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SOME ECONOMIC PROBLEMS OF THE ILLINOIS RIVER VALLEY

Papers presented before the Economics Section of the Illinois State Academy of Science

Peoria, Illinois, May 8, 1931

DEPARTMENT OF REGISTRATION AND EDUCATION

STATE WATER SURVEY DIVISION

A. M. BUSWELL, Chief

Urbana, Illinois

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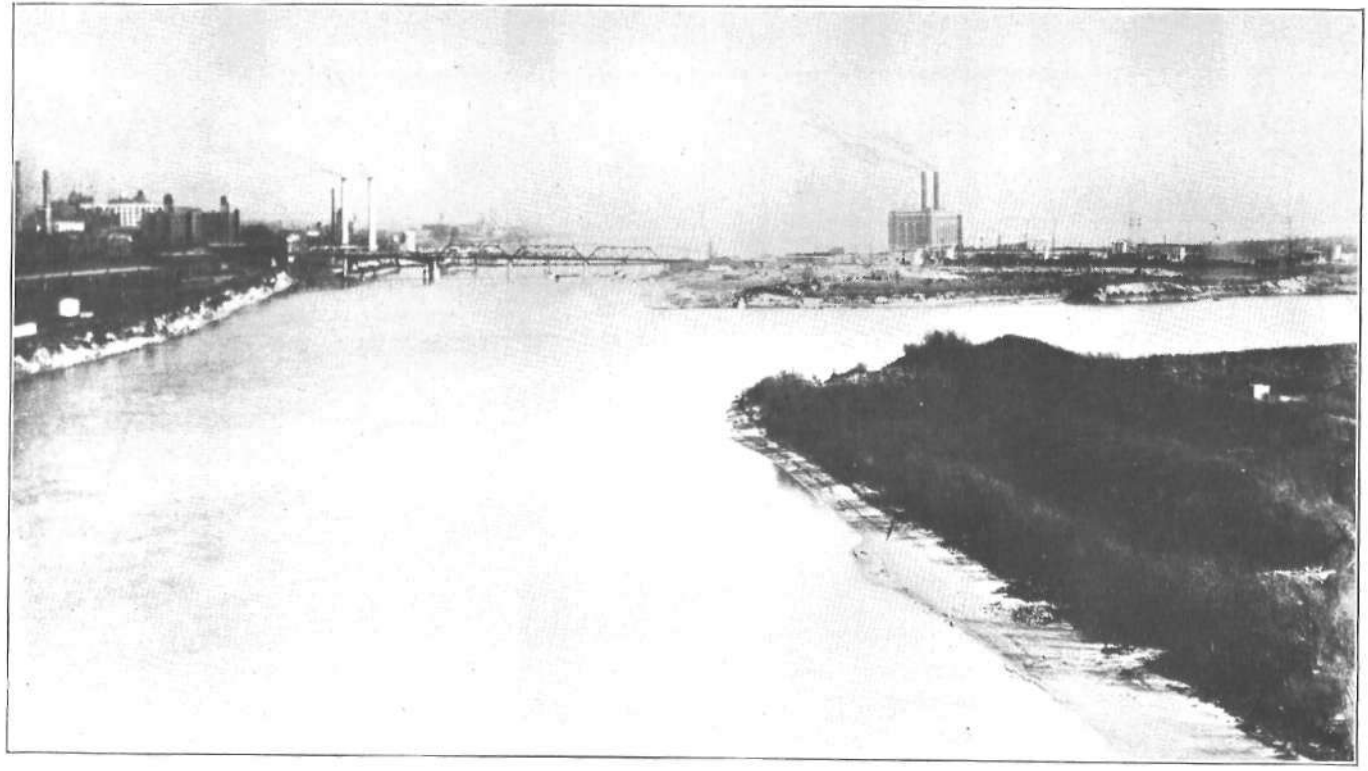

ILLINOIS RIVER AT PEORIA (Courtesy Peoria Star)

STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

Division of the

State Water Survey

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URBANA, ILLINOIS

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LETTER OF TRANSMITTAL

STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

STATE WATER SURVEY DIVISION

URBANA, ILLINOIS, *July 31, 1931.*

M. F. Walsh, Chairman, and Members of the Board of Natural Resources and Conservation Advisers:

GENTLEMEN: Herewith I am submitting papers presented before the Economics Section of the Illinois State Academy of Science in Peoria, May 8, 1931, recommending that they be published as Circular No. 12 of the Illinois State AVater Survey. Authority for publication of this material has been granted by the officers of the Illinois State Academy of Science.

Respectfully submitted,

A. M. BUSWELL, *Chief.*

ECONOMIC HISTORY OF THE ILLINOIS RIVER VALLEY

BY

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The topic which has been assigned to me is a large one. and in order not to wander too far afield, I shall confine myself to certain aspects of the economic history of this river valley, especially those connected with the development of transportation. The men who first settled this country were pioneers, and I think that we do not always realize the hardships which the early pioneers experienced. The people who left the Atlantic seaboard, then the industrially and culturally most advanced section of the United States, and moved out west undoubtedly did so in order to improve their economic position. But when they did so, we must remember that they cut themselves off from everything which they held dear. The journey from, say, Connecticut to Illinois was more toilsome and expensive than the journey, three times as long, from Europe to Connecticut, and it constituted more of a break with home and friends.

After the pioneers had reached this Illinois country, then practically untenanted and undeveloped, they built homes and proceeded to raise food and develop the resources. But, cut off as they were from the older sections of the country by poor and inadequate means of transportation, they could neither obtain supplies nor market their own surplus and were almost wholly dependent upon their own production. They were true backwoodsmen. Because they were poor, they lacked most of the things which we accept as a matter of course today, both household equipment and industrial and agricultural tools; and because they did not have intercourse with the East or with Europe they were unable to buy these things by selling the products of their farms. As a result they carried on a self-contained economic existence, but were una.ble to raise their standard of living. As producers they lacked market facilities and as consumers they lacked the opportunity of getting the things they needed. The only method by which they could extricate themselves from this dilemma was by improving the means of transportation. This was the essential condition of the opening up the interior of the continent. Always important, it became absolutely vital after the westward movement carried the population across the Appala-

chian mountains and away from accustomed markets on either side of the Atlantic ocean.

Let us note briefly the position of the earlier settlers in the Ohio Valley. For them there were two routes to markets: one was overland to the East and the other was down the Ohio and Mississippi rivers to New Orleans. The overland route to Philadelphia or Baltimore, through one of the mountain passes in the Appalachian chain, was long and difficult and over it only articles of considerable value and small bulk could be profitably transported, such as furs and ginseng. Some hogs and cattle were also driven east, but in general this route was unsatisfactory. The other route, down the rivers, was easier and cheaper. Products could be loaded on rafts, barges, arks, and other water craft and floated downstream to New Orleans. Goods would be accumulated during the winter in the upper valley and, when the spring freshets made it possible to float them down, whole flotillas of vessels would cut loose and start their journey. The market at New Orleans, small and precarious at best, was soon glutted and the returns were frequently very small. The farmer of one hundred years ago got as little for his crops as his descendent does today.

Illinois, situated far to the west, was able to avail itself of only one of these routes, that down the Mississippi. The settlers in this territory had therefore a very limited outlet for their products. This was the situation until 1814 when the first steamboat was built at Pittsburgh and proceeded downstream. But although the boat had gone down it could not return up the river against the swift current. Not until 1816 were sufficient improvements made in boilers, paddle-wheels, and other parts, so that the steamers could move upstream by their own power. In that year, the *Enterprise* steamed up the river from New Orleans to Cincinnati, and a new epoch in western transportation was begun.

The advent of the steamboat spelled a new era of prosperity for this part of the country. Eiver towns in Illinois now came into their own. Cairo was pictured as a commercial metropolis central to all the Union, at whose wharves ocean-going ships laden with the produce of Europe and the West Indies would discharge their cargoes—the Venice of the New World. Alton showed the steadiest commercial development during the 'thirties and was expected to surpass St. Louis. In 1826 Peoria was laid out along the Illinois River and four years later the first steamer arrived here. In 1831, seventeen steamboats landed their cargoes at the wharves of the village, which was growing fast and promised to become one of the important towns of the west. In 1838 Peoria had daily stage connections with Springfield, and three times a week stages ran between it and Galena, Ottawa, and Rushville.

But those parts of the state not touched by rivers remained undeveloped and untenanted. The northern part of the state was more or less a wilderness. Peoria was really an outpost on the northern fringe of settlement in Illinois. Beyond it were to be found only a small settlement at the mouth of Chicago River and another at Galena near the lead mines. In all this territory, between Peoria on the south to Wisconsin on the north and east to the Indiana border, the population in 1830 was only 1310. The movement of traffic was not sufficiently great as yet to warrant the building of means of transportation in addition to the natural waterways. These served adequately the needs of the sparsely settled and scattered Illinois settlements. The movement for further improvement in transportation facilities had to come from some more densely settled eastern state, and the necessary impetus was furnished by New York.

In 1825 the Erie Canal was opened and at once the complexion of the east-west trade was changed. A through water route was provided by which products could be shipped between Ohio, Indiana, or Illinois, and the Atlantic seaboard. This canal had profound and revolutionary effects. New York City grew as never before and soon far outstripped Philadelphia and other eastern seaports. At every point on the canal where a river touched it a new town sprang up, as at Rochester, and these cities grew rapidly. But the greatest effect was on the West, especially along the Great Lakes. The western farmer profited in two ways: the goods he bought from the East could now be had at one-half or one-third the former prices, and he was able to sell his agricultural products for double or treble what he had formerly obtained. If these benefits were to be distributed to the settlers in the central or southern parts of the western states, away from easy access to the Great Lakes, it would be necessary for these states to build their own canals. This fact was quickly appreciated and Ohio led the way in 1835 with the construction of the Ohio Canal, running from Cleveland to Portsmouth on the Ohio River, and followed soon after with the Miami and Erie Canal. Indiana built a long canal clear across the state, and Michigan and Wisconsin projected improvements far beyond the needs or financial capacity of their scanty populations. Illinois was the last state to enter the field of canal building, with the Illinois and Michigan Canal.

Illinois was late because most of her population had settled in the southern half of the state, which was adequately served by the river traffic. By 1835. however, the northern section had a considerable population, which became increasingly insistent upon connection with Lake Michigan and the advantages of the through water route to New York. The General Assembly responded to the pressure by passing the act of

February 10. 1835. providing for the appointment of a canal commission and the issue of a state loan. The federal government was also persuaded to make a grant of public land for five miles on either side of the proposed route. On July 4 of the following year the new declaration of independence of transportation was celebrated with appropriate ceremonies with the beginning of the Illinois and Michigan Canal at Canalport on Chicago Eiver.

The route of a canal across the state of Illinois was clearly marked by nature, and had long been recognized—by Marquette, by Gallatin, and by later writers. When the state was admitted to the Union in 1818, the northern boundary had been pushed sixty-one miles to the north in order that this natural route might lie wholly within the state of Illinois. As an engineering project the way was clear. But from a financial standpoint a more inauspicious time could not have been chosen. Several difficulties at once arose. As is usual in such undertakings the cost of construction had been underestimated and the initial estimate was revised several times, and always upward. The financial panic which came in 1837 proved a very serious blow to the prospects of an early completion of the canal. Most of the money was borrowed from England and as the financial situation became worse, especially after the repudiation of their debts by certain of the states, it became impossible to obtain additional funds from this source. An appeal was made to the English bondholders to advance sufficient money to complete the canal, since the unfinished project was utterly worthless. This they finally agreed to do on condition that the canal be managed by trustees of their selection until they were repaid. As this was manifestly to the advantage of all concerned this arrangement was made, and the canal was thus administered for twenty-three years or until the canal debt was expunged in 1871.

The Illinois and Michigan Canal was completed in 1848 and at once proved a great success. In endeavoring to estimate its economic importance we must, however, distinguish at least three different periods in the history of the canal. The first one, to 1848, was one of construction and was marked by land speculation and rapid settlement. The population in the district between Peoria and Chicago grew from about 20,000 in 1835 to 125,000 in 1850. Chicago, which was only a trading post in 1834, had 20,000 inhabitants when the canal was opened in 1848. The story of land speculation and the enormous rise in prices is so familiar that it need not be repeated here.

The second period, between 1848 and 1854, was that of the canal's greatest prosperity. We today cannot estimate its value or its importance to the domestic commerce of Illinois at that time. It represented a

tremendous move forward and provided a through waterway across the state between New York and New Orleans. The Ohio and Indiana canals had been handicapped by large lockage and by shortage of water, but the Illinois and Michigan Canal was superior in both these respects. Through the canal came lumber, shingles, posts, and other forest products from Michigan, which found their way as far west as Leavenworth, Kansas. Merchandise from the East and agricultural implements of Chicago manufacture passed in the same direction for distribution to the canal and river towns and by them to the interior settlements. In return the farm products from the regions traversed by the canal and Illinois River, together with sugar, molasses, coffee, and other tropical products from New Orleans found their way through this water route to northern and eastern markets. Its effects on the cities along its route were similar to those observed on the Erie Canal twenty-five years earlier.

A strong impetus was given to the development of Peoria, whose population doubled between 1847 and 1850. During this period 579 building's were erected, and in the latter year some 1,286 steamers touched at the Peoria wharf. Even more rapid was the growth of Chicago, whose population increased from 20,000 in 1848 to 75,000 in 1854, and whose importance as a commercial distributing point dates from this period. The effect on prices was also significant. Before the opening of the canal wheat sold on Illinois River at 50 cents, whereas the usual price in Buffalo was about $1.20 a bushel. After the completion of the canal the prices of farm products in Illinois doubled and the cost of eastern manufactures and other goods was cut in half.

The third period marks the rise of effective railroad competition and the gradual but steady decline in importance of the canal and river traffic. In 1847, Rock Island and LaSalle Railroad was chartered to run between these two towns in the apparent expectation that it would serve as a feeder to the canal by drawing to it some of the upper Mississippi trade. Four years later the road was extended to Chicago and renamed Chicago and Rock Island Railroad. It paralleled the canal and at once became a competitor rather than a supplement. The passenger traffic deserted the canal for the quicker rail route almost immediately, and soon the freight began to follow. A long but hopeless struggle now began, the outcome of which is familiar to you all. It was not until 1899, however, that the first serious break in canal traffic occurred, but this was followed the next year by a sharp drop and within a few years the traffic was so small that statistics of its amount were no longer collected.

The story of the construction of the Sanitary Ship Canal and of the revival of the Illinois River commerce will be told by others. Permit me to say just a word in conclusion. What shall we judge from this brief survey? There is one thing which I think we may learn, and that is that the transportation problem is never solved. Most of us came here by automobile. One of your speakers has just mentioned the airport to be built at Peoria, and the next speaker will discuss the Inland Waterways Corporation. We never stand still. Illinois and Michigan Canal, with Illinois River, was a phase of the economic development of this river valley, and although we have left that far behind he would be a bold man who would speak dogmatically of the future. We must be open-minded as to what constitutes good transportation. Did the canal pay? That is hard to say, as it depends somewhat upon who makes up the statistics, but an accountant would undoubtedly answer in the negative. But from the broader social point of view I should say that the state made a good investment at the time it built this canal. It played its part, served its turn, and today has passed into history. Prom this history let us learn the lesson that it offers.

COORDINATION OF RAIL, WATER, AND MOTOR TRANSPORTATION

BY

MAJOR GENERAL T. Q. ASHBURN

Inland Waterways Corporation.

No well informed man, except for political purposes, is advocating the extension of any of our interior waterways solely as navigable streams, unless such extension can be proven to be in accordance with sound economics and sound engineering principles.

Congress has announced its policy to be to promote, encourage, and develop waterways, and to foster and preserve in full vigor, both rail and water transportation.

It has created the Inland AVaterways Corporation as its pioneering and demonstrative agency to prove that, through proper coordination of rail, water, and motor transportation, there will result for the people a better and cheaper form of transportation, and that from the results of such cooperative efforts the participating carriers will receive a living revenue.

When this highly desirable end has been attained, when the operation of common carriers upon our interior streams has become attractive and financially profitable for private capital, then the government will sell its facilities, step out of the picture, and let private capital carry on, under such conditions that water transportaion shall never again be throttled.

The problem confronting the people of the United States is this:

We have hundreds of millions of dollars—nearly $1,500,000.000—invested in our harbors and navigable waterways, and we have been appropriating annually vast sums of money to continue making navigable streams in the hope that by their utilization there will result a cheaper means of transportation whereby the whole country will profit. This vast project has been only partly completed, and it will require a comparatively small sum to complete that part of it which has been found to be in accordance with sound economics and sound engineering principles. Upon its completion we may look with certainty to the fact that through cheaper and better coordinated water-rail-motor service there will result a system of transportation better and cheaper than any single

system, affording every one a real return upon the money which he has invested in the form of taxes.

