HISTORY OF THE LAKES NEAR LAPORTE, INDIANA.

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In October, 1921, the writer's attention was called to the recession of the lake level in the vicinity of LaPorte, Indiana, by an appeal from the Park Board of LaPorte to the State Conservation Commission for suggestions as to the cause of the recession and means of raising the lake level. Since that time I have spent about three weeks in the field about LaPorte and have found a peculiar and very interesting problem. On my first visit to LaPorte I was accompanied by Prof. Will Scott of the Zoölogy Department of Indiana University and on my third and last visit I was assisted by Mr. W. A. Thomas, a student of Geology at Indiana University. I wish to acknowledge the services and suggestions of these men and also Mr. Maurice Fox, President of the Park Board of LaPorte; Dr. W. N. Logan, State Geologist; Mr. Burtis Thomas, City Engineer of LaPorte; Mr. Robert Day, Assistant City Engineer; Mr. W. A. Cummings, Park Superintendent of LaPorte; Messrs. J. W. and Archie Good, well drillers of LaPorte and many others whose suggestions and services were of value.

PHYSIOGRAPHY AND GEOLOGY OF LAPORTE COUNTY.

The physiographic conditions of LaPorte County are dominated by the influence of the Wisconsin glaciation. Mantle rock derived from glaciation overlie the Devonian limestones and shales to a depth of 100 to 250 feet or more. There are no bed rock exposures in LaPorte County. By reference to figure 1, the type of surface rock are evident. The southeastern 60.1 per cent of the county is an old lake flat. It is now called the Kankakee valley or Kankakee lowland. This region slopes gently toward the south from an elevation of somewhat less than 800 feet on the north to the Kankakee River somewhat above 700 feet on the south. The average slope of this region is about five feet per mile. Gravels and sands on the north merge into finer sands, clays and peat on the south. Great areas along the Kankakee were covered by swamp until recent drainage projects have reduced them materially. Considerable swamp land still prevails, however.

Lying northwest of this lake flat is the great Valparaiso moraine. This area comprises 29.6 per cent of the county. The crest of this moraine is represented in general by the divide on figure 1 and that part lying north and west of LaPorte is shown accurately. This crest is undulating reaching elevations about 950 feet and seldom reaching lower elevations than 900 feet. The south margin of the moraine has an elevation of about 800 feet, usually slightly less. The north margin has an elevation of from 650 to 680 feet. Thus the north slope is much steeper than the south slope. The surface of this moraine is of the knob and basin character typical of well developed morainic regions. The north slope is undergoing severe stream erosion where the tributaries

"Proc. 38th Meeting, 1922 (1923)."

of Trail Creek have invaded it. The south side has a few small streams which empty into swamps or small lakes but the tributaries to the Kankakee have not invaded this morainal area. The Little

