ago in an effort to drain the lake. Judging from the evidence along the banks, the water in the lake formerly stood a foot and a half above its present level.

Silt and decaying moss and water plants form the bottom. It is believed that this would make good agricultural land if drained.

Recommendations.

The Commission recommends that permission be given for the drainage of this lake, whenever a district is organized to drain the surrounding lands, and that the state retain title to the lake bed, tile it out and rent it until it will sell for \$125.00 per acre or more.

This recommendation is based on the fact that the lake is nothing but a marsh at present, and that owing to the shape of its banks, considerable land would be damaged by raising the water level. It is difficult to estimate the assessments which will fall on the lake bed. The district in Minnesota will, of course, stand some part of the expense, as will the land owners below the lake along the outlet.

At \$20.00 an acre, the cost for the outlet will be \$3,040.00. Tile can be put in for \$30.00 an acre or \$4,560.00 for the entire lake bed. This makes a total of \$7,600.00. To this should be added a reasonable amount to cover interest during the construction and the cost of subduing the land.

BIRGE LAKE, EMMET COUNTY.

Lake No. 32. Survey made by order of the Executive Council. Inspection made August 8, 1916.

Birge Lake occupies parts of sections 7 and 18, township 100 north, range 32 west, and of sections 12 and 13, township 100 north, range 33 west. It is four miles northwest of Dolliver, and fourteen miles to the northeast of Estherville. Tuttle Lake lies three miles to the northeast.

A township road along the north side of section 13 is in bad shape where it passes the north end of the lake. Traffic along this road formerly went to the north, across private property. This passage has recently been fenced off and the road is impassable except during the driest seasons.

The lake really forms one of a series of sloughs which occurs along the valley of Soldier Creek. It is difficult to tell why this one was meandered and the others not. The banks are rather low and swampy. The water is shallow, not over three feet deep at ordinary stage, and grown up to rushes and other water plants.

The area of the lake at the time of survey, was 140 acres. The meander encloses 168 acres. The area of the water shed is 12,948 acres, 9,948 of which are in Minnesota.

So far as could be learned from inquiry in the vicinity, the lake is used but very little. Some shooting is done by local boys, and a few muskrats are caught occasionally. The water is not deep enough to permit of its being stocked with fish.

The lake is fed and drained by Soldier Creek, a branch of the Des Moines. Its valley is shallow and undeveloped and its slope, light. In times of flood, it carries considerable water; at other times, it is dry or nearly so. The fall in the first four miles below the lake is sixteen feet.

The bottom of the lake is composed of silt and decaying vegetable matter. Even along the shores, there are very few places where any

sand is visible. It now supports a dense growth of vegetation, and no reason appears why if properly drained out and cared for, it should not make good farm land.

The fall in Soldier Creek, above the lake, is slight. For this reason, considerable land, as well as the road, would be damaged if the lake level were raised.

Legal Status.

A petition for the drainage of this lake was presented to the Executive Council in 1912. At a hearing in September of the same year, no opposition being offered, drainage was authorized and the land ordered sold as required by law. No steps were taken toward draining the lake under the authority granted.

A reproduction of the map prepared for the Executive Council, is presented with this report. A second survey was not deemed necessary. Conditions on the ground were carefully looked into.

One of the principal reasons for the desire to have the lake drained, lies in the fact that a Lutheran Church is located just northwest of the lake. Many of the congregation live in the vicinity of Dolliver, and because of the condition of the north road, find it necessary to make a detour to the south, to reach the church. They, for this reason, as well as others, favor drainage.

Recommendations

It is the opinion of the Commission that the drainage of this lake should be authorized when the counties affected, organize their district. The land should be tiled out and subdued by the state, and rented until it commands a price of a hundred and twenty-five dollars an acre. This opinion is based on the urgent need of drainage in this vicinity, on the impracticability of improving this body of water without buying up considerable areas of damaged land, and on the fact that there are six other lakes within this same county which offer opportunities of every kind of recreation.

When this lake is drained, it will be as a part of a large district. Until more complete surveys of such a district are at hand, it is impossible to estimate with any degree of accuracy, the assessments which will be made on the lake bed. At \$15 an acre, the cost of the outlet will be \$2,100. Tile can be put in for \$30 an acre or \$4,200 for the lake. This makes a total of \$6,300. A reasonable amount should be added for getting the land under crops. At \$125 per acre, the state would receive \$17,500 for the land.

TUTTLE LAKE, EMMET COUNTY.

Lake No. 33. Survey made by the State Highway Commission. Inspection made August 8, 1916.

Tuttle Lake occupies parts of sections 10, 11 and 12 of township 100 north, range 32 west in Iowa, and of sections 18, 19, 20, 21, 22, 27, 28, 29, 31, 32 and 33, of township 101 north, range 31 west in Minnesota. It is sixteen miles northeast of Estherville and eleven

miles northwest of Armstrong. Iowa Lake is five miles to the east, Swan Lake is eleven miles southwest. It is most easily reached by driving from Dolliver on the C. & N. W. Ry. A township road skirts the south and east banks in Iowa. A state road parallels it on the west in Minnesota and township roads skirt its east and north shore.

In general appearance, the lake is a large, irregular shaped body of open water, from five to six feet deep. The shores are sandy, the banks are high and covered with native timber in places. In other places, they open out into broad areas of pasture land that lie very little above the lake level.

The area of the lake is 2,816 acres, 981 of which are in Iowa. The area enclosed by the meander line is 2,753 acres. The water shed tributary to the lake is estimated at 92,160 acres.

There are no pleasure resorts on the shores of this lake. One cottage known as the Elsworth bungalow is situated on its southern

FIG. 18—Tuttle Lake, Emmet County. Tuttle Lake has an open body of water of good depth, covering approximately four and one-half square miles. It acts as an immense storage reservoir for regulating the flood waters of the Des Moines River.

shore. The lake is used mostly by hunters and fishermen. The large expanse of open water, together with the more shallow rush grown bays and outlying sloughs, makes this a favorite resort for game birds. There is shelter enough along the banks so that ducks in considerable numbers nest here.

Fishing is very good and all the common fishes are caught in good numbers. The lake lies on the state line and so far as could be learned, has never been stocked by either state.

The water shed tributary to this lake is larger than those of most of the lakes of the state. The water level varies from year to year, but so far as could be learned, the lake has never gone dry. The main feeder

is Ten Mile Creek which enters the lake from the northwest. This stream has very little fall in the first two miles; the water surface being only 1.0 feet above the water in the lake. Its valley is low, broad and subject to overflow by floods. Another large territory on the north drains into Tuttle Lake through Bright and Clayton Lakes. The outlet is to the south into the east fork of the Des Moines River. The stream curves and twists through areas of slough lands which are subject to overflow in times of high water. The river has an average fall of a foot and a half per mile for the first six miles of its length below the lake.

The bottom is covered with a deposit of black silt, though at places considerable beds of gravel were encountered in the borings.

Local sentiment is somewhat divided. People in Iowa, and a great many in Minnesota wish the lake kept. Owners of low land north of

FIG. 19—Tuttle Lake, Emmet County. There is an active movement on foot by the owners of low land to the north of Tuttle Lake in Minnesota to drain the lake. While such a procedure would undoubtedly benefit the low farm land in Minnesota, no plans have been proposed which could reclaim the lake bed and not subject the Iowa farmers in the Des Moines River Valley to damage by floods.

the lake, wish to see it drained, or its level so regulated that they may get good drainage for their lands.

Special Problem.

The drainage situation around this body of water is peculiar. Reference to Figure 20 will help make the situation clear. Ten Mile Creek as has been said before, is the main feeder for the lake. This stream drains a large area of land in Martin and Jackson Counties, Minnesota, and is subject to extreme floods. An effort has been made to drain four small lakes which lie on the branch that extends north toward Sherburn. Further west, the main creek has been dredged out and several drainage districts outlet into it. All this work doubtless results in the waters from heavy rains reaching Tuttle Lake somewhat quicker than was formerly the case.

North of Tuttle Lake, lie Perry, Erigh, Mud and Pierce Lakes. These nominally drain to the south into Tuttle Lake. Clayton and Bright Lakes

FIG. 20.—General map of Tuttle Lake region. This chart shows the lakes and low lands to the north of Tuttle Lake. Minnesota, by draining Monger, Prairie, Smith and Holmes Lakes, has aggravated the flood damage immediately north of Tuttle Lake.

have virtually the same water level as has Tuttle Lake. Pierce Lake is only six feet higher.

During times of flood, the water which falls on the Ten Mile Creek water shed, is rushed down into Tuttle Lake, much faster than it can be taken away by the Des Moines River. Tuttle Lake rises. Its water level becomes higher than that in the lakes to the north. The natural drainage is reversed and the water from Ten Mile Creek flows north into Clayton, Bright and Mud Lakes, and spreads out over the low lands surrounding them. Later, when Tuttle Lake has again fallen to a normal stage, this water drains away to the south, through Tuttle Lake to the Des Moines River. According to the testimony of old residents, this same thing has always happened. No doubt the drainage work which has been done to the west, has aggravated the floods. Later when the tile is all put in, the floods should be less sharp. Nevertheless, it appears that the reclamation of lake beds which has been carried out south of Sherburn, has been partly at the expense of the people owning farms on the flat ground north of Tuttle Lake.

A drainage district costing some forty thousand dollars has been constructed west of Pierce Lake. Its outlet is into Bright Lake. The fact that this outlet would not prove very satisfactory, was pointed out by Mr. G. N. Miller, the engineer of Fairmont, at the time of the hearing for the establishment of the district. In the face of this, the big ditch was put in. It does give some relief, but not nearly so much as was hoped for.

The people living in Tenhassen and Rolling Green Townships, Minnesota, need drainage, and need it badly. They can get it by continuing their ditch on down through Tuttle Lake to an outlet several miles below in the Des Moines River. This of course, would drain the lake, and pass the flood waters on down stream, for the people living along the Des Moines River to handle, at their own expense. Such a plan does not cure the trouble, but simply shifts it to other property owners.

This lake, and those to the north, form a great natural reservoir, for the pondage of storm water. The people along the Des Moines River have enough trouble with floods as conditions are now. They have too much bottom land lying idle, or used only for pasture, to look kindly on any scheme which will add to their burden.

Moreover, it is well to remember that those who most desire this drainage, bought their land, knowing conditions. That they bought it because it was cheap land and that in all fairness they should be the ones to pay for a system of drainage, which will not prove a hardship to other people. The preparation of anything like a complete plan to provide such drainage falls outside the province of this report. It will be of value however, to consider briefly one or two plans which could be adopted.

The first plan contemplates such a system of levees as would prevent any water from Tuttle Lake or Ten Mile Creek ever backing into the lakes to the north. Reference to the large map which accompanies this report will show that such a system is entirely practical and will not prove expensive. A flood gate where Clayton Lake empties into Tuttle

Lake will allow natural drainage to the south, as at present, but will not permit water from Ten Mile Creek to flow north.

With this done, there still remains the problem of disposing of the rain water which falls on this territory during the times when Tuttle Lake is too high to permit of its drainage by gravity to the south. The most natural way of handling this, and one which has met with entire success in southeastern Iowa, is by means of a pumping plant.

A careful study of conditions leads to the conclusion that such a plant, not including the cost of embankments, and main ditches, should not be more than two dollars an acre for the district, to the north of Tuttle Lake and east of the range line through Welcome. Fixed charges and operating expenses should not exceed one dollar and thirty cents per acre per year.

Second plan: Iowa Lake to the east is twenty-eight feet below Clayton Lake. A ditch across here would be four miles in length, and have a maximum cut of thirty feet. If the same district as above, is all drained through this ditch, its first cost, not including damages incurred by taking the water out of its natural course, will be higher than the first cost of the pumping plant, but the annual cost will be lower. Sufficient information is not at hand to warrant a final comparison of the two schemes.

Either one of these plans will greatly reduce the area over which the water is now stored, and as a consequence, unless arrangements are made to allow a greater fluctuation in the level of Tuttle Lake, will decidedly increase the flood flow in the outlet. How this question can be handled to the best advantage, can only be decided after actual measurements of the flows in Ten Mile Creek, the Des Moines River, the inlet from Clayton Lake, and the variation of level in Tuttle Lake, have been made, during high water.

Recommendations.

The Commission recommends that enough measurements of the flood flow in the Des Moines River at the outlet be made to determine what the natural flow of the river is. When this has been decided, a dam should be built at the outlet which will maintain the lake, as it is today. It is estimated that such a dam will cost \$3,100.00. They recommend farther that a park be purchased fronting on the lake, and estimate its cost at \$6,600.00.

In the event that it is thought wise to adopt the doubtful expedient of trying to maintain the lake at an unchanging level, by throwing the flood flow directly down the Des Moines River, plans for the work should not be approved by the Iowa authorities until they are altogether satisfied that adequate provision has been made to protect the property owners along the Des Moines River from damage by floods. Such channel improvements will cost many times what would be required to drain the lands along the river. This increased cost should be paid, by the lands north of the lake, as they will be the only ones benefited.

IOWA LAKE, EMMET COUNTY.

Lake No. 34. Survey made by the State Highway Commission. Inspection made August 8, 1916.

Iowa Lake occupies parts of sections 11, 12 and 14, township 100 north, range 31 west, in Iowa, and of sections 29, 31, 32 and 33, township 101 north, range 30 west, and of section 25, township 10 north, range 31 west, in Minnesota. It is most easily reached by driving from Armstrong on the C., R. I. & P. Railway. Township roads on the state line, touch it both on the east and west sides. Tuttle Lake is five miles to the west, Swag Lake three miles to the east.

The lake is a beautiful sheet of open water, of most irregular shape. The banks are high and well timbered. Two small areas of slough lie between Iowa Lake and Silver Lake on the north. These and two ponds in Iowa are the only undrained lands in the vicinity.

A total of 832 acres are covered by the lake; 478 of which are in

FIG. 21—Iowa Lake, Emmet County. This photograph shows another view of the same lake shown in the frontispiece. Iowa Lake has one of the best wooded shore lines of any lake in Iowa. Several roads touch the lake but the shore line, suitable for camp sites, is all privately owned.

Minnesota and 354 in Iowa. The areas enclosed by the meander are 433 and 308 acres respectively.

The lake is but little used at present. Splendid cottage sites and camping grounds are to be found along the shores. The water varies from five to nine feet in depth. All the common varieties of fish are caught. So far as could be learned from inquiry, it has never been stocked.

There are no streams of any size feeding the lake. On the northwest, a line of tile has diverted water from the Tuttle Lake drainage and furnishes a fairly steady supply. On the south, one small creek outlets into the lake. South Silver Lake drains into Iowa Lake from the north.

Relatively speaking, the water supply for this lake is good, although it has suffered from a lack of water during the worst dry seasons.

The outlet is in Minnesota. A small creek leads away to the east, crosses the state line into Iowa about two miles from the lake, and empties into Swag Lake a mile further down. In making the survey of this lake, all elevations were referred to a datum plane 100 feet below the water surface of Swag Lake. The water surface of Iowa Lake is 40 feet above Swag Lake.

Old residents say that at one time, the outlet was lowered nearly five feet. Later, the lake was again raised to within two feet of its natural level. An examination of the shore does not bear this out. It seems probable that the normal level of the lake has been very little, if any, higher than at present. The bottom is a fine black silt which overlays beds of sand, gravel and clay.

The sentiment in the locality seems all to be in favor of retaining the lake. Some would like to see it lowered a little so as to give better drainage outlets. There is very little low land surrounding the lake and such a course of action should not be considered seriously.

Silver Lake to the north, is also a beautiful lake, perhaps twenty feet deep. There are two summer resorts on its shores. Various people in this vicinity are anxious to see a canal built connecting this to Iowa Lake. The plan seems entirely practical. It does not appear that such a canal could in any way, affect Iowa Lake adversely.

Recommendations.

The Commission recommends that the lake be preserved, that a park be purchased on its shore and that an effort be made to co-operate with the Minnesota authorities in the building of a permanent dam at the outlet.

Land for the park may cost \$3,300. The outlet dam should be built for \$800.00.

WEST SWAN LAKE, EMMET COUNTY.

Lake No. 35. Survey made by order of the Executive Council. Inspection made August 5, 1916.

West Swan occupies parts of sections 29, 30 and 31 of township 99 north, range 32 west, and of sections 25, 35 and 36 of township 99 north, range 33 west. It is eleven miles southeast of Estherville, and twelve miles southwest of Armstrong. Tuttle Lake is twelve miles northeast, Mud and High Lakes two miles southwest. A township road crosses the outlet, and other township roads touch it on the south side so that all parts of it are easily reached.

The lake is a pleasing body of open water from six to eight feet in depth.

The banks are sharp and in many places covered with natural timber, except at the southwest where the drainage from Mud Lake enters. Here the creek enters through a big marsh that extends back nearly to the other lake. Aside from this marsh, there is very little wet land that drains into Swan Lake.

FIG. 22—Iowa Lake, Emmet County. The outlet to Iowa Lake lies in Minnesota. Iowa authorities should co-operate with the Minnesota authorities in building a permanent dam to maintain the water level.

FIG. 23—Iowa Lake, Emmet County. Surrounding many of the Iowa lakes there are walls or dikes which almost appear to have been the work of man. These dikes have in reality been formed by the ice pushing and carrying out the earth and boulders from the lake bed to the shore line. This movement is almost imperceptible in a single year, yet in the course of thousands of years, some of the lakes have built up embankments as shown in this picture, five and six feet in height. The fact that these are always formed where the shore line is low, adds to the impression that these walls have been designed and built by man to raise the shore line and improve and protect the lake. These walls account for the fact that there are so many "Wall Lakes" in Iowa.

The lake has an area of 1,038 acres. The water shed includes that of Mud and High.

This lake is a favorite hunting ground for people of that part of the

FIG. 24—West Swan Lake, Emmet County. Swan Lake is an open body of water covering about one and one-half square miles. The shore line in parts, is heavily wooded. The shore line is all private property and there is no easy means of access.

state. Fishing is also reported as good and all the more common varieties of fish are caught. So far as learned, the lake has never been stocked.

No fault is to be found with the water supply. The lake level varies somewhat from year to year, but not enough to be objectionable. Attention has been called to the large slough at the inlet. Some of the land

FIG. 25—West Swan Lake, Emmet County. East Swan Lake, immediately adjoining West Swan Lake, has been drained and a dam built to protect West Swan Lake. Property owners around this lake value it very highly. They feel that its proximity to their land, adds value to their farms as homes.

owners would like to see the lake lowered but it seems that this is a case in which such a step should not be seriously considered.

The outlet is through a dredge ditch to the east which follows the valley of Jack Creek to the Des Moines River. A concrete dam and fish-way at the outlet maintain the lake level. The bottom is a layer of silt and decaying vegetation overlying the Wisconsin drift.

Legal Status.

Petition for the drainage of Swan Lake was made in 1904, and a survey and report as required by law, followed. In December of the same year, the Executive Council gave as their opinion that the East Lake should be drained and the West Lake preserved, by a dam located at the point where the highway crosses the lake. Plans for a dam and spillway were approved in 1911. In 1913, there was an effort made to have the height of dam changed but after considering all petitions and having the high water line determined from an examination of the ground, the Executive Council reaffirmed its first order.

Recommendations.

The Highway Commission is of the opinion that this lake should be preserved as it is. The purchase of a park fronting on the lake is recommended, at an estimated cost of about \$6,000.00.

MUD LAKE, EMMET COUNTY.

Lake No. 36. Survey made by the State Fish and Game Department. Inspection made August 5, 1916.

Mud Lake occupies parts of sections 11, 12, 13 and 14, township 98 north, range 33 west. This lake, like High Lake, is thirteen miles south-east of Estherville. A township road touches it on the south side.

The banks, except on the south side, are high and considerable timber lines the shores. The water is from four to seven feet in depth. Perhaps one-quarter of the area is grown up to rushes; the other three-quarters are open water. One slough of 49 acres drains in from the north.

The area is 363 acres. The meander encloses 421 acres. The water shed consists of 6,154 acres.

There is one small shooting lodge where the sportsmen gather for trap shooting two or three times a year, situated on the southeast shore of Mud Lake. Many attractive camp and cottage sites are to be found around its shores.

Although no fish have been put in, the fishing is reported to be fairly good. All the more common varieties are taken. The lake with surrounding sloughs and its timbered banks makes an ideal place for bird life.

The water supply is only moderately satisfactory. Residents in the vicinity state that during dry years the level is about three feet lower than during ordinary years. At one time the bed became entirely dry. The largest part of the supply comes from High Lake, which drains into Mud Lake through a slough of 205 acres on the south.

West Swan Lake, a mile and a half to the north, receives the water from the outlet. Between the two lakes, lies a considerable area of slough land, that cannot be drained by gravity without draining Swan Lake. The fall between the two lakes is 5 feet. In sounding the lake, it was found that a pole could easily be pushed down from twelve to fifteen feet below the water surface. The material encounter-

ed was a heavy black silt. Mosquitoes and blackbirds are as plentiful as would be expected in a locality such as this. There is very little complaint made of either.

Local sentiment is divided. The land owners in the immediate vicinity would favor drainage, because of the benefits which would accrue to them from such a course. People living further away are indifferent. The sportsmen are heartily opposed to the destruction of the lake itself.

Recommendations.

The Commission recommends that the lake be preserved and that a small dam be built at the outlet to aid in maintaining the lake level. The cost of the dam is estimated at \$1,800. Land for a public park fronting on the lake should be purchased at an estimated cost of \$3,500.00.

HIGH LAKE, EMMET COUNTY.

Lake No. 37. Survey made by the State Fish and Game Department. Inspection made August 5, 1916.

High Lake occupies portions of Sections 14, 15 and 23, township 98 north, range 33 west. Estherville, the county seat, is thirteen miles northwest. Swan Lake, in the same county, is four miles northeast. It is most easily reached by driving from Wallingford on the C. R. I. & P. Ry. A county road touches it on the east side.

In general outline, it rather resembles the old fashioned hour glass; its two large bodies of open water being connected by a narrow neck. The banks on the north and south sides are high and covered with timber. From four to six feet of water were found in sounding. 112 acres of slough on the north drains into the lake through a narrow break in the bank and a smaller area drains in from the west.

The survey showed an area of 451 acres in the lake proper. The meander encloses an area of 467 acres.

Considerable hunting is done here in the open season. This lake with its outlying sloughs offer good shelter and feeding grounds for wild fowl which nest here to some extent. No pleasure resorts or cottages are maintained along the banks, though nice locations are to be found both for cottages and temporary camps. Most of the fishing done is confined to the spring of the year when pickerel, buffalo and carp are running. The lake has never been stocked and the water is scarcely deep enough to warrant it.

During dry years the lake suffers from lack of water just as do practically all the lakes of the state. During wet years, on the other hand, there is a super-abundance here as in other places. The outlet is to be to the east through a big slough to Mud Lake. There is 1.2 feet of fall between the two lakes. The bottom of the lake is a heavy mud.

Very little is said in this vicinity about damage caused by black-birds. Complaints of the annoyance occasioned by mosquitoes are numerous.

Recommendations.

The Commission recommends that this lake be retained in its present condition. Land suitable for a park should be purchased, planted to trees and a road built to give the public entrance to the lake shore and park. The cost of these improvements is estimated at \$4,000.00.

TWELVE MILE LAKE, EMMET COUNTY.

Lake No. 38. Survey made by the State Fish and Game Department. Inspection made August 5, 1916.

This lake occupies parts of sections 20, 21 and 29 of township 98 north, range 34 west. It is nine miles south of Estherville. Raleigh on the M. & St. L. Ry. is the nearest railroad point. Lost Island Lake is seven miles south; High Lake seven miles east. A township road touches the southern end.

The lake is a pretty little sheet of water, five feet deep, more than half of which is free from rushes. Its banks are high, except near the outlet, and covered with scattered timber. At two or three places the shore is sandy. Very little low land is dependent upon the lake for a drainage outlet.

The area of the lake is 211 acres. The area enclosed by the meander line is 290 acres. The water shed is composed of 929 acres.

Local people use the lake for fishing and outing purposes. Hunting is considered good though so far as could be learned, ducks do not nest there.

No tile, streams or springs form a visible source of water supply. The run-off from a small drainage area seems to be all that keeps the lake up. At the time of the examination the water stood a foot below the outlet. The outlet is a shallow valley leading away to the southwest. There is a project on foot to tile the outlet, in which case a small dam will have to be constructed to maintain the lake. The bottom is a soft black mud, through which a pole can be pushed down for eight or ten feet.

People living in the vicinity wish to see the lake retained and make very little complaint of any nuisance arising from its presence.

Recommendations.

The Commission is of the opinion that a dam should be built at the outlet to maintain the present level. Its estimated cost is \$2,000.00.

GOOSE LAKE, GREENE COUNTY.

Lake No. 39. Survey made by order of the Executive Council. Inspection made September 26, 1916.

Goose Lake includes parts of sections 6 and 7, township 84 north, range 30 west, and sections 1 and 12, Township 84 north, range 31 west. It is located seven miles north of Jefferson, the county seat. The Twin Lakes of Calhoun County are thirty-four miles to the north.

Wall Lake in Sac County, is thirty-two miles to the northwest. The lake is easily reached from a township road which skirts its southeast shore.

The banks are well marked on the south and east sides. On the

FIG. 26—Goose Lake, Greene County. Goose Lake is a shallow marsh of about three-quarters of a section. It has been famous as a central Iowa hunting resort. The great disadvantage at Goose Lake is that there is an insufficient natural water supply and that there is no source from which an artificial supply can be obtained at a reasonable expense.

north and west, the slopes of the banks are more gradual. With the exception of a few scattered willows there is no timber near the shores.

No large areas of low land are dependent upon the drainage of the lake for their reclamation. The land which borders upon the lake is in use up to the fence lines, either for crops or for pasture land.

The water is no where more than five feet deep, though this, of course, varies with the water level. Rushes and lily pads cover the largest part of the surface.

The area was found by survey, to be 411 acres. The meander line

FIG. 27—Goose Lake, Greene County. Goose lake is covered with a scattered growth of rushes and other vegetation. Farmers in the vicinity of Goose Lake complain bitterly of the damage done by blackbirds which find their nesting place in the marsh.

encloses 477 acres. The water shed consists of approximately 824 acres of land.

So far as can be learned the lake is used exclusively for hunting purposes. Sportsmen of the state value it highly as a shooting resort. There is excellent cover and feeding grounds for all kinds of water fowl.

The water supply is limited by the small size of the drainage area. A road extends across the natural outlet, and so far as could be learned from inquiries in the vicinity, the lake does not overflow here for years at a time.

In 1894 the lake is reported to have gone dry and crops to have been raised on a part of the bed. With the exception of pumping

FIG. 28—Goose Lake, Greene County. This photograph shows a road across the outlet to Goose Lake. There is no culvert in the road, yet it has not overflowed in years. This is an indication of the inadequate natural water supply.

from deep wells, no artificial water supply is to be had. This method is considered too expensive to be undertaken.

Silt and decaying vegetation form the lake bottom. It is believed that this should form valuable agricultural land when thoroughly tilled out and subdued. A great deal of complaint is made of the damage to crops caused by swamp black birds which frequent the place.

Legal Status.

In 1913, application was made to the Executive Council for permission to drain the lake, in connection with a large county drainage district which is to build up the creek through which the lake outlets. Hearings were had at which the testimony, both of those in favor of drainage and of those opposed to it, was taken. No decision had been reached when the present law went into effect.

Recommendations.

It is the opinion of the Commission that this lake should be drained; the state reserving the title to the land. This conclusion is based on three considerations: The first is the fact that at a public hearing held at the lake, some fifty people, residents of the vicinity and familiar with local conditions, expressed unanimously the opinion that the lake should be drained. This was the only hearing held during the entire investigation where such was the case.

The second is the fact that due to physical conditions surrounding this lake, particularly to the difficulty of getting an artificial water supply, improvements will prove more expensive than at most of the other lakes which were examined. The Commission feels very strongly that such improvements cannot be carried to a successful conclusion without the enthusiastic co-operation of the local people.

The third is that in its present condition the lake is an eyesore, and something of a nuisance. As agricultural land, it should be valuable to the state, and pay more than the interest on any investment made for its improvement.

If the lake is drained it will be as a part of a large district. It is, of course, impossible to say exactly how the costs will be apportioned. The state should insist that the work be thoroughly done so as to entirely drain the land and render it fit for cultivation. The outlet will cost approximately \$35.00 an acre, or \$14,400.00 for the lake. Tile will cost \$30.00 an acre or \$12,300.00. This makes a total of \$26,700.00 for the lake. A certain amount should be added to this to cover the cost of getting the land to producing crops.

This lake bed, when drained, will be an ideal place for the state to establish a custodial farm. There is land enough; it is compact, and lies in the midst of as good a farming district as can be found in the state.

LITTLE WALL LAKE—HAMILTON COUNTY.

Lake No. 40. Survey made by the Executive Council. Inspection made October 12, 1916.

Little Wall Lake is situated in sections 9, 10, 15 and 16 of township 86 north, range 24 west. It is most easily reached by driving three miles south of Jewell Junction. The highway leads directly to the lake and skirts its western shore. Webster City is twenty-two miles to the northwest, Iowa Falls thirty-four miles to the northeast. The nearest lake is Big Wall in Wright County which is twenty-three miles due north.

This lake is not prepossessing on first sight, due largely to the fact that a large part of its surface is grown up to rushes. The banks, however, are good and on the east side considerable natural timber is found. In several places around the shores typical walls pushed up by the ice are to be seen. These seem to show that at some time in the past the water level was considerably above where it is at present.

Scarcely any low land which cannot be drained is to be found near the lake.

The water varies in depth from three feet in the northwestern part of the lake to six feet in the southeastern part.

The area now is 230 acres. The area enclosed by the meander is 273 acres. The water shed is very small.

At the present time the lake is more of a hunting resort than anything else. A hunting lodge is maintained on the west bank and several boats are to be seen along the lake shores. It is reported that fair strings of bullheads are taken from its waters.

The water supply is not all that can be desired. The tributary area so far as surface drainage is concerned is so meager as to make

FIG. 29—Little Wall Lake, Hamilton County. Little Wall Lake is a shallow lake. Portions of it are filled with heavy growth of rushes and other vegetation but there are stretches of open water. It is famous as a hunting resort in central Iowa. Sentiment in the locality is strongly opposed to the drainage of this lake. Conditions around this lake are such that it offers a favorable opportunity for a trial of a more extensive lake improvement.

one wonder why there is a lake at all. It seems probable that this lake, like some others, must receive a part of its water by a gradual infiltration from the gravels of the glacial drift on which it lies. It is reported to have gone dry as did many of the lakes of the state in 1894. During most years, however, there is water there.

A low place in the bank on the southeast side of the lake is the natural outlet. This leads away to the southeast and empties into the Skunk River. The water in the lake is nearly three feet lower than the outlet.

In the northern part of the lake the bottom is of silt. In the southern and eastern parts considerable sand and gravel is found.

Blackbirds and mosquitoes are only normally troublesome.

People living in the vicinity are in favor of keeping the lake and they wish very much to see it improved.

Legal Status.

In 1913, an application for drainage having been received a survey was made by order of the Executive Council. In January of 1914 drainage was denied.

Recommendations.

It is the opinion of the Commission that the lake should be kept and improved. If this can be done a large community which otherwise is a long way from any place suitable for outing purposes will be served.

There are two methods by which the lake can be bettered. The first consists of placing a dam at the outlet and raising the water

FIG. 30—Little Wall Lake, Hamilton County. Plans for the improvement of Little Wall Lake contemplate the dredging of a portion of the lake bed, using the spoil material in building up land for a park in the more shallow portion of the lake bed. The shores and the new land should be forested. If this lake should be improved, it will provide an attractive lake resort in a part of the state which has few natural attractions of the kind.

level. Additional water can be obtained by pumping from wells or from a drainage ditch which passes fifteen hundred feet north of the lake and is seventeen feet below the water surface. This plan is objectionable because of the expense incurred in pumping year after year.

The second method and the one which the Commission recommends consists in dredging out the lake bottom. The cost of this work over an area of forty acres is estimated at eighty-five thousand dollars. From the spoil obtained enough land should be made to provide a public park. This method of doing the work will reduce the size of the lake and thereby decrease the loss of water due to evaporation. It is thought that by so doing it will be possible to keep the lake in good condition without pumping in water. The made land can be planted with trees at a cost of five hundred dollars.