These savings, inherent in water transportation, will be available not only to those communities fortunately located upon our navigable streams, for when this coordinated system of joint routes and rates is fully developed in accordance with the Denison Act. the shipper in the interior will receive the same savings in cents per hundred pounds through joint rates as the man located on the river. The general principle governing in the application of the water saving to the joint rate is to apply the water saving between the river ports to the all-rail rate betweeen the point of origin and destination, and then to establish a joint route via the Federal barge lines (by rail and water, or by motor and water), cheaper by the water saving than the all-rail or all-motor rate.

This is exactly what we propose to do for every interior shipper, and yet the opponents of waterway development and the operations of the Federal barge lines propose that we should abandon this vast network of waterways, already partially completed, charge it to profit and loss, and admit that our whole policy of 110 years has been a colossal failure, instead of spending the money necessary to make the system complete. It is submitted that no business organization, no combination of capital would abandon any such sum as $1,500,000,000, already spent to complete seven-eighths of a project which until completion is of little value, when by the appropriation of the additional one-eighth necessary to complete the project there would result a reasonable return upon the whole investment.

Whence comes this apprehension on the part of the Securities Owners Association that the development of our waterways may prove destructive to an adequate return on the investment in many railway systems, this belief that the savings in freight charges to the users of the waterways are more than offset by hidden costs borne by the taxpayer.

These, my friends, are the red herrings drawn across the trail to distract your attention from the fact that, through the utilization of such of our interior waterways as are navigable in connection with railways, the people of the United States *are* getting what they have taxed themselves for a hundred years to get, cheaper transportation. If there be any one thing likely to affect the value of your rail securities to depress them, it is the constant harping by certain individuals that the railroads are bound for destruction unless they can be delivered from their competitors; amongst which they include waterways. These vociferous pro-

mulgations of the idea that the railroads are headed straight to perdition do you more harm than good.

The people, as shippers and as receivers, and as users of commodities shipped, are not interested in academic discussions of the relative costs per ton mile of rail or water or motor traffic; they are not vitally interested in statistical nebulae disseminated from unknown or biased sources; they are vitally interested in whether the transportation for which they pay is cheaper and better by one form than another; and you as "Owners of Eailroad and Public Utilities Securities," are not interested in these statistical nebulae; what you are interested in is the effect the development of water transportation will have upon your securities. Hold these facts in your mind, get the problem squarely before you, and then let us discuss it amicably without regard to any gas attack designed to befuddle you.

Every new country passes through four stages of transportation; transportation by water, by paths and roads, by rail, and finally the stage of coordination and cooperation—the stage through which we are now passing.

Each of these stages follows as naturally as day follows night, each performs its function satisfactorily considering the conditions involved, each in the order named inevitably leads to the other; and as a better and cheaper and more satisfactory form appears, the less satisfactory and the more expensive form fights constantly to prevent the people of the United States from enjoying such transportation, and always on the ground that "the existing forms of transportation fill all our needs, and if you allow competition it will destroy our revenue. We are too important to be destroyed or hurt; we have expanded at the people's demand, and it is unfair competition to subsidize some other form of transportation to our disadvantage."

It will be observed that there is no thought anywhere in this argument that the people who have paid and paid to get transportation, who have allowed one form to supersede another (and always by subsidies), have any legal or ethical right to patronize that form of transportation which is of most value to them.

Let us see what this billion and a half dollars of which mention has been made, has been spent to accomplish.

About one-half of it has gone to the construction and maintenance of our harbors, one-third to flood control, and one-sixth for purely navigation purposes.

Out of this sum have been constructed the great harbors of Boston, New York, Philadelphia, and others on the Atlantic, ports on the Gulf,

the Pacific Coast, and the Great Lakes, and this money has been spent as much for the railroads as for any other system of transportation.

In a recent pamphlet issued by J. Hampton Moore, Ex-Congressman, Ex-Mayor of Philadelphia, he says:

"In what position would the Reading Railroad be if the Federal Government should permit the Delaware River to be closed by refusing to make appropriations for its improvement or maintenance? In the first place, the Federal Government would shut off approximately $50,000,000 a year which is collected at the Port of Philadelphia, not from the local taxpayers, but from the foreigner who is doing business with the United States. In the second place, without reference to the national influence of the Navy Yard on the river or the millions of tons of commerce that come and go, or the billion dollars worth of industrial business, including employment, done in one way or another on the river for the benefit of the railroads and all other business, commercial and transportation institutions, it would force the Reading Railroad or the Baltimore and Ohio, if it is to take over the Reading, to completely reorganize its business, with a possibility of unemployment the end of which cannot be foreseen."

This example could be multiplied ad infinitum.

Flood control projects cover, to some extent or another, practically every state in the Union, and particularly those of the Mississippi Valley; and the money so spent has been spent largely to protect the very valuable railroad properties lying parallel to, or behind the rivers. What would happen to these if the government ceased to spend money for flood control?

A very considerable proportion of what has been spent for navigational purposes solely, was spent before the advent of our railways, and present navigation has been brought about largely by funds spent for other purposes. Any project for flood control inevitably is bound up with improvement of navigation; and the vast sums of money with which the operators of transportation facilities on our inland streams are charged as subsidies is a palpable hoax. It is a more palpable hoax to attempt to charge these entire costs, as subsidies, to the Inland Waterways Corporation, an agency of the people, owned by the people, created by the people for the sole purpose of demonstrating that our whole national policy of 110 years regarding interior water communications has not been a colossal failure, but was a demonstrably good policy.

When the Inland Waterways Corporation was created in 1924—just about 6½ years ago—to make this demonstration, there was no hue or cry raised against its operations, because the opponents of water transportation were so immeasurably secure in the belief that interior water transportation was too moribund to be resuscitated, and the whole theory of promoting, encouraging and developing water transportation, while at the same time fostering and preserving in full vigor rail trans-

portation, seemed too fantastic for utterance. But when this organization was created, when it turned an annual operating deficit of a million dollars a year into an average net operating revenue of about $81,000 per annum, when, during the calendar year of 1930, despite an unprecedented period of depression, a long continued drought of such proportions as to become a national calamity, its net operating income was slightly more than $66,000.00; when the floating equipment upon our navigable streams involved hundreds of private, common, and contract carriers; when the total invested by such carriers aggregated a sum between a hundred and fifty and two hundred million dollars; when, in fact, the Inland Waterways Corporation was demonstrating what it set out to do, then began that insidious but persistent, and finally open, opposition, which has taken the virulent form of misleading the people into the belief that the success of water transportation means the destruction of railways, the lowering of their securities and bonds, and is generally a damnable ogre which should be destroyed. The same arguments which are being advanced are the arguments advanced by the opponents of railways in their early days, and the same arguments now being advanced by the Eastern Railways in their opposition to a new short rail line between New York and Chicago.

The arguments against completing the project of a main arterial system, with its ramifications extending outward from the main system in the order of their economic necessity (and only when in accordance with sound engineering principles), run about as follows :

1. That hundreds of millions of dollars have been spent to create navigable streams, in the vain hope that cheaper transportation would result from their utilization.

Speaking before the Atlantic Deeper Waterways Association, the then Secretary of War, Mr. Good, said:

"In the early days of our Government, the handling of commerce by means of shallow-draft boats upon streams in their natural state was in many cases the only means of transportation available into the interior of our country. Our people worked their way from the Atlantic Coast to the Rockies, building a nation as they went, the winning of each step forward being made possible by use of all available waterways. Many of our earlier projects provided for channels of but 4 feet, and in some instances of 2 feet and even 1 foot in depth. These depths were adequate to meet the needs of those times, but this is no longer true. Larger barges and boats are now required and the shallow draft channels have become obsolete, except in isolated cases where they are the only available means of communication.

"In computing the total expenditure of the Government on the improvement of waterways of this kind, their cost can not be charged up as a loss, as they paid for themselves many times over during the earlier years. Our waterway plan was not built in a day. It was a matter of growth. This was

so of necessity, for it would manifestly be a waste of public funds to undertake the improvement of all waterways at one time, regardless of the economic need. The only solution, therefore, was to build those parts of a waterway where the economic situation was such as to justify each section as it was built. However, we are now fast approaching the time when we can visualize the completion of the entire project and when the sums necessary for such completion can be provided without undue strain upon the Treasury."

2. That there is no necessity for such development, as the railroads are amply able to care for our expanding commerce.

Although it is undoubtedly true that the railroads can amply take care of our expanding commerce, it will be at such a tremendous expenditure as to be stupendous.

Between 1920 and 1930 it was repeatedly stated by prominent railway executives that the cost to the railways of keeping pace with our expanding commerce was approximately a billion dollars a year, and railway expenditures between those years approximately kept pace with this estimate. In order to raise this revenue there has been a persistent urge for increased freight rates, and this urge, and its accomplishment to a certain extent, has brought about a most unbalanced and unequitable situation.

The great central west, which we speak of generally as the Mississippi Valley, has been penalized to such an extent by these freight rates that it is decreasing in production, manufacturing, and population.

We, as a people, have gradually reached the sound conclusion that the prosperity of the nation is bound up in the prosperity of its component parts, and that when one section is penalized at the expense of another, when one section is prosperous and another impoverished, that it is the business of the nation as a whole to restore an economic balance.

This economic balance in the middle west can only be restored through the medium of cheap river transportation, in cooperation with rail and motor transportation.

B. C. Forbes, in the Finance Section of the Washington Herald of February 20th, quotes with approval the following letter from a correspondent :

"Whether intentionally or not, the present railroad policy, of giving the best service at the point where there is plenty of competition, is drawing to those points business which will have to be shared with others and is taking away from other points business which the railroads would get 100 per cent."

A manufacturer locates where he can assemble his raw material cheaply, and distribute his finished products cheaply-. When these costs get out of line, either for the assembly of raw material, or for the distribution of the finished product, he moves to some place where he can find these conditions, and always he moves to the lakes, the gulf, the sea-

coast, or our interior navigable streams. If on our interior navigable streams, he locates at that place where proper terminal facilities for interchange between rail and water and motor facilities exist.

The utilization of Mississippi River and its tributaries is restoring the economic parity destroyed by the diversion of traffic between East and West by the Panama Canal, and by the railroad policy outlined by Forbes, and if we cannot restore that economic parity, then the nation as a whole is bound to suffer.

There is a very vital relation between the prosperity of a city and its environing community. If a small city loses a large manufactory, by removal to some other city, or a, large city loses a number of its manufactories, it hurts the agricultural environment by the loss of that much of its market, and throws it into the position where it must reduce its output, or seek other markets where transportation costs put them at a disadvantage; and they may be compelled to sell at a loss, or even lose the market. This condition reflects itself in the purchasing power of the agriculturist, and this limitation of such purchasing power is again reflected in the failure of the city merchant to dispose of his stock promptly, if at all; and further, the railways lose transportation, to their disadvantage.

The reverse is true, as I shall demonstrate.

3. The third general charge is that the utilization of our interior waterways will result in a loss of revenue to the railroads, to their vital injury.

The utilization of our interior streams, as demonstrated by actual experience, does not result in a loss of revenue to the railroads, to their vital injury.

There is a cycle of transportation leading to saturation. This saturation point is reached for any city when the cost of collecting the raw material and distributing the finished product is greater for that particular city than for some other location; and it will inevitably result, as many cities have reason to know, in the abandonment of particular manufactories in that city, and the establishment of the same manufactories in some other more suitably located community, where the transportation facilities are not saturated; and almost always the new point selected is a city on a navigable stream, the lakes, the Gulf, or the seacoast.

Let us examine this cycle as it has worked out in Pittsburgh. The location of the steel manufactories at that particular point was determined by the fact that ore, coal, and other articles necessary to the manufacture of steel could be assembled there more cheaply than any place else at that time.

The establishment of the steel industry drew workers, naturally, who wanted the necessities, the comforts, and the luxuries of life. As the industry expanded, more raw material had to be collected, more finished products distributed, more workers and their families came, each of these causes contributing to an ever increasing demand for transportation. This cycle expanded continuously, until today Monongahela Eiver is carrying annually 26,000,000 of tons and the Pennsylvania Railroad, instead of being hurt, has four times expanded its Monongahela division, which is practically given over to freight handling. Other railroads have similarly expanded. What the river took away from the railroads in its handling of bulk commodities, it returned four-fold to the railroads in the creation of demands for supplies and distribution that could not be handled by the river alone.

When the railroads first entered the transportation field, in spite of the aid granted them by the Government, States, counties, communities, etc., through land grants, special privileges, and what not, the financial burden upon them compelled, as they pushed their way ever westward and northward and southward, that they create communities, towns, and cities to furnish them freight enough to pay their expenses of pioneering and expansion, and as unfettered competition sprang up amongst railroads touching the same points by various routes, began that system of rate making which is so involved and intricate, but which resulted in the creation of flourishing communities west of the Mississippi and east of the Rockies. The movement of freight into, and out of the states west of the Mississippi was enormous, and most of the railroads east of the Mississippi profited by it. It is largely the loss of this freight, brought about by the policy of which Forbes speaks, the forcing of competition, with the consequent necessity of dividing business amongst many carriers, which, if normally distributed, would go to single railroads, that is greatly responsible for the present condition of our Western carriers. Let us examine a recent example of what occurs when a navigable stream is properly utilized.

What located the great aluminum ore works at East St. Louis, Illinois, employing hundreds of men, and distributing its finished products all over the world? It was the cheap cost of transporting bauxite ore from the British Guianas by ship, thence up Mississippi River by the Federal Barge Lines. This great plant would never have been located there unless the Federal Barge Lines had given a water rate sufficient for the company to compete with Baltimore rates.

Who profits by the location of this plant at East St. Louis ? Every railroad which connects with East St. Louis.

How? Through exactly the same cycle as has been described for Pittsburgh. But here nothing was taken from the railroads. A new industry was created by which they profited.

4. The fourth general inclusive charge is that the waterways are subsidized, and that the Inland Waterway Corporation is in unfair competition with the railroads, that the railroads are unduly restricted by regulations, and that they pay part of the water saving.

The truth is, that waterways and railways, properly coordinated and cooperative, are indispensable to each other.

It seems strange to me that the railways should be so bitterly opposed to interior waterways, when this form of transportation is the only form that gives them back more and better traffic than it takes away. There would be more sympathy for the railways in regard to restrictive legislation, if they themselves could agree whether they wanted these restrictions removed or wanted to impose them on their competitors.

The charge that in our joint rates with the railroads they are compelled to absorb 50 per cent of the saving by water is too ridiculous to answer. Our policy is, where there is a comparable route, all rail, to a comparable rail-water route, that the rail line performing its part of the rail-water haul, should get as its proportion of the accruing revenue, precisely what it should get from its connecting rail carrier for the same service.

Where there is no comparable route, we insist that each participating carrier shall get for its share of accruing revenue for joint service performed, a *fair* share, bearing some real relation to the cost of the service performed. The charge that the waterways are subsidized, and for that reason, are in unfair competition with the railroads, falls of its own weight. It is an endeavor to becloud the real issue.

Although the Federal Barge Lines have had a net operating income since the inception of the Inland Waterways Corporation; although no money has been appropriated for anything except expansions of the line; although the corporation could exist and operate and furnish cheap transportation indefinitely on its net operating income; although it has saved the public millions of dollars, charts such as the one published in connection with Prof. Ripley's article are constantly being presented to lead the public to believe that it is being mulcted. It is well to note that the Inland Waterways Corporation has existed only since the latter part of 1924, yet the greater part of these charges apply to the total expenditures on the waterways on which we operate.

"Certainly the people have been taxed to create and maintain our navigable streams, our harbors, our lighthouses, etc., to accomplish a certain definite purpose, and since they have been taxed once to create

them, why, in order to bolster up a case of 'hidden costs' should they be charged again with 'tax exemption.' 'maintenance of waterways' 'interest and sinking fund on waterways,' 'interest on the corporation (their own) property'?"

The Inland Waterways Corporation is an agent owned by the people themselves, created by Congress to prove that, having taxed themselves to create navigable waterways, they can get that for which they have been taxed—cheaper transportation by water—something they had been unable to get for years, because water transportation had been destroyed by the railroads; and to saddle it in its pioneering demonstrative work, which is bringing back water transportation, with a preposterous system of charges which do not exist, which the people have willed should not exist, is to deny to the people the right to reap the benefit of the investment made.

But assuming that what our opponents claim should be charged against water transportation in the chart referred to are actually things which should be considered, let us point out the errors and discrepancies and let the reader judge whether they make a legitimate case.

This chart was evidently prepared from data contained in my annual report of 1928. Let us examine it.