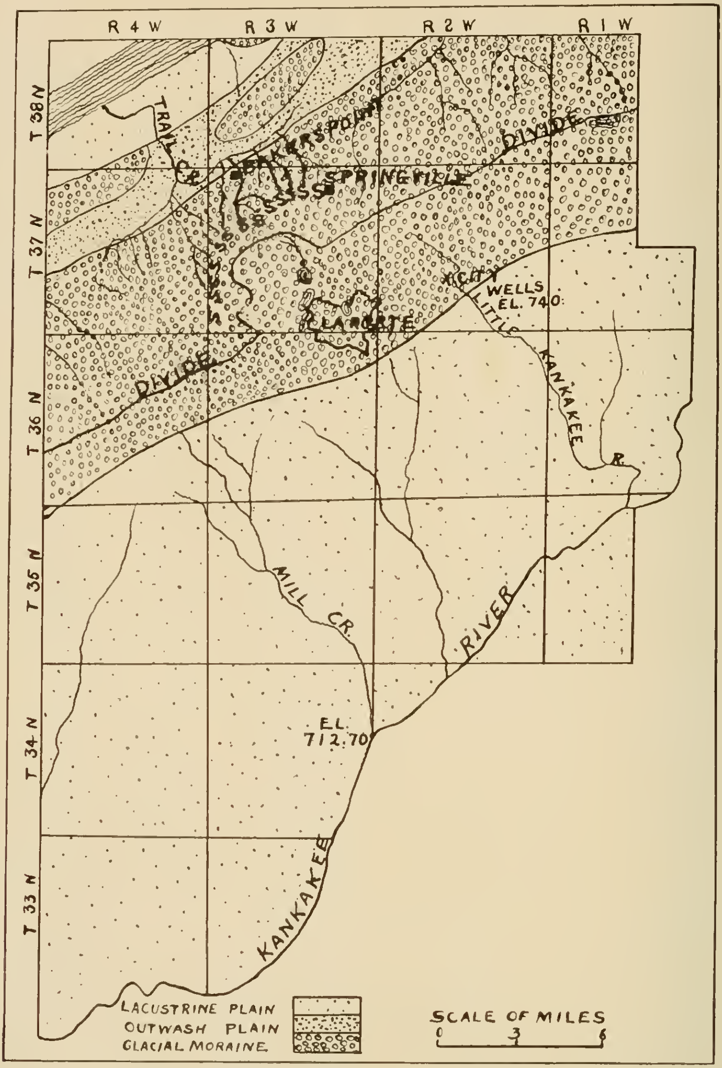

Fig. 1. Map of LaPorte County, Indiana, showing glacial deposits and other data. (After Leverett.)

Kankakee, east of LaPorte, is an exception to this rule. It rises in a glacial stream valley which lies within the moraine. The moraine is composed of sand and gravel with occasional lenses of clay. According

Fig. 3 Map of Laporte, Indiana, and surrounding territory, showing hydrographic features.

to Mr. Leverett[1] this moraine is predominately clay west of Valparaiso and sand and gravel east of that point.

Four other small areas lie to the northwest of the Valparaiso moraine in LaPorte County. These are a belt of outwash about two miles wide comprising 3.9 per cent of the county, small patches of moraine comprising 1.8 per cent, a lacustrine plain, part of the bed of Lake Chicago comprising 2.8 per cent and a part of Lake Michigan comprising 1.8 per cent. Sand dunes have encroached upon much of the land portions of these areas. Since these areas have little to do with the problem of the LaPorte lakes they will not be discussed in detail.

Origin of Lakes. Three types of lakes occur in LaPorte County. Those which lie in the Kankakee lowland are remnants of the great marginal lake which once occupied this area. Those which lie within the Valparaiso moraine are principally of the irregular type of lake which occupy the irregular depressions left by glacial deposit. There are probably some kettle hole lakes which are formed by melting of buried masses of ice within the moraine. This type of lake is small, nearly circular and deep. They are usually closely associated with the irregular type and are sometimes hard to distinguish from them. The group of lakes which lie west and north of LaPorte are of the irregular type. The group of lakes of which this paper treats specifically form a crescent partially within the city limits and partially on the northwest edge of the city. The limbs of the crescent point north and beginning with the northeasternmost lake we find, Lower, Clear, Lily, Stone, South Pine and North Pine, the last forming the northwest limb. On the northeast limb to the north of Lower Lake are three other small lakes, Lower and Upper Fishtrap and Horseshoe Lakes. These three lakes, however, are detached from the other groups by considerable divides and lie at considerably different levels so are treated only incidentally in this paper.

