WISCONSIN
STATE PLANNING BOARD

THE MILWAUKEE RIVER BASIN

MILWAUKEE RIVER FLOOD CONTROL

FOREWORD

Floods occur on practically all streams, both large and small, but they do no particular harm until human occupancy of their flood plains takes place. When such occupancy becomes dense, so that numerous human habitations are flooded, or a type of agriculture that is badly damaged by periodic flooding becomes profitable, then there is always a demand for relief. The history of the demands for flood control on the lower Mississippi River and efforts to bring about its accomplishment is the classic example.

There has been a demand for flood control on the Milwaukee River since about 1924. Its history is set out briefly in Chapter I of this report. Two principal methods of accomplishing such flood control have been suggested: (1) by a diversion of flood waters into Lake Michigan at a location approximately opposite Thiensville; (2) by flood detention reservoirs, for which there are two possible sites. The downstream end of the principal reservoir site is located approximately one mile upstream from the village of Waubeka. The second, which is on Cedar Creek, is located about one mile west of Horn's Corners in the town of Cedarburg, Ozaukee County. An improvement in flood conditions at the place where these are the most damaging (that is, in the Lincoln Park district just north of Lincoln Park, Milwaukee) is possible by means of channel improvement, but since the data available are insufficient, no extended discussion is attempted.

The purpose of this report is to present, in a form that will be understandable, the principal facts with reference to conditions on the Milwaukee River as they affect flood conditions, the facts with reference to floods that have occurred within the period of record, the probability as to future floods, the various methods of flood control that have been proposed, what would probably occur if flood control works should be constructed, how their construction would affect the people of the locality where they would be constructed, and their probable cost. It is necessary that the people who are most affected shall have the best and most comprehensive available information on which to base any decisions they may be called on to make with respect to any flood control measures that may be proposed. Among these decisions are the following: (1) Shall flood control works be built? (2) If flood control is to be accomplished, shall this be by means of diversion of flood waters to Lake Michigan or by flood detention reservoirs, or by some other means, such as deepening and widening the channel of the river where most of the damage now takes place? (3) If flood control works are undertaken, how shall they be financed?

This report contains in a condensed form substantially all of the information that is available on the subject. If

CHAPTER II

PRESENT DEMAND FOR FLOOD CONTROL--STATEMENT OF EXTENT OF FLOODING

General Discussion

Probably the most insistent present demand for the control or diminution of floods on the Milwaukee River comes from people who are interested in occupying lands within the flood plain of the river within areas located as follows: (1) that portion of the flood plain in Milwaukee County lying north of Lincoln Park and along Lincoln Creek, (2) in Ozaukee County, in the low-lying lands along the river in the first six tiers of sections north of the Milwaukee County line, (3) in the village of Thiensville, (4) in the village of Saukville and low-lying lands in the vicinity extending along the river to a point about 2½ miles north of Saukville, and (5) the village of Waubeka. This is the territory which suffers most from floods. Considerable portions of the lands described, outside the three villages named, are platted for residential purposes. There are summer cottages along the river which would be occupied the year around were it not for the probability of flooding during the spring. As it is, the occupants move out during the winter, taking such precautions as are necessary to protect the furnishings from high water when it comes, and return after the spring floods subside. The farmers along that portion of the river below Waubeka are not greatly harmed by floods, unless they come during the season when there are crops to be damaged. A large portion of those lands is in "wild pasture" which is benefited by the sediment deposited by floods. Floods damage crops only during the growing season; most of the Milwaukee River floods have occurred in the early part of the year, before spring planting.

The Flood Plain--Lincoln Park to Waubeka Dam Site

Prior to 1935, the City of Milwaukee considered setting up a WPA project for the construction of diversion works near Thiensville. However, the proposal was not pressed, presumably because those originally in favor of this project became aware of the many obstacles involved, and were convinced of the difficulty in overcoming them. At any rate, there was no action on the part of the city to press the diversion proposal.