It claims a "hidden cost" to the taxpayer of 0.7 mills per ton-mile on the ground of "tax exemption."

The total corporation "tax exemption," hidden cost as figured in this chart — .7 mill per ton-mile for 1928 — would amount to $1,066,741.90 or since the operating revenue for the year was $6,707,575.57, almost 16 per cent of the total revenue. According to statistics of railways in the United States, published by the Interstate Commerce Commission for 1928, taxes of class 1 steam railways were 6.37 per cent of the total operating revenues. Why charge the Inland Waterways Corporation almost 16 per cent tax exemption, or nearly three times as much as the railways are actually taxed? On the same basis that railroad taxes are calculated this "hidden cost" would be 0.26 mill per ton-mile.

But we have a better way of arriving at this than by comparison with railroad taxes; that is, by the actual taxes paid by common carriers by water in the United States. Out of 138 common carriers listed by the Interstate Commerce Commission on December 31, 1929, there were twenty companies which did not pay any taxes. The taxes paid by the remainder of the common water carriers amounted to only 1.55 per cent of the total operating revenues of these lines, instead of the 6.37 per cent paid by the railroads, and about 16 per cent charged against the Inland Waterways Corporation to make a case of "hidden costs." On the same

basis of taxation as other water carriers, the Inland Waterways Corporation would have paid 0.068 mill per ton mile, instead of 0.7 mill per ton mile, with which it is charged in the table for 1928.

On the basis of the original chart the "hidden cost" as given by the chart, of "maintenance of waterways," would be $2,773,528.94; "interest and sinking fund," $5,409,905.35; "interest on corporation property," $838,154.35 —a total of $10,088,330.54 —while the total freight revenue received by the corporation amounted to $6,445,353.70.

Why is this item "maintenance of waterways" charged to the Inland Waterways Corporation? According to a pamphlet issued by the Department of Commerce, there are 200 common carriers, 98 contract carriers and 187 private carriers, with a total value of $150,000,000, operating on the inland waterways of the United States. In 1928, to which year the table evidently referred, our value was approximately $16,000,000 or 10.66 per cent of the total invested on our inland waterways. Our proportionate share then (if such charge is legitimate) would be 0.19 mill per ton mile for maintenance of waterways, instead of 1.82 mills per ton mile. The interest and sinking fund on waterway (if such charge be legitimate) would be 0.378 mill per ton mile.

Our "interest on the corporation property" evidently is here figured at 5.5 per cent of our actual value at the time. As a matter of fact the government can get all the money it wants at 4 per cent, so our interest would amount to only 0.4 mill per ton mile.

Now add to the actual items the disclosed costs (which included a net income of $327,712.30) all that the table purports to give as hidden costs to get our final cost per ton mile, and we have:

	Mills per ton mile
Tax exemption	* .26
Maintenance of waterway	.19
Interest on sinking fund	.38
Interest on corporation property	.40
Cost paid for transportation	4.23
Total	5.46

* On the basis of taxation of other water carriers this would be reduced to .068.

This total of 5.46 is opposed to 10.85 mills per ton-mile of the chart, and opposed to the actual operating costs of the railroads of almost exactly 10 mills per ton-mile, which do not disclose any "hidden costs" to the public of the donation of land grants to the railways since 1850, amounting to 132,173,224 acres, or of the $40,000,000 per annum subsidy through Pullman subcharges, or other items to be mentioned later.

It would undoubtedly surprise the public to know that this "land grant" by the government to the railroads is a continuing subsidy, since in the fiscal year 1930 there were 62,249.29 acres of land certified or patented on account of railroad grants by the United States to the railroads precisely as they were certified or patented (or granted) in the early days. One cannot be certain exactly what the 132,000.000 and more acres were sold for, but according to an advertisement issued by the Northern Pacific Eailroad in 1871. the lands granted to the Union Pacific sold for $4.46 per acre: the school lands of the Illinois Central grant at $11 per acre, and the advertisement quotes an "average of $4 per acre."

The government price per acre at this time was given as $2.50 so that, taking this extremely low price, there is a "hidden cost" to the people of the United States of 132,000,000 acres at $2.50 per acre, or $330,000,000 given to the railroads to secure a "right of way," just as the money spent for rivers was given by the people to the people themselves to secure a "river right of way." The advertisement further states —"At only $2.50 per acre, government price, these lands (granted the Northern Pacific) will build and equip the road, leaving it free of debt, and place a surplus of twenty-five million dollars in the company's treasury."

Further, the rights of way thus given to the railroads by the government are carried in the value of the railroads, taken up as "investment in road and equipment," on which investment the people are requested to pay an additional 5¾ per cent return.

Not only were these land grants given by the government, but Texas, for example, donated many thousands of acres; counties and towns gave cash bonuses, or the proceeds of bond issues, for various purposes.

The people are entitled to the best form of transportation available at the cheapest possible rate, and if they desire to pay a part of the cost of transportation by highway, or by inland waterways, or by granting to the railways the present existing $40,000,000 subsidy of a surcharge on a Pullman ticket, they have a perfect right to do so. It would appear to be a much better policy on the part of all concerned not to attempt to mislead the people about hidden costs, but to furnish the best and cheapest possible transportation. Such transportation will come about through proper coordination and cooperation of all forms of transportation. It cannot be brought about by crying aloud that one form of transportation will destroy another, by bickerings, evasions of self-evident truths, or by unfair propaganda.

If one form of transportation is better and cheaper than any other, it will prevail, whether it destroys or partially destroys any other form or not.

There need be no fear of such contingency, however.

Personally, we believe that in giving the railroads the subsidies which have been mentioned, the people of the United States have done a wise and legitimate thing; we have no quarrel with the railroads—they are essential to our progress, and must be protected. It is only because they themselves have unfairly propagandized against so called "unfair and subsidized" competition, because they have attacked waterways, motorways, airways and pipe lines, that their attention is called to the fact that they, while living in a house of glass, have been caught throwing stones.

5. The charge that the railroads are being unjustly taxed to create a form of transportation calculated to hurt them has heretofore been answered by the Counsel for the Associated Industries of New York State in the following words :

"All property within the States is taxed, and the railroads are no exception to the general rule. The State not only has the right to tax property within its borders but it also has the right to spend the money so collected in the improvement of its highways, or for any other legitimate purpose. The suggestion that the State should not spend any tax money for the upkeep of the canal simply because some of the taxes are collected from the railroads is hardly to be taken seriously. By the same token the railroads might complain because some of the tax money is spent to build good roads. I might complain because some of my tax money goes to educate the children of my competitor. A street car company might complain because some tax money is spent to improve pavements over which taxicabs operate. Farmers might complain because some of their tax money is spent in the city. City dwellers might complain because some of their tax money is spent in aiding agriculture. And almost everybody might complain because Congress has directed that freight rates be made high enough to yield the railroads a fair return."

6. To the charge that thousands of railroad employees will be thrown out of business, if the waterways increase in their success, I challenge any railroad in the United States to quote one single instance where a. freight train has been removed from its schedule on account of purely water competition. Data collected by the St. Louis Chamber of Commerce, reading as follows, show quite the reverse:

"Referring to Annual Report of Rail and River Tonnage for 1926, * * * it shows that the increase in tonnage by all rail lines was 2.6 per cent and that the increase by the rail lines paralleling the Mississippi, increased 6 per cent. In other words, while there was an increase by all railroads of only 2.6 per cent, the lines in competition with the boat lines, show an increase of 6 per cent."

Such charges grow and bloom from statements like the following, issued by the N. C. & St. L. Railroad to its employees:

"Five years ago the N. C. & St. L. Railroad had 9,684 employees, now it has 6,807. * * * Consider, for a moment, what will happen if the present situation is not corrected—more employees will lose their jobs. * * * The railroads have a right to urge that its competition in the public transportation business shall not be unduly favored in matters of regulation, public safety and taxation. It has a right to equal conditions of competition; it asks nothing more. * * * You should study this pamphlet and undertake to interest your family and friends, and above all, urge your representatives in the Legislature to favor such laws as will deal fairly with the situation."

A very careful study of this pamphlet reveals not the slightest critism of our waterways, but of motor trucks and passenger vehicles. Nevertheless, extracted as I have extracted it, quoted in connection with attacks upon the waterways, the rank and file of the railway employees jump to the conclusion, or are deftly led to the conclusion, that the development of our waterways will hurt them by decreasing the number of trains. With cooperation, water development will increase the number of railroad employees.

A recent address by Mr. Rome C. Stephenson, President, American Bankers Association, who may be assumed to be an independent investigator, seems to me to confirm what has just been said. He hurls no charges against water transportation, although he does attack motor transportation and pipe lines.

The answer to the charge that the Inland "Waterways Corporation should cease to exist, lies in the law itself, which prescribes when and how it may get out of business. A reasonable compliance with this law will certainly expedite getting the government out of business, and if you still feel that the operation of our Federal Barge Lines is a menace to rail prosperity, I call upon you to advise your railway executives to comply willingly and sympathetically with the law, and help us all attain quickly what we desire, the retirement of the government from the transportation business.

Demand from them that they comply with the spirit and intent of the law known as the Denison Act, to cooperate with the waterways to their own advantage, and not try to turn through technicalities, a law designed to increase and expand our water carriers and rail carriers through cooperation, into a weapon to destroy what the people have willed should exist, a great coordinated, cooperative, rail, water, motor, transport system.

ELECTRICITY IN THE ILLINOIS RIVER VALLEY

BY
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North American Light and Power Company, Chicago

Since the earliest recorded history, the water courses of a nation have been the center of its grea.te.st industrial and social development. In early times, this was due to the fact that these water courses afforded facilities for transportation permitting the interchange of goods as well as the intercourse of people. This condition lasted for many centuries and it was not until the railroads were generally extended over great sections of any country that the use of the water courses became less important. Even with the railroad development, the rivers have not entirely lost their first great usefulness to mankind.

In the last few years, however, a new condition has arisen as a result of which the water courses have again become important as centers of great industrial development with attendant increases in population. The primary reason for this change is the great quantity of water required for industrial operations.

The increase of population in growing industrial centers requires increasingly large supplies of food and for that reason industrial development is most rapid even under our present highly efficient rail transportation system, in the agricultural portions of the country where inexpensive fuel is available for the industries.

These conditions are present in the Illinois Kiver Valley and have been generally recognized ever since Cavalier de La Salle made his report to Louis XIII to the effect that this area had the potential possibilities of becoming an empire as great or greater than the Kingdom of France, with all and more of the advantages which his own country had, made available to the growth of civilization.

LaSalle, however, did not even dream of the powerful agent which was to be discovered in later years, and which was to have probably the greatest effect upon industrial and social development of all of the great discoveries which have been known to man—the discovery of electricity and the development of its possible uses.

I have been asked to discuss briefly this development in connection with the Illinois Kiver Valley. In doing this, I have included the area

lying between Joliet and Alton and extending for perhaps 50 or 60 miles on either side of the main channel of Illinois River. This area contains approximately 10,000 square miles of which practically all the rural territory is rich farm land. Within this area are some 900,000 people, about half of whom live in prosperous and thriving communities and about half on the 42,000 farms throughout the agricultural portion. The many and varied industries require a total of approximately 375,000 horsepower for their operation. Horsepower used averages .42 per capita, which is indicative of the great industrial development that has taken place in this valley.

Power in some form has always been necessary for the development of any territory, and this is unusually true of the territory with which we are concerned. The need for this power was felt early in the history of the valley, and its development first took the form of water power. In 1830, a man by the name of John Green built a dam on the Pox Biver at Dayton, Illinois, and used the water power to operate a grist mill. In 1839, the State of Illinois built a new dam at this place for the primary purpose of delivering water to the Illinois and Michigan canal at Ottawa.

To the owners of the mill at Dayton, however, was reserved one-quarter of the water supply, amounting to about 475 horsepower, and with this supply, which was much greater than that available from the old dam, the Green family operated the first woolen mill in Illinois. It continued in operation until 1882 when it was converted into a pressed brick plant, which in turn continued to operate until 1901. This was the first general industrial development of power in the Illinois Biver Valley, although a number of smaller grist mill operations had been conducted on the subsidiary streams during this time.

In February of 1881, the Joliet Electric Light & Power Company was incorporated for the purpose of building a steam plant for the production of electricity. This date is earlier than that of the incorporation of the company that built the Pearl Street Station in New York City, which was the first one put into operation in United States for the commercial production of electricity. However, the Pearl Street Station went into operation in 1882 and the Joliet station did not begin to deliver electricity until 1883. In the year 1899 a power station was operated at Ottawa, Illinois, for the purpose of supplying energy to an electric street railway company. This was the first electrically operated railway in the State.

Initially in the electricity industry, energy was generated as direct current and could be distributed only short distances from the center of generation. With the development of alternating current and the im-

provement of insulation material, which permitted higher voltage generation, the area that could be supplied from the central station was greatly increased. Greater numbers of people learned of the advantages that could be obtained by the use of electricity and demanded service so that the engineers of the industry were required to develop rapidly methods of distributing this energy greater distances. This led to the transmission line. In 1893 a single phase line with a voltage of 1,100 was built from Elmwood to Yates City, and in 1901. a 33,000 volt line, with a type of construction very similar to that now in use, was built from Joliet north to Blue Island. These were apparently the first transmission lines in operation in this great river valley.

The development of the steam turbine probably had the greatest single effect upon the development of the electricity industry for the reason that it permitted the production of electrical energy with constantly decreasing quantities of fuel. The first turbines which were installed early in this century required from 4 to 5 pounds of Illinois coal to produce one kilowatt hour. At the present time turbines are producing as much energy with slightly more than one pound of such coal. The first turbines had capacities ranging from 1,000 to 5,000 kilowatts; at present turbines on single shafts as large as 160,000 kilowatts are in operation.

This development, resulting from the increased necessity of reducing the costs of generating energy and the ability to control high voltage have resulted in the concentration of energy production in large central power stations from which the energy is distributed over large areas. However, the production of this *energy* from large central stations requires enormous quantities of water, with the result that such large centers of production must be located where large quantities of water are available and if possible, near sources of reasonably inexpensive fuel supplies. For example, the city of Peoria requires approximately 8,750,000 gallons of water per day for its normal operations. The plant across the river from Peoria which supplies this area with electrical energy uses approximately 55,000,000 gallons per day or more than six times as much as the whole city of Peoria.

A typical example of a modern central production plant is that at Powerton near Pekin on Illinois River. This station has a present capacity of approximately 225,000 kilowatts and another unit of 110,000 kilowatts will shortly be installed. It has a proposed ultimate capacity of more than 500,000 kilowatts and requires at the present time the enormous quantity of 240,000,000 gallons of water per day for its operation. It is the most efficient power station in the world, so far as records can be

obtained, and it is without question the most efficient power station in the United States.

The Powerton plant is one of the sources of electrical energy supply for the Illinois River Valley area. The plant across the river from Peoria with its capacity of approximately 60.000 kilowatts is another major source of such supply. A number of smaller plants are located in the Illinois Eiver Valley area, and the total available capacity of such stations for this territory is approximately 535.000 kilowatts.

By means of the transmission line network which extends through the valley, these stations are interconnected with the enormous pool of power in the Chicago area which has a capacity of almost 1,500,000 kilowatts. They are also connected with the great St. Louis pool, which is interconnected with the hydro-electric plant at Keokuk and will shortly be connected with the new great hydro-electric development at Bagnell, Missouri, when it will have a total available capacity of 550,000 kilowatts.

Energy is distributed in this area largely by 66,000 and 33,000 volt transmission lines. The main trunk line which follows generally the Illinois River Valley from Pekin to Chicago operates at 132,000 volts. There are more than 6,600 miles of transmission and distribution lines in this area, which deliver energy to 200,000 consumers.

The construction of these large central stations, high voltage lines, and distribution networks is enormously expensive, as evidenced by the tremendous increases in capital investment which are necessary from year to year to provide equipment to meet the growing demands of the people for electric service. More than ten billion dollars worth of this equipment is now in use in this country and nearly one billion dollars are expended annually in order to keep pace with the growing demands.