Status of Lakes at Earliest White Settlement. The six lakes named in the first group above are remnants of two lakes which existed when white settlers first came to this region. Lower, Clear, Lily and Stone lakes were then parts of one lake the extent of which is shown in figure 2. The elevation of this lake was about thirteen feet higher than the present level of Clear Lake or about 804 feet above sea level. The two Pine lakes were united at that time and the extent of this lake is shown in figure 2. The elevation of this lake was about twenty feet higher than the present level of North Pine Lake or about 809 feet above sea level. The divide between these two lakes was a low narrow ridge through which a channel was cut to allow the passage of a small steam boat. This boat was used to convey passengers from LaPorte to the Old Baptist Assembly ground on the north end of North Pine Lake where Pine Lake Village now stands. This steamer discontinued operation about forty years ago. During these early years Clear Lake had an outlet overland through the city of LaPorte somewhat north of the business section. This outlet ceased to flow forty or fifty

[1] Monograph LIII, U. S. Geol. Surv.

years ago according to the testimony of early settlers. Thus the decline of the lakes began long ago. However, the old shore lines, with their small terraces and small wave-cut cliffs, on which stand large trees whose lake side roots are deformed by ice and wave action, remain as mute testimony to the survey of 1829 when the extent of these lakes was as shown in figure 2.

Relation of Original Lakes to Present Lakes. Since the overland channel of Clear Lake has been closed the entire drainage of these lakes has been underground. A survey of 1847 shows the area of the lakes very greatly reduced from that of 1829 and the area at present is much smaller than that of 1847. The areas of the two lakes shown by the survey of 1829 and the areas of their present remnants as determined by planimeter from figure 2 are as follows:

North Lake of 1829	1.388 sq. mi.	North Pine Lake	.167 sq. mi.
		South Pine Lake	.275 sq. mi.
		Total	.442 sq. mi.
		Per cent of former lake	31.4
South Lake of 1829	1.317 sq. mi.	Stone Lake	.196 sq. mi.
		Lily Lake	.020 sq. mi.
		Clear Lake	.135 sq. mi.
		Lower Lake	.035 sq. mi.
		Total	.386 sq. mi.
		Per cent of former lake	29.3

From this we find that the areas of the two original lakes were very near the same and that the present remnants are not far different from each other, each representing about 30 per cent of the original. The levels of the remnants are fairly uniform. It is interesting that North Pine Lake is the lowest of the group and each lake of the crescent is slightly higher until Lower Lake at the other end of the crescent which is the highest. The following figures show the elevations of the various lakes as determined by Burtis Thomas, City Engineer of LaPorte, in December, 1921, and my own check on North Pine and Clear lakes in June, 1922, during a severe drought:

Lower Lake	792.75 feet	(Thomas)		
Clear Lake	791.76 feet	(Thomas)	791.62 feet	(Check)
Lily Lake	791.31 feet	(Thomas)		
Stone Lake	790.40 feet	(Thomas)		
South Pine Lake	789.58 feet	(Thomas)		
North Pine Lake	789.31 feet	(Thomas)	788.59 feet	(Check)

Figure 3 shows the elevation of Lily Lake from 1898 to 1914, inclusive. The record of the lake level was kept by the city waterworks employes for each day during this period. The elevation indicated for any year on this graph was derived by averaging the level readings for the first day of each month during the year. The monthly fluctuations were slight so that this gives a comparatively accurate elevation for the year. To convert these readings to the datum of sea level add 762.32 feet. This graph shows that Lily Lake fluctuated in this period between low level of 29.42 feet (791.74) in 1901 and high level of 33 feet (795.32) in 1909. At the beginning of the period the lake stood at 793.19 feet and at the end at 792.79 feet. The average for the whole time was 793.13 feet. These elevations compared with the elevation of 791.31 feet late in 1921 shows a decline of less than two feet since 1898. Thus the general decline in Lily Lake has been comparatively small since 1898 if the records are all correct. Records upon other lakes are not available except occasional records upon Clear Lake which have been kept by Mr. W. A. Cummings, Park Superintendent, who asserts that Clear Lake has declined five feet or more in the last eight years.

Relation of Lakes to Ground Water Table. This group of lakes has no inlets except sheet drainage of very small areas and has no outlet. Therefore the lake levels are evidently maintained by ground water.