The City of Milwaukee did, however, take steps to relieve flood conditions in Lincoln Park by increasing the capacity of the river channel. Within the park, there was a series of ox-bow bends in the river, which tended to decrease the velocity of the flood water and to cause it to rise and spread out over the low-lying portions. The flow was further retarded by a limestone ledge, which obstructed the channel for more than a mile in the park, and half that distance below it. About 1935 the City of Milwaukee carried out a WPA project to remove the obstruction by deepening the river channel through this limestone obstruction so as to provide a uniform grade. The result was to improve the grade of the river and to increase the size or cross-section of the channel the entire distance. In early 1937, the city undertook another project to cut through the ox-bow bends in the park, thereby improving the alignment of the channel and still further increasing its capacity. The bed of the river now has been cut to a uniform grade and a uniform bottom width of 200 feet from a point 1600 feet below the Port Washington Road bridge to the upper end of the park, 5300 feet above the bridge. The channel deepening at the Port Washington Road bridge is about five feet, and at a point about 1,000 feet upstream from the bridge, is about six feet. It is reported that consideration is also being given to continuing the channel improvement north to Kletsch Park dam.

The level of the water in Lincoln Park is regulated by a dam in Estabrook Park, below the lower end of the channel improvement. This dam is provided with gates which will make the full capacity of the channel available when needed. It is the opinion of the Milwaukee County Regional Planning Department that the stream channel in and below Lincoln Park is of such capacity that no serious damage will result from a flood equal to that of August, 1924.

The areas which are specially affected by floods, referred to at the beginning of this chapter, are shown on the following maps:

Map 2.* Topographic Map. Silver Spring Road to Milwaukee River Boulevard.

Map 3. * Topographic Map. Port Washington Road to Kletsch Park Dam.

Map 4A. Milwaukee River-Kletsch Park Dam--Ozaukee County Line.

Map 4B. Milwaukee River-Kletsch Park Dam--Ozaukee County Line.

Map 4C. Milwaukee River-Kletsch Park Dam--Ozaukee County Line.

Map 5. Milwaukee River in Ozaukee County.

<u>Lincoln Creek District</u>

Lincoln Creek enters the Milwaukee River near the upper end of Lincoln Park. Its headwaters are in a very flat area

* Maps 2 and 3 are reproductions of a map in the office of the City Engineer of Milwaukee.

in the northwest part of the City of Milwaukee. Through a WPA project carried out in 1936 and 1937, certain large storm sewers were built near Park Lawn, a housing development, to carry this stream; also channel improvements designed to increase the capacity of the channel and speed up the velocity of the flow were made farther down stream. These works will relieve the storm water situation in northwestern Milwaukee, but it is reported that the ultimate development in that area will greatly increase the rate of storm water discharge into the main river. This will probably be a benefit, since it seems likely the discharge from Lincoln Creek will be out of the way before the high water from the upper river gets down to Lincoln Park.

Lincoln Park to Kletsch Park

It is in the territory along the river, between these two parks, where there are the greatest number of houses that are subject to inundation. The straight line distance is about 8,000 feet (1 3/4 miles); along the river the distance is 11,200 feet (about 2 1/8 miles). Many houses and other buildings have been built on land that is below the grade of even moderate floods. Most of these buildings are on the west side of the river. Information regarding the elevation of the ground along the river and at the buildings, and the elevations of the tops of the foundations of most of the houses is available through a topographic map made by the City Engineer's Department of the City of Milwaukee, dated September 23, 1936. This is reproduced here at a reduced scale as Map 3. A summary of this information is given in Table 1. Survey stations are spaced 100 feet apart. The houses and other buildings that are included in the tabulations are those which are likely to be affected by high water. The elevations of the tops of the foundation are averages. The elevation which represents a flow of 14,700 cfs. was the maximum flood stage during August, 1924; the elevation representing a discharge of 6400 cfs., which is a moderate flood stage, was on a later day, when the water had subsided to a moderate flood stage. The location of the various stations is as follows:

Station 92 - North Boundary Lincoln Park.
" 98 - C. and N. W. Ry. Crossing.
" 121 - Silver Springs Road.
" 150 - Lower Sharp Bend - Narrow Constricted Channel.
" 170 - Upper Sharp Bend - Narrow Channel.
" 190 - Bender Road.
" 200 - C. and N. W. Crossing - Belt Line.
" 206 - Kletsch Park.