Of necessity the new developments which require these enormous sums of money must be made with a capacity far in excess of the present requirements. It would be extremely improvident to build for today without giving careful consideration to the demands of tomorrow. This fact presents a very serious problem to the management of the electricity supply companies, that of making rates for the sale of electric service so low that the greatest possible number of people and industries may have the advantages which electric service brings, yet of maintaining the rates sufficiently high that a reasonable return may be earned on the initial investments which have been made to provide for future demands. The gentlemen among you who are connected with the operation of manufacturing plants know the effect of mass production on the cost of making and distributing a product. It is upon the effect of mass production and distribution that the electricity supply industry is de-

pending to make these expenditures for the future successful, from a financial standpoint. The manufacturing industry which is producing electricity for its own use does not usually consider the fixed charges on the investment in its power station as' a part of its total cost of power. A great many times this investment has already been written off out of the profits of the industry. This is not true of the electricity supply business and at times it becomes very difficult to supply electrical energy from a super-power network; at a rate which must include the fixed charges on the investment, to an industry which considers as the total cost of its own electricity only the operating charges necessary to manufacture it. However, the fact is patent that as these industries grow they will require additional power facilities when the fixed charges will become an obvious element of the power cost. As the electricity supply from a, super-power system grows, the amount of investment which must be charged per unit of electric service becomes continually smaller, and therefore, the power supply company will continually improve its position in respect to being able to deliver quantities of energy to manufacturing plants at costs attractive to manufacturers. Of this gradual change in the economic relation of power supply to the industries, I invite the serious consideration of those gentlemen who are responsible for the lowest possible costs of their manufactured product.

Of the total power requirements of the industries in this Illinois Valley area, amounting to 375,000 horsepower, 300,000 horsepower is operated electrically and of this latter figure, approximately 250,000 horsepower is supplied from this distribution network. This indicates the extent to which the business men in charge of these industries realize the advantages of the uses of electrical energy.

However, these uses are not confined to the urban population and to these industries. There are approximately 42,000 farms in this area. Ten years ago, only a very few of these farms were supplied with electricity, but at present time more than 5,350 of them or 12.7 per cent of the total number, are supplied. This percentage compares very favorably with that of the entire State of Illinois, which is 9.8 per cent of the total number of farms in the State. Farm homes are demanding electrical service and rapid progress is being made in connecting them.

It is an aspiration of the men who have given their lives to the development of an adequate and economical supply of electricity, that within a reasonable time there shall not be one single home, business establishment, or industry which shall not have at an economical cost the advantages that electric service from a super-power system can bring. This conception is almost unbelievable in its far reaching possibilities. We do not realize that although there are more than two hundred thou-

sand users of electricity in the Illinois Valley, yet even at the present cost of electric service which is generally lower than it has ever been in this history of the industry, in 65 per cent of the homes in this area, the old dust raising broom is still used for sweeping floors; in 75 per cent of the homes the old-fashioned washboard and wringer are still in use; in 96 per cent of the homes in towns that have no gas supply the old fashioned range is still operated when the same wire that brings the light to the home could also furnish a fuel available at the turn of a switch which would cook more efficiently than either coal or wood.

That is generally the case, but suppose we look at the rural communities. Only 13 per cent of the homes have electric service and in only 9 per cent of these homes is electricity used to sweep the floors or help' in the other household work. Less than 7 per cent use electricity for pumping water into the house. In only 4 per cent of the farm homes is there an electric cooking range. The power separator is used in less than 3 per cent of all the farms and in only 2 per cent are there electrically driven sewing machines.

In the industries, however, the use of electricity is further advanced. Based on the report of The Power Survey Committee for the Great Lakes Division of the National Electric Light Association it has been determined that in 1920 there were approximately 180,000 horsepower of electric motors in the Illinois Eiver Valley connected to super-power service. Based upon the rates of growth over the past twenty years, by 1910 or nine years from now, there should be a total horsepower installed in the industries of the Illinois Eiver Valley of nearly one million. If by that time only one-half of this large amount of motive power were supplied by the super-power networks, this would still be approximately twice the present amount of motive power supplied and would represent an increase of more than 250,000 kilowatts for these industries alone.

In addition to these uses there will be special developments in the use of electricity, for the electrification of railroads, the development of the wireless communication systems and for the operation of devices which are even now only in the process of being discovered.

There is a new civilization being developed here in this great country of ours. A civilization, not built as those old civilizations were, on the slavery of human muscles, but founded upon the development of natural resources and upon the power and energy of ions and molecules controlled through the knowledge obtained from the advancement of the physical sciences: a far more stable and enduring foundation than that above which the civilization of Greece and Rome towered and finally fell when their foundations of human slavery crumbled.

President Hoover is quoted as saying "As we furnish power at less and less cost and as we increase the volume of its supply, we decrease the sweat of men and the drudgery of women." So we may look forward to a time not so distant in the future when by means of these great super-power networks, if they are permitted to develop unhampered by the narrow prejudices-of short-sighted political leaders and may have the continued intelligent supervision of State regulating bodies, the whole Illinois Valley will be so completely, adequately, and economically supplied with electric service that the physical toil in the home and in the industries will be practically removed and this great social and industrial development of ours, so far ahead of that of any other country in the world, will reach a point almost unimaginable in the growth of industry, and in the comforts of living.

LAND UTILIZATION IN THE ILLINOIS RIVER BASIN

BY

CHARLES L. STEWART

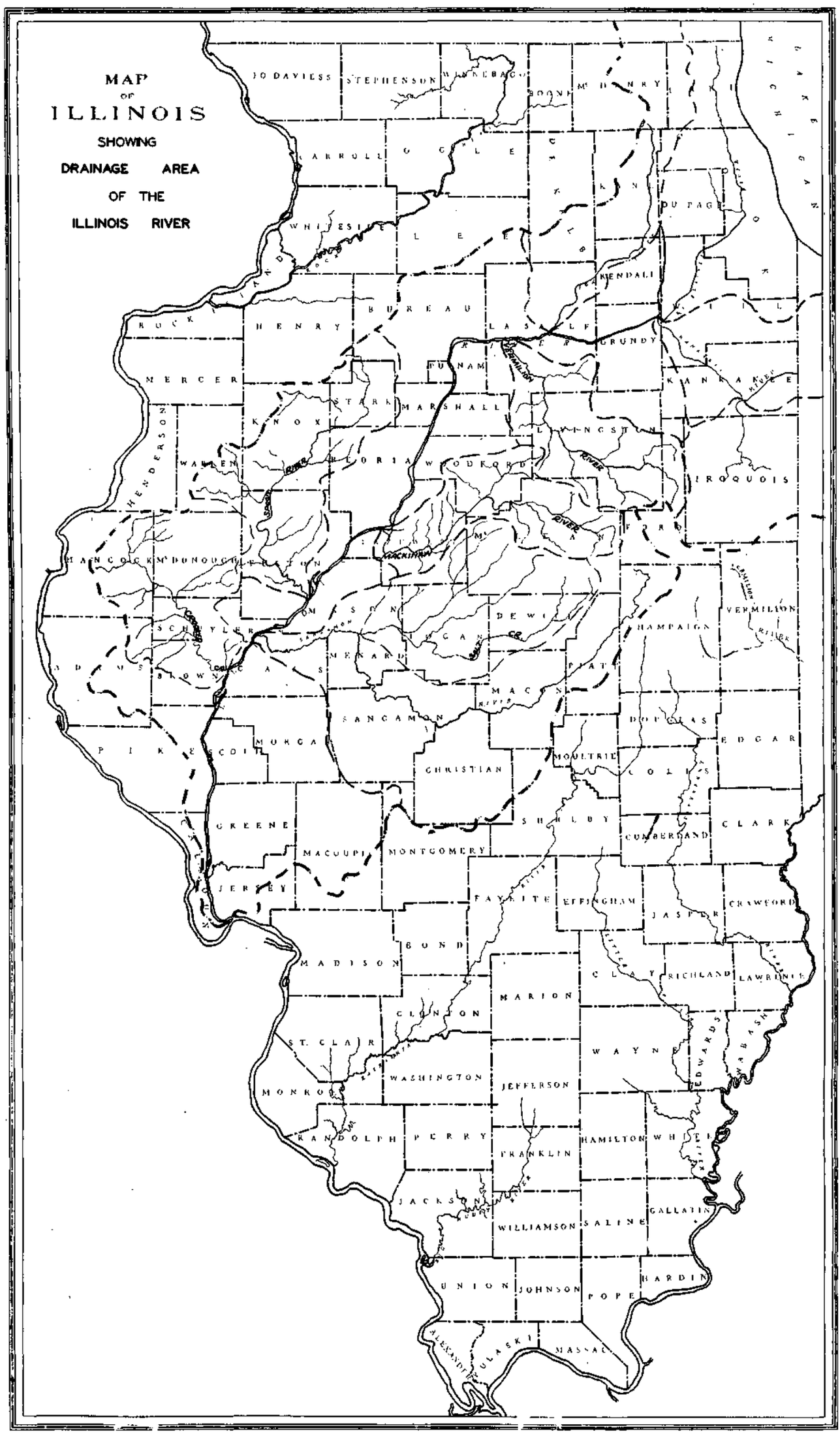
University of Illinois, Urbana.

The Illinois River system serves as an outlet for an entire area of 26 Illinois counties containing nearly nine million (8.747.520) acres, and for parts of 27 additional counties. In those 27 counties more than 6½ million (6.695.680) acres are estimated to be drained by Illinois River and its tributaries. The l5½ million acres in the 53 counties of Illinois which send their water to Illinois Kiver constitute all but 14 per cent of the total area drained by this river and its tributaries. Nine counties in Indiana and four in Wisconsin also contribute, the former through the Kankakee and Iroquois, the latter through the Pox and Des Plaines rivers. The total area drained through the Illinois River system is equal to 50 per cent of the 35,867,520 acres of land in Illinois. Illinois Kiver drains 43 per cent of the State and the area in all counties drained entirely by the Illinois Kiver system is 25 per cent of the State.

Nine main tributaries empty directly into Illinois Kiver. These are the Kankakee, Des Plaines, Fox, Vermilion, Mackinaw, Sangamon, and Spoon rivers and Crooked and Macoupin creeks, each of which drains more than a half million acres. Two of them, in their turn, have large tributaries—the Kankakee has the Iroquois Kiver, and the Sangamon has its South Pork and Salt Creek. Counting these tributaries the Kankakee and Sangamon each drain more than 3¼ million acres.

In addition to the nine main streams feeding directly into the Illinois there are many small ones. The amount of land served by this immediate drainage is 7,055 square miles, which is nearly one-third of the Illinois area served by the river.

With this background, we may turn toward some of the questions of land utilization in the watershed of Illinois Kiver with its outreach into the heart of one of the nation's most important agricultural regions. According to computations based on the 1930 census figures which have become available for the first time within the past ten days, the 26 counties dependent entirely upon Illinois Kiver drainage had 95.4 per cent of their land area in farms. It would be difficult to find a more complete utilization of land in agriculture than in some of these counties.


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

Using as our basis all land in farms, it appears that 73.5 per cent of it was crop land in 1929, 22.2 per cent pasture land, 1.1 per cent woodland not pasture, and 3.2 per cent all other farm land. Taking the 6 million (6,155,190) acres of crop land by itself, 94.3 per cent was harvested in 1929, 2.8 per cent had crop failure, and 2.9 per cent was idle. For so large an area as a whole, less idle or failure land could hardly be expected in that year of considerable overflow.

The 1929 ratios of crop land which were classified as failure and idle land were larger in the lowland counties. Counties in which more than 5 per cent of the crop land was classified as having crop failure that year were as follows: Cass, 8.1; Logan, 7.5; Schuyler, 6.9; Mason, 6.3; Fulton, 5.4; and Menard, 5.0 per cent. Idle crop land was similarly prominent in Greene, 10.6; Scott, 8.3; Cass, 7.2; Schuyler, 6.5; Brown, 5.8; and McDonough, 5.5 per cent. When both types are added together, Cass with 15.3; Greene, 14.6; Schuyler, 13.4; and Scott, 11.9 per cent take the lead.

Taking the nearly two million (1,843,761) acres of pasture land by itself, 45.5 per cent was plowable, 33.7 per cent was woodland, and 20.8 per cent was neither woodland nor plowable. Of the 7½ million (7,524,726) acres of pasture in Illinois as a whole, 55.5 per cent was plowable, 26.5 per cent was woodland, and 18.0 per cent was other pasture land. Woodland occupied a larger relative place in the 26 counties than in the rest of the state, this being due in considerable measure to the fact that land broken by streams normally carries a larger proportion of woodland.

For the period 1925 to 1930, the trends in land use in the 26 counties may be summarized as follows:

Area of all land in farms increased 2.0 per cent in the basin and decreased 0.1 per cent in the state as a whole.

Harvested crop land decreased 0.2 per cent in the basin and 4.4 per cent in the state.

Crop failure land increased in both basin and state, 6.0 and 13.0 per cent, respectively.

The same was true of idle land, but increases were much more marked, being more than 340 per cent in the basin and nearly 70 per cent in the state.

Woods pasture was increased 3.0 and 5.0 per cent, respectively, in both basin and state; plowable pasture increased in the basin 3.5 per cent but decreased 0.2 per cent in the state; other pasture increased 7.0 per cent in the basin and 10 per cent in the state. The fact that this permanent pasture on non-tillable land increased in the basin more markedly than did both plowable and woodland pasture, and that all

pasture increased 4 per cent in those counties is all the more significant when viewed in the light of reduced acreage of land in harvested crops. It is only as the increased area of crop failure and idle crop land is included that it is possible to say that the area of crop land was increased in the basin.

This comparative stability in the utilization of the land in the parts of Illinois referred to may be somewhat surprising in the light of the subsidence of land valuations. In 1930 the estimated value of the average acre of farm land, excluding buildings, in the 26 counties was less than that of 1920 by 46 per cent. In the state as a whole the decline was nearly 50 per cent. Almost exactly half of it occurred between 1925 and 1930.

This decline was not confined to any part of the basin territory. Only one county, DuPage, failed to show a decrease. Counties of lowest valuations in 1920, such as Brown, Greene, Schuyler, Mason, Scott, Cass, and Fulton, had rates of decrease somewhat smaller than counties having high valuations in 1920. The decreases in counties such as McLean, Livingston, DeWitt, Woodford, Logan, and LaSalle, ranged from $145 to $182 per acre. Decreases in lowland counties were about $100 less per acre. This was probably a result of a tendency for the upland counties to be vastly overvalued in 1920, a condition which applied to limited portions of the lowland counties, also. The land especially suited to corn and wheat, whether in the reclaimed areas or in the uplands, was outstandingly overvalued in 1920. Township figures on Illinois farm land valuations have been published for 1920 for only the counties near Chicago, but figures for 1930 will shortly be available for the entire state. Although no such comparisons with 1920 figures will probably be available for most of the 26 counties included here, there-is little doubt that shrinkages in valuation in drainage townships have in many cases been very severe.

The valuation of buildings on the farms of the 26 counties, as in the state as a whole, held their own from 1920 to 1930. In 1930, for the first time we are able to know the valuation of farm dwellings apart from the barns and other buildings. Farm dwellings averaged $2,185.50 per farm in the 26 counties, an amount larger by $391.30, or 18 per cent, than in the state as a whole. In general, the other buildings had a valuation as large or slightly larger than that of the dwellings.

It has been suggested that the valuation of farm real estate had much to do with the proportion of farm land that found its way into tenant operation. Farm tenants were found operating a larger proportion of the farms where acre valuations were high and this is the present situation to a considerable degree. The percentage of farms operated by tenants

in the 26 counties in 1930 ranged from 36 in Brown to 67 in Grundy. In 14 of the counties more than 50 per cent of the farms were tenant operated. In four of them. Grundy, Logan, Livingston and McLean, the percentage exceeded 60. Outside of the United Kingdom there is probably no other equally large area in which, in the absence of differences in race or caste, such large proportions of the farm real estate are in tenant hands. It is precisely in the counties of most valuable real estate that tenant operations have reached largest prominence.

The decline in land valuations has not brought a decline in prominence of tenancy. In fact, decline in proportion of farms rented, from 1920 to 1930, was found only in Fulton, Mason, Peoria, Morgan, and Livingston counties. The largest change was less than 2 percentage points in any of these five counties. The 21 counties showing increase in tenancy also showed relatively small changes in most instances.

Information as to land mortage indebtedness on farms is not yet available from the 1930 census, but it is probable that a larger proportion of owner farmers have mortgages and that the ratio of mortgage debt to real estate valuation is higher than at previous census dates.

Land tax delinquency for 1929 has been ascertained in 10 of the 26 counties. The amount of taxes on land sold in 1930 for 1929 general taxes ranged from $1,484.58 in Menard County to $42,428.19 in Schuyler, the total being $104,851. This was 81 per cent more than the corresponding figures of three years before.

The land in drainage enterprises comes in for special attention in any study of land utilization in watersheds. The 1930 census includes information for 22 of the 26 counties in a form comparable to that collected in 1920. The acreage reported in 1930 was 994,327, an increase of nearly 30 per cent over the 771,312 acres reported in 1920. This is a rate of increase slightly in excess of that shown for the state as a whole. It indicates little, in the opinion of the writer, inasmuch as the more accurate survey of 1928 made by Professor G. W. Pickels and associates at the University of Illinois, showed 10 per cent more land in active drainage enterprises than even the 1930 census shows.