EAGLE LAKE—HANCOCK COUNTY.

Lake No. 41. Survey made by the Civil Engineering Department, Ames, Iowa. Inspection made June 13, 1916.

Eagle Lake occupies parts of sections 13, 18, 19, 24 and 30 of township 96 north, ranges 24 and 25 west. It lies just north of the county road between Garner, the county seat, and Britt. On the east, north and west, township roads make it easy to reach from any direction. Crystal Lake lies about nine miles to the northwest, Clear Lake about fourteen miles to the east.

The western bank of the lake is rather high and covered with native timber. The eastern bank is, in general, less abrupt, and a large part is under cultivation, or used for grazing. The bottom of the lake is largely peat, the product of decaying vegetable growth. Underlying the peat the borings show blue clay and gravel.

The water is shallow, four feet being the greatest depth found and so badly grown up with rushes that even a light duck boat is handled with

FIG. 31—Eagle Lake, Hancock County. Eagle Lake is a large shallow, partly open body of water covering more than one square mile. Over fifty species of birds nest here. Ornithologists and students of bird life from institutions all over the United States come to this lake to make studies of the bird life of the middle west.

difficulty. Young men living in the vicinity, however, tell of sailing and of running ice boats on the lake, so that it appears that the growth of rushes must be of recent date. With the exception of a few bull heads, no fish are caught.

The area of the lake at the time of the survey was 837 acres. The area within the meandered line is 906 acres. The area of the water shed is 6,866 acres.

The lake is now used almost entirely as a hunting resort. Three or four boat houses are maintained on the western shore by local sportsmen, and the lake is visited by many parties of hunters from more distant points. The reeds and rushes in the lake itself, and the timber along the shore, make the best of cover and nesting places for a great

variety of birds. Ornithologists from this and other states frequently visit the lake to make field studies of the fifty varieties of birds that find shelter in this little patch of wilderness.

It receives its water supply from extensive areas of slough land lying to the south and east. Four ditches which drain considerable land enter from the south. The drainage area is not as large as could be desired to maintain a uniform water level in the lake during all years.

The outlet at present is from the north end, to a drainage ditch which leads to the Iowa River. Old settlers say that in the early days the outlet was more to the west through a chain of sloughs lying close to the hills. In times of flood, some of the surplus water undoubtedly finds its way out in this direction even today.

Legal Status.

In the September term of the district court in 1910, William Jakobek, through his attorneys, Seneff & Bliss, brought an action against the board of supervisors of Hancock County, against E. W. Burgitt as

FIG. 32—Eagle Lake, Hancock County. Local sentiment is so strong for the preservation and improvement of Eagle Lake, that in the spring of 1916, when there was danger of the lake outlet cutting out and emptying the lake into a nearby drainage ditch, some forty or fifty men of the community spent several days, without pay, repairing the dam to save the lake.

engineer, and against Henry Boutilier and William Vescelius as contractors, asking an injunction to prevent the defendants from constructing any dam or embankment at the outlet of Eagle Lake, and a mandatory injunction commanding them to remove the structure already built. The claim made was that it caused water to overflow his land, prevented drainage of his land, and hindered access to the lake. The case was dismissed by the court, no injunction being granted.

Special Problem.

The remains of the concrete spillway which was the cause of the action still stand but the earthen dike is badly washed out. The outlet between the deep drainage ditch on the section line and the lake is cutting very fast and now endangers the lake.

An embankment such as is required at the outlet will be about 3,800 feet long, and for the most part will be built outside of the meander line.

The people of the vicinity are very anxious that the lake be maintained and improved. They have expressed themselves as willing to co-operate with the state authorities.

Recommendations.

In the opinion of the Commission, Eagle Lake should be kept and some money expended to make it of more use to the public. The shallow water, the shape of the banks, and the broad flat outlet all will render it difficult and rather expensive to improve this lake. As it stands today, it has an unquestionable value as a shelter for game and bird life. Places of this sort are becoming scarce in Iowa. Then too, the deep peat beds in this lake will render drainage difficult. Unless an exceptionally thorough and expensive plan were undertaken it seems probable that the lake would merely be reduced to a marsh.

An earthen dike, reaching five feet above the lake level, with a concrete spillway of proper capacity should be installed at the outlet. The dike should be well protected by fences to prevent its being trampled down by cattle. This work can be done for \$14,000.

Land should be purchased for a park, and a road built to connect it with the highway. Three thousand dollars should prove ample for this purpose.

Perhaps forty acres of the lake should be dredged out so as to provide a place for boating, and to allow the fish to winter. In this way all classes of people will be served. Seventy-seven thousand dollars is a fair estimate of the cost of this work.

WOOD LAKE—HANCOCK COUNTY.

Lake No. 42. Survey made by Civil Engineering Department, Ames, Iowa. Inspection made June 13, 1916.

Wood Lake is situated in section 24, township 96 north, range 25 west. It is only six hundred feet from Eagle Lake, and should be considered in connection with that body of water. Erritt is the most convenient railroad point from which to reach this lake. A township road passes very near its western bank.

A growth of plant life covers the water surface. The water is from two to three feet deep. The banks are distinct and covered with timber on the north and east sides. On the south and west, the country is low, and the shores are less sharply defined.

The lake now has an area of 42 acres, though the government meander encloses 52 acres.

No fish are caught in this marsh whose only use is as a feeding ground for ducks. Because of its small area, few game birds nest here. They come and go from Eagle Lake.

People familiar with the lake say that it occasionally goes dry. This is to be expected because there is no visible source of water supply, except the run-off from a little of the land which surrounds it.

The outlet is through a small ditch to Eagle Lake. There is enough fall so that the bed could be drained if its bottom were solid. The bottom, however, for eight feet in depth, is of peat, and this renders the success of drainage doubtful.

Recommendations.

The Commission recommends that the lake be kept as it is for the present. It may perhaps be useful in the development of a park at Eagle Lake.

CRYSTAL LAKE—HANCOCK COUNTY.

Lake No. 43. Survey made by the Civil Engineering Department, Ames, Iowa. Inspection made June 13, 1916.

Crystal Lake is located in sections 9, 10, 15 and 16, township 97 north, range 25 west. Just to the south is the village of Crystal Lake, a town of perhaps one hundred and fifty people, on the Titonka branch of the C., R. I & P. Railway. It is nine miles north of Britt and eight miles

FIG. 33—Crystal Lake, Hancock County. Crystal Lake is a beautiful open body of water of approximately one-half square mile. It is one of the most beautiful lakes in the state and one which should, in the future, have great value as a place of recreation.

southwest of Forest City. Eagle Lake in the same county, lies nine miles to the southeast. Clear Lake in Cerro Gordo County is about twenty-four miles away. A county road from the south, and township roads from the east, make it easy to reach the lake by motor.

The banks of this lake are rather abrupt, except on the west, where drainage enters. Native timber covers quite a part of the shores. The water is open, free from rushes, clear, cold, and from six to seven feet deep. People who have lived here for years give the depth as fifteen feet. The soundings showed from two to seven feet of almost liquid mud, below which lies sand and gravel.

The area of the lake at the time of the survey was 274 acres. The area within the meandered line is 238 acres. It is to be noted that the old meander line does not follow the actual shore line very closely. The water shed consists of 2,134 acres.

So far as can be learned from inquiries the lake has never been stocked with fish. At the present time, only bull heads can be caught, though formerly perch and pickerel were to be found in large numbers. The lake seems to be only a local resort, due largely to its proximity to

Clear Lake. With its clear water, good boating, and inviting banks, it merits more attention than it apparently receives.

The drainage area is decidedly limited and no doubt a large part of the water supply comes from springs. Any attempt to raise the water level will overflow the low land lying to the northwest. This is not desirable. The outlet is to the southeast through a concrete culvert under the highway and thence through a dredge ditch to the Iowa River. The present water level represents a normal high stage. A rise of two feet would put the water over the road at the outlet and imperil the railroad track in places.

Local people are united in a desire to have the lake kept and improved. They are justly proud of this beautiful little sheet of water. They regard it as an asset to the community and express themselves as willing to co-operate in every way for its betterment.

Special Problems.

Attention has been called to the large deposit of silt which is taking place in this, as well as in other of the lakes. In the course of time the deposit here will have to be removed or the lake will be ruined. How serious a menace this is in any particular lake can only be determined by careful soundings taken over a period of years.

Recommendations.

This is one of the lakes which should be preserved. It is recommended that steps be taken to raise the county road just east of the outlet. Sufficient land should be purchased fronting on the lake to form a public park. Land in this vicinity is valued at from \$150.00 to \$200.00 an acre. Without reference to any particular tract, it is estimated that \$5,000.00 should purchase the required land and pay for an entrance.

EAST TWIN LAKE—HANCOCK, COUNTY.

Lake No. 44. Survey made by the State Highway Commission. Inspection made June 15, 1916.

This is one of a pair of lakes, the other of which is known as West Twin. It occupies portions of sections 19, 20, 29 and 30 in township 94 north, range 24 west.

Kanawha, a town of five hundred people, on the M. & St. L. Ry., is four miles west of the lake. Goodell, a town of three hundred population, on the C., R. I. & P. Ry., is five miles east. The lake is easily reached from the highway that skirts it on the west. On the north the highway is not far from the lake and could, to advantage, be relocated so as to follow the shore even more closely.

The banks on the north and south are high and covered with good sized groves of natural timber. On the west is one small slough which cannot be drained. The east one-quarter of the lake is shallow, and grown up to rushes; the rest is open water about a foot and a half deep.

The area at the time of the survey was 184 acres. The area inside the meander line is 193 acres. The area of the water shed is 2,292 acres.

East Twin is now used mostly as a resort for hunters. The fishing is reported to be good, though the water has not been deep enough to shelter game fish or to make it advisable to stock it. From the south, the drainage from a long string of sloughs enters the lake through a narrow break in the bank. The water surface in the most northern slough of this group is below the level to which the lake will be raised. Those farther south, are a little higher. A plan for draining these sloughs through a saddle in the hills southeast of the lake has been considered. An earth embankment five hundred feet long would be needed to prevent the lake draining out through the same ditch.

As will be seen from the map, there is not a great deal of fall from these sloughs to the river, and it seems improbable that the northern ones can ever be completely reclaimed.

About two-thirds of the water shed tributary to the lake enters by way of these sloughs, and of course, will be cut off in case an attempt is made to drain them.

At the time the survey was made, a dam was being built by the Fish and Game Department, at the outlet, which will raise the water level 3.25 feet, or to an elevation of 103.25, referred to the map. The dam consists of a concrete spillway twelve feet long, and an earth embankment eleven hundred feet in length. This will increase the depth to about five feet.

The outlet is to the east, across a flat to the dredged-out Iowa River. In times of flood, this flat is covered with back water from the ditch.

Silt and decaying vegetation forms the bottom.

The lake, when the water rises, will form a valuable addition to Iowa's lakes, and the local people are well pleased with the work being done. They would like, however, to see the lake deepened by dredging. No complaint was heard of any nuisance arising from the lake.

Legal Status.

About twelve years ago, Mr. E. M. Sheffield of Belmont, deposited a sum of money with the Board of Supervisors of Hancock County as part payment for the bed of the lake. Later he brought an action in the district court to compel them to fulfill their engagement. The matter was at last settled out of court, Mr. Sheffield renouncing all claim to the lake bed that he may have had heretofore.

Recommendations.

In the opinion of the Commission, this lake should be retained and further improvements made. They recommend that land fronting on the lake be purchased for use as a public park. The estimated cost is placed at \$4,000.00.

WEST TWIN LAKE—HANCOCK COUNTY.

Lake No. 45. Survey made by the Civil Engineering Department, Ames, Iowa. Inspection made June 15, 1916.

West Twin occupies parts of sections 19 and 30, township 94 north, range 24 west, and of sections 24 and 25, township 94 north, range 25

west. It is three miles east of Kanawha, and six miles west of Goodell. Eagle Lake is ten miles north; Twin Sisters Lake, seven miles south.

This is a nice, clear body of open water from five to six feet deep. There is no inlet and at the present elevation of the water surface, no outlet. The banks are good. There is practically no low land dependent on the lake for drainage. On the southeast, a grove of natural timber forms a pleasant picnic ground.

The area of the lake at the time of survey was 109 acres. The area enclosed by the meander line was 109. acres. Two hundred and twenty-nine acres of land are included in the water shed.

Only local people use the lake for fishing purposes. It has never been stocked, but bullheads are found in abundance. There is very little natural shelter around the shore and as a consequence, it is not of any importance as a nesting place for wild fowl. Occasional flocks only are to be found during the spring and fall migrations.

Owing to the very limited area which drains into the lake, the water supply is not all that can be desired. The water level fluctuates considerably. If the water were to rise two feet above its present level, it would escape to a small ditch south of the lake and follow down a natural depression to East Twin Lake which is 29 feet lower. If it were to rise a trifle higher, it could also escape to the southwest into the Boone River. The lake is almost exactly on the divide. The bottom is of mud and decayed vegetable matter.

Local testimony indicates that the lake is filling rapidly. This is due in a long measure to dust carried in by the wind from the surrounding plowed fields. The sentiment of the people living in the vicinity is generally in favor of preserving the lake as a resort. Very few complaints are heard about the lake.

Recommendations.

The Commission is of the opinion that it should be kept for the use of the local people and that the State should purchase a public park on its banks. The estimated cost is \$3,500.00.

NOEL'S LAKE—HARRISON AND POTTAWATTAMIE COUNTIES.

Lake No. 46. Survey made by State Highway Commission. Inspection made September 26, 1916.

Nobles Lake occupies parts of section 2, township 77 north, and of section 35, township 78 north, range 45 west. It is twenty miles north of Council Bluffs and eight miles southwest of the Missouri Valley. Loveland, on the C. & N. W. Ry., lies about four miles directly east of the lake. Two lakes in the parks of Council Bluffs are the nearest bodies of water to the south. Blue Lake, at Onawa, thirty-six miles away, is the nearest lake on the north.

Taken as a whole the lake is rather attractive. The west shore has low, grass covered banks. The east bank is high and has several nice groves of timber. The water is open over the greatest part of the area. Ten feet of water was the deepest encountered in the sounding, but most

of the lake is more shallow. Comparatively little wet land is found in the immediate vicinity of the lake.

Wilson's lake, or Minnewashta lies just north of Nobles Lake. This was sold by the county, and a quit claim deed issued to private owners in 1899. The lake has been partly drained by a ditch leading into Nobles Lake, and a considerable part of the bed is under cultivation.

A ditch leading south from Nobles Lake is under construction, which will lower the water surface about two feet below its present level, and afford better drainage to Wilson's Lake bed.

Permission to lower Nobles Lake is said, by those interested in the drainage of Wilson's Lake, to have been granted by the State. The records of the Executive Council do not confirm this statement.

It is our opinion that this lowering of the water level may in a measure help to stop the cutting which has been going on along the east bank of the lake.

The area at the time of the survey was 160 acres. The area enclosed by the meander was 80.5 acres. This difference in size is due to the fact that the Missouri river cut into the lake from the northwest in 1912.

Automobile picnic parties from Council Bluffs come frequently to the lake for a day's outing. Two or three cottages are kept for rent on the east shore.

An abundance of different kinds of fish are caught. The lake connects directly with the river and has never been stocked. During the shooting season the lake is a popular resort for the sportsmen who get good bags around its shores as well as along the river bottoms. The lake lies but little above the river and can not well be drained out. In May, 1916 (Omaha gauge 10.1, Sioux City gauge 9.3), the river level west of the lake was three feet below the lake level. The low place on the river bank is about three feet above lake level. The bottom is of blue clay.

Recommendations.

In the opinion of the Commission this lake should be kept. They believe that a considerable amount of the damage from the river would be avoided if the roads west of sections 35 and 2 had permanent embankments. The work will not be expensive in any event and the State may perhaps co-operate with the township in doing it.

ROUND LAKE—HARRISON COUNTY.

Lake No. 47. Survey made by State Highway Commission. Inspection made September 26, 1916.

Round Lake occupies parts of sections 13, 14, 23 and 24 of township 80 north, range 45 west. It is most easily reached from the town of Mondamin from which point a county road leads, north two miles to the lake. Nobles Lake is sixteen miles to the south, Blue Lake about twenty-four miles to the northwest.

The east half of the lake is open water from four to six feet deep. The west half of the lake is shallow, grown up to rushes, and in times of low water goes entirely dry. The east and south banks of the lake

are rather high. On the north and west as well as on the island the slopes are very gradual, and in times of high water as when the survey was made, the lake covers ground that generally is used for agricultural purposes. On the south of the lake there is one good grove of timber, and willows are found scattered along the shore in several places.

The area of the lake is 327 acres. The meander encloses 409 acres. The water shed is very small. But little use is made of this body of water. Scarcely any fish are caught, although they are reported to have been abundant several years ago. Some few ducks and geese stop here during the spring and fall immigration but so far as could be learned they do not summer nor nest in the vicinity.

The land around the lake is about the same as generally found along the Missouri River. It is rather low and subject to occasional overflow from the river, but during ordinary years produces good farm crops.

The drainage area tributary to the lake is small and the water surface varies considerably. So far as could be learned from inquiry the east half never goes dry.

Soldier Creek Cut-Off passes the lake about 1,000 feet to the north. At times of ordinary flow the water in the ditch is about five below the water level of the lake. In times of flood the water surface in the ditch rises somewhat above the lake level, so that the lake can be partly drained into the ditch if desired, or flood waters from the ditch could be turned into the lake.

As things are today the lake has no outlet though one could be obtained in the county ditch a mile and a half to the south. The bottom of this ditch was nine feet below the lake level at the time the survey was made.

The bottom of the lake is a sandy loam, comparatively hard and only in a few places was soft mud encountered.

The area of the lake is 327 acres. The government meander encloses 409 acres. The water shed, as at all of the Missouri bottom lakes, is very small.

Legal History.

All of the land included in this lake was selected as swamp land by the county, under the Federal Act of 1850. The records in the state house do not show that the lake has been disposed of. Records on file in the county court house show that the lake was sold by the county in 1899.

SWAN LAKE—JOHNSON COUNTY.

Lake No. 48. Survey made by the State Highway Commission. Inspection made September 30, 1916.

Swan Lake occupies parts of sections 32 and 33, township 31 north, and of sections 4-5, township 80 north, range 7 west. It is six miles northwest of North Liberty, and about sixteen miles from Iowa City. A township road follows along the north shore and allows access to the lake.

The banks are well defined, and mostly under cultivation. The water is shallow, and the maximum depth found was only two feet and a half.

Most of the area is grown up to rushes. Indications along the shore and the testimony of residents agree that the lake has been about two feet higher at times. Practically no low land is to be found around its shores.

The area of the lake is 37 acres. The government meander encloses 44 acres. The drainage area consists of 119 acres.

There are no fish to be caught there in later years. Some time ago the place is reported to have been well stocked with the more common varieties of fish. Shooting is said to be fairly good though the small size and absence of timber makes it rather exposed for breeding purposes.

There is no outlet. In times of high water the lake sometimes overflows the road and the water drains away toward the river. There is no channel, however.

The bottom of the lake consists of a thin layer of silt, overlying a sandy clay.

Legal Status.

In 1914, Mr. Frank C. Carson of the Johnson County Savings Bank made application to the Executive Council for the lease of the lake for a period of ten years.

After investigation by Secretary Allen, a lease at \$1.00 an acre was executed subject to termination upon other disposition of the land as provided by law.

Mr. A. J. Roup, Jr., and Mr. Frank Fisher, who owns land to the east and west of the lake, now hold the land, and use it for hog pasture.

Recommendations.

The Commission recommends that the lake be drained and the land retained by the state until such time as its value as farm land is established and it will sell for \$125.00 per acre or more.

These recommendations are made because the lake is of no value as a resort for the people, and that due to its location no artificial water supply seems practical.

A ditch in section 33 will furnish an outlet. There is 17 feet of fall from the lake to the ditch. The entire outlet will cost \$2,300.00, some part of which will be paid by land outside the lake. Probably \$1,300.00 will be assessed against the lake bed. At \$30 an acre, the tile in the bed will cost \$1,110.00. Something should be added to this for getting the land under crops.

BABCOCK LAKE—JOHNSON COUNTY.

Lake No. 49. Survey made by the State Highway Commission. Inspection made September 30, 1916.

Babcock Lake is situated in sections 30 and 31, township 81 north, range 7 west of the Fifth Principal Meridian. It is most easily reached by driving from the town of North Liberty, a distance of seven miles. Swan Lake, in the same county, lies two miles southeast of Babcock Lake.

A casual investigator would, no doubt, simply call this tract bottom land along the Iowa River. It is only upon an examination of the government plats, that it becomes apparent that it is a lake. A more minute scrutiny of the ground results in the discovery of a slight depression in the form of a capital "J"; the top of which nearly touches the river and whose foot touches the higher land which is used as farm land. The area at the time of the survey was 58 acres. The meander encloses 58 acres.

A tiny stream which drains a limited area to the south trickles down through the sag. During high water, the river backs in. The banks are fairly well defined on the eastern side. On the western half they shade off until they are hardly noticeable. The bottom is of sand and gravel mixed with silt. The flat inside the bend is from five to nine feet above the river, is covered with grass and timber and is used for pasture land. A little of the bottom land east of the lake is under cultivation.

There is no fishing, and the place is only used for hunting, as are the other abandoned river channels and flats which are to be found all along the river. Indeed, even old residents expressed considerable surprise on being informed that this land is a lake.

Recommendations.

In the opinion of the Commission, this land should be appraised and sold without being drained.

It is not practical to make a lake at this point owing to the lack of a water supply and to the continual attack to which it would be subjected on the river side.

The depression is not high enough above the river to be drained and kept dry. It is doubted whether the land will sell for enough to more than pay the expenses.

People residing in the vicinity inform us that these bottom lands do not sell. That in trades they are regarded as having a value of from twenty to thirty dollars an acre.

GOOSE LAKE—KOSSUTH COUNTY.

Lake No. 50. Survey made by the State Highway Commission. Inspection made September 29, 1916.

Goose Lake occupies a part of section 17, township 100 north, range 30 west of the Fifth Principal Meridian. Swag Lake in the same county lies a mile to the northeast. Iowa Lake in Emmet County is four miles to the northwest. It can be reached by driving a distance of twelve miles, either from Armstrong or Swea City. A township road touches it on the east side.

The banks of the lake are steep and high, with only a few scattered trees to shade them. The water is open, over most of the area, and from two to three feet deep.

The area at the time of the survey was 103 acres. The area within

the meander line is 74 acres. A noticeable discrepancy between the area of the lake and of the meander may be in part explained by the recent completion of the tile line from Eagle Lake, and the construction of the dredge ditch from the west. Both tend to make the water high. People residing in the neighborhood and who have been familiar with the lake for years bear out this conclusion.

The lake is used only by hunters during the short duck season in the fall. The sloughs to the east and west are valued as trapping grounds by the farmers' boys who gather from them a harvest of muskrat skins during the winter. Fish cannot winter because of the shallow water.

Both a tile line which drains Eagle Lake, and a large dredge ditch from the southwest outlet in the lake at about its present level. Land owners whose tile empty into the dredge ditch will object to the level of the lake being raised. The outlet is to the east, through a slough, to Swag Lake. When the survey was made, there was a fall of three and a half feet between the two. In times of flood there is practically none. During dry years the bed of Goose Lake has been without any water. At other times the water has been high enough to damage the

FIG. 34—Goose Lake, Kossuth County. Goose Lake is a shallow open body of water. It covers seventy-four acres. It is entirely surrounded by private property and there is no access to it. It is valuable as a hunting resort.

highway grade on the east. The bottom is of mud and decayed vegetable matter, but owing to the slight fall along the outlet it cannot be drained for farm use.

Local sentiment seems to be rather in favor of drainage, if it could be accomplished at a reasonable cost. This is due to the fact that black-birds congregate here in the fall. The fact, too, that Iowa Lake lies only three miles away, doubtless leads the people to under-value this body of water.

Recommendations.

The Commission recommends that this lake be retained as it is, and that nothing be done to it for the present.

SWAG LAKE— KOSSUTH COUNTY.

Lake No. 51. Survey made by the State Highway Commission. Inspection made September 29, 1916.

Swag or Burt Lake is situated in sections 9 and 10, township 100 north, range 30 west of Iowa and sections 35 and 36, township 101 north, range 30 west of Minnesota. It is twelve miles northwest of Swea City on the C. R. I. & P. Railway, from which point it is most easily reached. A township road touches it on the east side.

It is a small but very attractive body of water lying partly in Iowa and partly in Minnesota. Its banks are steep and high, except where tributary drainage breaks through. Several groves of native timber add to the natural beauty of the locality.

The water is shallow, four feet being the deepest sounding recorded

FIG. 35—Swag Lake, Kossuth County. Swag Lake is a beautiful open body of water. It lies on the Minnesota-Iowa state line. It covers approximately one-quarter of a section. The shore line is partly wooded. The lake is skirted by the highway for a considerable distance, but there is no available recreation spots except on private property. The lake is one of the few which drains north into Minnesota. It drains into the Blue Earth River.

at the time the survey was made in the fall of 1915. The surface of the lake is subject to far greater changes of level than any of the lakes examined heretofore, due to the fact that it is the outlet for a large drainage area so formed as to concentrate the flood waters at this point. In the spring the water is frequently over the grade on either side of the highway bridge that spans the outlet.

Aside from the sloughs on the inlet, there is only one low piece of ground that cannot be drained without disturbing the lake. This is a small slough on the southeast.

The entire area is 120 acres of which about 46 acres are in Iowa. The meander encloses 129 acres. The drainage area includes about 21,000 acres, including the lakes before mentioned.

The bottom is of black silt six or eight feet deep, overlying beds of various colored clay.

The outlet is to the north, in Minnesota, through the Chain Lakes to the Blue Earth River, and finally to the Mississippi.

Swag Lake was dry in 1889, according to Mr. W. M. Burt of East Chain, Minnesota.

The lake is quite a resort for local fishermen in spite of the fact that it freezes over from time to time and kills out all the fish. Large quantities of pickerel, buffalo and carp are speared in the outlet during the spring.

In the fall, ducks stop on the lake and the neighborhood people enjoy good shooting. During the winter, the low lands to the north and south furnish large quantities of muskrats' pelts for trappers.

The inlets are two, one from Iowa and South Silver Lakes; the second from Goose and Eagle Lakes. These join perhaps a quarter of a mile south of Swag Lake. The drainage from Iowa Lake, which lies on the state line nearly four miles to the west, comes down through Minnesota in a fairly well defined channel which crosses the state line into Iowa about a mile west of the lake and spreads out over marshy flats.

The drainage from Goose Lake, which lies about a mile to the southwest, reaches Swag Lake through a stretch of slough. Eagle Lake, which has recently been drained with the permission of the State, was diverted from its natural outlet to the south. Its waters enter Goose Lake through a 26-inch tile and so come down to Swag Lake through the slough.

Local sentiment seems to favor keeping the lake. It would be desirable to drain the sloughs on the south if this could be done without draining the lake. Unfortunately, this does not seem practical.

Recommendations.

The Commission recommends that the lake be kept. The state should buy some land fronting on the water which the public can use as a park. If necessary, this should be planted with trees. The cost is estimated at \$3,500.

GREEN BAY LAKE—LEE COUNTY.

Lake No. 52. Survey not possible. Inspection made October 14, 1916.

Green Bay is located in sections 26, 27, 28, 29, 31, 32 and 33 of township 68 north, range 3 west. It is a long narrow body of water which lies parallel to the Mississippi River and formerly outleted into it at the lower or most westernly end. Its water level rose and fell with the level of the river. In times of flood the river formerly swept in from the eastern end, over the low intervening ground, and covered considerable low land surrounding the lake.

It is most easily reached by a five-mile launch trip up the river from Ft. Madison. Formerly a township road also led to the lake but this is impassable at present.

The banks were high in many places and covered with timber. The

water was of a good depth, and afforded boating, fishing and shooting resorts for the people from Ft. Madison and the surrounding country.

Several clubs and many individuals built cottages along its shores and it was easily the most popular summer resort in this part of the state.

Two hundred and seventy-one acres of land were covered by the lake at ordinary stage. Considerable flat land drained into it from the northwest.

In speaking of this lake the past tense has been used advisedly.

The recently completed dam in the Mississippi River at Keokuk has raised the water at the lake about twelve feet. The timber is submerged and is dying off, some of the cottages have been moved, and some are partly under water. In places the high banks project a little above the water, but the land behind is flooded. The place now is as sad and desolate a waste as can be encountered anywhere.

The county board in November, 1915, approved plans for a levee and drainage district which includes some 14,000 acres of land, bounded on the north by Skunk River, on the east and south by the Mississippi, and on the west by the C. B. & Q. Railway.

The two rivers are to be shut off by levees. Drainage ditches will be run into Green Bay and a pumping plant will lift the water from the lake, over the levees, into the Mississippi. The lake will be used as a collecting basin and the pumps will hold the water at its old normal level (514 ft. Memphis datum) no matter what the stage of the river may be.

Plans for the district have been prepared by the Edmund T. Perkins Engineering Co., 1110 First National Bank Building, Chicago. Mr. Isham Randolph acted as consulting engineer.

Recommendations.

It is the opinion of the Commission that this drainage district, even aside from consideration of the reclamation of the land, should be approved by the state for the benefit which it will be to the lake itself. The state should maintain supervision of the lake, particularly regarding the matter of the level at which it is held, and the regulation of ditch outlets, so as to keep the silt deposits out of the main body of the lake.

The only objection to the drainage district that can be raised is that the lake will, of necessity be cut off from the river. However, the lake is deep enough so that fish can winter and no difficulty should be experienced in maintaining a good supply of game fish.

No reason appears why the state should pay any drainage assessments on the former lake bed.

Plans or estimates have not been included for public parks or roads in the vicinity of this lake. The Commission is strongly of the opinion that both should be provided but believes that such provision can be more intelligently made after the construction of the district has advanced farther than at present. Attention is called to them as worthy the careful consideration of whatever new management the state shall see fit to provide.

BLUE LAKE—MONONA COUNTY.

Lake No. 53. Survey made by the State Highway Commission. Inspection made September 27, 1916.

Blue Lake occupies parts of sections 1, 2, 3, 10, 11, 12, 13 and 14 in township 83 north, range 46 west, and of sections 34 and 35 in township 84 north, 46 west. Onawa, the county seat, is three miles to the east. Brown's Lake is twenty-six miles to the northwest, Nobles Lake is thirty-five miles to the south.

The lake is a horseshoe shaped body of water; one of the many loops cut off by the Missouri River in its wanderings. The water in the northeastern part is 17 feet deep and open. The south and western parts are more shallow and have considerable quantities of water plants and rushes growing in them.

The banks are good. Natural timber is found scattered along the shores, and among the sand dunes on the "island."

The area of the lake is 918 acres. The meander encloses considerably more land—1,599 acres being given in the report of the land of-

FIG. 36—Wright's Park, Blue Lake, Monona County. This is a privately owned park on the shores of this beautiful Missouri Valley lake. The extent to which this private park is utilized during the summer months, demonstrates the advisability of the establishment of a state park open to the general public. The shore line is all owned by private parties and there is no access to any recreation grounds except over private property.

fice. At the time of the original land surveys, some very serious error seems to have been made in this vicinity. In 1904, Fred Heyer, W. B. Bailey, J. H. McCaskey and twenty-two other property owners in this vicinity, petitioned the district court to appoint a commission to determine the corners and lines of sections 2 and 11. Morris McHenry, C. H. Holbrook and Mitchell Vincent were appointed as a commission by the court.

They retraced some of the old lines, and found many of the original corners. Their report was made to, and approved by the court, which fixed the corners and subdivision lines according to their plat.

These lines have been shown on our map of the lake. It will be noticed that where the east and west lines intersect the lake, large offsets occur.

The meander, plotted from the government notes, has the general shape of the lake. If the sections are assumed as rectangles one mile square, as they are supposed to have been laid out on the ground, the meander would run from meander post to meander post without any very serious errors being apparent.

On the map submitted with this report, the meander posts have been plotted by scaling the required distances taken from the government notes, from the section corners. The meander line has then been plotted in each direction from these posts. This method of plotting does not give a closed figure, but has the merit of indicating in a general way, where the line was probably run in the field, and what land it enclosed.