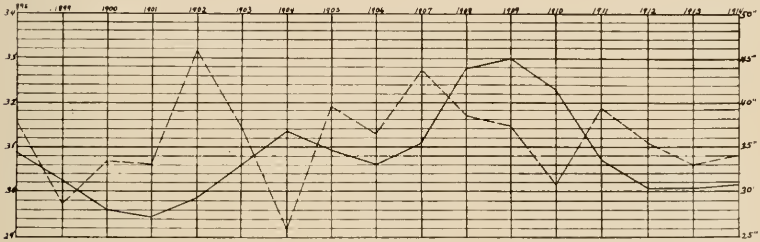

Fig. 3. Graph showing relation between the rainfall and the level of Lily Lake, Laporte, Indiana, from 1898 to 1914. Rainfall shown by broken line and referred to inches at right. Lake level shown by solid line and referred to feet at left. Datum of city bench mark.

The lake levels stand at the level of the water table. They rise and sink with the water table. So-called airholes in the ice in winter indicate that there are springs within the lakes which means that there is addition to the lakes by ground water. The mean annual rainfall at LaPorte is 36.83 inches[2], and the annual evaporation from free water surfaces is about 34 inches[3]. Thus, it is evident that these two factors almost balance each other with a small margin in favor of the increase of lake volume. Also, since there is a constant decline of lake level it is evident that there must be a loss through ground water movements.

Inasmuch as the movements of ground water are dominated by static head or steepness of slope and porosity of the material through which the movement takes place, the slopes to various possible outlets for the underground water from these lakes have been determined. These slopes are indicated in the following table.

[2] Condensed Summary of Climatological Data for 1915 by J. H. Armington, Indianapolis, Indiana, U. S. Weather Bureau.

[3] Russell: Monthly Weather Review, Dec. 1904.

TABLE 1. Elevations of low points about Clear Lake in relation to the elevation of Clear Lake, and the fall per mile.

POINT	Elevation ft.	Fall from Clear Lake, ft.	Distance, mi.	Fall per mile ft.
Clear Lake	791.62	....	....	....
Outlet of main sewer	769.77	21.85	2.75	7.94
Kankakee River at mouth of Mill Creek	712 70	79.92	15.00	5.33
City wells in Little Kankakee Valley	740 00	51.62	3.87	13.34
Springs north of divide near Springville	724.00	67.62	4.00	16.90
Pine Lake	788.59	....	....	....
Springs	724.00	68.59	3.00	22.86

NOTE: The last two show same relation between Pine Lake and Springs north of divide.

This table shows that the static head in feet per mile from Clear Lake to the springs north of the divide is slightly greater than that to the city wells which is the greatest to points south of the divide. The static head from Pine Lake to the springs is much greater than from Clear Lake. Since the material toward the north in the moraine is coarser than that at the edge of the moraine on the south, both slope and porosity indicate that the loss of water from the lakes is mainly northward. Clear Lake seems to be near the ground water divide and probably loses water in both directions.

Hypothesis of the Actual Water Loss from Lakes in Ten Years. The data concerning the actual decline in lake level for the past ten years is somewhat contradictory. Figure 3 shows Lily Lake to have been 793.19 feet elevation in 1898, and 792.79 feet in 1914 while the elevation at the end of 1921 was 791.31. These data indicate less than two feet fall since 1898. On the other hand the data collected by Mr. W. A. Cummings at intervals of a year or less for seven or eight years indicate that Clear Lake has declined five or five and a half feet in that time. The testimony of reputable citizens seems to bear out Mr. Cummings' data. These citizens point out definite points along the shores of Pine and Stone Lakes where the water stood ten years ago and these points are invariably about five feet above the present water level. It may be that the bench mark from which the data on Lily Lake was taken was not accurately located and was considered several feet lower than it actually was. This seems probable for it is not reasonable to think that Lily Lake was lower in that time than were the other lakes which would be the case if we recognize Mr. Cummings' data and the testimony of citizens as authentic. However, the data on Lily Lake can be considered authentic so far as fluctuation is concerned.