The fact that only one-fifth of the drainage district land of the state is in the 26 counties may seem strange. One of the counties which drains partly into the Sangamon, namely Champaign county, has nearly half as much acreage in drainage districts as the entire 26 counties.

In the case of the land served by both drainage ditches and dikes, or levees, the situation is more critical. Testifying before the Committee on Irrigation and Reclamation, U. S. House of Representatives, in April, 1930, there were few officials of state associations of drainage and levee

districts who painted a more dismal picture than did President J. P. Kerr, of Illinois. He pointed out that:

"In the first place agriculture has not been a paying business. This has been especially burdensome on drainage district farms. . . . Since 1920 until the present year, there have been storms and floods, wet seasons on such a scale and to such an extent never before equalled in the history of the state. . . . These flood conditions, as they have continued year after year during the last decade, have greatly weakened, and in many cases destroyed, original levee works, and have caused a vast acreage of land in side levee districts to be unproductive because of water-soaked soils.

"In years past drainage bonds sold at a premium and promptly. Today such bonds will not sell at all, or only in very rare cases, where they will sell at a high rate of interest."

The distinction between upland drainage districts and lowland drainage districts becomes important at this point.

The capital invested in drainage enterprises, as reported by the census of 1920, was $43,595,069. In 1930 the aggregate is given as $74,333,065. The average per acre was about $11 in 1920 and nearly $15 in 1930. In upland counties such as Champaign or Ford the capital invested per acre has been below these averages. In some of the lowland counties, however, the amounts run several times as high. In Peoria county, for example, 6,446 acres in drainage enterprises were credited with a capital investment of $484,935. Where the reclamation outlay has been so large, it is only in the rarest instances that carrying charges have been easily met.

Data supplied in tabular form to Congressional committees last year may be summarized as follows for the 15 drainage and land districts included along Illinois Eiver from Hennepin to Grafton:

Number of land owners	1,164
Acres in districts	99,319
Acres in cultivation	94,936
Acres cleared, not cultivated in 1930	1,775
Assessed valuation	$3,872,174.00
State and county taxes, 1930	$82,793.80
Drainage taxes, 1930	$331,340.24
All other taxes, 1930	$35,000.00
Acres delinquent, 1930	5,529
Drainage bonds outstanding	$2,437,164.87

Of the land in the Illinois valley levee and drainage districts included here, 95 per cent was in cultivation. In 20 other districts for which information was given in the House hearings, only about 20 per cent was in cultivation. Even so $4.50 an acre taxes on land producing staple farm products has been an enormous load in periods of low prices and high costs.

It is evident that these lowland drainage districts represent for the most part investments which reflect agricultural hopes of the period before 1920 rather than realizations of the period since. A post-war land utilization reversal has struck many of these enterprises a staggering blow.

Suggestions that a cleaned river will mean the reappearance of new uses for the flood plain areas are all about us. Will restored lakes in some cases afford the quiet waters needed by young fish when inland fisheries again become prominent on Illinois Eiver? Will recreational uses, private, commercial, and public, take in some of this area to the relief of the drainage farmers ? Will a. rewriting of the bonded indebtedness on a basis of slower amortization and a tempered interest rate help to stabilize the situation for existing owners and operators of drainage land?

Whatever the answers to these questions may be, five points seem to the writer to be worth the serious attention of our students of theoretical and applied economics.

(1) The river drainage basin as a differential area in land utilization studies, although less significant in the heart of the corn belt than in many other regions, may, nevertheless, be recognized as having an economic as well as legal unity, the importance of which is to be noted especially when the dominant upland portions of the basin throw their run-off upon the servient lowland portions with exceptionally widespread damage in flood-plains of the river itself and of its principal tributaries.

(2) The economic relation of dominant to servient areas presents more acute problems in the valleys of the Mississippi and its tributaries, most of them notably muddy rivers, than in the valleys of the clear rivers of England, with respect to which the common law conceptions which we inherited were developed. With our more spasmodic climate, with flat areas provided with tile and ditch drainage, and with the removal of forest and other cover which might delay the run-off of rain and melted snow, the servient areas are called upon to aid the dominant areas in a degree beyond that of earlier years. This relationship holds to some extent in the more outlying watersheds and to an especially marked degree in the downstream areas. It is difficult to base State and Federal participation in the cost of river control upon a. formula expressing indisputable equities, but a considerable degree of such participation is ordinarily justified.

(3) Shifts in prices, without corresponding changes in drainage, levee, and general property taxes and in interest charges have placed former overflow land at a comparative disadvantage, so that in utiliza-

tion they can not compete equally with lands having better natural drainage.

(4) Districts overwhelmed by delinquencies might in some cases be taken over advantageously for purposes of general river conservation.

(5) A comprehensive study of the situation in the original flood-plain of the Illinois and some of the tributaries to the end that an adequate public policy may be formulated is plainly needed. Data concerning land utilization, land valuations, and some other subjects will shortly be available not merely on the county basis, which only crudely fits the need of the problem, but also on the basis of townships. With 1930 census results analyzed for the 1860 or more minor civil divisions of the state—without expense so far as many of the more important lines of information are concerned—and with additional information as to soils, drainage, and other problems already assembled in the Agricultural and Engineering Experiment Stations, in the State Geological, Natural History, and Water Surveys, the State Departments of Agriculture and Conservation, and elsewhere in the various state institutions and administrative agencies, the informational basis for a replanned use of the troubled lands and waters should be laid readily and well. The return of a clean river, with increased flow of water at least in all but flood periods, may open the way for a utilization less wasteful, less competitive with agriculture in the uplands, and better adjusted to the needs of the state.

SOME PROBLEMS IN FLOOD CONTROL

BY

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INTRODUCTION

Flood problems are as old as civilization. History, tradition, and the remains of prehistoric structures disclose the work of man for flood control. Natural stream channels are developed and continuously modified by erosion and deposition of soil materials. Steep slopes produce velocities of greater eroding and transporting power. Soil materials are disintegrated and reduced to smaller particles by the rubbing and grinding incident to the movement by flowing water. In alluvial valleys, stream channels develop bank-full capacities approximately equal to the average annual flood discharges. Maximum floods exceed the average annual flood by two to ten fold. The channels of streams which have frequent floods and greater annual flows are more stable, other things being equal, than those which have lower annual.flows and occasional great floods.

WATER

Water, the universal solvent, occupies a most prominent place in the scheme of nature and in the life and attainments of man. It is found and used as vapor, liquid, and solid and is combined with other elements into innumerable substances in nature or produced in the kitchen, laboratory, or factory.

Water occupies three-fourths of the earth's surface. Water vapor, evolved from the water surfaces, is carried by warm air currents and is precipitated as rain or snow when condensed by mingling with colder air currents.

PRECIPITATION

The distribution of precipitation (rain and snow) on land and sea follows nature's laws, but due to varying conditions of climate, including effects of temperature, air currents, and the topography of the land, precipitation ranges from practically nothing on so-called arid areas to a maximum depth of 25 feet-or more annually. The annual range of precipitation in this locality—Peoria, Illinois—is from about 20 inches to more than 60 inches.

The time and amount of precipitation are not within the control of man but by study of the accumulated meteorological records many of the laws, conditions, and forces influencing precipitation have been identified and satisfactorily accounted for. so the time, location, and amount of precipitation may be predicted with some degree of assurance. However, the future occurrence of excessive precipitation can only be anticipated by applying mathematical theory of probabilities based on recorded experiences. The records frequently are too few and their accuracy only approximate. The first problem in flood protection or prevention is *precipitation, its duration, amount, intensity and local distribution and the prevailing temperatures.*

RELATION OF RAINFALL TO RUN-OFF

Destructive floods on small streams are produced by excessive rainfall, frequently referred to as cloudbursts, and on larger streams by prolonged rainfall of unusual intensities over large areas. In the temperate zones, snow is frequently melted by warm rains and adds to the spring freshets. In the Mississippi Valley, spring and summer rains follow in cycles of about one week and the great floods follow unusually heavy storms when the ground is frozen or saturated and the channels full from previous rains. Our second problem is therefore the *relation of rainfall to runoff.*

PUBLISHED DATA

Eainfall and stream flow data have been collected and published by the U. S. Weather Bureau and the U. S. Geological Survey for many years. This work is supported by the states and supplemented by cities and other public and private interests. These data as they apply to each stream are used in flood control studies. Estimates of probable flood discharges and frequency are based largely upon the daily flow of the stream, if it has an acceptable record for ten years or more, using mathematical probability curves found to most nearly follow the flood experiences with similar areas having longer records. In some eastern states flood-flow records are available for more than one hundred years. In Europe some records cover three hundred to five hundred years.

For streams with few or no flow records, flood flows are estimated by analogy from data of other watersheds. Eainfall records cover much longer periods than stream flow data. The relation of rainfall to run-off where both are known furnishes a basis for the extension of flood predictions and their application to similar watersheds similarly situated.

GEOLOGICAL AND TOPOGRAPHIC FORMATIONS

The geological formation and topography of a watershed, and the prevailing temperatures are next in importance to rainfall in determ-

ining flood flows. Open, sandy, level land will store much water which flows underground and does not contribute to floods. Frozen, heavy, or rocky land will absorb little and the major portion of all rain produces flood flow. Lakes and reservoirs and overflowed valley lands store or detain surface flow. The third problem in flood control studies may readily be the *storage capacities underground, in lakes and reservoirs, and on low level lands,* and their bearing upon the relation of rainfall to run-off.

EROSION AND TRANSPORTATION OF SOIL MATERIALS

Soil materials, clay, silt, sands and gravel, are eroded from the hillsides, transported by flowing water to the valleys and deposited where the velocities are retarded. These eroded materials are carried along by the streams and deposited in the valleys, thus forming plains or deltas of alluvial soils which are the most fertile agricultural lands. Cultivation exposes the surface to erosion. In rolling and hilly areas terracing is applied to prevent erosion. This method of cultivation also detains the rain on the ground longer than farming on natural slopes and reduces floods from such areas. Erosive velocities are to be avoided as far as practicable in channel improvement for flood relief.

The fourth problem therefore in flood control may refer to the consideration of *methods of prevention of erosion and transportation of soil by surface waters and streams.*

DIVERSION FROM LAKE MICHIGAN

During the past thirty years an average of about 8,000 cubic feet per second of water has been flowing from Lake Michigan through Chicago River and Chicago Sanitary and Ship Canal into Des Plaines Eiver at Lockport, thence through Illinois and Mississippi rivers to the Gulf. This flow has been practically continuous and frequently when Illinois Eiver and its tributaries are in flood, the flow from the sanitary canal at Lockport has been more than the average. This diversion from Lake Michigan into Illinois Eiver has increased the flood hazard and increases the cost of flood protection works.

The stages of Illinois Eiver have been increased by diversion from Lake Michigan through the Chicago Sanitary and Ship Canal about 5½ feet at low water and about 1½ feet at high water on the Peoria gauge. The high water stages of the Illinois are increased by diversion from Lake Michigan about 1 foot on the Beardstown gauge since the levees were built and from 5/10 to 6/10 of a foot before the levees were built.

ILLINOIS FLOODS IN RELATION TO NAVIGATION

Illinois Elver is being improved by the Federal government for a 9-foot navigable depth at low water with an 8-foot gauge height at Peoria. Five dams with navigation locks are located in the upper Illinois and Des Plaines rivers as follows: at Starved Rock above LaSalle; at Marsailles; at Dresden Island, below the junction of the Kankakee and Des Plaines rivers which form the Illinois; at Brandon Bridge, below Joliet; and at Lockport, the west end of Chicago Sanitary and Ship Canal. This plan was based upon a flow from Chicago Sanitary and Ship Canal of about 6,500 cubic feet per second through the controlling works at Lockport during low water in Illinois Eiver. It may be necessary to" continue to maintain dams and locks in the lower Illinois River to sustain a navigable depth of 9 feet if the diversion is reduced to 1,500 cubic feet per second, as indicated by the decision of the Supreme Court a few months ago. Four dams have been maintained in Illinois Eiver for a navigable depth of 6 or 7 feet and experience has shown that these dams have had no material effect on flood stages. The dams in Illinois Eiver between Lockport and Starved Bock are designed with gates so that the flood stages are not to be increased. The construction and maintenance of dams for navigation in Illinois Eiver therefore are not considered to present any new flood-control problems.

FLOOD PEEVENTION AGENCIES

Flood prevention in its early stages was by individual initiative. A landowner, to protect some cultivated area from overflow, constructed small levees. This was followed by other owners acting individually or by mutual agreement and subsequently by organizing taxing districts for constructing and maintaining such work. In the Illinois Valley a number of small private levees were built by individual owners before the State Legislature enacted laws for the organization of levee districts with taxing powers. All levees along Illinois Eiver are now under the levee laws of the State. Other states in the Mississippi Valley have enacted similar laws.

Along Mississippi Eiver and some of the larger tributaries the flood areas extend into two or more states. Portions of 31 states, 40 per cent of the entire area of the United States, drain through Mississippi Eiver, and the Mississippi flood problem has been recognized as national in scope since the United States came into possession of both banks of the river. Numerous reports have been made under authority of Congress, from 1850 to the present time. The Chief of Engineers of the United States Army has recently made a report to the Secretary of War with recommendations for the completion of the flood control work on

Mississippi Eiver from Cape Girardeau to the Gulf, substantially as authorized by an Act of Congress in 1928 following the disasterous flood of 1927.

The Illinois Legislature, since the flood of 1926-1927, in recognition of the public interest and the public benefit resulting from the protection of the property of its citizens, has appropriated more than $3,000,000 for flood relief and flood protection, a large portion of which applied to the Illinois Valley.

The agencies of flood control are therefore (1) the owners of the land, acting individually or collectively, (2) the district or municipality, (3) the State and (4) the Federal Government, each contributing its proportionate share as the benefits may appear.

ENGINEERING METHODS OF FLOOD BELIEF

Three general methods are employed for flood relief works, namely,

1. Channel improvement giving greater carrying capacity.
2. Levees for protection from overflow with resulting increased flood heights.
3. Storage in holding reservoirs or in detention basins.

The first two methods, cha,nnel improvement and levees, are the most commonly used, but each method produces new problems and frequently may produce new flood hazards. Alluvial valley stream channels are unstable. In streams of steep valleys the bed and banks are being eroded continuously. Some portions of the bank are removed and deposited in an eddy forming bars at down-stream points. In this way the stream 'tends to lengthen and establish itself on a flatter gradient with a more stable channel. When bends are cut, the velocity is greater, erosion is increased and channel protection is required to maintain a stable channel. The usual effect of stream straightening in this locality is for the channel to widen by erosion and become filled by the coarser sand and gravel so that in a few years it is necessary to re-excavate a portion of the channel to have the water-table in the adjacent valley low enough for agricultural drainage.

Levees remove overflowed land from the floodway, increasing flood heights, first, by reducing the storage area available and making it necessary for the floods to pass through the valley in less time and at greater rate of flow; and second, by reducing the flood cross-section of the stream thus causing the river to rise higher between the levees to overcome both of these restrictions.

Storage, in order to be effective in reducing floods, must be empty when the floods come. On the other hand, conservation of flood waters for municipal and power purposes, for irrigation or for maintaining

navigation through the low water periods requires that the storage reservoirs be maintained full because the time and amount of precipitation can not be predetermined. Therefore, flood control through detention and storage reservoirs that are to function for conservation of the water, must be a compromise.

The engineering methods that are to be employed therefore depend upon the economic conditions and will change as population and industrial enterprises in the Illinois Valley increase. It is reasonable to anticipate that within the next two or three decades the industrial development in the Illinois Valley will call for the conservation of the flood waters and will result in helping to solve some of the flood control problems in connection with our water supply developments.

DETENTION AND STORAGE RESERVOIRS

Flood prevention by storage has been applied successfully on many streams in Europe. The most striking example in America is the flood detention reservoirs of the Miami Conservancy District in Ohio where the flood water is detained behind dams with outlets restricted to a capacity which the channel below will carry without damage to the adjacent valley lands and property.

Many storage reservoirs have been constructed for municipal and sanitary water supplies, for power development and for irrigation. The cities located upon the Great Lakes, Chicago, Detroit, Cleveland, Buffalo, etc., obtain their water supplies from the lakes upon which they are located; New York City from storage reservoirs located in the mountainous areas north of the city; Philadelphia by pumping from the Delaware River and filtration; Boston from storage reservoirs on the Merrimac and other streams of the State; St. Louis, New Orleans and many of the other Mississippi River cities by pumping from the river and by filtering; western cities on both sides of the Rocky Mountains by storage reservoirs. Los Angeles now takes its principal supply from a mountain stream 275 miles from the city and will take an additional supply from the new Hoover Dam on the Colorado River more than 300 miles from the city.