TABLE NO. 1. SHOWING RELATION OF ELEVATIONS OF BUILDINGS AND GROUND LEVELS ALONG THE MILWAUKEE RIVER TO FLOOD WATER HEIGHTS IN THE FLOOD OF AUGUST, 1924, FROM LINCOLN PARK TO KLETSCH PARK

Survey Stations	Number on West Bank	Number on East Bank	Buildings along River – Average Elevations – Top of Foundations – West Bank Buildings	Top of Foundations – East Bank Buildings	Ground – West Bank	Ground – East Bank	Flood Water Elevations – 14,700 cfs. Peak	Flood Water Elevations – 6,400 cfs. Peak
92 to 98	14	4	44.5	49.7	43.0	41.0	46.3	43.3
98 to 121	91	8	45.0	46.0	44.0	45.0	47.0	43.8
121 to 130	20	0	45.5		42.0	49.0	47.7	44.2
130 to 140	23	10	45.0	56.0	42.0	54.0	48.1	44.5
140 to 150	15	10	45.0	62.0	41.0	60.0	48.4	44.8
150 to 160	16	0	46.0		43.0	41.0	48.7	45.3
160 to 170	13	0	46.0		46.0	42.0	48.8	45.5
170 to 180	24	2	47.0	52.0	44.0	44.0	48.9	45.9
180 to 190	14	5	47.0	51.0	45.0	45.0	49.0	46.2
190 to 200	2	7	51.0	51.0	49.0	45.0	49.2	46.4
200 to 206	8	10	56.0	51.0	51.0	47.0	49.3	46.8
Total	240	56 - Total buildings both sides - 296.						

Elevations are referred to zero of Milwaukee city datum, which is elevation of Lake Michigan, 580.6 feet above mean sea level.

From Table I it is apparent that the general level of the tops of foundations of buildings on the west side of the river is very close to the peak flood level of the moderate 6,400 cfs. discharge stage. Many of the buildings are lower than this stage. The general building level is from 3 to 4 feet below the 14,700 cfs. discharge stage. In a flood of such magnitude, the floors of most of these buildings will be under water, some of them as much as 5 feet.

According to the calculations of the City Engineer's office, the deepening and straightening of the channel, which has been carried out through Lincoln Park and below, will have a decided effect in lowering flood heights on that portion of the channel which has been deepened and straightened. They estimate that with the recurrence of a flood similar to the 14,700 second feet flood of August, 1924, the water will be approximately five feet lower through the improved channel than during the August 1924 flood. It seems probable that appreciable improvement in flood conditions could be effected on that part of the river below Kletsch Park by continuing the deepening of the channel as far north as the Kletsch Park dam. It would also be necessary, in order to secure the full benefit of such channel improvement, to widen the channel in two places, and to ease two of the turns, as will be explained later.

Channel Constriction

At the time of the spring break-up, there is great fear of ice jams in the area just north of the Silver Springs Road. This was particularly in evidence in the spring of 1936. The severe cold weather of the preceding January and February had caused thick ice to form. Pressure was brought on the public authorities to secure the removal of ice from the channel by such means as cutting with saws, dynamiting, etc. Fortunately, conditions during the spring break-up were such that no trouble resulted. This demand recurs each year, however.

A condition favorable to the formation of ice jams exists between the Bender Road and the Silver Springs Road. The situation is shown on Map 2. At Station 180 of the City Engineer's Survey, about 1,000 feet south of the Bender Road, the river is about 130 feet wide. At a point about 500 feet down stream, Station 173, the channel narrows down to a low water width of about 70 feet. This bottleneck continues for about 300 feet, and from this point the width of the low water channel is 100 feet or less for a distance of more than 1,000 feet. Between Stations 151 and 145, the river makes a sharp turn to the right through approximately 130 degrees, with a radius around the inner side of the curve of approximately 200 feet. The low water channel at the beginning of the curve is approximately 160 feet in width, but just below the turn, the channel narrows to a width of about 70 feet. A concrete wall has been built on the west side of the river, at the narrowest point, apparently to keep the bank from washing away.

The combination of sharp turns, together with the narrow channel, is conducive to the formation of ice jams when weather conditions are favorable. Such jams can easily dam the river, and cause flooding of the low banks even when the river is at a moderate stage.

The entire west bank and much of the east bank, from Bender Road to Silver Springs Road, is platted into lots. This portion of the west bank is the most thickly built up of any section along the river, and most of it lies at elevation approximately 44.0, which is 1.3 feet lower than the level of the 6,400 cfs. floods at that point. Very little building has been done on the east bank above Station 150, the location of the sharp turn mentioned. Here the ground level ranges from 40 to 44, from 5 to 8 feet below extreme high water mark. There is considerable building on the east bank below Station 150, but here the ground is high, several feet above the level of even the highest floods.