The decline of five feet in the level of this group of lakes has greatly reduced its area. By estimate the present area is slightly more than half the area when the lakes stood five feet higher. If we consider that area to have been twice the present area it gives us a working basis to determine the actual loss of water in the ten years. The area of the present lake surface is .828 square mile. The former area if twice as large was 1.656 square miles. The average area for the ten years has been 1.242 square miles, which is 34,624,972.8 square feet. The volume on this average area to five feet deep is 173,124,846 cubic feet, the water loss in ten years. Thus, the loss per year has been on the average 17,312,485 cubic feet. This loss has been much more rapid than in the preceding years according to the testimony of citizens and according to the record kept at Lily Lake. While the consistent loss since white settlement of this region can be explained by deforestation and systematic drainage of the land, the increased decline within the last ten years is no doubt due to the installation of the sewage disposal system in the city of Laporte.

Apparent Relation of Lake Level to Ground Water Level Prior to Installation of Sewage System. When white settlers came to this region and for a long time thereafter Clear Lake drained eastward through the present city of LaPorte. During that time Clear Lake stood at a lower level than Pine Lake. This is shown by the levels of the old shore lines. Even at that time, however, there was underground drainage from Pine Lake through the Valparaiso moraine to the springs whose location is shown in figure 1. There is every indication that this drainage existed because of the steep gradient shown in table 1. Some idea of the drainage of the region north of these lakes and no doubt of the lakes themselves may be gained from observations at Harding Pond, Section 22. Considerable areas north of this pond are drained into it by tile drainage, one an eighteen-inch tile. During heavy rains this tile and others flow full into the pond and fill it up to a certain level above which the lake does not rise. Neither is there indication of water entering Pine Lake from this pond. The two are separated by a divide over fifty feet above Pine Lake. The distance from the pond to Pine Lake is about one-half mile and the difference in elevation 10 feet. Thus the gradient from Harding Pond to Pine Lake is 20 feet per mile but the springs north of the moraine are 75 feet lower than the pond and two and one-half miles away. Thus the gradient to the springs is 30 feet per mile.

The peculiar topography of this moraine with its abrupt northern slope leaves the whole southern slope perched so high above it that the tendency of the ground water below lake level is to pass beneath the moraine and appear at the springs. There are no large springs on the south side of the moraine. The material of the moraine is principally gravel and sand while that of the Kankakee lowland is fine sand and clay. There is every evidence that there is a deep seated underground drainage even from the Kankakee valley itself toward Lake Michigan.

Figure 4 illustrates the general idea. In order to prove this point a well test was made to determine the direction of ground water flow on the north shore of North Pine Lake at the point indicated by the letter W in figure 2. The point selected for the test was located fifty feet from the present lake shore, about five feet above present lake level on the old lake bed. A three-inch well was sunk to a depth of twenty-nine feet, which brought it to the level of the deepest point in Pine Lake. The deepest point in Pine Lake was 24 feet, located three hundred feet directly out from where the well test was made. Using the three-inch well as a center and a radius of six feet, a circle was described. On this circle at the cardinal and intercardinal points two-inch wells were sunk to the same depth as the three-inch well. The water rose in these wells to various heights from 2.73 to 3.08 feet below lake level. This circumstance proved that the ground water was not moving toward the lake at the surface of the lake. Some of the wells

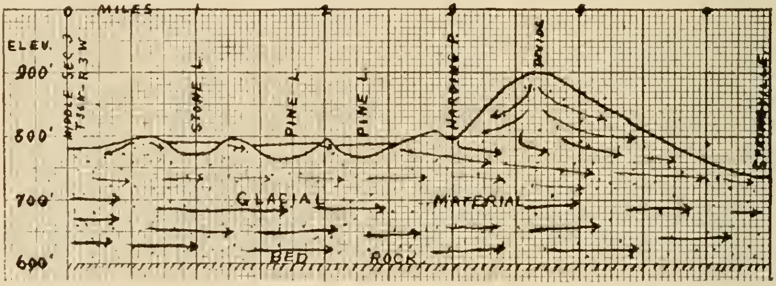

Fig. 4. Cross-section from middle of section 3, T. 36 N., R. 3 W. northward through Stone and Pine Lakes and Harding Pond, to Springville, showing probable ground water movements.

had clay pockets in the drilling and these wells stood at the highest level. All the wells were in gravel at the bottom.