Blue Lake is the only recreation spot in this part of the state, and is

FIG. 37—Blue Lake, Monona County. There is splendid fishing in Blue Lake, probably the best in western Iowa. Good strings of bass and perch are caught here. There are twenty-five fish in the string shown in the picture. A county road has been built across the lake upon an embankment. If a state park were established at this lake, this is the road which would lead to the park.

made use of for hunting, fishing and camping. At Wright's Park on the east shore, several cottages have been built for rent.

Until 1912, the fishing is reported to have been good, many fair sized bass being taken. That winter, most of the fish smothered. The lake has since been restocked by the Fish and Game Department.

Game birds are said to be plentiful. The lake is large enough and provides sufficient shelter so that many ducks summer here and raise their families. A State Game Reserve fronts on the west lake.

The lake has no direct outlet, but the low land on the south would permit flood water to escape toward the Missouri. There are no inlets and the drainage area is very limited. Drainage engineers report that

the lake is so high that it is impossible to drain even the land in the immediate vicinity into the lake.

Water level is so little above the river that it could not be drained. On April 21, 1916, the river level was five feet below the lake surface.

The county highway running west from Onawa, crosses both arms of the lake on embankments. No small amount of trouble and expense is incurred in their upkeep, due to burrowing animals and the action of waves and ice.

Recommendations.

The Commission recommends that this lake be preserved, and improved. There is considerable waste land inside the toe of the horse shoe. Some of this is enclosed in the meander.

Title should be perfected to perhaps forty acres, and this should be planted to trees.

Right of way should be obtained and a road built from the county road, to this park, and continuing north, across the shallowest part of the lake, to a junction with the township road above the lake.

Ten thousand dollars should cover the cost of these improvements.

RUSH LAKE, OSCEOLA COUNTY.

Lake No. 54. Survey made by the State Fish and Game Department. Inspection made September 28, 1916.

Rush Lake is located in sections 30 and 31, township 100 north, range 39 west, and sections 25 and 36, township 100 north, range 40 west. Ocheyedan, a town of six hundred people on the C. R. I & P. Railway, is a mile southwest of the lake. Iowa Lake, on the state line, lies six miles to the north; Silver Lake in Dickinson County, is seven miles to the east; Spirit Lake is twenty miles due east. A county road passes just to the north of the lake. It may also be reached from the south, although the township road is not open.

The banks around the west, north and east sides are high. On the south, a typical wall has been pushed up by the ice. The meadow land just south of the lake is but little higher than the water surface of the lake. Two small areas of slough land outlet into the lake from this side. On the north also two larger sloughs drain into the lake.

The water varies from three to four feet in depth, and over half of it is covered with a growth of rushes. The bottom is a black alluvial silt.

The area as shown by the survey was 317 acres. The government meander line encloses 359 acres. The drainage area consists of 1,944 acres of land.

The lake is valued now chiefly as a hunting resort and offers excellent shelter for all kinds of water fowl. The water is too shallow for game fish, only a few bullheads and carp are caught. Blackbirds and mosquitoes are only normally troublesome.

The water supply is not as satisfactory as could be wished. A proposed drainage district of some 2,100 acres just to the north, can be made to empty into the lake at no expense. Arrangements to assure this supply should be made at once.

The outlet is from the southwest corner by way of the Ocheyedan River to the Little Sioux. There is a fall of thirteen feet between the lake and the place where the outlet crosses the C. R. I. & P. track about a mile below.

FIG. 38—Rush Lake, Osceola County. People of Ocheyedan and the surrounding community are enthusiastic over the prospect of improving Rush Lake, which lies near that town. It is partly open water and partly covered with rushes and vegetable growth. It covers about one-half square mile. The famous Ocheyedan mound is in the vicinity of this lake.

Legal Status.

In 1904, application was made to the Executive Council for the drainage of the lake. This was vigorously opposed by residents of the vicinity, and the Council found that the lake should be preserved.

FIG. 39—Rush Lake, Osceola County. The water supply in Rush Lake is inadequate but there is a drainage system to the north, part of the water from which could be turned into the lake with advantage.

Recommendations.

The Commission believes that the lake should be kept. Steps should be taken at once to insure the increased water supply mentioned herein. Land should be made from the spoil obtained by dredging forty acres, trees planted and the whole made into a public park. The estimated cost of the dredging is \$80,000. The planting of trees will cost perhaps \$200.00.

IOWA LAKE, OSCEOLA COUNTY.

Lake No. 55. Survey made by the State Fish and Game Department. Inspection made September 28, 1916.

Iowa Lake occupies part of section 9, township 100 north, range 39 west in Iowa, and of sections 31 and 36, township 101 north, ranges 38 and 39 west in Minnesota. It is five miles northwest of the village of Harris on the C. R. I. & P. Ry. Rush Lake is six miles southwest. Silver Lake is nine miles southeast.

This is a pleasant appearing little lake, long and narrow, with well defined banks. On the east and south, the shores are timbered; on the north and west, they are under cultivation.

The water is from three to four feet deep and free from plant life, over the greatest part of the area. One small slough is connected to the lake on the south, otherwise the surrounding country is well drained.

The area as shown by the survey is 242 acres; 116 acres of which are

FIG. 40—Iowa Lake, Osceola County. Iowa Lake is on the Iowa-Minnesota line. It is a clear open body of water of less than one-half square mile. The east shore is nicely wooded. There is no access to the lake except over private property and no camp sites except on private property.

in Iowa and 126 in Minnesota. 241 acres are enclosed by the meander line. The water shed is composed of 4,320 acres.

No summer resorts are found here. There are good cottage sites but scarcely enough water in the lake to make it attractive for such uses. It is used for hunting and provides good shelter and nesting places for water fowl. Some fishing is done by local people especially in the spring.

A small stream from the south drains into the lake, and is the main source of water supply. A fifteen-inch county tile also outlets in the slough just south of the lake. A variation of three feet in the water level is reported by people living in the vicinity.

The outlet is from the north end. There is fall enough in a very short distance so that the lake could be drained. On the other hand, a short dam could be built here that would raise the water level a foot or two. Such a raise would damage very little land.

Soft black silt forms the bottom. A pole can easily be pushed down

six or eight feet below the water surface before firm footing is encountered.

Very few complaints as to blackbirds or mosquitoes were made. The sentiment among people residing in the vicinity seems to be in favor of keeping the lake.

Recommendations.

In the opinion of the Commission, the lake should be preserved. No improvements are recommended at this time.

MEDIUM LAKE, PALO ALTO COUNTY.

Lake No. 56. Survey made by order of the Executive Council. Inspection made August 4, 1916.

Medium Lake is a long slender body of water which lies in sections 5, 7, 8, 18 and 19, township 96 north, range 32 west, section 24, township 96 north, range 33 west, and section 32, township 97 north, range 32 west. The southern end is in the town of Emmetsburg. A road along the eastern shore makes the lake easily accessible.

The water varies from three to five feet in depth. The banks are good and there is not a great deal of low land in the vicinity. Some scattered timber grows along the banks of several wooded islands add to the attractiveness of the scene. The lake has an area of 991 acres. The meander encloses 945 acres. The water shed is small.

Situated as it is, close to the town, the lake is used to quite an extent, for boating and picnic purposes.

The outlet is from the east side through a creek into the Des Moines River. A concrete dam has been built at the outlet by local people. The bottom is the same as is found in most of Iowa's lakes, a deposit of silt overlying a mixture of sand, gravel and clay.

Legal Status.

An application for drainage was made in 1907. The lake was surveyed by order of the Executive Council, and a report filed with them. At a hearing in 1908, drainage was denied.

Special Problem.

The people residing in Emmetsburg became interested, and the Medium Lake Improvement Association was formed with Mr. W. H. Vaughan as President and Mr. W. E. G. Saunders as Treasurer. Under their direction, a subscription list was circulated which insures an income of \$3,800.00 annually for five years, to be spent on lake improvement.

In 1913 and again in 1914, the Executive Council authorized the appropriation of \$2,500.00 from the Fish and Game Fund for the same purpose. The work which has been done here is of particular interest because it forms the first attempt at lake improvement which has been undertaken on a serious scale in the state. It is very easy to be over-optimistic regarding the cost of work of this character. Many difficulties, and delays develop in the actual dredging operations which are difficult to foresee. Here the work has actually been accomplished.

So far, the work has been confined to the part of the lake between the C. R. I. & P. Ry. and the town. This part has an area of 94 acres. The work consists in deepening the lake, in forming banks and beaches, and in reclaiming adjacent low land to form parks and drives. Two dredges have been employed. The dipper dredge has a wooden hull 60x24 feet in size. The dipper has a capacity of one and a half yards. This dredge moves parallel to the shore from fifty to a hundred feet out in the lake and throws up a dike of the most solid materials from the lake bottom to form the new shore. The dredge was built by Mr. L. J. Nutzman, her captain. The machinery used in her was nearly all second hand. She cost approximately \$3,500. A new dredge of the same size would cost in the neighborhood of \$10,000.

The second dredge is of the suction type, without cutter head. Her hull is of wood 60x32 feet in size. The boiler is a 200 H. P. Scotch Marine type; the engine is a Ball cross compound of 150 H. P. This is connected by a rope drive to a 12-inch Morris sand pump. Her machinery was all new, and she cost, with 700 feet of discharge pipe, \$12,000. She has an estimated capacity of 1,000 cubic yards a day.

She follows behind the dipper dredge and fills in between the old bank and the new with the softer material which she sucks up from the lake bottom.

Thirty dollars a day will cover the actual operating expense of either one of these machines. The cost of moving material, is given by those in charge, as varying from as high as 60 cents a yard, where sand was being washed out, to form a bathing beach, and the same material had to be handled several times, to as little as 8 or 10 cents a yard for the work on the eastern shore. It seems probable that the work this season will be handled a little cheaper, for perhaps 6 to 7 cents. These prices do not include any overhead charges, engineering, interest on money invested, or depreciation on the plant.

In the five year period over which construction work will run, they plan to spend, roughly, about \$100,000. for dredging, and for improvements on shore.

Recommendations.

In the opinion of the Commission, the State will do well to contribute to this work as they have done heretofore, that is, \$7,500. in three yearly installments. Following this, the State should dredge out a channel up the lake from the railroad, so that launches will be able to operate. The cost of this work is estimated at \$65,000. making a total of \$72,500.

SILVER LAKE, PALO ALTO COUNTY.

Lake No. 57. Survey made by the Fish and Game Department. Inspection made August 9, 1916.

Silver Lake occupies parts of sections 18, 19, 20, 21, 28, and 29 of township 95 north, range 34 west. It is located six miles south of Ruthven and fifteen miles southwest of Emmetsburg. Ayrshire on the C. R. I & P. Ry. is two miles east of the lake. Lost Island Lake is nine miles to

the north. Rush Lake five miles to the south. A county road skirts the lake on the south, and township roads follow the north and east banks very closely.

This is a beautiful sheet of open water from five to seven feet in depth. The banks for nearly their entire length, are high, and a fringe of natural timber skirts the shore, widening out into good sized groves in places. A number of bathing beeches extend out into the lake. There are several small areas of slough land on the south and east which can not be drained with the lake at its present elevation.

The survey shows the lake to have an area of 667 acres. The government meander encloses 638 acres. The drainage area consists of 7,120 acres of land.

There are no summer resorts on the lake. One private park furnishes picnic grounds for the people who congregate here on Sundays. Good camp sites are plenty and now that the water is up, the lake will doubtless be used more than in the past.

The fishing has not been good for the past two years, but no reason appears why it should not once more become as good as in any of the smaller lakes. Hunters from the surrounding country report the shooting as fair though the lack of cover prevents this being as good a duck lake as is Rush Lake five miles farther south.

On the whole, the water supply is very satisfactory. One large drainage ditch enters from the north. Several lines of tile outlet at different points around the shore. Three small springs are to be found near the west end. At a farm just west of the lake, there is a flowing well.

The outlet is to the southeast, through Silver Creek to the Des Moines River. The Fish and Game Department has built a dam at the outlet which holds the water at what seems to be a fair level. There are, of course, some people who would like to see the lake lowered and others who as stoutly maintain that it should be raised.

The greater part of the bottom is of mud and quantities of wild celery and water grasses are found in places.

There is very little complaint either as to the black birds or the mosquitoes. The local sentiment is all in favor of the retention of the lake.

Recommendations.

The Commission recommends that the lake be preserved and that the State purchase land for a park fronting on the water. The estimated cost is \$3,500.00.

RUSH LAKE, PALO ALTO COUNTY.

Lake No. 58. Survey made by order of the Executive Council. Inspection made September 28, 1916.

This lake occupies parts of sections 20 and 21 in township 94 north, range 34 west. The towns of Curlew and Mallard on the C. R. I. & P. Ry. are distant eight and nine miles respectively to the east. Webb, in Clay County is seven miles to the west. Silver Lake is five miles to the

north and Pickerel Lake four miles to the southwest. A township road touches the lake on the west.

Rush Lake is at present little more than a marsh. The water is not more than three feet deep. Rushes and other water plants cover nearly all of the water surface, though occasional small patches of open water appear.

The banks are nearly all high and considerable hard wood timber is found on the south, east and west shores, as well as many willows. These banks all bear witness to the fact that sometime in the past, the water stood from a foot and a half to two feet above its present level.

On the south, one slough of perhaps forty acres in extent, and which is only slightly higher than the lakes, breaks through the banks and drains into the lake. This is the only low land of importance which is tributary and depends for its drainage on the lake.

In its present state, the only value that the lake has is as a hunting resort. Several shooting camps have been put up along the western shore.

FIG. 41—Rush Lake, Palo Alto County. Rush Lake is of the marsh type, the lake bed being filled with vegetable growth. It has an area of nearly a square mile.

The lake affords cover and feeding grounds for ducks, while the shelter on the shores should make it a good nesting place. This conclusion is borne out by the fact that more ducks were seen here than at any other lake visited during this investigation.

The principle inlet is through a dredge ditch which comes in from the west and drains Mud Lake and considerable surrounding farming country in Clay County.

The outlet at the time of the examination (Aug. 1916) was a stream of water perhaps twelve feet wide and six inches deep in the middle, known as Lizard Creek. This winds away to the east and empties into the Des Moines River. Its fall is light for the first three miles. An outlet could be had four miles below the lake.

The bottom of the lake is of silt and decaying vegetable matter overlying gravel and clay. In common with most of Iowa's smaller lakes, this one went entirely dry in 1894. The outlet is very broad and storm water passes off rapidly instead of being stored. There is doubtless some ground for the complaint that the water gets stagnant and gives off disagreeable odors during the latter part of the summers.

Mosquitoes were no more numerous than in other parts of the state. No black birds were seen in the time spent in making the examination, although they are probably numerous at some seasons of the year.

Legal Status.

A petition for the drainage of this lake was made to the Executive Council in 1911, and a survey as required by law, was made. This survey showed the lake as having an area of 460 acres. The government meander enclosed 500.6 acres.

In December of 1912, the Council decided that the drainage of the lake should be denied, and that a dam which would raise the water a foot, should be built at the outlet.

The question of drainage was re-opened in 1913. A second hearing was had, and in 1914, drainage was authorized.

Soon after this time, the present law went into effect, and no opera-

FIG. 42—Rush Lake, Palo Alto County. Rush Lake is one of the Iowa lakes which for the time being, has been saved by the Iowa lake bed survey law. Permission for the drainage of the lake bed had been granted by the State Executive Council but work had not started at the time the new law was passed.

tions leading toward drainage have been undertaken. The cost of an outlet has been estimated at \$14,000.00. In the neighborhood of 2,000 acres of wet land, (including the lake) will be benefitted.

Recommendations.

This Commission is of the opinion that the lake should be retained, and that a dam should be constructed at the outlet which will raise the lake to its old shore line. The estimated cost is \$1,400.

LOST ISLAND LAKE, PALO ALTO AND CLAY COUNTIES.

Lake No. 59. Survey made by State Highway Commission. Inspection made August 9, 1916.

Lost Island Lake is situated in sections 5 and 6, township 96 north, range 34 west, sections 31 and 32, township 97 north, range 34 west,

section 1, township 96 north, range 35 west and section 36, township 97 north, range 35 west. It is thirteen miles west of Emmetsburg and twelve miles east of Spencer. Trumbull Lake is about two miles west of Lost Island. Two good highways lead north from Ruthven on the C. M. & St. P. Ry. to the lake, the one to the east gives easy access to a very pleasant summer resort and hotel on the south side. the one on the west crosses the southwestern arm of the lake on an embankment and from thence leads to Round and Trumbull Lakes. A fairly good road skirts the northern shore.

The water is of remarkably uniform depth throughout the main body of the lake. Twelve feet may be taken as an average. The part south of the highway is perhaps four feet deep, and considerable quantities of rushes are to be found there. Rushes are also found in the neighborhood of the inlet from the southeast that drains a large

FIG. 43—Lost Island Lake, Palo Alto County. Lost Island Lake is one of the prettiest of the small lakes of Iowa. It has an area of about one and one-half square miles. The shores are wooded. Roads touch the lake, giving access to it. Camping sites are, however, all on private property.

area of slough whose bottom is from two to four feet below the water level of the lake.

The banks are firm, high and in places fringed with timber. South of the highway embankment, however, while well defined, they are low and grass covered, and at the outlet they shade off into a long shallow slough.

The area of the lake is 1,076 acres. The area within the meander lines is 1,260 acres. The water shed consists of 5,900 acres. The original government survey included considerable more land on the north and southwest. In 1898 a new survey was authorized by the Department of the Interior. This survey was made by A. W. Barber, detailed from the land office, and some 1,230 acres of land in sections

19, 20, 29 and 30 of township 97 north, range 34 west, and in sections 25 and 36, township 97 north, range 35 west, were disposed of.

One summer resort is located on the southeast shore. Outside of the immediate neighborhood the lake is little known, and it does not receive the attention to which it is entitled by its many charms.

It is well supplied with fish. Perch, pickerel, bass and bull heads abound. During the last two years the fish and game department has shipped in pike and stocked the waters with these game fish as well.

Altogether, the water supply may be said to be fairly satisfactory. No streams of any size enter the lake but the water level does not vary seriously. The present level, from all the testimony of old settlers, and from all indications along the shore, may be taken as a normal high water level.

The outlet is to the southwest through a long slough into a creek which also serves as the outlet for Elks and Trumbull Lakes and Dan Green's Slough.

Plans have been formulated for the digging of a consent ditch to drain the low land along the outlet. This will necessitate the erection of a dam to maintain the lake level. This dam should be built at the present lake outlet so as to preserve the shallow water south of the highway as a part of the lake. This area is about the only water suitable for spawning ground for fish, and should, by all means, be retained. Mud Lake on the north is several feet lower than Lost Island. At one point in section 30, the divide is merely a low ridge of loose sand pushed up by the ice.

At present people of the vicinity are hauling considerable sand away from this bank. They are getting it above high water line and along a public highway, and are perhaps within their legal rights. At the same time this course of action if persisted in will form a serious menace to the lake. The ridge is very narrow and composed of material which will wash easily, if the water once gets started through.

Recommendations.

The Commission recommends that the lake be maintained and a permanent concrete outlet be built. The highway embankment which crosses the lake costs the township considerable for maintenance. It is suggested that an arrangement might be entered into by the state and the township whereby the highway could be relocated so as to cross the outlet near the old M. & St. L. embankment. This same fill could then be used as a dam. It is thought that this fill would not be subjected to as severe wave action as is the present road and that the state and the township would each pay their part of the upkeep. The estimated cost of construction is \$15,200. The purchase of a park fronting on the lake is recommended at an estimated cost of \$4,000.

VIRGIN LAKE, PALO ALTO COUNTY.

Lake No. 60. Survey made by order of the Executive Council. Inspection made August 9, 1916.

Virgin Lake is situated in sections 29 and 30 of township 96, range 34. Ruthven, a town of seven hundred people, on the C. M. & St. P. Ry., is the nearest railroad point, and is only two miles away in a direct line. From this point, good roads lead to the south shore of the lake. Lost Island Lake is about four miles directly north.

This is a beautiful, little body of clear, open water lying among the hills. The banks are high and timbered on the east. On the west the banks are lower, and one big bay terminates in a slough. The water is from five to eight feet deep, and almost free from any plant growth. Two or three timbered islands add to the beauty of the scene.

While the government survey gives an area of 192 acres, the true area is 200 acres. The meander does not fit the present outlines of the lake on the southwest.

There are no resorts of any kind maintained along its shores. Hunting parties frequently visit the locality during the shooting season, and the low lands just south of the lake are considered good duck grounds. Almost any summer day, fishermen are found scattered along the banks. The lake has never been stocked but large strings of the ordinary pan fish, reward their efforts.

The water shed is small, yet so far as could be learned from inquiry, the lake has never gone dry nor suffered as much from a lack of water as have many of the smaller lakes.

A narrow marshy creek leading away to the north, is the outlet. This empties into a ditch which drains Elbow Lake. There is enough fall so that Virgin Lake could easily be drained. Neighboring people have built a rough masonry dam where the creek leaves the lake.

Black silt forms the lake bottom. This rests on the clays and gravels peculiar to the Wisconsin drift.

Legal Status.

Application for the drainage of Virgin Lake was made to the Executive Council in 1905, at the same time that the drainage of Elbow Lake was authorized. A survey and report were made, as required by law. This report recommended the drainage of Elbow Lake and the preservation of Virgin Lake.

The desire for drainage seems to have grown from the fact that the road across the swamp south of the lake is expensive to maintain, and that a school house standing south of the lake, can only be reached from the north by a rather round about road.

Recommendations.

In the opinion of the Commission, this lake should be retained. The state should purchase sufficient land on its banks to serve as a public park. The estimated cost is \$3,500.00.

CLEAR LAKE, POCAHONTAS COUNTY.

Lake No. 61. Survey made by the State Highway Commission. Inspection made September 29, 1916.

This lake is located in sections 5 and 6, township 91 north, and sections 31 and 32, township 92 north, range 34 west. It lies eleven miles directly west of Pocahontas, and about six miles southeast of Albert City.

Storm Lake is twenty-one miles to the southwest, Silver Lake in Palo Alto County is twenty miles to the north. A highway follows the eastern bank for a considerable distance and renders the lake easy of access to hunters or picnic parties.

The water is five feet deep. The bottom is of mud and the lake is so badly grown up to rushes and moss that it is nearly impossible to row a boat. These rushes are reported as having grown within the last three or four years. Before that time, the water was very much more open. The banks are high. Three or four groves at farm houses border on the lake, and in part make up for a lack of natural timber. There is no wet land along the shore that would make the drainage of the lake advisable to supply an outlet.

At the time of the survey, the area was 165 acres. The area included by the government meander was 187 acres. The water shed has an area of 522 acres.

People residing in the vicinity say that until a few years ago, the lake was a nice sheet of open water, and a popular place for picnics. In its present condition, it is used only for hunting, and as an outlet for a few small drains.

The water level of this lake varies as does that of most of the small lakes of the State. During dry periods, the water becomes very low and the lake is regarded as something of a nuisance. In normal years, it fills up again and forms a very pleasant outing place for the community.

As will be seen from the map, Cedar Creek loops in to within twelve hundred feet of the lake on the northeast. It has been proposed that this stream be diverted to form a water supply for the lake. At this point, the water in the creek is six feet below the lake. A canal could be constructed which would divert the creek water and bring it into the lake, by going back up stream more than two miles.

The county board is considering deepening the channel of Cedar Creek, and this would necessitate moving the intake even farther up stream. Moreover, this creek goes dry just at the time when the lake most needs water so that such a plan is not to be recommended.

The outlet is to the southwest through a line of tile to an open ditch, down Cedar Creek to the Coon River. A concrete dam has been constructed at the outlet by local parties. At the time of the inspection, this dam was in bad shape. A great deal of water was escaping through the gravel under the dam, and through a large crack in the structure itself. There is a fall of eight feet in eight hundred from the dam to the open ditch.

The citizens of Albert City and of Varina are very much interested,

and anxious to co-operate in any improvements which seem practicable.
Recommendations.

The Commission recommends that the lake be retained. As a first step toward improvement, a new dam should be put in at the outlet which will raise the water a foot above the level maintained by the old one. This can be done with scarcely any damage to property. Such a dam will store considerable water in the spring, and aid in taking care of the summer's evaporation. Its estimated cost will be \$600.00.

Forty acres of the lake should be dredged to a depth which will enable fish to winter comfortably. The cost of this work may be estimated at \$75,000.

Sufficient land can be made from the spoil to provide a park of good size.

LIZARD LAKE, POCAHONTAS COUNTY.

Lake No. 62. Survey made by the Executive Council. Inspection made September 29, 1916.

Lizard Lake occupies parts of sections 22 and 27 in township 91 north, range 31 west. Twin Lakes in Calhoun County are twenty miles to the southeast. Silver Lake in Palo Alto County is about forty-five miles to the northwest. Clear Lake in Pocahontas County is twenty-five miles to the west. The City of Ft. Dodge is twenty miles to the southeast. Pocahontas is perhaps fourteen miles to the northwest.

The lake creates a very favorable impression on first sight and one wonders why it is not more used and more appreciated. The water is open and free from the vegetation that detracts from the beauty of so many of Iowa's lakes. From three to four feet seems to be the average depth, although the people of the neighborhood report five feet in places.

On the east are two groves of native timber. On the south a fringe of trees follows the bank. In several places the shores show clean gravel beaches. The banks are high nearly all the way around the lake, but both on the east and west, there are considerable areas of land at about the water level. These drain into the lake through narrow openings in the banks, and would, of course, be flooded, should the lake level be raised. Several tile from surrounding farm lands, empty into the lake, but little above its present level.

As things are at present the lake is scarcely used at all. A little hunting is done, but there is not enough cover to make it a good lake for ducks. The water is too shallow for fish to winter safely, though all of the common varieties are caught at times.

The area of the lake is 251 acres. The area enclosed by the meander is 268 acres. The water shed consists of 1,320 acres. This lake is subject to the same limitations which affect the other shallow lakes of the state.

In normal years it is very pretty little sheet of open water. With a succession of dry years, the water shed is not large enough to keep up the water level. Eight years out of ten it should serve the public well as a pleasure resort. The outlet is from the north

and west, through a stream that bends around to the northeast and empties into Lizard Creek. The fall is about twenty-six feet in a mile.

The bottom is reported to be hard, largely clay and gravel. The fact that rushes have never gained a foothold, indicates that the deposition of silt has not advanced as far here as in many other lakes.

Legal Status.

In 1913 the Executive Council was asked to take action regarding the leasing of the lakebed. A survey and report were made by W. B. Warrington, County Engineer. A second petition was made to the Executive Council asking authority to build a dam at the outlet. Owners of adjoining property objected vigorously to the raising of the lake level, because of the damage which would be caused to land and to existing drainage systems.

Recommendations.

The Commission believes that a lake in this location will serve as an outing place for a large number of people who at present are without opportunities for this kind of enjoyment. They, therefore, recommend that the lake be preserved, and that a dam which will control the water level, be put in at the outlet. The estimated cost is \$700.00. They also recommend that 40 acres of the lake be dredged and that the spoil be used to fill one of the sloughs if one of these can be purchased to advantage, or if not, that land be made in what is now the lake bed. This made land should be planted to trees and used as a public park. The cost of dredging is estimated at \$75,000. The cost of tree planting and of obtaining a road is estimated at \$1,800.00.

WALL LAKE, SAC COUNTY.

Lake No. 63. Survey made by the Civil Engineering Department, Ames, Iowa. Inspection made August 10, 1916.

Wall Lake occupies parts of sections 2, 3 and 4 in township 86 north, range 36 west and of sections 33, 34 and 35 of township 87 north, range 36 west. Lake View, a town of 800 people on the C. N. W. Ry. is just west of the lake. The town of Wall Lake is four miles southwest. Storm Lake is thirty miles northwest. Twin Lakes in Calhoun County are twenty-eight miles northeast. Township roads touch the lake on the north, south and east, and make it easy of access by automobiles.

The lake is about two and a half miles in length east and west and varies in width from one-half mile to something more than a mile. The depth averages between six and seven feet. The banks are in general from five to fifteen feet high except at the extreme eastern end where the land drops away rapidly from the lake draining towards Indian Creek, and at the extreme southwest corner at which the inlet enters. The only low land which cannot be drained is situated along the inlet.

The area of the lake is 923 acres; the meander encloses 957 acres. The area of the water shed, 3,616 acres.

This lake is quite famous as an outing place, there being three different resorts around the shores. Lakewood Park on the north shore is perhaps the largest and best known. There are here some fifty summer cottages together with a hotel and the usual layout of summer resort amusements. Cottage Grove at the east end of the lake comprises some twenty cottages, together with a hotel and other amusements. Provost Park on the south shore consists of some twelve or fifteen cottages. There are also three or four cottages at the west end of the lake in the city of Lake View. A line of steamers carry passengers back and forth over the lake in the summer season.

Fishing is considered good; all the ordinary varieties being taken.

During average years the water supply is as satisfactory as at the other lakes in the state. There occurs occasional series of dry years when the run-off from the surrounding land does not equal the evaporation from the lake's surface. At such times, the water level may not rise as high as the top of the outlet dam for two or three years.

Wall Lake outlets to the northeast, through Indian Creek to the Coon River. The summer resort known as "Cottage Grove", occupies a small hill on the east shore of the lake. North and south of this hill is low ground, which in former years was subject to overflow.

The state has made appropriations amounting to \$4,000.00 for improvement of this outlet. The work was carried on under the direction of Mr. Geo. A. Lincoln, then in charge of the Fish and Game Department. A concrete outlet dam and fishway were built, and an earth embankment thrown up across the low places north and south of Cottage Grove. These embankments were originally sixteen feet wide on top, and averaged about three feet high, with a maximum height of perhaps six feet. The embankment on the south was well protected by willows, and is in good shape today. The part to the northeast is more exposed to wave and ice action and cuts badly. The top of the embankment is used as a road and carries a heavy traffic, especially during summer months, as it furnishes the only means of reaching Cottage Grove. Cars coming from the direction of Carroll, also use this route instead of the longer one through Wall Lake.

Some means should be found to widen these fills out to a standard roadway. They are now so narrow as to be dangerous when cars meet. The township trustees have no funds with which to do the work.

The inlet is a creek having its source in Carroll County, being quite a small stream until within about two miles of the lake, at which point, it comes practically to the lake level and widens out into what is really an arm of the lake, varying from 100 to 200 feet wide.

The soil at the bottom of the lake is about three feet of black mud, under which there is a layer of snail and other shells. With the apparatus in hand, it was impossible to go deeper than this, but the country surrounding is quite largely gravel, and it is to be expected that the lake also is underlain by gravel.

Special Problem.

Some effort was made to ascertain whether it would be possible to augment the water supply of the lake at times of low water. There are two possibilities, one of which is pumping from Indian Creek, which at the nearest point, lies about one-half or three-quarters of a mile to the north. Indian Creek is some twenty feet below the lake level, and the hill between the lake and the creek is nearly twenty feet high in the low places so that it would be necessary in starting, to pump against a forty foot head in order to bring water from Indian Creek into the lake. Persons who have lived in this vicinity a number of years, say that they have never seen Indian Creek entirely dry. In this connection, it should be noted that the City of Lake View is extending its sewer system and is building a septic tank near Indian Creek at a point about one-quarter of a mile up stream from the point at which it would be best to pump water for the lake supply. For this reason, the water supply is not considered acceptable.

Another possible source of water supply is mentioned in a report by a member of the staff of the United States Department of Agriculture dealing with the drainage of what is known as "The Goose Pond." This pond is a large flat area better than a mile north and south, and some three miles or more east and west, lying immediately to the south and partly in the town of Wall Lake. Into this large flat area, streams run from nearly all directions. It has two outlets, one to the west into the Boyer River, and the other to the east through the inlet into Wall Lake. Of the streams which empty into this Goose Pond, two are known as Lime Creek and Klitzke Creek. It is suggested in the report above referred to, that it would be feasible to divert water from both of these creeks into the lake.

Upon inquiry and examination, it appears that Klitzke Creek is not a creek at all but simply a sort of valley down which the water runs in time of rain, but which is dry the greater part of the time. Lime Creek carries water except in extremely dry times but not a very large stream. Klitzke Creek drains 3,320 acres of land; Lime Creek about 7,680 acres.