As pointed out earlier, the deepening of the channel through these sharp bends would lower the flood level, but it would be necessary also to ease the sharp turns and to widen the channel or solid as snow, sleet, or hail, which become liquid in due season. After the water has fallen, a part of it remains on the surface until it has evaporated again (evaporation), a part is absorbed into the earth (absorption), a part is used by plant life (transpiration), and a part flows over the surface to some stream and thence to a lake or to the sea. If the amount of the water removed from the earth's surface by absorption, transpiration, and evaporation is subtracted from the total amount which has fallen, the difference is the amount that finds its way into our rivers. This is known as "runoff". If the amount of runoff reaching a river during any time interval exceeds the amount which the river channel can carry away during that interval, the river overflows its banks and flood conditions prevail.

The amount of water that will be absorbed will vary greatly, according to the character and condition of the soil. In general, clay will absorb less than sand, and some other formations less than clay. The quantity of humus in the soil will increase its capacity to absorb water. The ability of any soil to absorb water will vary greatly under different conditions. Frozen ground will shed water like a roof. A beating rain falling on plowed ground may pack the soil, and decrease its ability to absorb water, or seal the surface with fine silt. Clear water is absorbed more readily than muddy water.

The annual rainfall (which includes all forms of precipitation) observed at West Bend during a total of 25 years of record (1895-1902 and 1922-1938, both inclusive) has averaged 30.34 inches. The annual average of 97 years observed rainfall at Milwaukee is 30.61 inches. In Wisconsin, the greatest rainfall generally occurs in the month of June. However, September has been the wettest month in the Milwaukee River Basin during the period of record. About 72 per cent of the rainfall occurs during the seven months from April to October, inclusive, when the soil is most capable of absorbing water. This is the condition most favorable for agriculture and to the firm flow of streams.

But there is great variation from year to year. The wettest year at West Bend was 1938, when the rainfall was 41.86 inches; the driest year was 1901, when there were only 19.72 inches rainfall. The greatest storm on record over this basin occurred August 3-6, 1924, when there was a total of 9.31 inches of rainfall in 4 days. The greatest flood on record occurred between March 17 and 23, 1918, reaching its peak on the 20th. The rainfall during this period was not great, totalling 0.83 inches over the basin on the 13th and 14th, but it fell on snow overlying frozen ground.

day of the storm, August 4, which was the day when most of the rainfall took place. On August 3, the river was almost dry, the discharge (at Milwaukee) being only 105 cubic feet per second, but on the 4th it had increased to 4880 cfs. On the third day it rose to 10,700 cfs., passing the flood stage of 5400 cfs., and on the fifth day to the peak of 14,700 cfs. It took three more days for the flood to subside to a moderate flood stage of 6400 cfs., and about three more to get down to a moderate stage of about 2000 cfs. (See Chart No. 2.)

Flood of March 1929

During the months of January and February, 1929, the accumulated precipitation amounted to the equivalent of 4.79 inches of water. The unusually cold monthly average temperatures for these two months, 12.4° F. and 19.0° F., respectively, supports the conclusion that most of this precipitation fell in the form of snow and that a large share of it held over until the spring thaw. During the period from March 11th to the 16th, the mean temperatures were above freezing continuously. On the 12th and 13th, a total rainfall of slightly less than one inch aided in the melting of accumulated snowfall. Starting with a discharge of 2000 cfs. on March 12th, the river rose to a maximum of 12,800 cfs. on March 15, dropped to 6600 cfs. two days later and maintained an average discharge of about 5500 cfs. for five days more.

It should be noted that this flood of March 1929 (see Chart No. 2), took about the same time as the floods previously described (three days) to rise from 2000 cfs. on March 12th to its maximum discharge of 10,800 cfs. on March 15, dropped to 6600 cfs. in two days, and maintained an average discharge of about 5500 cfs. for five days more. Though the maximum rate of discharge was less than in either of the two previously described floods, the total amount of water discharged during the flood period was approximately equal to that of August 1924.

The greatest rainfall in the basin has come in late summer and early autumn, but the greatest observed flood, in fact two of the greatest, have come in March as a result of relatively light rains on snow overlying frozen ground. Not only is the probability of floods the greatest at that time of year, but the possibility of damage to buildings that are subject to flooding is increased by the probability of floating ice and ice jams. At such times moving cakes of ice are likely to lodge where the channel is narrow, crooked or obstructed. There are instances where a semi-frozen slush (frazil) has formed and caused rivers at moderate stage to rise above their banks. This occurred on the Rock River in late February 1922, when the river rose about ten feet, suftopography, and the uniform slope of the stream, an estimate on this basis seems as good as any that can be made. Prorated estimates of the total discharges during five floods at the Waubeka dam site are given in Table No. 4. These figures are the bases on which the preliminary design of flood control works and estimates of the extent of submergence of land have been made.