At six a. m., July 4, 1922, the center well was charged with fluorescein, which colors the water a vivid green. Samples were taken from the outer wells each hour during the afternoon. At 7:00 p. m. a faint color was detected in the northwest well which became distinct at 7:15. Thus the ground water at that point was moving northwestward at the rate of six feet in thirteen hours, 11 1/13 feet per day. If this rate is uniform the time necessary for it to travel to the springs north of the divide is almost four years. This is rather rapid for ground water flow but the rapidity is due to the gradient of twenty-two feet per mile and the coarse sand and gravel through which the flow occurs.

The result of this test when associated with the fact that the lake levels are successively lower from Lower to North Pine and that there are overland channels which flow from Lily to Stone and from Stone to South Pine part of the year leaves no room to doubt that the principal ground water drainage from the lakes is from North Pine northward.

Springs Between Springville and Bakerspoint. A careful examination of the springs north of the moraine was made. The springs issue from the hill slope in bogs which sometimes cover several acres. Within these bogs the whole surface is filled with water and trembles as one steps upon it. In wet weather it is impossible to walk across them. The highest of these bogs was at an elevation of about 724 feet. From the bogs the water immediately forms a definite stream which flows down a steep slope until it joins Trail Creek. The seven springs shown as tributary to the east fork of Trail Creek (figure 1) discharged on June 22, 1922, 2.8628 cubic feet per second. This measurement was carefully made by weir and calculated by Francis' formula. The western one of these springs was by far the largest and discharged 1.75 cubic feet. No measurements were made on the springs tributary to the west fork of Trail Creek but the two forks are not far from the same size. The measured discharge amounts to 90,181,260 cubic feet per year. From the topography of the region it appears that about twelve square miles drain through the moraine in the vicinity of LaPorte. The discharge of the springs would account for about three and one-half inches of rainfall over this area. Since no measurements were made on the springs on the west fork of Trail Creek that discharge would account for considerable more. Since the rainfall is about thirty-six inches and the run-off usually about 25 per cent to 35 per cent, the amount to be accounted for would be about 9 to 12 inches. Therefore it is evident that these springs account for a considerable percentage of the drainage of this region.

Figure 8 has already been discussed to some extent on page 86 of this paper. The rainfall data shown in this graph was taken from reports of the United States Weather Bureau for LaPorte and are referred to inches on the right of the graph. It will be noticed that the lake response to heavy or light rainfall occurs two years later. An analysis of the graph shows an interesting relation. Low rainfall occurs in 1899 and low lake level two years later; high rainfall in 1902 and high lake level two years later; low rainfall in 1904 and low lake level two years later; high rainfall in 1907 and high lake level two years later; low rainfall in 1910 and low lake level two years later. Two slight contradictions to this response occur. A slightly diminished rainfall in 1906 has no corresponding depression of lake level in 1908 and relatively high rainfall in 1911 is not succeeded by high lake level in 1913. The latter case can be explained by the fact that the city water was drawn from the lake from July, 1908, to November, 1912. This fact may also account for the rapid decline of the lake from 1909 to 1912. The responses are too regular to be accidental and there must be some cause for it.