Moreover, while it is possible to divert these streams and cause them to discharge into Wall Lake, the advantage of so doing does not appear proportional to the expenditures which would be necessary. The largest amount of run-off from the areas drained by them, will reach the lake in the spring, and unless the dam is raised so as to store the water, it will simply pass on down the outlet.

Recommendations.

The Commission recommends that the lake be preserved and that the dike at the outlet be widened to a standard road section and protected with riprap. The cost of so doing is estimated at \$4,200.00. They further recommend that a park be purchased fronting on the lake. The estimated cost is \$8,000.00.

DUCK LAKE, WINNEBAGO COUNTY.

Lake No. 64. Survey made by State Highway Commission. Inspection made June 14, 1916.

Duck Lake occupies parts of sections 20 and 21 of township 100 north, range 24 west. Forest City is about seventeen miles to the south. Lake Mills about twelve miles to the southeast. The nearest lakes are Silver in Worth County, fourteen miles to the east, and Crystal in Hancock County, twenty-two miles to the southwest. It is most easily reached by driving from Scarville which is located on the C. & N. W. Railway. No public highway touches the lake. A private road from the north affords the only means of access with vehicles.

The first impression gained of the lake is generally not a favorable one. The water is shallow, three-fourths grown up to rushes, and is dotted here and there with muskrat houses. Three and a half feet was the deepest water found.

The banks on the south and northeast are steep, on the west a low flat ridge separates the lake from a large swamp area which drains away from the lake. A large grove of native timber is located on the eastern shore. The area at the time of the survey was 77 acres. The area inside the meander lines is 72 acres. The area tributary to the lake is 421 acres.

At present the lake is used only for hunting and trapping. Its rather secluded location and the shelter both in the lake and around the shores makes it a favorite resort for ducks and many of them summer there. The water freezes so deep during the winter that few if any fish are found.

The outlet is to the southeast through a dredge ditch to Lime Creek. The ditch has very little fall and is badly silted up. The ditch is not directly connected to this lake, and at the time of the examination, the water in the lake which stood about twelve inches below high water mark, was a little higher than the water in the ditch. An outlet could be obtained by dredging out the ditch for a distance of three or four miles.

A considerable area of slough which nominally drains into the lake, lies to the southwest. This could be diked off from the lake and drained out the other way. Such a course of action would reclaim considerable land for private owners, but would rob the lake of almost exactly one-half of its drainage area. The water can easily be raised by increasing the height of a private roadway which crosses the outlet and providing a concrete spillway. In case this were done, it would be necessary to purchase the area of a slough spoken of before, or to dike it off.

An examination of the lake bottom shows it to be composed of silt and decaying vegetation, to a considerable depth.

Recommendations.

In the opinion of the Commission this lake should be retained and improved. A dam should be built at the outlet which will raise the water five feet and will act as a roadway across the outlet. The cost of such a dam is estimated at \$2,800.00. Twenty acres of low land will be

flooded and should be purchased. Twelve hundred dollars should pay for this kind of land. The dikes on the southwest can be built for twenty-five hundred dollars. In addition to this, some land should be purchased for a park and for a road leading to it. Four thousand dollars is a reasonable estimate to cover these items.

BROWN'S LAKE, WOODBURY COUNTY.

Lake No. 65. Survey made by the State Highway Commission. Inspection made September 26, 1916.

Brown's Lake is situated in sections 28, 29, 32 and 33 of township 87 north, range 47 west. It is located two miles west of the town of Salix, on the Omaha Railway, and twelve miles south of Sioux City. Blue Lake at Onawa, eighteen miles to the south, is the nearest of Iowa's lakes. Two fair sized resorts, Bigelow's Park and Strand Park, have been erected on the east shore of the lake. Cottages and boats

FIG. 44—Brown's Lake, Woodbury County. Brown's Lake is a popular resort for the people in the vicinity of Sioux City. It is an open body of water, covering nearly one and one-half square miles. This is a comparatively new lake, being a cut off bend of the Missouri River. There is good fishing. Access to the lake and its camping sites are all on private property.

are kept for rent and various forms of amusement are furnished. Both places have a good patronage and are justly popular with people in this section of the state.

Description.

In general outlines, this lake resembles a great horseshoe. The eastern arm is open with a maximum depth of fourteen feet. The western arm and the northern portion are more shallow, and scattered patches of rushes dot their surfaces. On the north and east the banks are high. To the west, the banks are lower and in very few places, rise as much as five feet above the water level. Some natural timber is found along the northeast and east shores.

Hoover's Island is comparatively flat. The north end is composed of numerous sand hills and little ridges, which at the time of the sur-

vey (in the spring of 1916) were surrounded by water. The water surface of the lake was, at that time, from one to two feet above its normal level. These sand hills are covered with scattered timber.

The area at the time of survey was 840 acres.

Two summer resorts are located on the lake shores. Cottages and boats are for rent, and provision has been made for all the usual forms of amusement, such as bathing and dancing. Fishing is reported to be good. All the common varieties of fish are caught in large numbers. The lake is also a popular resort for hunters during the time when ducks are flying. The river forms a natural highway for them to follow in their migration and the tangled river bottom offers shelter and feeding ground.

There are no streams feeding the lake and its watershed is very small. Like other lakes, characteristic of this part of the state, it seems likely that the main source of water supply is from ground water, which seeps in from the surrounding soils. The lake is so nearly at the river level that it cannot be drained.

The outlet is a sluggish creek which passes under the township road on the south shore of the lake and drains off through a series of swamps, to the river. About half a mile south of the lake a dike has been thrown across the outlet. Its top is two feet above the lake level, and perhaps three feet above the river (Sioux City gauge 13.7). The dike stretches away for nearly a mile through the woods south of the lake. It was built by local people to keep the river from backing into the lake, but was cut this spring to let the water drain out.

Legal Status.

Brown's Lake will not be found among the original meandered lakes of the state. When the land was divided by the government surveyors, this body of water was connected to the river, and its outside rim was meandered as the river's edge. The plats filed at that time show what is now the lake as a bayou.

Since that time the river has moved to the south and to the west, leaving the old horse shoe shaped channel entirely isolated, except for a narrow creek which now serves as an outlet. It was not until 1896 that the Department of the Interior caused a new survey to be made by Hall, by whom, what is known as Hoover's Island; on the inside of the horseshoe was sub-divided into lots.

There is some doubt as to the ownership of the bed of the lake. The question as to title should be carefully looked up before money is expended in the way of betterment.

Recommendations.

The Commission is of the opinion that a lake situated as is this one, will serve as an outing place for a large community, and should be owned by the state. The Commission recommends that steps be taken to determine the ownership, and that if necessary, the state enter into negotiations for the acquisition of the whole or a part of the lake, and of land bordering the lake, for a public park.

SILVER LAKE, WORTH COUNTY.

Lake No. 66. Survey made by the State Highway Commission. Inspection made June 14, 1916.

Silver Lake occupies parts of sections 14 and 15, of township 100 north, range 22 west. Forest City is twenty-six miles southwest; Northwood twelve miles southeast. It is most easily reached by driving from Emmons which is on the M. & St. L. Ry.

This is one of the most attractive of Iowa's smaller lakes. The banks are high, and a naturally heavy growth of native timber has been preserved. The water is clear and open except in a few of the more shallow bays, and varies from four to six feet in depth. There is one small area of low land at the west end of the lake which

FIG. 45—Silver Lake, Worth County. Silver Lake is an open body of water of about one-half square mile in extent. Along its shore are found some of the most attractive native groves in the state. The water is of good depth.

is enclosed by the meander. Aside from this, there is very little slough land along its shores.

The area of the lake is 310 acres. The meander encloses 318 acres. The water shed has an area of 2,160 acres, 320 of which are in Minnesota.

Just across the state line are several of the best lakes for wild fowl shooting, in this part of the country. The ducks fly back and forth from those to Silver Lake, and the shooting there is especially good.

Up until three years ago the fishing has always been fair. At that time the fish were killed by a severe winter. They are coming in again from the river, and in a year or two there will be plenty more.

On the southeast shore is located one of the prettiest picnic grounds in the state. Large crowds from the surrounding country gather here for their annual day's outing.

The water supply is fairly satisfactory, as Iowa's lakes go. The lake level varies perhaps two feet between wet and dry years. On the north a large slough connected to the lake by a ditch, is so little above its level that any attempt to raise the lake will flood it.

The outlet is by way of a small creek which flows to the east and unites with the Shell Rock. Immediately below the lake and separated from it only by a low ice-formed wall, is a slough which follows the outlet creek. The bottom is of silt which overlies the usual sandy clay. Old settlers say that before the prairies were broken up, the lake was sixteen feet deep, and had a gravel bottom. A pole can be pushed down through the silt without effort.

Local sentiment is strongly in favor of keeping the lake. At the

FIG. 46—Silver Lake, Worth County. Hunting and fishing are good on Silver Lake. The outlet to the lake is soft and is cutting rapidly. A dam is needed at once to properly protect the lake.

same time, a great deal of opposition would develop against raising it. No complaint is made either of the blackbirds or mosquitoes.

Recommendations.

The Commission recommends that the lake be retained and that the state put in a permanent dam at the outlet, which, it is estimated, will cost \$1,600. They also recommend that land for a public park be bought, fronting on the water. This will cost \$3,500.00.

CORNELIA LAKE, WRIGHT COUNTY.

Lake No. 67. Survey made by the Civil Engineering Department, Iowa State College. Inspection made June 15, 1916.

This lake, frequently called Little Wall, is to be found in sections 9 and 16, township 92 north, range 24 west. Just to the east is the village of Cornelia on the C. G. W. Railway. It is six miles northeast of Clarion, the county seat. Elm (Elin or Ellen) Lake lies less than a miles to the south. Big Wall Lake is about twelve miles directly south, and the Twin Sisters Lakes about four miles directly north. Clear Lake, easily reached by rail, is about thirty miles to the north-east. Township roads follow both the eastern and western shores closely, rendering it easily accessible for outing purposes.

Speaking as a whole, the lake is rather a pleasing little body of water. The banks are high except to the south, and small patches of

timber are scattered here and there. About fifty per cent of the water surface is covered by rushes that gained a foothold during preceding dry seasons. A few years ago the waters were stocked by the state and several bass weighing from two to three pounds were caught here during the season of 1915. Camping and picnic parties from Clarion and the surrounding country frequently take advantage of the opportunities here offered for a few days' outing.

The water at present will average perhaps six feet in depth. The natural drainage is to the west over a saddle, three feet above the lake surface as it stands. Residents report that three or four times during the last twenty years, the lake has overflowed in this direction to the White Fox ditch and so to the Des Moines River. An examination of the shore locates ordinary high water mark about a foot below this level. Elm Lake, on the other hand, drains to the south-east into the Iowa River, and the divide between the two is very low.

The bottom of the lake is of silt, underlayed by sand and clay. Seven or eight years ago when the lake bed was dry good hay and some corn was raised on parts of the bed. The area of the water surface at the time of the survey was 262 acres. The area within the meander line is 285 acres.

Cornelia Lake lies directly on the divide between the Iowa and the Des Moines Rivers and its drainage area is very meager. The watershed has an area of 696 acres.

Drainage for the area of slough land lying to the north can be obtained by pumping into the lake, or by a line of tile with cemented joints which would skirt the northwest corner of the lake and lead away to the west.

The lake in its present shape is a very popular resort, and although subject to large fluctuations in water level with the wet and dry cycles, is not in need of immediate expenditures.

Recommendation.

The Commission's opinion is that this lake should be saved. At present no improvements, other than the purchase of land for a public park, are recommended. The estimate cost is \$4,000.00.

ELM LAKE, WRIGHT COUNTY.

Lake No. 68. Survey made by the Civil Engineering Department, Ames, Iowa. Inspection made June 15, 1916.

Elm Lake is to be found in sections 21, 22, 27 and 28 of township 92 north, range 24 west. Cornelia Lake lies just to the north. Either one is easily reached from Cornelia on the C. G. W. Railway, or by driving from Clarion a distance of about six miles.

The county road skirts the north end of the lake for a short distance. This is the only place where it can be reached except by crossing private property. Roads could easily be built to reach the lake from both the east and west along the line between sections 22 and 27 and between 21 and 28. On the east one-fourth mile of road will reach

the township road; on the west one-half mile is needed to connect the lake to the county road.

The character of the two lakes is much the same, though Elm Lake is not quite so deep as Cornelia Lake; the water varying from four to six feet in depth. At the present time, comparatively few rushes are to be found in Elm Lake while Cornelia Lake is nearly half covered with a rank growth.

The banks are low and grassy. A few clumps of willows are scattered along the shores, but good shade trees are lacking, and a grove of native timber would add much to the value of the lake for picnic parties.

Several boat houses are maintained along the north shore by outside people, and are used as hunting lodges during the fall shooting.

A number of tile outlet into the lake a foot or two above its present level.

The area at the time of the survey was 429 acres. The meander enclosed 463 acres. 1,639 acres of land are contained in the limits of the water shed.

During ordinary years, this is a very pretty little lake and holds its level fairly well. It is reported to have been dry in 1894, and hay was raised on the northern half. The southern end was too sandy to produce anything. Borings showed a layer of silt underlayed by gravel or clay.

The outlet is to the southeast over ground two feet above the lake level, at the time of the survey, through a ditch to the Iowa River. There is abundant evidence to be found indicating that the lake at times, rises and overflows.

The local sentiment seems to be in favor of the retention and ultimate improvement of this lake in spite of the fact that large variations in water level are to be expected.

Recommendations.

In the opinion of the Commission, this lake should be retained. The outlet is not satisfactory, and a weir and embankment should be constructed to regulate, in some measure, the lake level, and to allow the drainage of lands lying near the outlet. The estimated cost is \$2,000. Forty acres of this lake should be deepened by dredging, at a cost of \$77,000. Enough land will be made from the spoil, to form a public park. A roadway and the planting of trees will cost \$4,900.

WALL LAKE, WRIGHT COUNTY.

Lake No. 69. Survey made by order of the Executive Council. Inspection made August 4, 1916.

Wall Lake is situated in sections 2, 3, 10, 11, 14 and 15 of township 90 north, range 24 west. It is located eleven miles southeast of Clarion and thirteen miles southeast of Eagle Grove. Elm Lake is ten miles to the north. Little Wall lake is twenty-three miles to the south. Township roads encircle the lake, but only on the south do they approach near enough to allow a view of the water.

The lake is an irregular body of water which extends for nearly two miles in a north and south direction, and is perhaps a mile in width. The water at the north end is very shallow, near the south end it is perhaps five feet in depth. Most of the surface is covered with a rank

FIG. 47—Wall Lake, Wright County. Wall Lake is one of the famous hunting resorts of Iowa. It is rather shallow and is badly grown up with rushes. It covers an area of about one and a half square miles.

growth of vegetation cut up by narrow channels of open water, through which a boat can be poled. On the south end there is a little open water.

The depth varies from two to five feet. The banks around the east, south and west are well defined. On the northern end of the lake the

FIG. 48—Wall Lake, Wright County. There is a narrow fringe of trees around part of Wall Lake. On the southeast, there is a beautiful camp ground in which there are erected about a dozen permanent cottages.

country is low and inclined to be wet. Natural timber grows on the east and south shores, and in places fringes the west shore. Two small, low sloughs lie close to the lake on the east side and during wet years some

land on the north of the lake is valuable only for grazing. This area cannot well be drained without draining the lake bed.

The lake has an area of 935 acres. The meander encloses 905 acres.

A small pleasure resort and several cottages are found in the grove south of the lake. Fishing is reported as being fairly good the last three years. Good strings of perch and bullheads are caught. The lake has never been stocked with game fish and until deeper water is provided such a step will not be warranted. Hunters from the surrounding counties use the lake during the open season. Considerable wild rice grows in its waters, which makes it a favorite feeding ground for ducks and geese. Some ice for local consumption is cut during the winter months.

Local testimony is to the effect that the lake bed was dry in 1894 and in 1901, as were other lakes of the state. No streams of any size enter the lake. The water shed is rather small. The outlet is to the south through Buck Creek, a tributary to the Boone River. The creek has a fall of sixteen feet in the first two and a half miles below the lake.

The bottom of the lake is a thick sheet of silt and decaying vegetable matter which overlies the glacial drift.

Many blackbirds nest in the rushes over the water, and considerable

FIG. 49—Wall Lake, Wright County. This photograph shows the outlet for Wall Lake, with a portion of the wall or embankment pushed up by the ice. It is from this wall that the lake takes its name.

complaint is made of their damage to crops on nearby farms. This question has been studied and reported upon in Part Two.

Legal History.

Application for drainage having been made, a survey and report, as required by law, were made in February, 1910. Drainage was denied.

Recommendations.

The Commission recommends that the lake be retained, and that a public park be purchased fronting on the shore. The estimated cost of such a park is \$3,500. They further recommend that about forty acres in the south end be deepened so as to provide open water for boating and as winter quarters for fish. The estimated cost of this work is \$75,000.

TWIN SISTERS LAKE, WRIGHT COUNTY.

Lake No. 70. Survey made by the Civil Engineering Department, Ames, Iowa. Inspection made June 15, 1916.

Twin Sisters Lake is situated in sections 28 and 29, township 93 north, range 24 west. It is four miles west of Belmond, a town of 1,200 population on the Estherville branch of the C., R. I. & P. Railroad. Little Wall Lake is about four miles to the south, and Twin Lakes in Hancock County about seven miles to the north. Township roads on the north and south sides render the lake easy to reach by team or car.

The banks are rather abrupt to the north and west, but lower and inclined to be marshy on the south. Very little native timber is found, but on the west, north and east, nice groves have been started around the farm houses on the lake banks.

The water is about five feet deep and to a casual observer, appears to be open, but it is in reality filled with a growth of very fine water grass that makes it unfit for bathing and boating.

The present area of the water surface is 100 acres. The area inside the meander line is 108 acres. The water shed has an area of 660 acres.

The lake is something of a hunting resort during the fall. In summer numerous fishermen and picnic parties are encountered every pleasant day along the southern shore. The lake has never been stocked with fish, but good strings of bullheads are caught and, a few years ago, pickerel were plentiful. One line of tile from the north empties into the lake at about the present water level.

Like several other lakes of the state this one lies right on top of the divide. Its water shed is very small. An artificial supply can be obtained by pumping from wells, but such a project would not be justified at present.

Flood waters pass to the southeast through a pond down a broad valley toward the Iowa River. The elevation of the ground at the outlet is two feet above the present water surface. This, by indications along the shore and testimony of the old residents, may be considered ordinary high water level.

The bottom is silt and decayed vegetable matter which would make good farm land if properly drained.

The water could be raised a foot or more by dyking off the small area of swamp land to the south. An outlet for this area can be obtained through the saddle just south of the road.

The general local opinion seems to be in favor of retaining the lake, although it is by no mean unanimous. Objections to the lake seem to be based more on the conduct of the hunters and fishermen who frequent it, than from a desire for drainage for its own sake.

Recommendations.

In the opinion of the Commission, the State should build a concrete culvert at the outlet. This, with the earth work, will cost \$1,200.00. Land fronting on the lake should be purchased for a public park and a grove planted on it. This will cost \$2,500.00.

PART TWO

Report of crop surveys in the vicinity of various lakes, to ascertain the damage resulting from blackbirds. Prepared by Farm Crops Section of the Agricultural Experiment Station, Iowa State College, under the direction of Prof. H. D. Hughes. Field examinations by Messrs. Clyde McKee, F. S. Wilkins, D. H. Zentmire, W. R. Hechler, J. A. Krall and H. D. Hughes, including a chapter on Food and Nesting Habits of Blackbirds, by Prof. H. A. Scullen, Department of Zoology.

CHAPTER ONE---REPORT OF FARM CROP SURVEYS

In nearly every case in which the drainage of one of Iowa's lakes has been petitioned, the great damage to crops caused by blackbirds, which congregate in the vicinity of the lake has been set forth as one of the principal reasons why drainage was petitioned. It is a matter of common knowledge that several different kinds of blackbirds nest near lakes and sloughs and that the birds congregate in great flocks just before their fall migration to the South. The actual amount of damage for which these birds are responsible is not so well known, and estimates of its extent differ greatly on farms that are side by side. With a view of ascertaining how serious this damage is, the Farm Crops Section of the Agricultural Experiment Station of the State College, under the direction of Prof. H. D. Hughes, undertook an examination of the farm crops in the vicinity of four typical marshy lakes. Messrs. Clyde McKee, F. S. Wilkins, D. H. Zentmire, W. R. Hechler, J. A. Krall and H. D. Hughes, made the field examinations.

Time of Examinations.

In the vicinity of Wall Lake in Wright County examinations were made about the middle of June and the last of September, 1915, and in November, 1916. Near Trumbull Lake in Clay County, the crops were examined in June, August and October, 1915. Trips were made to Goose Lake in Greene County in June, July and October, 1915, and in October, 1916. Examinations of crops near Muscatine Slough in Muscatine and Louisa Counties were made in June and September, 1915.

Areas Examined.

In each vicinity many different farms were visited. Some of these lay very close to the lakes, others were back at distances varying from one-quarter mile to four miles from the lake shore. By so doing, it is believed that fair and representative results have been obtained. The locations of the fields examined are shown on the maps which accompany the records in Chapter Two.

Method of Making Examinations.

The examinations in each vicinity have consisted of interviews with the farm operators, and of actual counts of damage found in the fields. In the interviews with farm operators, a carefully prepared list of questions was used in every case. These questions were so arranged as to bring out the operator's knowledge of the kind and number of blackbirds which visited his farm during the different seasons, the damage they caused to small grain and to corn at different stages in their growth, and his estimate of the loss he sustained through their agency. In the spring examination counts were made of the hills of corn destroyed by

blackbirds. Damage is done by the blackbirds digging small holes beside the young corn plants just after they have come through the ground and from then on, until they are an inch or two high. The birds do this to obtain the kernel and the stalk of corn is incidently destroyed.

The damage to standing corn when it is in the roasting ear stage is done by the birds tearing the husks from the tips of the ears and picking off the immature kernels. The ears which are erect at this time, offering a place for the birds to stand upon, suffer the most. In a wet fall, the damage amounts to more than the corn actually taken by the birds because the open husks catch the rain and the water rots the corn.

During the fall examinations, the amount of damage in each field was

FIG. 50—Wall Lake, Wright County. This photograph shows a huge flock of blackbirds over Wall Lake. Many blackbirds are to be found around the lake during the entire summer, but it is in the fall when they gather into flocks, as shown in the picture, that they do the most damage to farm crops.

usually estimated by walking through the field from a farther edge toward the grove and buildings, counts being made at different points. In each count all damaged ears were counted on an area 25 hills in length and 4 hills wide. Any ear which was picked on the tip the least bit was counted as damaged. The percentage of damaged ears in the field, was figured from an actual count of the per cent stand, but averaged about 250 stalks in each 100 hill area. From counts of stand made in the different corn fields, this seemed to be a fair average stand.

In Chapter Two, the numbers used in the schedules correspond with the numbers on the maps, and indicate the location of the fields where such counts were made.

Conclusions.

A study of the data in Chapter Two, Schedules 3 to 17, leads to four conclusions:

First, that there is a certain amount of damage done to corn at about the time it is coming through the ground, but that this damage is slight and is confined to very limited areas near where the blackbirds nest.

Second: The examination of a large number of fields of small grain, indicate that the damage from blackbirds, is practically all confined to the time when grain is in the shock, that this damage is serious only when the shocks stand in the field for a long time, and is confined to small areas located close to groves, sloughs or patches of sunflowers.

FIG. 51—Goose Lake, Greene County. Study of the photograph will show the tips of four ears of corn, badly damaged by blackbirds. The crop damage is not confined to the few kernels destroyed on the tips of the ears. Water often enters where the husks are stripped back, and the entire ear is injured by rotting. Grain buyers, it is claimed, are accustomed to dock the corn grown in the vicinity of Goose Lake from 1 to 2 cents per bushel.

Within the territory one mile from the lake, this damage does not average more than one dollar per acre.

Third: The amount of damage to corn in the milk varies not only with the distance of the field from a lake or slough, but with its distance from a grove.

Fourth: An average of all the examinations, shows that on farms within one-half mile of the lakes in question, 13.2% of the ears were damaged. On farms from one-half to two miles from the lakes, an average of 5.7% of ears were damaged. On farms more than two miles from a lake, 1.6% of the ears were damaged.

It is to be understood that these figures represent the percentage of ears damaged, not the damage to the crop. Counts show than an average

FIG. 52—Wall Lake, Wright County. A group of badly damaged ears of corn from the vicinity of Wall Lake. These ears were selected for the special purpose of showing damage and it must not be thought that all of the corn in the fields adjoining the lake is so badly damaged.

FIG. 53—Goose Lake, Greene County. These five ears of corn are fairly representative of the most severely damaged corn which could be found in the vicinity of Goose Lake at the time the inspection was made.

of 20 kernels are destroyed on each ear. As the average ear of corn has 1,000 kernels, 20/1000 or 1/50 of the corn on the damaged ears is destroyed. Since 13/100 of the ears were damaged, $1/50 \times 13/100 = 1/384$ of the crop is destroyed. The average yield of corn per acre during the last 10 years has been 34.4 bushels, which has sold at 46.6 cents per bushel. On this basis, the average loss per acre is a little more than four cents.

Fields close to a lake or a grove, or a field planted either very early or very late, suffer much greater loss than these average figures indicate. From the damage done in the spring, the loss of seed corn is a small matter as compared to the annoyance and expense incidental to replanting small portions of a field. The fall damage also to certain fields of parts of fields is several times that indicated by the average figures. Take for example a field near Goose Lake in Greene County where a count in one particular place, showed 75% of the ears damaged, and probably three-fourths of the kernels on these ears destroyed. $\frac{3}{4} \times \frac{3}{4} = 9/16$ of the crop destroyed. If this particular acre gave a yield of 50 bushels and the corn sold at 60 cents a bushel, the actual loss would amount to approximately \$17.00 on this one acre.

There is also a loss wet years, due to the entrance of water, and the rotting of the ear. If the corn were sold, the loss would be still further increased, due to the fact that such grain would grade lower than would the average crop. Taking all these factors into account, it does not seem probable that even the most unfavorably situated farm ever suffers a damage to the corn crop, which will exceed one hundred dollars a year.

CHAPTER TWO---EXAMINATION OF CROPS IN THE VICINITY OF WALL LAKE, WRIGHT COUNTY, 1915

SCHEDULE 3.

Showing Percentage of Damaged Ears on All Farms Visited Within Half Mile of a Lake.

No. of Farm	Percentage Ears Damaged	Distance from Grove
2	34.0	$\frac{1}{4}$ mile
3	0.0	(Late Corn)
5	30.0	$\frac{1}{2}$ mile
.....	0.0	$\frac{1}{2}$ mile (Late Corn)
8 and 9	30.5	$\frac{1}{8}$ mile (Late Corn)
10	0.0	$\frac{1}{8}$ mile (Late Corn)
19	29.2	$\frac{1}{2}$ mile
.....	18.8	$\frac{1}{2}$ mile
.....	0.0	$\frac{1}{2}$ mile (Late Corn)
Average	15.8	.3 mile

SCHEDULE 4. (WALL LAKE 1915.)

Showing Percentage of Damaged Ears on All Farms Visited From One-Half to Two Miles From Lake.

No. of Farm	Distance from Lake	Approx. Percentage Ears Damaged	Distance from Grove
1	1 mile	1.5	Next
4	1 mile	1.5	Next
6	$\frac{3}{4}$ mile	29.2	Next
11	1 mile	0.0	$\frac{1}{2}$ mile *Late
12	$1\frac{1}{2}$ mile	0.0	$\frac{1}{4}$ mile
13	$1\frac{1}{2}$ mile	0.0	$\frac{1}{4}$ mile
15	$1\frac{1}{2}$ mile	0.0	$\frac{1}{2}$ mile
16	1 mile	32.5	1 mile
16	1 mile	0.0	1 mile *Late
17	1 mile	15.8	$\frac{1}{2}$ mile
17	1 mile	0.0	$\frac{1}{2}$ mile *Late
18	1 mile	0.0	.....
Average	.....	6.7	.....

*Corn late planted—immature at time of examination.

It will be observed on studying the above Schedules that there is considerable variation in the amount of damage done. In order that these data may be more easily studied, Schedules No. 5 and No. 6 were compiled to show how distance from groves influences the amount of damage done.

SCHEDULE 5.

Showing Percentage of Damaged Ears on All Farms Visited Within One-Quarter Mile of Grove.

No. of Farm	Percentage Ears Damaged	Distance from Lake
1	1.5	1 mile
2	34.0	Next
4	1.5	1 mile
6	29.2	$\frac{3}{4}$ mile
8 and 9	30.5	$\frac{1}{2}$ mile
10	0.0	Next (Late)
12	0.0	$1\frac{1}{2}$ miles
13	0.0	$1\frac{1}{2}$ miles
14	0.0	3 miles
Average	10.7	1.0 (Plus) miles

FIG. 54—Map showing the fields examined during 1915 in the vicinity of Wall Lake, Wright County.

SCHEDULE 6.

Showing Percentage of Damaged Ears on All Farms Visited Over
One-Quarter Mile From Grove.

No. of Farm	Percentage Ears Damaged	Distance from Lake
5	30.0	Next
....	0.0	Next (Late)
11	0.0	1 mile (Late)
15	0.0	1½ miles
16	32.0	1 mile
....	0.0	1 mile (Late)
17	15.8	1 mile
....	0.0	1 mile (Late)
19	29.2	Next
....	18.8	Next
....	0.0	Next (Late)
Average	11.4	.5 (Plus) mile

The averages of the two tables above show very little difference in the amount of damage done, whether the field is under $\frac{1}{4}$ mile or over $\frac{1}{4}$ mile from the grove. Out of eight counts, showing more than 15% of damaged ears, 3 counts were made under $\frac{1}{4}$ mile from groves, while 5 counts were made in fields which were over $\frac{1}{4}$ mile from groves. However, in studying the data further, it will be observed that in 3 out of 5 instances where counts were made over $\frac{1}{4}$ mile from groves, the fields were next to the lake. This, as will be brought out in the following schedules, may account for the large amount of damage done in those fields which are located some distance from groves. Making allowance for this fact, the data presented above, might seem to indicate that corn is damaged more near groves than at a distance. However, it is certain that sufficient data has not been gathered from which to draw any definite conclusions.

The year of 1915 was an exceptionally wet year and it seemed desirable to make examinations during 1916 when weather and crop conditions were more nearly normal.

Examination of Crops Around Wall Lake, Wright County, 1916:

SCHEDULE 7. (WALL LAKE 1916.)

Showing Percentage of Damaged Ears in All Fields Visited Within
Half Mile of Lake.

Farm No.	Distance from Lake	Approx. Percentage Ears Damaged	Distance from Grove
3	$\frac{1}{2}$ mile	7.5	$\frac{1}{8}$ mile
3	$\frac{1}{2}$ mile	13.0	$\frac{1}{8}$ mile
3	$\frac{1}{2}$ mile	13.2	$\frac{1}{8}$ mile
4	$\frac{1}{4}$ mile	26.5	$\frac{1}{2}$ mile
4	$\frac{1}{4}$ mile	19.5	$\frac{1}{2}$ mile
4	$\frac{1}{4}$ mile	26.0	$\frac{1}{2}$ mile
5	$\frac{1}{2}$ mile	9.8	10 rods
5	$\frac{1}{2}$ mile	10.6	10 rods
5	$\frac{1}{2}$ mile	9.0	10 rods
Average	.....	15.0	.....

FIG. 55—Map showing the location of fields examined during 1916 in the vicinity of Wall Lake, Wright County.

SCHEDULE 8. (WALL LAKE 1916.)

Showing Percentage of Damaged Ears on All Farms Visited From One-Half to Two Miles From Lake.