TABLE NO. 4. SHOWING ESTIMATED TOTAL DISCHARGE OF THE MILWAUKEE RIVER AT WAUBEKA IN ACRE FEET FOR VARIOUS PERIODS DURING FLOODS OF RECORD

Flood of	Fifteen high days	Ten high days	Eight high days	Five high days	Four high days
March, 1918	105,516	91,737	84,632	60,056	59,654
April, 1923	62,653	55,227	49,514	38,109	30,787
Aug., 1924	96,478	80,096	75,505	61,777	54,086
March, 1929	104,982	81,497	70,822	49,793	41,850
April, 1933	38,830	33,106	30,450	24,899	22,363
Feb., 1937	38,242	33,112	30,991	25,956	23,192

It will be noted that the estimated total discharge of the flood of March 1929 for the 15 high days, is about 10 per cent greater than that of the flood of August 1924, although the maximum rate of discharge was only three-fourths as great. (See Table No. 3, "Array of Annual Flood Events", for maximum rates of discharge.) This is because it lasted substantially longer.

It must not be forgotten that runoff from the 261 square miles of drainage area below Waubeka, which will not be controlled by a reservoir, is capable of producing floods which will tax the capacity of the channel in the Milwaukee area. The peak discharge of the 1918 flood represented a runoff of 22.8 cubic feet per second per square mile. A recurrence of such a flood would result in a discharge in excess of 5,950 cubic feet per second at Milwaukee, even should the Waubeka reservoir be in operation. Should a flood of a magnitude of 17,000 cubic feet per second occur, the discharge would be in excess of 6,700 cubic feet per second at Milwaukee, 700 cubic feet per second or more above the channel capacity in the Milwaukee area. Thus can be seen the need for complete control of the 400 square miles above Waubeka.

Another impending development is the probable increase in storm sewer discharge into the Milwaukee River, due to increased residential development in an area in the northwestern portion of the city of Milwaukee. In 1935, 1936, and 1937, in immediate connection with the Parklawn residential development (as stated earlier) a very large storm sewer was built to drain into Lincoln Creek. Also, the capacity of the creek channel farther good for farming will continue to be farmed. The probability is that its capacity to produce will be reduced very little. The land that will be submerged most often is of the least value. Although the area below elevation 802.5 includes 28.0 per cent of the total area, the assessed valuation of the improvements is only 3.9 per cent of the total improvements; of the land, 27.1 per cent; and of both 23.3 per cent of the total assessment. Of this area below elevation 802.5, the lowest portions are already overflown from time to time. As to the land above elevation 802.5, the frequency and duration of submergence will diminish very greatly according to the increase in the elevation of the land.

Whether the dam would be subject to taxation under Wisconsin law is a question. Probably it would be, and this increased valuation will go far to meet any reduction in assessed valuation through periodic submergence. True, the dam site is located in a town which contains only about 16 per cent of the assessed valuation within the reservoir site, but any inequity resulting from such a condition can probably be corrected by legislation. Appendix B gives information that is pertinent as regards the effect of periodic submergence on land values.

The outstanding advantage of the diversion method of control is that it offers complete protection to the Milwaukee area. This would be true even for floods of the greatest expected magnitude. Two disadvantages are the $500,000 greater cost and the fact that no protection is afforded to the lands, developments and villages north of the diversion point opposite Thiensville. Neither can the effect of diversion on lake shore property be ignored.

Both methods depend on the human elements for effective operation. Failure, through improper handling of the gates, to obtain the maximum control available is more probable in the case of the reservoir than in the diversion method, however. The consequences resulting from a failure of the reservoir dam would be much more serious than those resulting from a failure of the diversion works. Failure, of course, is not anticipated; every care is taken to design dams to withstand the forces acting upon them, but the failure of any dam remains a possibility, even though it be remote.

The justification for constructing flood control works that will be adequate, whether it be the reservoir at Waubeka, or the diversion opposite Thiensville, should and will depend upon the benefits, and this will depend largely on the extent to which the use of the flood plain of the river for residence purposes is reasonable.

The flood plain of the Milwaukee River is well adapted to use for recreation. This may be the best use. Milwaukee County is already developing a system of parks and parkways based on its streams, which is admired and emulated all over America. Summer residences are a means of recreation for those who can afford it, and the history of the residential developments in this area