Hypothesis to Explain Responses of Lily Lake Level to Rainfall. The response of Lily Lake and probably of the whole system to the rainfall cannot be explained by the influence of any condition near at hand. While the actual movement of ground water from the crest of the moraine north of the lakes to them, if such movement takes place, would probably require two years, yet the rise of the water table at that point would show its influence much sooner. It is my opinion that this response comes from a stimulus in the great morainic area of Steuben County and vicinity. Figure 5 shows the general idea. It is an interesting thing that artesian wells occur at many points between Steuben and LaPorte Counties. At South Bend there is a lens of impervious clay as shown in figure 5. A well drilled into the gravel beneath this clay will overflow in the lowlands along the St. Joseph River while a well sunk into the gravel above the clay will not overflow. In other places in this vicinity the same condition exists. The same influence communicated to the bottom of the lake system at La Porte would influence its level. The position of these lakes at the edge of the great clay deposits of the Kankakee lowland would account for the hydrostatic head by which the lake level is sustained slightly above this lowland. The response to the static influence from this great distance would lag far behind the stimulus. I know of no experiment or investigation which has ever been made to determine the rate of response of stimulus from hydrostatic head through rock. No conclusive

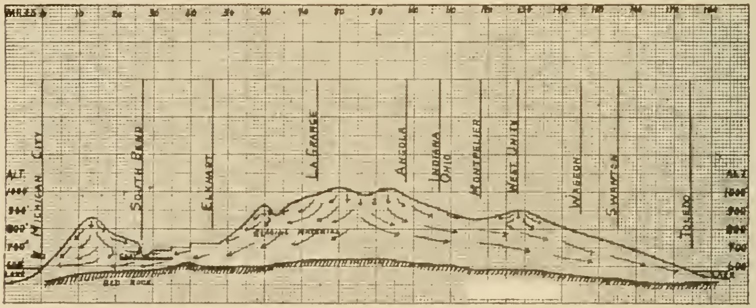

Fig. 5. Cross-section profile from Lake Michigan to Lake Erie showing major ground movements as dominated by major relief features.

statement as to the cause of the response shown in figure 3 can be made, but as before stated the responses are too definite and persistent to be ignored.

Apparent Effect of Installation of Storm Sewage System in LaPorte upon the Lakes, with Explanation. The storm sewage disposal system of LaPorte was constructed in 1912-13. The extent of the main lines of this system is shown in figure 2. Laterals extend to all parts of the city along these mains. All that part of the system north of the junction of the Fifth Street main with the main sewer line is above the level of Clear Lake. Following the installation of this system there has been a rapid decline in the level of the lake system. As previously stated, Mr. W. A. Cummings, Park Superintendent, has determined this decline to have been about five and one-half feet in eight years. Because of the coincidence of the beginning of the rapid decline of the lake level with the installation of the sewage system it is apparent that they are related.

The soil underlying the city of LaPorte is principally sand and gravel with small amounts of clay. Formerly much of the water which fell in the city as rain entered the soil and became ground water. Thus, the water table was held up. After the installation of the sewage system the storm water was drained directly from the streets into the sewers. As a result there was a loss of water to the water table and it declined. Mr. J. W. Good, well driller of LaPorte, stated that he finds the water table about seven feet lower now than at the time of the installation of the sewer system. He states that the water table is now from twenty-eight to thirty feet beneath the surface of the city. The city bench mark on the court house lawn is at 812.32 feet elevation. Therefore the water table, according to Mr. Good, is at 782.32 to 784.32 feet elevation. If we consider the present water table as being at 783.32 feet elevation in the business section of LaPorte, seven feet lower than in 1913, and Clear Lake at 791.76 feet elevation or five and one-half feet lower than in 1913, we have the following comparison of levels:

	Clear Lake Level	Water Table Level	Difference
1913....................	797.26 feet	790.32 feet	6.94 feet
1922....................	791.76 feet	783.32 feet	8.44 feet

If we now consider the business section of LaPorte as one-half mile from Clear Lake, we find that the fall of 6.94 feet in the half mile is practically the same as the fall of 13.3 feet per mile toward the city wells (see page 88). By the installation of the sewage system the water table was lowered about Clear Lake, thus steepening the water table slope. This slope is still steeper than it was before the installation of the sewage system, so it may be that Clear Lake will decline further. Since the supply of water to the lakes was not increased when the sewage system was installed and the water table lowered on this side of the lake it serves the same purpose as removing a retaining wall from the side of a pond except that the response is slower due to the very slow movement of the ground water.