Farm No.	Distance from Lake	Approx. Percentage Ears Damaged	Distance from Grove
1	1 mile	0.4	$\frac{1}{2}$ mile
1	1 mile	7.5	$\frac{1}{2}$ mile
2	1 mile	0.9	$\frac{1}{2}$ mile
2	1 mile	1.5	$\frac{1}{2}$ mile
2	1 mile	1.8	$\frac{1}{2}$ mile
6	$\frac{3}{4}$ mile	9.0	$\frac{1}{8}$ mile
7	1 mile	18.1	$\frac{1}{8}$ mile
12	$\frac{3}{4}$ mile	38.1	$\frac{1}{2}$ mile
13	1 mile	3.0	Next
13	1 mile	17.2	Next
14	1 mile	7.0	Next
14	1 mile	1.6	Next
15	1 mile	1.2	$\frac{1}{2}$ mile
15	1 mile	4.8	$\frac{1}{2}$ mile
16	1 mile	1.8	$\frac{1}{2}$ mile
17	1 mile	0.6	$\frac{1}{2}$ mile
17	1 mile	5.0	$\frac{1}{2}$ mile
33	$1\frac{1}{2}$ miles	0.0	$\frac{1}{2}$ mile
33	$1\frac{1}{2}$ miles	0.0	$\frac{1}{2}$ mile
33	$1\frac{1}{2}$ miles	0.0	$\frac{1}{2}$ mile
33	$1\frac{1}{2}$ miles	0.0	$\frac{1}{2}$ mile
34	$\frac{3}{4}$ mile	0.0	$\frac{1}{8}$ mile
35	$\frac{3}{4}$ mile	2.2	10 rods
35	$\frac{3}{4}$ mile	2.8	10 rods
36	$1\frac{1}{2}$ miles	0.0	$\frac{3}{4}$ mile
36	$1\frac{1}{2}$ miles	0.4	$\frac{3}{4}$ mile
37	2 miles	0.8	$\frac{3}{4}$ mile
38	2 miles	0.0	$\frac{3}{4}$ mile
39	2 miles	13.3	$\frac{1}{8}$ mile
39	2 miles	10.0	Next
39	2 miles	12.2	10 rods
39	2 miles	16.0	$\frac{1}{8}$ mile
Average	.....	5.9	.....

SCHEDULE 9. (WALL LAKE 1916.)

Showing Percentage of Damaged Ears on All Farms Visited Over Two Miles From Lake.

Farm No.	Distance from Lake	Approx. Percentage Ears Damaged	Distance from Grove
18	3½ miles	0.0	½ mile
18	3½ miles	0.2	½ mile
18	3½ miles	0.0	½ mile
19	3½ miles	0.0	¼ mile
19	3½ miles	0.2	¼ mile
20	3½ miles	0.0	¼ mile
21	3½ miles	0.0	¼ mile
22	4 miles	0.0	¾ mile
22	4 miles	0.0	¾ mile
23	4 miles	7.5	6 rods
23	4 miles	2.8	6 rods
24	4 miles	1.0	½ mile
25	4 miles	0.0	¼ mile
25	4 miles	0.6	Next
26	3½ miles	0.0	½ mile
26	3½ miles	9.6	Next
27	2½ miles	0.0	¾ mile
28	2½ miles	4.0	10 rods
29	2½ miles	1.0	¾ mile
30	2½ miles	1.4	¾ mile
31	2 miles	6.7	Next
31	2 miles	4.7	Next
32	2 miles	0.8	¾ mile
32	2 miles	3.8	10 rods
40	3½ miles	0.0	.....
40	3½ miles	0.0	.....
Average	.....	1.7	.....

The influence of groves on the per cent of damaged ears is readily apparent. Of 23 examinations showing 5% damaged ears or over, seventeen are located ¼ miles or less from a grove, while only six are located over ¼ mile from a grove. Of these six counts made over ¼ miles from a grove and showing serious damage, three are located within one-fourth mile of the lake and a fourth is located only three-fourths of a mile from the lake. The remaining two of the six are located one mile from the lake, but these show relatively much less damage, namely 5 and 7 per cent.

FIG. 56—Map showing the location of fields examined in 1915 in the vicinity of Trumbull Lake, Clay County.

Examination of Farm Crops in the Vicinity of Trumbull, Round and Mud Lakes, in Clay County, 1915:

SCHEDULE 10.

Showing Approximate Percentage of Damaged Ears on All Farms Visited Within Half Mile of Lake.

Farm No.	Distance from Lake	Approx. Percentage Damaged Ears in Field
19	Borders Trumbull	20.0
23	Borders Mud	30.0
1	Borders Trumbull	0.0
6	½ mile from Trumbull	28.0
4	Borders Trumbull	50.0
3	Borders Trumbull and Round	30.0
25	Borders Trumbull	6.0
5	Borders Round	6.0
9	Borders Trumbull	4.0
10	½ mile from Trumbull	1.0
11	¼ mile from Trumbull	3.0
12	½ mile from Trumbull	11.0
15	½ mile from Mud	0.2
26	¼ mile from Round	0.1
27	½ mile from Round	5.0
28	½ mile from Round	0.1
37	Borders Trumbull	0.0
41	Borders Lost Island	0.0
43	Borders Trumbull	0.6
44	Borders Trumbull	16.0
48	½ mile from Lost Island	12.0
46	½ mile from Mud	11.0
Average	.....	10.61

SCHEDULE 11.

Showing Approximate Percentage of Damaged Ears on All Farms Visited Between One-Half and Two Miles of a Lake.

Farm No.	Distance from Lake	Approx. Percentage Damaged Ears in Field
20	1½ mile from Trumbull	0.5
2	¾ mile from Trumbull	0.1
14	1½ mile from Trumbull	14.0
17	1½ mile from Trumbull	6.0
30	¾ mile from Round	3.0
29	¾ mile from Round	0.0
31	¾ mile from Round	5.0
32	1½ mile from Round	0.0
33	1½ mile from Round	0.0
36	¾ mile from Trumbull	1.5
40	1 mile from Trumbull	0.0
42	¾ mile from Trumbull	0.0
47	¾ mile from Mud	8.0
Average	.....	2.93

FIG. 57.—Map showing location of fields examined in 1915 in the vicinity of Goose Lake, Greene County.

SCHEDULE 12.

Showing Approximate Percentage of Damaged Ears on All Farms Visited
Two Miles or Over From a Lake.

Farm No.	Distance from Lake	Approx. Percentage Damaged Ears in Field
21	3½ miles from Trumbull	0.0
22	5 miles from Trumbull	0.0
24	2 miles from Mud	3.0
7	3 miles from Trumbull	8.0
*8	2 miles from Trumbull	18.0
13	1 mile from Trumbull	0.0
16	¾ mile from Trumbull	0.0
†18	1¼ miles from Trumbull	2.0
34	2½ miles from Round	0.0
35	2 miles from Round	0.0
‡38	3 miles from Trumbull	2.0
‡39	2½ miles from Trumbull	2.0
45	2½ miles from Trumbull	3.0
49	3 miles from Mud	0.0
50	3 miles from Mud	0.0
51	4½ miles from Mud	0.0
Average	.....	2.37

*Very early field.

†Near large slough.

‡Bordering outlet of Lost Island Lake.

Examination of Farm Crops in the Vicinity of Goose Lake, Green County, 1915:

SCHEDULE 13.

Showing Approximate Percentage of Damaged Ears on All Farms Visited
Within Half Mile of the Lake.

Farm No.	Distance from Lake	Approx. Percentage Dam- aged Ears in Field
1	Borders	6.0
1	Borders	75.0
2	Borders	28.0
4	½ mile	5.0
5	⅛ mile	9.0
7	½ mile	3.0
8	Borders	9.0
9	Borders	8.0
10	Corners	9.0
20	Borders	0.1
21	½ mile	6.0
Average	.....	14.36

FIG. 58—Map showing location of fields examined in 1916 in the vicinity of Goose Lake, Greene County.

SCHEDULE 14.

Showing Approximate Percentage of Damaged Ears on All Farms Visited
Between Half and Two Miles of Lake.

Farm No.	Distance from Lake	Approx. Percentage Damaged Ears in Field
3	$\frac{3}{4}$ mile	5.0
11	2 miles	1.0
12	$1\frac{1}{2}$ miles	2.0
13	$1\frac{1}{4}$ miles	2.0
14	1 mile	9.0
15	1 mile	4.0
16	$\frac{3}{4}$ mile	4.0
17	$\frac{3}{4}$ mile	0.8
18	$1\frac{1}{4}$ miles	13.0
19	2 miles	5.0
22	1 mile	11.0
Average	.....	5.16

The examinations of crops near Goose Lake in 1915 showed very little damage by blackbirds except during the roasting ear stage. The season of 1915 was very wet and it seem advisable to secure additional data on this damage during 1916 when weather conditions were more normal than in the preceding year. Inspectors visited the lake in October of 1916 and determined the extent of damage in forty-five fields of corn, nearly all of which were situated within two miles of the lake. Eighty-three determinations of damage were made, two or three sometimes being made in the same field where large variations were to be expected.

SCHEDULE 15. (GOOSE LAKE 1916.)

Showing Percentage of Damaged Ears on All Farms Visited Within Half
Mile of Lake.

Farm No.	Distance from Lake	Approx. Percentage of Damaged Ears	Distance from Grove
16	10 rods	2.2	$\frac{1}{2}$ mile
16	10 rods	5.6	$\frac{1}{2}$ mile
16	10 rods	7.6	$\frac{1}{2}$ mile
17	5 rods	50.2	Next
17	5 rods	26.8	Next
18	$\frac{1}{4}$ mile	24.0	30 rods
18	$\frac{1}{4}$ mile	17.2	$\frac{1}{4}$ mile
18	$\frac{1}{4}$ mile	11.2	$\frac{1}{4}$ mile
18	$\frac{1}{4}$ mile	9.6	$\frac{1}{4}$ mile
18	$\frac{1}{2}$ mile	26.4	$\frac{1}{4}$ mile
19	$\frac{1}{4}$ mile	2.9	$\frac{1}{2}$ mile
20	$\frac{1}{4}$ mile	5.5	Next
20	$\frac{1}{4}$ mile	10.5	Next
21	$\frac{1}{2}$ mile	19.0	30 rods
21	$\frac{1}{2}$ mile	3.0	$\frac{1}{4}$ mile
21	$\frac{1}{2}$ mile	3.5	$\frac{1}{8}$ mile
21	$\frac{1}{2}$ mile	21.0	20 rods
22	$\frac{1}{4}$ mile	0.8	$\frac{1}{2}$ mile
23	$\frac{1}{2}$ mile	0.4	$\frac{1}{2}$ mile
24	$\frac{1}{2}$ mile	3.8	$\frac{1}{4}$ mile
33	$\frac{1}{2}$ mile	0.8	$\frac{1}{4}$ mile
34	$\frac{1}{2}$ mile	0.2	$\frac{1}{4}$ mile
34	$\frac{1}{2}$ mile	3.2	$\frac{1}{4}$ mile
35	$\frac{1}{4}$ mile	5.5	$\frac{1}{4}$ mile

LAKES AND LAKE BEDS OF IOWA

SCHEDULE 15—GOOSE LAKE, 1915—Continued

Farm No.	Distance from Lake	Approx. Percentage of Damaged Ears	Distance from Grove
35	$\frac{1}{4}$ mile	7.5	$\frac{1}{4}$ mile
36	$\frac{1}{2}$ mile	0.6	$\frac{1}{4}$ mile
37	$\frac{1}{4}$ mile	7.5	Near
37	$\frac{1}{4}$ mile	8.5	Near
38	$\frac{1}{4}$ mile	20.3	Near
38	$\frac{1}{4}$ mile	18.5	Near
39	$\frac{1}{2}$ mile	6.0	$\frac{1}{4}$ mile
39	$\frac{1}{2}$ mile	2.0	$\frac{1}{4}$ mile
39	$\frac{1}{2}$ mile	1.1	$\frac{1}{4}$ mile
43	Next	9.2	$\frac{1}{4}$ mile
43	Next	12.0	$\frac{1}{4}$ mile
43	Next	5.7	$\frac{1}{4}$ mile
Average	.....	10.0	.....

SCHEDULE 16. (GOOSE LAKE 1916.)

Showing Percentage of Damaged Ears on All Farms Visited From One-Half to Two Miles From the Lake.

Farm No.	Distance from Lake	Approx. Percentage of Damaged Ears	Distance from Grove
6	2 miles	30.5	Next
6	2 miles	4.4	5 rods
6	2 miles	0.0	$\frac{1}{4}$ mile
6	2 miles	0.0	$\frac{1}{4}$ mile
7	2 miles	0.0	$\frac{1}{2}$ mile
8	2 miles	0.3	$\frac{1}{2}$ mile
8	2 miles	7.2	$\frac{1}{2}$ mile
9	$1\frac{1}{2}$ miles	5.3	$\frac{1}{2}$ mile
9	$1\frac{1}{2}$ miles	1.0	$\frac{1}{2}$ mile
9	$1\frac{1}{2}$ miles	4.7	$\frac{1}{2}$ mile
10	$1\frac{1}{2}$ miles	3.7	$\frac{1}{2}$ mile
11	$1\frac{1}{4}$ miles	9.2	Next
11	$1\frac{1}{4}$ miles	2.4	30 rods
11	$1\frac{1}{4}$ miles	19.2	Next
12	$1\frac{1}{4}$ miles	24.5	Next
13	$\frac{3}{4}$ mile	10.4	40 rods
13	$\frac{3}{4}$ mile	2.8	40 rods
13	$\frac{3}{4}$ mile	11.6	20 rods
13	$\frac{3}{4}$ mile	25.0	Next
13	$\frac{3}{4}$ mile	27.2	Next
14	1 mile	8.3	6 rods
15	$\frac{3}{4}$ mile	3.5	$\frac{1}{2}$ mile
15	$\frac{3}{4}$ mile	3.5	$\frac{1}{2}$ mile
15	$\frac{3}{4}$ mile	4.2	$\frac{1}{2}$ mile
25	1 mile	1.2	$\frac{1}{2}$ mile
25	1 mile	0.5	$\frac{1}{2}$ mile
26	1 mile	0.4	$\frac{1}{4}$ mile
27	1 mile	8.4	Next
27	1 mile	0.8	15 rods
40	$\frac{3}{4}$ mile	0.5	$\frac{1}{2}$ mile
41	$\frac{3}{4}$ mile	6.8	$\frac{1}{4}$ mile
42	$\frac{3}{4}$ mile	21.0	Next
42	$\frac{3}{4}$ mile	9.5	10 rods
42	$\frac{3}{4}$ mile	4.0	$\frac{1}{4}$ mile
Average	.....	7.7	.....

SCHEDULE 17. (GOOSE LAKE 1916.)

Showing Percentage of Damaged Ears on All Farms Visited Over Two Miles From the Lake.

Farm No.	Distance from Lake	Approx. Percentage of Damaged Ears	Distance from Grove
1	4 miles	0.2	$\frac{1}{4}$ mile
2	4 miles	2.0	$\frac{1}{4}$ mile
3	3 miles	0.0	$\frac{1}{2}$ mile
4	3 miles	1.0	3 miles
5	3 miles	3.5	5 rods
44	6 miles	0.0	$\frac{1}{4}$ mile
45	9 miles	0.0	Next
28	3 miles	0.0	$\frac{1}{2}$ mile
29	3 miles	0.0	$\frac{1}{2}$ mile
30	3 miles	0.0	$\frac{1}{2}$ mile
31	3 miles	0.4	$\frac{1}{2}$ mile
32	2 miles	0.2	$\frac{1}{4}$ mile
32	2 miles	0.8	$\frac{1}{4}$ mile
Average	.....	0.6	.....

These data bring out several important facts. Of nineteen examinations located two miles or more from the lake, only one showed important damage. This was in field 6, in which four counts were made. In a small portion of the field, near a grove, 30.5 per cent of the ears had been damaged; five rods from the grove 4.4 per cent, and a fourth of a mile, no damage. Of 13 inspections one mile from the lake but less than two, only two showed damage to 10 per cent of the ears, and both of these were next to groves of trees. Of forty-four examinations within a mile from the lake, seventeen showed a damage to over 10 per cent of the ears, and nine a damage to 20 per cent or over. There is an apparent relation between the distances of the fields from the lake and the extent of the damage.

Another important factor enters in, however, and this is the distance of the corn from a grove of trees; as for example, a wind-break such as is found near most farmsteads. Of twenty examinations showing 10 per cent of damaged ears or more, sixteen were within a few rods of a grove, and none over $\frac{1}{4}$ mile of a grove. Of twenty-five examinations made $\frac{1}{2}$ miles from a grove, not one showed a damage to 10 per cent. Of thirty-eight examinations showing five per cent of the ears, or over, twenty-three were within a few rods of a grove and only four were $\frac{1}{2}$ mile from a grove. Several counts were made in many of the fields and the influence of the distance from a grove of trees on the per cent of damage was nearly always apparent. Important variations were also found in some fields in which the distance from groves apparently had no influence. The time of maturity of the corn is also found to have an important bearing on the extent of damage. Field No. 16, next to the lake, showed a damage to less than ten per cent, while field No. 17, also next the lake, showed from 26 to 50 per cent of the ears to be damaged. Field No. 6, two miles from the lake but next to a grove, showed 30 per cent of damaged ears, while field No. 20, one-quarter mile from the lake but next to a grove showed only from five to ten per cent of damaged ears.

While the per cent of damaged ears in any field will vary somewhat in different parts, it is believed that the average of the eighty-three examinations may be considered as truly representative for the community for the year 1916. The average per cent of damaged ears in the forty-five fields examined is 7.84. In view of the very low average damage over one mile from the lake, these may be omitted when the average for those one mile from the lake or less is found to be slightly less than ten per cent of damaged ears. This ten per cent represents the ears which were damaged and does not represent the per cent loss on the crop. From a number of examinations and tests it was determined that on an average probably twenty kernels are lost from each ear damaged. Since the average ear of corn contains in the neighborhood of 1,000 kernels, this will mean a loss of approximately 2.0 per cent of each ear, or where ten per cent of the ears are damaged a loss of 0.2 of one per cent of the crop. The average acre yield in Iowa for ten years is 34.5 bushels. On this basis the loss per acre will amount to 0.0695 of one bushel. As near as we can determine, there are 5,210 acres of land within one mile of the lake, of which 1,914 acres are in corn, on which 132 bushels are lost as a result of damage from blackbirds. At the average price of corn for the ten-year period, 46.6 cents, this corn has a value of \$61.50 or a loss of \$2.06 per farm.

In addition to this loss there is, of course, a very small loss per farm due to the oat crop when in the shock. It is estimated, however, that this loss cannot exceed \$1.00 per farm. It must, of course, be recognized that the loss to the corn crop on a very few farms is relatively high, as is also the loss to the oat crop on perhaps half a dozen farms which are very close to the lake and which are also close to the grove.

Examination of Farm Crops in the Vicinity of Muscatine Slough, Muscatine and Louisa Counties:

Corn.

At the time of the June examination most of the corn was large enough for the first cultivation, although some of the late planted corn was just coming through the ground, and replanting was still in progress. The extremely wet and cold spring had delayed planting in many cases and was responsible for poor germination and unfavorable early growth in many of the fields. The poor stand was due mainly to the wet weather, although cut worms and wire worms were responsible in a number of places. There were only a few fields where the birds had pulled up the corn or injured the corn in any way whatsoever. In September the damage noticeable from birds was, with the exception of a few fields, negligible. Blackbirds had eaten the corn from the exposed tip ends in a number of fields, particularly where they were located near woodland. They apparently did no more damage near the undrained areas than a few miles distant.

These observations agree with the testimony of the large number of farmers interviewed, practically every farmer making the statement that during the past several years blackbirds had done practically no damage to crops.

FIG. 59—Map showing location of fields examined in 1915 in the vicinity of Muscatine Slough, Muscatine and Louisa Counties.

Small Grain.

The acreage of small grain which is much smaller than that of corn, consists mainly of oats, with some wheat, rye and barley. No particular bird damage to the small grain was observed or reported, other than that occurring in every neighborhood from sparrows.

CHAPTER THREE---FOOD AND NESTING HABITS OF BLACKBIRDS

Nesting Habits and Presence of Blackbirds in the Vicinity of Iowa Lakes.

In considering the possible damage done to crops by blackbirds it is necessary first to determine their feeding habits. The influence which the presence of lakes may have on the extent of damage to crops in the immediate vicinity of these lakes as compared to the damage done in other communities will, no doubt, depend largely upon the attractiveness of the nesting conditions found there.

In attempting to get definite information regarding these items inspection trips were made to various Iowa lakes in the vicinity of which serious damage from blackbirds has been reported; specimens of the blackbirds were secured and their stomachs analyzed, and the reports of previous studies of the food of blackbirds reviewed.

During the past years a large amount of damage from blackbirds has been reported from the vicinity of Wall Lake in Wright County, Goose Lake in Greene County, Round and Trumbull Lakes in Clay County and Mud Lake in Palo Alto County, also Muscatine Slough, Muscatine County. These lakes are representative of the more marshy lakes of the state and on this account they were selected for special investigations. These lakes have all been visited from one to three times. The two species of blackbirds around which the investigations are centered are the Red-Winged (*Agelaius phoeniceus*), and the Yellow-headed blackbird (*Xanthocephalus xanthocephalus*). Both of these species have a habit of collecting in large flocks and feeding on the nearby farm land. A third specie commonly known as Crow Blackbird or Grackles, also congregate in large flocks at certain times of the year and considerable damage to corn has been attributed to them. This specie nest most frequently in groves adjacent to farm buildings and, therefore, their presence as a result is not influenced to any great extent by the presence of the lake.

The male of the Yellow-headed blackbird is black in color with head and breast a bright yellow. The female is more brownish with head paler and mixed with more brown. This specie nests in upright canes over water in ponds and sloughs, the nests usually being placed from four inches to two feet above the water. This specie was found in the vicinity of lakes in Central and Northern Iowa. It is quite numerous

in the northern part of the state and to some extent in the central part but is very seldom found in Southern Iowa except during migration. The distribution of these birds is much more limited than that of the Red-winged specie.

The male of the Red-winged blackbird is black in color with scarlet and buff shoulders. The female is brownish black above and streaked below. This specie usually nests at low elevations in bushes or in coarse grasses around the edges of ponds or in sloughs. Nests are also frequently found in low lying wet pastures. This specie is very generally distributed over the state wherever suitable breeding grounds may be found. It will be noted that this specie is not at all dependent on the presence of lakes but more particularly on marshy land. Since much of this land exists in the vicinity of certain lakes these birds are found there in large numbers. Mud Lake in Palo Alto County and Round Lake in Clay County are really extensive marshes grown up with rushes. These present ideal nesting places and many Yellow-headed birds were found to be nesting there. There is considerable slough and marshy land in the vicinity of these lakes and these birds were also found nesting here as well as the Yellow-headed species.

Food Habits of Blackbirds:

It is well known that the blackbirds consume more or less grain at certain times of the year and are, therefore, considered objectionable. Before drawing any definite conclusion regarding the undesirability of certain birds, however, it is important that we determine the extent to which the birds feed on valuable grains and to what extent upon weed seeds, insects, etc. Through the co-operation of the State Game Warden and his deputies a few specimens were secured; 43 of the Red-winged specie and 16 of the Yellow-headed blackbirds. These specimens were all obtained between September 3d and November 6, 1915, in the vicinity of Spirit Lake and Wall Lake. Analyses of the stomachs were secured through the co-operation of the Biological Survey.

SCHEDULE 18—ANALYSES OF BLACKBIRD STOMACHS.

United States Department of Agriculture, Washington, D. C. The contents of the stomachs of the specimens secured on various dates, are shown in the following table:

FOODS	Red-winged Blackbirds										Yellow-headed Blackbirds				
	September							Oct.		Nov.		September		Oct.	
	2d	4th	15th	20th	26th	28th	30th	8th	16th	6th	Aver.	2d	4th	28th	Aver.
No. of Specimens	2	1	1	1	7	1	1	5	12	12		5	3	6	2
Animal Predaceous Insects					0.1			2.4	0.5		0.4				
Parasitic Insects					t.					0.3	0.1		0.2		
Snout Beetles	t.			t.					0.1		0.1		0.7	t.	0.2
Other Beetles	t.			t.				0.2	t.	0.2	0.1	t.	8.5	13.0	6.5
Lepidoptera					0.9						0.1				
Grasshoppers					0.1						0.1		4.1	t.	1.4
Other Insects		t.	t.	0.1			t.	t.	0.2	0.1	0.1	t.			0.1
Spiders, etc.									0.2						
Other Animal Food															
Total Animal Food	t.	t.	t.	t.	1.1	0.0	t.	2.6	1.0	0.5	0.9	t.	13.5	13.0	8.2
Vegetable Fruit															
Corn					24.9	76.0	50.0	29.6	27.1	31.2	26.7	9.3	3.7		3.6
Oats	28.5	55.0		30.0			t.				3.3	35.7	28.1		16.4
Wheat															
Other Grain															
Weed Seeds	71.5	45.0	100.0	70.0	74.0	24.0	50.0	67.8	71.9	68.3	69.1	55.0	54.0	87.0	71.1
Other Vegetation												t.	0.5		0.7
Rubbish													0.2		
Total Vegetable Food	100.0	100.0	100.0	100.0	98.9	100.0	100.0	97.4	99.0	99.5	99.1	100.0	86.5	87.0	91.8

t. signifies a trace.

The number of stomachs of specimens analyzed as shown above is altogether insufficient to be of much value. It will be noted, however, that the stomachs of the Red-winged birds show that 26% of the food was corn and 69% weed seeds, while the stomachs of the Yellow-headed blackbirds show that their food consisted of 2.7% corn, 17% oats (which must have been picked up from the ground at this time), and 63% weed seeds, with 8% insects.

It is important that we know something of the food of these birds throughout the entire year. Such information has been secured by the Biological Survey of the United States Department of Agriculture and

FIG. 60—An analysis of 1,083 blackbird stomach contents by the Biological Survey, Washington, D. C. (Bulletin No. 13, U. S. Department of Agriculture.

is reported in their Bulletin No. 13. These specimens were secured mainly in Iowa, Southern Minnesota and in the Dakotas. The average of 1,083 stomachs of Red-winged blackbirds as presented in the accompanying photograph shows that the food of these birds consists mainly of weed seeds and injurious insects, the proportion of useful insects and of grain being relatively small. During the latter part of April and May some grain is consumed but this is only 10% of their food, the balance being made up almost entirely of injurious insects and weeds. In June the injurious insects are consumed almost to the exclusion of anything else. In the latter half of July and in August 50% of the food is corn, with some small grain. By the first of Octo-

ber the grain constitutes not over 10% of the food, 80% or more consisting of weed seeds. As an average for the entire year it consists of 4.6% corn, 6.3% oats, 2.2% wheat, 8% other grains, making a total of 13.9% of grain food consumed. This must be offset by the weed seeds which constitute 54.6% of the food, and injurious insects, 18.2%.

SCHEDULE 19.

Total averages for the year were as follows:

Grain (Corn 4.6%, Oats 6.3%, Wheat, 2.2%, other grains, .8%)	13.9%
Weed Seed	54.6%
Other vegetable food	4.3%
Injurious Insects	18.2%
Useful Insects	2.5%

From this data it would appear that the common Red-winged blackbirds are not such a nuisance and pest as is sometimes regarded. It may even be said that the Red-winged blackbird is a benefit in crop production.

The analyses of 138 stomachs of Yellow-headed blackbirds, as reported in Bulletin No. 13, Biological Survey, United State Department of Agriculture, show that as an average for April, May, June, July, August, September and October, the months when they are found in this region, they consume much larger numbers of insects than does the Red-winged birds. 33.7% of their food is found to consist of insects with 9.8% corn, 3.5% wheat, 25.6% oats, and 27.1% weed seeds. While the average of all stomachs examined shows that the food consisted of 9.8% corn it will be noted that nearly all of this was found in the month of April. This is a month when these birds are very scarce indeed, while in the month of July, when 72.9% of the food was insects, and in August, when 36% of the food was weed seeds, they are very abundant. It would appear that this species does not consume nearly so much corn as does the Red-winged species, and that of the grain consumed much of it is waste grain picked up from the ground. It will be noted that oats constituted 21.9% in June, 14% in July, 43% in August and 63% in October. This large amount of oats can be accounted for throughout all these months only by crediting these birds with picking up waste grain in the fields and in feed yards and pastures.

A summary of the examination of 138 stomachs of the Yellow-headed blackbird made by the Biological Survey is shown in the following table. (Bulletin No. 13, Dept. of Agriculture).

(Number of stomachs examined: April, 9; May, 31; June, 14; July, 16; August, 60; September, 5; October, 3; total, 138.)

SCHEDULE 20.

Food	Apr.	May	June	July	Aug.	Sept.	Oct.	Aver.
Animal	%	%	%	%	%	%	%	%
Predaceous Beetles -----	2.7	8.0	4.1	4.7	0.1	-----	-----	2.8
Other Beetles -----	3.9	12.6	7.8	7.8	0.7	-----	2.3	5.0
Caterpillars -----	0.1	6.0	4.4	21.5	0.1	-----	-----	4.6
Grasshoppers -----	-----	1.0	0.4	32.0	8.0	15.6	24.3	11.6
Other Insects -----	2.6	5.3	22.6	6.9	0.8	19.0	10.4	9.7
Total Animal Food.....	9.3	32.9	39.4	72.9	9.7	34.6	37.0	33.7
Vegetable								
Corn -----	48.8	9.0	9.7	-----	1.1	-----	-----	9.8
Wheat -----	-----	5.7	3.4	5.8	9.9	-----	-----	3.5
Oats -----	23.8	21.9	12.8	14.4	43.2	-----	63.0	25.6
Weed Seed -----	18.0	30.5	34.0	6.6	36.1	64.4	-----	27.1
Other Vegetable Food.....	-----	-----	0.7	0.3	-----	1.0	-----	0.3
Total Vegetable Food.....	90.7	67.1	60.6	27.1	90.3	65.4	63.0	66.3

In considering the general question of injury to crops by birds attracted as the result of the presence of lakes we are of the opinion that we must not overlook the fact that the open water found in these lakes, as well as the marsh land nearby attracts many other species of birds which have always been recognized as of great value in crop production. These lakes also provide feeding and breeding ground for the various species of game birds which are now becoming so scarce. These game birds require marsh land, rather than the open water found in some of the Iowa lakes.

PART THREE

Report on the vegetation of Iowa's lakes, prepared by Dr. L. H. Pammel, Department of Botany, Iowa State College. Field observations by Messrs. L. H. Pammel, J. L. Seal and L. W. Durrell.

FIG 61—Bulrush (*Scirpus validus*-Vahl). This plant is common in shallow water. It harbors small animal life, which in turn, serves as food for fishes.

CHAPTER ONE---THE VEGETATION OF IOWA LAKES

At the request of the Iowa Highway Commission, an investigation of the vegetation of the Iowa lakes was made by the writers, Mr. J. L. Seal and Mr. L. W. Durrell, during the summers of 1915 and 1916. During the summer of 1915 the following lakes were investigated by the writer and Mr. J. L. Seal: Rush Lake, Pickerel Lake, Storm Lake, East Okoboji Lake, West Okoboji Lake, Gar Lake, Marble Lake, Hottes Lake, Robinson's Lake, Diamond Lake, Center Lake, Swan Lake, Tuttle Lake and Spirit Lake.

During the summer season of 1916, the following lakes and lake beds were studied with reference to the vegetation by L. W. Durrell and the writer: Twin Sister Lakes in Wright County, Cornelia Lake, Mud Lake and Elm Lake in the same county, Eagle Lake and Crystal Lake in Hancock County, Rush Lake in Palo Alto County, Iowa Lake, Tuttle Lake and Swan Lake in Emmet County, Swan Lake bed near Laurens and Cairo or Mud Lake near Jewell Junction.

The writer is especially indebted to Mr. J. L. Seal and Mr. L. W. Durrell for the painstaking care they displayed in carrying on the work. For the photographs he is indebted to Mr. L. W. Durrell, Professor G. B. MacDonald and Mr. J. W. Eichinger. The writer is indebted to Miss Charlotte M. King for making the excellent chart showing the depth of water and the growth of water plants. We wish also to express our appreciation to Mr. R. I. Cratty for his help in a study of the plants of the lakes in Emmet County.

In our investigation, we tried to make a study of the vegetation of the shore lines in the lakes and the plants of the old lake beds which have been drained and are being used for agricultural purposes.