IRRIGATION AND FLOOD CONTROL

Irrigation of the arid and semi-arid lands of the western portion of the United States is made possible by storing the flood waters and feeding it out as needed. All of these storage projects influence the flood stages of the streams upon which they are located.

It does not seem probable that storage of water for irrigation will be a factor in flood control in the Illinois Valley.

FLOOD PREVENTION IN THE ILLINOIS RIVER

Storage Effects

Consideration has been given to the prevention of floods by storage, but to appreciably reduce flood stages in the Illinois Valley, much valuable agricultural land would be taken for flood control reservoirs. Levees for flood protection have therefore received the approval of State authorities and landowners.

The extent of storage areas required in the Illinois Valley may be illustrated by considering the natural storage in one of the major floods between Peoria and La Salle. The length of the valley from Peoria to LaSalle is about 60 miles and the average width at flood stage is about 11/2 miles, an area of about 57,000 acres. The river had been at about a 19-foot stage for more than two weeks and rose 5.45 feet to 24.65-foot stage at Peoria from April 16th to April 24th, 1927. On May 15th the flood had receded to a 19-foot stage. During that thirty-day period, 2,500,000 acre-feet of water flowed past Peoria. During the 9 days of rising stage, from April 16th to 24th, the total discharge at Peoria was 778,000 acre-feet and the added storage was 315,000 acre-feet, or a total flood-water inflow of 1,092,000 acre-feet. The added storage was about 28.8 per cent of the total inflow or 40½ per cent of the total outflow for the rising period. At the beginning of this rise on April loth there was an average depth of overflow in this portion of the Illinois Valley of about 7 feet, and storage of about 500,000 acre-feet making 800,000 acre-feet stored at the crest of the flood. When we consider that the amount of water storage in the Illinois River Valley at this flood period was sufficient to cover 800,000 acres, or an area 60 miles long and 21 miles wide one foot deep, we may visualize the magnitude of the problem of providing storage area sufficient to materially modify flood stages.- It is also necessary to have in mind that storage, to be available for reducing flood stages, must be empty when the flood waters come, otherwise it would be of no value. The conservation of water for municipal and industrial purposes in storage reservoirs is useful for flood relief only before the storage capacity- is filled. The records show that the great floods have always been produced by heavy rainfall after the underground storage and the lakes, ponds, reservoirs and overflowed areas have been substantially filled.

LEVEES FOR PROTECTION OF ILLINOIS VALLEY LANDS

The Illinois River Valley from Starved Rock to the Mississippi, a distance of about 230 miles, is from one mile to six miles wide, and averages more than two and one-half miles in width. The total overflowed area, including river channel, is about 400,000 acres, of which

about 60.000 acres is above Peoria. From Beardstown to the mouth of Illinois River, a distance of about 90 miles, the overflowed valley is from two and one-half to four miles wide and practically all of this area has been leveed, leaving a floodway from 1,200 feet to 2,500 feet wide.

Between Beardstown and Peoria about 70 per cent of the overflowed area, has been leveed. Between Peoria and LaSalle only one small district of 2,600 acres near Hennepin has been leveed. The areas of Illinois Valley reclaimed lands are as follows:

Grafton to Peoria	166,000	acres
Beardstown to Peoria	80,000	acres
Peoria to LaSalle	2,600	acres
Total reclaimed area	248,600	acres

This represents 60 per cent of the total area of overflowed lands in the Illinois Valley between LaSalle and the mouth of Illinois Biver.

The overflowed lands protected by these levees were all in a fine state of cultivation prior to the floods of 1922 and 1926. The levees have been repaired since those floods and most of this land is again in a good state of tilth.

DESTRUCTIVE FLOODS

Three or four levees were constructed along Illinois Biver before 1904 and most of the others were completed before 1922. There have been three destructive floods in the Illinois Valley since the levee-building era began, namely, in 1913 with about half of the present levees constructed a number of the levees failed: in 1922, about half of the levees failed; and in October, 1926 the greatest flood occurred and continued through the spring and early summer of 1927 breaking about half of the levees and flooding approximately half of all the reclaimed lands. The flooding of these districts checked the rise in the river which would have been about 1.7 feet higher at Beardstown if all levees had held.

ILLINOIS BIVER LEVEES BESTORED

All but one or two of the Illinois Biver levee districts, aided by state appropriations, have restored their levees since the 1926-1927 flood. The Mississippi Biver Commission, in charge of the flood control work on Mississippi Biver and up the tributaries as far as the back-water of the Mississippi extends, has taken over Illinois Biver from its mouth to Beardstown. The Mississippi Biver Commission, with appropriations from the Federal Government, is authorized to pay two-thirds of the cost of building and strengthening levees on the tributaries and has allotted $2,000,000 for the levees on Illinois Biver below Beardstown.

The Illinois Legislature in 1929 appropriated $1,000,000 for strengthening levees on Illinois Biver. Several districts below Beardstown are

availing themselves of these appropriations to have their levees raised and strengthened. All flood control plans of the Mississippi River Commission are subjected to the approval of the Chief of Engineers of the U. S. War Department. The Commission plans for Illinois Eiver levees conform substantialy with the plans in the Illinois Eiver Flood Control Eeport of 1929. This plan provides for setting levees back where the fioodway is too narrow and for raising and enlarging the levees.

EFFECT OF ILLINOIS EIVER LEVEES ON FLOOD HEIGHTS

Flood control studies of Illinois Eiver show estimated flood stages 9 feet higher at Beardstown and 3.0 feet higher at Peoria than the 1844 flood stage which was the highest known flood prior to the building of levees. In 1926 the observed flood stage at Beardstown was 3.86 feet above the 1844 flood. With all existing levees holding, the estimated flood stages will be 5.2 feet higher at Beardstown and 4.9 feet higher at Peoria than the record flood of 1926. At Beardstown a sea wall along the river front and levees back to the high land have been constructed by the State of Illinois.

The effect of the Mississippi River levees on flood stages has been similar and of greater magnitude than on Illinois Eiver. Along the Mississippi several hundred miles of levees from 20 feet to 30 feet high are now required where the banks were overflowed only a few feet deep before any levees were built. Surveys show that the average depth and cross-section of the Mississippi River channel, and therefore its carrying capacity, below bank-full stage is substantially the same as before the levees were built.

The following illustration shows what would happen at Peoria if the river from Peoria to LaSalle, a length of about 60 miles and an average flood width of about 1½ miles, should be reduced to 1,500 feet between levees. The flood, beginning April 16, 1927 with river stage 19.2 feet at Peoria, crested at 24.65 feet on April 24th. The increase in storage computed from the stage heights and valley cross-sections and the total inflow is equal to the outflow at Peoria plus the increase in storage. Under present conditions, with only one levee enclosing about 2,600 acres of bottom land at Hennepin, the remaining overflowed area including river channel is about 58,000 acres. If the channel were reduced by levees or other means to a flood width of 1.500 feet including the river channel, the total area of water surface would be 13,700 acres or about 23½ per cent of the present flood area. The rise in the river for the nine days from the 16th to the 24th of April, inclusive, was 5.45 feet. The total discharge at Peoria for that period was 778,000 acre-feet

and the increase in storage was 315,000 acre-feet, or a total inflow of 1,093,000 acre-feet. The storage was 28.8 per cent of the total inflow, or 40½ per cent of the total outflow. During this rise in the river, the storage was almost half of the inflow on the day of maximum inflow and the maximum rise in the river for one day was 1.4 feet. The reduction in storage would have produced a rise at Peoria on the day of maximum inflow of 4 feet, instead of 1.4 feet. The river would have crested two days earlier and 3.75 feet higher at a stage 28.4 feet. A stage of 28.4 feet would have overflowed all of the industrial area opposite Peoria and would have been about 3 feet deep in the Rock Island Depot at Fulton and Liberty streets.

There would have been a material increase in hydraulic slope from Peoria to LaSalle and the rise above would have been greater than at Peoria, due to the combined effect of reducing the flood channel and the overflowed area.

CONCLUSIONS

The following conclusions are suggested:

1. That flood relief presents new problems as population increases, as agriculture and industry develop, and with the physical changes produced by natural forces and the works of man.

2. That engineering methods of flood control depend upon economic conditions and will be modified to meet economic changes.

3. That flood flows depend on precipitation, condition of the soil, topography of the watershed, and atmospheric temperature.

4. That diversion through the Chicago Sanitary and Ship Canal increases flood heights in the lower Illinois Eiver from 0.5 foot to 1.5 feet.

5. That the construction of locks and dams for low-water navigation on the Illinois does not increase flood heights.

6. That economic conditions do not now justify development of detention reservoirs for flood control.

7. That storage reservoirs for municipal and industrial purposes are not now a factor in flood control in the Illinois Valley, but may be within two or three decades.

8. That the construction of levees along Illinois Eiver has greatly increased flood heights requiring additional levees for areas naturally above overflow.

9. That the flood protection plans of the Illinois Division of Waterways and of the Mississippi Eiver Commission, by setting back and strengthening the levees along Illinois Eiver, will provide adequate flood protection for the 248,000 acres under levees so long as no new levees are built.

10. That higher levees or detention basins in the tributaries will be required to offset areas hereafter taken from the valley floodway.

REFERENCES

1. Report of U. S. War Department Engineers on a Fourteen-foot Waterway from Chicago to St. Louis. House Document 263, 59th Congress, First Session. 1905.
2. Report of the Rivers and Lakes Commission of Illinois by Alvord and Burdick, "The Illinois River and Its Bottom Lands With Reference to the Conservation of Agriculture and Fisheries and the Control of Floods." 1915.
3. "Illinois River Flood Control Report" of the Illinois Division of Waterways by Jacob A. Harman. 1929.

POLLUTION STUDIES OF ILLINOIS RIVER

BY
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INTRODUCTION

The State of Illinois has been conducting sanitary chemical and biological studies on Illinois River since 1874, or 26 years prior to the time Chicago started to divert her wastes into its waters. The earlier studies were conducted by the State Natural History Survey and were mainly biological in character. They were, however, supplemented from time to time by chemical studies. The State Water Survey, since its foundation, has been furnishing chemists and bacteriologists for these studies, and has been in full charge of the sanitary chemical and bacteriological studies since 1923. A number of papers and bulletins have been published on the general subject of the pollution of Illinois Kiver. Such publications may be secured for a very nominal sum by consulting the publication indexes of the State Natural History Survey, the State Water Survey, and the U. S. Department of Public Health. These different studies, besides giving routine data as to the river's condition, have rendered to sanitary chemistry much fundamental information as to the pollution capacities of streams, their rates of biological oxidation, rates of reaeration, and the like.

The economic history and utility of Illinois Kiver has already been dwelt upon by previous speakers and papers. One's attention should be called to the fact that any large body of water, such as Illinois River, is of vast economic importance as a natural resource which if properly used may safely dispose of a considerable volume of domestic and industrial wastes. The simplest and cheapest method of disposing of sewage is to empty it into some river or lake, and there to allow nature to take care of it without human aid. If, however, this body of water is over-taxed with this pollution load, then numerous other important economic factors come into play. Some of these factors have already been discussed by previous speakers and will be further discussed in forthcoming papers.

THE POLLUTION LOAD OF ILLINOIS RIVER

The pollution load of Illinois River proper, that is the wastes added directly to Illinois River, as well as the pollution load of the entire Illinois River drainage basin, is summarized in Table I. As the wastes

from the rural districts and from those cities located on tributaries, are largely stabilized by the time they reach the Illinois River proper, those cities which are located in the immediate vicinity of the river are the only ones responsible for the gross pollution of the stream. Table I shows that the total population equivalent of these cities amounts to more than seven million. The Illinois-DesPlaines River at Lockport, which has an average flow of only about 600 cubic feet per second, has, since 1900, received all the sewage and dilution water from the City of Chicago. The pollution load of the City of Chicago is equivalent to a population of 5,602,000 [3]. With the building of treatment plants and the recovery of by-product wastes by the industries, this load has been reduced about 26 per cent (Table I).

The only other cities along Illinois River that add appreciable volumes of wastes are Peoria and Pekin. Peoria furnishes 16 per cent of the total pollution load thrown upon the river, whereas Pekin furnishes only 3 per cent. It is gratifying to note that Peoria has realized its debt to society and has recently built, and is putting into operation this spring, a very modern plant for the treatment of its wastes.

TABLE I

EQUIVALENT POPULATION OF ILLINOIS RIVER CITIES.*

Place.	Station (miles from Grafton).	Sewered population (1930).	Population equivalent of industrial wastes.	Total sewered population contributing.
Chicago	292	3,880,000	1,722,000	†5,602,000
Joliet	288	41,753	26,000	67,753
Rockdale	285	‡1,477	.....	1,477
Morris	263	5,563	30,000	35,563
Marseilles	247	‡1,706	102,000	103,706
Ottawa	237	15,042	3,000	18,042
LaSalle	223	13,084	.....	13,084
Peru	222	9,121	1,000	10,121
Spring Valley	218	5,272	.....	5,272
Lacon	189	1,546	500	2,046
Peoria Heights	165	3,280	50,000	53,280
Peoria	162	104,788	1,000,000	1,104,788
Pekin	152	16,096	200,000	216,096
Havana	120	3,445	.....	3,445
Beardstown	88	6,353	.....	6,353
Total	.....	4,108,526	3,134,500	7,243,026

Population in drainage area, urban + rural	5,700,000
Population equivalent of industrial wastes	3,100,000
Total population equivalent of Illinois River drainage basin	8,800,000

* Revised Table I, State Water Survey Bulletin No. 28.

† Sewage treated by Chicago Sanitary District:

Partial treatment, population equivalent..... 2,153,000

Treatment. 100 per cent basis..... 1,473,000

‡ Population in 1920.

PARAMETERS USED IN RIVER STUDIES

Of the various tests that are used in scientific studies of polluted streams and their self-purification, the following are the most important :

1. *Dissolved Oxygen.* The dissolved oxygen test accurately measures the amount of dissolved oxygen gas that is available in any given sample of water for oxidative reactions and for aquatic life.

2. Biochemical Oxygen Demand. This test measures the amount of oxygen needed to biologically stabilize any given sample of water or water-borne waste. It is usually expressed in terms of a 5-day demand.

3. *Bacteriological and Biological Counts.* These tests determine the total number and type of organisms found in any given volume of water. Knowing the characteristics and most common habitant of these organisms, the water may be classified accordingly.

The technique of making the above determinations is not so difficult, but factors relative to the manner of sampling, points of sampling, time of day. variations in pollution load, amount and type of dilution, rate of flow, temperature, biological flora found in the water being sampled, and the like, play such an important part in the actual data collected that only those experienced in such work should collect and, above all, interpret such data.

POLLUTION ZONES

On the basis of data collected, and as an aid in the classification of these data, the writers [1, 2] have divided Illinois River into the following six sections or zones, each of which is briefly characterized:

1. *Zone of Recent Pollution.* That section of the Illinois-Des-Plaines River which extends from the point of confluence of the Des-Plaines River and the diluted wastes from the Chicago Drainage Canal down-stream to about Ottawa, has a very rapid and turbulent flow. As noted in Figure 1, which gives a profile view of the entire Illinois River, there is a fall of some 80 feet in this 50-mile stretch of the river. This upper river constitutes an ideal mechanism to insure maximum biochemical activity. There is relatively little sedimentation. The biochemical oxygen demand of the water in this zone is high, but, as noted in Figure *2.* it is also removed very rapidly, due to the high degree of reaerafion and active decomposition. The bacteriological counts are of a high order of magnitude (fig. 3) as are also the counts for colonial cileates, tubificid worms, and other forms of biological life common to heavy pollution. The dissolved oxygen of this very turbulent water is always low and in summer the stream is usually completely void of this all important gas.