Proposed Plans for Restoring Lake Levels. On page 89 the average loss of water per year from the lake system for the last ten years is given as 17,312,485 cubic feet. Any means of restoring the lakes to their former level must therefore furnish at least this much water. Two plans are suggested. The first is to reverse the storm sewage of the city into Clear Lake. All of the system north of and including the Fifth Street sewer could be reversed. The area drained by this part of the system is about two square miles and the annual rainfall on this area slightly more than thirty-six inches. If we consider that the sewers carry away one-tenth of the water which falls within the area drained by them the amount disposed of during the year would be 16,727,040 cubic feet or almost enough to supply the deficiency. Since it is highly probable that much more than one-tenth of the rainfall is disposed of by the sewers and since the average loss per year to the lakes is probably considerably over-estimated, this reversal of drainage would probably be sufficient to prevent a further decline of lake level and also tend to raise the level.

A second plan is to drain areas of the morainic area north of the lakes into them. As previously pointed out, there is now little of this area draining into the lakes. However, between the lakes and the crest of the moraine there are about 3,500 acres which could be drained into the lakes. Three lines of drainage are suggested and shown in figure 2. The eastern line of drainage beginning in section 14 would drain an area of about 1,000 acres without laterals and possibly half that much more by lateral connections. This drainage introduced into Lower Lake would silt it up and gradually reduce this lake to solid ground, which would be highly desirable, since Lower Lake is now virtually a swamp and nobody is interested in restoring it. This would admit the drainage into Clear Lake virtually free from sediment. The second line of drainage in sections 21 and 22 has already been surveyed by Mr. Thomas, City Engineer of LaPorte. It is proposed by Mr. Thomas to tunnel about 1,600 feet from Harding Pond to Pine Lake. This line of drainage would drain about the same amount of land as the former line. The third line of drainage in sections 20, 29 and 33 would drain a smaller area. The total area drained would be not less than 2,000 acres and if fully developed about 3,500 acres. The slopes along the drainage lines would vary from 30 to 50 feet per mile. The discharge delivered by these drainage lines if properly installed would vary from 25 to 40 per cent of the rainfall. This would be from 9 to 15 inches per year from the area. If the higher estimate of 15 inches from 3,500 acres is considered the discharge would be 190,575,000 cubic feet per year. If the lower estimate of 9 inches from 2,000 acres be considered the discharge per year would be 65,340,000 cubic feet. Even the lower estimate is 3.7 times the yearly loss of water from the lakes and the result of this drainage would be the immediate restoration of the lakes to higher levels.

The result of restoration of the lakes to higher levels would be to increase the ground water slopes from the lakes. In order to determine the amount of this increase we will consider a seven-foot rise in lake level. This would increase the slope from Pine Lake to the springs from 68.59 feet to 75.59 feet, an increase of 10.2 per cent. The increase from Clear Lake east to the city wells would be from 51.62 feet to 58.62 feet, an increase of 13.5 per cent. Since the movement of ground water depends upon slope and the porosity of the rock, and since the porosity would be unchanged, the increase in ground water loss would be from 10.2 to 13.5 per cent. If we consider this to be 12.5 per cent the estimated loss of 17,563,392 cubic feet per year would be increased to 19,758,816 cubic feet. This would still make the estimated discharge to the lakes over three times the estimated loss from them. I am sure the loss in this case is over-estimated and the gain under-estimated so that these figures are very conservative.

Some minor advantages would be derived by carrying out the proposed plans. Considerable areas of fertile land would be drained and made suitable for agricultural purposes along each of the three proposed drainage lines. The water table would be restored under the city of LaPorte which would restore wells to their former levels and also be of great value to the vegetation of the city. Clear Lake, which is now in the last stages of lake existence and rapidly becoming an unsightly swamp, would be made a fine open lake which would add greatly to the health and beauty of the city.