Our study of these lakes was greatly facilitated by the previous studies made by R. I. Cratty¹, B. Shimek², Wylie³, T. J. Fitzpatrick⁴, R. E. Buchanan⁵, J. C. Arthur⁶, C. E. Bessey⁷, A. S. Hitchcock⁸, and the writer⁹.

1. Notes on the aquatic phenogams of Iowa. Bull. Lab. Nat. Hist. State Univ. Iowa 3: 136-152. Flora of Emmet County, Proc. Iowa Acad. sci. 11: 201-251.

2. Notes on Aquatic Plants from Northern Iowa 4: 313-375. The Plant Geography of the Lake Okoboji Region. Bull. Laboratories of Natural History, State University of Iowa, 7: 1-90 pl. 1-8 1 map.

3. The Staminate Flowers of Elodea. Proc. Ia. Acad. Sci. 17: 82. Notes on *Heteranthera dubia*. Proc. Ia. Acad. Sci. 19: 131-132.

4. Manual of Flowering Plants of Iowa. 1899.

5. Notes on Algae of Iowa. Proc. Ia. Acad. sci. 14: 47-84.

6. Contributions to the Flora of Iowa. Charles City 1876. Contributions to the Flora of Iowa. No. 6. Proc. Davenport Acad. Sci. 4: 64-75.

7. Contributions to the Flora of Iowa. Biennial Report Iowa State Agri. College 4: 90-127.

8. A catalogue of the Anthophyta and Pteridophyta of Ames, Iowa. Transactions St. Louis Acad. Sci. 5: 477-532.

9. Notes on the Flora of Western Iowa. Proc. Ia. Acad. Sci. 3: 106-135. A comparative study of the vegetation of swamp, clay and sandstone areas in Western Wisconsin, Southeastern Minnesota, Northeastern, Central, and Southeastern Iowa. Proc. Davenport Acad. Sci. 10: 32-126. f. 1-42.

Shimek and Cratty have given special attention to the aquatic plants of Emmet and Dickinson counties, a region containing more lakes than any other portion of the state. The aquatic plants in other portions of the state are not numerous and many of the species have disappeared. R. I. Cratty, who during his long residence in Emmet county has explored every portion of that county, reports that in many places in that county these plants are less numerous than formerly. The wild rice (*Zizania palustris*) which was abundant in many of the little ponds of that county ten or fifteen years ago and for that matter as far south as Story county, has become a rare plant. It is a most useful species for some of the game birds like the duck. Many of the other aquatic plants like Pond weeds (*Potamogeton*), Wild Celery (*Vallisneria spiralis*) and even the bulrush (*Scirpus validus*) are valuable for fish and wild game.

The number of species of aquatic plants is not large. Emmet and Dickinson counties are more favored than other sections of the state and yet the list of species is not a large one. Cratty lists for northern Iowa only 26 species, Shimek lists 75 species of aquatic seed plants and of plants found in moist situations in the vicinity of the lakes. Thirteen species of pond weeds (*Potamogeton*) occur in the lakes of Emmet and Dickinson counties. These papers do not list many of the species of algae generally called pond scums.

The aquatic plants are distributed in the following families of plants: Cattail family (*Typhaceae*), Burread family (*Sparganaceae*), Pondweed family (*Najadaceae*), Alisma family (*Alismaceae*), Frog's Bit family (*Hydrocharitaceae*), Grass family (*Gramineae*), Sedge family (*Cyperaceae*), Duckweed family (*Lemnaceae*), Pickerel-Weed family (*Pontederiaceae*), Hornwort family (*Ceratophyllaceae*), Water Lily family (*Nymphaeaceae*), Crowfoot family (*Ranunculaceae*), Mustard family (*Cruciferae*), Water Starwort family (*Callitrichaceae*), Loosetrif family (*Lythraceae*), Water Milfoil family (*Haloragidaceae*), Carrot family (*Umbelliferae*), Bladderwort family (*Lentibulariaceae*), Sunflower family (*Compositae*).

The aquatic seed plants occur in water of varying depths. Some on the muddy shores, some in water up to eight feet in depth. Comparatively few species occur in deep water. The following pond weeds occur in water at a depth of eight feet: *Potamogeton Amplifolius*, *P. dimorphus*, *P. natans*, *P. pectinatus*, *P. praelongus*, *Vallisneria Spiralis*. These plants do not show above the surface of the water and while all of these species are fairly abundant, do not render the lakes objectionable. They only occur in the deeper lakes. In water from five to seven feet deep the following species are common: *Potamogeton americanus*, *P. Friesii*, *P. pusil-*

lus, P. Richardsonii, Zannichellia palustris, Elodea Iowensis, Ceratophyllum demersum.

In water having a depth of three to five feet the following species occur: *Elodea Canadense*, *Nymphaea advena*, *Castalia tuberosa*, *Ranunculus sylvestris*, *Callitriche palustris*, *Myriophyllum spicatum*, *Bidens Beckii*.

In water having a depth of one to three feet, the following plants are common: *Sagittaria latifolia*, *S. arifolia*, *Echinodorus cordifolium*, *Alisma Plantago*-var. *americana*, *Phragmites communis*, *Glyceria nervata*, *G. grandis*, *Eleocharis acicularis*, *E. ovalis*, *E. Palustris*, *Scirpus Fluvialis*, *S. validus*, *Cares filiaformis*, *Spirodela polyrrhyza*, *Lythrum alatum*, *Bidens cernua*, *Cicuta bulbifera*.

The general character of the vegetation may be gleaned from the accompanying plate.

It will be noted from this that only five species of water plants grow in water from eight to ten feet deep. These all belong to the genus *Potamogeton*. Sixteen species grow in water from five to seven feet deep. Twenty-five species of plants were found in water from three to five feet deep. Forty-three species thrive in water from one to three feet deep.

By increasing the depth of the water in the lakes, nearly all of the plants generally considered injurious will be eliminated. The common bulrush will be confined to a few of the shallow places on the margins of the lake. East and West Okoboji lakes, Gar lake and other lakes connected with this chain of lakes in Dickinson county are well known and are visited by a large number of people. No one would think of draining any of these lakes even if such a thing were possible. The only objectionable feature found is in the blue green scum (*Rivularia*) and other algae, which occurs in great quantities during the summer. The small bays will continue to produce some rushes (*Scirpus validus*) and Arrowhead (*Sagittaria*), etc., etc. Such conditions are unavoidable and occur in all fresh bodies of water. East Okoboji is, however, shallow. The Arrowhead (*Sagittaria variabilis*) and bulrush (*Scirpus validus*), Water Lily (*Castalia tuberosa*) and Pond Weeds (*Potamogeton*) will always grow in shallow places in these lakes. Much can be done to remove them by cutting them off with a water mower.

It should, however, be borne in mind that these rushes, pond weed, wild celery (*Vallisneria spiralis*), etc., serve an excellent purpose in giving food to small crustacea that serve as food for fishes.

The rush, moreover, is used by muskrats to build their winter quarters, and if we desire to have muskrats, these beds should be preserved in part at least.

Crops on the Old Lake Beds.

As to the growing of crops on the drained lake beds, it may be said that the growing of cereals (except corn some years) has not been a great success. Corn crops were seen on Swan Lake near Laurens and old Mud Lake near Jewell. The corn fields in both cases were very weedy. No doubt this was due to the newness of the land. The corn on the old Cairo Lake bed was very late. It is probable that in the course of time and with more thorough drainage, better crops can be produced. Some excel-

[illegible]

FIG. 62.—Chart showing the depth of water in which the plants, common to Iowa's lakes, thrive.

CHART SHOWING PLANTS IN LAKES

Plants	Common Name	Marsh	Depth of Water			
			1-3	3-5	5-7	7-10
<i>Typhaceae</i>						
<i>Typha latifolia</i>	Cattail					
<i>Sporangaceae</i>						
<i>Sporangium americanum</i>	Bur-reed					
<i>eurycomum</i>						
<i>simplex</i>						
<i>Najasceae</i>						
<i>Potamogeton americanus</i>	Pondweed					
<i>amphifolius</i>						
<i>dimorphus</i>						
<i>epiphydus</i>						
<i>Friesii</i>						
<i>foliosus</i>						
<i>heterophyllus</i>						
<i>natans</i>						
<i>pectinatus</i>						
<i>prolongus</i>						
<i>pustillus</i>						
<i>Richardsonii</i>						
<i>zosterifolius</i>						
<i>Sagittaria palustris</i>	Horned Pondweed					
<i>Angia flexilis</i>	Najas					
<i>Alismaceae</i>						
<i>Sagittaria arifolia</i>	Arrow-leaf					
<i>latifolia</i>						
<i>Eichnadorus cordifolius</i>						
<i>Alisma plantago-aquatica</i>	Water-plantain					
<i>Hydrocharitaceae</i>						
<i>Elodea canadensis</i>	Water-weed					
<i>Elodea lawansis</i>						
<i>Valisneria spiralis</i>	Eel-Grass					
<i>Gramineae</i>						
<i>Phragmites communis</i>	Reed Grass					
<i>Glyceria nervata</i>	Manna Grass					
<i>grandis</i>						
<i>Cyperaceae</i>						
<i>Eleocharis acicularia</i>	Spike-rush					
<i>ovata</i>						
<i>palustris</i>						
<i>virginis</i>						
<i>Wolffii</i>						
<i>Scirpus fluviatilis</i>	Greater Bulrush					
<i>validus</i>	Bulrush					
<i>Carex comosa</i>	Sedge					
<i>riparia</i>						
<i>lanuginosa</i>						
<i>filiformis</i>						
<i>stipata</i>						
<i>Lemnaceae</i>						
<i>Spirodela polyrrhiza</i>						
<i>Lemna insulula</i>	Duck-weed					
<i>Wolffia punctata</i>						
<i>Pontederiaceae</i>						
<i>Heteranthera dubia</i>	Mud plantain					
<i>Iridaceae</i>						
<i>Iris versicolor</i>	Blue Flag					
<i>Ceratophyllaceae</i>						
<i>Ceratophyllum demersum</i>	Horn-Wort					
<i>Nymphaeaceae</i>						
<i>Nymphaea advena</i>	Gow Lily					
<i>Costaria tuberosa</i>	Water Lily					
<i>Ranunculaceae</i>						
<i>Ranunculus aquatilis-capillaceus w</i>	Water Crowfoot					
<i>scleranthus</i>	Cursed Crowfoot					
<i>Callitha palustris</i>	Marsh Marigold					
<i>Cuscutaceae</i>						
<i>Scutellaria bulbosa</i>	Spring Grass					
<i>Psycula palustris</i>	Marsh Grass					
<i>Callitricheaceae</i>						
<i>Callitriche palustris</i>	Water Starwort					
<i>Lythraceae</i>						
<i>Lythrum alatum</i>	Loose Strife					
<i>Cistaceae</i>						
<i>Ludwigia polycarpa</i>	False Loose Strife					
<i>Epilobium adnascens</i>	Fireweed					
<i>Myriophyllaceae</i>						
<i>Myriophyllum spicatum</i>	Watermilfoil					
<i>Umbelliferae</i>						
<i>Cicuta bulbifera</i>	Water hemlock					
<i>miculata</i>	Cowbane					
<i>Sium cicutaefolium</i>	Water parsnip					
<i>Lentibulariaceae</i>						
<i>Utricularia vulgaris Amer</i>	Bladder-wort					
<i>Compositae</i>						
<i>Bidens Beckii</i>	Sticktight					
<i>cernua</i>	Boobyach					
<i>Senecio palustris</i>	Squaw-weed					

FIG. 63—Chart showing the depth of water in which the plants, common to Iowa's lakes, thrive.

	Five to Seven				Eight to Ten			
Potamogeton americanus	1	1	1	1	5	5		
P. amplifolius	1	1	1					
P. dimorphus	1	1	5					
P. fresii	1	1	5		1			
P. foliosus	1	1	5					
P. natans	1	1	5					
P. pedunculatus	1	1	5	1	5	5		
P. praelongus	1	1	5					
P. pusillus	1	1	5		1	5		
P. Richardsonii	1	1	5	1				
P. zosteraefolius	1	1	5	1	1	5		
Zannichellia palustris	1	1	5					
Elodea Iowaensis	1	1	5					
Vallisneria spiralis	1	1	5					
Ceratophyllum demersum	1	1	5	1	1	5

FIG. 63—Pondweed (*Potamogeton natans*). One of the pondweeds found floating on the water surface in many of the Iowa lakes.

lent clover and grass were produced on Mud Lake near Jewell and also some good potatoes.

In 1914 Swan Lake near Laurens was covered with weeds and a large number of young almond leaved willow. These willows were easily killed. Hon. J. H. Allen in a letter of recent date, states that the lake was drained during the years 1912 and 1913 with a large drainage ditch. The first crop of corn was raised in 1914, but this was put in late. An early variety was used. The crop made about forty-five bushels to the acre. In 1915 the frost killed the crop. This year, 1916, the crop is corn and is about an average.

In both of the old lake beds there was found a great abundance of water hemp (*Acnida Tuberculata*) small ragweed (*Ambrosia artemisiifolia*), Spanish needle (*Bidens frondosa* and *B. discoidea*). These weeds greatly reduce the crop yield.

The reports made by L. W. Durrell and J. L. Seal are incorporated with the observations we made on some of the lakes.

Our studies at the lakes bring out the fact that the vegetation occurs in zones and that different aquatic plants occur in different depths of water. For instance, near the shore, where the water is shallow, from one to three feet deep, such plants as cattail, rush, arrowhead, and water lily occur. Where the water is shallow as in Rush lake, most of the lake contains rushes, cattails, and some pond lilies. Where, however, the depth of the water is from four to six feet, the rushes disappear and the water is fairly clear.

The photographs accompanying the report will show the nature of the vegetation.

It seemed to us important to make a study of the groves along the shore lines, if these lakes are to be used for recreation purposes. For a few of these lakes we have indicated the abundance of the tree species.

Storm Lake, Buena Vista County.

Storm Lake is an illustration of what can be done by protection. It is a beautiful sheet of water lying just south of the city of Storm Lake, and is used and enjoyed by the people of that city and vicinity. A dam at the outlet has been built high enough to hold back the flood waters and has increased the depth of the water several feet. At the time of our visit in July, 1915, we found scarcely any water plants except in a few of the bays and near the shore close to the city. The common rush, except as noted above, was almost entirely absent. No one in the vicinity of Storm Lake would consider draining this lake. It is regarded as an asset to the community.

Pickerel Lake, Palo Alto County.

This small lake has been preserved through the efforts of the people of Palo Alto and Buena Vista counties who have built a low dam at the outlet. This little dam has increased the depth of the water several feet. At the time of our visit, July, 1915, we observed a few rushes on the margin. The water contained large numbers of pond weeds (*Patamogeton* and *Najas*) and algae like *Spirogyra* and *Chara*. Because of the warm

weather these algae were abundant. Their growth cannot be prevented in deep water. Such algae are objectionable only for a very short season. The action of the waves destroys them. This lake has the advantage of a fine grove consisting of bass wood, slippery elm and bur oak, which is much used by the people of the surrounding country as a picnic ground.

FIG. 64—Rush Lake, Palo Alto County. Typical growth of Greater Bulrush (*scirpus fluviatilis*).

FIG. 65—Rush Lake, Palo Alto County. This photograph shows typical growth of cat tails, one of the most common varieties of vegetation in the Iowa lakes and marshes.

Rush Lake in Palo Alto County.

There has been much discussion in regard to the drainage of Rush Lake. The water level was lowered some years ago by a ditch cut through a natural dike, consequently much of the lake during our visit in 1915, and Mr. Durrell's visit in July, 1916, was covered with water plants, the rush predominating. The depth of the lake varies from one to five feet. The bottom is made up of black mud and decaying plants. The Greater Bulrush (*Scirpus fluviatilis*) is abundant and with it occur the bladderwort (*Utricularia vulgaris*) and some pond weed (*Potamogeton pectinatus*). The latter grows not only with the rush but in the open pools. In one place the water in the lake is open and practically no water plants are to be seen.

A portion of the land adjacent to the lake is used for pasture. The shores are covered with arrowhead (*Sagittaria latifolia*), sweet calomel (*Acorus calamus*), Cattail (*Typha latifolia*) Duckweed (*Lemna minor*), Bluejoint grass (*Calamagrostis canadensis*), Iris (*Iris versicolor*) and sedge.

The banks are low and very few trees occur except that the west shore has a narrow belt of timber.

The Lakes of Wright County.

The lakes investigated are Twin Sisters Lake, Mud Lake, Cornelia Lake and Elm Lake. The Twin Sisters Lake near the city of Belmond varies in depth from two to four feet. The base consists of gravel and clay. The shore line is grassy with the exception of a few clumps of trees on the south and north banks. This lake is nearly free from vegetation except some rushes near the shore line. The pond southeast and separated from the larger body of water by a low ridge is filled with plants, mostly Cattail (*Typha latifolia*), Greater Bulrush (*Scirpus fluviatilis*), Duckweed (*Lemna minor*) and different kinds of algae.

Cornelia Lake near the town of the same name, has water varying in depth from five to seven feet. The bottom is sand but covered with peat from one to three feet in depth. The shores are conspicuously terraced. At one time, according to an old resident, the lake was filled up to the highest terrace. About fifteen years ago the entire body of water dried up and the lake bed was planted to corn. The next fall the bed again became filled with water, since then it has remained at the same level. The shore line is sandy or a sandy loam. There is a sparse fringe of willows, ash and some poplar on the southwest and northeast shore. The entire lake is filled with plants, the rush up to 150 feet of the shore, the water lily (*Castalia tuberosa*) and Spatter dock (*Nymphaea advena*) from three hundred to six hundred feet from the shore. The center of the lake is filled with pond weeds (*Potamogeton*) and algae-like Chara are abundant.

South of Cornelia near the line of the C. & G. W. R. R. is a small lake of some 2,000 feet long by 1,000 feet wide to which the name of Mud Lake was given by local people. The water is shallow. Mr. L. W. Durrell, at the time of his visit in July, found that it was grown over with Bulrush (*Scirpus validus*) and Marsh smartweed (*Polygonum Muhlen-*

bergii). On the margin of the lake the last named plant occurs in shallow water. The various duckweeds were common wherever the rushes and cattails occurred, not, however, in deep water. Mr. Durrell noticed, as in some other cases, that where cattle had access to the lake the rushes and other aquatic vegetation was destroyed. The fence in the picture divides the pasture from the unpastured areas in the lake. It was also found that the small inlets of the lake were green with various algae, *Spirogyra*, *Cladophora*. The blue green algae (*Rivularia*) was common as in many other lakes causing the so-called "working of the lakes."

Elm Lake, which is considerably larger than the other adjacent lakes, has water to a depth of four to six feet. It is fairly free from rush, except a fringe near the shore line. Further towards the interior there

FIG. 66—Eagle Lake, Hancock County. These two views show typical growth of rushes and arrowhead in the Iowa lakes and marshes.

is a bed of water lily (*Castalia*) and Spatter dock (*Nymphaea*). By increasing the depth of this lake another foot, the rush would practically disappear.

The Lakes of Hancock County.

Eagle Lake, situated about four miles from Britt, is about four miles long by two miles wide, and a rather shallow lake. The greatest depth is about four feet. The bottom is peat resting on clay. Water plants are plentiful. There is an abundance of bulrush (*Scirpus validus*) as in other lakes of this character, scattered in patches over the entire lake. The Greater Bulrush (*Scirpus fluviatilis*) and Cattail (*Typha latifolia*) are common on the margins. The plants are intermingled with Bur-reed (*Sparganium eurycarpum*) and patches of arrowhead (*Sagittaria variabilis* and *S. arifolia*) and some wild rice (*Zizania palustris*). The Water plantain (*Alisma Plantago* var. *Americana*) and Iris (*Iris versi-*

FIG. 67—Eagle Lake, Hancock County. Three views showing vegetation in the lake.

color) occur on the shore. The stone root (*Chara*), pondweeds (*Najas flexilis*), *Potamogeton* were distributed with the other water plants. The little pools on the shore were covered with duckweed (*Wolffia columbiana*) and *Lemna trisulca* and *Spirodela polyrrhiza*. Interesting successions and zonal distribution were noted from the shore to the open water. On the shore sedges, plants of marshes Slough grass (*Spartina Michauxiana*) were found in the mud, Water plantain (*Alisma Plantago* var. *Americana*) then Bluejoint grass (*Colamagrostis canadensis* var. *acuminata*) followed by wild rice (*Zizania palustris*) occurred. The arrowheads (*Sagittaria*), Iris (*Iris versicolor*) and Ber reed (*Sparganium eurycarpum*)

FIG. 68—Crystal Lake, Hancock County. Upper view shows heavily timbered banks. Lower view shows a bed of arrowhead on a bar.

grew in shallow water. In deep water the rush (*Scirpus validus*), Pond weeds (*Potamogeton*) followed by pond weeds (*Potamogeton* and *Najas*), Water lily (*Castalia tuberosa*) and Spatterdock (*Nymphaea advena*) flourished. A low wooded ridge separates Eagle Lake from Wood Lake. This lake is little more than a marsh. Here occurred many of the plants found on the shore line of Eagle Lake. One of the most conspicuous plants is the Greater Bulrush (*Scirpus fluviatilis*).

Crystal Lake, about twelve miles north of Eagle Lake, is a clear body

of water. The depth varies, but in some places it is seven feet deep. The bottom is much like Eagle Lake, the depth of the water prevents many of the plants from growing. Clumps of *Sagittaria* and *Scirpus* occur on the shallow southeast shore. Near these many floating algae were found. A portion of the shore line is well wooded.

Lakes of Emmet County.

These lakes were visited during the latter part of August by Mr. R. I. Cratty, Mr. L. W. Durrell and the writer. Under this head we will include Silver Lake, Minnesota, just across the line in Minnesota. This is a clear body of water with a depth in some places, of thirty feet. It has splendid shore lines which are well wooded. Many people from Iowa visit this lake, some owning cottages on the shore. Only in a few places where the water was shallow did we observe aquatic plants like the bulrush (*Scirpus validus*). On the sandy and moist shores *Alisma Plantago* var. *Americana* *Sagittaria variabilis*, *Eleocharis acicularis* and *E. intermedia* occur. The pine groves on the shore line undoubtedly are one of the lake's most attractive features. The distribution of the trees found on the shores is as follows:

SCHEDULE TWENTY-ONE.

Percentage of Trees Found on Shores of Silver Lake.

	South Shore	East Shore	Bottom
<i>Quercus macrocarpa</i> (Bur Oak).....	15.1	18.6	0.0
<i>Juglans nigra</i> (Black Walnut).....	2.1	2.9	9.4
<i>Tilia americana</i> (Basswood).....	21.5	12.8	4.7
<i>Crataegus mollis</i> (Red Haw).....	2.2	1.0	4.7
<i>Celtis occidentalis</i> (Hackberry).....	4.3	1.0	12.6
<i>Ulmus fulva</i> (Slippery Elm).....	12.9	5.9	9.2
<i>Fraxinus Pennsylvania</i> var. <i>lanceolata</i> (Green Ash).....	27.9	27.4	27.5
<i>Acer saccharinum</i> (Soft Maple).....	6.4	2.9	4.7
<i>Prunus virginiana</i> (Choke Cherry).....	0.0	2.0	0.0
<i>Fraxinus Pennsylvanica</i> (Red Ash).....	2.4	3.9	0.0
<i>Ulmus americana</i> (American Elm).....	0.0	7.8	9.4
<i>Populus deltoides</i> (Cottonwood).....	2.5	1.4	4.7
<i>Juniperus virginiana</i> (Red Cedar).....	0.0	1.0	0.0
<i>Salix amygdaloides</i> (Almond leaved willow).....	2.7	1.6	13.1
<i>Hicoria glabra</i> (Pignut).....	0.0	1.0	0.0
<i>Ostrya virginiana</i> (Ironwood).....	0.0	8.8	0.0

Iowa Lake, a part of which lies in Minnesota, is a shallow lake, but the depth of water can easily be increased. The greatest depth of water is about six feet. Even with the present depth few aquatic plants were seen above the water. In a few places on the shore the bulrush (*Scirpus validus*) was observed. A marsh situated south of the lake is covered with the Greater Bulrush (*Scirpus fluviatilis*), some Cattail (*Typha latifolia*) and Bur reed (*Sparganium eurycarpum*). The vegetation there is essentially the Great Bulrush. Iowa Lake has splendid shore lines and rather steep banks. Some of the interesting shrubs occurring here are the Red osier (*Cornus stolonifera*) and dogwood (*C. Amonum*). The former dogwood is not common in Iowa. Poison Ivy and Sumach are also found.

FIG. 69—Iowa Lake, Emmet County. Typical red cedar tree which is to be found in considerable numbers in the vicinity of this beautiful Iowa lake.

Along the southern shore is a low sandy ridge about thirty inches high which was pushed up by the ice. The trees and shrubs on the shore are a haven for birds. The birds have scattered various plants along the fences in the immediate vicinity. Plants observed on such places were the hackberry, dogwood, elder, and wild grape. The following trees were observed on the shores of Iowa Lake:

SCHEDULE TWENTY-TWO.

Percentage of Trees on Shores of Iowa Lake.

Name of Tree	East Shore Bottom and Beach	East Shore Low Ground	West Shore
<i>Salix amygdaloides</i> (Peach leaved willow).....	42.0	1.0	28.7
<i>Ulmus fulva</i> (Slippery Elm).....	0.0	0.0	15.0
<i>Quercus macrocarpa</i> (Bur Oak).....	0.0	1.8	10.0
<i>Populus deltoides</i> (Cottonwood).....	21.0	5.4	0.0
<i>Talia americana</i> (Basswood).....	0.0	0.0	15.0
<i>Ulmus americana</i> (American Elm).....	12.0	25.2	5.0
<i>Fraxinus Pennsylvanica</i> (Green Ash var. lance- olata).....	13.0	19.8	15.0
<i>Fraxinus Pennsylvanica</i> (Red Ash).....	0.0	1.8	0.0
<i>Crataegus mollis</i> (Haw).....	6.0	0.0	0.0
<i>Celtis occidentalis</i> (Hackberry).....	6.0	34.2	5.0
<i>Prunus americana</i> (Plum).....	0.0	5.4	3.5
<i>Prunus virginiana</i> (Choke Cherry).....	0.0	5.4	0.0
<i>Acer nigrum</i> (Hard Maple).....	0.0	0.0	2.8

It will be seen from these notes of the trees and the shores of Iowa Lake that the wooded areas not only protect the bird life, but that there are many places where the people of the vicinity may find comfort on the hot days of summer.

Tuttle Lake, only a small part of which is in Emmet County, is a shallow body of water covering a considerable area. An ice floe occurs on the

FIG. 70—Arrowhead (*Sagi. Haria latifolia* Wiled). Grows in very shallow water around the margin of Iowa lakes.

south shore. The beach is sandy. At the time of our visit, but little water was passing out of the lake. We found it an easy matter to cross the stream. The lake at this time was also quite free from vegetation. In a few places some rushes grew in the water and cattails near the shore line. Much of the shore line is free from trees and shrubs. Among the shrubs we noted dogwood (*Cornus stolonifera* and *C. Amonum*), Snow-berry (*Symphoricarpos occidentalis*), Poison Ivy (*Rhus Toxicodendrum*), False Indigo (*Amorpha fruticosa*), Sandbar Willow (*Salix fluviatilis*), Moonseed (*Menispermum candense*), Black Currant (*Ribes floridum*) and

FIG. 71—Group of Red Cedar trees planted by birds near Iowa Lake, Emmet County. Views show the well wooded shores on this lake.

wild grape (*Vitis vulpina*). Forest trees occur in a narrow belt on the shore. On the south shore the belt is somewhat wider and covers a larger area. This timber belt follows the course of the Des Moines River for a short distance. Beyond the influence of the lake very few trees occur. The following table gives the percentage of trees on the south shore of the lake.

FIG. 72—Hackberry, dogweed, grape, poison ivy, and Virginia creeper planted by birds along a fence south of Iowa Lake, Emmet County.

FIG. 73—West Swan Lake, Emmet County. Upper view shows a bay covered with reddish algae sphaerella. Lower view shows stream at outlet.

SCHEDULE TWENTY-THREE.

Percentage of Trees South Shore Tuttle Lake.

Name of Species		Name of Species	
Ulmus americana (American Elm)	14.9	Salix cordata (Pussy Willow)	8.0
Fraxinus Pennsylvanica var. lanceolata (Green Ash)....	16.6	Celtis occidentalis (Hackberry)	9.2
Fraxinus Pennsylvanica (Red Ash)	3.2	Salix amygdaloides (Peach leaved willow)	15.3
Prunus americana (American Plum)	10.6	Crataegus mollis (Red Haw)..	2.5
		Populus deltoides (Cottonwood)	19.7

Swan Lake in Emmet County, with its well wooded shores and high banks, is a beautiful body of water. The North bay is separated from a swamp of considerable size in which the most conspicuous plant was the

FIG. 74—A large black walnut tree on the shore of West Swan Lake in Emmet County. Mr. R. I. Cratty standing alongside gives an idea of the size attained by the tree.

Greater Bulrush (*Scirpus fluvialis*) from three to five feet tall. The small bay next to this embankment contains a great many of the Bulrush (*Scirpus validus*), some pond weeds and bladderwort. The floating plants consisted of Duckweed (*Lemna and Spirodela*) and some algae. By increasing the depth of the water one foot, most of the rush would dis-

appear. The lake otherwise was fairly free from aquatic vegetation, except the east bay where the rush and burreed occurred in considerable quantity. The muddy shores were lined with a red alga (*Sphaerella*) which imparted to the water a red color. The more important shrubs found here were dogwood (*Cornus stolonifera* C. Amonum C. asperifolia), Currant (*ribes floridum*), Poison Ivy (*Rhus Toxicodendrum*), Sumach (*rhus glabra*), Hazlenut (*Corylus americana*) and snowberry (*Symphoricarpos occidentalis*).

SCHEDULE 24.

Percentage of Trees Near Swan Lake, Emmet Co.

Name of Species	Northeast Shore	Flat N. E. Shore of Lake
<i>Quercus macrocarpa</i> (Bur Oak).....	8.1	11.8
<i>Ulmus fulva</i> (Slippery Elm).....	4.5	7.3
<i>Fraxinus Pennsylvanica</i> var. <i>lanceolata</i> (Green Ash).....	10.5	6.2
<i>Fraxinus Pennsylvanica</i> (Red Ash).....	1.5	0.0
<i>Tilia americana</i> (Basswood).....	27.0	2.3
<i>Ostrya virginica</i> (Ironwood).....	15.8	0.0
<i>Ulmus americana</i> (American Elm).....	7.5	5.6
<i>Prunus virginica</i> (Choke Cherry).....	2.2	26.0
<i>Acer negundo</i> (Box Elder).....	0.0	5.6
<i>Salix amygdaloides</i> (Peach Leaved Willow).....	4.3	0.0
<i>Populus deltoides</i> (Cottonwood).....	6.8	0.0
<i>Salix cordifolia</i> (Pussy Willow).....	4.5	0.0
<i>Celtis occidentalis</i> (Hackberry).....	2.7	5.0
<i>Prunus serotina</i> (Blackberry).....	0.7	0.0
<i>Prunus americana</i> (American Plum).....	3.9	2.8
<i>Juglans nigra</i> (Walnut).....	0.0	23.5
<i>Crataegus mollis</i> (Red Haw).....	0.0	3.4
<i>Crataegus punctata</i> (Haw).....	0.0	0.5

Worth County Lakes.

Silver Lake, which is located in Worth County, has splendid shores varying in height from six to fifteen feet. Along the low south shore is a bank two to three feet high pushed up by the ice.

The prevailing trees on the east and south shores are bur oak (*Quercus macrocarpa*), Quaking ash (*Populus tremuloides*) and Iron wood (*Ostrya virginiana*), while on the banks next to the water, peach leaved willow (*Salix amygdaloides*) abound. Other trees found on the lake are *Quercus*, cottonwood (*populus deltoides*), basswood (*Tilia americana*), hackberry (*Celtis occidentalis*), slippery elm (*Ulmus fulva*), and American Elm (*Ulmus americana*), red ash (*Fraxinus pennsylvanica*) and green ash (*Fraxinus pennsylvanica* var. *lanceolata*.)