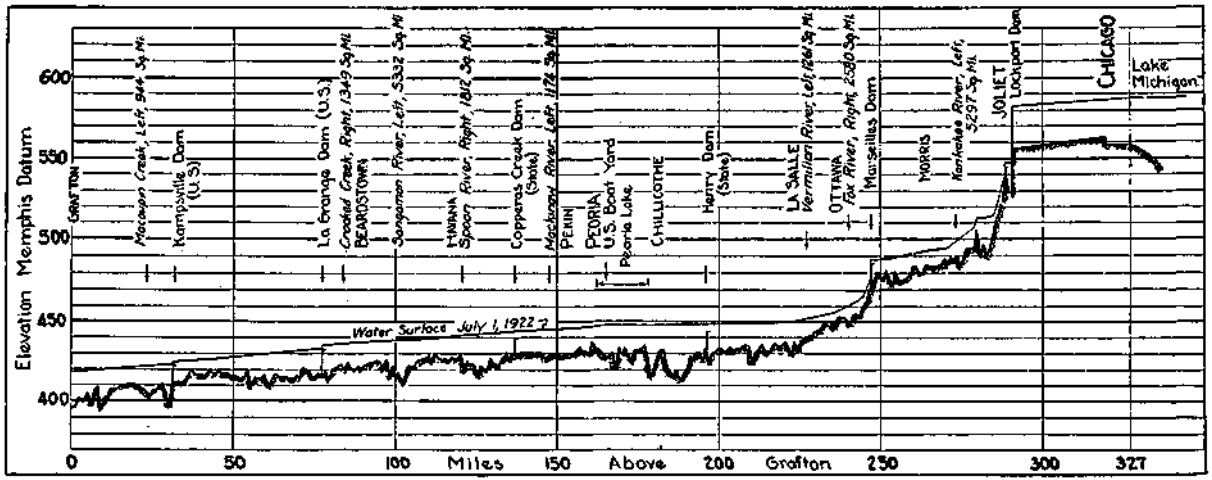

FIG. 1.—Profile of the Illinois River and the Chicago Drainage Canal
(By courtesy of U. S. Public Health Service)

2. *Septic Zone.* Due to the fact that the drop in elevation of the river between Ottawa and Henry is only about 10 feet in 50 miles (fig. 1) as compared with 80 feet in 50 miles in the "Zone of Recent Pollution." the rate of flow found in this second zone is sufficiently low so that much sedimentation takes place. This organic sediment lies practically dormant on the river bottom during the cooler months, but during the summer and fall biological action is accelerated by the increase in temperature to such an extent that an extremely high oxygen demand is thrown upon the river water that flows over this sludge bed. This demand for oxygen is so great that, in spite of reaeration, no free

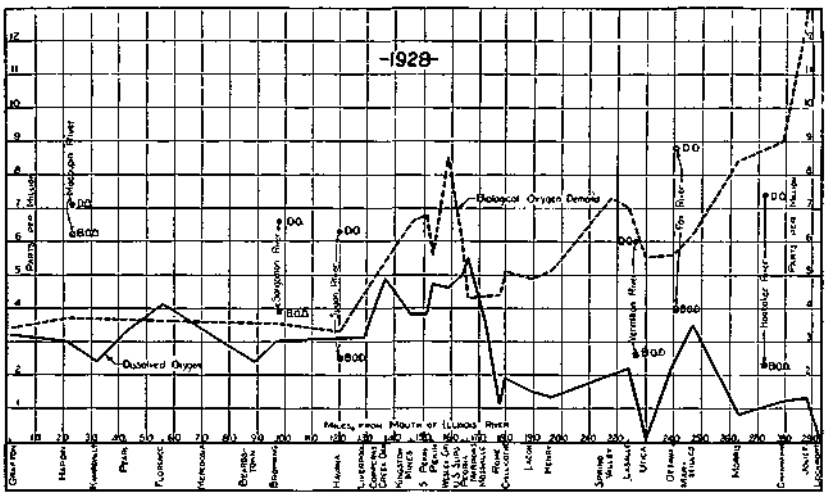

FIG. 2.—Summer averages of biochemical oxygen demand and dissolved oxygen data for 1928.

oxygen is found present. Following the removal of all of this gas from the water, anaerobic decomposition sets in and the offensive odors common to this type of degradation are then liberated. It is a regretable fact that one of the State's most historic, most beautiful and most visited parks, namely Starved Eock Park, should be located on the banks of such a stream.

With the completion of the numerous dams that are now being built along the upper Illinois Eiver in connection with the Great Lakes to Gulf Waterway System, there seems little doubt but what the flow between these dams will be sufficiently slow so that the organic matter, which now settles out on the river bottom between Ottawa and Chillicothe, will settle out between these dams which in summer will then virtually become large septic tanks. This septic condition could, of

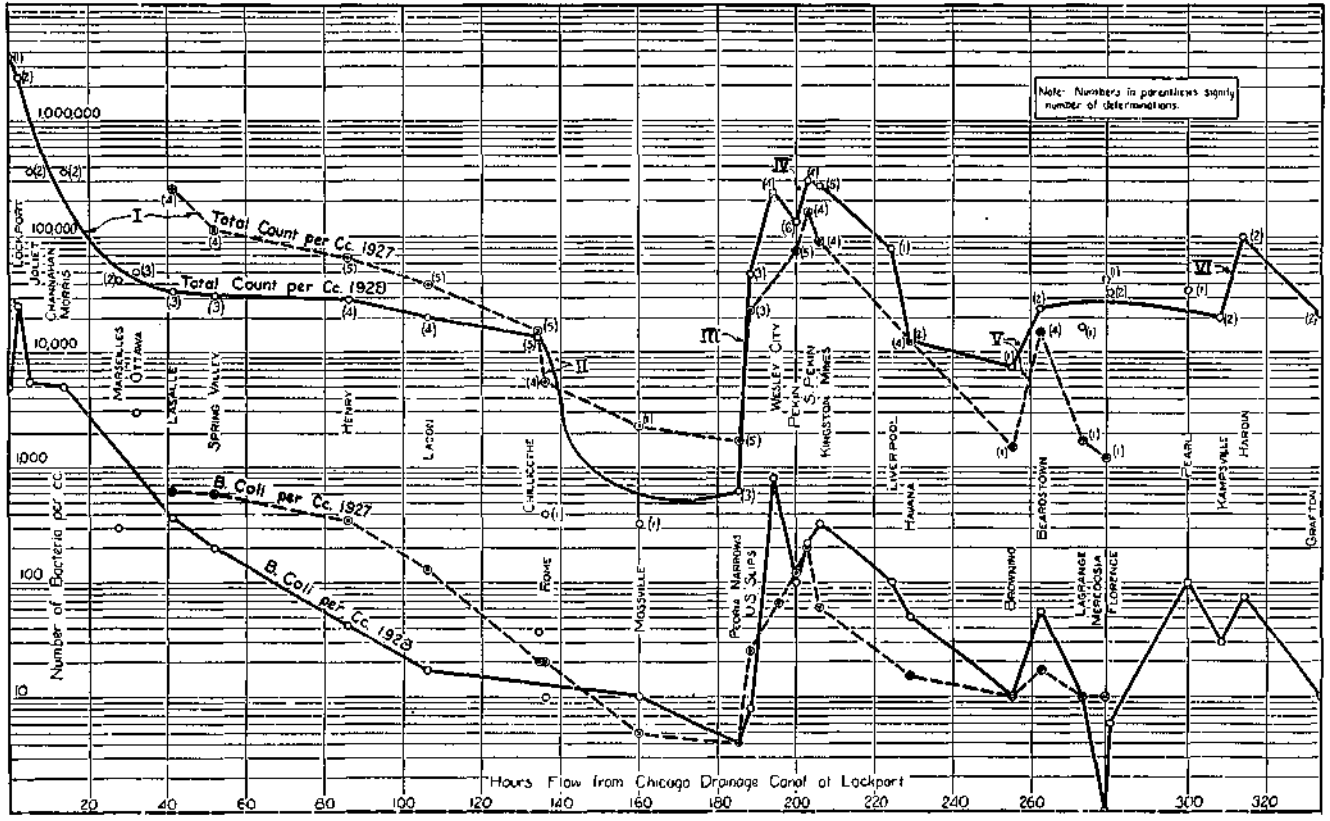

FIG. 3.—Graph of bacteriological data for 1927 and 1928.

course, be overcome by frequent dredging. With the advent of complete sewage treatment by the City of Chicago this problem would be eliminated.

3. *Polluted Zone.* That section of the river immediately following the septic zone is in many respects very much like its immediate predecessor. The river bottom carries a heavy blanket of sludge, but, as it is more nearly stabilized, the load on the stream is not as heavy. Chemical and bacteriological data bear out this fact.

4. *Zone of Marked Becovery.* That reach of the river between Chillicothe and Peoria is one of the most interesting of the entire river. The river widens in this section and forms the Upper, Middle, and Lower Peoria Lakes, which in all are about 18 miles long and from one-half to one mile wide. The average rate of flow in this reach ranges from 0.3 to 0.6 miles per hour, depending on the stage of water. This slow moving, wide expanse of water makes conditions ideal for the completion of the stabilization and purification of the wastes added to the river at its headwaters. Sedimentation, photosynthesis, reaeration, and the abundant growth of pure water organisms found in these lakes all play an important part. Chemically and bacteriologically (figs. *2* and 3) the river is sufficiently pure at Peoria Narrows so that with mere filtration and chlorination it could safely be used by the City of Peoria as its public water supply.

During hot summer seasons of low stage of water the pollution zones move further downstream, and if it were not for the Peoria Lakes, the Illinois River at Peoria, during such seasons, would be very foul. During the low water season of 1930, the anaerobic zone at times moved as far down stream as South Rome which is located four miles below the head waters of Upper Peoria Lake.

5. *Zone of Repollution.* The Illinois Kiver no sooner gets rid of its one pollution load than it is again polluted. The cities of Peoria and Pekin are at present adding untreated domestic and industrial wastes equivalent to a population of about 1,400,000. The chemical and bacteriological data shown in figures *2* and 3 pictorialize the effect of these wastes. The flow of the river in this zone (Peoria to Kingston Mines) is such that no very definite sludge bed is formed in either this or the following reach of the river.

6. *Zone of Slow Becovery.* The river from Kingston Mines to its confluence with the Mississippi at Grafton has an average flow at medium stage of from 1.2 to 1.5 miles per hour. The soil in the lower Illinois Kiver valley is such that the river is turbid practically all the time. This turbidity inhibits the growth of algae which play such an important part in the reaeration of a stream. As a result of this, and

other factors which need not be mentioned here, and the heavy load added by Peoria and Pekin, the lower river always possesses a moderate biochemical oxygen demand, a moderate bacteriological count, and only a fairly high dissolved oxygen content. This lower-most reach of the river with its odorless water, harbors but few tubificid worms and practically no colonial ciliates both of which are so abundant in the upper river. It is, however, relatively abundant with a variety of gill-breathing insect larvae and other forms common to slightly polluted and unpolluted waters.

It has been the purpose of this paper to show in a general way how river studies are made and to point out the inter-dependency of the various physical, biological and chemical factors involved in the self-purification of a polluted stream. With the complete treatment of Chicago's wastes and the wastes of Peoria, Illinois River should again become the stream described by scenic beauty admirers and sportsmen of the "nineties" as the most picturesque river and the best fishing and hunting grounds in the State. This may all be possible even though the river is called upon to take care of the treated effluent from the Chicago and Peoria waste treatment plants.

LITERATURE CITED

[1] Boruff, Ind. Eng. Chem. *22.* 1252 (1930).
[2] Boruff and Buswell, State Water Survey Bulletin No. 28, 1929.
[3] Chicago Sanitary District Report to U. S. Supreme Court (1931).

ILLINOIS RIVEE SANITATION

BY

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GENERAL STATEMENT

During the last decade or so there has been a growing public interest in river sanitation. An increasing knowledge of the latent hazards of pollution by bacteria of human origin has been a factor. The great development of transportation has increased the recreational use of rivers and thus called public attention to the disturbance of the natural condition of river waters by industrial and human pollution. Illinois River is no exception to the other great waterways of the United States and thus has been given much study and effort in the direction of improved sanitation.

THE ILLINOIS RIVER

Illinois Eiver has a drainage area above the Mississippi of 28.344 square miles; and above Peoria of 13.479 square miles. Since 1903, it has received water by diversion from Lake Michigan at Chicago which has materially increased the low water rates of flow. Prior to this diversion, flows of 2,000 to 3,000 second-feet at Peoria are recorded. After the diversion, the dry-weather flow was seldom less than G.000 to 7,000 second-feet and was more often upwards of 10,000 second-feet. As the ability of a river to receive and assimilate sewage depends in part upon the river flow, these changing characteristics are important. The Supreme Court of the United States has ruled that, after December 31, 1933, the annual average diversion be limited to 5,000 second-feet; and after December 31, 1938, to 1,500 second-feet, both in addition to the flow from domestic water supplies (or the sewage from the municipalities).

CHARACTERISTICS OF POLLUTION

Illinois Eiver receives human and industrial sewage at its head waters from Chicago and from other centers of population on the drainage area. This pollution is decreasing at Chicago as treatment works go into operation and will increase in other cities as the population and industry increase, except as sewage treatment works are built. The natural condition of the river has been seriously disturbed by increas-

ing pollution during the last 10 to 20 years, with an expected marked improvement during the next few years as treatment works are completed at Chicago, Peoria, and probably elsewhere.

Two characteristics of river pollution should be noted. One is the general effect of pollution on the river as a whole, which takes into account the balance between pollution and the resources of the river and its tributaries. The other is the local effect of pollution adjacent to sewer outlets and below centers of population. Both characteristics require consideration.

RIVER POLLUTION INVESTIGATIONS

From the view point of sanitation, the large rivers of the United States have been the subject of many important investigations. The United States Public Health Service have made extensive reports on the pollution of the Ohio, Illinois, and Mississippi rivers. In addition, Illinois River has been comprehensively studied by the Illinois State Water Survey and the Sanitary District of Chicago. The recent exhaustive studies of the upper Mississippi by the Metropolitan Drainage Commission of Minneapolis and St. Paul are of interest because of the similarity, in certain respects, with the Illinois. The sewage from the Twin Cities pollutes a. stretch of the river extending some 60 miles to Lake Pepin, with conditions somewhat comparable on a broad scale to the pollution from Chicago in the 138 miles of river above Lake Peoria.

ECONOMIC BALANCES

Throughout these investigations some consideration has been given to the economics of river sanitation such as might be indicated by a comparison of the cost of sewage disposal works and the value of the resulting cleaner waterway. So far the cost of sewage disposal has not been regarded as prohibitive, but consideration has been given to a progressive installation over a term of years. The program worked out by the Metropolitan Drainage Commission for the Twin Cities calls for some 40 per cent complete sewage treatment by 1940 with the work gradually extended to complete treatment by about 1970.

VOLUME BALANCES

All the many engineering and bio-chemical aspects of river sanitation cannot be included in a brief statement. A rough picture is afforded by the relation between the river flow and population equivalent discharging sewage into the stream. With due reservations as to the influence of individual local river characteristics, the Engineering Board of Review of the Chicago Sanitary District expressed the view that for each 1.000 of contributing population equivalent, there should be a

flow of 6.0 second-feet for untreated sewage, 4.0 second-feet for clarified (settled) sewage and 1.0 second-feet for the effluent of trickling filters, aeration tanks, or similar treatment works. However, the Supreme Court allowed only 1,500 cubic feet per second which might figure about 0.26 second-feet per 1,000 population equivalent by the end of 1938.

PROGRESS AT CHICAGO

The present population equivalent of human and industrial sewage from the Sanitary District of Chicago has been estimated as approaching 5,500,000. The sewage treatment works now in operation are estimated to be treating the equivalent of more than 2,100,000 population or on a 100 per cent treatment basis, more than 1,473,000 people. When the program outlined in the decree of the Supreme Court is completed during the next seven or eight years, the Court expects evidently that the allowed diversion will care for residual and uncontrollable pollution, so that the river will start its journey through the state in a somewhat stable condition. The indications are that with the flow allowed, interest in sewage treatment projects will be increased markedly in other cities along Illinois Eiver.

POPULATION AND EIVER FLOWS

Approximate estimates based on the Federal Census of 1930 indicate an urban population in the drainage area of Illinois Eiver outside of the Chicago Sanitary District of about 1,000.000. In addition there is the sewage of industries which would increase this estimate to a very much higher population equivalent, perhaps in excess of 2,000,-000. The indicated rates of dry weather flow in the river during the next decade (very likely less than 5,000 second-feet and as low as 3,500 second-feet at times at Peoria) do not appear to be sufficient to assimilate crude or untreated sewage, even for the river as a whole, while local considerations of immediate pollution point to the need for the installation of treatment works as at Peoria and at a number of cities on the major tributaries. No present statement can be made as to the extent and cost of additional sewage disposal works needed in the development and use of Illinois Eiver. A start should be made in the larger cities by having these projects planned in a preliminary way so that public improvements built in the near future will not add unreasonably to the cost of sewage disposal works and so that financial programs can be arranged.