The bottom of the lake consists of sand and loam, with some peat. The lake as a whole is free from vegetation. There are a few patches off rush (*Scirpus validus*) and Arrowhead (*Sagittaria latifolia*). On the south shore these plants, especially the rush extend out about fifty feet. On the southwestern shore these plants cover a large area, extending out into a spit for about a hundred and fifty feet. At this point wild rice (*Zizania palustris*) is abundant and associated with it Blueflag (*Iris versicolor*), smartweed (*Polygonum Hartwrightii*) and duckweed (*Spirodela polyrrhyza*).

CHAPTER TWO---CONCLUSIONS

The writer is convinced from his observation and the studies made by Messrs. Seal and Durrel that the objectionable feature of all the lakes can be prevented by increasing the depth of the water from one to three feet. The tables showing the depth of water in which certain plants grow point out in a striking manner how rushes can be eliminated. Some land now used for pasture purposes no doubt will be covered by increasing the depth of the water but the state can well afford to purchase such lands.

The trees on the shore lines of the lakes are important from the standpoint of recreation. Their presence on the shores makes the lakes

FIG. 75—Silver Lake, Worth County. Upper view shows plant life in the west end of the lake. Lower view shows ice-formed bank on the south shore.

much more desirable for summer cottages and for picnic grounds. Few of the lakes in Iowa are completely surrounded by trees, which seem only to have found a footing in the more favorable situations. Silver Lake across the border in Minnesota presents a good illustration of a lake with well timbered banks.

FIG. 76—Silver Lake, Worth County. Three views showing the heavily wooded shores and plant life along the waters edge of this lake.

FIG. 77—Wild Rice L. (*Zizania palustris*). This plant grows in shallow water. It forms a valuable food for water fowl. It could easily be planted in many of the more shallow lakes.

FIG. 78—Pondweed (*Potamogeton zosterifolius* Schum.). This plant is rather common in the deeper Iowa lakes and marshes.

FIG. 79—Greater Bulrush (*Scirpus fluviatilis*-Torr), Grey. This plant is very common on the more shallow Iowa lakes and marshes.

The tables showing percentage of trees illustrates the manner in which nature covers the shore lines. It will be seen that the trees are such as are common in other parts of the state. Around Swan Lake there were some usually good sized black walnuts, hackberry and bur oak, and these same varieties can doubtless be induced to grow at the other lakes.

The groves on the lake shores should sooner or later become the property of the state or county by purchase. The value of such places can hardly be estimated in dollars and cents. People will come to these groves and the lakes from the surrounding country. Silver Lake across the line in Minnesota draws hundreds of Iowa tourists. The water saw autos by the dozens going to this one lake during the past summer. There is no question but that the demand for outing places is a real one, and one moreover which is growing.

No difficulty should be encountered in replanting some of the more desirable water plants such as the wild rice. Nor would the cost of thus providing feeding grounds for wild fowl be great.

The drained beds of Swan Lake and Mud Lake in Hamilton county have produced some good crops of potatoes, grass and corn for silage. In some years corn has ripened. Their value as agricultural land, however, is small as compared to that which they would have had either as places of amusement, or as reservoirs for holding back the flood waters in the spring.

PART FOUR

A REPORT ON THE POSSIBILITIES OF IMPROVING IOWA'S
LAKE SHORES BY FORESTATION.

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CHAPTER ONE---POSSIBILITIES OF FORESTATION WORK ABOUT THE IOWA LAKES

Lakes with forested shores are a big asset in any state. They not only furnish places of recreation for the people of the immediate locality but they also attract many visitors from other localities, as well as great numbers from other states. Minnesota has been more richly endowed with timbered lakes, and, according to the State Forester, draws thousands of people annually from Iowa, Nebraska, the Dakotas, and

FIG. 80—Small patch of native timber along the shore of Little Wall Lake. A great variety of trees is represented in this small clump. The list includes willow, cottonwood, bur oak, hickory, box elder, haw and black cherry. The most valuable timber in this location has been cut. Bur oak stumps 20 inches in diameter are to be found. These trees were apparently cut some fifty years ago. They were probably several hundred years old. The planting of a large number of tree species could be successfully done around Little Wall Lake.

Wisconsin. These thousands spend from a few days to several months in summer homes or camps on the timbered shores of her numerous lakes.

Some of the Minnesota lakes are controlled by the state (the lakes of Itasca State Park) or by the Federal Government (Cass Lake). The lakes are well cared for, timbered camp sites are available, fishing is good, and the people find at these lakes, places for invigorating recreation, free from the undesirable features to be found on many lakes where the frontage is privately owned.

Although Iowa has few lakes with large bodies of timber covering their shores, yet a slight estimate of the appreciation of such lakes by

FIG. 81—This photograph shows the forested shore of one of Minnesota's beautiful lakes. This lake and the surrounding country are under the control of the United States Forest Service. Thousands of people frequent the lake annually. The Government provides for the proper protection and maintenance of the shore line.

FIG. 82—The forested slopes bordering the lakes always serve as an attractive place for students. Reforestation work about the lakes would make these shores even more attractive by the adding of a large number of tree species.

the people, may be gained by observation of the extent to which Lake Okoboji is used during the summer months for recreational purposes.

Iowa lakes, with proper surroundings, the waters stocked with fish

FIG. 83—The forested shores of the lakes often serve as an outdoor laboratory for the use of students for educational purposes. The students of a forestry school in camp adjoining one of Minnesota's numerous lakes.

and the shores controlled by the State, will equal in beauty and usefulness the much sought lakes of other states.

Improvement by Reforestation.

From the standpoint of usefulness to the public, lakes with bare shores are of little value for recreation. Aside from boating and fishing, little benefit comes to the people. The lakes of the State which are most frequented by the people are those which have some timber on their shores. Campers and cottage builders seldom select a treeless lake for their recreation grounds.

The people of Iowa are beginning to realize that attractive forest parks and lakes are a real asset to the State. If Iowa had adequate pleasure grounds, many of our summer tourists would remain at home instead of seeking recreation elsewhere. The average citizen feels the need of getting away from the humdrum of life and finds it profitable to spend a week or more in the forest or at some lake.

It is unfortunate that provision for the retention of most of the lake shores, for the use of the public, was not made years ago when the work could have been accomplished much easier and at much less expense. Even now the State can do much toward providing woodland parks and beautiful lakes. Although this cannot be accomplished in a year's time nor in ten years' time, a start can be made which will bring gratifying results.

FIG. 84—Planted grove of European larch about thirty-five years old. In a close stand, such as is shown in the picture, the European larch grows straight and tall. When spaced more openly the tree takes on a more beautiful conical form. The tree makes a thrifty growth on most slopes. Most of the trees are 60 to 85 feet tall.

Purposes of Forestation Works About the Lakes.

The work of forestation about Iowa's lakes will serve the following purposes:

Places of recreation will be made available for the people. The bare shores of the lakes can be forested much faster than is commonly believed. By the use of proper species of trees, good results can be secured in a short period of years. In certain instances at least it will be most profitable to plant quick-growing trees—this planting to be supplemented with more permanent varieties which are generally slower in growth. As an illustration of what can be accomplished in a

FIG. 85—A steep bank along the east shore of North Twin Lake. The scattering growth of trees at this point were not sufficient to protect the bank from erosion. A deep gully has already been cut out through the action of the water. A cultivated field extends up to within a few feet of this bank. Unless this erosion is checked, it will only be a few years until the gullies have eaten their way to a considerable distance back from the shore line. The planting of suitable species of trees would not only check erosion but would beautify the shore line for recreational purposes.

short time, the following is interesting: A small area of Carolina poplar trees, set out by the Agricultural Experiment Station in 1909, when measured in 1916, showed that many of the trees had reached a height of between 40 and 50 feet.

The improved lands about the lakes, if purchased by the state, counties or municipalities, would serve as nuclei for the State, county or municipal forest parks, which are needed in every portion of the State. The coming of the automobile and good roads has made it possible for the average family to go to a considerable distance for a day's recreation.

Forested lands about the lakes could well serve as game and bird preserves, and assist in the better protection of our wild life.

The planted lands adjoining the lakes could be made to produce a substantial revenue, in time, from the sale of old tim-

ber from trees which are no longer needed. This matter of having the forest serve both for recreational purposes and for the production of timber for the market is not new. In European countries it is the common practice. Municipal forests in Switzerland and Germany, in addition to providing a play ground for the people bring in a net revenue of from \$5.00 to \$12.00 per acre each year from the sale of their timber. This sum, in some cases, is sufficient to pay the entire city taxes for the people.

Another purpose of forestation work is the protection of

FIG. 86—A strip of shore line along Blue Lake, in Monona County. At this point the sand has blown out to a depth of nearly 10 feet, as shown by the exposed roots on the cottonwood tree. These shifting sands have apparently filled in portions of Blue Lake. Approximately 400 acres of land of this character between the two arms of the lake could be purchased at a very small price and planted to trees. This would form the basis for a forest park, which is very much needed in this locality.

steep banks from erosion and the resultant filling in of the lakes.

Where the Reforestation Work Should Start.

The tree planting about the lakes should be done in different localities, so far as practicable, in order that as many people as possible may be benefited.

In general, if extensive work of this character is attempted, it will probably be desirable to start on those lakes where the work can be carried on with the least expense to the State.

The following procedure is suggested:

First improve the lands which are now owned by the state. This would include certain areas within meander lines, and possibly some lake beds which are drained and retained by the State.

The second class of lands along the lakes, which should be planted, are the sandy waste areas with little or no agricultural value, which might be purchased at a very small cost. Such lands in certain instances are now a menace to the adjoining lakes through the shifting of the sands. (Blue Lake in Monona County). This class might also include overflowed areas or swampy lands which might be put into condition for tree growth at a small expense.

Next for consideration should be those lakes where there is considerable local interest now in evidence for the improve-

FIG. 87—The forested shore of Spirit Lake, Iowa, showing an area which is privately owned. It is not an uncommon sight in Iowa to see live stock in a lake and doing damage to the banks and tree growth adjoining. If the lake borders were owned by the state, this nuisance could be done away with, and the lake shores made more attractive for the recreation of the people.

ment of the shores, and where co-operation in an improvement project might be secured, either by cities donating tracts of land for the forestation work or where cities, organizations, or private individuals will pay part or all of the expenses of the forestation work (except the cost of supervision and trees).

The next class of land in order for improvement would be the lands of agricultural value which should be purchased by the State and improved by planting.

Next, if certain lands about the lakes are not to be controlled by the State, it would then be desirable to assist in the reforestation of those lands which are now owned by towns, cities or other organizations.

The last for improvement would be private lands adjoining the lakes which will not be purchased by the State.

Control of State-owned Lake Shores.

It is hardly necessary to mention the many advantages in the State owning the land adjoining the valuable lakes. Among the more im-

FIG. 88—A slope which has been denuded of tree growth. A number of areas such as this, which formerly were covered with a dense stand of timber, have been rendered unsightly and of practically no value for recreational purposes, due to the cutting of the timber. Such areas as this might be purchased by the state, reforested at a relatively small cost, and held for the use of the people.

FIG. 89—A native stand of pine timber adjoining Cass Lake, Minnesota. This area is under the supervision of the U. S. Forest Service and is protected at all times against fire and grazing. The results of this protection are evident from the heavy stand of young trees which are shown on this area.

portant reasons for state control are, first, such controlled lands will be better insured for the use of other generations, and second, the public will have access to the lakes at all times without the interference of private interests.

Lands acquired by the State should be placed preferably, under the supervision of some existing body of the State, with a Forest Warden,

FIG. 90—A swampy area adjoining Little Wall Lake, in Hamilton County. Portions of this area would now support tree growth. By draining the very wet portions the entire area, at a small expense, could be made over into a forest park.

Park Commissioner, or State Forester, without salary, to execute the proposed reforestation work and provide for proper protection and regulation of the lands acquired.

A large part of the State owned land about the lakes should be held for the use of all the people, who would be permitted to camp or to

FIG. 91—A slope bordering one of Minnesota's lakes. The land is owned by the U. S. Building sites are leased to private individuals at a small fee, under certain regulations.

use the grounds for picnic purposes, under such restrictions as are necessary for the proper protection of the land.

Under certain conditions it would no doubt be desirable to permit

FIG. 92—The shore line of one of Minnesota's lakes, showing a long row of summer cottages. Private parties are permitted to build summer cottages on these lake shores by paying a rental fee of \$5.00 per year. On this lake several miles of shore line are lined with such cottages and more are being built each year. A system similar to this might be adopted in connection with the state owned lands bordering Iowa's lakes.

the erection of summer cottages along portions of the lake frontage, a system which is followed by the United States Forest Service with good results. A nominal annual rental fee, generally not exceeding \$5.00, is charged for the land occupied by such cottages.

CHAPTER TWO---TREES SUITABLE FOR REFORESTATION WORK IN IOWA

Iowa has a long list of trees suitable for reforestation of the lake shores, including both deciduous and evergreen species. The native timber of the State is largely made up of the deciduous or broad leaved trees, although the eastern white pine and the red cedar are native to Iowa—the former being one of the best timber trees of the country. The native list of trees is supplemented with a number of exotics, both

FIG. 93—The shore line of one of Minnesota's lakes, showing a row of tents used by campers. The forested shores of Minnesota lakes attract many thousands of people from the states of Iowa, Wisconsin, Illinois, and Nebraska annually. The timbered borders more than any other one feature, add attractiveness to the lake.

deciduous and evergreen, which have been planted in the State with good results.

The following indicates the more important trees which will be of value in reforestation work:

Hardwood or Deciduous Trees.

Cottonwood: The common cottonwood is probably the most rapid growing tree to be found in Iowa. It has been planted extensively during the past sixty years throughout this section of the country. It thrives best on moist soils and will be exceptionally well bordering swamps.

A large number of measurements which have been taken over the northern part of the State, show that the cottonwood, under favorable conditions, will make a diameter growth of about 1 inch and an average height growth of 3 to 5 feet per year, during the first twenty to thirty years. The tree is relatively short-lived, reaching its maturity between

thirty and forty years. This makes this tree somewhat less desirable for forestation work, however, it is a tree that will make good showing in a relatively short time. It will make a good growth on over-flowed land and probably next to the willow, will endure as wet a soil as any of Iowa's trees.

The cottonwood will be very serviceable for beginning certain plantations along the lake shores where protection is needed for some of the more permanent trees which are to be planted.

As a timber producer, no other tree in Iowa is better. Measurements of a large number of plantations shows that in thirty to forty-five years' time as much as 50,000 board feet per acre, in addition to cord

FIG. 94—This photograph shows young cottonwood trees, which are making a thrifty growth on overflow lands. At the time this picture was taken the water was several inches deep, and remained at this depth for several weeks without injury to the trees. The cottonwood is one of the most desirable trees for planting on areas which are subject to overflow at certain periods of the year. This tree is also desirable for planting where quick results are desired, since it is one of the fastest growing species found in the state.

wood, can be produced under conditions which are not most favorable for tree growth.

Elms: Both the white elm and red elm should be used extensively in the forestation work about Iowa's lakes. The trees, in addition to being rather rapid in growth, are among our most desirable shade trees. Both of these species thrive best on a moist soil.

Hackberry: The hackberry is closely related to the elms. It is a tree which will make quite a satisfactory growth on dry situations, and at the same time makes a very pleasing appearance. It will be very serviceable for forestation of certain dry slopes adjoining some of the Iowa lakes.

Ashes: The white ash is found naturally on moist soil and is a very valuable timber tree for planting in Iowa. The green ash is much hardier, being able to make a satisfactory growth where the rainfall is

FIG. 95—This view shows thrifty growth which is made in one summer from Carolina poplar cuttings. These cuttings were planted in low, moist ground, and after three months' growth some of the sprouts showed a height of from 6 to 8 feet. This same tree, set out on overflowed bottom land on the grounds of the Iowa Agricultural Experiment Station, has shown that the trees in seven years' time will reach a maximum height of about 50 feet, and a maximum diameter of 9 inches. This species would be of great value for planting about some of Iowa's lakes, inasmuch as it would give quick results and could be supplemented by planting species which are longer lived. The tree is one of the best for planting on low-lands.

rather uncertain. Although rather slow in growth, the tree is desirable for reforestation work on certain lands in Iowa.

Oaks: The bur oak is found naturally about a great number of Iowa lakes. It is one of the hardiest species among the oaks, being able to withstand dry, wind-swept situations almost better than any other tree. In the drier portions of the State the tree is of small size. It should not be used extensively where the more desirable species, red oak and scarlet oak, can be successfully planted. The latter are faster in growth where there is sufficient moisture.

FIG. 96—Planted grove of hardy Catalpa. This species, because of the rapidity of its growth during the first few years, and also because of the peculiarly large foliage, will make it a desirable tree for planting in restricted sections about some of Iowa's lakes. The tree cannot be planted on all locations in northern Iowa, since it is not as hardy as some other species. The tree makes its thriftiest growth on low moist land, such as may be found around many of the Iowa lakes.

FIG. 97—Planted grove of white pine about fifteen years old. This species, under favorable conditions, will probably make as good a growth as any other coniferous tree in Iowa. It will serve exceptionally well for reforestation work on many of the slopes adjoining the lakes. The tree will not do its best on poorly drained soil. Instead of planting the trees in rows as is shown in the accompanying picture, the spacing should be irregular. After the trees reach a height of 20 to 25 feet, the lower branches should be trimmed off.

Black Walnut: The black walnut in natural stands selects moist bottom-land soil. It is one of the most desirable trees in the State for planting. In addition to serving as an ornamental tree, the food furnished by the nuts is an item worth giving consideration. In addition, at the present time black walnut timber in the State is being sought for more than any other species.

Hickories: Several species of hickories should be used in moderate amounts for forestation work about Iowa's lakes.

Soft Maple: The soft maple has been planted in Iowa probably as much as any other tree. It is rapid in growth and will stand considerable shading. However, it is short-lived and cannot be expected to be serviceable for a period greater than forty to fifty years. This tree

FIG. 98—Planted grove of white pine in central Iowa where the trees are between 35 and 40 years old. Some of the trees show a diameter growth of about 17 inches. In planting about the lakes, the white pine could very well be mixed with other evergreens or broad leaved trees.

will be of service in forestation about Iowa's lakes because of its rapidity in growth. However, it should not be planted where more desirable trees can be used.

Hard Maple: The hard or sugar maple, or its variety the black maple, is rather slow in growth, but, on account of the very dense foliage and symmetry of the crown it is much desired for planting in the State. This tree would be well adapted for planting in locations where an open spacing of the trees is desired. On account of its great shade-enduring qualities it could be successfully grown under the shade of such a fast-growing tree as the cottonwood.

Basswood: Although rapid in growth, the basswood is rather short-lived. It naturally selects moist situations, has a dense foliage, and might be used for planting certain areas about the lakes.

Sycamore: The sycamore is a lowland species and could be well used for reforestation work on low, flat areas adjoining some of the lakes. The peculiar mottled appearance of the bark would add an attractive feature for park planting.

Willows: The willows should not be used for reforestation work where more desirable trees can be planted. However, the fact that most of the willows will withstand a great amount of moisture in the soil, it might be desirable to use the black willow or one of the other species for planting on certain areas bordering swamps about the lakes.

Other Species: Other species which might be planted to a certain extent are the Russian olive which is very hardy and has a very beautiful foliage. The tree, however, is small. The white birch, or possibly some of the other species of birch, would add a variety to the planting because of the characteristic color and markings of the bark. The hardy catalpa is not as hardy in northern Iowa, as its name would imply, and for this reason should be planted sparingly, if at all, about the lakes.

Conifers or Evergreen Trees.

White Pine: The white pine is one of the few native evergreen trees to be found in Iowa. It has the distinction of being probably the tree which has been used more than any other for lumber in the United States. It is one of the most beautiful among the evergreen trees and is rapid in growth during the first fifty years. The tree will endure a sandy soil but not one that is poorly drained.

The tree has been widely planted in Iowa, with good results. Measurements of plantations throughout the State, show that a good production of timber can be secured in forty to fifty years' time. Unless the planting of white pine is thought to be undesirable because of the present ravages of the white pine blister rust, there is probably no other coniferous species available which would be more serviceable for reforestation work about Iowa's lakes.

Red or Norway Pine: The red pine is almost as rapid in growth as the white pine. It has a coarser foliage and will endure poorer soils than the white pine.

Jack Pine: This tree is considered a poor species when associated with the white and red pines in native stands of the Lake States. The tree, however, makes a faster growth during the first ten years than most any others of the evergreens. It is a tree also, which will withstand the driest, sandiest soils and yet make a satisfactory growth.

Other Pines: Austrian and Scotch pines which have been introduced from Europe, have been extensively planted over the State. Both trees are very hardy and will withstand dry situations. For this reason both will be serviceable for planting work about the lakes. Western yellow pine is also a tree which should be planted in limited quantities.

European Larch: This tree makes its best growth on moist slopes. It can be grown in very dense stands during the first twenty-five to

thirty years, forming trees which are slender and tall. When spaced widely apart the trees take on a beautiful conical form.

Spruces: The Norway spruce, an exotic from Europe, has been planted probably more than any other spruce in the State. The tree is not rapid in growth but has a dense foliage which makes the tree quite attractive for planting work. It will not withstand as dry a soil as the hardier variety, Black Hills spruce, which has also been planted more or less throughout Iowa.

Hemlock: The Eastern hemlock would be serviceable for planting on lowland situations which are protected from the sweeping winds. The hemlock is one of the most beautiful of the evergreen trees and should be used for planting certain areas about the lakes.

Red Cedar: Red cedar, or juniper, which is a native tree of Iowa, can be planted with success in many parts of the State. Although not

FIG. 99—Young stand of Black Hills spruce and Austrian pine. Although slow in growth, the spruce can very well be used for planting certain areas along the lakes. Both this spruce and Austrian pine are well adapted to dry situations.

rapid in growth, its extreme hardiness recommends it for forestation work.

Arborvitae: The arborvitae will withstand vary wet situations. Although rather slow in growth, it should be used for planting certain areas adjoining the lakes.

FIG. 100.—Group of Colorado Blue Spruce, hard maple and birch planted in Central Iowa. By properly combining several species of trees, in planting areas about the lakes, very pleasing effects can be secured. Although the Colorado blue spruce has not been planted extensively, except for ornamental purposes, throughout the state, because of its relatively slow growth, yet the tree will be particularly valuable for planting certain stretches along the lake shores where an open stand effect is desired. The white birch to the left, as well as the hard maple to the right, are both valuable trees for forest park planting.

CHAPTER THREE---STATE FOREST NURSERY

Forestation about the Iowa lakes might be greatly facilitated by the establishment of a state forest nursery preferably under some existing department or institution. Such a nursery would make it possible for the State to take up the question of improvement of the lake shores on a scale which would accomplish appreciable results, and at the same time reduce the expense to the minimum. A state nursery is not an experiment since many of the other states have already made good progress in forestation work through this means.

The Department of Forestry in Idaho maintains a forest tree nursery

FIG. 101—The Carolina poplar makes very rapid growth in river bottom land. The photograph shows a planting five years old. Some trees are 35 feet in height and 7 inches in diameter.

of 1,000,000 trees. The trees are distributed to private planters at a slight increase over cost of production. Kansas has two state nurseries which are strongly endorsed by the State Forester. The trees suitable for reforestation work are furnished at approximate cost of production. Kentucky has two state forest nurseries; Maine, one, under the Department of Forestry of the University; Maryland, one state nursery where trees are supplied at cost of production.

Massachusetts maintains three forest nurseries. About 1,200,000 trees are supplied annually, free of charge for planting on the state lands (state forests and state lands under other State Departments). Michigan plants about 200 acres of land annually with trees supplied from her state nursery. Minnesota has a state nursery which supplies forest trees for planting on the state forest lands and at Itasca State Park. North Dakota has a state nursery in connection with the State School of Forestry. Trees are supplied annually for public and private planting, free of cost, to practically every county in the state. New Hampshire has reforested many thousands of acres with trees supplied from the state

FIG. 102—Forestry seed beds at the nursery of the Iowa State College at Ames. If extensive tree plantings or forestation is attempted at any of the Iowa lakes or marshes, seeds and young tree plants for the work would be supplied from the college nurseries.

nursery. New York has done much work in reforestation and now maintains five state forest nurseries. Trees for public planting are furnished at the nominal price of 50 cents per thousand. In addition to the planting of the state lands, an area of about 15,000 acres has been planted privately.

Ohio has supplied more than 2,000,000 trees for public and private planting from a state nursery under the State Agricultural Experiment Station. Pennsylvania maintains twenty-six state forest nurseries which supply trees, free of cost, for public or private planting. In 1917 Pennsylvania will furnish about 5,000,000 trees from her state nurseries, which will reforest from 2,500 to 5,000 acres. Vermont has furnished over

4,000,000 trees in the past seven years from her state nursery; and Wisconsin produces 1,000,000 trees annually, sufficient to reforest 1,000 acres.

It is probable that other states, not included in the above list, have state forest nurseries for the production of trees for planting the state and private lands. Iowa's needs for reforestation work are probably greater than those of many of the states above listed.

Advantages of a State Nursery.

In providing a state nursery under competent management, it would be possible to produce the trees best adapted for planting on the different sites where reforestation work is needed.

Capacity, Land Required, Etc.

It is recommended that the proposed nursery be started with a capacity of 1,000,000 trees annually. This would not mean that 1,000,000 trees

FIG. 103—Men at work transplanting young trees in field. View shows reforestation work on some waste lands adjoining the Mississippi River. There are many areas bordering the lakes which are quite similar to these lands which might be profitably planted to trees and eventually serve as forest parks.

would be available during the first year, since many of the trees most suitable for reforestation work, especially the evergreens, must be three to five years old before being planted. The capacity of the nursery could be increased as needed. An area of approximately ten acres would be required for this nursery.

Furnishing Trees for Forestation Work.

The trees should be supplied without cost for reforestation work about the lakes, either when state land is being planted or when the planting is done by counties, towns, organizations or private parties, so long as the land thus improved is open to the use of the public.

Surplus Tree Stock.

Trees raised in excess of those needed for the lake improvement should be furnished, first, for planting other state lands which may be designated as state parks, etc.

Any remaining trees should be made available for the planting of areas which will be of public interest, such as county or municipal forest parks, the trees to be furnished without cost, for such projects. Surplus trees might also be utilized for the reforestation of some of the denuded bluff lands adjoining some of our larger water courses, where erosion of the hillsides not only threatens the beauty of the localities but also causes the excessive filling in of the river beds.

A good opportunity is also afforded for using some of the trees grown at the state nursery, for planting along the transcontinental and principal state highways. The planting of uniform varieties of trees—if properly spaced and trimmed—would add an attractiveness to our highways which at the present time is largely wanting. The counties through which

FIG. 104—Island land in the Mississippi River, showing cottonwood, birch, and elm trees, which thrive in very wet situations. This is similar to many areas found bordering the Iowa lakes. The Agricultural Experiment Station has conducted some tree planting experiments on lands similar to this, which have given good results.

these highways pass would unquestionably give substantial co-operation in this work.

Funds for Nursery and Planting Work.

The sum of \$5,000 annually would be needed for the proper installation and maintenance of a state nursery. This sum would provide for an annual output of from 1,000,000 to 2,000,000 trees, depending on the species, age, size, and number of times the trees were transplanted. The capacity would necessarily be under this figure for the first two or three years.

A state forest nursery might well be established in connection with the State Agricultural Experiment Station and the Forestry Department at Ames. The following advantages would be found in this location:

The cost of administration would be minimized, since the technically trained foresters of the Forestry Department would supervise the nursery work.

A large part of the land needed for a state nursery is now available for nursery purposes without additional cost to the state.

A nursery with a capacity of 100,000 trees is now in operation under the Experiment Station and Forestry Department.

The use of student labor would cut down the cost of production.

FIG. 105—Bare stretch of shore line along the southeast shore of Little Wall Lake. The planting of coniferous and broad leaved trees along this stretch would make a beautiful park for the use of the people in the vicinity.

A central location in the state is desirable, together with its good transportation facilities, to make the shipment of trees easy and economical.

CHAPTER FOUR---A PLAN FOR THE FORESTATION OF LANDS ADJOINING NORTH TWIN LAKE

North Twin Lake in Calhoun county was not selected to illustrate the possibilities for forestation work because it is a more desirable lake to improve than many others in the state, but merely to show what might be accomplished at a relatively small cost, by planting trees on a strip about 500 feet wide about the lake.

North Twin Lake, located about five miles north of Rockwell City, is particularly desirable for improvement work, since a summer resort is now in operation at the south end, which seems to attract a large number of people. At this point, there is a relatively large amount of native timber which extends up the eastern side of the lake for a short distance. In another clump of timber within a short distance of the north end, there are at present five summer cottages. Around the balance of the lake, the timber occurs only as a very thin fringe, in most places

consisting of willow, ash, white elm, bur oak, cottonwood, red elm, ironwood, and basswood. On the east shore of the lake the burr oak predominates, while on the west side very little oak is found. The timber on the west shore is much less conspicuous than that on the east shore.

A road now extends along a portion of the west shore of the lake. If improvement work is undertaken, a road should be extended around the entire lake, in order that the shore may be made accessible from as many points as possible.

The investigation did not determine the detailed cost of the land recommended for planting, since this would involve a more extended survey. On parts of the shore, the land has greatly increased in price, due to the fact that private resorts are now being established. Considerable areas along the border could now, without question, be purchased

FIG. 106—Section of the shore line on North Twin Lake, in Calhoun County, which needs little improvement except the widening of the strip of timber by planting additional trees.

at the prevailing prices for agricultural land. Other areas not suitable for agricultural purposes could be obtained at a smaller figure.

The lake indicates one type where it will be necessary for the state to purchase agricultural land in case the shores are to be developed for the use of all the people.

It is the purpose of the following detailed report to show what trees can be successfully planted on the various situations about the lake. For convenience, the shore line of seven and two-thirds miles has been divided into forty-eight blocks or areas, with recommendations for the planting of each. The average width of the land recommended for forestation is 500 feet.

The costs given indicate the approximate costs for the trees required for the planting work and the cost of labor in planting. The figures are

based on the trees being grown at a state nursery in considerable quantities. The cost figures do not include the cost for care during several years following the planting, which would be small, nor for the adjustment of boundary fences, building roads, etc.

TREES RECOMMENDED FOR PLANTING ON THE SHORES OF
NORTH TWIN LAKES (CALHOUN COUNTY), WITH
AN ESTIMATE OF THE INITIAL COST.

The following figures on cost of planting do not take into account the cost of the land, since the investigation did not cover this point. About 80 per cent of the areas listed (see Blocks 1 to 48 on Plate 71), are agricultural, the remaining 20 per cent are steep banks or low, wet lands.

FIG. 107—Section of shore line along North Twin Lake, showing the very thin fringe of trees which occupy the shore. By planting a strip of timber 500 feet in width, the shores would eventually attract a large number of people for recreational purposes.

The prices for trees are based on having the trees supplied from a state forest nursery.

The following shows the trees recommended and the cost of planting, by blocks:

Block 1. Has a few scattered bur oak trees which should be preserved.

Trees recommended are bur oak, white elm and red pine.

Area—5.28 acres.

Total trees required—3,000.

Total cost of trees and planting—\$60.00.

Block 2. Consists of lower land than Block 1. Cottonwood, basswood and willow should be planted on the lowest lands adjoining the lakes, and white elm and Norway spruce on the remainder of the area.

Area—15.78 acres.

Cottonwood and willow cuttings—5,000.

Basswood, elm and Norway spruce trees—6,600.

Cost of cuttings, trees and planting work—\$120.00.