SUMMARY OF FACTORS IN EIVER SANITATION

The several important factors which influence the condition of Illinois Eiver as regards sanitation may be summarized as follows:

a. The number of persons connected to the sewer system and discharging sewage into the river, and the volume of sewage.

b. The amount and character of industrial sewage, including its temperature, content of oil and sulphur, reaction, oxygen demand, and the like. Coarse suspended matter may lodge in sewers or strand along the river banks.

c. The rate of flow in the rivers, including the frequency and duration of floods and of protracted periods of low flow.

d. The thoroughness of mixing the sewages and river water with reference to a favorable use of the oxygen resources of the stream.

e. The physical properties of the river with seasonal variations including temperature, time of flow, ice conditions, conditions affecting reaeration and the like.

f. Biological conditions in the river water with reference to chlorophyl-bearing organisms, dead organisms absorbing oxygen, and the kind and number of plankton.

g. The uses to which the river water in its normal state is adapted.

h. The amount of sewage treatment upstream and the quantity of diversion from Lake Michigan.

i. The accuracy and extent of analytical data.

j. Financial considerations. As a matter of common law, no one has a right to injure a river water by pollution. This doctrine is often tempered by special situations. Sometimes, however, financial considerations are important if justly related to the population within the range of pollutional influence.

A FEW REMARKS ON CONSERVATION IN THE ILLINOIS RIVER VALLEY

BY

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NOTE: In planning the symposium on the economics of the Illinois River valley, this subject was assigned to Director Ralph F. Bradford, of the State Department of Conservation, but due to his unavoidable absence it was handled extemporaneously by R. B. Miller, Chief Forester of the Department of Conservation, Division of Forestry.—Editor.

INTRODUCTION

Briefly, the property owned and operated by the State Department of Conservation may be classified under the head of fish hatcheries, game farms, fish and game refuges, and state forests. The total acreage devoted to these various purposes, according to the latest figures, amounts to 10,457 acres and possibly as much more is under lease as game refuges. Each class of property will be discussed briefly in order, with its purposes and outstanding features.

FISH HATCHERIES

The main state fish hatcheries are at Spring Grove, Mattoon, Bockford, and Carlyle, the first being the oldest and best developed, serving as a standard to work for. There seems to be a disposition on the part of the state not only to make these places function for the production of fish for restocking Illinois lakes and rivers, but also to develop them as places of interest to the community. With this end in view modern cottages for the care-takers are being erected at Mattoon, Eockford, and on the state forest and the grounds are being landscaped and made attractive, taking the fullest advantage of whatever natural beauty the site may already have. A neat brick pumping station has been built at Mattoon and the difficulty of keeping the hatchery ponds full, which has been giving some trouble, will be surmounted in time by the city of Mattoon by the construction of a new dam in the Little Wabash lower down than the present spillway. This will greatly increase the storage capacity of Paradise Lake, the public water supply, from which water has been pumped into the state ponds.

GAME FARMS

At the Yorkville Game Farm various species of pheasants are being raised [1], also quail on a tract of more than 700 acres near Mount Vernon and at the State Fair Grounds,. Springfield, where forty acres are given over to the purpose and where another custodian's cottage will be erected. A trained game breeder who has worked under Coleman, of Virginia, with great success is now in charge of raising quail at the Fair Grounds and there is ample space for laying and rearing pens. The eggs are hatched in an electric incubator and the chicks are transferred to brooders which are entirely off of the ground, each of which can be kept at a controlled temperature. The other method of quail encouragement applicable to farms in the corn belt is called the Stoddard method because he developed it in Georgia. It has been proved that the number of quail coveys on the average farm can be greatly increased by creating the proper environment for them in the way of food, shelter, and reduction of the number of their enemies. In this connection it may be said that the destruction of coverts along streams, roads, and ravines by fire and grazing as well as the disappearance of the Osage Orange hedge from the majority of the farms in the corn belt is largely responsible for the gradual decrease in the number of quail or bobwhite as a farm bird.

FISH AND GAME REFUGES

The Horse Shoe Lake property of 3,160 acres situated 18 miles north of Cairo, in Alexander County, is a fish and game refuge and although the lake dried up the past summer (1930), it was a most opportune time to put in a dam which will hold the water to the proper level for ducks, geese, and fish as well as to perpetuate the cypress (Taxodium distichum) which is there found in its virgin condition along with plenty of tupelo gum swamps.

Dr. C. L. Stewart, of Urbana, in his paper on land utilization in the Illinois Eiver Valley will no doubt mention the fact that many drainage districts are not able to pay land and drainage taxes and I would suggest that such land might be more profitably used for the production of timber, fish and game, and for another purpose which will pay good dividends namely, recreation. According to some reports land for duck shooting purposes varies in price from $50 per acre in the lower Illinois Eiver valley to $400 in the Beardstown area. The usual charge for looking after hunters is now $15 per day per man or $25 for two men. Sometimes ten guns are placed at a single hole or blind, which would mean $150 per day. This amounts to about $1 per duck and when we

add to this the amount the hunter spends at hotels, for gasoline and oil, car hire, ammunition, and other incidentals it may amount to as much as $2 per duck, which means quite a revenue for the farmer, for hotels and restaurants, filling stations, and a certain number of men employed during the season as pushers.

STATE FORESTS

The Union County State Forest located northwest of Anna and Jonesboro, now totals 3.319 acres and is suited for the production of timber, for watershed protection, for the preservation of wild life, and for recreation, since the law provides that state forests may also be declared game preserves. State forests can also be used for recreation the same as state parks, the National Forests of the United States having attracted more than 31,000.000 visiters in 1930. A full description of this property will be found in the "Illinois Farmer" of November 10, 1930, and in the April 1931 issue of the "Illinois Teacher."

HUNTING CLUBS

Contrary to the statement in the May issue of the National Geographic magazine by Wood [2] that "a law in Illinois forbids luring wild ducks with food," such legislation has never been passed, as a study of the state game law will reveal. The putting out of shelled corn in fields or in the Illinois Eiver bottoms is commonly practiced, the method being to fill a boat full of shelled corn and anchor it to a tree in the evening. During the night the ducks sometimes come in in sufficient numbers to eat all of the corn in the boat, so that in the morning the boat floats in the water.

According to records in the office of the State Department of Conservation there were 440 hunting clubs licensed in the state in 1930, each club paying a ten dollar license fee. Our estimate is that 303 of these are located along the Illinois Eiver or in contiguous territory, in about 19 counties extending from LaSalle to Madison County. Mason County leads with 89, Havana being a center for sportsmen; Cass is next with 38, Beardstown being a hunters' rendevous; Marshall has 38 clubs, Putnam 29, Woodford 20 and Calhoun 18. Each gun club is required by law to keep an account of the number and species in the daily kill made by members and others at the club and to send this report in to the office of the Conservation Department, but such records are far from complete so that the total kill of ducks on the Illinois Eiver can be only an estimate.

EFFECT OF LOW WATER IN 1930

Although for several summers prior to 1930 the high water in Illinois Eiver had killed many trees, even the pecan, cottonwood, and willow, the summer of 1930 was characterized by very low water levels. According to one of your speakers there was only 20 inches of rainfall at Peoria, which is the lowest in 80 years. This has affected unfavorably the growth of trees over the state, actually killing a great many and slowing up the growth of those that remained alive. What was true of trees has also been true of the growth of fishes, if authorities can predict correctly. Adams [2] says, "It has long been known that by making a study of the scales of fish, it is possible not only to determine the exact age of the individual but also to learn something of the conditions under which it developed. If the rings, or annuli, are close together, with small spaces between them in a certain part of the scale we can infer that the conditions were not favorable to growth during the period when the part was added."

Several hunting clubs did not do any shooting at all in 1930 on account of the low water in the Illinois, one man saying that it would have taken an increase of four and one-half feet of water to make the proper conditions at their club.

COMMERCIAL FISHING

The value of the commercial fishing in the Illinois Eiver can be calculated better by others here present but if I am not mistaken, it was once estimated at well over $2,000,000 yearly. In addition to this there are pearl and mussel fisheries and the value of the pearl button blanks made from shells at several points on the Illinois River. Certain stretches of the river are closed to mussel fishing in order that the stock may have a chance to recover, which is in the interest of both the state and the mussel fishermen.

CONSERVATION MEASURES

All the values I have mentioned could be greatly augmented by proper conservation measures, such as the prevention of stream pollution and closer observance of the fishing and hunting laws. Under the advice and help of the Sanitary Water Board, many of the cities along the Illinois, including the city of Chicago, are making efforts to treat their sewage so that in time only purified water will be returned to the stream. When that time comes, as we confidently believe it will, the

Illinois will return to its own in the way of transportation, hunting, fishing, and recreation, all matters of land utilization will have been worked out for the highest interest of land owners and the state, and there will be no need of a half day of discussion showing what is needed to be done but a full day to show what has been accomplished by the various agencies represented here today.

REFERENCES

[1] WOOD, JUNIUS B., Illinois Crossroads of the Continent, with illustrations from photographs by Clifton Adams, staff photographer, and a special map supplement of Illinois, The Natural Geographic Magazine, Vol. LIX, No. 5. May, 1931, pp. 523-594, Washington, D. C.

[2] ADAMS. L. A., Transactions of the Illinois State Academy of Science, Vol. 23, No. 3, March, 1931.

THE FISHING INDUSTRY OF ILLINOIS RIVER

BY

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Perhaps most of you have heard it remarked that Illinois Eiver is one of the most productive bodies of fresh water in the world. This great productivity is due to the high fertility of the soils in the Illinois drainage basin and to wide areas of bottomland lakes connecting with the river winch permit this fertility derived from the soils to be utilized efficiently in the production of fish. A natural chain of biological reactions from the fertile elements of the water to fish takes place. In these basins there is time for the channel water to be transformed into microscopic life, or plankton, which is fed upon by worms, snails, insect larvae, and crustaceans, which in turn are used as food for fishes. The great productivity of the connecting bottom land waters of the Illinois Valley is analagous to the high productivity of the overflow lands of the Nile Valley and is explicable in the same terms—their fertility is periodically renewed from the river itself. In 1908, Illinois Eiver produced 60 per cent of the total fisheries products of the entire state. At that time all of the waters of the state were open to commercial fishing and included fishes taken from the boundary waters of the Mississippi, the Ohio, the Wabash, and the Illinois portion of Lake Michigan; as well as from the Eock, Fox, Sangamon, and Kaskaskia rivers and other lesser streams so numerous within the state.

It may be appropriate at this time to scan the trend of the yield of commercial fishes from Illinois Eiver. At various times from 1896 up until 1922 the Illinois Fishermen's Association, the Illinois Fish Commission, and the U. S. Bureau of Fisheries have taken censuses of the yield of commercial fishes. Beginning in 1896 the yield was 7 million pounds; in 1897, 10 million pounds; in 1899 and 1900 it was 11½ million pounds; in 1907, 15 million pounds; in 1908 two different sets of statistics gave 19 million pounds and 24 million pounds; in 1921, when fishing conditions were poor, 4 million pounds; and in 1922, when conditions were much above normal, l0½ million pounds. Estimates made during 1930 would seem to indicate that the yield has remained near the high figure of 1922. The sharp decline in yield fron

the peak of 1908 to 1921 and 1922 is due primarily to two causes—pollution and the appropriation of wide areas of the middle and lower Illinois Valley for agricultural purposes. Following the completion of the Chicago Sanitary Canal in 1900, increasing amounts of organic wastes from the Chicago area seemed to be reflected by increases in the fish yield, but by 1910 and 1912 the amount of these wastes reached a point where the amount of oxygen in the water was depleted and the fishes as far downstream as LaSalle were wiped out. Further increases in the volume of wastes during succeeding years completed the destruction of the commercial fishery in the channel waters down as far as Chillicothe. Whether or not fishes were able to live in the connecting bottomland lakes of that section depended upon whether or not its lakes received channel water at ordinary water levels. Striking reductions were noted in Peoria Lake and in the channel as far southward as Havana. The peak of pollution was reached between 1916 and 1920. Since that time, partly because of reduction in the load of organic matter contributed to the river due to a slackening of wartime industry and to its treatment in sewage disposal plants; and partly because of prolonged periods of high water in which the sewage is so diluted that it is less harmful, such extreme effects of pollution on the fish yield have not been repeated.

Any discussion of the fisheries yield from the Illinois cannot be complete without mentioning the European carp and its place in the Illinois Eiver fishery. The carp first made its appearance in Illinois Eiver about 1885 from a stock brought from Europe and it first became an important item in the fishing industry soon after 1890. By 1898 the Illinois Fishermen's Association reported that the catch of carp exceeded in value that of all other commercial fishes and in 1908 it constituted 64 per cent of the catch, or 15,400,000 pounds. Data gathered by the Natural History Survey in recent years indicate that carp make up about 90 per cent of the entire catch of commercial fishes. The phenomenal success of carp in the Illinois Eiver results from two outstanding facts. The Illinois Eiver and its connecting bottomland lakes provide a habitat better adapted for the growth and multiplication of carp than did its ancestral home in Asia and in Europe. The carp is a close relative of the goldfish and like the goldfish is versatile and hardy. As the Illinois Eiver became heavily polluted it was found that the carp could tolerate these unfavorable conditions with greater success than any of our native fishes. During a few years before and after 1920 when Peoria Lake was quite foul the carp was left in almost complete control.

In 1923 I noticed that many of the carp in the fishermen's catch showed abnormally formed heads. More complete studies made in 1926

and 1927 showed that this abnormality was closely akin to what we know as rickets in man and other higher, warm blooded animals. At that time it was found that 50 to 90 per cent of all the carp between LaSalle and Pekin showed this abnormality. When the rate of growth of these abnormal carp was compared with the rate of growth of normal carp found farther downstream, it was found that the latter grew at a rate about twice that of the rachitic carp. Further studies seemed to indicate that the stunted condition of carp in the upper and middle river was due to the destruction of the green algae by pollution, and to substitution in its stead of blue-green algae and protozoa which cannot provide young carp with as complete a diet as do the green algae.

Estimates of the yield of fishes made about 1910 by the Natural History Survey showed that many of these bottomland lakes have annual yields as high as 150 to 300 pounds per acre. These yields are as high as those obtained from fish ponds under good cultivation in Germany. I might mention here that the area of the river channel between LaSalle and Grafton at the gage 10 feet Beardstown, which is about an average stage of water since 1910, is 45 square miles. The area of connecting bottomland lakes at this same stage of water is 201 square miles.

Formerly all fishes were fair game for the commercial fishermen and could be marketed at all times. Within recent years the State has regulated commercial fishing on the Illinois Eiver by closed seasons, by prohibiting the sale of bass, crappies, and sunfishes at any time, and by placing minimum length limits on carp, buffalo, and catfish which make up 99 per cent of the commercial catch. In the beginning of the fishing industry on Illinois Eiver the catch was sold locally in summer with shipments to the larger cities of the middle west in winter. Following that time ice came into general use and fishes were shipped as far as the eastern seaboard at all seasons. Still more recently live-cars have come into wide use for the shipment of live carp and buffalo to the New York and Philadelphia markets.

In recent years there has been a great deal of complaint about the table qualities of the fishes handled commercially from Illinois Eiver. This disagreeable quality has been described as a taste or smell resembling carbolic acid, kerosene, or coal tar, and is commonly referred to by fishermen as the "gassy" taste. It seems quite certain that this "gassy" taste is caused by decomposition products of sludge and sewage absorbed by the fiesh of the fish. During the past winter the price of Illinois Eiver fish has been unusually low, largely because of the difficulties in selling "gassy" fish. The "gassy" taste seems to affect carp, buffalo, catfish, and sheepshead, all common commercial fish. The commercial fishermen at a number of places between Peoria and Meredosia get rid of some

of this "gassy" taste by holding their fish in ponds of fresh water with clean bottom for a few weeks or months before they are sold.

The past fifteen years have been depressing ones to the commercial fishermen of Illinois River. They have seen the fishing industry wiped out of large areas of the upper and middle Illinois River by pollution from the Chicago area and to a lesser degree from Peoria and Pekin. The carp which makes up 90 per cent of the catch in the middle Illinois River has been stunted until it grows at only one-half the normal rate. Throughout the length of the river all kinds of commercial fishes have been rendered unpalatable by flavors absorbed from sludge and products of the decomposition of sewage. During this same period many of these highly productive bottomland lakes have been levied and emptied of their water and converted to agricultural uses. The outlook was indeed gloomy, but I think there are several reasons to expect the fishing industry of the Illinois to come back. The Chicago area, and Peoria as well, is committed to a program of sewage disposal plant construction which will lessen the load of organic matter thrown on the river. It seems likely that the amount of Lake Michigan diversion will be reduced so that there will be more time for the natural purification to take place before it reaches the productive fishing waters. Also the completion of the deep waterway will involve the construction of several dams between Lockport and Utica which will impound large volumes of water, and these will act as huge settling basins to diminish further the hazard of pollution to the Illinois River fishery. There is also some indication that many of the drainage districts of the Illinois Valley are proving unprofitable and will be abandoned as agricultural projects and will again be productive of fishes.