- Block 3.* This block is composed of a park-like stand of bur oak, ash, basswood and elm, with some scattering willows along the shore front. The present stand of trees should be improved by trimming and in a few places a few additional trees could be added to the stand. However, no additional extensive planting would be required in this block.
Area—1.3 acres.
- Block 4.* This block has a scattering stand of timber of species similar to those found in Block 3. The stand might be improved in places by planting a few clumps of Norway spruce and arbor vitae.
Area—3.22 acres.
Additional evergreen trees required—300.
Total cost of trees and planting—\$5.00.
- Block 5.* This area is relatively high and the soil well drained. The white pine planted in rather dense clumps would make a good tree for this situation.
Area—5.97 acres.
Trees required—4,200.
Total cost of trees and planting—\$60.00.
- Block 6.* This area is now pasture land. Trees recommended are the white elm, red oak and arborvitae.
Area—7.75 acres.
Total trees required—5,000.
Total cost of trees and planting—\$75.00.
- Block 7.* A scattered stand of ash, basswood, bur oak and haw is found on the area. Reproduction of these trees has been prevented, due to the fact that the land has been heavily grazed by hogs and sheep. The present stand of timber should be cleaned up and additional trees of white elm and Norway spruce should be planted.
Area—5.06 acres.
Additional trees required—1,500.
Cost of trees and planting—\$25.00.
- Block 8.* This block consists of a low point without any native tree growth. The land is low and swampy in places. Trees recommended are cottonwood, Norway spruce and arborvitae.
Area—.81 of an acre.
Total trees required—500.
Total cost of trees and planting—\$9.00.
- Block 9.* This area consists of improved agricultural land of good quality. It is suggested that the area be planted with a variety of trees—black walnut, birch, hard maple, red elm, Austrian pine and red cedar.
Area—15.97 acres.
Total trees required—10,000.
Total cost of trees and planting—\$160.00.

- Block 10.* An open stand, mostly bur oak, with an undergrowth of haw. The undergrowth has been damaged through excessive grazing and should be cleared out before additional planting is attempted. The present stand should be supplemented by planting Norway spruce and hemlock—both shade-enduring species.

Area—.97 of an acre.

Total trees required—200.

Total cost of trees and planting—\$5.00.

- Block 11.* This is a narrow strip of open timber—bur oak, basswood and ash. A number of the present trees are defective and should be removed. Trees recommended for additional planting are hard maple and arborvitae.

Area—.92 of an acre.

Total trees required—200.

Total cost of trees and planting—\$5.00.

- Block 12.* This block has no tree growth except a row of the poorer species at the water's edge. This should be treated in a similar manner to Block 9, by the planting of a variety of trees including scarlet oak, black walnut, hard maple, white elm, Russian olive. Scotch pine and European larch.

Area—17.05 acres.

Total trees required—8,500.

Total cost of trees and planting—\$160.00.

- Block 13.* This area consists of rather low land but is not swampy. Trees recommended are white elm, hard maple, hemlock and red cedar.

Area—2.53 acres.

Total trees required—1,500.

Total cost of trees and planting—\$25.00.

- Block 14.* This area is similar to Block 13. Trees recommended are white elm, basswood, Norway spruce, and arborvitae.

Area—2.59 acres.

Total trees required—1,500.

Total cost of trees and planting—\$25.00.

- Block 15.* Consists of good agricultural land higher than either Block 13 or Block 14. Trees recommended are white birch, red elm, red oak, hickory, and western yellow pine.

Area—12.4 acres.

Total trees required—6,000.

Total cost of trees and planting—\$120.00.

- Block 16.* This area is high and well drained. Trees recommended are white pine, red pine, European larch, Russian olive, and red oak.

Area—18.1 acres.

Total trees required—8,000.

Total cost of trees and planting—\$175.00.

Block 17. This area consists of a relatively high bank. A thin fringe of trees is present at the water's edge. The bank should be protected by the planting, in a rather dense stand, of red cedar, arborvitae, Norway spruce and white pine.

Area—2.36 acres.

Total trees required—2,400.

Total cost of trees and planting—\$30.00.

Block 18. This block consists of a relatively high knoll. Trees recommended are white pine, European larch, Norway spruce, scarlet oak, and hard maple.

Area—3.56 acres.

Total trees required—2,100.

Total cost of trees and planting—\$35.00.

Block 19. This block consists of good agricultural land. Trees recommended are ash, hackberry, bur oak, Austrian pine, western yellow pine, and red cedar.

Area—9.3 acres.

Total trees required—5,500.

Total cost of trees and planting—\$85.00.

Block 20. Consists of a small stretch of low land suitable for hardy catalpa, arborvitae, and Norway spruce.

Area—.57 of an acre.

Total trees required—400.

Total cost of trees and planting—\$7.00.

Block 21. This area has a good stand of native bur oak timber. The plot is enclosed with a fence and five summer cottages have been erected near the shore line. No additional planting is needed in this block.

Block 22. Consists of a long strip of land bordering the northern point of North Twin Lake. This area has a northerly exposure. Trees suitable for planting are white elm, hackberry, bur oak, basswood, western yellow pine, Norway spruce and arborvitae.

Area—23.8 acres.

Total trees required—13,000.

Total cost of trees and planting—\$210.00.

Block 23. Consists of a strip of low land bordering the northern tip of north Twin Lake. Some of this area is too swampy for any species. Parts of the area should be planted with willow, cottonwood, arborvitae, and Norway spruce.

Area—3.68 acres.

Total trees required—2,400.

Total cost of trees and planting—\$25.00.

Block 24. This area is similar to Block 23, except that it has a slight southerly exposure instead of a northerly one. Trees to be used should be similar to those recommended for Block 23.

Area—5.63 acres.

Total trees required—4,000.

Total cost of trees and planting—\$50.00.

Block 25. This area comprises a strip about 3,000 feet in length, with a southerly exposure. Trees recommended for planting should be somewhat drought resistant because of the exposure. Trees recommended are the hackberry, green ash, bur oak, Russian olive, red pine, Austrian pine, western yellow pine, red cedar, and Black Hills spruce.

Area—30.45 acres.

Total trees required—20,000.

Total cost of trees and planting—\$285.00.

Block 26. Consists of a small area of planted willows. The trees are old and badly decayed and should be underplanted with a few shade enduring species such as hard maple, Norway spruce, arborvitae and red cedar.

Total—.69 of an acre.

Total trees required—300.

Total cost of trees and planting—\$8.00.

Block 27. This area is a portion of a farmstead adjoining the lake. The block consists of planted timber—mostly ash. The trees have been damaged by stock and overcrowding. The trees should be thinned out and a few additional hardy trees planted. The area also includes a narrow strip along the shore of the lake, where a scanty growth of native timber is found. The trees recommended for planting here are the Black Hills spruce, Scotch and Austrian pines where there is sufficient light, and bur oak.

Area—1.95 acres.

Total trees required—1,000.

Total cost of trees and planting—\$18.00.

Block 28. This block is also a portion of a farmstead, having been planted with soft maple trees. The plantation is now about twenty-five years old and is in fair condition. In order to make the planting permanent, it is recommended that the present stand be underplanted with the more tolerant trees, including hard maple, Norway and Black Hills spruces, hemlock, and arborvitae.

Area—3.1 acres.

Total trees required—1,800.

Total cost of trees and planting—\$25.00.

Block 29. This area lies between the main portion of north lake and the shallow arm extending to the eastward. Trees recommended are the white elm, black walnut, basswood and red cedar.

Area—1.95 acres.

Total trees required—1,000.

Total cost of trees and planting—\$20.00.

Block 30. This area comprises a stretch about 3,000 feet in length on the north shore of Twin Lake. The entire area consists of good agricultural land and a good variety of trees should be planted, including white elm, red elm, hackberry, scarlet and red oaks, black walnut, white birch, European larch, white pine, and Norway spruce.

Area—29.5 acres.

Total trees required—20,000.

Cost of trees and planting—\$275.00.

Block 31. Comprises low areas adjoining a shallow arm of north Twin Lake. The block extends around three sides of this arm. Portions of the area are too swampy for tree growth; however, most of this land can be planted. The trees recommended are the willow, cottonwood, and arborvitae for the lowest situations; sycamore, basswood, white elm and Norway spruce for the remaining areas.

Area—23.3 acres.

Total trees and cuttings required—15,000.

Total cost of trees and planting—\$210.00.

Block 32. Comprises flat lowland but which is apparently well drained. Trees recommended are white elm, walnut, Norway spruce, arborvitae, and red cedar, and red elm.

Area—8.55 acres.

Total trees required—6,000.

Total cost of trees and planting—\$75.00.

Block 33. This area is similar to Block 32. The same species should be used.

Area—10.33 acres.

Total trees required—7,000.

Total cost of trees and planting—\$90.00.

Block 34. This area is slightly higher than Blocks 32 and 33. Trees recommended for planting are the white pine, red pine, Norway spruce, red oak, and Russian olive.

Area—3.36 acres.

Total trees required—2,000.

Total cost of trees and planting—\$30.00.

Block 35. This is made up of good agricultural soil. Species recommended for planting are white elm, hackberry, black walnut, white birch, hardy catalpa, red cedar and arborvitae.

Area—15.34 acres.

Total trees required—9,000.

Total cost of trees and planting—\$150.00.

Block 36. This block comprises a low meadow, most of the area being from 1 to 2 feet above the water level of the lake. Lowland species should be used in planting this area, such as cottonwood, willow, soft maple, and arborvitae.

Area—10.33 acres.

Total trees required—6,000.

Total cost of trees and planting—\$90.00.

Block 37. Good agricultural land. The rather steep slope bordering the shore of the lake should be planted to the species—red cedar, Austrian pine, Scotch pine, and arborvitae; the balance of the area, to white elm, white pine, black walnut, and hackberry.

Area—15.34 acres.

Total trees required—10,000.

Total cost of trees and planting—\$150.00.

Block 38. Consists of a farmstead partially planted with some cottonwood, soft maple, and ash trees. The timber is in bad condition and should be improved. In order to make the planting of a permanent nature, the present growth of trees should be underplanted with Norway spruce, red cedar, hard maple, and arborvitae. The area of the farmstead needing replanting would approximate 4 acres.

Total trees required—1,500.

Total cost of trees and planting—\$30.00.

Block 39. Comprises a narrow strip, mostly a rather steep bank along the shore of the lake. A straggling growth of inferior trees is to be found at the water's edge. The slope should be protected from erosion by the planting of white pine, Norway spruce, red cedar, arborvitae, and Russian olive.

Area—1.61 acres.

Total trees required—1,000.

Total cost of trees and planting—\$15.00.

Block 40. This is an area of good agricultural land and should have a variety of trees. Those recommended are the white elm, black walnut, scarlet oak, white birch, white pine, yellow pine, European larch, and Norway spruce.

Area—27 acres.

Total trees required—20,000.

Total cost of trees and planting—\$260.00.

Block 41. A small area bordering the lake, which is low but under ordinary conditions, is not swampy. Trees recommended are the cottonwood, soft maple, Norway spruce, and arborvitae.

Area—1 acre.

Total trees required—800.

Total cost of trees and planting—\$10.00.

- Block 42.* This block has several rows of soft maple and ash trees. The space between these rows should be planted with elm, Norway spruce, and basswood.
Area—1.95 acres.
Total trees required—1,000.
Total cost of trees and planting—\$16.00.
- Block 43.* This block is similar to Block 42, except that no trees are at present found on the land. The same species should be planted as in Block 42.
Area—4.32 acres.
Total trees required—3,000.
Total cost of trees and planting—\$40.00.
- Block 44.* This area consists of rather low land extending on each side of a drainage ditch. Cottonwood, arborvitae, and Norway spruce would be desirable for planting here.
Area—2.24 acres.
Total trees required—1,800.
Total cost of trees and planting—\$20.00.
- Block 45.* This area consists of good farm land. Most any species of trees would thrive on this soil. Those recommended are the white elm, black walnut, white birch, hardy catalpa, white pine, European larch, and arborvitae.
Area—17.7 acres.
Total trees required—14,000.
Total cost of trees and planting—\$160.00.
- Block 46.* This area is at present, treeless but adjoins the land now designated as the Twin Lakes Resort. The trees recommended for planting on this area are the white elm, white birch, red oak, hard maple, Russian olive, red pine, Norway spruce, and arborvitae.
Area—11.48 acres.
Total trees required—8,000.
Total cost of trees and planting—\$100.00.
- Block 47.* This area is a swamp which would probably be impossible to drain. It is possible that a few trees might be able to survive if placed along the shores; however, practically all of the area would not be suitable for tree growth.
- Block 48.* This area includes what is now known as the Twin Lakes Resort. The area is quite well timbered at the present time. A number of buildings occupy the land and the resort seems to be used to a considerable extent, especially by people from Rockwell City. Portions of this resort could unquestionably be improved by planting a few trees.

SUMMARY AND RECOMMENDATIONS.

Total area of land recommended for improvement, 388 acres.

Total cost of land, if purchased by the State, not determined.

Total cost of trees required for planting the 500-foot strip about North Twin Lake (388 acres), including cost of labor for planting, \$3,893.00.

If extensive improvement is attempted, a careful survey should be made to determine the cost of the land suggested for improvement, and the possible elimination of certain areas which may now be too expensive for purchase by the state.

It is suggested that the improvement work be extended over a period of approximately ten years—the Blocks for first improvement to be designated after subsequent investigation on cost of land.

CHAPTER FIVE---A PLAN FOR THE REFORESTATION OF LANDS ADJOINING BLUE LAKE IN MONONA COUNTY

Blue Lake which is situated almost midway between Sioux City and Council Bluffs, is one of the lakes in western Iowa, which, if properly developed, will mean much to the people in that portion of the state.

Unlike some of the "cut-off" lakes along large streams, the water of Blue Lake is clear and, with proper surroundings, would be as attractive as any other body of water in the state. If developed, the lake will serve as a summer resort and recreation grounds for the people, and, at the same time, can be made attractive from the sportsmen's standpoint, by the proper protecting of the fish and by stocking the adjacent areas with game.

Although it is probable that the state does not now control any of the land adjoining the lake, as is supposed by certain individuals in the locality, yet the land is such that it could be purchased at a very small figure. By referring to Plate 72, it will be noted that the lake forms a U. Several hundred acres of land included between the two arms of the lake are little more than waste areas. A considerable area is flat, while half or more of the area is made up of small sand dunes. It is stated that in the early days this land was fairly well timbered. At the present time, however, due to overgrazing and excessive cutting, the few scattering trees now remaining are merely those which were not good enough for cutting. Investigation covering the area, showed that considerable areas of the sand dunes were shifting. Due to the destruction of the native timber and due to heavy grazing, the sand is loose and subject to wind erosion. In one place it was found that the sand had been blown out to a depth of fully 10 feet. It is quite probable that, unless some measures are taken for preventing the excessive wind erosion, adjoining lands may be overblown with sand and rendered worthless. It is even possible that the lake may be partially filled in and the locality made of little value for recreational purposes.

If the development of the lake is attempted, one of the first things to be done is to get the shifting sands under control. Even though the reforestation of a relatively small area of the peninsula be started during the next year or so, it must be eventually followed up with other planting, in order to secure the lake and reforested areas against the shifting sands.

Although there are only a few species of timber now in evidence on this portion of the peninsula, it is probably due to the fact that the more desirable trees have been cut. The soil and climate are such as would warrant the planting of many desirable species of trees. It is probable that in handling the areas where the soil is shifting, it will be necessary to start reforestation work with some tree species which is rapid in growth during the first few years. Cottonwood is particularly well adapted for

this work. Planting on these areas should then be carried forward, using the longer-lived trees as far as possible.

Area and Description.

Although the improvement work around Blue lake should eventually include other areas, this plan considers only a portion of land known as the "neck", which is included between the two arms of the lake.

The area for which this planting plan is prepared consists of approximately 400 acres. About one-half of this area is quite flat and is less than five feet in elevation above the lake. The remainder is made up of low sand hills—the highest being about fifteen feet in height.

The surface soil on the lower areas is a sandy loam with some occasional clay. The soil of the low undulating hills is almost pure sand which is badly eroded by the action of the wind where the light vegetative cover is broken. The vegetation on the flat areas bordering the lake

FIG. 108—Scattered growth of timber on the neck of land between the two arms of Blue Lake, in Monona County. The sandy stretches shown in the picture are shifting from year to year through the action of the wind. In places the trees have been practically uprooted. This makes up a portion of the area recommended for improvement along Blue Lake. By planting suitable species of trees, the blowing sand will be checked and a beautiful forest park will be made available for the use of the people. It is probable that this land could be purchased at a price of a few dollars per acre, since it has little or no agricultural value.

is made up of grass and weeds of sufficient density to form a moderately heavy sod.

Where the First Reforestation Work Should Start.

Block 1 on Plate 72 shows the area which should be improved first. This adjoins one of the most beautiful sections of the lake; is more easily accessible from the nearest town, Onawa, than other parts; and lends itself readily to reforestation work. The planting plan provides for the completion of the reforestation of this area of about 400 acres in ten years, by planting annually approximately 40 acres. (See accompanying map.) If other areas are included at a later date, the planting plan might either be extended for a longer period of years, or the plan might be adjusted so as to provide for the planting of more than 40 acres annually during the ten year period.

Type of Reforestation Work.

The sentiment of the residents in the locality of Blue Lake indicates that a forest park is desired—one which is free from the formal features of city parks, but which, in addition to the reforestation of the areas, provides for adequate drives.

The group system of planting, with an irregular spacing of the trees, and allowing open spaces, should be followed in carrying out the work.

Drives.

As soon as possible the drive, indicated as crossing the extreme north end of the lake and extending the length of Block 1, should be constructed, in order to make the area easily accessible to the public. This would necessitate the construction of a dam or fill across a shallow portion of the lake. The road should connect with the county road to the south. Other drives, as indicated, should be constructed as the area is developed.

Shifting Sands.

Although the plan calls for the planting of definite areas during each year of the ten-year period, the work of subduing the shifting sands

FIG. 109—Blue Lake, Monona County. A stretch of flat land adjoining Blue Lake. This area should be planted with groups of elm, arborvitae, basswood, Norway spruce, and other species.

should proceed as fast as funds will permit. It is quite probable that on the worst portions of the area, some preliminary planting of fast-growing trees should be done in order to prevent the covering or up-rooting of the slower-growing, permanent trees which will make up the final stand.

Trees for Planting.

A large variety of trees will be suitable for planting. The Red and White elms should be well represented on the flat lands bordering the shore of the lake. The cottonwood and soft maple should be used in places to give quick results but should be reinforced with longer lived trees—thus allowing the removal of the temporary trees after a period of from twenty to forty years. Some of the other broadleaf trees which should be planted are the black walnut, basswood, bur oak and red oaks, catalpa, Russian olive, hickories, hard maple, sycamore, ash, birch, and honey locust. (See accompanying map.)

On the rolling sandy areas the pines will be very effective in the reforestation work, since they are much less exacting and will thrive on poor sandy soils. Most of the pines are slow in initial growth, and, as a result, in planting the areas where the sand is being moved by the wind, it will be necessary to make use of shelter trees. The cottonwood will be very effective for this shelter planting, since it is very rapid in growth. After the pines are established the shelter trees may properly be removed and marketed for lumber or other purposes. The pines which should be used are the white pine, red pine, western yellow pine, Austrian pine, Scotch pine and Jack pine. Other evergreens which should be included for planting the different areas are the Norway and Black Hills spruces, European larch, red cedar and arborvitae.

An Estimate of the Cost of Proposed Reforestation Work Adjoining Blue Lake in Monona County.

The figures do not include the cost of purchasing the 400 acres of land of poor quality suggested for planting, since the investigation did not cover this point. Also the figures do not include the cost of road construction, which would be small, nor the cost of protection and maintenance of the improved areas.

As previously stated the planting plan suggests the reforestation of an area of approximately 40 acres each year for the next ten years.

For the tree species recommended for planting in the various subdivisions of the Block, see the accompanying map.

Block I—(1917)

Some sentiment about Elue Lake favors the development of the area designated as Block I, first, since this is more accessible and joins one of the most desirable sections of the lake.

Total area of Block—40 acres.

Total trees of all species required—17,000.

Estimated cost of planting, including trees—\$420.00.

Block II—(1918)

Total area of Block—40 acres.

Total trees of all species required—16,000.

Estimated cost of planting, including trees—\$410.00.

Block III—(1919)

Total area of Block—40 acres.

Total trees of all species required—17,500.

Estimated cost of planting, including trees—\$435.00.

Block IV—(1920)

Total area of Block—40 acres.

Total trees of all species required—20,000.

Estimated cost of planting, including trees—\$475.00.

Block V—(1921)

Total area of Block—40 acres.

Total trees of all species required—25,000.

Estimated cost of planting, including trees—\$490.00.

Block VI—(1922)

Total area of Block—40 acres.

Total trees of all species required—35,000.

Estimated cost of planting, including trees—\$525.00.

Block VII—(1923)

Total area of Block—40 acres.

Total trees of all species required—27,000.

Estimated cost of planting, including trees—\$500.00.

Block VIII—(1924)

Total area of Block—40 acres.

Total trees of all species required—22,000.

Estimated cost of planting, including trees—\$525.00.

Block IX—(1925)

Total area of Block—40 acres.

Total trees of all species required—22,000.

Estimated cost of planting, including trees—\$525.00.

Block X—(1926)

Total area of Block—40 acres.

Total trees of all species required—24,000.

Estimated cost of planting, including trees—\$500.00.

Summary of Costs.

Total area of Blocks I to X, 400 acres.

Total trees required for Blocks I to X, 225,500.

Estimated total cost of planting the 400 acres, distributed over the 10 year period, \$4,805.00.

CHAPTER SIX---SUMMARY AND RECOMMENDATIONS

The investigation has brought out several points which should be given consideration. These are as follows:

(1) A large number of Iowa's lake shores are devoid of tree growth or have only limited numbers of trees present, a condition which makes the lakes much less attractive for the use of the people.

(2) In many instances private interests about the lake shores render access to the lakes either difficult or impossible.

(3) Privately owned lands which are cultivated close to the lake borders, often cause a filling in of portions of these lakes through the washing of the loose soil.

(4) The steeper slopes bordering the lakes, which have been denuded of tree growth, are being cut up into unsightly gutters, a condition which might be remedied or prevented by reforestation.

(5) Many low areas, bordering the lakes, and unsuited for other purposes, might profitably be planted to trees.

(6) Sandy or barren areas which occur bordering some of the lakes of the state which are now of little value, could be reforested at a small expense and would serve as state forest parks.

The following suggestions or recommendations are offered:

(1) That the state authorize the establishment of a state forest nursery with a capacity of from 1,000,000 to 2,000,000 trees annually, to furnish proper trees for reforestation work about the lakes and on other lands.

(2) That the state authorize the furnishing of trees from a state nursery, for reforestation work, free of cost, to counties, towns, or other organizations which are planting land which will serve as forest parks for the people.

(3) That the state provide for the purchase, at an early date, of certain land bordering the lakes which are, without question, desirable for reforestation purposes, and which should be held by the state.

(4) That provision be made for experimental forestation work on lake beds which have been, or will be drained, and which have little value for agricultural purposes.

CHAPTER SEVEN---FINANCIAL REPORT

The act of the Thirty-sixth General Assembly providing for the investigation and report on Iowa Lakes, provides that the State Highway Commission shall conduct such investigation and make report, with the assistance of students and instructors in the Engineering Departments of the Iowa State College and the State University of Iowa. Under the general terms of this act, all salaries are to be paid from appropriations already provided, and all expenses from the general state fund.

In preparing this statement of the cost of the lake bed investigation, endeavor has been made to set out all expenditures, from whatever funds paid, and all expenditures have been included except salaries of instructors in the above named state institutions. This statement includes all salaries of employees of the State Highway Commission and of the Fish and Game Department, and all expenses incident to the investigation and preparation of this report.

All expenditures made prior to July 1, 1916, from the appropriation for the State Highway Commission and charged to this investigation are included in the total expenditures of the Highway Commission as published in the 1916 annual report of the Commission and in the report of the Executive Council for the biennial period ended June 30, 1916.

While it is desirable that the portion of the cost of the investigation chargeable to each lake be shown, it would require a very detailed system of accounting to show such portion by direct charge. Furthermore, in the beginning of the investigation, the extent of the undertaking was hardly appreciated and no such detailed records were instituted. In finally arriving at the cost of the survey and report on each lake, it was decided to apportion the total cost on the basis of the number of acres surveyed in connection with each lake. In many respects this manner of distributing the cost among the various lakes is more equitable than a direct charge of each expenditure, as the cost of the field work done during the winter was much greater than the cost of that done during other seasons of the year, and the necessity of completing the survey and report at a stated time, made it necessary to prosecute the work through all seasons of the year.

In the schedules which follow, the items of expense have been classified both according to the funds from which paid and according to the departments conducting the work.

SCHEDULE 25.—EXPENDITURES FROM APPROPRIATIONS FOR
STATE HIGHWAY COMMISSION.

Salary of Drainage Engineer.....	\$ 2,765.00
Salaries of Engineers and Assistants.....	6,649.96
Salaries of Draftsmen.....	2,753.68
Total	\$12,168.64

SCHEDULE 26.—EXPENDITURES FROM FISH AND GAME PROTECTION FUND.

Salaries of Engineers and Assistants.....	\$ 2,700.09
Total	\$ 2,700.09

SCHEDULE 27.—EXPENDITURES FROM GENERAL STATE FUND.

Expenses of Drainage Engineer.....	\$ 1,027.61
Expenses of Engineers and Assistants employed by State Highway Commission	7,521.63
Expenses of C. E. Department, I. S. C.....	1,480.67
Expenses of Fish and Game Department.....	1,647.90
Expenses of Farm Crops Department.....	253.29
Expenses of Botanical Department.....	139.94
Expenses of Forestry Department.....	7.96
Expenses of Chief Engineer.....	84.90
Expenses of Commissioners.....	317.81
Supplies	291.16
Total	\$12,772.97

SCHEDULE 28.—EXPENDITURES FOR WORK DONE BY EMPLOYEES OF STATE HIGHWAY COMMISSION.

Salaries of Engineers and Assistants.....	\$ 6,649.96
Expenses of Engineers and Assistants.....	7,521.63
Salaries of Draftsmen.....	2,753.68
Supplies	291.16
Total	\$17,216.43

SCHEDULE 29.—EXPENDITURES FOR WORK DONE BY ENGINEERING DEPARTMENT OF IOWA STATE COLLEGE.

Expenses of Instructors and Students, I. S. C.....	\$ 1,480.67
Total	\$ 1,480.67

SCHEDULE 30.—EXPENDITURES FOR WORK DONE BY FISH AND GAME DEPARTMENT.

Salaries of Engineers and Assistants.....	\$ 2,700.09
Expenses of Engineers and Assistants.....	1,647.90
Total	\$ 4,347.99

SCHEDULE 31.—EXPENDITURES FOR FARM CROPS, BOTANICAL AND FORESTRY INVESTIGATIONS.

Expenses of Farm Crops Department.....	\$ 253.29
Expenses of Botanical Department.....	139.94
Expenses of Forestry Department.....	7.96
Total	\$ 401.19

SCHEDULE 32.—EXPENDITURES FOR ADMINISTRATION AND SUPERVISION OF WORK DONE BY ALL DEPARTMENTS.

Salary of Drainage Engineer.....	\$*2,765.00
Expenses of Drainage Engineer.....	*1,027.61
Expenses of Chief Engineer of Commission.....	84.90
Expenses of Commissioners.....	317.31
Total	\$ 4,195.32

SCHEDULE 33.—GENERAL SUMMARY OF ALL EXPENDITURES, APRIL 15, 1915, TO JANUARY 1, 1917.

Salary of Engineer in charge of surveys and field investigations.....	\$ 2,765.90
Salaries of Engineers and Assistants of State Highway Commission.....	6,649.96
Salaries of Engineers and Assistants of Fish and Game Department.....	2,700.09
Salaries of Draftsmen of State Highway Commission.....	2,753.68
Field expenses of Engineers and Assistants of the State Highway Commission	7,521.63
Field expenses of Engineering Department, Iowa State College.....	1,480.67
Field expenses of Fish and Game Department.....	1,647.90
Field expenses of Farm Crops Investigation.....	253.29
Expenses of Botanical Investigations.....	139.94
Expenses of Forestry Department Investigation.....	7.96
Supplies for Field Work.....	283.21
Supplies for Map Work.....	7.95
Expenses of State Highway Commissioners.....	317.31
Expenses of Chief Engineer of Commission.....	84.90
Expenses of Drainage Engineer in charge of Investigation.....	1,027.61
Total cost of investigation.....	\$27,641.60

SCHEDULE 34.—SHOWING TOTAL COST OF SURVEY AND REPORT ON EACH LAKE.

SURVEY MADE BY STATE HIGHWAY COMMISSION.

Name of Lake	In What County	No. of Acres Surveyed	Cost
Babcocks.....	Johnson.....	545	\$ 178.82
Blue.....	Monona.....	3,380	1,109.03
Brown's.....	Woodbury.....	1,530	502.01
Clear.....	Cerro Gordo.....	4,918**	1,613.66
Clear.....	Pocahontas.....	1,425	467.56
Dan Green's Slough.....	Clay.....	1,035	339.60
Duck.....	Winnebago.....	785	257.57
East Okoboji.....	Dickinson.....	9,240	3,031.77
East Twin.....	Hancock.....	1,045	342.88
Elk.....	Clay.....	1,275	418.35
Goose.....	Kossuth.....	570	187.02
Iowa.....	Emmet.....	1,950	639.82
Lost Island.....	Clay and Palo Alto.....	2,845	933.48
Nobles.....	Pottawattamie & Harrison..	1,260	413.42
Pickerel.....	Buena Vista and Clay.....	945	310.07
Round.....	Harrison.....	1,050	344.52
Silver.....	Delaware.....	138	45.28
Silver.....	Worth.....	1,085	356.00
Spirit.....	Dickinson.....	7,630	2,503.51
Storm.....	Buena Vista.....	4,880	1,601.20
Swag.....	Kossuth.....	520	170.62
Swan.....	Johnson.....	165	54.14
Tow Head.....	Calhoun.....	692	227.05
Tuttle.....	Emmet.....	10,100	3,313.95
Total.....		59,008	\$19,361.33

*The Drainage Engineer had general charge of the investigation and preparation of the report, but most of his time was spent with the field parties of the Highway Commission and of the Engineering Department of the Iowa State College.

**Area now completed being about 50% total.

SURVEY MADE BY ENGINEERING DEPARTMENT, IOWA STATE COLLEGE.

Name of Lake	In What County	No. of Acres Surveyed	Cost
Cornelia.....	Wright.....	1,280	\$ 419.99
Crystal.....	Hancock.....	1,005	329.75
Eagle (and Wood).....	Hancock.....	1,515	497.09
Elm.....	Wright.....	2,220	728.41
North and South Twin..	Calhoun.....	3,780	1,240.27
Twin Sisters.....	Wright.....	750	246.09
Wall.....	Sac.....	2,260	741.54
West Twin.....	Hancock.....	365	119.76
Wood (see Eagle).....	Hancock.....	.....	.....
Total.....		13,175	\$ 4,322.90

SURVEY MADE BY FISH AND GAME DEPARTMENT.

Name of Lake	In What County	No. of Acres Surveyed	Cost
Center.....	Dickinson.....	565	\$ 185.38
Diamond.....	Dickinson.....	300	98.43
Grass.....	Emmet.....	340	111.56
High (and Mud).....	Emmet.....	2,090	685.76
Hottes (and Marble).....	Dickinson.....	1,015	333.04
Iowa.....	Osceola.....	411	134.85
Jefferson Slough.....	Dickinson.....	440	144.37
Little Spirit (in Iowa)...	Dickinson.....	960	314.99
Marble (see Hottes).....	Dickinson.....	(See Hottes)	.....
Mud (see High).....	Emmet.....	(See High)	.....
Pleasant.....	Dickinson.....	260	85.31
Prairie.....	Dickinson.....	355	116.48
Rush.....	Osceola.....	1,005	329.75
Silver.....	Dickinson.....	2,000	656.23
Silver.....	Palo Alto.....	1,035	339.60
Swan.....	Dickinson.....	715	234.60
Twelve Mile.....	Emmet.....	460	150.93
Welch.....	Dickinson.....	110	36.09
Total.....		12,061	\$ 3,957.37

GRAND TOTALS—ALL DEPARTMENTS.

Acres surveyed	84,244
Total cost	\$27,641.60
Unit cost per acre.....	\$.328114

SCHEDULE 35.—COST OF WORK DONE BY VARIOUS DEPARTMENTS.

Department	Area Surveyed	Cost per Acre	Total Cost
Field Work	84,244	\$0.2374	\$20,000.25
Map Work	84,244	.0327	2,753.68
Administration and supervision of all departments	84,244	.0497	4,195.32
Farm Crops, Botanical and Forestry Investigations	84,244	.0048	401.19
Supplies	84,244	.0035	291.16
Total	84,244	\$0.3281	\$27,641.60

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